The Parliament of the Commonwealth of Australia

The Senate Standing Committee on Foreign Affairs, Defence and Trade

VISITS TO AUSTRALIA BY NUCLEAR POWERED OR ARMED VESSELS:

Contingency Planning for the Accidental Release of Ionizing Radiation

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Senator W. R. Wood (New South Wales) until 17 May 1988

This inquiry was commenced in the 34th Parliament by the Senate Standing Committee on Foreign Affairs and Defence, whose membership was:

Senator G. D. McIntosh (Western Australia) Chairman
Senator T. Aulich (Tasmania)
Senator J. R. Black (Queensland)
Senator R. L. D. Boswell (Queensland)
Senator Hon Sir J. Carrick, KCMG (New South Wales)
Senator D. J. Hamer, DSC (Victoria)

TERMS OF REFERENCE FOR THE INQUIRY

The Senate referred the following matter to the Committee:

> The adequacy of current contingency planning by Federal and State authorities to deal with the accidental release of ionizing radiation from visiting nuclear powered or armed vessels in Australian waters and ports.

LIST OF RECOMMENDATIONS

The Committee **RECOMMENDS** that:

1. either the Visiting Ships Panel (Nuclear) obtain confirmation that, for each port receiving visits, adequate controls exist to prevent hazardous cargo being dealt with in the vicinity of visiting nuclear powered warships; or that a provision to prevent this be added to the general conditions of entry. (para. 8.21)

2. an additional condition of entry be introduced. This should require the existence of a specific safety plan for those ports where the Visiting Ships Panel (Nuclear) considers that a specific plan is necessary to ensure safety in the event of an accident. (para. 8.64)

3. the zone of complete isolation around a remote anchorage be specified as 1.6 kilometres. (para. 8.68)

4. use be made of local land-use planning procedures to ensure that any change in land use that would affect an approved berth or anchorage is automatically notified to the Visiting Ships Panel (Nuclear). Where this method, or an effective substitute, is not possible or practical, approved berths and anchorages should be reassessed by the Visiting Ships Panel (Nuclear) before each visit to ensure changed land use has not affected their status. (para. 8.78)

5. no visits by nuclear powered vessels take place to either Port Adelaide or Townsville until the berths have been re-assessed to ensure that changed land use has not affected their status. (para. 8.79)

6. where there is a State/Territory contingency plan relating to nuclear powered warship visits to a particular port and the plan is not publicly available, the Commonwealth should:
   (a) advise the State/Territory that it is desirable that the plan be publicly available;
   (b) allow a reasonable time for editing the plan so as to remove any sensitive information (such as passwords or telephone numbers) which might otherwise inhibit its release; and
   (c) withhold approval for visits to any port for which the plan is not publicly available after this time. (para. 8.85)

7. the Visiting Ships Panel (Nuclear) ensure that a set of the Commonwealth planning documents is placed in each State and Territory Library, and, outside capital cities, in the main

public library of each port approved to receive visits from nuclear powered warships. Further, the deposited material should be kept up to date. (para. 8.91)

8. where land-based monitoring is too remote from an anchorage to provide early warning of an accident, ship-borne early warning monitoring be required in two cases: first, when the specified vessel removal time is less than 24 hours, and, secondly, when adequate measures cannot be made to ensure that people are not in the vicinity of the vessel. (para. 8.123)

9. the Visiting Ships Panel (Nuclear) confirm that the wind force measuring equipment at the approved berths at Fisherman Island, Brisbane is now adequate. (para. 8.145)

10. the Commonwealth Government produce a document containing all the necessary scientific background on naval nuclear reactors; the nature of the potential hazards resulting from accidents involving the reactors which the plans have to address; and other background information which is common to all the plans. The document should be suitable for incorporation in, or attachment to, individual port safety plans. (para. 9.21).

11. the wording of the WA Port Safety Scheme be clarified on the question of whether vessel removal procedure differs according to whether the accident is notified by the vessel commander or detected by early warning monitoring. (para. 9.42)

12. the Visiting Ships Panel (Nuclear) develop guidelines to assist decision-makers in determining under what circumstances vessel removal is appropriate. In particular, the guidelines should indicate under what circumstances and at what ports automatic removal following an accident would be appropriate. (para. 9.46)

13. the Department of Defence seek information and assurances from the United States Navy that, with respect to its multi-reactor vessels:

    (a) the likelihood of a reactor accident leaving one without propulsion power is not sufficiently credible to require planning; and

    (b) the biological shielding and ventilation arrangements are adequate to permit the continued operation of the vessels following the reference accident occurring to one reactor.

    If adequate information and assurances are not obtained, the Committee RECOMMENDS that condition (e) of the conditions of entry be amended to require the provision of a towing capability during visits by multi-reactor warships. (para. 9.55)

14. the Department of Defence confirm that condition of entry (e) is interpreted by the commanders of visiting warships having more than one reactor as requiring that a second reactor be kept in a sufficient state of readiness to be used for post-accident vessel removal. If the Department is unable to confirm this, the Committee RECOMMENDS that condition (e) be reworded to make this state of readiness a condition of entry for multi-reactor warships. (para. 9.59)

15. the Department of Defence determine if assistance from one or more tugs would be essential to effect the speedy removal from any approved berth of a multi-reactor vessel with a damaged reactor, and, if so, require as a condition of entry for the visit that the necessary assistance be available during visits to that berth. (para. 9.63)

16. condition (e) of the conditions of entry be reworded to put beyond doubt that towing facilities are required to be made available as soon as possible after an accident, rather than merely within the maximum time of 24 hours specified for vessel removal for berth assessment purposes. (para. 9.75)

17. it be a requirement that a person sufficiently trained to conduct radiation monitoring be on board a vessel designated for emergency towing following a reactor accident. (para. 9.87)

18. no visits to berths at Fisherman Islands, Brisbane be approved until adequate, documented, provisions are made: <u>either</u> for the evacuation of port workers, persons on ships in the vicinity, and tourists and other recreational land users likely to be within the inhalation hazard zone (Zone 2); <u>or</u> for avoiding the presence of such persons during a visit by a nuclear powered warship. (para 9.109)

19. the approved berths up-stream (ie. closer to Brisbane) of the ones currently used at the Container Terminal not be used until adequate, documented, provisions are made for the evacuation of residents from within the Zone 2's for the berths. (para. 9.109)

20. no visits be permitted to the northern approved anchorage or to either of the approved berths at Darwin until detailed provision is made in the Darwin Port Safety Plan for evacuation of the relevant Zones 1 and 2. (para. 9. 113)

21. the berth approval for Macquarie Wharves, Hobart be rescinded. (para. 9.120)

22. no approval be given to any berth or anchorage where a major hospital lies within the zone in which evacuation may be required (ie. Zone 2) following an accident. (para. 9.120)

23. no visits be made to the primary approved anchorage in the Derwent near Hobart until adequate, documented, provisions are made for evacuation of residents and others from within 1.2 km (ie. Zone 2) of the anchorage. (para. 9.122)

24. before further visits are permitted to Jervis Bay there should be an examination of whether contingency planning for evacuation and other countermeasures in respect of areas outside HMAS CRESWELL is required. This examination should include consideration of the need for liaison with New South Wales authorities. (para. 9.124)

25. the Western Australian planners delete their provision for distribution of potassium iodate tablets to the general public beyond Zone 2. (para. 9.152)

26. the Government seek advice to determine if there is a practical need to administer stable iodine for several days, rather than as a single dose, in order to provide continued blocking of thyroid uptake of radioiodine following a brief exposure. The Committee RECOMMENDS that, if the advice received by the Government states that administration over several days is required, plans relating to stable iodine distribution be amended accordingly. (para. 9.160)

27. visits not be approved to berths unless detailed provisions are in place to ensure that those evacuating the surrounding Zone 1 and emergency personnel entering the Zone 1 are able to be supplied with stable iodine. (para. 9.163)

28. the Department of Defence advise the authorities responsible for the individual port safety plans of the need for the plans to contain specific criteria to assist post-accident decision-makers in deciding if sheltering should be adopted as a countermeasure in the particular circumstances prevailing. (para. 10.6)

29. the Department of Defence and ANSTO investigate whether water-spray drenching of an accident-stricken vessel would provide a useful supplementary protective measure. (para. 10.17)

30. no visit to a port be allowed unless the Visiting Ships Panel (Nuclear) is satisfied, after consultation with the relevant State/Territory planners, that the safety plan for that port has been exercised in sufficient depth to demonstrate its adequacy and efficacy. (para. 10.26)

31. no visit to a port be allowed unless, immediately before the visit, there has been an exercise of the port safety organisation. No exercise should be required, however, if an exercise has been held at the port during the previous 12 months, and there has been no change in key personnel since that exercise. (para. 10.31)

32. port safety plans for alongside berths include arrangements, such as those existing for HMAS STIRLING, for the monitoring of evacuees from Zone 1, and for the decontamination of those found to be contaminated. For anchorages, where the Zone 1 comprises no land area, the Committee RECOMMENDS that the plans require that advice be given to those who might be within Zone 1 and downwind of the vessel of the need to take decontamination measures. (para. 10.53)

33. the Department of Defence, based on consultation with the navies of the countries to which the visiting warships belong, provide guidance to State/Territory planners on the planned role of civilian firefighters in the highly unlikely event of a combined fire and radiation hazard on a visiting nuclear powered warship. The Department should attempt to ensure that plans make clear either the role that civilian firefighters have, or the fact that they have no role, as the case may be. If the role requires specialist training and equipment, these should be provided as part of the plans. (para. 10.70)

34. the Department of Defence confirm that, with regard to the public information response to a reactor accident on a visiting warship, measures are in place to ensure:
    (a) that the response of Commonwealth bodies, the State/Territory concerned, and the country to which the warship belongs be coordinated through a single information centre;
    (b) that technical expertise about naval reactors, nuclear weapons, radiation effects and safety measures be available to that information centre; and
    (c) that before visits are approved these public information measures be in place. (para. 10.87)

35. the Department of Defence ensure that the report on the inadequacies of the public information provisions of APTCARE are drawn to the attention of State/Territory planners, together with the results of the review of these provisions in APTCARE. Further, the Department should ensure that the planners incorporate in their plans all relevant lessons of the public information response at Lucas Heights following the 18 March 1987 fire there. (para. 10.91)

36. steps be taken to make better provision in the port safety plans for the making and long-term keeping of records of individuals' presence in the vicinity of the vessel at the time of an accident, of the levels of radiation to which they might have been exposed, and of any evacuation or decontamination which they may have undergone. In particular, the Committee RECOMMENDS that the Natural Disasters Organisation's 'National Inquiry and Registration System' be examined with a view to using it to provide a means of recording and preserving this information. (para. 10.112)

37. no dry-docking of nuclear weapons capable vessels be permitted unless <u>either</u> the vessel has been de-ammunitioned outside Australia <u>or</u> it can be guaranteed that the level of safety is at least as high as that for vessels berthed alongside a wharf, as is the normal practice. (para. 11.90)

38. the Department of Defence continue work on the current unofficial draft document outlining possible procedures for responding to a nuclear weapon accident in an Australian port, with a view to producing an officially approved document. The document should then be made available to the public, in the interests of better informing the community on appropriate response procedures. (para. 11.117)

39. the Commonwealth Government confirm that the State and Northern Territory Governments have adequate plans to deal with shipping accidents involving hazardous cargoes in their ports. The Commonwealth should encourage the States and Northern Territory to make these plans public where this is not already the case. (para. 12.68)

GLOSSARY

Absorbed Dose The energy that is deposited by radiation in any material. (see table following this Glossary)

Activity In terms of radiation measurement, the activity of a radioactive material refers to its rate of radioactive transformation or decay. (see table following this Glossary)

AIRAC Australian Ionising Radiation Advisory Council.

ANSTO Australian Nuclear Science and Technology Organisation (prior to 27 April 1987, the Australian Atomic Energy Commission).

ARL Australian Radiation Laboratory.

Arming As applied to explosives and weapons, the changing from a safe condition to a state of readiness for initiation.

ASROC Anti-submarine rocket launched from surface ships, and capable of carrying either a nuclear or conventional warhead.

Attack Class Submarines Submarines whose primary mission is that of attacking other ships. US submarines in this category are generally capable of deploying theatre nuclear weapons.

Ballistic Missile Submarines Submarines armed with inter-continental ballistic missiles. Submarines of this type do not visit Australia.

Becquerel The unit in the international system of measurements for measuring the activity of a radioactive source. (see table following this Glossary)

Biological Shielding Material placed around a nuclear reactor to protect operating personnel and others from exposure to radiation in excess of permitted levels.

Cladding A thin layer of metal totally enclosing nuclear fuel which protects the fuel from chemical attack (corrosion) by the coolant, prevents the escape of fission products, and provides structural support.

Containment A structure which completely surrounds the reactor system and is designed to contain the releases from accidents with little or no significant release to the environment.

Control Rod A solid element that absorbs neutrons and hence, when inserted into the reactor core, decreases reactivity, producing a decrease or shut-down in power production. Control rods are used for reactor control.

Coolant In a pressurised water reactor, the water passed through the core of a reactor to remove the heat liberated in the fission process. The coolant may also be referred to as the primary coolant.

Core See 'Reactor Core'.

Core Melt The term applied to the overheating of a reactor core as a result of the failure of reactor cooling systems, leading to melting of the fuel and the structures which hold it in place. Also called 'meltdown'.

Critical Just capable of sustaining (at a constant level) a chain reaction. A nuclear reactor is critical when the rate of neutron production is equal to the rate of neutron loss. A reactor is said to be subcritical when it can no longer sustain a chain reaction and supercritical when it is more than capable of sustaining such a reaction.

Critical Mass The least mass of fissionable material that will permit a self-sustaining chain reaction.

Curie The traditional unit for measuring the activity of a radioactive source, now being replaced by the Becquerel. (see table following this Glossary)

Decay Heat The heat produced by radioactive decay of fission products in the reactor's fuel.

Dose (of Radiation) Amount of energy delivered to a unit mass of a material by radiation travelling through it.

Dose Equivalent The absorbed dose multiplied by a modifying factor that reflects the fact that different kinds of radiation having the same amount of energy per unit mass have different biological effects. For example, one gray of alpha radiation can cause about twenty times the biological damage caused by one gray of gamma radiation. By use of dose equivalents, the effects of absorbed doses of different types of radiation can be added together. (see table following this Glossary)

Emergency Core Cooling System (ECCS) A separate cooling system designed to maintain core cooling in a shutdown reactor, following an accident that has disabled the normal coolant system.

Emergency Reference Level (ERL) A level of exposure to radiation which regulatory authorities recommend should not be exceeded in an emergency, and which serves as a guide to when emergency protective measures should be taken

Enriched Uranium Uranium in which the proportion of the fissile isotope uranium-235 has been increased above its natural level of 0.7%.

Fission The breaking of a nucleus into two lighter fragments (known as fission products) plus free neutrons - either spontaneously or as a result of absorbing a neutron.

Fission Products Nuclides produced directly by nuclear fission or by the subsequent radioactive decay of such nuclides.

Fuel Element The smallest individual unit of a reactor core containing nuclear fuel as its principal constituent.

Gamma Radiation High energy radiation of considerable penetrating power emitted by some radioactive substances.

General Accounting Office An agency created by the United States Congress to monitor government expenditure and to review government programs. It is an approximate equivalent to the Australian Auditor-General's Office.

Gray The unit in the international system of measurements for measuring the energy that is deposited by radiation in any material (ie. the absorbed dose). (see table following this Glossary)

Half Life (Radioactive) The time taken for the activity of a radioactive material to lose half its value by radioactive decay.

Insensitive High Explosive (IHE) As defined by the US Department of Energy, explosive substances which, although mass detonating, are so insensitive that there is negligible probability of accidental initiation or transition from burning to detonation. IHE is used for the explosive trigger in most US nuclear weapons developed since the late 1970's.

Iodine A non-metallic element. In radioactive forms it is one of the radionuclides that may be released from the reactor core in a reactor accident.

Ionising Radiation Any radiation that directly or indirectly displaces electrons from the outer domains of atoms.

Isotopes Nuclides having the same number of protons in their nuclei, and hence belonging to the same chemical element, but differing in the number of neutrons. Such atoms have identical chemical properties but their nuclear characteristics, e.g. neutron absorption or fissile properties, may be vastly different (as, for example, the isotopes of uranium U-235 and U-238).

Light Water Reactor A nuclear reactor which uses ordinary water as both coolant and moderator.

Loss of Coolant Accident (LOCA) An accident resulting from a failure in the normal reactor cooling water system (primary coolant system) leading to a loss of the cooling water from the system.

Megawatts Thermal - Mw(t) The amount of power in the form of heat produced by a reactor, measured in millions of watts.

Meltdown See 'Core Melt'.

Noble Gases The elements helium, neon, argon, krypton, xenon, radon. They are all chemically inactive.

Non-volatiles See 'Volatiles'.

NPW Nuclear Powered Warship.

Nuclear Weapons Capable Warship A vessel equipped with the means to carry nuclear weapons. In a narrower sense, the term is also used to refer to vessels equipped to use nuclear weapons, thereby excluding replenishment and transport vessels.

Nuclear Weapons Certified Warship A US nuclear weapons capable warship that has been fitted with extra safety devices required in relation to nuclear weapons and has undergone the necessary inspection, and whose crew have met the selection, training and inspection standards required in order to be permitted to handle nuclear weapons.

Nuclide A particular kind of atomic nucleus characterised by the number of protons and neutrons and, in some cases, by the energy state of the nucleus; e.g. U-235 and U-238 are nuclides contained in natural uranium.

One-Point Detonation The detonation at one point of the high explosive which surrounds the nuclear material in a nuclear weapon and acts as a trigger.

One-Point Safe A US design standard under which there must be less than 1 : 1,000,000 chance of a nuclear weapon producing a nuclear fission yield of more than 4 lbs (1.81 kg) TNT equivalent energy release following a one-point detonation.

OPSMAN 1 The short title of the Australian Department of Defence's manual of procedures governing visits by nuclear powered warships to Australian ports.

Plume The trail of airborne contamination from a radiation accident, fire, etc.

Power Excursion Very rapid increase of reactor power above the normal operating level.

Pressure Vessel In water-cooled reactors, the reactor vessel is designed for a substantial operating pressure; the vessel is therefore often called a pressure vessel.

Primary Circuit The main circuit of the reactor through which coolant passes so as to remove heat from the core.

Pressurised Water Reactor (PWR) A reactor using water under pressure as a coolant and moderator.

Rad The traditional unit for measuring the energy that is deposited by radiation in any material (ie. the absorbed dose), now being replaced by the Gray. (see table following this Glossary)

Radiation Neutrons, alpha or beta particles or gamma rays which radiate out from radioactive substances.

Radioactive Decay The decrease in activity of a radioactive material as it transforms spontaneously from one nuclide into another or into a different energy state of the same nuclide.

Radioactivity The property, possessed by some atoms, of disintegrating spontaneously with the emission of radiation in the form of alpha or beta particles, gamma rays, or neutrons. See the table following this Glossary for the units used in measuring radiation.

Radionuclide A synonym for radioactive nuclide.

Reactor Core The part of a nuclear reactor in which a chain reaction takes place; the reactor core contains the fuel elements, moderator and support structures, and the coolant passes through it.

Rem The traditional unit for measuring the biological effectiveness of a dose of radiation (ie. the dose equivalent), now being replaced by the sievert. (see table following this Glossary)

Risk The combination (usually expressed as the product) of the probability of occurrence of an accident and the magnitude of the consequences of the occurrence.

Runaway An increase in power or reactivity that cannot be controlled by the normal reactor control system.

Safing As applied to weapons, the changing from a state of readiness for initiation to a safe condition.

Scram Of a reactor, its rapid shutdown (to prevent or minimise a dangerous condition) which is initiated when some operational parameter reaches a level determined by operational or safety requirements.

Secondary Circuit The system to which heat is transferred from the primary system.

Sievert The unit in the international system of measurements for measuring the biological effectiveness of a dose of radiation (ie. the dose equivalent). (see table following this Glossary)

Source Term A quantitative description of the release of radioactive material in a nuclear accident. The description includes the physical and chemical form of the nuclides released.

Stable Iodine Iodine that is not radioactive. Iodine taken in this form will block for a time the uptake by the human thyroid gland of any radioactive iodine that may be inhaled or ingested.

Standard Statement A statement issued by the United States Government containing assurances regarding the safety and operation of its nuclear powered warships during visits to other countries. The United Kingdom Government has given assurances in virtually identical terms in relation to its nuclear powered warships.

Steam Explosion A phenomenon in which molten nuclear fuel rapidly fragments and transfers its energy to the reactor coolant resulting in steam generation, shock waves and possible mechanical damage.

SUBROC Rocket with 40-55 km range launched from a submarine which, after flight, re-enters the water to strike against other submarines. There is no version of SUBROC with a conventional warhead.

Theatre Nuclear Weapons A category of weapons of relatively short range that excludes ballistic missiles, which are classed as strategic or intercontinental weapons. Ballistic missiles are not carried on the types of warships that visit Australia.

Thyroid In humans, a small gland weighing about 20 grams situated in the lower front part of the neck. The gland concentrates and stores iodine taken into the body.

Transient A condition of the nuclear plant in which parameters are varying, usually sharply, either because of planned operations, such as load changes, or because an unplanned departure from the specified function of a system or component has occurred.

Volatiles Substances that evaporate easily or rapidly and hence, in the reactor accident context, are more readily dispersed than less volatile substances.

VSP(N) Visiting Ships Panel (Nuclear) - an interdepartmental committee, chaired by a representative of the Australian Department of Defence, which since its formation in 1972 has dealt with safety and other issues relating to visits by nuclear powered warships to Australia. Since February 1988, the VSP(N) has also had responsibilities relating to visits by nuclear weapons capable warships.

UNITS USED IN RADIATION MEASUREMENT

Units are needed to measure a number of different characteristics of radiation. In addition, two separate systems of measurement are used, the International System of units (in French, Le Systèmе International d'Unités from which comes the standard abbreviation, SI units), and the non-SI units. The former are gradually replacing the latter.

Physical Quantity	SI Unit	Non-SI Unit	Relationship
Activity	becquerel (Bq)	curie (Ci)	1Ci = 3.7 X 10^{10}Bq
Exposure (x rays and gamma rays only)	coulomb/kilogram (C/kg)	roentgen (R)	1 R = 2.58 X 10^{-4} C/kg
Absorbed dose	gray (Gy)	rad	1 rad = 0.01 Gy
Dose equivalent	sievert (Sv)	rem	1 rem = 0.01 Sv

CHAPTER 1

INTRODUCTION

Arguments for and against Visits

1.1 The terms of reference for the present inquiry do not relate to arguments for or against visits by nuclear armed and/or powered vessels. They take as their starting point the fact that these visits take place. The Committee has conducted its inquiry accordingly.

Origin of the Reference

1.2 On 27 March 1985 the Chairman of the Senate Standing Committee on Foreign Affairs and Defence, Senator G. D. McIntosh, asked the Minister representing the Minister for Defence, Senator the Hon G. J. Evans, in a question without notice, to comment on an article in the Age newspaper. The article contained a suggestion that local authorities would be excluded from cleaning-up operations in the event of nuclear accidents involving United States nuclear armed and/or powered warships in foreign countries.

1.3 In response Senator Evans said:

> the United States has accepted absolute liability for any nuclear damage which might result from a nuclear incident involving the reactor of a United States warship. Australia expects that this will involve full co-operation in assisting with clean-up procedures, including assistance with radiation monitoring and decontamination. Australia would expect similar assistance in the event of a nuclear weapons accident. ... State authorities would co-ordinate responses

> to nuclear accidents. However, the Commonwealth Government would provide assistance in the form of capabilities for radiation monitoring, decontamination and related clean-up activities. ... safety planning for foreign ship visits or anything of that kind is the responsibility of State and Territory governments rather than the Commonwealth. Within those jurisdictions, organisations have developed specific plans to cover nuclear reactor accidents.[1]

1.4 The Minister for Defence provided additional information to the Chairman by letter on 18 July 1985. The Minister drew attention to the conditions of entry to Australia for nuclear powered warships and in particular the condition relating to safety planning, namely:

> an operating safety organisation, competent to conduct a suitable radiation monitoring programme and able to initiate actions and provide services necessary to safeguard the public in the event of a release of radioactivity following an accident, must exist for the port being visited.

1.5 In his letter the Minister reiterated that a safety plan:

> is prepared and, where necessary, implemented by a State or Territory NPW visits committee ... The Commonwealth assists in the provision of overall guidelines, advises on safety plans and radiation monitoring assistance, and co-ordinates through the National Disasters Organisation any additional Commonwealth support necessary.

1.6 The Chairman drew these responses to the attention of the Committee, which agreed that further information should be sought.

1.7 In August 1985 the Committee wrote to the State and Northern Territory Governments regarding safety procedures

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1. Senate, Hansard, 27 March 1985, p. 878.

applying to the presence of nuclear powered warships in Australian ports and the emergency plans that were in place to respond to an accidental release of radiation. The Committee sought comment also on the demarcation of responsibilities between local, State/Territory, Federal and United States authorities in the event of a nuclear accident.

1.8 In response the Queensland, Tasmanian, Western Australian and Northern Territory Governments stated they had detailed contingency plans.[2] The Tasmanian and Northern Territory Governments said that they were satisfied that the visits of nuclear powered warships could be accommodated safely in their ports. The Western Australian Premier said that his State's Port Safety Scheme was under review.

1.9 The New South Wales Premier wrote that his State did not have any specific plans for dealing with accidental release of radiation from a nuclear powered vessel.[3] He said that 'the [NSW] Government believes that many of the guidelines set down in the Federal Government document "Environmental Considerations of Visits by Nuclear Powered Warships to Australia" cannot be met in NSW ports'.

1.10 The Premier of Victoria replied that his Government opposed visits by nuclear powered vessels to his State, and expressed the view that if such visits took place then the Commonwealth 'should ... accept responsibility for all matters of health and safety'.[4]

1.11 The Premier of South Australia replied that the establishment of appropriate safety arrangements for visits had

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2. Letters from the Premiers of Queensland (11 October 1985), Tasmania (14 October 1985) and Western Australia (4 September 1985), and the Chief Minister of the Northern Territory (23 August 1985).
3. Letter dated 29 October 1985. The view of the NSW Government on the status of Plan Point Piper is noted at para. 2.45 below.
4. Letter dated 22 August 1985.

not been proceeded with in South Australia.[5]

1.12 This variety of responses indicated to the Committee that what it saw as the desirable objective of uniform, agreed, Federal/State or Territory contingency plans, had not been achieved. It also suggested varying interpretations of the role of the Commonwealth with regard to nuclear powered ship visits.

1.13 The Committee believed that these discrepancies should be examined. Accordingly, on 17 September 1986 the Senate referred the following matter to the Committee:

> The adequacy of current contingency planning by Federal and State authorities to deal with the accidental release of ionizing radiation from visiting nuclear powered or armed vessels in Australian waters and ports.[6]

Conduct of the Inquiry

1.14 The Committee advertised nationally and wrote seeking submissions from organisations and persons with a special interest in the reference. The Committee also wrote to a number of diplomatic missions in Canberra seeking information on their countries' safety plans relating to visits by nuclear powered or armed warships.

1.15 The Committee held public hearings on 3 days in Canberra. The Committee held a brief hearing in camera with witnesses from the Department of Defence. In February 1987, members of the Committee visited the Lucas Heights reactor site of the Australian Atomic Energy Commission (which on 27 April 1987 became the Australian Nuclear Science and Technology Organisation - ANSTO).

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5. Letter dated 27 August 1985.
6. Journals of the Senate, 1986, p. 1207.

1.16 Both the Senate Standing Committee on Foreign Affairs and Defence and the reference lapsed with the dissolution of the 34th Parliament on 5 June 1987. On 22 September 1987 the Senate established the present Committee and referred to it the original terms of reference.[7] Of the members of the present Committee, only Senator Hamer was a member of its predecessor and has been involved with the inquiry since its inception.

1.17 Members of the present Committee visited Fremantle and HMAS STIRLING at Cockburn Sound, WA in February 1988 to inspect and be briefed on aspects of safety and emergency planning relating to warship visits. Similar visits were made to Sydney and Hobart in March, 1988. A public hearing was held during the visit to Sydney. Three further public hearings were held in Canberra in May and June 1988. The Committee also held an in camera hearing at which an officer of the Department of Defence provided information on the safety aspects of nuclear weapons design and storage. Much material was obtained in response to questions put in writing by the Committee to the Department of Defence, ANSTO and others.

1.18 The inquiry received 102 submissions. Appendix I contains a list of those who made submissions. The persons appearing at all public hearings are listed in Appendix II.

Advisers

1.19 Because of the technical nature of some of the issues raised by the terms of reference, the original Committee in December 1986 appointed a technical adviser to assist it. The appointee was Mr G. K. Greenslade, who is the Head, Nuclear Plant Safety Unit, ANSTO. Mr Greenslade was re-appointed to assist the present Committee. Lieutenant Commander E. T. James, RAN was also appointed. The Committee records its appreciation to Mr Greenslade and Lieutenant Commander James for their assistance. It

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7. Journals of the Senate, 63rd Session, 1987, pp. 96, 102.

also expresses its appreciation to ANSTO and the Minister and Department of Defence respectively for making them available.

Overseas Witnesses

1.20 A number of suggestions were put to the present Committee that it should invite private individuals from overseas to appear before it, so as to overcome what was perceived to be a lack of information within Australia on a number of key matters. The original Committee did hear Professor Jackson Davis from the United States, when he was in Australia.[8] The Committee also invited Mr William Arkin of the Institute of Policy Studies in Washington, and the Stockholm International Peace Research Institute to provide any information they might have that would assist the Committee. They did not do so. Apart form these invitations, the Committee did not act on these suggestions.

1.21 As explained at various points in this report, the Committee found itself unable to obtain information on some key matters. This was due to the policy of official secrecy which surrounds nuclear weapons and naval reactors. It seemed to the Committee highly unlikely that private individuals overseas with access to classified material would be willing to disclose that material to the Committee.[9]

1.22 Accordingly these individuals were not approached. Their writings and public testimony before committees of the United

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8. Evidence, pp. 444-617.
9. For example, one individual whose name was put forward more than once as a suitable witness either did not know, or (more plausibly) believed it would be improper to disclose, such a basic fact as whether or not US naval reactors have containment. The situation was the same with respect to the power level of these reactors and other aspects of their design and operation. Another person whose name was put to the Committee as a possible witness was retired Rear Admiral La Rocque, USN. When appearing before a US Congressional Committee he (quite properly) declined to reveal classified information: US Congress, Joint Committee on Atomic Energy, Subcommittee on Military Applications, Proliferation of Nuclear Weapons - Hearing, 10 September 1974, p. 17.

States Congress were, however, noted by the Committee, in a sincere attempt to ensure that all relevant publicly available material was considered.

Reason for a Detailed Report

1.23 It became apparent to the Committee during the course of its inquiry that there is a widespread lack of accurate information in the Australian community on the subject matter of the inquiry. The restrictions imposed by official secrecy have already been noted. But there is much relevant information in the public domain in fragmentary form which many of those interested in the subject do not appear to be aware of. Accordingly, the Committee considered that it would be useful to document extensively the sources of information available and on which it has relied.

1.24 Many of those who made submissions to the original inquiry appeared to be unaware of the contents of relevant Commonwealth documents. These documents, which are described in the following chapter, were incorporated in the transcripts of the December 1986 and March 1987 public hearings. Supplementary information received from the Department of Defence, ANSTO and others was also incorporated. The present Committee decided in May 1988 to send a copy of these transcripts to all those who made submissions, thereby giving them an opportunity to make further submissions based on the documents and information. Very few did so.

CHAPTER 2

PRESENT POSITION AND ISSUES CONSIDERED

NUCLEAR WEAPONS CAPABLE VESSELS

Presence of Nuclear Weapons

2.1 It is the policy of nuclear weapons countries to neither confirm nor deny the presence of nuclear weapons aboard their warships. The declared purpose of this policy is to deny strategic information to potentially hostile powers. It has been the policy of successive Australian Governments not to require other governments to reveal whether their warships making routine visits to Australian ports are carrying nuclear weapons.[1]

2.2 In 1985, the Minister for Defence was asked if equipment existed for the detection of nuclear weapons on visiting warships, and if so, whether Australia possessed such equipment. In a written reply he responded:

> Highly sensitive detectors capable of detecting the low levels of radiation emanating from nuclear weapons have been in laboratory use for many years. Consistent with the practice of successive Australian Governments, it is not proposed to comment on whether Australia

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1. e.g. see HR, Hansard, 12 March 1981, pp. 712, 713 and 30 May 1984, p. 2397; Senate, Hansard, 9 December 1987, p. 2752.

possesses, operates or has access to specific intelligence gathering capabilities...[2]

2.3 Although official information is not publicly available on whether any particular ship is nuclear armed, the fact that a ship is capable of deploying nuclear arms (i.e. is nuclear weapons capable) can generally be determined from publicly available materials. Using these materials, it has been calculated that 87 per cent of United States warships which visited Australian ports in 1980-85 were nuclear weapons capable.[3] The Committee comments on factors relevant to the accuracy of this figure in chapter 11.[4]

Current Contingency Planning

2.4 In 1987, 36 United States Navy ships visited one or more Australian ports. The 16 ports which received visits, together with the number of visits received by each, were: Albany (1), Brisbane (7), Bunbury (1), Cairns (2), Darwin (4), Fremantle and Gage Roads, WA (30), Geelong (1), Geraldton (1), Gladstone (1), Hobart (3), Mackay (1), Melbourne (1), Newcastle (1), Sydney (9),

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2. HR, Hansard, 16 October 1985, p. 2257. See also Evidence, p. 231 (Department of Defence), p. 441 (letter from Dr D. G. Walker, ANSTO). For background, see G. Brown, Detection of Nuclear Weapons and the US Non-disclosure Policy, (WP No. 107, ANU Strategic and Defence Studies Centre, Canberra, 1986). At a press conference in Washington on 10 December 1987 the Soviet leader, Mikhail Gorbachev, said that his country had developed a technical means of verifying not only the presence of nuclear weapons on warships, but also the weapons' capacity, without any actual inspection on the vessels themselves: USSR Embassy in Canberra, Soviet News Bulletin, No. 40, 14 December 1987, p. 4. In a letter to the editor, Australian Financial Review, 5 December 1988, p. 14, Mr Andrew Mack, Head of the Peace Research Centre, Australian National University, commented that this claim:

> is simply not true. Both Soviet and US experts now agree that nuclear weapons on surface ships can be shielded in such a way that their presence can be disguised from even the most sensitive radiation detectors.

3. Submission from Mr R. Bolt, p. 15 (Evidence, p. 965). cf. the submission from Greenpeace Australia (NSW) Ltd, p. 31: at least 4 in every 5 US warships visiting Australia in the period 1976-1984 were nuclear weapons capable.
4. See paras. 11.30-11.31.

Townsville (1) and HMAS STIRLING, Cockburn Sound, WA (1).[5]

2.5 Visits by vessels of the Royal Navy are less common. It is unclear how likely it is that they would be carrying nuclear arms.[6] It seems to be widely assumed that visits by French vessels likely to be carrying nuclear weapons have not taken place.[7]

2.6 At present nuclear weapons capable warships are permitted to visit any port in Australia, subject only to standard navigational safety requirements and berth availability.[8] There is no requirement that specific plans exist to deal with an accident involving release of ionizing radiation from a nuclear weapon. Such an accident would be dealt with under whatever plan existed for the particular port to deal with shipping/cargo

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5. Senate, Hansard, 15 March 1988, pp. 796-97.
6. UK, Parliamentary Debates (Commons), 6th Series, vol. 129, Written Answers, 7 March 1988, col. 62: all British nuclear forces, including maritime tactical nuclear weapons, are committed to NATO. This would appear to reduce the likelihood of nuclear weapons being aboard a British vessel visiting Australia. However, the British Government stated that its vessels due to visit Australia in the latter part of 1988 'will remain assigned to NATO' during the visit: ibid., vol. 130, Written Answers, 28 March 1988, col. 62. See also UK, Parliamentary Debates (Lords), 5th Series, vol. 498, 15 June 1988, Written Answers, col. 364. Other factors suggesting a reduced likelihood of nuclear weapons being on board during visits are the apparent smallness of the British nuclear arsenal per vessel compared to that of the US, and the more limited range of weapon types within it: see para. 11.23 below on these points.
7. e.g. submissions from the Peace Squadron (Sydney), p. 4: Mr R. Addison, p. 4.
8. Submission from the Department of Defence, p. 3 (Evidence, p. 8); Senate, Hansard, 19 August 1986, p. 53.

accidents,[9] or under more general civil emergency procedures.[10]

2.7 Two possible exceptions to the position stated in the previous paragraph emerged during the Committee's inquiry. One related to suggestions that the Commonwealth had drawn up contingency plans to deal with a nuclear weapon accident in an Australian port. The other related to allegations that a nuclear weapon accident plan existed for the port of Sydney. Neither in fact proved to be an exception.

2.8 With regard to the Commonwealth plan, the Government stated on 27 September 1988 that a preliminary draft of document outlining procedures for responding to nuclear weapon accidents had been prepared within the Department of Defence. The document had, however, no status as it had neither been approved within the Department of Defence, by the relevant interdepartmental committee, nor by the Minister of Defence.[11]

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9. See generally on planning for such accidents, Natural Disasters Organisation, Department of Defence, Port Disaster Seminar, 26-29 April, 1982: Report of Proceedings, (Australian Counter Disaster College, Mt Macedon, Vic., 1982). For example, in Western Australia the transport emergency scheme for chemical accidents was in early 1988 being rewritten to apply to all types of transport accidents and would then be used for an accident involving a nuclear weapon: information supplied at briefing to Committee members by WA officials, 1 February 1988.

10. cf. Senate, Hansard, 27 March 1985, p. 878; 2 May 1986, p. 2292; 19 August 1986, p. 53; 24 September 1986, p. 754; 14 November 1986, p. 2360. In South Australia, for example, the State Disaster Plan would be used: South Australia, Council, Parliamentary Debates, 18 November 1986, p. 1962. In P. Hayes and others, 'Nuclear Weapons Accidents: Are we ready?', Current Affairs Bulletin, September 1988, vol. 65(4), p. 26 it is stated that plans for nuclear weapon accidents exist in Tasmania, Western Australia, and the Northern Territory. This is not correct. The authors appear to have erroneously assumed that contingency planning in place for accidents involving the reactors of visiting warships also deals with the possibility of a nuclear weapon accident. In 1988, the Queensland Premier said that the safety plan for visits by nuclear powered warships to Brisbane also catered for nuclear weapons accidents on visiting vessels: Queensland, Parliamentary Debates, 7 September 1988, p. 603. The plan does not, however, contain any provisions relating to nuclear weapon accidents.

11. Senate, Hansard, 27 September 1988, p. 753. In a letter of 22 December 1988, the Minister for Defence stated that, as the document was still in the development stage and had no official status, he did not believe its release to the Committee would serve a useful purpose.

2.9 The Committee was informed by the New South Wales Government of the current arrangements for the port of Sydney.[12] These provide that the general marine counter-disaster plan, MARDAP, would apply to an accident involving a nuclear weapon on a visiting warship.

> MARDAP has recently been amended so that it specifically lists an incident involving a nuclear capable ship as one of the thirteen separate natural or man-made circumstances which might cause the Maritime Services Board to order activation of the plan. Specifically, it states that, in an incident involving a nuclear capable ship, the Radiation Health Services Branch of the Health Department should be contacted immediately with a view to monitoring any potential radiation leakage.[13]

NUCLEAR POWERED VESSELS

Introduction

2.10 The nuclear powered vessels that have visited Australia have all belonged to the United States Navy. About forty percent of the United States Navy's combatant fleet is currently nuclear

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12. Letter from the Premier, the Hon N. Greiner, 31 October 1988. See also NSW, Assembly, Parliamentary Debates, 22 September 1988, pp. 1773-74.
13. Letter from the Premier, the Hon N. Greiner, 31 October 1988, p. 2. The letter notes:

> Nuclear capable warships also visit Newcastle and Port Kembla. These ports have their own counter disaster plans. The Maritime Services Board has briefed the harbour masters of both ports on the changes to MARDAP which are discussed ... [in the extract quoted in the text] so that they can follow the MARDAP procedures in the event of an incident involving a nuclear capable warship in their ports.

powered.[14] About ninety percent of these nuclear powered vessels are submarines, all of which are powered by a single reactor. The remainder are cruisers or aircraft carriers, each powered by two reactors except for the aircraft carrier USS Enterprise, which is powered by eight reactors.[15]

2.11 From the first visit in 1960 until 1971 fourteen visits were made, during none of which was there any incident involving leakage of radioactivity.[16] A moratorium on nuclear powered warship visits was imposed in 1971.[17] This was done to allow consideration of issues relating to safety, environmental impact and legal liability. The moratorium was lifted in mid-1976.[18] Since then nuclear powered warship visits have occurred every year except 1977 and 1988. The number of visits has fluctuated from year to year, being lower since 1985 than earlier in the decade. (Appendix 3 contains a table setting out the vessels, dates and places visited in the period 1976 to 1988.)

Ports Visited

2.12 From the beginning of 1980 until the end of 1988 the ports in Australia which have been visited by nuclear powered

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14. US, H of R, Committee on Armed Services, Subcommittee on Seapower and Strategic and Critical Materials, Hearings on National Defense Authorization Act for FY 1988/1989 - H. R. 1748, 10 March 1987, p. 453 (Admiral K. R. McKee).
15. US, Departments of Defense and Energy, A Review of the United States Naval Nuclear Propulsion Program, (June 1986), p. 3 states that 137 nuclear powered submarines and 13 nuclear powered surface ships were operational. The latter total was made up of 4 aircraft carriers and 9 cruisers. A further 24 submarines and 3 aircraft carriers were either authorised or under construction. An additional 14 nuclear powered submarines had been decommissioned or were not in service. The comparable figures for the UK are 16 nuclear powered vessels in operation, with 4 more undergoing refit or on standby; all 20 are submarines: UK, Secretary of State for Defence, Statement on the Defence Estimates 1988, (Cm 344-1, HMSO, London, 1988), vol. 1, p. 70.
16. Australia, Environmental Considerations of Visits of Nuclear Powered Warships to Australia, (May 1976), p. 2 (Evidence, p. 119). Only four ports received visits - Bunbury, Fremantle, Melbourne and Sydney: ibid.
17. ibid., p. 3 (Evidence, p. 120).
18. HR, Hansard, 4 June 1976, p. 3039.

warships have been Albany (2 visits), Brisbane (3 visits), Darwin (2 visits), Hobart (6 visits), Jervis Bay (1 visit), HMAS STIRLING (Cockburn Sound, WA) (56 visits) and Gage Roads (off Fremantle) (5 visits). It is unlikely there will be a requirement to visit many additional ports in the foreseeable future.[19] As a result, the Committee's inquiry in regard to nuclear powered warships focused on contingency planning for these ports.

Lifting of 1971 Moratorium

2.13 During the 1971-1976 moratorium an assessment was made of the safety and environmental aspects of nuclear powered warship visits. A draft environmental impact statement was prepared by the Department of Defence with assistance from other Commonwealth agencies.[20] This statement remained classified until recently.[21]

2.14 A document was prepared from the statement which contained the maximum amount of information which at the time the Government considered could be released.[22] This document was entitled Environmental Considerations of Visits of Nuclear Powered Warships to Australia and dated May 1976. It was tabled in Parliament by the Prime Minister on 4 June 1976, when he announced the Government's intention to end the moratorium and to permit nuclear powered warship visits, subject to conditions.

2.15 The Prime Minister stated in his announcement that all necessary control and safety measures would be implemented at the

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19. Evidence, pp. 229-30 (Department of Defence). But note Senate, Hansard, 17 October 1985, p. 1409 (Senator Evans): 'The Government has indicated that it would like to see a wider spread of port visits by United States vessels; the United States Government has similar interests'. Presumably this relates to conventionally powered warships.
20. Department of Defence, The Environmental Impact of Visits by Nuclear Powered Warships to Australia, (July 1974).
21. The declassified version supplied to the Committee in March 1988 has some deletions on security grounds.
22. HR, Hansard, 4 June 1976, p. 3039.

berths to be used.[23] The tabled document set out the general conditions of entry which would apply to nuclear powered warship visits.[24] It also dealt with the characteristics of nuclear propulsion plant, radiation hazards, possible accidents and their consequences, and safety precautions.

2.16 The measures introduced in 1976 were directed at two possible types of events: the discharge of radioactive wastes, and reactor accidents causing a major release of radiation to the environment. The latter category was the main focus.

The Reference Accident

2.17 It is necessary to determine what types of accidents are likely or possible in order to have a basis for devising appropriate counter-measures. The Australian Atomic Energy Commission (AAEC) acted as consultant and technical advisor to the Department of Defence in the reassessment that led to the resumption of visits in 1976.[25] In its submission, the AAEC explained the basis used for the measures introduced in 1976.

> Despite the excellent safety record and the high degree of protection inherent in the design and quality of nuclear propulsion plant, the remote possibility of an accident causing the release of radioactive material cannot be ignored. In the interests of public safety it is prudent to consider the consequences of hypothetical accidents and to make emergency arrangements to protect the public.
>
> It is physically impossible for any reactor accident to result in an atomic bomb type explosion. However, it is nevertheless conceivable that serious accidents could result from component failures, material faults, design weaknesses, human errors or deliberate human acts.

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23. HR, Hansard, 4 June 1976, p. 3040.
24. See paras. 12-13 of the document. The complete document is set out in Evidence, pp. 114-82.
25. Australia, Environmental Considerations of Visits of Nuclear Powered Warships to Australia, (May 1976), p. i.

> The AAEC approach to this problem has been to review the various possible accident mechanisms, discarding those which it is considered could result only in trivial activity releases and those with probabilities so low as to be considered incredible (ie, of no practical significance). This procedure identifies a range of credible and significant accidents, and in the particular case of warship reactor systems, leads to a single Reference Accident (contained loss of coolant ...) which is considered to represent an upper limit of risk in terms of its probability and consequence. This Reference Accident is used as the basis for judging the acceptability of berths and also for planning emergency procedures. The emergency planning does not take account of accidents judged to be incredible (e.g. uncontained loss of coolant accidents).[26]

2.18 This approach to planning and the particular reference accident identified remain the basis of current contingency planning.[27]

Federal Government Conditions of Entry

2.19 In September 1981, the Department of Defence issued a manual entitled Visits by Nuclear Powered Warships to Australian Ports: Procedures (OPSMAN 1). This contained a revised statement of the general conditions of entry. These conditions were further revised in 1982.[28] The manual also set out the detailed procedures and allocation of responsibilities for dealing with visit requests, radiation monitoring, security, safety, etc. A list of approved berths and anchorages was included in the manual. A revised version of this manual, OPSMAN 1 (Revision 1), was issued in October 1986. A second edition was issued in September 1987, and further amendments were issued in May

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26. Submission from ANSTO, attachment 1, p. 1 (Evidence, p. 247). The AAEC became the Australian Nuclear Science and Technology Organisation (ANSTO) on 27 April 1987. For simplicity, the body is referred to as ANSTO throughout the remainder of this report.
27. Evidence, pp. 370-71 (ANSTO); submission from the Department of Defence, p. 8 (Evidence, p. 13).
28. HR, Hansard, 8 December 1982, pp. 3078-79.

1988.[29] The manual is publicly available.

2.20 Paragraphs 201-202 of the revised version state:

> Conditions of entry to Australian ports by visiting NPWs have been established by the Australian Government. Approval of visits is subject to satisfaction of these general conditions, which are:
>
> a. visits will be for purposes such as crew rest and recreation, and not for fuel handling or repairs to reactor plant (necessitating breach of reactor containment);
>
> b. visits will be subject to satisfactory arrangements covering liability and indemnity, and to provision of adequate assurances relating to the operation and safety of the warships while they are in Australian waters;
>
> c. movement of vessels must take place during daylight hours under conditions where visibility is not less than three-quarters of a nautical mile;
>
> d. navigational controls on other shipping will be applied during the time that NPWs are entering and leaving port;
>
> e. there must be a capability to remove the vessel, either under its own power or under tow, to a designated safe anchorage or a designated distance to sea, within the time frame specified for the particular berth or anchorage, and in any case within 24 hours, if an incident should occur; and
>
> f. an operating safety organisation, competent to conduct a suitable radiation monitoring programme and able to initiate

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29. The text of OPSMAN 1 (Revision 1) is set out in Evidence, pp. 34-113. The major changes since Revision 1 affect approved anchorages at Hobart and Cockburn Sound, WA, and the terms of reference of the Visiting Ships Panel (Nuclear). Other changes are relatively minor, mostly relating to changes in the titles of departments, offices and organizations. Paragraph numbering remains unchanged. Although footnote references are to the latest version, for convenience cross-references are supplied to the Evidence pages containing the corresponding (usually identical) paragraph from Revision 1.

actions and provide services necessary to safeguard the public in the event of a release of radioactivity following an accident, must exist for the port being visited.

The acceptance of visits under these conditions is applicable to current classes of NPWs of the United States Navy and the Royal Navy.

2.21 The Commonwealth Government in 1986 stated that the conditions of entry have always been complied with.[30]

Visiting Ships Panel (Nuclear)

2.22 The Commonwealth Government established in 1972 an inter-departmental committee called the Visiting Ships Panel (Nuclear), abbreviated to VSP(N).[31] The present terms of reference for the Panel are to:

a. make recommendations to the Minister for Defence on the approval of NPW visits;

b. develop and maintain procedures related to NPW visits;

c. generally oversee the implementation of specific arrangements, especially safety requirements, for visits by NPWs; and

d. maintain and oversee safety arrangements for visits by nuclear weapons capable warships.[32]

2.23 The addition of item (d) to the terms of reference was approved by the Minister for Defence on 9 February 1988. This was done in response to this Committee's activities: 'the VSP(N) considered that the Panel should be the forum to produce safe-

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30. HR, Hansard, 19 August 1986, p. 135.
31. Second supplementary submission from the Department of Defence, p. 4 (Evidence, p. 238.259).
32. OPSMAN 1 (2nd edn.), para. 305. See Evidence, p. 61 for the previous terms of reference.

guards should they be necessary'.[33]

2.24 The VSP(N) is made up of representatives from:

a. Department of Defence:
   (1) Director General Joint Operations and Plans - Chair;
   (2) Joint Operations and Plans Branch - Secretary;
   (3) Navy Office;
   (4) Strategic and International Policy Division;
   (5) Natural Disasters Organisation (NDO); and
   (6) Defence Science and Technology Organisation.

b. Australian Nuclear Science and Technology Organisation (ANSTO);
c. Department of Arts, Sport, the Environment, Tourism and Territories; and
d. Department of Health.[34]

Representatives from other federal Departments may be invited to attend particular meetings. There is no provision for State or Territory representation.

Approval of Berths and Anchorages

2.25 Irrespective of who bears responsibility for port safety organisation, the VSP(N) determines the suitability of particular berths or anchorages for use by visiting nuclear powered warships.[35] No primary or alternative berth or anchorage may be used without approval from the VSP(N).[36] A similar constraint applies to any remote anchorages, to which a vessel may be towed in the event of an accident. Diplomatic clearance (ie. formal permission to enter Australia) for a particular visit specifies

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33. Letter from Cdre N. J. Stoker RAN, Chairman of the VSP(N), 26 April 1988, p. 2 (Evidence, p. 706.717). See also Evidence, p. 1246 (Department of Defence).
34. OPSMAN 1 (2nd edn.), para. 303 (Evidence, pp. 60-61).
35. ibid., para. 204 (Evidence, p. 50).
36. ibid.

the berths or anchorages to be used for the visit.[37]

2.26 Assessments of the suitability of berths and anchorages 'have been made with respect to the radiological consequences on the population of a reference accident in the light of the constraints imposed by the Conditions of Entry'.[38]

2.27 Not all major ports have been assessed for nuclear powered warship visits. Sydney is the only port which has been assessed and not approved (in terms of meeting the radiological and zoning criteria).[39] The only berths and anchorages approved in South Australia (at Adelaide) have never been used by nuclear powered warships as these ships have never visited South Australia.[40] The only currently approved anchorages in Victoria are off Melbourne, but no nuclear powered warship visits have been made to Victoria since 1979.[41] The State Governments take the view that development, population movement and other factors would necessitate the suitability of the approvals for both Adelaide and Melbourne being reassessed should nuclear powered warship visits be contemplated.[42]

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37. ibid., para. 206 (Evidence, p. 50).
38. ibid., para. 203 (Evidence, p. 50). For greater detail on the basis for berth assessment see the submission from ANSTO, pp. 2-3 and attachment 2 (Evidence, pp. 244-45 and 258-60). The berth assessment for Brisbane is set out as an illustration at attachment 3 (Evidence, pp. 261-73).
39. Second supplementary submission from the Department of Defence, p. 5 (Evidence, p. 238.260).
40. First supplementary submission from the Department of Defence, section 6B, (Evidence, p. 238.251).
41. During 24-29 October 1979, USS Gurnard berthed at Station Pier, Melbourne, which at that time was an approved berth: second supplementary submission from the Department of Defence, p. 5 (Evidence, p. 238.260). The berth is no longer available due to changed land use.
42. Submissions from the South Australian Government, p. 2; the Victorian Government, pp. 5-6. See also the second supplementary submission from the Department of Defence, p. 13 (Evidence, p. 238.268). But contrast Evidence, p. 1291 (Department of Defence), where it is said there may be no need to alter the approved locations.

Radiation Monitoring

2.28 Radiation monitoring services are provided by the Commonwealth during all nuclear powered warship visits, with State assistance where available. The monitoring is controlled by the Australian Nuclear Science and Technology Organisation (ANSTO) in conjunction with the Australian Radiation Laboratory and State or Territory authorities.[43]

2.29 Monitoring is conducted by reference to guidelines, the current version of which date from May 1988.[44] The guidelines are available to the public. The aims of monitoring programs are to detect the release of radioactive waste and to provide warning of any reactor malfunction on a nuclear powered warship which might lead to a release of radioactivity.[45] A handbook of some 50 pages governs the operational detail of carrying out the monitoring.[46]

2.30 Annual reports have been issued on environmental radiation monitoring during nuclear powered warship visits to Australian ports for each year since 1976, except for 1977 and 1988, when no visits occurred.[47] The reports, which are publicly available, were made until 1986 under the aegis of the Department having responsibility for the environment. Since then the Department of Defence has taken on responsibility for reporting.[48]

2.31 The annual reports describe the steps taken to monitor each nuclear powered warship visit and the results obtained.

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43. OPSMAN 1 (2nd edn.), para. 307 (Evidence, p. 62).
44. Department of Defence, Environmental Radiation Monitoring during Visits of Nuclear Powered Warships to Australian Ports: Requirements, Arrangements and Procedures, (May 1988).
45. ibid., Part 1, para. 1.
46. ANSTO, Radiation Monitoring Handbook for Visits by Nuclear Powered Warships to Australian Ports, (ANSTO, Lucas Heights, NSW, 1985). The text of the handbook is set out in Evidence, pp. 293-344.
47. The report for 1985 is set out as an example in Evidence, pp. 345-65.
48. Submission from the Department of Arts, Heritage and Environment, p. 4; Letter from Cdre N. J. Stoker RAN, Chairman of the VSP(N), 26 April 1988, p. 3 (Evidence, p. 706.718).

These results have been uniform. In no case has any infringement of Australian public health standards been detected. Monitoring has never detected any release of radioactive material. Nor has any radiation measurement indicated any value in excess of background levels of ionizing radiation either during or subsequent to any nuclear powered warship visit. There have, however, been a number of false alarms caused by faulty instruments.[49]

Responsibility for Port Safety Organisation

2.32 The Royal Australian Navy is responsible for the implementation and control of safety plans for nuclear powered warship visits to those ports under its control that receive visits, which at present includes only an anchorage off HMAS CRESWELL at Jervis Bay, ACT and HMAS STIRLING at Cockburn Sound, WA.[50] For ports under the jurisdiction of State or Northern Territory authorities, the State or Territory is responsible for drawing up contingency plans and for control of the port safety organisation.[51] The Commonwealth provides technical expertise, trained manpower and specialised equipment to assist the State or Territory to carry out its role.[52]

State and Territory Port Safety Organisations

2.33 OPSMAN 1 sets out the desirable characteristics for the operating safety organisation required by condition (f) of the conditions of entry. It notes that each State/Territory has

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49. Evidence, p. 433 (Mr P. Wright, ANSTO):

> I would require notice to give the exact frequency of occurrence of faults, but I can say that I know of at least four occasions in the past seven years where false alarms have occurred. But these alarms were thoroughly investigated at the time. All of them were due either to some electrical problem or mechanical bumping and could not be interpreted as representing a release of radioactive material into the compartment, or a plume.

See also para. 8.126.

50. OPSMAN 1 (2nd edn.), para. 306 (Evidence, p. 62).
51. ibid. See also paras. 402-03 (Evidence, p. 69).
52. ibid., para. 403 (Evidence, p. 69).

established a nuclear powered warship visits committee charged with the responsibility for creating and administering the State/Territory safety organisation.[53] The States and Northern Territory all have some form of organisation established to deal with natural disasters and other civil emergencies. For the ports which receive nuclear powered warship visits, these organisations have been given the responsibility for reactor-related accident contingency planning.

Port Safety Plans

2.34 Strictly interpreted, condition (f) of the conditions of entry for nuclear powered warships does not make the existence of a port safety plan a specific precondition for visits.[54] However, OPSMAN 1 states that 'each port likely to be visited will require a general safety plan as well as a detailed instruction for each specific visit'.[55] It also contains guidelines for the preparation and maintenance of these plans and instructions. The guidelines state that the general plan should address the following topics: background information; introduction; facilities; State/ Territory organisation; procedures; and radiation monitoring.[56] Detailed instructions are also referred to as Visit Operation Orders. OPSMAN 1 states that a typical order would contain: a summary of the nuclear powered warship's characteristics; the visit timetable; the location of the fixed radiation monitoring post; details of the port emergency communications net; a personnel contact directory; and personnel rosters.[57]

2.35 The Natural Disasters Organisation, a unit within the Department of Defence, holds copies of all State/Territory plans

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53. ibid., para. 436 (Evidence, p. 78).
54. First and second supplementary submissions from the Department of Defence, section 6B and p. 4 respectively (Evidence, p. 238.251 and p. 238.259).
55. OPSMAN 1 (2nd edn.), para. 404 (Evidence, p. 69).
56. ibid., Annex H to Chapter 4, para. 2 (Evidence, p. 108). Paras. 3-11 elaborate on each topic.
57. ibid., para. 12 (Evidence, p. 111).

and is informed of all amendments to the plans.[58] It has the responsibility for confirming that a completed safety plan is in existence for a particular port.[59]

2.36 Of the two ports under Royal Australian Navy control that are approved for nuclear powered warship visits, only HMAS STIRLING at Cockburn Sound, WA has a port safety plan. The plan forms a sub-set of the standing orders for the base and is intended to be read in conjunction with the Western Australian plan described in the next paragraph. The standing orders have not been publicly available. However, an unrestricted version of the plan was prepared in 1988,[60] and was supplied to the Committee. For HMAS CRESWELL at Jervis Bay, the normal emergency plan for the base has been considered adequate by the Department of Defence, given the isolation of the anchorage used for visits.[61]

2.37 The current Western Australian Government plan for Gage Roads (off Fremantle) and Cockburn Sound (where HMAS STIRLING is located) was issued in August 1986.[62] Amendments, although not formally adopted, have been developed to the stage where they could be implemented prior to the next warship visit.[63] The plan is publicly available. Although earlier arrangements existed, the present plan is the outcome of a Commonwealth initiative in 1983.[64]

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58. ibid., para. 15 (Evidence, p. 111).
59. Second supplementary submission from the Department of Defence, p. 14 (Evidence, p. 238.269).
60. Department of Defence, Nuclear Powered Warship Visits to HMAS STIRLING: Nuclear Powered Warship Visit Sub-Plan, (1988, incorporating amendments made by Change 1, 30 September 1988).
61. Second supplementary submission from the Department of Defence, p. 13 (Evidence, p. 238.268).
62. Western Australia, State Emergency Service, Western Australian Port Safety Scheme for the Visits of Nuclear Powered Warships to Fremantle and Cockburn Sound.
63. Letter from the Assistant Director, Operations, WA State Emergency Service, 21 September 1988.
64. Second supplementary submission from the Department of Defence, p. 14 (Evidence, p. 238.269).

2.38 Albany in Western Australia has received two visits by nuclear powered warships. The last such visit occurred in November 1984. A draft plan, based upon the arrangements for Gage Roads/Cockburn Sound, was employed during the visits. A revised draft (July 1987) has not been formally ratified, but the Committee was told that it 'is in sufficient detail to be used should a need arise'.[65] Further visits to Albany are regarded by the Western Australian authorities as unlikely: the approved anchorages at Albany are exposed to rough weather and are therefore not attractive for visits.[66] A copy of the draft plan was made available to the Committee on a confidential basis.

2.39 The Queensland Government has prepared a safety plan for Brisbane.[67] The plan is publicly available.[68] A summary statement, 'Details of Queensland Government Safety Organisation for N.P.W. Visit', was released publicly in 1983.[69] The plan is currently undergoing revision.

2.40 Although berths at Townsville have been approved for nuclear powered warship visits, changes to land use require that these be reassessed before they are used.[70] No visits have been made to Townsville. No safety plan exists,[71] although it appears that some work on preparing a plan has been done.

2.41 The Tasmanian Government has prepared a port safety scheme for nuclear powered warship visits to Hobart. The

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65. Letter from the Director, Western Australian State Emergency Service, 30 November 1988.
66. ibid.
67. Queensland State Counter Disaster Organisation, Safety Plan for the Visit by Nuclear Powered Warships to the Port of Brisbane, (undated).
68. Letter from the Director-General, Queensland Premier's Department, 28 November 1988: 'the Plan is no longer classified as Confidential and is freely available to the public upon written application'.
69. Submission from the Queensland Government, p. 1.
70. Evidence, p. 1290 (Department of Defence).
71. Submission from the Department of Defence, p. 7 (Evidence, p. 12).

Tasmanian Government summarised the elements in this scheme in its submission and gave the Committee a detailed briefing on it during the Committee's visit to Hobart in March, 1988. It subsequently provided a copy of the plan to the Committee.[72] Copies of the scheme are not available to the public, although the Tasmanian Government has undertaken to have details of it published prior to the next nuclear powered vessel visit to Hobart.[73]

2.42 The Northern Territory Emergency Service has prepared a plan for the visit of nuclear powered warships to Darwin.[74] The plan has not been released to the public. A copy was provided in confidence to the Committee.

2.43 In Victoria a limited plan exists.[75] The plan has not been released publicly, and appears to lack current Victorian Government approval.[76] The Department of Defence informed the Committee that were further nuclear powered warship visits to

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72. Tasmania, Nuclear Powered Warships Visits Committee, Safety Scheme for Visits of Nuclear Powered Warships to Tasmania, (25 November 1987). A copy of a supplement to the scheme, 'Royal Hobart Hospital Arrangements', was also provided. The Committee was advised that the supplement was 'currently under further review': letter from Hon R. Cornish, Minister for Police and Emergency Services, 31 March 1989. From the copy of the main scheme that was provided, the two sections which relate to personal contact details and security arrangements for major public buildings were removed for security reasons.
73. Tasmania, Assembly, Debates, 5 October 1988, p. 3169.
74. Northern Territory Emergency Service, Safety Plan for the Visit by Nuclear Powered Warships to Port Darwin, (Interim, 1984 with amendments to June 1988).
75. Visits of Nuclear Powered Ships: Standing Plan: Police Role in Safety Organisation. The authorship of the plan is unclear. A copy containing amendments to August 1985 was released in 1986 under the Victorian Freedom of Information Act: submission from Coalition Against Nuclear Powered & Armed Ships, p. 4 (Evidence, p. 1376). See also the second supplementary submission from the Department of Defence, p. 13 (Evidence, p. 238.268).
76. e.g. letter from the Victorian Minister of Police and Emergency Services, the Hon R. Mathews, to Senator J. Vallentine, 15 July 1986: 'Victoria has not developed a Port Safety Plan which specifically addresses contingencies involving visiting nuclear powered or armed vessels'.

take place to Victoria, consideration of the adequacy of planning would be required.[77]

2.44 For New South Wales and South Australia, the Department of Defence informed the Committee in March 1987 there was no requirement foreseen for detailed plans to be developed at that stage, as no visits were planned.[78]

2.45 The authors of some submissions referred to a confidential 'Point Piper Plan',[79] which they believed related to visits to Sydney Harbour. The New South Wales Government told the Committee that this plan was drawn up by the New South Wales Police in 1976 for the evacuation of some harbour-side residential areas in the event of a reactor accident on a visiting warship. It was assumed then that visits to Sydney would occur. This has not happened, and there are no berths or anchorages at Sydney approved for use by visiting nuclear powered warships. The New South Wales Government told the Committee that, given this, it regarded the plan as 'irrelevant'.[80]

2.46 The Department of Arts, Heritage and Environment assured the Committee that the plans for HMAS STIRLING and Gage Roads in Western Australia, and for Brisbane, Hobart and Darwin have all been extensively examined and approved by both the VSP(N) and the Australian Ionising Radiation Council (AIRAC).[81] The Committee was provided with a copy of AIRAC's 1984-85 review of the Brisbane, Hobart and Darwin plans, together with a report on

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77. First supplementary submission from the Department of Defence, section 6B (Evidence, p. 238.251).
78. ibid. See also NSW, Assembly, Parliamentary Debates, 27 February 1985, pp. 3844-46 and 22 September 1988, p. 1774.
79. e.g. submissions from Illawarra People for Nuclear Disarmament, p. 1; Dr B. Ewald, p. 2; Medical Association for the Prevention of War (NSW), p. 5.
80. Letter from the NSW Premier, the Hon N. Greiner, 31 October 1988, p. 1. See also NSW, Assembly, Parliamentary Debates, 22 September 1988, p. 1774.
81. Submission from the Department of Arts, Heritage and Environment, p. 4.

actions taken to follow up AIRAC's comments and recommendations.[82]

2.47 All the State and Territory plans are based on the reference accident. State officials made it clear to the Committee that they regarded the Commonwealth as having the responsibility to define the basis of planning, that is the reference accident.[83] State or Territory officials have not re-evaluated the reference accident chosen by the Commonwealth.

ISSUES CONSIDERED BY THE COMMITTEE

Types of Visiting Nuclear Powered Vessels

2.48 Non-military nuclear powered vessels have not visited Australia. The only vessels of this type currently in service are vessels with ice-breaking capability employed by the Soviet Union in Arctic waters. Because non-military nuclear powered vessels are not likely to visit Australia in the foreseeable future the Committee has not thought it necessary to consider safety planning issues which would be raised if such visits were to occur.[84]

2.49 Current planning permits the entry only of existing classes of United States and British nuclear powered warships.[85] The only nuclear powered naval vessels that have visited Australia have been those of the United States Navy. This is likely to remain the case. At present all British and French nuclear powered vessels are submarines. For operational reasons

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82. The documents are incorporated in Evidence at pp. 752-70.
83. Information supplied at briefings to Committee members by WA officials, 1 February 1988; Tasmanian officials, 21 March 1988.
84. cf. Evidence, p. 191 (Department of Defence).
85. OPSMAN 1 (2nd edn.), paras. 105 and 202 (Evidence, pp. 42 and 50).

these appear unlikely to visit Australia.[86] Nuclear powered vessels from other navies also appear unlikely to visit in the foreseeable future.

2.50 The Committee therefore focused its inquiry on United States nuclear powered warships currently in service.[87] Its conclusions apply only to those vessels, although the Committee has no reason to consider that its conclusions would not be equally applicable to current British vessels.

2.51 Nuclear powered submarines visiting Australia have been attack-class vessels (ie. designed and armed to attack other vessels). Submarines armed with ballistic missiles have never visited Australia. For operational reasons, these vessels are unlikely to visit in the future.[88] Accordingly the Committee excluded these vessels and the weapons that they carry from its inquiry. The Committee noted that the Australian Government has not assessed the safety of the reactors used by ballistic missile submarines. Under the current framework for permitting visits by nuclear powered vessels, such an assessment would be required

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86. cf. Evidence, p. 189 (Department of Defence) relating to the Royal Navy.

87. A new type of US nuclear powered submarine, the SSN-21, is planned to enter service in the 1990's. The Committee has not considered the question whether its reactor design will be sufficiently different from current designs to warrant a fresh assessment by Australian authorities.

88. The operational role of a ballistic missile submarine involves its remaining submerged from the time it leaves its base until it returns. The aim is to minimise the opportunity for opposing forces to target the vessel. This in turn maximises the deterrent value of the weapons aboard, as it increases the likelihood that a first strike made against the forces of which the submarine is a part would fail to locate and destroy it. Making casual port visits while on patrol is incompatible with this role, as it removes the submarine's greatest value - its relative invulnerability while submerged. Moreover, because of the location of the targets at which their weapons are aimed, ballistic missile submarines do not normally patrol in the southern hemisphere and hence would have no occasion to visit Australia. See J. Handler and W. M. Arkin, Nuclear Warships and Naval Nuclear Weapons: A Complete Inventory, (Neptune Papers, No. 2, Greenpeace/ Institute of Policy Studies, Washington, 1988): 'US ballistic missile submarines operate regularly in the Arctic, north Atlantic, and north Pacific Oceans and the Mediterranean Sea' (p. 12), and their British counterparts patrol in the north Atlantic (p. 25).

before a visit would be permitted.[89]

Only Current Planning Considered

2.52 A number of submissions argued that visits had taken place in the past to ports for which there were not then adequate contingency arrangements in place.[90] For example, the fact that the current Western Australian plan dates from only 1984-86, while visits took place from 1976, was put to the Committee to support this argument.[91] The Committee's terms of reference refer to 'current' contingency planning. As a result, the Committee has considered previous plans and the process that led to those plans only to the extent necessary to assess the adequacy of current planning.

Nuclear Weapons Capable Vessels

2.53 The United States and United Kingdom policy of neither confirming nor denying the presence of nuclear weapons on vessels was noted earlier in this chapter. Whatever the validity of the arguments used to justify this policy, it is unlikely to change. This means that official information from a foreign country on whether one of its vessels entering an Australian port or harbour is nuclear armed will remain unavailable.

2.54 For the purposes of its inquiry the Committee adopted the hypothesis that nuclear weapons are on board some visiting

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89. The distinction drawn in Australian berth and anchorage assessment criteria based on a vessel's reactor size is noted in para. 8.44 below, and the method of assessing reactor size is explained in para. 4.12. The reactor size on the newer US ballistic missile submarines, the Ohio class, is too large to meet the criteria for all currently approved berths, and all but one of the currently approved anchorages, that at Gage Roads off Fremantle which is approved for visits by Nimitz-class aircraft carriers.
90. e.g. see submissions from Mr R. Bolt, p. 4 (Evidence, p. 954); Coalition Against Nuclear Powered & Armed Ships, p. 4 (Evidence, p. 1376).
91. Submission from Senator J. Vallentine, p. 4 (Evidence, p. 1047).

warships.[92] As most of these vessels are from the United States, the Committee concentrated its inquiry on United States nuclear weapons and nuclear weapons capable vessels.

2.55 If contingency arrangements are thought necessary to deal with potential nuclear weapon accidents, they could be put in place whenever a nuclear weapons capable warship visits an Australian port. On this basis, the policy of neither confirm nor deny is not, in the Committee's view, a serious obstacle to specific contingency planning. The effect would be that the expense of whatever contingency planning was thought desirable would be incurred unnecessarily in the case of those visits in which nuclear weapons were not in fact on board.

Territorial Waters

2.56 Australia claims a territorial sea extending three nautical miles (5.6 km) from its shores. Australia's ability to control events occurring outside its territorial waters is limited in both a practical and legal sense.[93] The effects on Australia of an accident occurring beyond its territorial waters would be limited, perhaps negligible, compared to a similar accident occurring in one of its ports. The Committee has interpreted the expression 'Australian waters' in its terms of reference as meaning Australian territorial waters.

2.57 In practice, nuclear powered and/or nuclear armed warships seldom enter Australian territorial waters except to

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92. It should be stressed that it is only a hypothesis. cf. submission from Mr R. Bolt, p. 15 (Evidence, p. 965): the fact that nuclear weapons are carried into Australian ports is 'evidenced by the terms of the enquiry for which this submission has been prepared'.
93. e.g. Evidence, pp. 210-11 (Department of Defence).

visit ports or to use anchorages adjacent to ports.[94] Accordingly the Committee has considered contingency planning only in the context of visits to ports and adjacent anchorages.[95]

Purpose of Visits

2.58 The issues raised by visits of nuclear weapons capable vessels for repairs involving dry-docking are considered in chapter 11. For nuclear powered warships, the Committee has confined its inquiry to visits made for goodwill purposes or to permit crew shore leave, and to routine operational visits. These are the only purposes for which visits are permitted under the current conditions of entry.[96]

2.59 The Committee has not considered issues which would arise if visits were for the purpose of major repairs, such as those involving dry-docking or disabling the vessel's main power plant. The Committee notes that the Government has acknowledged that 'dockyard repair and maintenance work on nuclear powered warships involve considerations significantly different from those that apply to port visits by those vessels'.[97] As is explained at various points in this report, the Committee's conclusions rest to some extent on assumptions that the vessel is afloat to permit easy flooding of its reactor, and that the vessel could quickly be moved to a remote anchorage if necessary.

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94. cf. Evidence, pp. 187-89 (Department of Defence); submission from the Department of Arts, Heritage and the Environment, p. 5; Senate, Hansard, 19 August 1986, p. 53. Contrast, for example, the submission from Mr R. Addison, p. 12 raising the possibility of a nuclear powered warship grounding and breaking up on an Australian coral reef. As part of the diplomatic clearance required of visiting nuclear powered warships intending to anchor in Australian waters, an obligation to observe the conditions of entry (set out at para. 2.20 above) is imposed: second supplementary submission from the Department of Defence, p. 5 (Evidence, p. 238.260).
95. For views that accidents in other areas should be considered, see for example the submissions from Assoc Prof P. Jennings, p. 3; the Victorian Government, p. 2.
96. See condition (a) set out in para. 2.20 above.
97. Senate, Hansard, 17 May 1983, p. 507. See also Evidence, pp. 377-78 (ANSTO).

Planning for Visits in Peacetime

2.60 All the planning that is the subject of this inquiry assumes that the visits in question will take place at a time when neither Australia nor the foreign country to which the vessels belong is at war. The Committee has made a similar assumption, recognising that planning in wartime raises different issues.[98]

Arrangement of Remainder of Report

2.61 In popular discussion reference is often made to visits by nuclear warships, without distinguishing vessels powered by nuclear reactors from conventionally powered vessels which are capable of deploying nuclear weapons. A vessel may of course be both nuclear powered and nuclear armed. But the Committee considers it essential to clarification of many of the issues raised by its inquiry that a distinction be made between nuclear powered warships and warships that may be nuclear armed.

2.62 Accordingly, the remainder of the report consists of two parts. Chapters 3 to 10 deal with the main issues relating to nuclear powered warship visits and the adequacy of current contingency plans. Chapters 11 to 13 deal with the question whether any specific planning is required for visits by nuclear weapons capable warship visits.

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98. cf. Evidence, p. 205-06 (Department of Defence); pp. 584-89 (Prof W. J. Davis).

CHAPTER 3

REACTOR ACCIDENTS - ASSESSING THE RISKS

Need to Evaluate the Reference Accident

3.1 The concept of planning on the basis of a reference accident, and the particular accident selected for this purpose, were identified in the previous chapter. The Committee considered whether it should interpret its terms of reference so as to limit its inquiry to the adequacy of the planning made on the basis of the reference accident currently used. A wider interpretation could lead to an examination of that reference accident, and thus the basis on which the current planning rested.

3.2 As indicated in chapter one, much of the correspondence and discussion prior to the original reference by the Senate in September 1986 suggested that the main concerns related to uncertainty over the roles of Federal and State agencies, the lack of uniformity between States, and the role in the event of an emergency of the country to which the visiting warship belonged. These concerns could be addressed by the more limited inquiry.[1]

3.3 Any wider inquiry would inevitably involve highly technical issues. A significant proportion of the technical information needed to address these issues is classified as secret and as such is not available to the Committee. Therefore the Committee had to consider whether it had the technical expertise to undertake a wider inquiry. Even if it did, it also

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1. cf. Senate, Hansard, 5 May 1986, p. 2388-89, where in the course of debate Senator McIntosh stressed these points but also raised the issue of 'the rationale behind safety planning for only a limited radiation accident'.

had to consider whether the available information would permit it to reach reliable conclusions.

3.4 On the other hand, if the concept of planning on the basis of a single reference accident is faulty, or the particular accident chosen is inappropriate, any resulting plans will almost certainly be flawed. The Committee saw little merit in evaluating the adequacy of current contingency planning by reference to what might be a faulty benchmark.

3.5 The Committee took the view that it should attempt to satisfy itself that the current reference accident provided an appropriate benchmark. If the Committee were to consider it flawed in any way, the Committee took the view that it should identify a more appropriate basis for contingency planning. Only after this had been done would the Committee consider it appropriate to evaluate the adequacy of current contingency planning.

3.6 In reaching this conclusion the Committee took account of views put in submissions from those who considered the present planning inadequate. Most of the strongly presented arguments in these submissions either explicitly or implicitly regarded the current reference accident as insufficiently severe, and therefore as inappropriate. In other words, if the current reference accident could be shown to be an appropriate basis for planning, a considerable part of the criticism directed at present planning would be groundless.

Not All Risks Necessitate Contingency Planning

3.7 The conventional approach to identifying relevant accidents, both nuclear and non-nuclear, was outlined in chapter 2, when describing how the current basis for planning was determined. After the elimination of types of accidents that are physically impossible, the process of selecting a reference accident involved excluding other physically possible accidents as a basis of planning. Exclusion might be on the grounds that their consequences would be trivial or would be catered for by planning for a more serious accident, or that their probability was too remote.

3.8 In attempting to identify relevant accidents, the Committee did not consider accidents affecting only the occupational health and safety of the reactor operators. Planning for accidents of this kind is a matter for the country to which the warship belongs.

3.9 An assumption is often made that planning in place to deal with the serious accident selected as the reference accident is also adequate to deal with less serious accidents of the same general type. Some submissions suggested that the reference accident used in current contingency planning provided an inadequate basis on which to plan for less serious reactor accidents. This criticism is considered in chapter 7.

3.10 The more controversial aspect of the conventional approach to accident planning was the proposition that the likelihood of some physically possible accidents occurring was too remote to justify contingency planning. In the language of the conventional approach outlined in chapter 2, these accidents are regarded as 'incredible'. Such a conclusion is arrived at after calculating both the probability of a specific accident occurring and the harm that would result if it were to occur.[2] The worst accidents that are physically possible are often not considered credible enough to form the basis of planning because their probability is assessed as being too remote.[3]

3.11 This conclusion is generally accepted in planning for non-nuclear accidents.[4] No submission expressly compared reactor accidents with non-nuclear accidents in terms of risk of or need

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2. Submission fom ANSTO, Addendum, p. 1 (Evidence, p. 379): risk is a combination (usually taken as the product) of consequences and likelihood, and the most serious consequences multiplied by a remote likelihood often gives a lower risk than less serious consequences multiplied by a higher likelihood. See also APS Study Group, 'Report to the American Physical Society of the study group on radionuclide release from severe accidents at nuclear power plants', Reviews of Modern Physics, July 1985, vol. 57(3)(partII), p. S32: 'The risk to the public is a combination of the frequency of the occurrence of adverse events ... and the magnitude of the consequence of the event'; International Atomic Energy Agency, Radionuclide Source Terms from Se·· ·e Accidents to Nuclear Power Plants with Light Water Reactors: Report by the International Nuclear Safety Advisory Group, (IAEA, Vienna, 1987), p. 3: in relation to contingency planning to protect the public 'risk is defined as the probability of occurrence of a postulated sequence multiplied by its off-site consequences'.
3. Submission from ANSTO, Addendum, p. 1 (Evidence, p. 379).
4. e.g. for contingency planning relating to floods, a floodplain is often defined as an area covered by a flood with a probability of 1 in 100 of being equalled or exceeded in any year: see D. I. Smith and J. W. Handmer, Flood Warning in Australia, (Centre for Resource and Environmental Studies, Canberra, 1986), p. 4. Areas where floods are less probable are excluded from consideration, even though floods there are not impossible.

for planning.[5] Some submissions indicated a strong reluctance to accept that the non-nuclear approach applied equally to nuclear accidents, and proposed that the most serious possible accident should provide the basis of contingency planning.

3.12 The reasoning underlying the adoption of this view is perhaps best encapsulated by the following description of concerns in the United States over nuclear power generation.

> What will happen under the worst conceivable circumstances is considered important by many people, despite assurances that the probability that these circumstances will arise is very low. Some analysts insist that concern with maximum harm irrespective of its probability is irrational, but people know that low-probability events of all kinds do occur, and they rightly consider the 'worst-case' outcome to be part of the burden of any energy choice. They are justifiably uneasy about assurances that the probability of a given event is 'one in a million' or 'one in a billion', because they know, at least

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5. cf. 'Expert: N-ship risks limited', West Australian, 22 May 1986, citing Dr Ted Maslen, chairman of the University of Western Australia's radiation safety committee, to the effect that oil tankers or cargo ships carrying explosive materials were a far bigger hazard than nuclear powered warships; A. C. McEwan, 'Health Physics Aspects of Nuclear Issues in New Zealand over the Last Decade', Australasian Physical & Engineering Sciences in Medicine, April-June 1986, vol. 9(2), p. 79: allowing for the emergency planning related to nuclear ship visits:

> port residents face much higher risks from oil tankers and hazardous cargoes such as LPG and chlorine and in addition face risks associated with storage depots commonly associated with ports. Regular visits to ports by nuclear powered ships would then make no material change to the overall risks already experienced by port residents.

See also US, Nuclear Regulatory Commission, Reactor Safety Study: An Assessment of Accident Risks in U. S. Commercial Nuclear Power Plants, (WASH-1400, NRC, Washington, 1975), chapter 6, 'Comparison of Nuclear Risks to Other Societal Risks', para. 7.5(c) of which concludes:

> Nuclear accident risks are relatively low compared to other man-made and natural risks. All other accidents, including fires, explosions, toxic chemical releases, dam failures, earthquakes, hurricanes, and tornadoes, that have been examined in this study are more likely to occur and can have consequences comparable to or greater than nuclear accidents.

instinctively, that the probability that the analyst is wrong is often significant in such cases.[6]

3.13 The Committee shares the concern that experts may be seriously in error in their risk assessments. Any basis for contingency planning must include an adequate margin for error. Alternatively it must have built into it pessimistic assumptions on points where reasonable scientific certainty is lacking.

3.14 The Committee does not accept, however, that it would be appropriate to go beyond this and to insist that contingency planning be based on the worst physically possible accident, regardless of its likelihood. The Committee does not consider that, even after making due allowance for the particularly serious potential consequences of nuclear accidents, planning for these accidents should rest on different principles from planning for non-nuclear catastrophes.

3.15 It follows from rejection of the worst physically possible accident as the planning basis that the Committee is prepared to accept some degree of risk. It was put to the Committee that the Australian Government should be able to guarantee that 'there is absolutely no risk'.[7] No government is in a position to give this type of guarantee with respect to non-nuclear accidents. The Committee does not consider that the risk of nuclear accidents should be treated differently.

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6. J. P. Holdren, 'Energy Hazards: What to Measure, What to Compare', Technology Review, April 1982, p. 35 (emphasis in original).
7. Submission from Mr M. Lynch, p. 6 (Evidence, p. 879). cf. UK, Department of Energy, Sizewell B Public Inquiry: Report by Sir Frank Layfield, (HMSO, London, 1987), para. 4.22: 'It is not sufficiently appreciated that there is no such thing as absolute safety.' The eight-volume Layfield Report resulted from a public inquiry, held between January 1983 and March 1985, into a proposal to build a pressurised water reactor at Sizewell in Suffolk, England. The reactor is to be used for commercial electricity generation, and its basic design is of United States origin.

A More Serious Case as a Reference Accident

3.16 The more common criticism in submissions was not that planning should be based on the worst case regardless of probability. Rather it was that the selection of the current reference accident was defective in that the probability of a worse accident had been seriously underestimated. On this view, the reference accident should be an uncontained, rather than a contained, full core meltdown. The meaning of the distinction is made clear in the following chapter, where the technical features of reactors are described.

3.17 There seemed to the Committee to be a general consensus that the choice of a reference accident lay between these two types, the present reference accident or the more serious, uncontained accident. No sustained argument was put to the Committee that it would be appropriate to adopt as a reference accident anything markedly less serious than the current reference accident. Accordingly the Committee did not canvass that possibility.

Assessment Methodology

3.18 The Committee had to determine the ways open to it to assess the probability of either a contained or uncontained core meltdown occurring to a naval reactor during an Australian port visit. Two approaches appeared to be available, in addition to reliance on assurances from overseas. One was to rely on the historical accident record. The other was to consider hypothetical ways in which the relevant accidents might occur, and attempt to evaluate each.

3.19 To perform the latter evaluation there appeared in principle to be two broad methods. One was the traditional method of relying on engineering and common-sense judgment to make a qualitative assessment.[8] The other was to attempt to apply one or some of the more recently developed techniques of quantitative assessment.

3.20 These ways open to the Committee were not seen, of course, as mutually exclusive. Nor were they as distinct as the above outline might suggest. In addition, due to military secrecy, there were restrictions on the Committee's ability to pursue any of these methods to the fullest extent. The effect of these restrictions was such that quantitative risk assessment techniques could not be used at all.

Inability to Quantify the Accident Risks

3.21 Sophisticated techniques have been developed in an effort to quantify the risks of accidents in hazardous industries for which adequate overall historical data are lacking and for which it is considered that reliance on engineering judgment would be inadequate.[9] One of these, probabilistic risk assessment, first came to public prominence when used to provide the basis for the United States Nuclear Regulatory Commission's 1975 study into the safety of reactors used for civilian power

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8. This method is sometimes referred to as deterministic or involving the use of a design base accident, and is perhaps more accurately thought of as encompassing a number of different techniques. A 'design base accident' is one that has been foreseen by the designer and for which the design provides. Assuming the provision is adequate and operates as intended, the occurrence of a design base accident in the reactor context should not result in any significant release of radiation to the environment. In this parlance, a beyond design base accident is a major accident that has not been foreseen at all or, more commonly, one that has been evaluated and found to be so unlikely that it can be disregarded for planning purposes. In the latter sense a beyond design base accident is roughly the same as one regarded as 'incredible': see para. 2.17 above on 'incredible' accidents.
9. One recent survey identified eight different techniques for evaluating risks in quantified terms: see J. C. Consultancy Ltd, Risk Assessment for Hazardous Installations, (Pergamon Press for the Commission of the European Communities, Oxford, 1986), p. 67.

generation.[10] This technique has also been used in other countries such as Britain and the Federal Republic of Germany, and has been applied to more than 20 nuclear plants.[11] Probabilistic risk assessment and other quantitative risk assessment techniques are widely accepted in the nuclear power industry as having a degree of validity,[12] although the details of particular techniques and their application in particular cases remain controversial.[13]

3.22 In broad terms and glossing over differences between techniques, the object of quantitative risk assessment techniques is to identify all the possible sequences of events in the component parts of a system that may lead to a failure of the system. Probabilities are then assigned to the occurrence of each event or fault. The probabilities may be derived from historical data if the particular component, for example a pump, has been widely used in other plants over a sufficient period of time. Otherwise, component failure probabilities are estimated on the

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10. US, Nuclear Regulatory Commission, Reactor Safety Study: An Assessment of Accident Risks in U. S. Commercial Nuclear Power Plants, (WASH-1400, NRC, Washington, 1975). The study is often referred to as the Rasmussen Report, after the name of the person who lead the study group. In the context of this Committee's inquiry, it is relevant to note that the study commenced in mid-1972 and the final report was issued in October 1975. The study cost about $US 4 million.
11. UK, Department of Energy, Sizewell B Public Inquiry: Report by Sir Frank Layfield, (HMSO, London, 1987), para. 17.3.
12. See for example US, General Accounting Office, Nuclear Regulation: Financial Consequences of a Nuclear Plant Accident, (interim, 16 July 1986) p. 5 (the report is incorporated in US, H of R, Committee on Science and Technology, Subcommittee on Energy Research and Production, Supplemental Legislative Inquiry on the Price-Anderson Act, November 1986, pp. 73-99): 'probabilistic risk analysis is considered the best tool available for analyzing potential accidents'. The US General Accounting Office monitors government expenditures on behalf of Congress, and also conducts reviews of government programs. It is broadly the equivalent to the Australian Auditor-General.
13. e.g. see UK, Department of Energy, Sizewell B Public Inquiry: Report by Sir Frank Layfield, (HMSO, London, 1987), paras. 17.28-17.48; L. Cave, 'Why do estimates of core melt probabilities differ?', Nuclear Engineering International, March 1988, pp. 40-41.

basis of engineering judgment.[14] It is hoped that by combining these probabilities the probability of overall system failure can be calculated.

3.23 Quantitative techniques are useful to plant designers and operators as well as to safety assessors and regulators because they help in identifying weak points in the design. For example, a pump whose operation is critical to plant safety may be identified, thereby allowing a backup pump to be incorporated in the design. The fact that several seemingly independent safety features are in fact dependent on, say, a common power source can be identified and an alternative power source provided as back-up.

3.24 A great deal of detailed information is required in order to carry out any type of quantitative risk assessment. As one recent survey has observed:

> a prerequisite of any worthwhile attempt to quantify the risks is that the analyst must have a detailed knowledge of the the plant to be assessed. This knowledge must include details of the form of the plant, exactly how it is constructed, the temperature and pressure conditions it will operate under, the materials it contains, an understanding of any reactions that will be taking place within the plant, how the plant will be operated, the capability of the people who will operate the plant, the life of the plant, and the inspection and maintenance patterns.[15]

3.25 Much of the relevant information on the design, safety features and operating standards of United States Navy reactors

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14. UK, Department of Energy, Sizewell B Public Inquiry: Report by Sir Frank Layfield, (HMSO, London, 1987), para. 17.7. Chapter 18 ibid. explains in some detail what is meant by the term 'engineering judgment', and shows the ways in which it involves more than unfounded expressions of opinion.
15. J. C. Consultancy Ltd, Risk Assessment for Hazardous Installations, (Pergamon Press for the Commission of the European Communities, Oxford, 1986), p. 68. See also the submission from Dr T. P. Speed, p. 4 (Evidence, p. 627).

is classified as secret. As such, little of it is available to the Australian Government or to the Committee. The United States has declared that it:

> does not make technical information on the design or operation of the nuclear powered warships available to host governments in connection with port entry. The United States Government cannot, therefore, permit the boarding of its nuclear powered warships for the purposes of obtaining technical information concerning their propulsion plants or operating instructions.[16]

Visitors to United States warships during foreign port visits are not allowed into the area containing the nuclear reactor.[17]

3.26 The Department of Defence told the Committee that, while it has a good deal of relevant information, its access to naval nuclear reactor information is limited. The Australian Nuclear Science and Technology Organisation (ANSTO) informed the Committee:

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16. 'Standard Statement' by the United States Government relating to visits by nuclear powered warships to foreign ports, para. 2(e). This statement does not appear ever to have been formally published. The text is set out as Appendix 1 to Department of Defence, The Environmental Impact of Visits by Nuclear Powered Warships to Australia, (July, 1974). A copy obtained in New Zealand using the Official Information Act was also supplied to the Committee through Mr R. Bolt and a copy was appended to the submission of Senator J. Vallentine (Evidence, pp. 1078-79). The statement is undated, but appears to have existed since at least 1967. The Committee was told that the contents of the statement continue to apply: Evidence, p. 184 (Department of Defence). The United Kingdom 'Standard Statement' contains a provision in virtually identical terms to the passage quoted in the text: for the full text of the statement, see 'UK Nuclear Powered Warships Safety Procedures', (Paper prepared for the Committee by the Australian Department of Defence, July 1988), Annex A (Evidence, p. 1300.16). The statement does not appear to have been formally published by the UK Government.
17. US, H of R, Committee on Appropriations, Subcommittee on Energy and Water Development, Energy and Water Development Appropriations for 1988 - Hearings, 11 March 1987, p. 891 (Admiral K. R. McKee). The rules permit exceptions so that a head of state or secretary of state equivalent can be shown the whole ship, provided they are not technically inclined: ibid.

> In relation to military reactors, such as those used in warships, ... [ANSTO] relies primarily on published information and on inference from civilian reactor technology, including the few nuclear powered merchant ships built or planned. We have, at best, very limited access to restricted information from the countries operating nuclear warships. ... Where we are able to obtain basic information from ... [these countries] we do not use this information in a direct, and public way. Rather we use this privileged information to ensure that our assumptions based on civil plant are as conservative as we intended them to be.[18]

3.27 During the course of the inquiry it became apparent to the Committee that ANSTO had rather more information than it was able to disclose.[19] Nonetheless it is clear that neither the Committee nor the Australian Government has the data necessary to quantify in a comprehensive way[20] the risk of an accident to the reactor of a United States warship.[21]

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18. Evidence, p. 367 (ANSTO).
19. e.g. see Evidence, p. 1300.52 (Department of Defence):
    > When it first made its assessments of the strength of NPW reactor containments, the AAEC (now ANSTO) possessed significant information on the design of NPWs from confidential sources.
20. Australia, Environmental Considerations of Visits of Nuclear Powered Warships to Australia, (May 1976), para. 35 (Evidence, p. 132) refers to a core meltdown of a naval reactor as having been 'calculated to have a probability of occurrence of less than one in ten thousand per reactor per year'. Insofar as this refers to calculations done in Australia, it refers to calculations done in respect of a pipework failure only: see Evidence, p. 1267 (ANSTO).
21. For the sake of completeness, it should be noted that the Committee was referred to a hybrid type of risk assessment which took as its point of departure the historical record of events that might have developed into accidents but in fact did not: see submissions from Dr T. P. Speed, p. 4 (Evidence, p. 627): Mr R. Bolt, p. 8 (Evidence, p. 958). These 'precursor' events are used to identify accident sequences, which are then subject to something akin to the theoretical assessment involved in probabilistic risk assessment. As Dr Speed told the Committee, to use this technique one would need access to the past operating experiences of naval reactors: ibid., p. 4 (Evidence, p. 627). Because the Committee lacked this data it could not adopt this approach. Therefore it did not pursue the validity of this hybrid approach to risk assessment.

3.28 There appears to be no evidence in the public domain that United States Navy reactors have ever been the subject of sophisticated quantitative risk assessment. The British Government has stated that the probability of a contained reactor meltdown on one of its submarines 'is assessed to be no greater than 1 in 10,000 years'; the probability of an uncontained accident 'is estimated to be no greater than 1 in 1,000,000 years'.[22]

3.29 The Committee has no information on how this assessment or this estimate were made. Therefore, in addition to not being able to conduct its own risk assessment, the Committee is not in a position to review the adequacy of whatever methodology has been used by the vessels' designers or operators to assess naval reactor safety.

Significance of Lack of Quantitative Risk Assessment

3.30 The Committee's inability to have any quantitative risk assessment carried out must be balanced against the criticisms levelled at this type of assessment.[23]

Wider Significance of Lack of Information

3.31 The lack of information which prevents any quantitative risk assessment had implications for the extent to which the Committee could make any worthwhile qualitative risk assessment.

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22. UK, Parliamentary Debates (Commons), 6th series, vol. 112, Written Answers, 20 March 1987, cols. 634-35 (Evidence, p. 1300.19). To put these figures in some sort of perspective, it was calculated for 1979-80 that the risk of at least one major oil spill (more than 120,000 litres) in an Australian port was 1 : 20 per year: Australia, Bureau of Transport Economics, Marine Oil Spill Risk in Australia, (Report No. 53, AGPS, Canberra, 1983), p. 138.
23. e.g. see Evidence, pp. 673-74 (Dr T. P. Speed); pp. 852-55 (Scientists Against Nuclear Arms). See also submissions from Scientists Against Nuclear Arms (Tas), p. 3 (Evidence, p. 822); Scientists Against Nuclear Arms (WA) and Medical Association for the Prevention of War (WA), p. 8 (Evidence, p. 794); Prof W. J. Davis, p. 121, (Evidence, p. 568).

For any detailed qualitative assessment to be undertaken would require access to much the same sort of classified information as that required for a quantitative risk assessment. As explained in chapter 5, the historical safety record is not sufficiently extensive to support firm conclusions if taken on its own. Therefore the threshold issue for the Committee was whether, on the basis of the incomplete information available, it could reach useful conclusions on the risk of a reactor accident.

3.32 Some submissions expressed concern that Australian authorities (and by implication, the Committee) did not have access to necessary technical information on naval reactors, thereby making impossible any independent Australian evaluation of the risks involved in nuclear powered warship visits.[24] It was suggested that experiences with items other than naval reactors indicate that official United States risk estimates are not necessarily reliable.[25]

3.33 Two analogies are relevant in considering the significance of the overall lack of information publicly available to Australian authorities and to the Committee. One is with land-based civil reactors. The other is with nuclear powered merchant ships.

3.34 A visiting nuclear powered warship places a relatively small nuclear reactor in an Australian port. If a large nuclear power plant were to be built in Australia for electricity generation it seems clear from recent overseas experience that its owner and operator would carry out some form of sophisticated quantitative risk assessment as part of the process of designing and locating the plant. Again relying on overseas experience in

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24. e.g. submissions from Scientists Against Nuclear Arms (ACT), p. 1 (Evidence, p. 779); Medical Association for the Prevention of War Australia (NSW), p. 1; Prof W. J. Davis, p. 85 (Evidence, p. 532); Milton-Ulladulla People for Peace, p. 3.
25. e.g. submissions from Scientists Against Nuclear Arms (ACT), p. 1 (Evidence, p. 779); Scientists Against Nuclear Arms (Tas), p. 3 (Evidence, p. 822).

countries comparable to Australia, it seems clear that local regulatory authorities would insist on verifying the validity of the assessment technique and the rigour with which it was applied.[26] Access to the relevant data would have to be provided to the regulators.[27]

3.35 This contrasts with the information available to Australian authorities on the nuclear plant aboard a visiting warship.

3.36 A second analogy that can be made is with nuclear powered merchant ships. Such ships have never visited Australia. In the 1960's and 1970's, the United States,[28] the Federal Republic of Germany[29] and Japan,[30] each developed a civilian-operated nuclear powered merchant ship. These ships, and proposals for other similar ships, led the international maritime and nuclear safety communities to agree on some standards relating to port visits by nuclear powered merchant ships. The need to rely upon these standards has been minimal, primarily because nuclear powered merchant ships are not now regarded as

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26. For example, in the United States the information required by 42 USC 2232(a), and regulations made pursuant to that provision, would have to be supplied to the Nuclear Regulatory Commission.
27. cf. UK, Department of Energy, Sizewell B Public Inquiry: Report by Sir Frank Layfield, (HMSO, London, 1987), para. 47.10: the need to observe commercial confidentiality imposed only minimal restraints on the information available to his inquiry into the proposed construction of a civil nuclear power station.
28. The NS Savannah reactor was first 'taken critical' in December 1961 and the ship operated as a commercial cargo ship between 1965 and 1970: J. G. Collier, 'Light Water Reactors' in W. Marshall (ed.), Nuclear Power Technology, (Clarendon, Oxford, 1983), vol. 1, pp. 222-23.
29. The NS Otto Hahn entered service in 1968 and was decommissioned in the late 1970's. During this period only about 30 ports were prepared to admit the ship, due to environmental concerns: 'End of the road for nuclear ships', New Scientist, 28 February 1980, vol. 85, p. 639.
30. The NS Mutsu was ready for sea trials in 1972 but these were delayed for two years by a blockade by local fishermen. The ship experienced problems on its first trial and has never operated in commercial service: 'Japan's vessel still adrift', Nature, 16 August 1984, vol. 330, p. 531.

economically viable. Hence the extent to which many countries would in practice accept the standards remains largely unknown.

3.37 The standards highlight differences between nuclear powered warships and merchant ships. The latter would be built to and operated under internationally agreed standards.[31] For merchant ships, a safety assessment, not necessarily quantitative, would be required and host-port authorities would be entitled to inspect the safety assessment[32] and the operating logs relating to the nuclear power plant, radioactive waste disposal and safety tests.[33] In addition port authorities would be entitled to inspect the reactor and to conduct independent monitoring on board the vessel.[34] In the 1960's the United States

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31. The main instruments are: the International Convention for the Safety of Life at Sea, London, 17 June 1960, (United Nations Treaty Series, 1965, vol. 536, p. 27) Chapter VIII: the similarly titled 1974 successor to this Convention, the text of which forms Schedule 1 to the Navigation Act 1912, and Chapter VIII of which deals with nuclear ships; the International Maritime Organization, Code of Safety for Nuclear Merchant Ships, (IMO, A XII/Res.491, 18 June 1982); and the Inter-Governmental Maritime Consultative Organization and International Atomic Energy Agency, Safety Recommendations on the Use of Ports by Nuclear Merchant Ships, (IMCO, London, 1980).
32. International Convention for the Safety of Life at Sea, 1974, Chapter VIII, reg. 7, part (b) of which provides: 'The Safety Assessment shall be made available sufficiently in advance to the Contracting Governments of the countries which a nuclear ship intends to visit so that they may evaluate the safety of the ship'. The format or methodology of the safety assessment is not defined in the Convention.
33. Inter-Governmental Maritime Consultative Organization and International Atomic Agency, Safety Recommendations on the Use of Ports by Nuclear Merchant Ships, para. 5.2.
34. ibid.

accepted similar standards in respect of the merchant ship NS Savannah.[35]

3.38 Australian authorities have far less information on visiting nuclear powered warships. In considering this comparison, it is important to stress that Australia's ability to obtain information relating to the construction, operation etc. of a visiting conventionally powered warship is much less than with a conventionally powered merchant ship.[36]

3.39 In the absence of access to classified information the Committee of necessity had to rely on five other sources:

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35. The United States entered into a series of bilateral treaties on port entry requirements for the NS Savannah. See for example the Agreement between the United States of America and the United Kingdom Relating to the Use of United Kingdom Ports and Territorial Waters by the NS Savannah, London, 19 June 1964 (United Nations Treaty Series, 1965, vol. 530, p. 99) Annex 1, article 2 (US shall provide 'detailed technical information concerning her design, construction, operation and the safeguards incorporated into the ship's nuclear plant and an analysis of hypothetical accidents'), article 7 (UK authorities to 'have reasonable access to N. S. Savannah for the purpose of inspecting and monitoring her and her records and programme data while she is within the territorial waters of United Kingdom territory and determining whether she is in a safe condition and is being operated in accordance with the Ships's Operating Manual'), and article 11(b) (UK authorities 'shall have the right to undertake such radiological monitoring in N. S. Savannah as they may consider necessary during her stay in any port in United Kingdom territory' - emphasis added). Other articles of the Annex set out further conditions.

36. e.g. much of the International Convention for the Safety of Life at Sea, 1974 does not apply to warships. In 1979 the US State Department responded to a request from the Egyptian Embassy for information on the international agreements relating to nuclear powered ships by stating in part (Digest of United States Practice in International Law, 1979, p. 1084):

> In recognition of the sovereign nature of warships, the United States permits their entry into U. S. ports without special agreements or safety assessments. Entry of such ships is predicated on the same basis as U. S. nuclear-powered warships' entry into foreign ports, namely, the provision of safety assurances on the operation of the ships, assumption of absolute liability for a nuclear accident resulting from the operation of the warship's reactor, and a demonstrated record of safe operation of the ships involved ... .

- information relating to nuclear power plants used to generate electricity for civil purposes. A vast body of literature is available on all aspects of civilian reactors, including actual and potential accidents, and contingency planning. The main issue for the Committee was the extent to which this information is relevant to warship reactors.

- information relating to actual or proposed civilian-operated nuclear powered merchant ships. The planning for these ships led not only to a body of technical literature and some internationally agreed standards but also to assessments of the need for, and production of, accident contingency plans.[37] A similar issue of relevance arose.

- publicly available information on the design, operation and safety record of nuclear powered warships. More information is available than is generally realised. One critic stated to the Committee his belief that it is sufficient to enable informed judgements to be made about the nature of naval reactors.[38] This information, apart from its direct

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37. See for example J. C. Chicken and M. A. King, 'Port Entry Arrangements' in Organisation for Economic Cooperation and Development, Nuclear Energy Agency, Symposium on the Safety of Nuclear Ships: Proceedings, Hamburg, 5-9 December 1977, (OECD, Paris, 1978), pp. 423-26: port of Southampton (UK) safety scheme for visits of nuclear powered merchant ships is based on experience gained from visits by these types of ships and from 'the numerous visits of various nuclear powered warships to ports in the United Kingdom' (p. 423).
38. Submission from Prof W. J. Davis, p. 54 (Evidence, p. 501). In 1983, the US Navy stated that officials involved in its Nuclear Propulsion Program 'have testified before congressional committees in open session over 100 times, amassing more than 5,000 pages of testimony on the procurement, design, and operation of naval nuclear powered ships': US, H of R, Committee on Armed Services, Subcommittee on Procurement and Military Nuclear Systems, Naval Nuclear Propulsion Program - 1984: Hearing on H. R. 5263, 28 February 1984, p. 194 (Appendix D, 'Navy Response to Article Entitled "The Nuclear Navy", 20 July 1983), (Evidence, p. 1300.59).

usefulness, assists in assessing the degree to which naval reactors are the same as civilian ones, and therefore the extent to which data on the latter are relevant to the risks arising from naval reactors.

- publicly available information on contingency planning in the United States and the United Kingdom. The scope of this material is discussed in chapter 6.

- assurances from those who have had access to all the relevant information. In effect, this means agencies and officials of the United States and United Kingdom Governments. These assurances can be supplemented by information both publicly available and informally obtained by Australian officers from colleagues overseas.[39]

Information Available to the Committee - Conclusions

3.40 The Committee acknowledges that its having to rely on these sources was considerably less than ideal. However in combination with the information available on the historical record of reactor safety the Committee considered that these sources provided a basis sufficient to enable worthwhile conclusions to be drawn.

Difficulties in Assessing Accident Consequences

3.41 It was noted at the beginning of this chapter that the calculation of a risk involves assessing the probability that accidents will occur and also the consequences of those accidents. The Committee faced problems of a different order in assessing consequences.

3.42 There is an abundance of publicly available information

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39. e.g. Evidence, pp. 193, 199, 201 (Department of Defence).

on the dispersion of radioactive material from reactor accidents and the effects of the dispersed material on people and the environment. There is considerable expertise on these matters available to the Australian Government which the Committee was able to draw on.

3.43 The difficulty for the Committee was that there is clearly much scientific uncertainty over what would be dispersed from a given reactor accident, how far it would be dispersed, and what its effects, especially in low doses, would be. This difficulty is not novel. In some respects it has confronted nuclear regulatory authorities since scientists first became aware of the risk posed by ionising radiation. The Committee's response mirrored that of regulatory authorities: where significant scientific doubt exists, safety-oriented assumptions should be made. The specific ways in which this has been done are indicated in later parts of this report.

Onus of Proof

3.44 The Committee did not regard it as appropriate to import the formal legal notion of the onus (or burden) of proof into its inquiry. However, the lack of critical information relating to accident likelihood and the scientific uncertainty relating to aspects of accident consequences limited the ability of both planners and objectors to present conclusive arguments on many key points. In this situation it becomes significant whether the planners are required to demonstrate that their plans are adequate, or if objectors are required to show that the plans are inadequate.

3.45 The Committee considered that it would be unreasonable to place the burden of making out their case onto the objectors.[40] Relative to the resources available to government, objectors are poorly equipped to locate and analyse even the

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40. See the submission from Mr P. Gilding, p. 3 (Evidence, p. 1336).

information that is publicly available. The Committee took the view that it was more appropriate to place the burden on the planners of proving that their plans were adequate.[41] The Committee was conscious that it was necessary to give effect to this view in a reasonable way. The planners were being asked in some respects to demonstrate a negative - that particular accident scenarios would not eventuate.[42] The Committee took into account the difficulties of doing this.

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41. cf. UK, Department of Energy, Sizewell B Public Inquiry: Report by Sir Frank Layfield, (HMSO, London, 1987), para. 47.3(g): the onus of proof was on the electricity authority to show that Sizewell B nuclear power station would be safe rather than on objectors to show the contrary.
42. cf. Evidence, p. 858 (Senator McMullan).

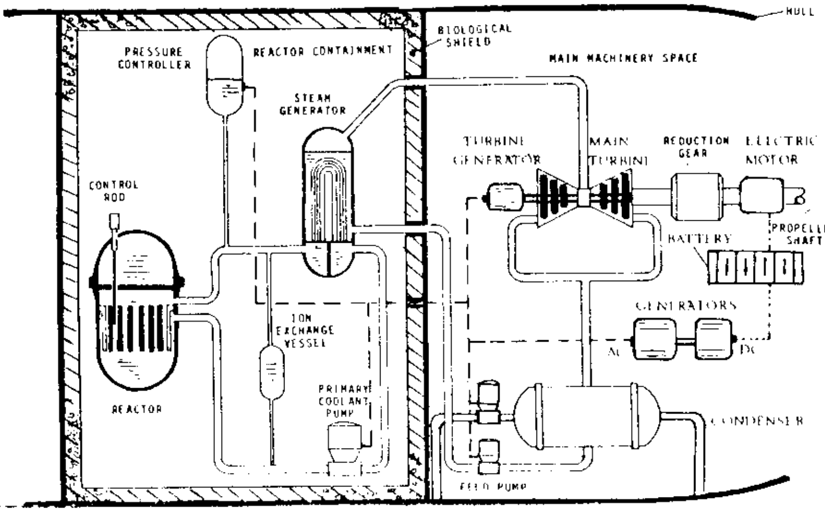
CHAPTER 4

NUCLEAR PROPULSION PLANT

CHARACTERISTICS OF PRESSURISED WATER REACTORS

Basic Features

4.1 All nuclear powered vessels known to be currently operated by the United States, British and French navies employ pressurised water reactors.[1] This type of reactor is also the most common type used for civil electricity generation.[2] A schematic diagram of a submarine's pressurised water reactor propulsion plant indicates the main features of this type of reactor.



1. Cdr M. K. Gahan, 'Nuclear Propulsion Systems - Technical Aspects', (Paper prepared for the Committee by the Department of Defence, February 1987), p. 3 (Evidence, p. 1300.34).
2. International Atomic Energy Agency, Bulletin, 1988, vol. 30(2), p. 67: at the end of 1987, 225 of 417 reactors in civilian use worldwide were pressurised water reactors, and 82 of the 120 under construction were also of this type.

4.2 Nuclear power plants operate by using the heat provided by the fission of atoms and by the resulting radioactivity in order to produce steam. Fission is the splitting of a nucleus of an atom into two or more lighter nuclei. This occurs after the nucleus has been struck by a neutron. Fission results in the atom being split into atoms of two or three lighter elements. In this process a great deal of energy is emitted and two or three free neutrons are released.

4.3 The neutrons released when a fission occurs may cause further fissions, which in turn create further neutrons, and so on. In this way a self-perpetuating chain reaction can be established. A controlled chain reaction takes place if on average exactly one neutron created by each fission causes a further fission. A nuclear reactor is designed to sustain a steady chain reaction which will produce heat safely. This is done by controlling the number of neutrons which can cause further fissions. Control is achieved by raising and lowering rods of neutron absorbing material into the reactor. By manipulating these rods in a controlled way it is possible to start up, control, or shut down the reactor. Provision is made for some or all of these rods to be lowered automatically in an emergency. Such an emergency shutdown is referred to as a 'scram' or 'trip'.

4.4 The point at which a self-sustaining chain reaction begins is known as criticality. Departures from this point are measured by the 'reactivity' of the reactor. This is positive if the reaction rate is increasing, negative if the reaction rate is decreasing. Because neutrons arising from fissions are fast-moving, and less likely to cause fissions than slower moving neutrons, a moderator is used to reduce the speed of neutrons produced during the fission process.

4.5 In a pressurised water reactor, water serves as both coolant and moderator. Without the moderator a chain reaction cannot be sustained and comes to a halt. As the water heats up its ability to act as a moderator is decreased, and the reactivity of the reactor will be reduced. In turn, this will lead to a decrease in the temperature of the water which will increase its effectiveness as a moderator. This self-regulating characteristic of pressurised water reactors, independently of the use of control rods, makes virtually impossible any uncontrolled, very rapid, increase in power above normal operating levels.[3] Because the same water is used as both moderator and coolant, loss of coolant shuts down the chain reaction. This provides an important fail-safe characteristic.

4.6 For United States submarine reactors it has been said that because of this self-regulating characteristic:

> the hafnium control rods aren't actually used that much, except for reactor start-up and shut-down, for adjustments to compensate for fission product poisoning and fuel burnup, and for power load changes of more than 20 per cent.[4]

4.7 Typically, pressurised water reactors use uranium as fuel. Naturally occurring uranium is made up of two isotopes, U-235 which is fissile and which constitutes about 0.7%, and U-238 which is not fissile. For use as fuel uranium may be enriched, that is, the proportion of U-235 increased by anything from a very slight amount to over 90%. Naval reactors are thought to use highly enriched fuel, while most civil pressurised water reactors use uranium enriched by less than 4%. The fuel is made up into what are called fuel elements, which may take the form of rods, pins, plates or tubes.

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3. e.g. see New York Times, 12 April 1963, p. 11, 'Rickover Cites Safety Factors': US Atomic Energy Commission had deliberately experimented to cause a rapid uncontrolled power increase (a 'runaway power excursion'), only to have the reactor automatically shut itself down..
4. R. O'Rourke, 'The Nuclear-Powered Submarine', Naval Forces, 1986, vol. 7(1), p. 84. See also P. Tyler, Running Critical: The Silent War, Rickover, and General Dynamics, (Harper & Row, New York, 1986), p. 40.

4.8 The fission process produces energy in the form of heat. It also produces what are called fission products and the radiation from these is also a source of heat. The heat would melt the fuel elements if they were not cooled. In a pressurised water reactor cooling is achieved by passing the water in the primary circuit around the fuel elements. Even when a reactor is shut down the fuel elements take time to cool. The fission products continue to provide a source of heat which gradually reduces as the products decay. It is essential that coolant be available to remove this decay heat if core melting is to be avoided.

4.9 The primary circuit is a closed loop with five main elements: a reactor pressure vessel, a pressure controller, primary coolant pumps, a steam generator, and the primary circuit piping. Water heated by the fission process taking place within the fuel elements passes to the steam generator. In the steam generator the primary coolant transfers its heat to the secondary circuit and then is passed back to the reactor by the main coolant pumps. The water in the primary circuit is kept at a high pressure to stop it from boiling. The pressuriser maintains and controls the system pressure.

4.10 The secondary circuit consists of steam going from the steam generator to the turbine system which provides power to the propeller shaft. This arrangement is much the same as on any ship in which steam is provided by an oil-fired boiler. There is no direct contact between the water in the primary circuit and that in the secondary circuit.

4.11 Reactor sizes can be measured by the amount of thermal power produced, expressed in millions of watts (megawatts thermal, abbreviated to Mw(t)). The extent to which it is possible to convert this thermal power to useful (e.g. electric) power is limited to about 30 to 40%. This gives an alternative measure of the size of nuclear power plants in megawatts electric - (Mw(e)).

4.12 The United States does not publicly disclose the thermal output of its Navy's reactors.[5] Published sources provide information on the shaft horsepower of naval vessels.[6] From this it is possible to calculate the size of reactor needed to produce the given shaft horsepower. Only an approximation can be made because of the need to estimate the efficiency with which the thermal power is converted to useful power. In addition, an assumption has to be made as to how much thermal power is used for purposes other than driving the propeller shaft (e.g. providing the ship's electricity).

4.13 Approximations made in this way indicate that for United States warships, each of the two reactors of a Nimitz-class aircraft carrier might be about 320 Mw(t),[7] a Los Angeles-class attack submarine's reactor at least 85 Mw(t), and each of the two

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5. HR, Hansard, 21 October 1982, p. 2479, and 19 August 1986, p. 160.
6. e.g. see the annual volumes of Jane's Fighting Ships, (Jane's, London).
7. It appears that the reactors on Nimitz-class vessels provide an exceptionally large electricity generating power in addition to providing propulsion power: US Congress, Joint Committee on Atomic Energy, Naval Nuclear Propulsion Program - 1975 - Hearing, 5 March 1975, p. 6 (Admiral H. G. Rickover). The figures for total output and the amount available for electricity generation have been deleted from the transcript on the ground of security. If a high generating capacity is available, the total power output of each reactor may be considerably more than 320 Mw(t). ANSTO advised that in its safety assessment of visits by Nimitz-class vessels to Gage Roads off Fremantle, it adopted a figure of 450 Mw(t) for reactor size in order to ensure that its assessment contained a margin for safety.

reactors of the cruiser USS Truxtun at least 75 Mw(t).[8] For comparison purposes, the reactor involved in the 1979 accident at Three Mile Island had a maximum design power of 2,772 Mw(t), the reactor involved in the 1986 accident at Chernobyl was rated at 3200 Mw(t), and the proposed Sizewell B reactor subject to lengthy inquiry earlier in the 1980's is planned to produce 3411 Mw(t).[9]

Radiation Hazards

4.14 The radiation hazards created by a pressurised water reactor can be divided into two broad categories: those arising from an accident involving the reactor, and those arising from the release of radioactive wastes in liquid, gaseous or solid form. The former is potentially far more serious and was the main focus of the inquiry.[10]

4.15 The hazards immediately following a major reactor accident can in turn be divided into two categories, according to whether or not the reactor containment is breached. If the accident involves the release of fission products <u>within</u> the reactor compartment they will give off gamma radiation of sufficient intensity to penetrate the hull. Unless prevented by

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8. Letter from Dr J. L. Symonds, 12 February 1987, p. 2. Prof W. J. Davis states that 'modern naval propulsion reactors range in power from 15 - 230 megawatts': submission from Prof W. J. Davis, p. 55 (Evidence, p. 502) citing A. Stirling, <u>The Global Disposition of Nuclear Powered and Nuclear Armed Vessels Presently in Operation</u>, (Greenpeace International, Lewes, England, 1986). The context makes it clear that Prof Davis is using megawatt thermal, not electric. The reactors on the other major category of United States nuclear powered warship to have visited Australia, the pre-Los Angeles class attack submarines, mostly are about half the power of those on the Los Angeles class, though the very early designs (now largely withdrawn from service) were even smaller. Contrast the submission from Mr R. Addison, p. 10: all visiting US nuclear powered warships except the early submarines have reactor powers greater than 100 Mw (again the context makes it clear that it is Mw thermal which is being referred to). No source is given as a basis for this claim.
9. Nuclear Engineering International, <u>World Nuclear Industry Handbook 1988</u>, pp. 58, 64, and 56.
10. See paras. 4.24-4.26.

shielding, this will pose a hazard to anyone in the immediate vicinity of the vessel. For a submarine reactor, British plans state that the area of risk from this 'gamma shine' is no more than 50 metres around the hull in air and 5 metres in water.[11]

4.16 The 'gamma shine' hazard, because of the limited area affected, is less serious than the second category. This arises if fission products are released to the atmosphere. Depending on the weather at the time and the quantity released, radioactive material could be dispersed a considerable distance from the vessel, affecting large numbers of people and property over a wide area. Therefore the possibility that this might happen is of particular concern to reactor designers and those responsible for reactor safety. It was also a central concern of that part of the Committee's inquiry that related to nuclear powered warships.

Accidental Release of Fission Products to the Atmosphere

4.17 Extensive precautions are taken in designing, constructing and operating nuclear reactors in order, first, to minimise the possibility of accidents and, secondly, to contain the fission products safely within the system should an accident occur. For the latter, what is sometimes referred to as defence-

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11. UK, Ministry of Defence, Devonport Public Safety Scheme, (1982 edn.) para. 0104. cf. ANSTO, Radiation Monitoring Handbook for Visits by Nuclear Powered Warships to Australian Ports, (ANSTO, Lucas Heights, NSW, 1985), p. 4 (Evidence, p. 298): after a reactor accident 'a severe external radiation hazard (dose rates greater than 500 mSv per hour) may exist alongside the vessel in the close vicinity, within say 30 metres, of the reactor compartment'. See also Evidence, p. 238.292: table provided by the Department of Defence indicates that at 30m from a submarine it would take 20 minutes for a person to reach the level of exposure at which evacuation should be considered (0.3 sieverts), while at 200m it would take 12 hours if (conservatively) no allowance is made for radioactive decay.

in-depth or a multi-barrier approach is employed.[12] Fuel elements are protected by cladding in order to prevent the escape of fission products.[13] The cladding may be made of alloys of zirconium, steel or other metals.[14] To cater for combat stresses, on United States warships the fuel modules are designed to survive without damage ten times more dynamic shock than commercial fuel modules.[15]

4.18 A second barrier is constituted by placing the fuel elements inside a pressure vessel, with its associated high integrity primary coolant circuit. If the cladding failed, fission products would be released to the coolant. The coolant

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12. cf. US, H of R, Committee on Appropriations, Subcommittee on Energy and Water Development, Energy and Water Development Appropriations for 1988 - Hearings, 11 March 1987, p. 889 (Admiral K. R. McKee): for naval reactors 'we have several levels of containment'. The remainder of the explanation was deleted from the published transcript on security grounds. See also 'U. S. Navy Statement on Safety of Operations of U. S. Nuclear Powered Warships', January 1987 (Evidence, p. 238.244): specific features of the multi-barrier approach used on US warships are classified.
13. In some US commercial reactors the fuel and fission products 'reside within a ceramic pellet which has a high melting temperature and will retain the vast majority of the fission products for essentially all operating and accident conditions': US, H of R, Committee on Science and Technology, Subcommittee on Energy Research and Production, Positive Safety Features of U. S. Nuclear Reactors: Technical Lessons Confirmed at Chernobyl - Hearing, 14 May 1986, p. 7 (Dr W. P. Chernock). These pellets reside within the cladding and therefore constitute yet another barrier to release of radiation from an accident. The Committee has no evidence as to whether these ceramic pellets are used in naval reactors.
14. US Congress, Joint Committee on Atomic Energy, Naval Nuclear Propulsion Program - 1974 - Hearing, 25 February 1974, p. 13 (Admiral H. G. Rickover): US commercial reactors use the same basic cladding material as US naval reactors - zirconium - and it is engineered to the same quality standard.
15. 'U. S. Navy Statement on Safety of Operations of U. S. Nuclear Powered Warships', January 1987 (Evidence, p. 238.244). See also US, Department of the Navy, Occupational Radiation Exposure from U. S. Naval Nuclear Propulsion Plants and their Support Facilities, (NT-86-2, February 1986), p. 28:

    > The design conditions for reactor fuel are much more severe for warships than for commercial power reactors. As a result of being designed to withstand shock, naval reactor fuel elements retain fission products including fission gases within the fuel.

circuit is designed to contain the release.[16]

4.19 An accident sequence might start with the rupture of the primary coolant circuit. This failure of the second barrier would deprive the reactor of coolant, and is referred to as a loss of coolant accident or LOCA. The decay heat would, in the absence of any alternative supply of coolant, melt the cladding (the first barrier) and the fuel. To meet this sort of sequence a third level of barrier available to designers is to enclose the pressure vessel and the pressurised primary coolant circuit inside some sort of structure designed to contain radioactive gases, solids and liquids should the first and second barriers fail.

4.20 This structure is referred to as the containment, and is not necessarily the same thing as the biological shielding put in place to protect operating personnel from exposure to radiation. The major portion of the biological shielding for submarine reactors is concentrated around the reactor core, with the remainder built into the containment.[17] If as a result of an accident fission products escape from the core to the containment, the submarine reactor's containment will not provide sufficient shielding to reduce radiation intensities to insignificant levels.[18]

4.21 Containment must be strong enough to withstand any pressure surge ('blow-down') that would occur if the primary coolant circuit were to be breached. Because the distinction between a contained and uncontained accident is relevant to discussion later in this report, it is important to note that containment cannot be absolute. Slow leakage under maximum design pressure is inevitable due to imperfections in cable and pipe

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16. J. E. Moore and R. Compton-Hall, Submarine Warfare: Today and Tomorrow, (Michael Joseph, London, 1986), p. 36; UK, Ministry of Defence, Liverpool Special Safety Scheme for Visits to Liverpool by Nuclear Powered Submarines, (April 1986), para. 4.
17. UK, Ministry of Defence, Liverpool Special Safety Scheme for Visits to Liverpool by Nuclear Powered Submarines, (April 1986), para. 8.
18. ibid.

penetrations of the containment.[19] For submarines, that part of the containment formed by the hull has to be leak-tight so as to keep water out at maximum diving depth. But the design specification allows for maximum leakage to adjoining compartments within the hull at up to 1% per day at accident pressure.[20]

4.22 A fourth level of barrier available is to take steps to prevent the containment and primary circuit being penetrated from the outside. For land-based reactors the threat for which such precautions might be required is an aircraft crashing onto the reactor. For maritime reactors ship collision is a more relevant threat.

4.23 In 1983, the American Physical Society formed a study group to carry out what was in effect a peer group review. The subject of the review was the technical base upon which rested the models of what quantities and types of radiation would be released from a severe commercial reactor accident. The quantity released is referred to as the 'source term'.[21] The study group reported:

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19. Evidence, p. 238.291 (Department of Defence). See also UK, Ministry of Defence, Devonport Public Safety Scheme, (1982 edn.), para. 0103. For commercial land-based reactors, US Nuclear Regulatory Commission regulations specify a maximum allowable leak rate in the rgion of 0.1% to 0.5% per day: APS Study Group, 'Report to the American Physical Society of the study group on radionuclide release form severe accidents at nuclear power plants', Reviews of Modern Physics, July 1985, vol. 57(3)(part II), p. S93. The leakage rate from the Sizewell B reactor containment is designed to be less than 0.1% of containment volume per day: UK, Department of Energy, Sizewell B Public Inquiry: Report of Sir Frank Layfield, (HMSO, London, 1987), paras. 27.23 and 29.38.
20. Evidence, p. 238.291 (Department of Defence), and p. 392 (ANSTO).
21. cf. C. Kelber, 'The Radiological Source Term of Nuclear Power Reactors', Nuclear Safety, January-March 1986, vol. 27(1), p. 36:

> No single definition of the source term really exists. Three definitions, however, are encountered more than others: They identify the source term as the inventory (by nuclide) of radionuclides (1) available for dispersal from the containment, (2) dispersed over the area outside the containment, and (3) potentially available for release to the containment during a hypothesized accident.

The author notes that the third of these is not often used today.

> The severe accident sequences that may result in large source terms must proceed not only through core melt, but also through containment failure.[22]

This underlines the importance of adequate containment.

Release of Radioactive Wastes

4.24 According to the United States Navy, its fuel is fabricated so that fission products are not released to the primary coolant in a way that is often the case with commercial reactors.[23] As the coolant water passes through the primary circuit, however, any impurities in it become radioactive. In addition it may pick up traces of corrosion or wear products from the piping. These impurities in the coolant undergo neutron bombardment as they pass through the reactor core and constitute the main source of radioactivity in liquid waste. Radionuclides of elements such as cobalt, manganese, tungsten and iron are produced.[24]

4.25 Coolant is released from the primary coolant system mainly as a result of expansion when it is heated to reactor operating temperature. The released coolant is passed through a

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22. APS Study Group, 'Report to the American Physical Society of the study group on radionuclide release from severe accidents at nuclear power plants', Reviews of Modern Physics, July 1985, vol. 57(3)(part II), p. S28.
23. 'U. S. Navy Statement on the Safety of Operations of U. S. Nuclear Powered Warships', January 1987 (Evidence, pp. 238.241-42).
24. The ways in which radioactive wastes are created, the degree of radioactivity present, the quantities released, and the places where release occurs are described in detail in annual US Navy reports on monitoring: see for example US, Department of the Navy, Environmental Monitoring and Disposal of Radioactive Wastes from U. S. Naval Nuclear-Powered Ships and their Support Facilities 1984, (NT-85-1, February 1985), pp. 3-9 (Evidence, pp. 238.298-301). The description in this section of the report is based primarily on these annual reports. For an alternative source, based on nuclear powered merchant ships, see UK, Department of Industry, Second Report on the Nuclear Ship Study, (HMSO, London, 1975), paras. 107-121.

purification system. The coolant is then held on board.[25] Eventually most of it is transferred ashore at ports outside Australia, when the vessel undergoes maintenance or repairs. If accidental discharge to the environment is ever going to occur, it is during this transfer that the risk is greatest. Some coolant is also released at sea outside Australian waters, under strict United States Navy controls.

4.26 The quantity of radionuclides in coolant will vary depending on the length of time the coolant water has been in use. Following reactor shutdown radioactive decay will reduce radioactivity. But unless there has been damage to the fuel cladding, the coolant that might be inadvertently released to the environment will not constitute more than a low-level hazard. According to a United States Navy statement, a few hours after reactor shutdown a person could drink the coolant without harmful effect.[26]

4.27 Radioactive wastes in solid form arise from maintenance and overhaul activities. According to the United States Navy, most of these activities take place in shipyards,[27] and hence are not relevant to port visits to Australia. Some solid wastes may, however, be on board as a result of activities since the vessel was last in a United States dockyard or base. Solid wastes include contaminated rags, filters, plastic bags and scrap

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25. See also for British vessels, UK, Parliamentary Debates (Commons), 6th series, vol. 146, Written Answers, 3 February 1989, col. 448: Royal Navy submarines are equipped with retention tanks to store excess reactor coolant.
26. 'U. S. Navy Statement on Safety of Operations of U. S. Nuclear Powered Warships', January 1987 (Evidence, p. 238.242). See also US, Department of the Navy, Environmental Monitoring and Disposal of Radioactive Wastes from U. S. Naval Nuclear-Powered Ships and their Support Facilities 1984, (NT-85-1, February 1985), pp. 4-9 (Evidence, pp. 238.298-301), for detail on the quantities and types of radionuclides present in coolant.
27. US, Department of the Navy, Environmental Monitoring and Disposal of Radioactive Wastes from U. S. Naval Nuclear-Powered Ships and their Support Facilities 1984, (NT-85-1, February 1985), p. 13 (Evidence, p. 238.303).

materials.[28] Coolant water is filtered through ion exchange resin beds to remove suspended radionuclides. The resin then constitutes a solid waste. All solid radioactive wastes from United States Navy reactors are disposed of in the United States at burial sites.[29]

4.28 The Committee was told that the amount of gaseous radioactivity created by the normal operation of a pressurised water reactor is extremely small.[30] United States Navy reactors are designed to ensure that there are no significant discharges of radioactivity in airborne exhausts.[31]

4.29 The United States has provided an assurance in respect of its nuclear powered vessels visiting Australia that:

> No effluent or other waste will be discharged from the ship which would cause a measurable increase in the general background radioactivity of the environment.[32]

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28. See ibid., p. 11 (Evidence, p. 238.302) for the sources, etc of solid wastes, and for the strict US Navy controls in place to account for such wastes.
29. ibid., p. 11 (Evidence, p. 238.302). Prior to 1970, some disposal at sea occurred.
30. Evidence, p. 1300.51 (Department of Defence). Because the amount released is within the daily variation in the level of natural background radiation, it is not detected by monitoring in place during visits. The monitoring is set to detect only levels above the natural background level: ibid. For details of the gaseous radionuclides generated in the primary coolant of a submarine's reactor, see UK, Parliamentary Debates (Commons), 6th series, vol. 143, Written Answers, 9 December 1988, col. 345. One of these, 'argon, which accumulates over time, is routinely released when necessary, with appropriate safety precautions'.
31. US, Department of the Navy, Environmental Monitoring and Disposal of Radioactive Wastes from U. S. Naval Nuclear-Powered Ships and their Support Facilities 1984, (NT-85-1, February 1985), pp. 25-26 (Evidence, p. 238.309).
32. 'Standard Statement' by the United States Government, para. 2(a) (Evidence, p. 1078). The corresponding UK statement contains an identical assurance (Evidence, p. 1300.16). See also US, H of R, Committee on Armed Services, Subcommittee on Procurement and Military Nuclear Systems, Naval Naval Nuclear Propulsion Program - 1988 - Hearings, 26 February 1987, p. 7 (Admiral K. R. McKee): 'We do not discharge any radioactivity in port from these ships that would cause an increase in the general background levels radioactivity already there'.

Monitoring for radioactive waste discharge during visits has been carried out by Australian authorities during each visit. No discharge has ever been detected.[33]

4.30 Nonetheless the Committee considered the possibility of such discharge as part of its inquiry, as a discharge, were it to occur, might have some harmful impact.[34] Without belittling the need to have regard for the possibility for radioactive waste discharge, the Committee considers it important to maintain a sense of proportion. It is clear that the major potential source of harm lies in release of fission products, not discharge of radioactive wastes during occasional port visits.[35]

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33. See above, para. 2.31.
34. The most significant exposure pathway for humans is through the possibility of the concentration of contamination in the marine food chain. This possibility is much lower where only occasional port visits occur than for a homeport or base where numbers of nuclear powered vessels may be frequently present. In the latter context, individual discharges, insignificant in isolation, may have a cumulative effect leading to measurable harm.
35. No figures appear to be available for the quantity of radioactivity present in wastes aboard an average nuclear powered vessel. However, the following figures give a rough comparison of the potential harm that might be caused by reactor accidents and waste discharges. In 1984, the 144 US nuclear powered vessels and their support facilities generated 41 curies of solid waste: USN Environmental Monitoring Report, above note 31, pp. 1 and 12 (Evidence, pp. 238.297 and 238.302). Significant radioactivity in liquid waste discharges from the same sources totalled less than 200 curies of tritium, less than 100 curies of carbon 14, and less than 0.4 and 0.002 curies at sea and within 12 miles of land respectively of other radionuclides with long half-lives (ie. more that a few hours): ibid., pp. 7, 8, 9, and 2 (Evidence, pp. 238.300, 238.301 and 238.297). In comparison, British figures state the maximum fission product release from the equivalent to the ANSTO reference accident could be 101,000 curies, and for an uncontained accident the release could reach 10,100,000 curies: UK, Parliamentary Debates (Commons), 6th series, vol. 112, Written Answers, 20 March 1987, cols. 634-35 (Evidence, p. 1300.19).

DIFFERENCES BETWEEN NAVAL AND LAND-BASED REACTORS

Introduction

4.31 In the previous chapter the lack of relevant information on naval reactors due to military secrecy was noted. Information on civil pressurised water reactors is widely available, creating the possibility that it may be used to fill gaps caused by military secrecy. It cannot be assumed that this information is always relevant to naval reactors because there are differences between the two types. Therefore it is important to indicate what the major differences are. It is convenient to begin to do this by dealing with the claims made in many submissions that naval reactors may be or are inherently less safe than their land-based counterparts.

4.32 There were a number of respects in which it was argued in submissions and by witnesses that the design, construction and operation of naval reactors may make them less safe than land-based reactors. These were:

- lack of any independent safety evaluation;
- high level of enrichment of the fuel used;
- longer life of fuel giving an increased inventory of fission products;
- design considerations, in particular the need for minimum weight and volume, leading to reduced containment, lack of an emergency core-cooling system, and a general lack of safety features;
- operational requirements, especially the need for more rapid power production and reduction;
- operator training and working conditions;
- the ageing of the United States nuclear powered fleet; and
- the risks arising from the fact that the reactor is in a warship: these include collision, grounding, capsize, and the need to store explosives and other dangerous items in the warship.

4.33 Before considering these specific points individually the Committee makes two general comments. First, it is acknowledged that the tasks required of a naval reactor differ from those of a land-based reactor designed for electricity generation, and as a result the reactor designs differ. Many submissions tended to assume that the differences meant naval reactors were less safe. The Committee was not prepared to accept this assumption. It is a question to be determined from the available information in each respect whether the designers and operators of naval reactors have overcome the different design and operating constraints imposed upon them. The remainder of this chapter addresses this question.

4.34 Secondly, on a more technical level, the Committee agrees with the following comment by Dr John Symonds on many of the submissions critical of the safety of naval nuclear power.

> It has been observed that, in some submissions, technical facts are stated with little supporting information which would assist the intelligent layman in following the line of argument satisfactorily. In other submissions, technical facts are stated, but out of context, without the precise situation mentioned and without any reference or qualifying remarks. These situations are then used to expand on the significance of the fact, leading to erroneous impressions. Neither of these approaches is truly enlightening.[36]

Lack of Independent Safety Evaluation

4.35 It has come to be accepted as important that land-based reactors should be subject to some measure of independent safety review both at the design stage and throughout their operating life.[37] With respect to naval reactors, one submission stated:

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36. Letter from Dr J. L. Symonds, 12 February 1987, p. 1.
37. See for example, US, H of R, Committee on Appropriations, Subcommittee on Energy and Water Development, Energy and Water Development Appropriations for 1987 - Hearings, 6 May 1986, p. 157 (Commissioner Asselstine, Nuclear Regulatory Commission): with respect to the Department of Energy's military nuclear reactors, 'there is a benefit in having an independent review to make sure that the military needs question isn't driving things to the point where safety gets sacrificed'.

> The design of nuclear power reactors for military ships and submarines is not subject to the sort of safety evaluation enforced upon civilian design, and yet the specifications and performance required by the military are often more demanding and so allow narrower safety margins. Once deployed, there exists no body with responsibility for monitoring, let alone regulating, the operation of nuclear power at sea.[38]

4.36 In contrast, the official Australian view in 1976 was that:

> nuclear warships are subject to a detailed safety assessment by recognised independent safety review authorities in the USA and UK. ... In the United States reviews are undertaken by the Reactor Licensing Division of the Nuclear Regulatory Commission (NRC) in conjunction with the Advisory Committee on Reactor Safeguards, a statutory body which advises the NRC on reactor safety. In the United Kingdom the reviews are undertaken by the Safety and Reliability Directorate of the UK Atomic Energy Authority in conjunction with the Nuclear Powered Warships Safety Committee, a civilian committee which advises the Minister of Defence independently on these matters.[39]

4.37 In response to this, Professor Jackson Davis told the Committee:

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38. Submission from Greenpeace Australia (NSW) Ltd, p. 4.
39. Australia, <u>Environmental Considerations of Visits of Nuclear Powered Warships to Australia</u>, (May 1976), p. 7 (Evidence, p. 124). Note the US 'Standard Statement' of assurances, para. 1 (Evidence, p. 1078), in which the US Government:

    > certifies that reactor safety aspects of design, crew training and operating procedures of the nuclear propulsion plants of United States nuclear powered warships are reviewed by the United States Atomic Energy Commission and the Statutory Advisory Committee on Reactor Safeguards, and are as defined in officially approved manuals.

    The Nuclear Regulatory Commission succeeded to some of the functions of the Atomic Energy Commission in 1974. See also 'U.S. Navy Statement on the Safety of Operations of U. S. Nuclear Powered Warships', January 1987 (Evidence, p. 238.241): 'the reactor safety aspects of design, crew training and operating procedures are reviewed by the U. S. Nuclear Regulatory Commission and the Statutory Advisory Committee on Reactor Safeguards'.

With respect to the independent safety assessment[s] by authorities in the U.S., ... these do not in fact occur. The primary civilian nuclear regulatory authority in the U.S., the Nuclear Regulatory Commission (NRC), has no jurisdiction whatever over naval propulsion reactors, which are accountable only to classified military review.[40]

4.38 Some background is useful to understanding the present position. Statutory responsibility for United States naval reactors rests with the Naval Nuclear Propulsion Program and the Program's director.[41] This program controls all aspects of naval nuclear propulsion[42] and is the joint responsibility of the Departments of Energy and the Navy. Its director is appointed jointly by the two Departments with the approval of the President. Both Departments are required to assign to the director their responsibilities relating to, amongst other things:

the safety of reactors and associated naval nuclear propulsion plants, and control of radiation and radioactivity associated with naval nuclear propulsion activities, including prescribing and enforcing standards and regulations for these areas as they affect the environment and the safety and health of workers, operators, and the general public.[43]

4.39 Prior to 1974, the United States Atomic Energy Commission (AEC) had responsibility for nuclear matters, including the design of naval reactors, and also had (ambiguous)

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40. Submission from Prof W. J. Davis, p. 14 (Evidence, p. 461). See also the submission from Mr R. Bolt, p. 7 (Evidence, p. 957).
41. The governing text is Executive Order No. 12344, 1 February 1982, (47 CFR 4979) but the Department of Defense Authorization Act 1985, s. 1634 provided that this Presidential Executive Order shall remain in force until changed by legislation. The basic structure set out in the Executive Order has existed since 1954: see R. G. Hewlett and F. Duncan, Nuclear Navy 1946-1962, (U. of Chicago, Chicago, 1974), pp. 342-45 and 362-65.
42. This includes 'all technical aspects of U. S. policy relative to the entry of U. S. nuclear powered ships into foreign countries or waters ...': US Congress, Joint Economic Committee, Economics of Defense Policy: Adm. H. G. Rickover, 28 January 1982, Part 1, p. 91 ('A Description of the Naval Nuclear Propulsion Program, January 31, 1982').
43. Executive Order 12344, 1 February 1982, (47 CFR 4979), ss. 5(c) and 8(a).

statutory responsibility for their safe operation.[44] The working arrangement arrived at was that the AEC would design naval reactors, have them built, and transfer them to the Navy.[45] The Navy would be responsible for the safe operation of the reactors, including the establishment and enforcement of its own safety standards. The AEC would, on request from the Navy, evaluate operating procedures and general safety standards. The Navy undertook to make available to the AEC the safety and security standards it established and all pertinent data on operations under these standards.[46]

4.40 The functions of the AEC were split in 1974. Broadly, its regulatory functions went to the newly created Nuclear Regulatory Commission (NRC). Its design, construction and nuclear energy promotion functions eventually went to the Department of Energy (DOE), which was created in 1977. The AEC's evaluation and advisory role in regard to naval reactors has passed to the NRC. A 1983 description of the Naval Nuclear Propulsion Program stated:

> Although the activities of the program are not subject to licensing by the Nuclear Regulatory Commission, the Director obtains comments from the Nuclear Regulatory Commission and Advisory Committee on Reactor Safeguards on all new shipboard and prototype reactor plant designs and on other nuclear safety matters related to

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44. See R. G. Hewlett and F. Duncan, Nuclear Navy 1946-1962, (U. of Chicago, Chicago, 1974), pp. 362-65 for details. The relevant legislation was the Atomic Energy Act 1954, ss. 91(b) and 161(b).
45. ibid., p. 343.
46. Pursuant to a Presidential directive of 23 September 1961, 'any disagreement as to safety aspects, arising as a result of comment by the AEC which cannot be directly resolved by the two agencies will be referred to the President for decision'. The terms of the directive are set out in 'Derivation and Execution of Responsibilities of the Director, Naval Nuclear Propulsion Program', 24 May 1979, para. II(C) incorporated in US, H of R, Committee on Science and Technology, Subcommittee on Energy Research and Production, Nuclear Powerplant Safety Systems, 24 May 1979, p. 981.

program work as he deems appropriate.[47]

4.41 A formal United States Navy Instruction in 1978 made the Commander, Naval Sea Systems Command, in cooperation with the Director, Division of Naval Reactors of the DOE, responsible for, among other matters related to nuclear safety:

> Submitting a Safety Analysis Report on each new reactor type to the Nuclear Regulatory Commission for review and comment.
>
> Making available to the NRC and the DOE, on a continuing basis, information on any changes in design or data on operations in which reactor safety is involved.
>
> Through the Director, Division of Naval Reactors, DOE, keeping the NRC and Advisory Committee on Reactor Safeguards properly informed with regard to naval nuclear propulsion matters.[48]

4.42 Statements that independent review occurs do not, as far as the Committee can determine, mean that the independent review bodies have statutory power to initiate any review or enforce

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47. US, H of R, Committee on Armed Services, Subcommittee on Procurement and Military Nuclear Systems, Naval Nuclear Propulsion Program - 1983 - Hearing on H. R. 2496, 4 March 1983, Appendix C, p. 53 ('A Description of the Naval Nuclear Propulsion Program, January 1983'). It appears that the position has not altered since 1983: see for example US, Senate, Committee on Armed Services, Subcommittee on Strategic Forces and Nuclear Deterrence, Safety Oversight for Department of Energy Nuclear Facilities - Hearings, 22 October 1987, p. 111 (J. D. Peach, General Accounting Office): 'NRC also reviews the designs of DOE's naval reactors'.
48. 'Derivation and Execution of Responsibilities of the Director, Naval Nuclear Propulsion Program', 24 May 1979, paras. II(D)(4), (5) and (10) incorporated in US, H of R, Committee on Science and Technology, Sub-committee on Energy Research and Production, Nuclear Powerplant Safety Systems, 24 May 1979, p. 982. It is unclear from this source if the parts quoted are a directly from, or merely a paraphrase of, OPNAVINST C3000.5C of 19 June 1978. This 1978 USN instruction replaced earlier versions, which extend back to at least 1958. The Committee is not aware if the 1978 version is still the current version. The Director of the Division of Naval Reactors, DOE, referred to in the text and quote also holds the position of Director, Naval Nuclear Propulsion Program, described in para. 4.38 above.

sanctions.[49] Nonetheless, review does occur, although the results of reviews that have taken place since 1974 are not publicly available as far as the research of the Committee's staff can discover.[50] The exact subjects reviewed are similarly difficult

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49. cf. the exchange in US, H of R, Committee on Science and Technology, Subcommittee on Energy Research and Production, Nuclear Powerplant Safety Systems, 24 May 1979, p. 1072:

> Mr Anthony: ... as I understand it from your testimony... NRC does review the design of the naval plant.
> Admiral Rickover: Yes, sir.
> Mr Anthony: They issue some type of authorization or permit based on their approval of the design?
> Admiral Rickover: Yes, sir. They issue a formal report not actually a permit or a license.
> Mr Anthony: What has been your experience with the NRC in reviewing the extensive training programs that you have indicated by your testimony that you have instituted in the naval program and do they monitor it on a continuing basis?
> Admiral Rickover: Well, the NRC conducts reviews, they do not monitor on a continuous basis.
> Mr Anthony: So NRC does not monitor your training program on a continual basis, so it is really left up to you --
> Admiral Rickover: They pretty well know, they are quite familiar with our training program and they know over a period of years how we operate and we certainly need no urging to continue this.

50. e.g. see US, Senate, Committee on Governmental Affairs, Reactor Safety Issues at Department of Energy Facilities - Hearing, 12 March 1987, pp. 34-35 (F. J. Remick, Vice Chairman ACRS): since 1974, the ACRS has 'participated in the review of some DOE facilities and activities, including, for example, ... the Naval Reactors Program'. The aspects reviewed are not stated. See also US, Senate, Committee on Armed Services, Subcommittee on Strategic Forces and Nuclear Deterrence, Safety Oversight for Department of Energy Nuclear Facilities - Hearings, 22 October 1987, p. 111 (J. D. Peach, General Accounting Office): the NRC reviews the designs of DOE's naval reactors. NRC Budget Estimates include under the heading 'Nuclear Reactor Regulation Programs' an item called 'Other Reviews'. This item includes 'safety reviews of projects covered by the Department of Defense and the Department of Energy': NRC, Budget Estimates FYs 1988-1989: Appropriation: Salaries and Expenses, (NUREG-1100, vol. 3, January 1987), p. 22. But no details of the topics to be reviewed are provided.

to determine, at least from this distance.[51] The Australian Department of Defence had no better information that it could provide to the Committee.[52]

4.43 The position appears to be similar for British naval reactors. The Australian Department of Defence informed the Committee:

> Since reactors which are part of a form of transport are specifically excluded from the UK Nuclear Installations Act, the UK Nuclear Installations Inspectorate does not have powers equivalent to those which require it to audit or inspect the safety arrangements for civil power reactors. Internal Royal Navy safety audits are therefore conducted to maintain comparable standards.[53]

In addition, the Royal Navy as a matter of practice refers

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51. One subject reviewed by the ACRS was the safety of the prototype and production versions of the S8G reactor used to power Ohio-class ballistic missile submarines (a submarine type that does not visit Australian ports), and in 1978 the ACRS concurred in the reactors' operation: see 'Derivation and Execution of Responsibilities of the Director, Naval Nuclear Propulsion Program', 24 May 1979, para. IV(A) incorporated in US, H of R, Committee on Science and Technology, Subcommittee on Energy Research and Production, Nuclear Powerplant Safety Systems, 24 May 1979, p. 984. The NRC has reviewed the Navy's standard instructions defining radioactive waste release limits and procedures to be used by its nuclear powered vessels: US, Department of the Navy, Environmental Monitoring and Disposal of Radioactive Wastes from U. S. Naval Nuclear-Powered Ships and their Support Facilities 1986, (NT-87-1, February 1987), p. 3.
52. In response to the Committee's request for further information, the Department replied (Evidence, p. 1300.50):

    > Information is available from unclassified United States documents to the effect that procedures exist for the NRC to review the safety of United States nuclear powered warships. At the time the ... document [cited at para. 4.36 above] was written ANSTO received information from confidential sources that such reviews did take place. ANSTO is not able to provide documentary evidence of this and does not have details of the procedures or the requirements placed upon the parties to these procedures.
53. 'UK Nuclear Powered Warships Safety Procedures', (Paper prepared for the Committee by the Australian Department of Defence, July 1988), para. 11 (Evidence, p. 1300.15).

matters relating to nuclear safety to independent assessors.[54]

4.44 It does not automatically follow, however, that lack of legally enforceable civilian review of naval nuclear safety means that naval reactors are less safe than commercial ones. It is clear from abundant testimony presented to United States Congressional committees over a long period of time that safety is taken very seriously within the Naval Nuclear Propulsion Program.[55] The Program operates in many respects independently of those having line responsibility for the operation of Navy

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54. ibid., para. 4 (Evidence, p. 1300.13). In its 'Standard Statement', para. 1 (Evidence, p. 1300.16), the UK Government certifies that the safety aspects of its nuclear powered warships 'are reviewed by the UK Nuclear Powered Warships Safety Committee and other appropriate UK authorities'. See also 'SRD celebrates quarter century', Atom, 1984, no. 335, p. 30: an independent safety unit within the UK Atomic Energy Authority, the Safety and Reliability Directorate (SRD), has among its 'current important projects' that of 'providing nuclear safety advice to the Royal Navy'. The SRD also acts as advisor to the consortium which builds reactors for the Royal Navy: D. Fishlock, 'Navy lifts veil on PWR research', Nature, 2 March 1978, vol. 272, p. 4. For further indication of the SRD's role in relation to the Royal Navy's nuclear program, see for example United Kingdom Atomic Energy Authority, Annual Report 1986-87, p. 42. Note also Vice Admiral Sir Ted Horlick RN, 'Submarine Propulsion in the Royal Navy', Proceedings of Institution of Mechanical Engineers, 1982, vol. 196, p. 76: ways in which the Royal Navy has met 'the steadily increasing demands of the nuclear safety authorities for demonstrable validation of safety'; and R. Pengelley, 'Stealth in practice: the Royal Navy's Trafalgar-class submarines', International Defense Review, 1989, vol. 22(1), p. 30: the crews' safety and operating logs 'are subject to scrutiny by both civilian and naval shore-based agencies'.
55. e.g. see US, H of R, Committee on Science and Technology, Subcommittee on Energy Research and Production, Nuclear Powerplant Safety Systems - Hearings, 24 May 1979, pp. 915-17 (Admiral H. G. Rickover) for a description of some of the examinations, inspections and incident reporting that occur with respect to USN reactors.

vessels.[56] To this extent the Program acts as an independent inspector and watch-dog on safety matters.[57]

4.45 The United States Department of Energy operates non-naval reactors substantially free of independent scrutiny. The Committee notes that the safety record with respect to these has come under considerable criticism recently.[58] One solution proposed by the critics is to bring Department of Energy reactors under the statutory oversight of the Nuclear Regulatory

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56. e.g. ibid., pp. 1046-47 and 1049-50 (Admiral H. G. Rickover). See also US Congress, Joint Committee on Atomic Energy, Subcommittee on Legislation, Naval Nuclear Propulsion Program - 1975 - Hearing, 5 March 1975, p. 26 (Admiral H. G. Rickover): in the Navy program

> we have inspection boards that make very thorough inspections of all our nuclear-powered ships, spending several days at a time for each ship. I have my own representatives at every shipyard working on nuclear-powered ships and at every prototype reactor site who regularly inspect those operations. They report directly to me what is going on.

The position appears to be broadly similar with respect to British submarines: 'UK Nuclear Powered Warships Safety Procedures', (Paper prepared for the Committee by the Australian Department of Defence), para. 4 (Evidence, p. 1300.13).

57. See Lt R. E. Chatham USN, 'Leadership and Nuclear Power', US Naval Institute, Proceedings, July 1978, pp. 78-82 for a critique of the way responsibilities for nuclear safety are carried out in operational US nuclear powered warships. The author alleged, in part, that there was excessive regard for reactor safety; the watch-dog activities of the Program interfered with the ordinary chain of command; safety exams and inspections of crews were excessively demanding and time consuming; there appeared to be a policy for reactor crews 'that no one should be permitted to know that he has done well: hubris causes mistakes' (p. 81); and the constant safety-checking of crew actions led to a perception by crew members that they could not be trusted to do things properly on their own. This critique generated a large correspondence from other officers serving, or who had served, in US nuclear powered warships: see the following 6 issues of the Proceedings. Some agreed with the critique, others strongly disagreed and regarded the steps taken as necessary to ensure reactor safety and reliability. The correspondence as a whole provides many details of the checking, inspecting and examining that occurs with regard to the day-to-day operation of USN reactors. See also Captain F. G. Satterthwaite USNR, 'Manning Nuclear Submarines', US Naval Institute, Proceedings, February 1985, p. 65: the frequent safety inspections and the commitment to zero defects and no nuclear safety violations can result in low morale and high operational costs on USN nuclear vessels.

58. e.g. US, Senate, Committee on Governmental Affairs, Report on the Nuclear Protections and Safety Act of 1987, 24 September 1987, pp. 3-8.

Commission. But, as far as the Committee can discover, the criticism does not extend to reactors on Navy vessels.[59]

4.46 The Committee does not attach great significance to the fact that there is apparently no legally enforceable civilian oversight of the United States Naval Nuclear Propulsion Program with respect to technical safety matters. The Committee notes that this position is not unique. Legally enforceable independent civilian monitoring of the safety aspects of conventional warships is not the norm. Moreover, it is clear that prior to 1974 significant civilian oversight occurred in practice.[60] The evidence indicates that since then there has not been any reduction in concern with naval reactor safety in the United States.[61]

Highly Enriched Fuel

4.47 Two submissions claimed that plutonium was used as a fuel in naval reactors.[62] The Committee is not aware of any authoritative evidence that plutonium fuel is used in the United States Navy's reactors. All the indications of which the

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59. e.g. US, Senate, Committee on Armed Services, Subcommittee on Strategic Forces and Nuclear Deterrence, Safety Oversight for Department of Energy Nuclear Facilities - Hearings, 27 October 1987, p. 191 (J. Salgado, Department of Energy).
60. For extracts from correspondence from the Advisory Committee on Reactor Safeguards (ACRS) and others relating to oversight in the late 1950's, see US Congress, Joint Committee on Atomic Energy, Naval Nuclear Reactor Program and Polaris Missile System - Hearing, 9 April 1960, pp. 10-18 and 37. Further examples of correspondence and of extracts from the minutes of the ACRS relating to oversight of naval reactor safety are included in US Congress, Joint Committee on Atomic Energy, Tour of the USS "Enterprise" and Report on Joint AEC-Naval Reactor Program, 31 March 1962, pp. 40-43.
61. In addition to sources already cited, see para. 4.133.
62. Submissions from Assoc Prof P. Jennings, p. 1 (ships 'use highly-enriched plutonium fuel'); Mr R. Addison, p. 4 (evidence that ships 'are now using metallic plutonium fuel rather than metallic uranium').

Committee is aware suggest that uranium is used,[63] and that it is enriched to more than 90% uranium-235.[64] The Committee has adopted this assumption.

4.48 Some submissions remarked that the uranium used in naval reactors is much more highly enriched than that used in land-based reactors but did not explain the relevance of this to the inquiry.[65] The advantage of using highly-enriched fuel is that it enables a more compact reactor to deliver the same power as a less compact one using fuel enriched to the commercial level of less than 4%. As noted later in this chapter, compactness in a naval reactor facilitates safer containment.

4.49 A high level of enrichment does not affect the inventory of radionuclides available for release in the event of an accident. This fission product inventory depends on the energy output of the reactor.[66] A 100 Mw(t) reactor with fuel enriched to 3 per cent uranium-235 would not have a significantly different radionuclide inventory from a 100 Mw(t) reactor using fuel enriched to 95 per cent.

4.50 The only explicitly stated safety allegation relating to the use of highly enriched fuel was that it created a risk of an uncontrolled nuclear reaction:

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63. e.g. see US, H of R, Committee on Merchant Marine and Fisheries, Disposal of Decommissioned Nuclear Submarines - Hearing, 19 October 1982, pp. 8, 9 (Mr C. H. Schmitt, Naval Nuclear Propulsion Program); US, H of R, Committee on Appropriations, Subcommittee on Energy and Water Development, Energy and Water Development Appropriations for 1982 - Hearings, 4 March 1981, pp. 554-55 (Admiral H. G. Rickover); Department of Energy National Security and Military Applications of Nuclear Energy Authorization Act 1988 (PL100-180, Division C, Title 1), s. 3111(2)(A), (appropriation of $141.5 m 'for uranium enrichment for naval reactors' for FY 1988).

64. e.g. see letter from Dr J. L. Symonds, 12 February 1987, p. 1; T. B. Cochran and others, Nuclear Weapons Databook, Volume II: U. S. Nuclear Warhead Production, (Ballinger, Cambridge, Mass., 1987), p. 71 (enriched to 97.3% U-235).

65. Submissions by Inner City People for Nuclear Disarmament, p. 1; Illawarra People for Nuclear Disarmament, p. 4; Friends of the Earth, p. 1.

66. Submission from Prof W. J. Davis, p. 55 (Evidence, p. 502).

If a large mass of fuel melts and forms a pool, an uncontrollable chain reaction may occur. Because the fuel is the same material used in bombs, a sufficiently large mass may cause a 'fizzle' explosion.[67]

4.51 Dr Symonds informed the Committee:

While it is true that a bomb can be made with as little as five kilograms of uranium-235 ... this quantity of material is only significant as an explosive device if it is highly compressed first to produce a very super-critical nuclear condition and neutrons inserted at the correct instant in the compression. The potential of an energy release through a nuclear excursion in a molten aggregate of highly enriched nuclear fuel has been known for a considerable time. For a significant explosion to occur, the configuration of the molten mass must be such that it forms into a shape which will produce a supercritical nuclear condition. Experiments with highly enriched metal fuel have given guidance on the extent of the energy produced. Very conservative estimates suggest that the explosion might reach the order of the equivalent of hundreds of pounds of TNT.

Designs have been put forward to ensure that the molten fuel never aggregates into, say, a near spherical shape which would increase the probability of a secondary criticality accident.[68]

A similar view was put to the Committee by the Department of Defence.[69]

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67. Submission from Mr R. Addison, p. 6.
68. Letter from Dr J. L. Symonds, 12 February 1987, p. 7.
69. Evidence, p. 1300.53 (Department of Defence):
We do not have access to sufficiently detailed information on core enrichment levels, core mass and composition or below-core geometrical design for naval propulsion reactors to assess that re-criticality [ie. formation of a critical mass] would be impossible following a core melt. However, in view of the long-standing recognition of the theoretical possibility of such events, it seems hardly credible that design provisions would not have been made to ensure sub-criticality of any fuel re-assembly.

4.52 A United States Navy report states with respect to its naval reactors: 'the reactor core is so designed that it is physically impossible for it to explode like a bomb'.[70] The Committee has no reason to interpret this narrowly so as to exclude a nuclear 'fizzle' from the meaning of 'explode like a bomb'.

4.53 A further possible significance of the use of highly enriched fuel relates to its effect on cooling requirements. Although not set out clearly in any submission, the Committee assumed that the concern was that the use of enriched fuel leads to higher power-density.[71] This enables production of the same amount of heat in a smaller space and thereby makes constant provision of adequate cooling more critical. Put simply, if there is a loss of coolant the fuel will melt more quickly in a high power-density reactor than in a low density one.[72]

4.54 As explained earlier in this chapter, the melting of fuel breaches the first barrier that is designed to prevent the release of harmful radioactivity to the environment. The most likely cause of the loss of coolant would be the failure of the second barrier, the pressurised primary coolant circuit. Thus the

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70. US, Department of the Navy, Environmental Monitoring and Disposal of of Radioactive Wastes from U. S. Naval Nuclear-Powered Ships and their Support Facilities 1984, (NT-85-1, February 1985), p. 9 (Evidence, p. 238. 301. For a similar statement in 1963 by the head of the US naval reactors program, Admiral H. G. Rickover, see 'Rickover Cites Safety Factors', New York Times, 12 April 1963, p. 11. See also UK, Ministry of Defence, Liverpool Special Safety Scheme for Visits to Liverpool by Nuclear Powered Submarines, (April 1986), para. 10: 'it is impossible for a reactor accident to result in an atomic-bomb type explosion ...'. Dr R. Webb, in a letter to Senator Vallentine, raised the possiblity of an atom bomb-type explosion in a US naval reactor: see Evidence, p. 1364. But he also claimed the US Government had never stated that this could not occur (ibid.), apparently being unaware of the sources cited above, and many other US Government documents containing similar statements.
71. 'Power-density' refers to the fission rate per unit volume of core.
72. Evidence, p. 438 (ANSTO). In response to a further question, the Committee was told that the time available for response to loss of coolant could only be properly determined by detailed analysis of the reactor design: Evidence, p. 1300.53 (Department of Defence).

scenario would lead to reliance on the third barrier, the containment, more quickly than in a low power-density reactor.

4.55 The Australian Nuclear Science and Technology Organisation (ANSTO) suggested that this did not increase the hazard to the public:

> although the fuel would melt more rapidly, the escape of fission products to the environment would be governed by the pressure rise in the containment. Since the heat capacity of the fuel is small compared with that of the total system, the rate of this pressure rise is almost independent of the enrichment level of the fuel. Thus the hazard posed to the public from a meltdown accident is not related to the enrichment level.[73]

4.56 The Committee accepts that, from the point of view of containment integrity, the rapidity of the fuel melt may not matter. However, the speed of the fuel melt does have relevance to the possibility of automatic or manual intervention to prevent the onset or continuation of fuel melting. In simple terms, it reduces the possibility of preserving the first barrier. The more that the first barrier remains intact, the less the third barrier needs to be relied upon. In this sense the use of highly enriched fuel weakens the defence-in-depth against accidental release to the environment. This has, however, been taken into account in assessing accident likelihood.[74]

4.57 The Committee asked the Department of Defence and ANSTO if there were any other respects in which the use of highly enriched fuel creates a greater safety hazard. The response stated that there were none that were relevant in the context of

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73. Evidence, p. 438 (ANSTO).
74. See below, para. 7.15 where it is indicated that in its assessment of accident likelihood, ANSTO have made the very conservative assumption that no automatic or manual intervention will occur once an accident sequence has commenced.

port visits to Australia.[75]

Higher Inventory of Fission Products

4.58 The inventory of fission products available for release from a given quantity of fuel in a reactor depends, among other things, on the period for which the fuel has been irradiated. This in turn will depend on the time between refuelling, and it was pointed out in submissions that naval reactors have longer refuelling cycles than commercial land-based ones.[76] The reactors on United States aircraft carriers now have to be refuelled only once every 15 years, when the whole core is replaced.[77] In contrast, commercial reactors tend to have part of their fuel replaced each year because it is more economical and because there is no need to run for long periods without refuelling.[78]

4.59 The Committee agrees that the longer refuelling cycle used by the United States Navy means that the inventory of fission products available for release is greater than for a

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75. Evidence, p. 1300.53 (Department of Defence). Hazards not relevant to the Australian context relate to fuel handling and storage: ibid.
76. Submissions from Mr R. Addison, p. 4; Prof W. J. Davis, p. 56 (Evidence, p. 503).
77. US, Departments of Defense and Energy, A Review of the United States Naval Nuclear Propulsion Program, (June 1986), p. 22. See also US, H of R, Committee on Armed Services, Subcommittees on Procurement and Military Nuclear Systems, and on Seapower and Strategic and Critical Materials, Naval Nuclear Propulsion Program - 1979 - Hearing on H. R. 2603, 1 March 1979, p. 51 (Admiral H. G. Rickover): ' a modern [reactor] core is capable of propelling nuclear ships for 10 to 15 years and over 400,000 miles'; US Congress, Joint Committee on Atomic Energy, Naval Nuclear Propulsion Program - 1974 - Hearing, 25 February 1974, p. 11 (Admiral H. G. Rickover): 'the liftime of cores we are installing in nearly all submarines now is 10 years, and in some surface ships it is 13 years'. The operating profiles, the details of reactor design, the fuel configurations and the fuel usage rate all vary between the four different classes of nuclear powered vessels (ie. ballistic missile submarines, attack submarines, aircraft carriers and cruisers). Hence the possiblity exists of variation in core life as between classes.
78. See for example F. J. Rahn and others, A Guide to Nuclear Power Technology, (Wiley, New York, 1984) p. 461: 'Refueling operations, in current LWRs, take place annually ... . Only partial fuel replacement takes place, typically one-third or one-fourth of the core.'

reactor of equivalent output using a typical commercial refuelling cycle. This does not affect the likelihood of an accident. But it is important that this difference be taken into account when calculating the consequences of an accident involving breach of containment. The extent to which calculation of the current reference accident does this is considered in chapter 7.

Lack of Adequate Containment

4.60 The authors of many submissions put the view that the need to integrate a reactor into a ship's hull would result in a loss of safety. The authors of some submissions took the view that because civilian power plants can be built without the same need to limit weight, size or shape, they are potentially much safer than naval reactors.[79] A number of ways in which this could be the case were put forward.

4.61 The single most common and possibly the most serious allegation made about naval reactors was that their containment is inferior to that of land-based reactors.[80] The seriousness of this allegation results from the fact that it casts doubts on the reference accident used for emergency planning purposes. This reference accident assumes a contained full-core meltdown. A breach of containment would result in consequences which are significantly greater than those used for emergency planning purposes.

4.62 The authors of submissions were not in a position to provide any details of naval reactor containment. Claims of lesser safety were based in part on the absence of any visible substitute on ships for the large concrete structures that

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79. e.g. see submissions from Assoc Prof P. Jennings, p. 1; Mr R. Addison, p. 4; the Manly Warringah Peace Movement, p. 1.
80. Submissions from Assoc Prof P. Jennings, p. 1; Albany Peace Group, p. 3; Mr R. Addison, p. 4; Derwent Valley Peace Group, p. 2; Mr R. Bolt, p. 7 (Evidence, p. 957); Scientists Against Nuclear Arms (Tas), p. 3 (Evidence, p. 822); People for Nuclear Disarmament, p. 3 (Evidence, p. 1305). See also Evidence, p. 980 (Mr R. Bolt).

feature in photographs of nuclear power stations. Assumptions were made that weight and dimension constraints on ship designers would result in less safe solutions to the need for containment. The Committee itself could obtain only limited information on naval containment.

4.63 On United States submarines, the items from which high levels of radiation are emitted during reactor operation (reactor vessel, primary coolant circuit, the steam generator) are all contained in the reactor compartment. This is formed by a section of the steel cylinder of the hull bounded on either end by thick steel bulkheads, which on the older United States submarines measures 30 feet (9.15 m) by 30 feet and weighs about 900 tons (816 t).[81] On British submarines the compartments on either side of the reactor compartment are designed to act as further containment.[82] The pressurised hull obviously is designed to be strong enough to resist the pressures encountered during deep dives.[83] It also is designed to resist depth charge attacks and other combat stresses: very high integrity is one of the main design objectives.[84]

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81. See the description and diagram provided by a representative of the Naval Nuclear Propulsion Program in US, H of R, Committee on Merchant Marine and Fisheries, Disposal of Decommissioned Nuclear Submarines - Hearing, 19 October 1982, pp. 16 and 26. See also the diagram in N. Friedman, Submarine Design and Development, (Conway, London, 1984), p. 135. The new naval submarine reactor being developed in Britain is contained, with the steam generator and associated equipment, in a reactor compartment 10 m in diameter and 23 m long, weighing about 1300 t: Nuclear Engineering International, July 1985, p. 3.

82. UK, Ministry of Defence, Liverpool Special Safety Scheme for Visits to Liverpool by Nuclear Powered Submarines, (April 1986), para. 7. See also J. E. Moore and R. Compton-Hall, Submarine Warfare: Today and Tomorrow, (Michael Joseph, London, 1986), p. 37. The point referred to is stated in general terms, but the authors have close links to the British Navy and it may be that their point applies only to submarines of that Navy.

83. Evidence, p. 1300.52 (Department of Defence):

> In the case of a submarine, ... the hull would be required to remain leaktight during normal operations at pressure differentials greater than would occur as a result of the reference accident.

84. US, H of R, Committee on Merchant Marine and Fisheries, Disposal of Decommissioned Nuclear Submarines - Hearing, 19 October 1982, p. 22 (C. H. Schmitt, Naval Nuclear Propulsion Program).

4.64 In response to a question from the Committee, ANSTO stated:

> The primary containment design specification allows for internal pressures due both to complete blowdown of the reactor primary coolant circuit, and to the hydrogen which might be generated by metal-water reactions under accident conditions.[85]

4.65 ANSTO also told the Committee that the reactor containment on a submarine 'is designed for the order of two megapascals internal pressure'.[86] This pressure is over four times the design pressure of the containment for the reactor involved in the 1979 Three Mile Island accident.[87] Marine reactor containments generally are designed to withstand greater pressure than those of land-based reactors, due to the more compact construction of the former.[88]

4.66 The Committee was able to confirm the basic features of containment design with respect to British submarines. The Liverpool safety scheme states: 'the reactor compartment is designed and constructed to provide primary containment and to withstand the severe pressure rises associated with the Maximum Design Accident'.[89] This accident is one involving a large coolant leak leading to core melting. The Committee has no reason

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85. Evidence, p. 443.462.
86. Evidence, p. 372.
87. Nuclear Engineering International, World Nuclear Industry Handbook 1988, p. 79 gives the containment design pressure as 4.9 kg/sq cm, which equals about 480 kilopascals.
88. W. Vinck and others, 'Technical Safety Problems in Nuclear Naval Propulsion as Related to Port Entry Considerations' in International Atomic Energy Agency and others, Proceedings of the Symposium on Nuclear Ships, Hamburg, 10-15 May 1971, (GKSS, Hamburg, 1971), p. 149. In simple terms, a containment is a box surrounding another box which is under pressure. The closer the outer box is to the inner box, the stronger it needs to be to contain the effects of a failure of the inner box.
89. UK, Ministry of Defence, Liverpool Special Safety Scheme for Visits to Liverpool by Nuclear Powered Submarines, (April 1986), para. 6.

to consider the containment has been designed to any lower specification on United States submarines. This design specification is the same as that for land-based commercial reactors.[90]

4.67 For nuclear powered surface ships the arrangement of the reactor compartment is said to be similar to that of submarines, except that the hull does not form part of the containment. The reactor compartment is a box-like structure designed to resist collision damage, action damage, and blowdown pressure following a loss of coolant accident.[91] Reactor compartments are located within the most protected places in the ship.[92]

4.68 There is no reason to expect surface warship containment to be designed to any lesser design specification than that of submarines. There is ample evidence that design specification of this type can be met with respect to nuclear powered merchant ships of various sizes, whatever other difficulties those ships

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90. F. J. Rahn and others, A Guide to Nuclear Power Technology, (Wiley, New York, 1984) p. 367:

> The containment building is designed to contain the energy and materials released in a complete, double-ended break of the largest pipe of the reactor coolant system and to withstand the impact of internally generated missiles.

91. Cdr M. K. Gahan, 'Nuclear Propulsion Systems - Technical Aspects', (Paper prepared for the Committee by the Department of Defence, February 1987), p. 3 (Evidence, p. 1300.34). The Committee lacks information on whether, as on British submarines, compartments adjacent to the reactor containment on surface warships provide secondary containment. For nuclear powered merchant ships, see W. Vinck and others, 'Technical Safety Problems in Nuclear Naval Propulsion as Related to Port Entry Considerations' in International Atomic Energy Agency and others, Proceedings of the Symposium on Nuclear Ships, Hamburg, 10-15 May 1971, (GKSS, Hamburg, 1971), pp. 149-50: 'the containments of the NS Savannah and the NS Otto Hahn are surrounded by an additional almost gas-tight reactor compartment which is vented through an elaborate filtering system'.

92. 'U. S. Navy Statement on Safety of Operations of U. S. Nuclear Powered Warships', January 1987 (Evidence, p. 238.244).

may have experienced.[93] On surface ships, there is no counterpart to the strong pressure hull which is used on submarines to form part of the containment. But this is offset by the fact that the space and weight constraints are less severe on surface ships.[94]

4.69 Any comparison of land-based and naval reactor containment must have regard to the much lower power and smaller size of the naval reactors. The difference in power and the use of highly enriched fuel in naval reactors have already been noted. These factors enable naval reactors to be much smaller than the typical land-based reactors which seem to have been used in a number of submissions for comparative purposes.

4.70 While this does not mean that naval reactor containment can be flimsy, adequate containment of a naval reactor is clearly more feasible the smaller the reactor is. Dr Symonds told the Committee that a naval reactor producing about 100 Mw(t) would contain about 150-200 kg of enriched uranium in a pressure vessel

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93. See for example the following papers in Organisation for Economic Co-operation and Development, Nuclear Energy Agency, Symposium on the Safety of Nuclear Ships: Proceedings, Hamburg, 5-9 December 1977, (OECD, Paris, 1978): M. Kawasaki and S. Yaguchi, 'Safety Studies on LOCA for N. S. Mutsu', pp. 202-05; K. Schmidt and others, 'Engineered Safety Equipment and Safety Analysis of NCS 80', pp. 268-70; N. Battle and R. V. Killingley, 'The Influence of Safety and Licensing Requirements on the Selecetion of a Reactor Plant for an Icebreaker', p. 667 and 672. See also D. W. Brideweser, 'The Path Ahead for Nuclear Merchant Ships', Society of Naval Architects and Marine Engineers: Transactions, 1966, vol. 74, p. 73 (NS Savannah, after modifications, had a containment leak rate of 0.7% per day at 60 psig, while its approval specification permitted 1.2%); R. F. Pocock, Nuclear Ship Propulsion, (Ian Allan, London, 1970), pp. 79 (NS Savannah), 147-48 (NS Otto Hahn).

94. For the way in which the US nuclear powered Nimitz-class aircraft carriers have been designed to withstand direct hits from conventional bombs, missiles and torpedoes, and the blast and shock effects of near misses by nuclear weapons see US, H of R, Committee on Armed Services, Subcommittee No. 3, Hearings on Nuclear Aircraft Carrier CVN-70, 27 March 1972, pp. 11,439-44 (Rear Admiral I. Linder). This illustrates the ways in which weight and cost penalties have been accepted in order to ensure safety and survivability.

of roughly one metre internal diameter and four metres high.[95] A scale diagram supplied by the United States Navy to Congress indicates a submarine's reactor pressure vessel is about 4.5 metres high, while that of a Nimitz-class aircraft carrier is nearly 10 metres high.[96]

4.71 For comparison, the pressurised water reactor involved in the 1979 Three Mile Island accident had an initial fuel inventory of 82.8 tonnes of 2.98% enriched uranium in fuel elements whose active length was 3.64 metres, supported in a pressure vessel whose height was 12.4 metres, internal diameter 4.8 metres, and wall thickness 214 mm.[97]

4.72 Additionally, Commander Gahan, RAN informed the Committee of other reasons why naval reactor containments could be made proportionally smaller than land-based reactor containments without loss of safety:

> Part of the volume of the commercial plant is taken up with pools of heavy water used to store fuel and irradiated reactor components. Additionally, heavy shielding required during fuel handling occupies a significant volume. These are not features of a Naval ship installation, since the reactor remains sealed

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95. Letter from Dr J. L. Symonds, 12 February 1987, pp. 3-4. On fuel quantities, see also T. B. Cochran and others, Nuclear Weapons Databook, Volume II: U. S. Nuclear Warhead Production, (Ballinger, Cambridge, Mass., 1987), p. 71: 'modern cores average about 200 kg' of highly enriched uranium each. Contrast the submission from Prof W. J. Davis, p. 56 (Evidence, p. 503), where, using the same basic data as Cochran, an average of 500 kg per core is calculated. This is done by allocating the total quantity of uranium known to be used for US naval reactors (about 5 tonnes per year) only to refuellings, without allowing for the portions of the total used for new reactors and for research. The submission from Assoc Prof P. Jennings, p. 2 appears to assume that several tonnes of (plutonium) fuel are present in a submarine's reactor, and the submission from Mr R. Addison, p. 6 states that up to 2 tonnes of fuel may be in an aircraft carrier's reactor. Neither submission provides a basis for the claims.
96. US Congress, Joint Committee on Atomic Energy, Naval Nuclear Propulsion Program 1970 - Hearings, 20 March 1970, p. 83.
97. Nuclear Engineering International, World Nuclear Industry Handbook 1988, p. 79.

until it returns for maintenance.[98]

4.73 A further factor is that naval reactor designers might be expected to have access to more sophisticated materials such as higher strength alloys. Cost might be expected to be less of a factor in the use of such materials than in commercial reactors.[99] The quantities required would be economically feasible, due to the much smaller volume required to be contained compared to a large commercial reactor.[100] The Committee has no way of verifying that more sophisticated materials have been used, but considers that it is not unreasonable to assume that they have.[101]

4.74 It was put to the Committee that naval reactors operated at higher temperatures and pressures than land-based ones.[102] If true, this would be relevant to the strength of containment, which has to resist this pressure in the event of a rupture in the pressurised elements inside the containment. However, other advice received by the Committee concluded that, on technical grounds, it was quite improbable that naval reactors would use

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98. Cdr M. K. Gahan, 'Nuclear Propulsion Systems - Technical Aspects', (Paper prepared for the Committee by the Department of Defence, February 1987), p. 8 (Evidence, p. 1300.39).

99. cf. US Congress, Joint Economic Committee, Economics of Defense Policy: Adm. H. G. Rickover - Hearing, 28 January 1982, p. 74 ('A Description of the Naval Nuclear Propulsion Program, January 31, 1982'): '... only premium products ... are used in the reactor ...'.

100. Letter from Dr J. L. Symonds, 12 February 1987, p. 4.

101. In view of the simplistic assumptions made in a few submissions about the absence of large concrete containments around warship reactors, it is worth noting that the use of concrete for containment is not without potential problems. For discussion of the way in which a molten reactor core may interact with concrete, and the uncertainties involved, see: APS Study Group, 'Report to the American Physical Society of the study group on radionuclide release from severe accidents at nuclear power plants', Reviews of Modern Physics, July 1985, vol. 57(3)(part II), pp. S59-S61.

102. Submission from Mr R. Addison, p. 4.

higher temperatures or pressures to any significant degree.[103] The Committee considered the latter advice to be far more soundly based.

4.75 The containment structure can only perform its function if it is unable to be by-passed. One possible by-pass mechanism arises where the primary circuit pressure relief valve vents direct to the atmosphere. If it vents within the containment, then any radioactivity released into the primary system is still contained from the environment. ANSTO told the Committee that for the purposes of establishing a reference accident, its

> model does assume that the primary circuit pressure relief system is within the containment, or that if the system does vent directly to the ocean, then it can be overridden in the event of a loss of coolant accident of the Three Mile Island kind.[104]

4.76 The Committee has no conclusive information on whether in United States Navy vessels the venting is within the containment or not.[105] Assuming venting is to the outside, two broad possibilities have to be considered. One involves coolant circuit overpressure in situations where there has been no accident involving fuel melt. In this situation, the potential amount of the radiation release would be small, as explained earlier in this chapter. Only in a second situation, where fuel melt has occurred accompanied by coolant circuit overpressure,

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103. Letter from Dr J. L. Symonds, 12 February 1987, p. 4. See also for example N. Friedman, Submarine Design and Development, (Conway, London, 1984), p. 134; R. O'Rourke, 'The Nuclear-Powered Submarine', Naval Forces, 1986. vol. 7(1), p. 84; J. E . Moore and R. Compton-Hall, Submarine Warfare: Today and Tomorrow, (Michael Joseph, London, 1986), pp. 39-40. The Department of Defence in its submission, p. 12 (Evidence, p. 17) stated that naval reactors would be operating at lower temperatures and pressures in port than when at sea. The Committee preferred ANSTO's view that there would be no significant difference: (Evidence, pp. 397, 412-13).

104. Evidence, pp. 438-39 (ANSTO).

105. cf. Cdr M. K. Gahan, 'Nuclear Propulsion Systems - Technical Aspects', (Paper prepared for the Committee by the Department of Defence, February 1987), p. 5 (Evidence, p. 1300.36): with reference to naval reactors generally, venting is within the containment.

would the potential radiation release via this route be major. The Committee notes that even in this case, if venting is under water rather than to the atmosphere, radionuclides present in the release in aerosol form would be scrubbed by the water.[106]

4.77 A second means of by-passing the containment exists if it has been designed with a pressure relief valve.[107] The aim of such a design would be to allow a small release to the atmosphere in order to reduce pressure and thereby avert a catastrophic containment failure, which would lead to a much larger release. The Committee lacked information on whether the reactor containments on visiting warships were fitted with pressure relief valves. However, there would appear to be little need for such devices, given that the containment is designed to withstand

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106. APS Study Group, 'Report to the American Physical Society of the study group on radionuclide release from severe accidents at nuclear power plants', Reviews of Modern Physics, July 1985, vol. 57(3)(part II), p. S49. Some types of commercial reactors have suppression pools containing water as a safeguard against containment failure due to overpressurisation: ibid., pp. S82-S83, where the parameters of effective water scrubbing are considered in some detail. See also US, Nuclear Regulatory Commission, Reactor Risk Reference Document, (NUREG-1150 (draft), NRC, Washington, 1987), p. 9-8: ' ... a key determinant of whether a [containment] bypass sequence involves major or only minor offsite releases is whether the release of radioactive material occurs into a water pool or sump that can provide scrubbing of released radionuclides'.

107. See for example L. G. Danilov and others, 'Certain Results Concerning the Experience of Operation of the Nuclear Icebreaker "Lenin"' in Organisation for Economic Cooperation and Development, Nuclear Energy Agency, Symposium on the Safety of Nuclear Ships: Proceedings, Hamburg, 5-9 December 1977, (OECD, Paris, 1978), p. 730: the nuclear powered icebreaker 'Arktika' has containment 'provided with a safety valve enabling the release into the atmosphere of the steam-air mixture which can appear inside the safety containment in the case of maximum credible accident - the tube rupture of the primary circuit'.

the full pressure following an accident.[108]

4.78 In the view of the Committee, based on the limited information available to it, there is no reason to suppose that naval reactor containment is any less effective in containing the consequences of accidents inside naval reactors than the types of reactor containment used for much larger land-based reactors is for those reactors.

Strength of the Reactor Pressure Vessel

4.79 The integrity of the reactor pressure vessel is of great importance because any leak would result in loss of coolant and the consequent risk of the fuel melting. Moreover a massive rupture of the vessel risks breaching the containment. For these reasons it has been said with respect to commercial reactors:

> Clearly, it is necessary to demonstrate conclusively that a disruptive failure of the reactor pressure vessel has a very low probability indeed.[109]

4.80 While the Committee is not in a position to have the

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108. See para. 4.64. In 1984 AIRAC raised the possibility of venting from the containment to the atmosphere: AIRAC, 'Review of Safety and Monitoring Arrangements for Visits by Nuclear Powered Warships', p. 5 (Evidence, p. 755). The VSP(N) queried the logic behind the assumption, and at an AIRAC-VSP(N) meeting in May 1987 'AIRAC agreed that venting overpressure in the reactor compartment [ie. containment] was not a conceivable requirement' following an accident during a port visit to Australia: ANSTO, 'Visits by Nuclear Powered Warships: Radiological Consequences of Releases from Remote Anchorages', (August 1987), p. 1. It is important to distinguish this scenario from one involving venting to the atmosphere from the machinery compartments outside the (primary) containment. It was noted in para. 4.63 that these compartments, on some vessels at least, are designed to act as secondary containment. There could be a slow leakage from the primary containment to these compartments. AIRAC also raised the possibility that a warship commander might consider it necessary to vent these compartments in order to reduce the hazard to crew who might be required to enter them. This scenario is considered at para. 8.69 in the context of the adequacy of the criteria for remote anchorages.

109. J. G. Collier, 'Light Water Reactors' in W. Marshall (ed.), Nuclear Power Technology, (Clarendon, Oxford, 1983), vol. 1, p. 269.

integrity of a naval reactor pressure vessel demonstrated to it in this way, all the available evidence indicates that reactor pressure vessels conform to very high safety standards.[110] There is no reason to assume that naval reactor pressure vessels are built to lower standards or are more prone to failure than those for land-based reactors. The point that the operating pressure is unlikely to be any greater in a naval than a land-based reactor has already been noted.

4.81 In addition there appears to no reason why the constraints imposed by having to place the pressure vessel in a ship should result in a pressure vessel of less integrity than in a land-based reactor. Conventionally powered steamships, including surface warships, have pressure vessels in the form of boilers. While the weight of the reactor pressure vessel has to be taken into account, the discussion or doubts on the effect of weight constraints on marine reactor safety have focused on the weight of shielding and containment. Compared to the potential weight of these items and the potential weight savings to be gained by skimping on safety with regard to them, the potential savings from skimping on pressure vessel safety would be small.

4.82 ANSTO told the Committee that it had confirmed with United States and United Kingdom authorities that quality assurance programs for naval reactor pressure vessels are of a higher standard than those for civil reactors.[111] ANSTO also stated that the 'design bases for the pressure vessels of the US nuclear warships reveal a design standard more rigorous' than the

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110. Submission from ANSTO, Attachment 1, p. 6 (Evidence, p. 252); US, Nuclear Regulatory Commission, Reactor Safety Study: An Assessment of Accident Risks in U. S. Commercial Nuclear Power Plants, (WASH-1400, NRC, Washington, 1975), para. 5.3.4.2; UK, Department of Energy, Sizewell B Public Inquiry: Report by Sir Frank Layfield, (HMSO, London, 1987), para. 33.76.

111. Submission from ANSTO, Attachment 1, p. 8 (Evidence, p. 254).

code for civil reactor pressure vessels.[112]

4.83 One way in which naval reactor pressure vessels may be less safe than their land-based counterparts relates to in-service inspection. The West German Reactor Safety Commission, for example, requires that there be sufficient space between the reactor pressure vessel and the radiation shielding to permit inspection of the vessel.[113] Naval reactors may not be designed to facilitate such inspection, partly due to space restricions,[114] and partly because requirements such as this did not exist when at least the earlier naval reactors were designed.[115]

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112. ibid. See also D. Fishlock, 'Navy lifts veil on PWR research', Nature, 2 March 1978, vol. 272, p. 5. Referring to the non-destructive testing program for the type of reactor pressure vessel used in British submarines, the article states:

> This vessel has to be much closer to the dimensions of that of a large power-station PWR than its power output suggests to meet the Navy's specifications for military robustness. Thus it is about two-fifths of the height, one-eighth of the weight and half the thickness of the vessel specified for a 1,300 MWe PWR - for one-fortieth of the rating. Studies have included 100% ultrasonic inspection of critical parts of the pressure vessel of the longest serving Navy reactor ... .

In US, H of R, Committee on Merchant Marine and Fisheries, Disposal of Decommissioned Nuclear Submarines - Hearing, 19 October 1982, p. 17 (C. H. Schmitt, Naval Nuclear Propulsion Program) US submarine reactor pressure vessels are said to employ 'several inches' thickness of 'heavy steel'.

113. J. Scharge and others, 'In-Service Inspection Program for the NCS-80 Reactor Pressure Vessel' in Organisation for Economic Cooperation and Development, Nuclear Energy Agency, Symposium on the Safety of Nuclear Ships: Proceedings, Hamburg, 5-9 December 1977, (OECD, Paris, 1978), p. 286.

114. For a journalist's description of the space constraints inside the reactor compartment of Los Angeles class submarines, see P. Tyler, Running Critical: The Silent War, Rickover, and General Dynamics, (Harper & Row, New York, 1986), pp. 137-38.

115. cf. R. D. Klake and R. Worschech, 'NS Otto Hahn - Non-Destructive Retesting' in Organisation for Economic Cooperation and Development, Nuclear Energy Agency, Symposium on the Safety of Nuclear Ships: Proceedings, Hamburg, 5-9 December 1977, (OECD, Paris, 1978), p. 247: the design of the NS Otto Hahn is such that , 'for structural reasons, inservice inspections of a standard comparable to that applied to present-day plants is possible only to a limited extent'.

4.84 The Committee has no information specifically on this point. More generally, the indications are that the early reactor and reactor compartment designs did make in-service inspection difficult in some respects.[116] But equally, the indications are that the penalty of longer out-of-service time was accepted, and safety not compromised.[117]

Emergency Core Cooling System

4.85 Different commercial nuclear power stations incorporate various engineered safety features such as sprays, coolers, water pools, and ice beds either singly or in various combinations to alleviate the build-up of pressure sufficient to destroy containment integrity following an accident.[118] It is difficult to generalise about the commercial use of many of these because they are features of specific designs, rather than in general use. For example, the latest West German pressurised water reactors have filtered vents from the containment which aim to filter out harmful radioactivity while allowing venting to relieve containment pressure.[119] The Committee has no information on the extent to which any of these features are relevant to, or incorporated in, the designs of naval reactors.

4.86 One safety system, however, the emergency core cooling system (ECCS) is now regarded as necessary in large land-based reactors.

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116. e.g. see Vice Admiral Sir Ted Horlick RN, 'Submarine Propulsion in the Royal Navy', Proceedings of the Institution of Mechanical Engineers, 1982, vol. 196, pp. 70 and 76.

117. ibid., p. 76; M. Smith, 'Turning up the power on nuclear subs', The Engineer, 1 October 1987, p. 23.

118. APS Study Group, 'Report to the American Physical Society of the study group on radionuclide release from severe accidents at nuclear power plants', Reviews of Modern Physics, July 1985, vol. 57(3)(part II), p. S89. The various features are described ibid., pp. S81-S84.

119. J. Varley, 'Germans take a new look at core melt consequences', Nuclear Enginering International, March 1987, p. 37. For a sugestion that US regulatory authorities do not regard containment venting as cost effective, see J. Varley, 'Putting the Finishing Touches to NUREG 1150', Nuclear Engineering International, March 1988, p. 38.

> The earliest light water reactors (as well as current ones) were necessarily equipped with systems to provide coolant makeup for normal operational losses of coolant (steam leaks, losses during refueling operations, etc.). Capability for long-term cooling of the fuel for removal of decay heat was also provided. Before 1966, however, high-pressure high-capacity systems to provide emergency coolant were not installed. Therefore, although the capability to cope with relatively small leaks or breaks existed, the unlikely break of a large primary-system component could have led to some fuel melting.[120]

4.87 It was the increasing size of reactors that was primarily responsible for raising official concern about the need to consider ECCS's, though no doubt a heightened concern about nuclear safety generally was also a factor.[121] Whether the concern would have arisen had land-based reactors remained closer in size to naval reactors is unclear. The Committee notes, however, that some form of ECCS was regarded by the 1980's as necessary for nuclear powered merchant ships.[122]

4.88 On a typical land-based reactor the ECCS includes a number of independent subsystems. These include both a high-pressure and a low-pressure water injection system.[123] According to one standard text, pumps for both would be activated about two seconds after a major loss of coolant (e.g. from a guillotine fracture of a primary coolant pipe) and water injection would commence after about 14 seconds from the high-pressure system and

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120. W. B. Cottrell. 'The ECCS Rule-Making Hearing', Nuclear Safety, January 1974, vol. 15(1), p. 31. This article is based entirely on US experience.

121. ibid.

122. e.g. see International Maritime Organisation, Code of Safety for Nuclear Merchant Ships, (IMO, A XII/Res.491, 18 June 1982), para. 4.11.2. The Japanese nuclear powered merchant ship, NS Mutsu, has a type of ECCS: M. Kawasaki and S. Yaguchi, 'Safety Studies on LOCA for N. S. Mutsu' in OECD, Symposium on the Safety of Nuclear Ships: Proceedings, Hamburg, 5-9 December 1977, (OECD, Paris, 1978), p. 199.

123. J. G. Collier, 'Light Water Reactors' in W. Marshall (ed.), Nuclear Power Technology, (Clarendon, Oxford, 1983), vol. 1, p. 266.

after about 30 seconds from the low-pressure system.[124] A further subsystem of a typical ECCS is an accumulator injection system. This consists of cooled water stored in tanks under pressure that will automatically (ie. without pumps, motor-driven valves, etc.) flow to the reactor vessel if a rapid depressurisation were to occur in the primary coolant circuit.[125]

4.89 It was put to the Committee that naval reactors lack ECCS's.[126] Of the schematic diagrams which the Committee has seen of naval submarine reactors, only one suggests the possible presence of an ECCS.[127] ANSTO informed the Committee:

> Naval reactors may or may not have emergency core cooling systems. These items are not necessarily bulky, for example the ECCS for HIFAR occupies very little space. Further, it does not follow that the lack of an ECCS for a shipboard reactor leads inevitably to a higher probability of fuel meltdown compared with a land-based system. For example, the initiating event, such as a primary coolant pipe failure, may be substantially less likely in a small, compact reactor designed to withstand battle damage.[128]

4.90 The United States Navy has pointed out that naval reactors sit 'in a source of unlimited seawater, which, if necessary, can be used to keep the reactor from overheating and

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124. ibid., p. 276. cf. F. J. Rahn and others, A Guide to Nuclear Power Technology, (Wiley, New York, 1984), p. 505: the first sign of an accident that a plant operator receives is usually the emergency reactor shutdown or the start of the ECCS.
125. J. G. Collier, 'Light Water Reactors' in W. Marshall (ed.), Nuclear Power Technology, (Clarendon, Oxford, 1983), vol. 1, p. 241.
126. e.g see submissions from Mr R. Addison, p. 4; Friends of the Earth, p. 1; Cdr M. K. Gahan, 'Nuclear Propulsion Systems - Technical Aspects', (Paper prepared for the Committee by the Department of Defence, February 1987), p. 8 (Evidence, p. 1300.39).
127. See N. Friedman, Submarine Design and Development, (Conway, London, 1984), p. 135.
128. Evidence, p. 438 (ANSTO). HIFAR is the reactor at Lucas Heights, NSW operated by ANSTO. This reactor uses heavy water as both moderator and coolant. It differs in a number of ways from a naval pressurised water reactor.

being damaged'.[129] One inference which might be drawn from this is that naval reactors lack an ECCS of the type now used on land-based reactors. The fact that most United States Navy reactors were designed prior to the raising of the issue of ECCS's for land-based reactors adds weight to this inference,[130] although retrofitting of ECCS's is a possibility. The inference is further supported by advice from the Australian Department of Defence that the lack of any ECCS is compensated for by design features incorporating the heat sink of the sea.[131]

4.91 In the absence of definite information the Committee

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129. 'U. S. Navy Statement on the Safety of Operations of U. S. Nuclear Powered Warships', January 1987 (Evidence, p. 238.243). A journalist's description of US submarine reactors based on interviews with shipyard workers and navy officials states: 'if anything ever happened inside the reactor that caused it to lose its coolant, automatic valves would open and the ocean flood in to stop the meltdown': P. Tyler, Running Critical: The Silent War, Rickover, and General Dynamics, (Harper & Row, New York, 1986), p. 137. See also ibid., p. 41: nuclear powered vessels were 'equipped with emergency core cooling systems whose sensors monitored the temperature of the reactor. At the first sign of trouble, the emergency system flooded the reactor with additional water'. It is said (ibid., p. 41) that the reactor pressure vessel on US submarines is sealed inside a tank of water to which boron (a neutron absorbing material) has been added. The tank is designed to act as a shield against radiation during normal reactor operation. The contents of this tank may be available for emergency core cooling purposes. Although the Committee lacks any evidence that this is the case, it is clear that the volume of water in the tank could not be sufficient to flood the reactor containment so as to immerse the core. It should be noted that in US, H of R, Committee on Armed Services, Subcommittee on Procurement and Military Nuclear Systems, Naval Nuclear Propulsion Program - 1988 - Hearing on H. R. 1748, 26 February 1987, p. 9, Admiral K. R. McKee said of Tyler's book: 'The author did a credible job of reporting on defense procurement, pretty accurate, but his understanding of submarines is abysmal. He doesn't know what he is talking about'.

130. cf. the response of Z. Levine (US Maritime Administration) to criticism by D. Crancher (Australian Atomic Energy Commission) of the safety assessment of the nuclear powered merchant ship, NS Savannah: 'It must be remembered that Savannah was designed 20 years ago, before the advent of emergency core cooling systems (ECCS) which would reduce if not totally eliminate the probability of a core meltdown': Organisation for Economic Cooperation and Development, Nuclear Energy Agency, Symposium on the Safety of Nuclear Ships: Proceedings, Hamburg, 5-9 December 1977, (OECD, Paris, 1978), p. 502.

131. Cdr M. K. Gahan, 'Naval Nuclear Propulsion Systems - Technical Aspects', (Paper prepared for the Committee by the Department of Defence, February 1987), p. 8 (Evidence, p. 1300.39).

assumes that naval reactors lack the sophisticated ECCS's now used on land-based reactors. This leads to the question whether the lack of an ECCS might increase the risk of core radioactivity escaping to the environment should an emergency occur, or whether flooding is an acceptable (and existing) substitute.

4.92 The issues of most concern to the Committee were whether any naval substitute for an ECCS would operate quickly enough to be fully effective and whether it would function automatically. These points gain added significance because, as noted above in discussing the effect of the use of highly enriched fuel, fuel melting may well occur more rapidly in a naval reactor than in a commercial one.

4.93 The Committee sought further information on the use of sea water to provide emergency cooling. The Department of Defence told the Committee:

> We understand that seawater coolers utilising natural circulation are a part of the reserve cooling capacity of NPWs. However, we do not have enough detail concerning the design of such coolers to represent them accurately in diagrams of the kind shown ... [in para. 4.1].[132]

4.94 The Department did provide information which gave some indication that sea-water coolers may provide an acceptable

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132. Evidence, p. 1300.54 (Department of Defence).

alternative to ECCS's in some circumstances.[133] However, the information was not sufficient to enable the Committee to come to any firm conclusion on whether naval reactors have effective equivalents to land-based reactor ECCS's.

Diversity and Redundancy

4.95 An important safety-related aspect of the design of land-based reactors is the provision of redundant features (e.g. a critical pump is duplicated) and diversity (e.g. not all pumps run off the same power source). It has been questioned whether the design of naval reactors is likely to be as sophisticated, due to limitations of space on vessels.[134]

4.96 In contrast the Department of Defence stated that 'there are high levels of redundancy in the systems, particularly with

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133. See Evidence, p. 1300.54 (Department of Defence) for some detail on the physical principles on which natural coolers operate, their relationship to the primary coolant circuit, and the unlikelihood that the presence of a natural cooler creates a significant path for the escape of fission products to the environment. It should be noted that circulation of coolant in the primary circuit by means of natural convection, rather than pumps, was relied on for cooling during normal low-power reactor operations on the submarine, USS Narwhal: N. Friedman, Submarine Design and Development, (Conway, London, 1984), pp. 135 and 137. The heat generated at low power is broadly equivalent to the decay heat that would have to be removed following a reactor accident. Thus the USS Narwhal design suggests that heat removal by natural convection following an accident is technically possible. For a schematic diagram and description of the emergency sea water cooling system on the nuclear powered merchant ship, NS Savannah, see T. Matsuoka, 'Reliability Analysis of Emergency Decay Heat Removal System of Nuclear Ship under Various Accident Conditions', Journal of Nuclear Science and Technology, 1984, vol. 21(4), pp. 267-68.
134. e.g. see submission from Mr R. Bolt, p. 7 (Evidence, 957).

the cooling, because of the battle damage aspects'.[135] Dr Symonds told the Committee:

> The compact nature of very sophisticated equipment used in the aerospace and aircraft industries demonstrates what can be done in limited space ... A personal inspection of the reactor control systems of the US submarine 'Halibut' back in the early 1960s indicated that the equipment was what would be expected in any land-based reactor of about 100 MWth. Furthermore, there was a high level of redundancy in the safety systems and in the instrumentation. Since that time, the advent of new solid-state technology would certainly allow improvement on that equipment ... and on its compactness.[136]

4.97 ANSTO, while admitting that a comparison of back-up and duplicate systems in naval and civilian reactors would require detailed design information which it did not have, suggested that 'surface ships have the room for these systems, submarines may not'.[137]

4.98 United States nuclear powered submarines are reported as having backup batteries, diesel generators and diesel-electric

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135. Evidence, p. 194 (Department of Defence). See also US Congress, Joint Economic Committee, Economics of Defense Policy: Adm. H. G. Rickover - Hearing, 28 January 1982, p. 74 ('A Description of the Naval Nuclear Propulsion Program, January 31, 1982'): one of the key points in the program's philosophy is to 'ensure adequate redundancy in design so that the plant can accommodate, without damage to ship or crew, equipment or system failures that inevitably will occur'. See also the letter from Cdr T. Blades USN (Ret.) in US Naval Institute, Proceedings, December 1978, p. 97: each of the two reactors of the USS Long Beach has four pumps in its primary coolant circuit. This is the same number as is typically found in US commercial land-based PWRs: see the individual reactor statistics in Nuclear Engineering International, World Nuclear Industry Handbook 1988, pp. 72-107.
136. Letter from Dr J. L. Symonds, 12 February 1987, p. 6. See also US, H of R, Committee on Science and Technology, Subcommittee on Energy Research and Production, Nuclear Powerplant Safety Systems - Hearings, 24 May 1979, p. 1058 (Admiral H. G. Rickover): 'we generally have duplicate gages on most things so if one goes wrong, we have another. We have a lot of duplication that way'.
137. Evidence, p. 439 (ANSTO). See also Evidence, p. 1300.55 (Department of Defence).

propulsion systems.[138] The Trafalgar-class nuclear powered submarines of the Royal Navy are reported to have both primary and secondary electric emergency propulsion motors, which are supported by two diesel generators.[139]

4.99 The Committee cannot give any conclusive answer to the question of lack of sophistication and redundancy, because of the lack of technical information available to it on naval reactors.

Rapid and Frequent Changes in Power Requirements

4.100 Reactors used to power ships at sea are subject to a range of operational and performance requirements that do not apply to land-based reactors.[140] Land-based reactors are intended for full-time operation at full power. Many submissions received by the Committee pointed out that warship reactors have to support rapid manoeuvring and that the consequent changes in speed require rapid load changes to be produced by the reactor. All components of the reactor system therefore experience frequent power cycles. It is claimed that these produce a much larger number of stress cycles from temperature and pressure changes than would be experienced by land-based reactors.[141]

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138. N. Polmar and T. B. Allen, Rickover, (Simon and Schuster, New York, 1982), pp. 424, 425; US, H of R, Committee on Appropriations, Subcommittee on Energy and Water Development, Energy and Water Development Appropriations for 1989 - Hearings, 23 March 1988, p. 1325 (Admiral K. R. McKee). In Australian ports, visiting nuclear powered submarines normally draw shore power, which provides a further level of redundancy.

139. R. Pengelley, 'Stealth in practice: the Royal Navy's Trafalgar-class submarines', International Defense Review, 1989, vol. 22(1), p. 30.

140. e.g. the N. S. Otto Hahn, on a typical entry up the Elbe river to her home port of Hamburg over 8 hours, experienced 60 power changes across a range between 15% to 80% of nominal power: D. Ulken and others, 'Further Development and Economic Aspects of the Integrated Pressurised Water Reactor in the Light of Experience Gained with the "Otto Hahn"' in Peaceful Uses of Atomic Energy: Proceedings of the Fourth International Conference on the Peaceful Uses of Atomic Energy, Geneva, 6-16 September 1971, (United Nations, New York, 1972), vol. 7, p. 293.

141. See for example submissions from Mr R. Addison, p. 4; Medical Association for Prevention of War Australia (Vic), p. 2; Australian Quaker Peace Committee, p. 2.

4.101 While there seems to be no doubt that ship reactors are subject to more frequent and perhaps more rapid changes in power demand than are land-based reactors, there does not appear to be any evidence that this increases the accident risk. Because the need to accommodate rapid power changes is known, it is taken into account at the design stage.[142] ANSTO, in discussing the reactivity changes necessary for rapid alteration of power level, argued:

> the associated changes in primary coolant circuit temperatures and pressures are quite small, and it is considered unlikely that they would substantially modify component reliability and integrity in comparison with similar land-based plant.[143]

4.102 In contrast, Britain's Chief Naval Engineer Officer in 1982 said that the comparison with land-based reactors was not valid, but that special measures were needed to ensure safety:

> Thermal cycling from frequent power changes is of course part and parcel of the day to day operation of a submarine reactor plant and poses problems of a different order from those in a land power reactor. The extension of core

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142. e.g. see US, H of R, Committee on Armed Services, Subcommittee on Seapower and Strategic and Critical Materials, Defense Department Authorization and Oversight - Hearings on H. R. 1872, 6 March 1985, p. 184 (Admiral K. R. McKee); US, H of R, Committee on Science and Technology, Subcommittee on Energy Research and Production, Nuclear Powerplant Safety Systems - Hearings, 24 May 1979, p. 1044 (Admiral H. G. Rickover); Cdr M. K. Gahan, 'Naval Nuclear Propulsion Systems - Technical Aspects', (Paper prepared for the Committee by the Department of Defence, February 1987), p. 7 (design of attack submarines) (Evidence, p. 1300.38); N. Friedman, Submarine Design and Development, (Conway, London, 1984), p. 134 (effect of design provision is that 'large changes in power plant load correspond to relatively small changes in temperature, so rapid manoeuvring does not entail large thermal stresses'). The design of the nuclear powered merchant ship, NS Savannah, included a 'steam dump' system which was 'designed to permit rapid manoeuvring and changes in demand on the propulsion system without appreciable change in reactor power level': C. K. Beck and E. G. Case, 'Safety of Nuclear Ships' in International Atomic Energy Agency, Nuclear Ship Propulsion: Proceedings of a Seminar held at Taormina, 14-18 November 1960, (IAEA, Vienna, 1961), p. 130.

143. Evidence, p. 443.449 (ANSTO).

life brought to prominence consideration of thermal fatigue in certain pipework and fittings. Considerable programmes of work to identify the mechanism of the process in stainless steel resulted in a much improved appreciation of methods of detail design to avoid susceptibility to thermal fatigue. It is probably not generally realized that it is possible to suffer incipient cracking from thermal variations of as little as 10^{0}C under certain loading conditions.[144]

4.103 The Committee notes that, apart from pipework problems, rapid power increases can also lead to cladding failure. For this reason one standard text on commercial reactors stated in 1983:

> Current operational practice is to limit the rate of any imposed power increases; for example, PWRs are limited to increases of 5 per cent per hour up to 93 per cent power, then progressively 3 percent per hour, and finally 1 percent per hour up to full power.[145]

4.104 Improved fuel-manufacturing techniques have done much to ameliorate this problem for commercial reactors,[146] but the Committee has no information on this point relevant to naval reactors.

4.105 A member of the United States Nuclear Regulatory Commission has suggested that in one respect the varying power drawn from naval reactors creates less problems:

> we ought to remember that the reactors we are working with are something like 30 to 50 times larger than the ones in the Navy. The Navy reactors tend to run most of the time at relatively low power, whereas with the commercial reactors you are trying to push everything you can out of them. So, in many

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144. Vice Admiral Sir Ted Horlick RN, 'Submarine Propulsion in the Royal Navy', Proceedings of the Institution of Mechanical Engineers, 1982, vol. 196, p. 73.
145. J. G. Collier, 'Light Water Reactors' in W. Marshall (ed.), Nuclear Power Technology, (Clarendon, Oxford, 1983), vol. 1, p. 279.
146. ibid.

ways it is a more difficult problem.[147]

4.106 One aspect of this related to decay heat, which, as already explained, must be removed to avoid fuel melting even after a reactor is shut down. In a land-based reactor, the decay heat at the time of shutdown may be about 10% of total heat at full power, falling to about 6 or 7% after one second, and about 0.6% after a day.[148] One factor in determining the amount of decay heat present at shutdown is the reactor operating history in the period prior to shutdown.

4.107 Unlike commercial land-based reactor output, marine reactor output is typically varied due to changes in ship propulsion requirements. The reactor of a warship in port would normally have been run at fairly low power while entering the port, and even lower power once berthed or anchored. This will reduce the amount of decay heat present in the reactor, which in turn will reduce the scope of a loss of coolant accident and

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147. US, H of R, Committee on Interior and Insular Affairs, Subcommittee on Energy and the Environment, Nuclear Regulatory Commission Budget Request for FY 1984 and 1985 - Oversight Hearings, 22 February 1983, p. 43 (V. Gilinsky). cf. US Congress, Joint Committee on Atomic Energy, Sub-committee on Legislation, Naval Nuclear Propulsion Program - 1976 - Hearing, 18 March 1976, p. 23 (Admiral H. G. Rickover): 'The average power level in port in a [Naval] nuclear propulsion plant is about 100 times less than that of a [land-based] commercial nuclear powerplant'.

148. UK, Department of Energy, Sizewell B Public Inquiry: Report by Sir Frank Layfield, (HMSO, London, 1987), para. 5.34. One standard text states that for a reactor operating at 2800 Mw(t), the decay heat is 100 Mw(t) one minute after shutdown, 37 Mw(t) one hour after shutdown, 10 Mw(t) one day after shutdown, 7 Mw(t) one week after shutdown, and 3 Mw(t) one month after shutdown: J. G. Collier, 'Light Water Reactors' in W. Marshall (ed.), Nuclear Power Technology, (Clarendon, Oxford, 1983), vol. 1, p. 264.

allow increased time to respond before fuel melting occurs.[149]

Degree of Operator Control

4.108 There are two reasons why United States nuclear powered warships rely less on automated controls than land-based plants. The first derives from the need to balance reactor safety against vessel safety. The second results from a deliberate preference for less automation by the warships' designers.

4.109 If a vessel's reactor shuts down, the vessel may be left in a potentially hazardous navigational situation, particularly in heavy seas where any auxiliary power for the propulsion plant may be inadequate for the vessel's needs. The sudden unexpected loss of reactor power in a submerged submarine may have dangerous implications for the submarine's safety. This scenario provides the basis for one theory to account for the loss of the USS Thresher in 1963.[150] The balance between ship safety and reactor safety can be a matter requiring careful judgement and not readily susceptible to automatic control. It is said that, since the loss of the USS Thresher, a 'battle-short' mechanism has been provided in submarines to override the automatic reactor shutdown

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149. e.g. see D. Okrent, Nuclear Reactor Safety: On the History of the Regulatory Process, (U. of Wisconsin, Madison, 1981), p. 84: if the nuclear powered merchant ship, NS Savannah, operated at limited power for 24 hours and then suffered a complete loss of coolant accident, a period of 2 hours would elapse before fuel melting would occur. In port entry conditions the ratio of power used to total power would be lower for a nuclear powered warship than for the NS Savannah. A typical port entry speed of, say, 10 knots represents about half of NS Savannah's speed at full power, but a third or less of a nuclear powered surface warship's speed at full power. As the power required for higher speeds rises much more quickly than the increase in speed, considerably less than one third of maximum power is needed to propel a ship at one third of its maximum speed. As indicated in footnote 142 above, however, alterations in reactor power level may not relate directly to alterations in vessel speed.

150. J. E. Moore and R. Compton-Hall, Submarine Warfare: Today and Tomorrow, (Michael Joseph, London, 1986), pp. 38-39 (small loss of water-tight integrity of the hull combined with sudden loss of reactor power). See also N. Polmar and T. B. Allen, Rickover, (Simon and Schuster, New York, 1982), pp. 433-34 for this and other theories involving a loss of reactor power on the USS Thresher.

if an operational emergency demands that reactor power be maintained.[151]

4.110 The Committee has no information on whether nuclear powered surface warships are similarly equipped. But because they all have more than one reactor the need to override would be much reduced, and possibly entirely absent. Nor does the Committee have firm information on whether what is in effect the manual override of a reactor safety system is disabled as part of port entry procedures.[152]

4.111 The requirement to override would seem unnecessary for vessel safety in these circumstances:

> Following an automatic reactor shutdown, enough steam power would be available to allow the vessel to avoid hazards, come to a halt and, if necessary, to anchor. It should also be noted that NPW submarines run their diesel engines when navigating in confined spaces

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151. ibid., p. 39. See also the Guardian (London), 3 March 1988, p. 1 'Catalogue of faults in UK nuclear subs'. The British navy's rationale for what it calls a 'Battle Short Switch' is described in some detail by Captain J. Jacobsen RN and others, 'The Safe Operation of Nuclear Submarines', Journal of Naval Science, 1979, vol. 5(2), p. 85.

152. Information based on hearsay and passed to the Committee is that, on British submarines at least, the 'battle-short' mechanism is for use only when the submarine is submerged. Captain J. Jacobsen RN and others, 'The Safe Operation of Nuclear Submarines', Journal of Naval Science, 1979, vol. 5(2), p. 85 state that 'the use of the Battle Short Switch is inhibited in harbour'. This leaves unclear the question of its availability in port approaches. J. Edwards and Cdr K. F. Tucker RN, 'Royal Navy Requirements and Achievements in Nuclear Training', Journal of Naval Science, 1978, vol. 4(3), p. 168 in discussing the scram override state: 'Reactor safety must always be important, however, for the protection of the crew and the environment and, in harbour and close to land, environmental considerations and public safety must make such reactor safety paramount' (emphasis added). The Department of Defence was not able to provide the Committee with any more specific information on the point: Evidence, p. 1300.55 (Department of Defence).

such as a harbour.[153]

4.112 The significance of overriding an automatic shutdown will vary according to the reason for the shutdown. The Committee has no information on the frequency of, or reasons for, automatic shutdowns of United States Navy reactors.[154] For British submarines it was said in 1979:

> An operating submarine can expect (statistically) a scram every 22 weeks and the mean time to recovery of propulsion power is measured in minutes.[155]

4.113 Even where automatic shutdowns are not spurious, it does not follow that a safety hazard, as opposed to some other kind of

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153. Evidence, p. 1300.56 (Department of Defence). cf. H. Fock and E. Schwieger, 'Experiences with Otto Hahn under Specific Operation Conditions' in Organisation for Economic Cooperation and Development, Nuclear Energy Agency, Symposium on the Safety of Nuclear Ships: Proceedings, Hamburg, 5-9 December 1977, (OECD, Paris, 1978), p. 711:

> Tests made during the commissioning phase showed that the [nuclear powered merchant] ship [Otto Hahn] after a scram can operate with fully opened turbine throttle for about three minutes. As under manoeuvring conditions the maximum load is only 60% of full power, the steam capacity is adequate to bring the ship in [sic] a safe condition.

154. cf. N. Polmar and T. B. Allen, Rickover, (Simon and Schuster, New York, 1982), p. 424: 'most submarines have experienced reactor scrams, some of which have put the submarines in precarious situations'. The statement refers to US submarines, but only one example is spelt out: the Polaris submarine, USS Von Steuben, experienced a scram while its diesel auxillary was out of service for maintenance, leaving the vessel on the surface without power.

155. Captain J. Jacobsen RN and others, 'The Safe Operation of Nuclear Submarines', Journal of Naval Science, 1979, vol. 5(2), p. 84. Of the scrams experienced during a five-year period, 29 of 106 are ascribed to operator error, with a further 39 being 'operator induced scrams to meet Operating Procedural requirements'. Spurious scrams (ie. those due to malfunction of the reactor protection system) 'are rare and to date occur once every 3 and a half reactor-operating years': ibid. With respect to recovery time, see also H. P. Alesso, 'Some Aspects of Nuclear Physics and Safety Design for Operational Needs of Nuclear Powered Ships', Naval Engineers Journal, December 1987, vol. 89(6), p. 81: 'it takes less than one second for a reactor to "scram", but it requires greater than one-half hour to return to power'. Contrast N. Polmar and T. B. Allen, Rickover, (Simon and Schuster, New York, 1982), p. 434: for US submarines, the interval of time to allow restoration of power after a scram has been reduced to six seconds.

reactor damage, will occur if the shutdown is overridden. Nor does it follow that, assuming operator decision is required to override, that decision will be made in a way that prejudices reactor safety so as to put the public at risk.[156]

4.114 The Committee recognises that the ability to override an automatic reactor shutdown distinguishes naval from other reactors. From the limited information available to it, however, the Committee does not regard the difference as of major significance to the likelihood of an accident.

4.115 The United States Naval Nuclear Propulsion Program has adopted as one of its avowedly conservative design criteria:

> Simple system design, so that minimum reliance must be placed on automatic control. Reliance is primarily placed on direct operator control.[157]

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156. e.g. for a vessel several kilometres off shore approaching a port it may decrease the hazard to the port population if the automatic shutdown is overridden and the vessel steered away from the coast, in the event of an incident that would normally trigger automatic reactor shutdown. cf. A. P. Honeywell and E. A. Saltarelli, 'Safety Audit of N. S. Savannah's Commercial Operations' in International Atomic Energy Agency and others, Proceedings of the Symposium on Nuclear Ships, Hamburg, 10-15 May 1971, (GKSS, Hamburg, 1971), p. 197: among the incidents reported was a

> departure from Technical Specifications by Captain's orders to provide for greater safety of ship operations when encountering rough weather following a reactor scram at sea less than 6 miles off shore. The departure from Specifications involved reducing the effectiveness of a power range channel scram until such time that the ship was in less dangerous waters.

157. US, H of R, Committee on Science and Technology, Subcommittee on Energy Research and Production, Nuclear Powerplant Safety Systems - Hearings, 24 May 1979, p. 891 (Admiral H. G. Rickover). In US Congress, Joint Committee on Atomic Energy, Subcommittee on Legislation, Naval Nuclear Propulsion Program - 1976 - Hearing, 18 March 1976, p. 28, Admiral Rickover gave as an example:

> Suppose a young draftsman decides to require four valves in a safety system where two could do the job. His logic is that if two are good, then four are better. But as a result, the operator has trouble keeping track of what valve is in what position and this could lead to a mistake or incident by inadvertently opening the wrong valve.

The reason for this is the belief that 'undue reliance on automation and computers for control can impair safety'.[158] At the same time great effort is put into designing reactors and their operating procedures so that the plant can be safely operated.[159] Operator selection, training and inspection, and

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158. 'Comments by Admiral H. G. Rickover, USN, Director, Naval Nuclear Propulsion Program in Meeting with Members of the President's Commission Commission on the Accident at Three Mile Island', 23 July 1979, p. 30, incorporated in US, H of R, Committee on Appropriations, Subcommittee on Energy and Water Development, Energy and Water Development Appropriations for 1981 - Hearings, 13 March 1980, p. 2108. Four reasons are given for this. First, for a computer to assist it must be programmed properly. This in turn requires that the accident sequence be foreseen, yet most major problems result from unexpected events. If the sequence can be foreseen, it is considered better to take steps at the plant design stage to obviate the particular risk. The program's emphasis has been not on more complicated or sophisticated control, but on designing and building a simple, stable plant that makes fewer demands on the control system and operators. Such a plant allows operators to develop a feel for plant performance and to recognise abnormal conditions in time to take corrective action. Second, in accidents the operator must have essential information in an understandable form: a computer can operate as an undesirable filter. Third, computers constitute an additional source of malfunctions which can mislead operators. Fourth, the use of automation and computers leads reactor operators to rely on the 'magic' they provide, and diverts attention from other areas.

159. See for example, ibid., p. 10 on the concept of 'sailor proofing' of Navy reactors, which means:

> the designer must assure that the plant, its equipment and its procedures are such that the sailors who will operate the plant can be expected, realistically, to understand, operate and maintain it properly. The concept also requires that the plant be designed to accommodate, insofar as practicable, operator errors that may occur - that it be 'forgiving' ... .

See also US, H of R, Committee on Armed Services, Subcommittee on Seapower and Strategic and Critical Materials, Hearings on National Defense Authorization Act for FY 1988/1989 - H. R. 1748, 10 March 1987, p. 321 (Admiral K. R. McKee): the design of Navy reactors so that they can be operated safely by a high school graduate.

operating instructions are also given close attention.[160] This contrasts with the situation that used to prevail with commercial reactors in the United States.[161]

4.116 On the other hand, greater reliance on operators can be seen as increasing the risk of operator error. It was claimed in many submissions that the possibility of human error was a major factor in increasing the likelihood of a reactor accident.[162] The Committee's attention was drawn to 1985 press reports stating that the crews of three United States vessels had failed their

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160. See for example US, H of R, Committee on Science and Technology, Subcommittee on Energy Research and Production, Nuclear Powerplant Safety Systems - Hearings, 24 May 1979, pp. 892 ff. (Admiral H. G. Rickover); US, H of R, Committee on Appropriations, Subcommittee on Energy and Water Development, Energy and Water Development Appropriations for 1984 - Hearings, 17 March 1983, pp. 919-21 (Nuclear Regulatory Commission): operator selection, training and discipline inferior for commercial reactors compared to naval reactors. In J. Bell, 'Nuclear safety need [sic] a rethink', New Scientist, 11 April 1985, p. 28 the views are reported of a researcher on classifying human errors with the aim of reducing them. Within this framework, the Three Mile Island accident is treated as involving knowledge-based error: the operators did not understand in time what was going on. The simpler, less automated design of naval reactors, coupled with the lengthy naval training on a prototype of the reactor actually to be operated suggest that naval reactor operators are less likely to make errors based on failure to understand what is happening that the operators described by this author.

161. US, Report of the President's Commission on the Accident at Three Mile Island, The Need for Change: The Legacy of TMI, (Washington, 1979), p. 49: TMI operators trained to required standards but these 'standards allowed a shallow level of operator training'. See ibid., pp. 70-71 for the report's recommendations for improvement.

162. e.g. see submissions from Assoc Prof P. Jennings, p. 1; Scientists Against Nuclear Arms (ACT), p. 1 (Evidence, p. 779); Scientists Against Nuclear Arms (WA) and Medical Association for the Prevention of War (WA), p. 8 (Evidence, p. 794); Nurses Against Nuclear War, p. 1; Coalition Against Nuclear Armed & Powered Ships, pp. 4-5 (Evidence, pp. 1376-77); Mr J. Ingersoll, p. 2. See also Evidence, p. 443.449 (ANSTO):

> We are not aware of evidence to support the suggestion that naval reactors place greater reliance on manual systems than do civilian reactors. If they do, then increased oportunities for operator errors to occur would certainly be a likely consequence.

reactor safety tests.[163]

4.117 What was not drawn to the Committee's attention was that the failures were believed to be the first since the United States Navy began to use nuclear powered ships; that a second try is permitted before drastic action is taken and the crews all passed on their second try; and that the tests are said to be amongst the most stringent in the Navy, with even a minor mistake leading to failure.[164] Viewed in the light of this additional information, the tests appeared to the Committee as further evidence of the degree to which safety is a major priority in United States nuclear powered ships.[165]

4.118 The Committee was also referred to a 1979 press report containing allegations that the United States Navy's training program for reactor operators is deficient in a number of respects.[166] A separate set of allegations relating to health and safety violations in a Navy reactor training unit was investigated in 1980 and found not to show any basic weaknesses in the

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163. Submissions from Assoc Prof P. Jennings, p. 1, citing West Australian, 30 April 1985, p. 31, 'US Navy Ships Fail the N-Test'; Coalition Against Nuclear Armed & Powered Ships, p. 4 (Evidence, p. 1376), citing New York Times, 28 April 1985, p. 26, 'Crews of 3 Navy Ships Fail in Nuclear Safety Tests'. See also Evidence, p. 847 (Scientists Against Nuclear Arms); submission from Mr R. Addison, p. 7.

164. New York Times, 28 April 1985, p. 26, 'Crews of 3 Navy Ships Fail in Nuclear Safety Tests'.

165. Contrast US, Report of the President's Commission on the Accident at Three Mile Island, The Need for Change: The Legacy of TMI, (Washington, 1979), p. 49: civilian reactor operators could be licensed even though they had failed those parts of their examinations that dealt with emergency procedures and equipment.

166. Submission from Prof W. J. Davis, p. 14 (Evidence, p. 461), citing Enlisted Times, December 1979: 'Instructor quits, says teachers don't know their stuff'. See also Evidence, p. 611 (Prof W. J. Davis).

unit's operations.[167] Given this, and the general high regard in which the United States Navy's training program is held in comparison to the training of civilian reactor operators,[168] the Committee does not attach significance to an isolated press item reporting criticism of naval nuclear training.

4.119 It was also pointed out to the Committee that more than one of the operators on duty at the time of the 1979 accident at the Three Mile Island reactor were former United States Navy reactor operators.[169] This point has been addressed by the director of the United States Naval Nuclear Propulsion Program. While rebutting the criticism of the training provided, he also argued that operator training was only one element of the program and that other essential elements were staffing levels, supervision, auditing and qualification, and re-qualification for the

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167. US, Senate, Committee on Armed Services, Subcommittee on Strategic Forces and Nuclear Deterrence, Safety Oversight for Department of Energy Nuclear Facilities - Hearings, 27 October 1987, pp. 209-10, summarising US, General Accounting Office, GAO's Analysis of Alleged Health and Safety Violations at the Navy's Power Training Unit at Windsor, Connecticut, (EMD 81-19, November 1980):

> In 5 of the 17 allegations, procedures or safety standards were violated, including one case with the potential for a serious personnel injury. None of the five violations involved radiation exposure to personnel, and all were investigated by Windsor facility officials at the time they occurred. In GAO's opinion, none of the events forming the bases for the 17 allegations, including the 5 cases in which violations occurred, were indicative of basic health- and safety-related weaknesses in the facility's operations.

The GAO made no recommendations to the Department of Energy relating to the facility arising from its analysis.

168. See for example P. Bayne, 'Nuclear Navy a Factor in Shaping U. S. Facilities', New York Times, 25 May 1986, sec. 22, p. 26; US, H of R, Committee on Science and Technology, Subcommittee on Energy Research and Production, Plans for Improved Safety of Nuclear Power Plants Following the Three Mile Island Accident - Hearing, 19 September 1979, pp. 46-47, and 53 (Dr C. Starr, Electric Power Research Institute); US, H of R, Committee on Appropriations, Subcommittee on Energy and Water Development, Energy and Water Development Appropriations for 1984 - Hearings, 17 March 1983, pp. 919-21 (Nuclear Regulatory Commission). For a detailed description of the US Navy's nuclear training program, testing and inspection of its reactor operators and auditing of the program, see US, H of R, Committee on Science and Technology, Subcommittee on Energy Research and Production, Nuclear Powerplant Safety Systems - Hearings, 24 May 1979, pp. 892-917.

169. Evidence, p. 611 (Prof W. J. Davis).

specific plant to be operated.[170] Particular stress has been placed on the much higher level of supervision and the ability to impose naval discipline.[171]

4.120 It seems clear that the United States Navy's operators are required to operate less automated equipment than their civilian counterparts. But it seems equally clear that the former are far better trained and supervised than the latter. As a result the Committee does not consider that naval reactors should be any less safe than land-based reactors due to their being less automated.

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170. 'Comments by Admiral H. G. Rickover, USN, Director, Naval Nuclear Propulsion Program in Meeting with Members of the President's Commission Commission on the Accident at Three Mile Island', 23 July 1979, p. 18, incorporated in US, H of R, Committee on Appropriations, Subcommittee on Energy and Water Development, Energy and Water Development Appropriations for 1981 - Hearings, 13 March 1980, p. 2096. See also US, H of R, Committee on Government Operations, Nuclear Regulatory Commission - The Rogovin Report - Hearing, 13 February 1980, p. 17 (M. Rogovin):

> In the nuclear Navy reactor program, enlisted men serve as reactor operators but they are supervised on the spot by engineer-officers 24 hours a day. Operators of the larger and vastly more complicated commercial plants and their supervisors are the equivalent of these enlisted men. The extra training and experience they have acquired in the commercial program often cannot suibstitute for an engineering background. Training alone cannot make control room operators into the equivalent of the Navy's 'engineer officers of the watch'.

171. US Congress, Joint Economic Committee, Economics of Defense Policy: Adm. H. G. Rickover - Hearing, 28 January 1982, p. 59 (Admiral H. G. Rickover):

> The senior watchstander at Three Mile Island had been in a nuclear ship. But the difference is that in the Navy we truly supervise. We require proper watchstanding. We check on everything. I get reports all the time, every week, from every one of our ships. In the civilian nuclear industry, there are no similar reports to one central authority. There is no equivalent supervision. One of the serious things wrong at Three Mile Island was the lack of supervision and carelessness in operation.

See also US, H of R, Committee on Appropriations, Subcommittee on Energy and Water Development, Energy and Water Development Appropriations for 1982 - Hearings, 4 March 1981, pp. 537-38 (Admiral H. G. Rickover).

Age of Vessels and Design

4.121 The increasing average age of the United States nuclear powered fleet raises the question whether its past safety can be expected to continue.[172] In 1986 the director of the Naval Nuclear Propulsion Program told a Congressional Committee;

> the nuclear fleet has grown from 90 ships in 1970 up to 149 ships today. In that period, the average age of the ships has gone from 5 to 15 years. To put that in perspective, these ships were originally designed for a 20-year lifetime. Now I am asked to make them go for 30 years, but they were designed for 20 years. We have a large fleet approaching its original design limit.[173]

4.122 In 1980 the then director said 'thus far we have not seen anything which would cause the nuclear plant to limit the

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172. Submission from Mr R. Addison, p. 7. See also Tasmania, Assembly, Debates, 9 December 1987, p. 5580 where Dr R. Brown said that as the USS Long Beach is the oldest nuclear powered surface warship, one can assume its reactors are the least safe of those in current use. cf. S. Novak and M. Podest, 'Nuclear Power Plant Ageing and Life Extension: Safety Aspects', International Atomic Energy Agency, Bulletin, 1987, vol. 29(4), pp. 31-33. This article deals only with commercial reactors, with respect to which it notes: 'Current methods of testing, monitoring, and maintenance are not adequate for coping with the ageing issue' (p. 33). It also notes that over long periods of time there occurs a gradual change in the properties of materials which:

> can affect the capability of engineered components, systems, or structures to perform their required function. ... All materials in a nuclear power plant can suffer from ageing and can partially or totally lose their designed function. Ageing is not only of concern for active components (for which the probability of malfunction increases with time) but also for passive ones, since the safety margin is being reduced towards the lowest allowable level (p. 31).

173. US, H of R, Committee on Appropriations, Subcommittee on Energy and Water Development, Energy and Water Development Appropriations for 1987 - Hearings, 18 March 1986, p. 1072 (Admiral K. R. McKee). See also ibid., p. 1073, where it is said that the surface ships in the program are now required to remain in service for up to 45 years.

lifetime of a ship'.[174] The USS Nautilus was decommissioned after 25 years service, but the decision to do so was not based on anything to do with the reactor.[175]

4.123 The Committee has no information on whether or how the latest ideas on reactor safety developed by civil regulatory authorities and the civil reactor industry have been incorporated in naval designs. The fundamental design of United States Navy reactors currently operating is over 20 years old.[176] Not all the changes which have occurred during that time relating to commercial reactors would necessarily be applicable to small naval reactors. In the absence of evidence, a conservative assumption should be made and a 20 year old reactor design regarded as less safe than the latest design. Of course, less safe is not the same as unsafe, as shown by the fact that regulatory authorities permit the continued operation of ageing civil reactors.

Collision Risks

4.124 The risk that a nuclear powered ship could be involved in a collision, grounding or similar maritime accident is an obvious and major difference between naval and land-based reactors.[177] These risks do not have to be taken into account for land-based reactors. The magnitude of these risks is considered in the next chapter in discussing the naval reactor accident

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174. US, H of R, Committee on Appropriations, Subcommittee on Energy and Water Development, Energy and Water Development Appropriations for 1981 - Hearings, 13 March 1980, p. 2239 (Admiral H. G. Rickover). See also Vice Admiral Sir Ted Horlick RN, 'Submarine Propulsion in the Royal Navy', Proceedings of the Institution of Mechanical Engineers, 1982, vol. 196, p. 76: due to increased understanding of the mechanism of crack initiation and growth, increased experience of naval reactor operation, and improvements in non-destructive testing techniques enabling in-service inspection 'the steadily increasing demands of the nuclear safety authorities for demonstrable validation of safety have been met'.
175. ibid., p. 2239.
176. US, H of R, Committee on Appropriations, Subcommittee on the Department of Defense, Department of Defense Appropriations for 1988 - Hearings, 30 April 1987, p. 960 (Admiral K. R. McKee).
177. e.g. see Evidence, pp. 980-81 and 999-1001 (Mr R. Bolt).

record, and in chapter 7 in discussing the appropriateness of the current reference accident.

4.125 While mobility adds to risk in this way, it operates to decrease risks in other ways. Unlike a land-based reactor, a damaged naval reactor can be moved. The ability to move the reactor following an accident affects only the consequences of an accident, not the likelihood that it will occur. But mobility also reduces accident likelihood in some respects.

4.126 Accident likelihood is typically measured in reactor years. Unlike a land-based reactor, a naval reactor is not present in port every day of the year. Were a lot of visits to occur, Australian ports could experience several reactor years during a single calendar year. In practice this has not happened. In the nine years 1980-1988 inclusive, Australian ports had a total of less than two reactor years of exposure to the risk of a reactor accident.[178]

4.127 The mobility of naval reactors further reduces the likelihood of an accident in an Australian port in that reactor fuel handling,[179] repairs, servicing, testing and so forth occur elsewhere. No equivalent to the risk at land-based reactors arising from on-site storage of spent fuel arises as part of port

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178. Calculation based on visit dates as set out in Appendix 3, counting the day of arrival as a full day, but not counting the day of departure. Allowance has been made for the fact that all surface vessels have multiple reactors, and it is conservatively assumed that all reactors would be operating at all times during port visits. The year with the most reactor visiting days was 1983 (175 reactor port days); those with the least were 1987 (28 reactor port days) and 1988 (nil); the average for the 9 year period was 73 reactor port days per year (ie. 20% of a year).

179. On the risks in refuelling see generally H. G. Schafstall and others, 'Safety Aspects for Fuel Element Handling on Board of Nuclear Ships' in Organisation for Economic Cooperation and Development, Nuclear Energy Agency, Symposium on the Safety of Ships: Proceedings, Hamburg, 5-9 December 1977, (OECD, Paris, 1978), pp. 317-29.

visits to Australia.[180]

Effects of Capsizing

4.128 There is no doubt that naval reactor safety systems would need to be capable of operating in difficult circumstances, even with the ship in a capsized or partially capsized condition. The Committee lacks direct information on this aspect of naval reactors.[181] However, the international safety code for nuclear powered merchant ships requires that the reactor fast shutdown (scram) system has to be capable of shutting down the reactor at angles of up to 90 degrees and has to be capable of maintaining shutdown at all angles.[182] It is not unreasonable to suppose that naval nuclear vessels meet the minimum standards set out in the code for nuclear merchant ships, particularly as both the United States and the United Kingdom were involved in the development of this code.

Storage of Hazardous Substances Near the Reactor

4.129 A land-based reactor is unlikely to be located in proximity to a store of conventional explosives, nuclear weapons,

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180. See US, Nuclear Regulatory Commission, Reactor Safety Study: An Assessment of Accident Risks in U. S. Commercial Nuclear Power Plants, (WASH-1400, NRC, Washington, 1975), pp. 23 and 29 on the magnitude of the total accident risk that is attributable to spent fuel. See also UK, Department of Energy, Sizewell B Public Inquiry: Report of Sir Frank Layfield, (HMSO, London, 1987), para. 27.25: one of the five 'most radiologically damaging design base accidents' is attributable to spent fuel storage.
181. cf. Evidence, p. 375 (ANSTO not aware that safety systems would not work, nor that they would work).
182. International Maritime Organization, Code of Safety for Nuclear Merchant Ships, (IMO, A XII/Res.491, 18 June 1982), para. 4.3.1.4.

or inflammables such as aviation or missile fuel.[183] A naval reactor is in a warship which may hold some or all of these items, thereby increasing the risk in comparison to a land-based reactor.[184] The increase may be due to one of these items starting an accident sequence that eventually affects the reactor. Or it may be due to the presence of these items increasing the consequences should a reactor accident occur.

4.130 The safety of warship magazines and nuclear weapons are considered in chapter 11. The conclusion reached there is that degree of safety is very high. From this it follows that the Committee does not consider that the risk of an accident to a naval reactor is increased to a significant degree by the presence in the same ship of conventional or nuclear weapons.

4.131 The possibility of a fire hazard due to the presence of inflammables is presumably highest on an aircraft carrier, due to the possible presence of large quantities of aviation fuel. At the same time the size of aircraft carriers permits inflammables to be stored well away from the reactors. While the Committee has not investigated the point, it considers that the location of, and safety precautions taken with respect to, inflammables are likely to be such as would not lead to a major additional hazard to reactor safety.

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183. But see International Atomic Energy Agency, Summary Report on the Post-Accident Review Meeting on the Chernobyl Accident: Report by the International Nuclear Safety Advisory Group, (IAEA, Vienna, 1986), p. 44: one of the main challenges for firefighters at the 1986 Chernobyl reactor accident was to prevent the spread of the subsequent fire to the flammable materials stored on-site, such as diesel oil, stored gas and chemicals.

184. e.g. see submissions from Mr R. Addison, p. 4; Scientists Against Nuclear Arms (ACT), pp. 3-4 (Evidence, p. 781-82).

FACTORS TENDING TO MAKE NAVAL REACTORS SAFER

4.132 By way of introduction, the Committee notes that submissions critical of the present position made no acknowledgement of the engineering conservatism and concern for safety that are generally recognised to have been a feature of the United States Naval Nuclear Propulsion Program.[185] The Program has been criticised on military grounds for adhering to tried and proven reactor technology, rather than adopting novel or cheaper technical solutions in order to obtain maximum advantage over potential enemy units.[186]

4.133 The United States Navy has every reason to place a very high priority on reactor safety. The effect of a single reactor accident in 1979 at Three Mile Island was to jeopardise the future of civil nuclear power in the United States. The United States Navy could not afford a similar effect following a naval reactor accident, because such a high proportion of its major

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185. e.g. see R. G. Hewlett and F. Duncan, Nuclear Navy 1946-1962, (U. of Chicago, Chicago, 1974), pp. 334-39. See also US, H of R, Committee on Science and Technology, Subcommittee on Energy Research and Production, Nuclear Powerplant Safety Systems - Hearings, 24 May 1979, pp. 1044-45 (Admiral H. G. Rickover), where eight different examples of conservatism in design are given. See also p. 1072 for an illustration of conservatism in the comparatively long time allowed for response to an accidental loss of feedwater to the steam generators on Navy reactors. The design used for reactors of the Three Mile Island type was such that the reaction time was very short - well under 2 minutes. This was considered an important factor in the TMI accident, and the design has since been altered to allow a longer reaction time: see D. W. Crancher and R. H. Nelmes, 'Accident at the Three Mile Island Power Station', Atomic Energy, July 1980, pp. 3-4. The design of Navy reactors has always provided for the longer reaction time.

186. e.g. see US, H of R, Committee on Science and Techonlogy, Subcommittee on Energy Research and Production, Nuclear Powerplant Safety Systems - Hearings, 24 May 1979, pp. 1047-48 (Admiral H. G. Rickover): P. Tyler, Running Critical: The Silent War, Rickover, and General Dynamics, (Harper & Row, New York, 1986), pp. 55 and 97.

fleet units are nuclear powered.[187] The entire submarine-based nuclear deterrent, for example, depends on nuclear propulsion.

4.134 In the aftermath of the reactor accident at the Three Mile Island nuclear power station, the widespread response of Congressional and other inquiries was to ask why the United States Navy could operate reactors safely when the nuclear power industry could not.[188] It is said, as evidence of the general regard in which United States naval nuclear safety is held, that no country responded to the Three Mile Island accident by cancelling or postponing visits by United States nuclear powered

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187. e.g. US, H of R, Committee on Armed Services, Subcommittee on Procurement and Military Nuclear Systems, Naval Nuclear Propulsion Program - 1988 - Hearing on H. R. 1748, 26 February 1987, p. 2 (Admiral K. R. McKee):

> Reactor safety is a big deal, and is particularly important to us, because when you put all the rhetoric aside, we operate on the basis of public confidence. We are allowed to do the things we do simply because of the public's confidence. That confidence is a function of our safety record.

188. e.g. US, H of R, Committee on Science and Technology, Subcommittee on Energy Research and Production, Nuclear Powerplant Safety Systems - Hearings, 24 May 1979, p. 887 ff (Admiral H. G. Rickover); US, H of R, Committee on Appropriations, Subcommittee on Energy and Water Development, Energy and Water Development Appropriations for 1981 - Hearings, 26 February 1980, pp. 194-96 (Nuclear Regulatory Commission); US Congress, Joint Economic Committee, Economics of Defense Policy: Adm. H. G. Rickover, 28 January 1982, pp. 1 and 59 (Senator W. Proxmire), p. 3 (Senator H. Jackson); US, H of R, Committee on Interior and Insular Affairs, Subcommittee on Energy and the Environment, Nuclear Regulatory Commission Budget Request for FY 1984/1985 - Oversight Hearings, 22 February 1983, pp. 42-43 (Nuclear Regulatory Commission); P. Bayne, 'Nuclear Navy a Factor in Shaping U. S. Facilities', New York Times, 25 May 1986, sec. 22, p. 26; T. C. Joerg, 'Chernobyl at Sea?', US Naval Institute, Proceedings, December 1986, p. 86. Note also how one trenchant critic of US commercial nuclear power development, operation and regulation uses the superior standards and practices that apply in the Naval nuclear program as one basis of his criticism: see D. Ford, The Cult of the Atom: The Secret Papers of the Atomic Energy Commission, (Simon and Schuster, New York, 1982), pp. 40 and 66 (use of prototypes), pp. 53 and 61 (quality of Rickover's supervision), p. 64 (in scaling up from small Navy reactors to large commercial ones, safety compromises allowed to occur so as to cut costs).

warships.[189]

4.135 In the context of the Three Mile Island accident, Admiral Rickover, the head of the United States Naval Nuclear Propulsion Program, was asked in 1979 if a meltdown could happen to a Navy reactor. He replied:

> It could happen but our plants, the plants that I am responsible for, are so designed there is much more time to take action. We have never experienced anything of the sort. We also have emergency systems for taking care of that situation.[190]

4.136 Turning to specific factors, submissions critical of current contingency planning naturally referred primarily to those factors in the design and operation of naval reactors which might render them less safe than land-based reactors. In the course of considering these factors some indication has been given of some respects in which the Committee considers that naval reactors may be safer. Some further respects are worth mentioning.

4.137 The first is standardisation. In 1987 it was said that the 107 commercial reactors then licensed in the United States were operated by 55 different utilities and very few were

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189. V. C. Thomas jr, 'Setting the Record Straight: Allegations and Reactions', Sea Power, September 1983, vol. 26(10), p. 58. Similarly, the ability to visit foreign ports was not affected by the Chernobyl accident: US, H of R, Committee on Appropriations, Subcommittee on Energy and Water Development, Energy and Water Development Appropriations for 1988 - Hearings, 11 March 1987, p. 891 (Admiral K. R. McKee).
190. US, H of R, Committee on Science and Technology, Subcommittee on Energy Research and Production, Nuclear Powerplant Safety Systems - Hearings, 24 May 1979, p. 1074.

similar.[191] It has come to be generally accepted that greater standardisation would lead to greater safety, apart from its more direct economic benefits, and the promotion of greater standardisation of commercial reactors is a major objective in the United States.[192] In contrast the United States Navy's larger number reactors consist of only a small number of designs built by a small number of suppliers.[193]

4.138 With a larger number of virtually identical operating reactors the lessons learned from one reactor can benefit others and lead to, for example, more effective preventative maintenance.[194] Standardisation also makes more viable greater expenditure on design, testing, devising operating procedures and manuals, and the provision of more thorough training and

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191. US, H of R, Committee on Appropriations, Subcommittee on Energy and Water Development, Energy and Water Development Appropriations for 1988 - Hearings, 19 March 1987, p. 13 (L. W. Zech, Chairman, NRC). See also US, Nuclear Regulatory Commission, Reactor Risk Reference Document, (NUREG-1150 (draft), NRC, Washington, 1987), pp. 9-4 - 9-5:

> Almost every containment associated with each of the hundred-odd existing U. S. LWRs has been individually designed and constructed ... . The details of the performance of most engineered aspects of the containments ... will vary from one plant to another because of different design details, different operating history, different test and maintenance protocols, and different emergency operating procedures.

192. See for example US, H of R, Committee on Interior and Insular Affairs, Subcommittee on Energy and the Environment, Nuclear Regulatory Commission Budget Request for FY 1984 and 1985 - Oversight Hearings, 9 February 1984, pp. 86-88 (Nuclear Regulatory Commission).

193. US, H of R, Committee on Appropriations, Subcommittee on Energy and Water Development, Energy and Water Development Appropriations for 1981 - Hearings, 13 March 1980, pp. 2240-43 incorporates a table indicating the type and source of the reactor on each USN vessel. The type 5 submarine reactor of Westinghouse is shown to have been used by 97 vessels. Apart from the USS Long Beach, all the cruisers are powered by the same reactor type from General Electric.

194. 'Comments by Admiral H. G. Rickover, USN, Director, Naval Nuclear Propulsion Program in Meeting with Members of the President's Commission on the Accident at Three Mile Island', 23 July 1979, p. 29, incorporated in US, H of R, Committee on Appropriations, Subcommittee on Energy and Water Development, Energy and Water Development Appropriations for 1981 - Hearings, 13 March 1980, p. 2107. See also US, H of R, Committee on Armed Services, Subcommittee on Military Installations and Facilities, Civil Defense Aspects of the Three Mile Island Nuclear Accident - Hearings, 14 June 1979, pp. 238-39 (Dr J. P. Wade, Department of Defense).

inspection.[195] When a number of reactors of the same type are to be built it becomes less un-economic to have, as the United States Navy does, a land-based prototype built and operated to discover design flaws.[196] The United States Navy also uses its land-based prototypes to train its reactor operators under both normal and casualty conditions.[197] In comparison, the ability to provide hands-on training in civilian nuclear power stations is limited by the economic need to continue generating electricity.

4.139 Related to standardisation is the number of reactors acquired by the United States Navy compared to individual electric power utilities. The then Chairman of the Nuclear Regulatory Commission said in 1983:

> The Navy can define quite well what it wants and has been in the business of procuring complex, highly technological equipment, whereas I don't think the utilities have been. Therefore, the utilities I think got into quite a bit of a problem with their procurement ... . When I say procurement, I mean with regard to getting the construction of the plant properly oriented in quality as well as productivity. Whereas the Navy has for a long time had quality as its central

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195. ibid., pp. 28-29 (incorporated at pp. 2106-07).
196. US, H of R, Committee on Science and Technology, Subcommittee on Energy Research and Production, Nuclear Powerplant Safety Systems - Hearings, 24 May 1979, p. 891 (Admiral H. G. Rickover): use of land-based prototypes is one of the examples of the Naval Nuclear Propulsion Program's conservatism in design. The operation of the prototype continues with a lead-time of two to three years over the production reactors for the full reactor lifespan, allowing flaws which only show late in the life of a reactor to be detected on the prototype before they occur on the reactors installed on vessels: US, Senate, Committee on Armed Services, Department of Defense Authorization for Appropriations for FY 1985 - Hearings on S. 2414, 4 May 1984, pp. 3687, 3697 (Admiral K. R. McKee).
197. US, H of R, Committee on Science and Technology, Subcommittee on Energy Research and Production, Nuclear Powerplant Safety Systems - Hearings, 24 May 1979, pp. 892, 912-13 (Admiral H. G. Rickover).

focus.[198]

Relative to commercial reactors, cost is less of a factor in the pursuit of quality in naval reactors.[199]

4.140 The relatively compact size of warships, particularly submarines, can add to safety in some respects. Clearly it facilitates close supervision and discipline of operators. The compact nature of naval reactor control rooms reduces the possibility that important readings will be overlooked.[200] Because the reactor operators not only work but also live in close proximity to the reactor and depend, especially in a single reactor submarine, on the reactor for their own safety they can be expected to have a high regard for safety. They can also be depended on to demand safe equipment.

4.141 The point has already been made that naval reactors are designed to withstand combat stresses such as depth-charging, and

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198. US, H of R, Committee on Interior and Insular Affairs, Subcommittee on Energy and the Environment, Nuclear Regulatory Commission Budget Request for FY 1984 and 1985 - Oversight Hearings, 22 February 1983, p. 43 (N. J. Palladino). It is said that the long-time head of the US Naval Nuclear Propulsion Program, Admiral Rickover, had a chronic distrust of the quality of the workmanship and materials of equipment suppliers: see N. Polmar and T. B. Allen, Rickover, (Simon and Schuster, New York, 1982), p. 489 where the example is given of nuclear plant pipe welds that had to be X-rayed and certified by the supplier, but the naval reactors staff then made its own X-rays as a double check.

199. T. C. Joerg, 'Chernobyl at Sea?', US Naval Institute, Proceedings, December 1986, p. 86: better safety record of naval reactors has come about 'through the expenditure of high premiums in material acquisition and manpower training'.

200. US, H of R, Committee on Appropriatons, Subcommittee on Energy and Water Development, Energy and Water Development Appropriations for 1982 - Hearings, 4 March 1981, p. 537 (Admiral H. G. Rickover):

> The commercial reactor companies tend to spread their control room out over a large area so no one person can see all the instruments. We don't do that. We design our control rooms so one man can see all the instruments. In the Three Mile Island plant some of the instruments were located so you couldn't even see them at all.

For the ways in which poor commercial reactor control room design contributes to operator error, see T. B. Sheriden, 'Human Error in Nuclear Power Plants', Technology Review, February 1980, pp. 26-28.

to survive battle damage.[201] As the director of the United States Naval Nuclear Propulsion Program said in 1985:

> we cannot afford a ship that could become a greater hazard to the crew than to the enemy if it sustains battle damage.[202]

CONCLUSIONS

4.142 Pressurised water reactors in warships and on land operate on the same physical principles. Beyond this, the differences between land-based and naval reactors are as significant from the point of view of safety as are the similarities. The discussion in this chapter has illustrated that there is no simple answer to the question whether naval reactors are less safe than land-based reactors.

4.143 As explained in the previous chapter, assessment of risk requires a consideration of both the likelihood that a given accident will occur and the consequences were it to do so. These two elements may move in opposite directions when comparing naval to land-based reactors. For example, even if the likelihood of a given accident involving a naval reactor is higher, the overall risk may still be lower because the much smaller size of the naval reactor ensures that consequences of that accident are bound to be much less than for the corresponding land-based reactor accident.

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201. As a further illustration, it is said that the reactor design used on the merchant ship, NS Otto Hahn, lacked the shock-restance which would be required if it were to meet military specifications: N. Battle, 'PWR Plant Development for Marine Propulsion', Nuclear Engineer, January-February 1984, vol. 25(1), p. 12.

202. US, H of R, Committee on Armed Services, Subcommittee on Seapower and Strategic and Critical Materials, Defense Department Authorization and Oversight - Hearings on H. R. 1872, (DOD Authorization of Appropriations for FY 1986), 6 March 1986, p. 184 (Admiral K. R. McKee).

4.144 Ultimately whether lesser consequences were outweighed by higher likelihood of occurrence could only be resolved by a quantitative risk assessment.[203] The Committee lacks the detailed data necessary to attempt any quantitative risk assessment, as explained in the previous chapter. However, it appears on the best qualitative assessment that the Committee was in a position to make that the reduced consequences of a naval reactor accident are unlikely to be outweighed by any greater likelihood that the accident will occur. This is particularly true in the context of the limited type of port visits that take place in Australia.

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203. cf. the view of ANSTO (Evidence, p. 438), which

> makes no claims on the relative 'safety' of naval versus land-based reactors. We do believe, however, that the hazards to the nearby public resulting from contained, meltdown accidents is less for the shipboard reactors than for land-based nuclear power stations.

The reasons for this are given as the ability to move the naval reactor and its lower fission product inventory.

CHAPTER 5

NUCLEAR POWERED WARSHIP SAFETY RECORD

Risk Assessment Based on Historical Data

5.1 Two broad approaches are possible in assessing the likelihood of an accident. One involves theoretical consideration of possible accidents. The ways in which this might be done were outlined in chapter 3. The second approach involves considering the historical record. This chapter takes this approach. The historical approach is familiar because it is widely used by insurers to assess the risk of everyday accidents such as house fires, road accidents and industrial accidents.

5.2 It is important to note that reference to the historical record can never prove in any absolute (as opposed to probabilistic) sense that an accident will not occur. Rather surprisingly, some witnesses attempted to argue from this point to the proposition that the accident record was simply not relevant. As the Committee understood it, the argument was that even if the past had been accident free, this did not establish anything significant as to accident likelihood in the future.[1] The fact that equipment had operated accident-free for, say, 3,000 machine-years allowed no statement as to the probability that an accident would not happen tomorrow.

5.3 The Committee does not accept this argument. In the Committee's view it rests on a mistaken or unacceptable notion of what is meant by proof. Once it is allowed that all the links in an accident scenario are physically capable of occurring, the

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1. Evidence, p. 865 (Scientists Against Nuclear Arms); p. 935 (Mr M. Lynch); pp. 995-96 (Mr R. Bolt).

only relevant statements are ones that relate to the probability of occurrence. In other words, a demand for proof that an accident will not occur can be interpreted as a request that occurrence of the accident be shown to be physically impossible. Once this interpretation is ruled out on the particular facts, the only alternative interpretation of the demand for proof is that what is sought is proof according to probability.

5.4 Broadly speaking, the best evidence of probability lies in the relevant historical record, as a number of submissions pointed out.[2] To be sure there are never enough relevant historical data: reliable use of the past record requires that the relevant activity has occurred frequently over a period of time and that a large amount of data exists on any accidents that have occurred during that activity. It is a question of fact whether for any accident scenario the data base is adequate.

5.5 Within limits, however, the question of adequacy is one of degree. The better the data, the greater the confidence can be placed in predictions based on that data. The degree of confidence the Committee considers can be placed in prediction based on the historical data relevant to the likelihood of serious naval reactor accidents is examined in this chapter. But the Committee rejects the suggestion put to it that it should place no value whatsoever on what is known of the naval reactor safety record, or that the historical record proves nothing.

5.6 A further issue in making predictions based on historical data is that no guarantee can be given that one or more of the relevant conditions surrounding the accident scenario under study will not alter in the future, thereby affecting the reliability of any prediction. The Committee recognises this as a valid point. But it is also relevant to note that experience

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2. e.g. see the submissions from Prof W. J. Davis, p. 121 (Evidence, p. 568); Scientists Against Nuclear Arms (Tas), p. 3 (Evidence, p. 822).

gained in operating civil and naval reactors has led to increased rather than decreased safety.[3] Moreover, the Committee has confined its consideration to existing United States, and to a lesser extent, Royal Navy reactors. It makes no statement on whether its conclusions would apply to naval reactors which may be developed in the future.

The Safety Record - Official Views

5.7 The radiation monitoring in place during nuclear powered warship visits to Australian ports since 1976 has never detected any release of radioactive material from the vessels.[4] Nor was there any incident involving the release of radioactivity during the visits prior to 1976.[5]

5.8 The 1987 statement to Congress by the United States Naval Nuclear Propulsion Program director indicated that there were 179 reactors operating under the program. There were 149 nuclear powered vessels, some having more than one reactor, and 8 land-based prototypes. This was nearly twice the number of operating reactors in the civil nuclear power industry in the

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3. cf. submission from Prof W. J. Davis, p. 121 (Evidence, p. 568): as the nuclear industry matures, accident probability may decline (with better safety standards) or increase (with aging components).
4. See the annual reports of radiation monitoring described in paras. 2.28–2.31. It was alleged to the Committee that the USS Sea Dragon, while in Hobart in 1983, 'suffered a leak from its reactor coolant into its secondary coolant system in excess of 300 rads ... The Sea Dragon went from Hobart to Hawaii where the whole vessel was sealed, decommissioned immediately and either sunk or scrapped or buried somewhere at Santiago': submission from Miss E. Ruzicka, p. 5. The Committee followed up this undocumented allegation and found it to be false: letter from Cdre N. J. Stoker RAN, 19 April 1988 (Evidence, p. 238.324). It should be noted that the submarine called at Jervis Bay after leaving Hobart, but radiation monitoring at Jervis Bay detected nothing abnormal: Department of Home Affairs and Environment, Visits by Nuclear Powered Warships to Australian Ports: Report on Radiation Monitoring during 1983, (DHAE, Canberra, 1984), pp. 9 (Hobart) and 11-12 (Jervis Bay).
5. Australia, Environmental Considerations of Visits of Nuclear Powered Warships to Australia, (May 1976), p. 2 (Evidence, p. 119).

United States.[6] A 1988 statement declared that these:

> 149 nuclear powered warships continue to have a remarkable record of safety and operational effectiveness. The safety record has been validated in over 75 million miles - 3,200 years of reactor operation - without a reactor accident or any radioactivity release having a significant environmental effect.[7]

5.9 There appears to be no formal United States Navy definition of what constitutes a reactor 'accident'.[8] However, annual reports by the United States Navy state:

> No civilian or military personnel in the Naval Nuclear Propulsion Program have ever exceeded the Federal limit which allows five rem exposure for each year of age beyond age eighteen. Since 1967 no person has exceeded

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6. US, H of R, Committee on Appropriations, Subcommittee on the Department of Defense, Hearings on Department of Defense Appropriations for 1988, 30 April 1987, p. 964 (Admiral K. R. McKee).
7. US, H of R, Committee on Appropriations, Subcommittee on Energy and Water Development, Energy and Water Development Appropriations for 1989 - Hearings, 23 March 1988, p. 1360 (Admiral K. R. McKee). See also US Congress, Joint Committee on Atomic Energy, Subcommittee on Legislation, Naval Nuclear Propulsion Program - 1976, 18 March 1976, p. 16 (Admiral H. G. Rickover): 'To date there has never been an operating occurrence, casualty, incident, accident, or whatever you want to call it, which has resulted in damage to naval fuel and the subsequent release of fission products from the fuel'.
8. In US, H of R, Committee on Armed Services, Subcommittee on Procurement and Military Nuclear Systems, Naval Nuclear Propulsion Program - 1984; Hearing on H. R. 5263, 28 February 1984, p. 195, Appendix D ('Discussion of Allegations Contained in Article "The Nuclear Navy"'), the Navy explained:

   > The statement by the Navy that no nuclear reactor accidents have occurred in the U. S. Naval Nuclear Propulsion Program is based upon the widely accepted definition of a nuclear reactor accident. Such an accident, as occurred at Three Mile Island in 1979, is an event in which there is damage to the reactor causing the release of radioactive fission products from the reactor core. The Navy has never had such an accident since the inception of the Naval Propulsion Program.

   Compare this with the formal US definitions of 'accidents' and 'incidents' to nuclear weapons, discussed below at paras. 11.97-11.98; and UK, Ministry of Defence, Devonport Public Safety Scheme, (1982 edn.), p. 1-3:

   > A reactor accident is defined as an unexpected event involving a nuclear reactor plant which is likely to lead to or has resulted in a radiological hazard external to the reactor plant.

> the Federal limit which allows up to three rem per quarter year, nor in this period has anyone exceeded the Navy's self-imposed limit of 5 rem per year for radiation associated with Naval nuclear propulsion plants.[9]

5.10 It seems reasonable to assume that had any sort of reactor accident or incident occurred (other than radioactive waste discharge) of any degree of seriousness these limits would have been exceeded for at least one of the reactor operators on board the vessel at the time. Waste discharges are considered separately below. But apart from the possibility of these discharges, the quoted passage strongly suggests that the United States Navy has never had any reactor problem which, were it to occur during an Australian port visit, would pose any health or environmental concern.

5.11 British nuclear powered vessels have had less than 300 reactor-years of operation.[10] In response to a Parliamentary question in 1988 relating to British nuclear powered submarines, a British Government spokesman stated that 'there has never been an incident involving such submarines where there was any radiological hazard to service men, base personnel or members of the

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9. US, Department of the Navy, Occupational Radiation Exposure from U. S. Naval Nuclear Propulsion Plants and their Support Facilities 1987, (NT-88-2, February 1988), p. 1. Similar statements appear in previous annual reports in the series. In the context of this reporting program, 'abnormal occurrences' are reported 'if the Navy evaluation determines that they meet either the Department of Energy criteria for Type A radiation exposure incidents or the Nuclear Regulatory Commission criteria for quarterly report to Congress as abnormal radiation exposure occurrences': p. 48. There were no abnormal occurrences in the period 1978-1987: p. 48. The report in this series for 1978 states that there were no abnormal occurrences in the period 1974-1978: see Table 8 of the report.
10. UK, Ministry of Defence, Devonport Public Safety Scheme, (1982 edn.), p. 1-3 states that 'the total number of RN reactor operating years to date is less than 200'. It seems reasonable to add a figure approaching 100 for the years of operation since 1982.

public'.[11]

5.12 The Canadian Government issued a White Paper in June 1987 in which it was proposed that Canada acquire a number of nuclear powered submarines. In the ensuing debate, a Canadian Department of Defence officer wrote:

> The British, French and U. S. navies, taken together, operate about 210 submarine-propulsion reactors of basically similar design. There has never been a reactor accident in any of these naval programs.
>
> It is apparent that in the Western world, naval-propulsion reactors are either inherently safer than their civilian counterparts, or are operated in a safer manner, or both.
>
> Specifically, Britain operates 42 power-generation reactors and 17 naval-propulsion reactors. One serious accident has occurred in the civilian program, none in the military. In the United States, there are 127 power reactors and 179 propulsion reactors. In spite of the greater number of naval reactors, none has ever caused an accidental release of radiation; one civilian reactor has. The French naval experience is equally impressive.[12]

The Safety Record - Other Views

5.13 A number of submissions took issue with the accuracy of

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11. UK, Parliamentary Debates (Commons), 6th series, vol. 129, Written Answers, 9 March 1988, col. 216. See also ibid., vol. 143, Written Answers, 9 December 1988, col. 345; and 'UK Nuclear Powered Warships Safety Procedures', (Paper prepared by the Australian Department of Defence for the Committee, July 1988), para. 11 (Evidence, p. 1300.15): 'There has been no accident to any Royal Navy reactor resulting in any release of fission products since the start of the Royal Navy's nuclear propulsion programme.'
12. H. A. Robitaille, 'No Reactor Accidents Have Stained the West's Nuclear Subs', the Globe and Mail (Toronto), 26 June 1987, p. A7. The International Atomic Energy Agency, Bulletin, 1987, vol. 29(2), p. 65 states that only 99 civil nuclear power reactors were operating in the US and 38 in the UK at the end of 1986.

official statements on naval reactor safety. Mr Richard Bolt stated in his 1986 submission:

> It is true that no evidence exists that any reactor accidents - serious or minor - have occurred on NPW's. This is almost certain to be a result of the tight secrecy surrounding sensitive military information. It is only in recent years that a reasonably complete record of the large number of accidents in civilian nuclear power plants has come to light. It would take blind faith to believe that disasters and near-disasters, as yet undisclosed, have not occurred in NPW reactors.[13]

5.14 Any simple inference from events in land-based civil reactors to naval reactors is questionable, as the material in the previous chapter illustrated. Moreover, the Committee does not consider it likely that United States officials have consistently lied to Congress over the years.[14] If for no other reason, this would be so because concealment of accidents of the types most relevant to the Committee's inquiry would be difficult in an open society such as the United States. These accidents, core meltdowns or other accidents involving serious core damage to reactors of United States vessels, would leave the reactor disabled and the ship out of service for lengthy and costly repairs. Yet Soviet authors,[15] United States investigative

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13. Submission from Mr R. Bolt, p. 8 (Evidence, p. 958). See also the submissions from Prof W. J. Davis, pp. 13-14 (Evidence, pp. 460-61); Greenpeace Australia (NSW) Ltd, p. 18. When Mr Bolt appeared before the Committee he withdrew his reference to 'disasters' having occurred, but maintained his view with respect to 'near-disasters' (Evidence, p. 996).
14. Contrast Evidence, p. 935 (Mr M. Lynch) referring to the US Navy's statement to Congress on reactor safety: 'there is no proof that that statement is true'.
15. A book whose title translates as Design of Nuclear Submarines by V. M. Bukalov and A. A. Narusbayev was published in 1968 and contains tables purporting to show various types of accidents that have occurred to US and British nuclear powered submarines. None of those listed involve a meltdown. The tables are reproduced in N. Polmar and T. B. Allen, Rickover, (Simon and Schuster, New York, 1982), pp. 683-87.

reporters and authors,[16] and those making submissions to the Committee have not suggested the existence of even a serious rumour that such an accident has ever occurred.

5.15 Accidents involving serious core damage during port visits would be particularly difficult to conceal (unless containment and shielding was 100 per cent effective) because of the independent monitoring that often occurs during such visits.[17] Even where there is no routine monitoring of visits as such, the effects of a major release of ionising radiation as a result of an accident would risk being detected by the sort of routine environmental monitoring that occurs in many countries. It was monitoring of this kind that first indicated to Western observers that the 1986 accident to the Soviet Union's nuclear power station at Chernobyl had occurred.[18]

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16. e.g. D. Kaplan, The Nuclear Navy, (Fund for Constitutional Government, Washington, 1983); N. Polmar and T. B. Allen, Rickover, (Simon and Schuster, New York, 1982).
17. For the US, see US, H of R, Committee on Armed Services, Subcommittee on Procurement and Military Nuclear Systems, Naval Nuclear Propulsion Program - 1984: Hearing on H. R. 5263, 28 February 1984, p. 200, Appendix D ('Discussion of Allegations Contained in Article "The Nuclear Navy"') (Evidence, p. 1300.67): independent monitoring of the radiological effects of nuclear powered warships in US ports has been done from time to time by federal, state and local authorities. For the independent monitoring occurring around the US submarine base in Scotland see UK, Parliamentary Debates (Commons), 6th series, vol. 146, Written Answers, 2 February 1989, col. 405. For the monitoring by local authorities that takes place during nuclear powered submarine visits to Japanese ports see M. Kuramoto, 'Some Considerations on the Safety of Nuclear Ships' in Organisation for Economic Cooperation and Development, Nuclear Energy Agency, Symposium on the Safety of Nuclear Ships: Proceedings, Hamburg, 5-9 December 1977, (OECD, Paris, 1978), p. 459. In New Zealand, the National Radiation Laboratory monitored the visits of all nuclear powered warships: S. McMillan, Neither Confirm Nor Deny: The Nuclear Ships Dispute between New Zealand and the United States, (Allen & Unwin, Wellington, 1987), p. 39. For the monitoring during Australian port visits, see paras. 2.28-2.31 and chapter 8 in this report. Contrast, 'Round-the-clock check on Snook', West Australian, 16 August 1976: captain of visiting USS Snook cited as saying monitoring not usually carried out in other parts of the world, except for Japan.
18. M. Eisenbud, Environmental Radioactivity from Natural, Industrial, and Military Sources, (3rd edn., Academic Press, Orlando, Fla., 1987), p. 378.

Loss of USS Thresher and USS Scorpion

5.16 Some submissions referred to the loss at sea through accident of the United States nuclear powered submarines Thresher in 1963 and Scorpion in 1968.[19] The implication was that these accidents refuted the official position on safety or were otherwise relevant to safety during port visits. In neither accident were there any survivors, and relevant wreckage of the vessels has not been recovered from the deep waters in which they lie. As a result no-one can say with certainty what caused either accident.

5.17 From the information publicly available, it is impossible to refute or confirm the various plausible accident causes, including those involving reactor accidents, that have been put forward unofficially over the years.[20] The official position is that the loss of neither submarine was related to reactor failure, and that subsequent environmental monitoring of the accident sites supports this conclusion.[21]

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19. e.g. see submissions from Assoc Prof P. Jennings, p. 2; Balmain People for Nuclear Disarmament, p. 4; Medical Association for Prevention of War (Vic), p. 1; Medical Association for the Prevention of War (NSW), p. 2. See also Evidence, pp. 862-63, 865 (Scientists Against Nuclear Arms).
20. See footnote 150 in the previous chapter for references to these theories in the context of reactor scrams. For the theory that the loss of the USS Scorpion was caused by the accidental detonation of a conventional warhead on one of its torpedoes see Jane's Defence Weekly, 5 January 1985, p. 6, 'Lost US submarine caused by torpedo damage'. See also US, Committee on Appropriations, Subcommittee on Energy and Water Development, Energy and Water Development Appropriations for 1988 - Hearings, 11 March 1987, pp. 895-96, where the then head of the US Naval Nuclear Propulsion Program, Admiral McKee, gave a detailed personal theory on the cause of the loss of the USS Thresher. This does not involve a reactor accident. His response to the question 'Was the Scorpion incident nuclear related?' has been deleted from the published transcript on security grounds.
21. See for example US, H of R, Committee on Armed Services, Subcommittee on Procurement and Military Nuclear Systems, Naval Nuclear Propulsion Program - 1984: Hearing on H. R. 5263, 28 February 1984, pp. 209-10, Appendix D ('Discussion of Allegations Contained in Article "The Nuclear Navy"') (Evidence, pp. 1300.79-80): monitoring has revealed no radio-activity from the reactor fuel elements and the presence of only very low levels of cobalt-60 from the reactor coolant systems.

5.18 Even if the official view of the causes of these accidents is rejected, it has to be shown what relevance these accidents have to safety during visits to Australian ports. The suggested causes that involve the reactor either could only happen while the submarine was submerged, or would only affect reactor safety while in that position. Thus they could not occur during a port visit.

Alleged British Accidents

5.19 The Committee's attention was drawn to what was claimed to be a meltdown that almost happened as a result of a fault in the reactor coolant system on board HMS Resolution while it was berthed at the base in the Clyde.[22] One media report quoted unnamed 'nuclear experts' as describing the incident as 'potentially catastrophic'.[23] A government spokesman, however, stated:

> The electrical malfunction which occurred on board HMS Resolution on 26 January posed no danger to the submarine's reactor, its crew or the public.[24]

5.20 The Committee was unable to draw conclusions as between the two views of what happened.

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22. Evidence, p. 1198 (Senator J. Vallentine).
23. 'N-sub minutes from disaster', Observer (London), 14 February 1988, p. 1. Another press report on the same incident claims that 'one man had to be scrubbed down for 24 hours after exposure to radiation': 'Catalogue of faults in UK nuclear subs', Guardian (London), 3 March 1988, p. 1.
24. UK, Parliamentary Debates (Commons), 6th series, vol. 127, Written Answers, 19 February 1988, col. 759. To the question how many military personnel or civilian employees were exposed to levels of radioactivity greater than the permitted dose as a result of the emergency on HMS Resolution on 26 January, the Government's answer was none: ibid., col. 758. To the further question whether any release of radioactivity occurred within the vessel, into the atmosphere, or into the sea as a result of the incident, the Government answer was no: ibid., col. 758. See also ibid., vol. 133, 10 May 1988, col. 297, where a Government spokesman described the press allegations relating to the incident as 'quite erroneous and alarmist' and stated that 'we have never had an accident to a Royal Naval submarine resulting in the release of radioactive material to the environment'.

5.21 The Committee's attention was also drawn to a recent press report stating:

> The reactors which power Britain's nuclear submarines were involved in more than 700 'incidents' during their first 16 years of operation ... . Captain Jim Bush, a nuclear veteran now working at the Centre [sic] for Defence [sic] Information, a private US think-tank frequently critical of Pentagon policies, said that of the 700 incidents 'probably no more than a dozen were significant in that they resulted in the release of radioactive material'.[25]

5.22 In contrast, the report upon which this media report is apparently based refers to 'some 700 "incidents"' and states:

> In all these "incidents", the remedial actions taken have been successful; no British nuclear submarine has been lost, although a major fire has required the lengthy withdrawal from service of one boat, and it must be emphasised that no incident has occurred which has caused a radiological hazard to the public.[26]

Accidents Involving Radioactive Wastes

5.23 In considering naval radiation accidents it is important to bear in mind the distinction between release of fission products following reactor core damage and the release of radioactive wastes.[27] A significant number of submissions that referred to the United States safety record failed to make or

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25. 'Catalogue of faults in UK nuclear subs', Guardian (London), 3 March 1988, p. 1. The report is based on 'an internal Royal Navy analysis' obtained by the Guardian. It also states that RN analysis of 435 of the 712 incidents showed 205 were caused by mechanical problems, 107 by operator error, and 123 by primary or secondary electrical faults. 'Incidents' are 'defined as events requiring operation away from the norm and which include all occasions when emergency drills have been initiated': J. Edwards and Cdr K. F. Tucker RN, 'Royal Navy Requirements and Achievements in Nuclear Training', Journal of Naval Science, 1978, vol. 4(4), p. 207.
26. J. Edwards and Cdr K. F. Tucker RN, 'Royal Navy Requirements and Achievements in Nuclear Training', Journal of Naval Science, 1978, vol. 4(4), p. 207.
27. The distinction is discussed in paras. 4.14–4.30.

appreciate this distinction.

5.24 Associate Professor Philip Jennings, for example, described the leaking of radioactive coolant water as having the potential to 'lead to far more serious consequences than those predicted for the reference accident'.[28] The much greater quantity of radioactivity available for release in the reference accident than in waste discharge makes this view difficult to credit.[29] A number of submissions referring to allegations of accidents referred to allegations which, even if correct, involved only the release of radioactive wastes.[30]

5.25 Many submissions referring to the accident record involving radioactive wastes, and a number of submissions referring to accidents generally, relied on a 1983 report by an investigative journalist, David Kaplan, entitled 'The Nuclear Navy'.[31] In view of the reliance placed on this report,[32] detailed examination is merited.

5.26 One submission contained what purported to be a quote from Kaplan's report: 'U. S. Navy ships have leaked radiation at

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28. Submission from Assoc Prof P. Jennings, p. 2. The context makes it clear that he is referring to low-level waste, not coolant contaminated by a meltdown or major fuel element failure.
29. See above, para. 4.30, footnote 35, where a very approximate indication of the comparitive quantities is given.
30. See for example the submissions from the Albany Peace Group, pp. 2-3; Waterside Workers' Federation of Australia (Melbourne), attachments 1 and 2; Ms E. Milne and Mr P. Lockyer, p. 1; Manly Warringah Peace Movement, p. 2.
31. D. Kaplan, The Nuclear Navy, (Fund for Constitutional Government, Washington, 1983). This report also was published in an edited version, without tables or accompanying footnotes, in the July 1983 issue of Oceans.
32. Submissions referring to the report include those of the Albany Peace Group, pp. 2-3; Waterside Workers' Federation of Australia (Melbourne), attachments 1 and 2; Ms E. Milne and Mr P. Lockyer, p. 1; Manly Warringah Peace Movement, p. 2; Illawarra People for Nuclear Disarmament, p. 3; the Medical Association for the Prevention of War (Vic), p. 1; Mrs L. Van Geloven, attachment 2; Coalition Against Nuclear Armed & Powered Ships, p. 4 (Evidence, p. 1376); People for Peace, p. 1; Prof W. J. Davis, p. 14 (Evidence, p. 461).

least 37 times since they began using nuclear reactors ... '.[33] The report contains no such wording and makes no such claim. The press release issued by one of the report's sponsors states that the report contains a table of 37 accidents involving the reactors (ie. not necessarily involving significant radiation leakage) aboard nuclear powered ships (ie. of all countries, not just the United States Navy).[34] This statement is not accurate either.

5.27 The report refers to 37 'incidents' involving ships' nuclear power plant.[35] This again is not accurate, assuming (as appears reasonable) the statement is supposed to be supported by the 37 items in an appended table. This table is headed 'Reactor-Related Accidents and Incidents Involving Nuclear Powered Vessels 1954-1983'. The heading is inaccurate, in that one of the 37 items identified relates to a land-based non-naval reactor and another relates not to an accident, incident or vessel but to the intentional disposal at sea of a decommissioned reactor.[36]

5.28 It is relevant for the purposes of this inquiry to note that of the remaining 35 items in the table two relate to non-naval ships,[37] five relate to USSR submarines,[38] and twelve

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33. Submission from Coalition Against Nuclear Armed & Powered Ships, p. 4 (Evidence, p. 1376). The same quote is attributed to the report in the submission from the Waterside Workers' Federation (Melbourne), attachment 2; and in material tabled in the Senate by Senator McIntosh on 5 May 1986, and provided to the Committee as an attachment to the submission from Action for World Development. None of these gave a page reference to the report from which they were purporting to quote. Without quoting directly, the same proposition was attributed to Kaplan's report by the submissions from the Manly Warringah Peace Movement, p. 2; People for Peace, p. 1. It appears that all these sources relied on the media, not the report itself, for their information as to its contents.
34. Press release of the Fund for Constitutional Government, 20 July 1983, p. 2.
35. At p. 16.
36. Items 5 and 6. Numbering was not supplied in original but has been added to facilitate reference.
37. Items 12 (NS Lenin) and 18 (NS Mutsu).
38. Items 11, 15, 17, 25 and 32.

others relate to activities at naval dockyards or submarine tenders.[39] At least three more relate to reactor types no longer in service,[40] and a further one relates to the USS Nautilus in 1954, prior to its commissioning.[41] Thus at least 23 of the 35 items are not directly relevant to port visits to Australia.[42] This is not, of course, a criticism of Kaplan's report but of the use made of it in submissions to the Committee.

5.29 Kaplan's table is more accurately described as one listing alleged accidents and incidents, in that it contains items which, in the official view, have been investigated and found to be without basis.[43] It also operates on the basis of a broad (but never defined) view of what constitutes an accident or

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39. Items 7, 16, 19, 20, 21, 22, 23, 24, 28, 33, 35 and 36.
40. Items 2 (reactor type S2G) and items 3 and 4 (reactor type S2W). In items 21, 23 and 35 the identity of the vessel is not given.
41. Item 1. The incident relating to the NS Mutsu (item 18) also occurred during its first sea trial. Nuclear powered vessels undergoing pre-commissioning tests or sea trials will not, of course, be visiting ports in Australia.
42. Items 10 (loss of USS Thresher) and 14 (loss of USS Scorpion) are also best viewed as not relevant to Australian port visits for the reasons given in paras. 5.17-5.18.
43. e.g. see item 13, high readings on radiation monitors during May 1968 visit of USS Swordfish to Sasebo, Japan. US Atomic Energy Commission personnel investigated. Their report, presented to Congress, concluded:

> that USS Swordfish did not at any time while in or near the port of Sasebo during the period May 2 through May 11 discharge radio-activity of any kind to the atmosphere or to the surrounding waters. ... If one assumes that the abnormal readings were, in fact, caused by some form of radioactivity, the radiation levels and radio-activity concentrations would be of the order of one thousand times less than those considered acceptable for the general public by such recognized authorities as the International Commission on Radiological Protection and the U. S. Federal Radiation Council.

Quoted in US, H of R, Committee on Armed Services, Subcommittee on Procurement and Military Nuclear Systems, Naval Nuclear Propulsion Program - 1984: Hearing on H. R. 5263, 28 February 1984, pp. 199-200, Appendix D, ('Discussion of Allegations Contained in Article "The Nuclear Navy"') (Evidence, pp. 1300.66-67). A number of submissions referred to the Sasebo incident as evidence of lack of safety, but none indicated awareness of the results of the investigation. See also M. Kuramoto, 'Some Considerations on the Safety of Nuclear Ships' in Organisation for Economic Cooperation and Development, Nuclear Energy Agency, Symposium on the Safety of Nuclear Ships: Proceedings, Hamburg, 5-9 December 1977, (OECD, Paris, 1978), p. 459: 'no accident whatsoever has ever occurred to date' during visits by nuclear powered warships to Japanese ports.

incident.[44] Many of the items listed relate to spills of small amounts of coolant almost certainly having very little radioactive content. For many years the United States Navy has prepared and provided to Congress an annual report on discharges of radioactivity from its vessels. Referring to liquid waste, these reports state;

> if one person were able to drink the entire amount of radioactivity discharged into any harbor in any of the last fourteen years, he would not exceed the annual radiation exposure permitted for an individual worker by the U. S. Nuclear Regulatory Commission.[45]

5.30 None of the authors of the submissions citing Kaplan referred to, or appeared to be aware of, the fact that Kaplan's report had been subject to a detailed and persuasive rebuttal by the United States Navy[46] and a critique by another journalist.[47] The Navy described Kaplan's report as containing 'many inaccurate statements' and told a Congressional Committee that after

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44. e.g. item 9 refers to an incident in which USS Thresher was in port with its reactor shut down. Shore power was unavailable and the diesel generator supplying the hotel load developed a fault. In working on the generator the crew let the electricity batteries run down to the extent that there was insufficient power left to provide the current to start the reactor. An external power source had to be used. See N. Polmar and T. B. Allen, Rickover, (Simon and Schuster, New York, 1982), pp. 425-26 for what seems to be a far more balanced account of the incident. Kaplan cites this work in his table as his source. He does not explain how the events constituted a nuclear hazard of any sort or could ever have led to such a hazard.

45. US, Department of the Navy, Environmental Monitoring and Disposal of Radioactive Wastes from U. S. Naval Nuclear-Powered Ships and their Support Facilities 1984, (NT-85-1, February 1985), p. 2 (Evidence, p. 238.297). The reports for other years contain similar statements.

46. US, H of R, Committee on Armed Services, Subcommittee on Procurement and Military Nuclear Systems, Naval Nuclear Propulsion Program - 1984: Hearing on H. R. 5263, 28 February 1984, pp. 195-212, Appendix D ('Discussion of Allegations Contained in Article "The Nuclear Navy"') (Evidence, pp. 1300.60-83). The substance of this response appeared in Oceans, September 1983.

47. V. C. Thomas jr, 'Setting the Record Straight: Allegations and Reactions', Sea Power, September 1983, vol. 26(10), p. 52. The text of this article has also been incorporated at pp. 213-17 of the transcript of the Congressional hearing cited in the previous footnote. The article draws heavily on the Navy's rebuttal.

receiving the Navy's response, 'news media interest quickly subsided, presumably because of the complete lack of substance to the claims contained in the report'.[48] As far as the Committee can discover, Kaplan has not made any published response to the Navy's critique of his report, although he has since repeated parts of his original allegations.[49]

5.31 This apparent lack of response would incline the Committee to prefer the Navy's version. The Committee, however, did not find it necessary to come to any conclusion as to the truth of Kaplan's allegations. This was because they concerned events not relevant to future port visits to Australia, or at best related only to waste discharges containing minimal amounts of radioactivity.

5.32 With respect to waste discharges from British nuclear powered warships, the Committee was informed: 'there have been no accidental discharges of radioactive waste, other than totally trivial amounts'.[50] The British Government has stated that, in respect of radioactive waste discharge, the Royal Navy's maintenance, operation and safety standards are no less exacting that those of the United States Navy.[51]

Relevance of the Soviet Accident Record

5.33 Some submissions referred to the Soviet Union's nuclear

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48. US, H of R, Committee on Armed Services, Subcommittee on Procurement and Military Nuclear Systems, Naval Nuclear Propulsion Program - 1984: Hearing on H. R. 5263, 28 February 1984, p. 19 (Admiral K. R. McKee).
49. e.g. D. E. Kaplan, 'Naval Reactors: The Silent Proliferation', Technology Review, April 1987, vol. 90(3), p. 10; D. E. Kaplan, 'A Chernobyl at sea haunts countries with nuclear subs', Globe and Mail (Toronto), 8 June 1987, p. A7.
50. 'UK Nuclear Powered Warships Safety Procedures', (Paper prepared for the Committee by the Australian Department of Defence, July 1988), para. 10 (Evidence, p. 1300.15). See also UK, Parliamentary Debates (Commons), 6th series, vol. 93, Written Answers, 11 March 1986, col. 426: absence of hazardous waste discharges at Holy Loch.
51. UK, Parliamentary Debates (Commons), 6th series, vol. 135, Written Answers, 17 June 1988, col. 347.

ship safety record as evidence of the lack of safety of ships visiting Australian ports.[52] The Committee did not regard this record as of assistance. In part this was because Soviet nuclear powered vessels do not visit Australian ports. In part it was because these vessels appear, on the limited information available, to be of different design and built to different standards than those of western navies.[53]

5.34 In part also it was because, while there are many references to purported Soviet accidents, the information remains fragmentary and often of doubtful accuracy.[54] It seems to be generally accepted that Soviet nuclear powered vessels are much

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52. e.g. see submissions from the Medical Association for Prevention of War (NSW), p. 2; Balmain People for Nuclear Disarmament, p. 4.
53. It seems to be generally accepted that some Soviet submarines use liquid metal as reactor coolant, a coolant-type that was rejected by the US after experience with the sodium coolant used in the USS Seawolf in the 1950s showed it suffered from safety and reliability problems: N. Friedman, Submarine Design and Development, (Conway, London, 1984), p. 134. It also seems to be generally accepted that in striking a balance between safety and reliability on the one hand and speed and deep-diving ability on the other, the Soviets emphasised the latter more than the US.
54. See for example, J. E. Oberg, Uncovering Soviet Disasters: Exploring the Limits of Glasnost, (Random House, New York, 1988), p. 69, where it is noted that many reports of Soviet nuclear powered submarine accidents derive from secondhand accounts by émigrés and 'the reliability of such hearsay reports is a major concern ...'. See also US, H of R, Committee on Armed Services, Subcommittee on Procurement and Military Nuclear Systems, Naval Nuclear Propulsion Program - 1982: Hearing on H. R. 6151, 29 April 1982, p. 19 (Admiral K. R. McKee): with respect to less-than-major reactor accidents:

> There is virtually no independent means of verifying Soviet nuclear submarine performance in releases of radioactivity to the environment, since these ships do not visit foreign countries where unbiased observation is possible and there are essentially no external, independent facts on which to judge their safety in port. This is in stark contrast when compared to the extensive U. S. nuclear powered warship record of port entry which is a matter of worldwide public knowledge. The Soviet Union has never made public any information on its its nuclear ship operations in port, occupational radiation exposures or the handling of radioactivity associated with their ships.

less safe than their western counterparts.[55] Even so, the Soviet accident record appears to contain one probable meltdown,[56] together with a further possible meltdown.[57] The uncertainty about both of these suggests that if they occurred they were contained rather than uncontained meltdowns. One might expect international monitoring to have detected the consequences of a massive uncontained accident. Moreover, if the meltdowns did occur, it seems that they did not occur during a port visit.[58]

5.35 The Committee noted the shipboard fire and sinking in international waters north of Norway on 7 April 1989 of a Soviet

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55. e.g. see N. Polmar, 'Soviet Nuclear Submarines', US Naval Institute, Proceedings, July 1981, p. 37; J. Bussert, 'The safety of Soviet nuclear submarines', Jane's Defence Weekly, 18 April 1987, p. 719. See also W. Arkin, The Nuclear Arms Race at Sea, (Neptune Papers No. 1, Greenpeace/ Institute of Policy Studies, Washington, 1987), p. 32, where it is claimed that 'the Soviet record for operations with nuclear propulsion is well-known and scandalous'.
56. The more common view is that the NS Lenin suffered a meltdown at some time in the 1960s, location unknown; e.g. J. Bussert, 'The safety of Soviet nuclear submarines', Jane's Defence Weekly, 18 April 1987, p. 718. Others take a more cautious view of the evidence of the accident, noting that a meltdown 'may have occurred': J. E. Oberg, Uncovering Soviet Disasters: Exploring the Limits of Glasnost, (Random House, New York, 1988), p. 249. See also US, H of R, Committee on Armed Services, Subcommittee on Procurement and Military Nuclear Systems, Naval Nuclear Propulsion Program - 1982: Hearing on H. R. 6151, 29 April 1982, p. 18 (Admiral K. R. McKee): 'there is strong evidence that this ship [ie. NS Lenin] experienced a nuclear related casualty [ie. not necessarily a meltdown] in the late 1960's ...'.
57. It has been suggested that the first 'Alpha' class submarine suffered a meltdown in 1970: e.g. see Bussert, ibid., p. 718. But US intelligence sources have apparently failed to confirm this: R. Hutchinson and A. Preston, 'Soviet submarine accidents - new details', Jane's Defence Weekly, 19 January 1985, p. 85; J. E. Oberg, Uncovering Soviet Disasters: Exploring the Limits of Glasnost, (Random House, New York, 1988), pp. 73, 281.
58. According to press reports, a loss of coolant accident occurred on the Soviet icebreaker, NS Rossiya, on 11 November 1988: Associated Press news dispatch, 6 March 1989 citing a report in the Soviet newspaper Vodny Transport. The accident occurred while the ship was undergoing maintenance in the port of Murmansk. One of the ship's two reactors was shut down. Coolant was mistakenly drained from the other reactor, which was still operating. According to the reports, a 30 or 40-minute supply of backup coolant was available for use before a melt down would have occurred, and remedial action was taken within 4 minutes. The incident is not relevant to nuclear powered vessel visits to Australian ports, as no reactor repair or maintenance activities take place during these visits: see condition (a) of the Australian conditions of entry (see para. 2.20).

nuclear powered and armed submarine.[59] The Committee also noted the reported comments of Norwegian scientists that their tests had not detected any increased radioactivity in the water or atmosphere where the sinking occurred.[60] Norwegian experts are also reported as saying that there is little chance of a radiation hazard from the sunken submarine.[61] It appears from reports that the fire was not related to either the reactors or the nuclear weapons, and the reactors were safely shut down before the crew abandoned the sinking vessel.

5.36 The reported circumstances of this accident[62] have not led the Committee to alter its conclusions expressed elsewhere in this report, which addresses matters associated with periodic visits to Australian ports by nuclear armed ships from the navies of Australia's allies.

5.37 However, the Committee takes the view that the Australian Government should seek the most comprehensive information available on this accident both from its allies and

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59. According to reports the submarine was a one-of-a-kind attack type, designated by western analysts as a 'Mike' class. It was used for experimental purposes, was powered by two reactors, and used liquid metal for reactor coolant, unlike the pressurised water used as coolant in western naval reactors. Western experts regard the use of liquid metal as entailing greater accident risks than pressurised water: e.g. see footnote 53 in this chapter.

60. e.g. see 'Radiation tests after super-secret Soviet sub sinks', Sydney Morning Herald, 10 April 1989, p. 13; 'Up to 60 die as Soviet N-sub sinks', Age, 10 April 1989, p. 9.

61. ibid. cf. 'A Soviet Nuclear Sub Catches Fire And Reportedly Sinks Off Norway', New York Times, 8 April 1989, p. 5: retired US admiral E. J. Carroll jr cited as saying that the sinking should pose no immediate environmental hazard, but the danger of contamination in the longer term was greater, as the reactor vessel and fuel covering deteriorated due to the effect of sea water. See also 'Radiation leak is inevitable: report', Sydney Morning Herald, 3 May 1989, p. 10 for a similar claim.

62. e.g. that it occured at sea rather than during a port visit; to a vessel of a Navy whose nuclear powered vessels do not visit Australian ports; to an experimental vessel; to a vessel whose reactors are cooled in a way that experts recognise entails a greater accident risk than the system used on vessels likely to visit Australian ports; that the cause of accident is reportedly not nuclear-related; that the reactors were safely shut down following the accident; and that no increase in background radiation levels occurred as a result of the accident.

from the Soviet Union. If information emerges that requires alteration of Australian arrangements, the Australian plans should be amended accordingly.

Non-Nuclear Mishaps to Nuclear Powered Warships

5.38 An approach taken in some submissions was to refer to mishaps involving United States nuclear powered warships but not affecting their reactors.[63] Publicly reported examples include events such as collisions with other ships,[64] strandings or

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63. e.g. see the submission from the Coalition Against Nuclear Armed & Powered Ships, p. 4 (Evidence, p. 1376), discussed in Evidence, pp. 1393-94 (Coalition Against Nuclear Armed & Powered Ships).
64. According to media reports, in 1969 the nuclear powered submarine USS Gato was struck at a 90 degree angle on the reactor compartment while submerged by a Soviet submarine travelling at about 7 knots: 'A False Navy Report Alleged in Sub Crash', New York Times, 6 July 1975, pp. 1, 26. Collisions serious enough to sink the other vessel have also been reported: e.g. 'Submarines of U. S. Stage Spy Missions Inside Soviet Waters', New York Times, 25 May 1975, pp. 1, 42 (North Vietnamese minesweeper sunk); 'U. S. Sub Rams, Sinks Japanese Cargo Vessel', Los Angeles Times, 12 April 1981, section 1, pp. 1, 34; Stockholm International Peace Research Institute, World Armaments and Disarmament: SIPRI Yearbook 1977, (MIT Press, Cambridge, Mass., 1977), p. 69 (merchant ship sunk) and p. 70 (tug sunk). For reports of other collisions not involving sinkings see for example, SIPRI, ibid., pp. 68-70; 'Collision of U. S. and Soviet Subs off Siberia in 1974 is Recounted', New York Times, 4 July 1975, p. 21 (following 'almost head-on' collision, repairs to USS Pintado took 7 weeks in dry-dock). The extent to which these reported events have been officially acknowledged varies.

groundings,[65] shipboard explosions and fires,[66] and other incidents.[67] The only one of these reported to have occurred during an Australian port visit was the collision with a wharf at Brisbane in July 1983 by the USS Texas.[68] The implicit suggestion was that the accidents had posed or might have posed a nuclear hazard. However no evidence was cited that this was the case.

5.39 It can be argued that these accidents indicate, contrary to the views of those referring to them, that nuclear powered vessels can be involved in quite severe conventional accidents

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65. e.g. 'Submarines of U. S. Stage Spy Missions Inside Soviet Waters', New York Times, 25 May 1975, p. 42 (US submarine aground in Soviet waters for two hours); 'Return of Carrier Enterprise to San Francisco Bay Proves Sticky Situation', Los Angeles Times, 29 April 1983, part 1, p. 18 (carrier aground for several hours trying to enter home port of Alameda); UK, Parliamentary Debates (Commons), 6th series, vol. 97, Written Answers, 9 May 1986, col. 266; vol. 106, Written Answers, 24 November 1986, col. 76; and vol. 106, Written Answers, 1 December 1986, col. 440 (USS Nathaniel Greene ran aground in the Irish Sea, sustaining major damage); 'Atomic Craft Aground Off Washington Coast', New York Times, 1 May 1988, p. A38 (submarine USS Sam Houston aground for 10 hours).
66. e.g. 'Blast on Atom Submarine Kills One: Damage Heavy', New York Times, 16 June 1960, p. 5 (oxygen explosion and fire in aft torpedo room of USS Sargo; room flooded to prevent further explosions); '24 Die, 85 Hurt on Carrier Enterprise As Blasts Follow Fire on 2 Plane Decks', New York Times, 15 January 1969, pp. 1, 40 (rockets, bombs and 20mm amunition explode in fires); 'Jet Crashes on Deck of Carrier; 14 Die, 48 Hurt', Los Angeles Times, 28 May 1981, pp. 1, 10 (fire on USS Nimitz took 70 minutes to extinguish).
67. The most detailed list of accidents presented to the Committee was that in the submission from Greenpeace Australia (NSW) Ltd, pp. 20-22. See also Stockholm International Peace Research Institute, World Armament and Disarmament: SIPRI Year Book 1977, (MIT Press, Cambridge, Mass., 1977), pp. 68-70 for a table of nuclear weapon incidents which includes over 20 fires, collisions, etc., on US nuclear powered vessels. These listings are best seen as relating to allegations of accidents and incidents, rather than confirmed occurrences. The seriousness of the events listed also varies widely.
68. See for example submissions from Coalition Against Nuclear Armed & Powered Ships, p. 4 (Evidence, p. 1376); Friends of the Earth, p. 1. See also Evidence, p. 1393 (Coalition Against Nuclear Armed & Powered Ships). Media reports suggested the the USS Pintado nearly ran aground on rocks during a 1981 visit to HMAS Stirling; e.g. see the West Australian, 27 June 1988, p. 1, 'Tug saved N-sub during storm'. But the captain of a tug at the scene was reported as saying that the incident was being over-dramatised and that it would never have led to a nuclear incident: Canberra Times, 28 June 1988, p. 1, 'WA Government questions report of N-ship mishap'.

without any nuclear accident eventuating.[69] These conventional accidents tend to bear out the claim that the design and construction of nuclear powered warships incorporates a safety margin for combat stresses, battle damage, depth charging and the like. This margin assists in withstanding peacetime navigational hazards.

Accidents to Land-Based Reactors

5.40 Some submissions referred to the accident record of land-based reactors.[70] The differences between these reactors and naval reactors were set out in the previous chapter. The Committee took the view that, due to these differences, the accident record relating to land-based reactors was very much a second-best in the context of assessing the safety of naval reactors. Because of the extensive record relating directly to naval reactors, the Committee saw little need to consider the land-based reactor accident record as such in any detail.[71]

5.41 Briefly, the Committee notes, however, that there has never been an uncontained meltdown involving a land-based pressurised water reactor - that is, the type of reactor in use in western navies.[72] There has been only one contained core meltdown in such a reactor, that at the Three Mile Island reactor

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69. cf. Evidence, p. 1393 (Coalition Against Nuclear Armed & Powered Ships).
70. e.g. submissions from Mr R. Bolt, pp. 7-8 (Evidence, pp. 957-58); Scientists Against Nuclear Arms (WA) and Medical Association for the Prevention of War (WA), p. 8 (Evidence, p. 794); Scientists Against Nuclear Arms (Tas), p. 3 (Evidence, p. 822). See also for example Evidence, pp. 979-80 and 981 (Mr R. Bolt).
71. The types of accidents that have occurred in land-based reactors are, of course, relevant to consideration of the types of accidents that may occur to naval reactors. But this is a diferent issue to the use of the accident frequency history of one type of reactor to assess the possible frequency of accidents to another.
72. See the table of reactor accidents that involved core damage in M. Eisenbud, Environmental Radioactivity from Natural, Industrial, and Military Sources, (3rd edn., Academic Press, Orlando, Fla., 1987), p. 225.

in 1979.[73]

5.42 Because so many submissions referred to the 1986 reactor accident at Chernobyl it is helpful to indicate the very limited ways in which the Committee saw that accident as relevant to its inquiry.[74] The accident indicates in a very general way that official statements by experts that an accident is unlikely may not be be borne out by events.[75] Similarly, it indicates that reactor operators cannot always be relied upon to follow safety rules. The fact that explosions occurred as the accident developed needs to be examined in evaluating possible accident scenarios for naval reactors. The consequences of the accident are of some relevance to assessing the consequences of a meltdown in an Australian port, were it to occur.

5.43 But beyond these points, the Committee saw the Chernobyl accident as having little bearing on its inquiry. The Chernobyl reactor, unlike the reactors on warships visiting Australian ports, did not have complete containment as part of its design. Moreover, it is physically impossible for the type of accident that occurred to the graphite-moderated reactor at Chernobyl to

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73. cf Evidence, pp. 404-05 (ANSTO): '... in terms of history the event that has come closest to the reference accident we have used in our berth assessment was in fact Three Mile Island'. During 1988 media publicity was given to reports of accidents, some apparently involving damage or potential damage to fuel, at the US Department of Energy's Savannah River complex: e.g. see Australian Financial Review, 4 October 1988, p. 54, 'Accidents at nuclear plant in US kept secret'. The reactors involved are cooled and moderated by heavy water, not the light water used in naval reactors, and are designed for the production of plutonium and tritium, not power generation: see generally T. B. Cochran and others, Nuclear Weapons Databook, Volume II: U. S. Nuclear Warhead Production, (Ballinger, Cambridge, Mass., 1987), pp. 60-70.

74. cf. Evidence, pp. 994-95 (Mr R. Bolt).

75. As a matter of strict logic an estimate that a particular accident will happen only once in, say, 10,000 years is not falsified if the accident happens tomorrow. Assuming the accident is a random event and that the estimate is correct, the single accident is just as likely to happen tomorrow as on any other day in the 10,000 year period. But the occurrence so early in the period intuitively leads to serious doubt as to the accuracy of the original estimate. See generally Evidence, p. 392 (ANSTO); pp. 686-87, 689 (Dr T. P. Speed).

occur to a pressurised water reactor.[76] There is no justification for including in the accident record relevant to naval reactors an accident that cannot occur to those reactors.[77]

5.44 The Committee was referred to projections that have been made of the likelihood of a serious land-based reactor accident derived from the historical accident record of such reactors.[78] The methodology of these studies differs in some respects from the theoretical quantitative risk assessment studies referred to in chapter 3. It was put to the Committee that these projections should be used to estimate the probability of a serious accident occurring to a naval reactor.

5.45 The Committee did not consider the accident record of land-based reactors to be a helpful basis upon which to assess the likelihood of a naval reactor accident. The directly relevant record showing the absence of serious accidents involving United States Navy reactors is available. There is no need to refer to what can in this circumstance only be a second-best source.

5.46 In addition, any attempt to use the historical accident record of land-based reactors encounters the threshold difficulties of what reactor types should be considered

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76. M. Eisenbud, Environmental Radioactivity from Natural, Industrial, and Military Sources, (3rd edn., Academic Press, Orlando, Fla., 1987), p. 377. This is because a graphite moderator does not have the self-regulating effect of a water moderator (this effect is explained at para. 4.5 above), but instead an increase in power level can make the core more reactive. In other words, the core power level is inherently unstable and requires operator or automatic control. Control was lost at Chernobyl due to a combination of circumstances, a very rapid power increase occurred, and explosions followed.
77. cf. Evidence, p. 443.448 (ANSTO). Another reason why the Chernobyl accident is of little relevance to assessing the possiblity of a naval reactor accident is that the former occurred during an experiment, yet experiments are not permitted during port visits to Australia.
78. e.g. submissions from Scientists Against Nuclear Arms (WA) and Medical Association for the Prevention of War (WA), p. 8 (Evidence, p. 794); Scientists Against Nuclear Arms (Tas), p. 3 (Evidence, p. 822).

relevant,[79] what allowance should be made for the many differences between land-based and naval reactors,[80] and how to exclude accident categories not relevant to port visit conditions.[81] Further difficulties arise with respect to particular historical studies.[82] Allowance needs to be made for what is widely accepted as the major increase in the safer operation of commercial reactors in the United States since the

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79. A number of submissions referred to a 1986 calculation based on actual accidents which showed the probability that a major reactor accident could happen during the next ten years was 86%: S. Islam and K. Lindgren, 'How many reactor accidents will there be?', Nature, 21 August 1986, vol. 322, p. 691. The mathematics of the calculation generated correspondence; letters in Nature, 4 December 1986, vol. 324, p. 417 and 18 December 1986, vol. 324, p. 622. Whatever the merits of the mathematics, the conclusion has little relevance to naval reactors because it was based on two accidents, one of which was Chernobyl: see Evidence, p. 433.448 (ANSTO). See also above, paras. 5.42-5.43 on the relevance of Chernobyl.
80. See the previous chapter for these differences.
81. e.g. accidents happening during reactor refuelling, reactor repairs, acceptance trials, none of which activities occur during port visits to Australia.
82. e.g. Mr R. Bolt referred the Committee to a study based on the historical record relating to land-based reactors licensed by the Nuclear Regulatory Commission: submission, pp. 8, 9-10 (Evidence, pp. 958, 959-60) and Evidence, pp. 981, 993-94. He suggested that this study indicated that the risk of a major reactor accident was far more likely that that indicated by theoretical risk assessments. However, the preface to the report of the study states:

> Inevitably, the results of this report will be compared with the data in the Reactor Safety Study (WASH-1400) and other probabilistic risk assessment studies. Although the casual reader may interpret ... [this report's] results as incompatible with other core damage estimates, it is quite likely that because of the statistical uncertainty, no significant difference exists. That, of course, remains to be demonstrated.

J. W. Minarick and C. A. Kukielka, Precursors to Potential Severe Core Damage Accidents: 1969-1979 - A Status Report, (Oak Ridge Nat. Laboratory for the Nuclear Regulatory Commission, NUREG/CR-2497, June 1982), vol. 1, p. viii. A follow-up based on later data and reviewers' comments on the initial report showed a decrease by a factor of ten in the likelihood of severe core damage compared to the original reported results: W. B. Cottrell and others, Precursors to Potential Severe Core Damage Accidents: 1980-1981 - A Status Report, (Oak Ridge Nat. Laboratory for the Nuclear Regulatory Commission, NUREG/CR-3591, July 1984), p. xxvi. 'Likelihood of damage' as used in these reports has a specific, defined meaning.

Three Mile Island accident in 1979.[83] Past accidents, while unfortunate, have provided costly lessons that nonetheless add to current safety.

Conclusions

5.47 The Committee accepts that, as a matter of logic, the fact that an accident has not yet happened does not prove in any absolute sense that it will not happen tomorrow. However, the safety record of United States Navy reactors extends over a large number of reactors across more than thirty years. In the Committee's view this safety record provides very persuasive evidence that the probability of any accident involving a significant release of radiation during a visit to an Australian port is extremely small.

5.48 At the same time the Committee recognises that reactor accidents are classed as rare events. Because of this it is prudent not to rely exclusively on the historical record, even the present safety record extending for over three thousand reactor-years.[84] Some regard for the theoretical accident likelihood is also appropriate and this is considered in chapter 7.

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83. e.g. US, Nuclear Regulatory Commission, Reactor Risk Reference Document, (NUREG-1150 (draft), NRC, Washington, 1987), p. ES-1: as a result of the Three Mile Island accident, 'numerous modifications to U. S. light-water reactor plant designs and operating procedures were made'.
84. As a very rough guide to the degree to which the historical record is not a reliable means of assessing accident probability and outcome, one study has suggested in passing that if something like 50,000 reactor-years of commercial operation had taken place direct reliance on the historical record would yield more accurate results than theoretical approaches: W. B. Cottrell and others, Precursors to Potential Severe Core Damage Accidents: 1980-1981 - A Status Report, (Oak Ridge Nat. Laboratory for the Nuclear Regulatory Commission, NUREG/CR-3591, July 1984), p. 2-3. It might be expected that the naval reactor-years required would be somewhat less as there are far fewer naval reactor designs and types, and less variation in operating standards.

CHAPTER 6

VISITS BY NUCLEAR POWERED WARSHIPS: ARRANGEMENTS IN OTHER COUNTRIES

INTRODUCTION

6.1 The Committee attempted to discover the extent to which visits by nuclear powered warships to ports in other countries were subject to environmental monitoring and to the existence of contingency plans for reactor accidents. The position in the United States and the United Kingdom was of particular interest. It would be reasonable to assume that decisions by the national governments there on the need for, and extent of, planning and monitoring would have been made in the light of full knowledge of the design and operating procedures of their own nuclear powered warships.

6.2 The position in other countries was seen as less significant in that decisions in these countries would presumably have been based on no better information than that available to the Australian Government or to the Committee.

6.3 It was argued that contingency planning for visits to Australian ports should be at least as extensive as that which exists for the ports of the countries to which the vessels belong.[1] The Committee accepted this, provided the distinction was drawn between visits of the limited type which take place to Australian ports, and port or dockyard visits which occur in the warships' home countries. Because reactor repairs, refuelling, testing, etc. may occur during the latter, the accident risks are

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1. e.g. submission from Scientists Against Nuclear Arms (Tas), p. 7 (Evidence, p. 826).

greater. Planning for these risks would not be required in Australia.

UNITED KINGDOM

Requirement for Plans

6.4 The Department of Defence told the Committee:

> The UK view is that the safety record and stringent design and operational controls exercised do not make it necessary for the host nation to have contingency plans to cover short, occasional visits during which no work is done on the nuclear propulsion plant.[2]

6.5 However, the British Government has stated that plans exist for all United Kingdom ports receiving visits:

> Safety schemes, detailing procedures and protective measures to be implemented in the unlikely event of an accidental release of radioactive material from a submarine are drawn up to cover the areas of all naval bases and other berths used by such vessels in the United Kingdom. These are produced in consultation with the appropriate local authorities, emergency services and other civilian agencies with a direct involvement, all of whom hold copies.[3]

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2. 'UK Nuclear Powered Warships Safety Procedures', (Paper prepared for the Committee by the Australian Department of Defence, July 1988), para. 3 (Evidence, p. 1300.13).
3. UK, Parliamentary Debates (Commons), 6th series, vol. 129, Written Answers, 9 March 1988, col. 216. Not all the plans appear to have been made public in full, although elements of them have been publicly described: e.g., ibid., vol. 113, Written Answers, 23 March 1987, col. 4; ibid., vol. 128, 3 March 1988, cols. 1199, 1211; 'N-Sub Minutes from Disaster', Observer (London), 14 February 1988, p. 1; 'Nuclear submarine safety measures', Independent (London), 16 July 1987, p. 5. Copies of the Devonport plan have been put in local public libraries, reportedly on the basis that, while it is unclassified, access to it should be limited to persons concerned with public safety on a need to know basis: 'Everyman's guide to doomwatch at Devonport', Guardian (London), 16 July 1987, p. 2.

6.6 It appears that no British port is cleared to receive casual visits from nuclear powered warships unless a safety scheme is in place for that port.[4]

6.7 The Royal Navy's Flag Officer, Plymouth, Vice Admiral Sir John Webster KBE, RN, greatly assisted the Committee by making copies of two of the plans available to it. One related to the naval base at Devonport and the other to the port of Liverpool, which receives occasional visits of the type made to Australian ports.[5]

Scope of the Liverpool Plan

6.8 In broad terms the Liverpool safety scheme is comparable to the Western Australian port safety scheme. Like the latter, the document setting out the Liverpool scheme is not completely self-contained but links to other documents and plans. There are,

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4. UK, Ministry of Defence, Liverpool Special Safety Scheme for Visits to Liverpool by Nuclear Powered Submarines, (April 1986), para. 28 states with reference to category Z (ie. casual visit) berths:

> A special safety scheme appropriate to the characteristics of the berth is written by the responsible area flag officer in consultation with the Chairman, Naval Nuclear Technical Safety Panel (CNNTSP) and the local naval and civil authorities. Once agreed, the scheme is issued by the area flag officer and the berth is then available for use.

ibid., para. 30 provides:

> A fully equipped NEMT [Naval Emergency Monitoring Team] is to be co-located at Z berths in England and Wales when occupied by a nuclear powered warship. ... Before approval is given for a nuclear powered warship to visit a category Z berth, CNNTSP must be satisfied that the arrangements contained in the appropriate safety orders can provide the necessary protection for the general public, and can be implemented satisfactorily.

5. British planning categorises berths as X or Z depending on whether they will be used for building, refitting, repairing, or for operational, rest and recreational purposes: UK, Ministry of Defence, Liverpool Special Safety Scheme for Visits to Liverpool by Nuclear Powered Submarines, (April 1986), para. 27. Devonport has X berths while Liverpool has Z berths. The UK port that received the most occasional visits from UK nuclear powered submarines in the period 1970-1988 was Liverpool (29 visits): UK, Parliamentary Debates (Commons), 6th series, vol. 129, Written Answers, 9 March 1988, col. 216. Statistics for visits of this type by foreign nuclear powered warships are not available: ibid.

not surprisingly, many differences of detail and the more significant of these are noted in the relevant contexts in later parts of the report.

6.9 Here it is sufficient to discuss two of the more general differences. First, unlike the Australian plans, the Liverpool plan does not use the terminology of a reference accident as a basis for planning, although to a considerable extent this difference is one of terminology only. Secondly, the Liverpool plan does not call for the use of pre-positioned radiation detection monitors to provide notice of an accident.

References to Uncontained Accidents

6.10 The Liverpool plan identifies for its purposes two conceivable accidents. First, it identifies as 'a very remote possibility' a contained accident involving core meltdown resulting from a large uncontrolled primary coolant leak.[6] This corresponds approximately to the reference accident which forms the basis of Australian plans.[7]

6.11 The plan states that the contained accident may result in the release from the primary to the secondary containment of iodine 131, together with other volatile and gaseous fission products over a period of 24 hours. It also states, however, that secondary containment procedures ensure that only a small proportion of this release will reach the atmosphere.[8] The Australian Nuclear Science and Technology Organisation (ANSTO) makes the pessimistic assumption that there will be no

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6. UK, Ministry of Defence, Liverpool Special Safety Scheme for Visits to Liverpool by Nuclear Powered Submarines, (April 1986), paras. 11 and 5. See also para. 15: the 'probability of this accident occurring is predicted at about once in 10,000 years of reactor operation'.
7. It is not possible to say that they are identical because the Liverpool plan does not state what leakage rate from containment is assumed. Nor does it state the core inventory or release fractions.
8. ibid., para. 15. The meaning of 'secondary containment' is explained in para. 4.63 above.

attenuation of the release due to secondary containment.[9]

6.12 In addition to this contained accident, the Liverpool plan identifies as 'an even less likely accident' the 'sudden and complete failure of the primary coolant system concurrent with a breach of the primary containment'.[10] It states that this uncontained meltdown accident may result in the release to the atmosphere within one hour of a greater quantity of the same material.[11]

6.13 Following the contained accident, the plan defines an evacuation distance comprising a zone of 550 metres radius centred on the submarine. Outside this zone, no countermeasures are necessary to prevent individuals exceeding the upper level of the emergency reference level of exposure, even if they are directly downwind from the accident.[12]

6.14 This 550 metre zone compares with the 600 metre radius Zone 1 specified in Australian plans. However, Australian plans call for a Zone 2 of up to 2.2 kilometres radius around the accident site. The limit of this zone represents the limit of the area considered by Australian authorities to be one in which a risk from inhalation hazard might exist following the reference accident.[13] The Australian plans assume that protective measures may be required in this zone. The size of zone two, therefore, is

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9. Evidence, p. 383 (ANSTO).

10. ibid., para. 6. See also para. 16: the 'probability of this accident occurring is predicted at about once in 1,000,000 years of reactor operation'.

11. ibid., para. 16. The quantities are not stated in the plan but are provided in UK, Parliamentary Debates (Commons), 6th series, vol. 112, Written Answers, 20 March 1987, col. 635 (Evidence, p. 1300.19) as 1,000,000 Curies of iodine 131 and 10,000,000 Curies of other volatile and gaseous fission products. The context makes clear that the former figure is a misprint, and should be 100,000. The quantities released are thus 100 times greater than those released from the contained accident described in Liverpool plan. ANSTO used a similar ratio of releases from its reference accident and an uncontained accident: see para. 7.13 below.

12. ibid., para. 23(c).

13. OPSMAN 1 (2nd edn.), Chapter 4, Annex B, para. 3 (Evidence, p. 93).

a measure of the extent to which Australian plans are more conservative (ie. safety-oriented) than the Liverpool plan.

6.15 For the far less likely uncontained accident, the Liverpool plan states that countermeasures may be required in the downwind sector out to as far as 10 kilometres. The probability of any risk to individuals further downwind is regarded as so remote that no planning is required for beyond the 10 kilometre distance.[14]

6.16 The plan provides that, following an uncontained accident, the area affected beyond the 550 metre evacuation distance is to be delineated by monitoring, and stable iodine tablets are to be distributed.[15] Because an uncontained accident could involve a rapid release of short duration, sheltering is not considered to be an appropriate automatic countermeasure, as the hazard will have passed before the people can be notified. Evacuation to avoid the airborne radiation hazard is not envisaged. Monitoring would be used to assist in deciding if evacuation was needed to prevent individuals exceeding an emergency reference level due to ground deposition of fission products.

6.17 Apart from these provisions, the accident response elements of the Liverpool plan are not specifically directed to an uncontained accident. The plan states:

> For the purposes of contingency planning, it is Ministry of Defence policy to assume that all accidents have consequences as severe as the Maximum Design [ie. contained] Accident.[16]

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14. UK, Ministry of Defence, Liverpool Special Safety Scheme for Visits to Liverpool by Nuclear Powered Submarines, (April 1986), para. 23. Milk and pastures would be monitored beyond 10 km, however: para. 24(d).
15. ibid., para. 24(c).
16. ibid., para. 24. Contrast UK, Parliamentary Debates (Commons), 6th series, vol. 140, Written Answers, 10 November 1988, col. 303: exercises held to test the Clyde area public safety scheme 'envisage a range of accidents greater than the maximum design accident in order to examine the consequences outside the naval base of such accidents'. This scheme covers areas around the US and UK nuclear powered submarine bases on the Clyde.

6.18 Thus the specific focus is on a contained accident, although much of the response structure for which provision is made would be applicable to either a contained or uncontained accident.[17] In this sense the Liverpool plan is best described as a plan based on a contained accident.[18]

6.19 The Committee asked ANSTO for its view on how the Liverpool plan compared to Australian plans based on a single reference accident. The Committee was told that there were differences in terminology and detail. However:

> In practical terms ... the Liverpool Special Safety Scheme and the Australian port safety schemes are very similar: automatic implementation of countermeasures upon notification of an accident, within 550 or 600 metres, and monitoring to determine the need for countermeasures beyond these distances.[19]

6.20 It is also possible to compare in a number of ways the consequences of the accident used as the basis of the Liverpool plan with the reference accident used as the basis of the Australian plans. ANSTO told the Committee that one measure, the dose to the child thyroid at 600 metres from the vessel, indicates that the Australian reference accident is an order of magnitude more severe in terms of consequences than the contained accident used as the basis of the Liverpool plan.[20]

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17. e.g. the provision for distribution of potassium iodate tablets makes detailed arrangements for the dock area, adjacent ships, tugs, etc. If these arrangements are followed, little of the total stock of 14,000 tablets (adult dose = 2 tablets) would be available for distribution outside the 550 metre zone: see para. 42(j). However the form of the leaflet to accompany distribution is applicable to householders with infants and older children: Annex 3F. Thus it could be used in a wider distribution, possibly using stocks of tablets not identified in the plan: cf. UK, Parliamentary Debates (Commons), 6th series, vol. 146, Written Answers, 7 February 1989, col 667. On the role of potassium iodate as a protective measure following a reactor accident, see chapter 9.
18. cf. Letter from Mr J. E. Cook (ANSTO), 1 September 1988 (Evidence, p. 1300.41): the Liverpool plan 'requires no actions specifically based on the presumption of an uncontained accident'.
19. ibid., pp. 1300.41-42.
20. ibid., p. 1300.42. for the calculation leading to this result.

Comparison of Monitoring Arrangements

6.21 Australian plans provide for continuous monitoring during the port visit of a nuclear powered warship. This provides a means independent of the warship's crew of detecting any significant reactor accident that might occur. In contrast, the Liverpool plan provides that monitoring is to begin as soon as an accident occurs.[21] Although not stated in the plan, it appears that the crew are relied upon to provide accident notification.

6.22 The Liverpool plan makes no provision for monitoring to detect low-level waste discharges. The Department of Defence conducts marine environmental monitoring at Royal Navy bases and around the United States base at Holy Loch on the Clyde, but not, it seems, at other ports.[22] It appears that no monitoring specifically directed at low-level nuclear wastes occurs in relation to nuclear powered warship visits to these other ports.

UNITED STATES

Absence of Plans?

6.23 The Committee asked the United States Embassy in Canberra if it could provide information relating to, amongst other things, safety plans for visits by nuclear powered warships to United States ports, other than ports where reactor repairs and maintenance, fuel handling, etc. occur.[23] No direct response

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21. UK, Ministry of Defence, Liverpool Special Safety Scheme for Visits to Liverpool by Nuclear Powered Submarines, (April 1986), para. 24(c).
22. UK, Parliamentary Debates (Commons), 6th series, vol. 108, Written Answers, 15 January 1987, col. 307. But contrast ibid., vol. 135, Written Answers, 17 June 1988, col. 346: Ministry of Defence also monitors UK territorial waters, as does the Ministry of Agriculture, Fisheries and Food.
23. Letter to the US Ambassador, Mr L. W. Lane jr, 17 February 1987. The fact that no reply had been received was noted when the request was made again on 18 February 1988.

was received.[24]

6.24 The naval attaché at the Embassy, however, confirmed to the Department of Defence that:

> It is the policy of the US Navy that individual communities, domestic or international, need not prepare specific accident plans for the occasional visits of US nuclear powered or capable warships. We believe commonly prepared civil disaster preparedness plans such as those dealing with fires, floods, hurricanes, etc, are appropriate and sufficient adjuncts to the Navy's internal plans. For this reason, we do not consult with agencies choosing to develop their own specific plans and neither comment [on] or evaluate the technical adequacy of such plans.
>
> Some communities in the USA have allegedly prepared specific plans for visits by USN warships. Where existing, these were prepared in isolation from the USN and I cannot speculate on any aspect of their content.
>
> Please note that the use of the term 'occasionally' is intended to differentiate from ports where numbers of warships may be home ported.[25]

6.25 At homeports, reactor-related activities will presumably occur which will not occur during visits to Australian ports. ANSTO told the Committee that it understood that berth assessment at US ports was based on radiological acceptance limits used for land based nuclear plants, modified to allow credit for vessel

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24. To an earlier, more general, request by the Committee made on 13 October 1986, the US Ambassador replied on 5 November 1986:

> the Government of the United States has passed relevant material on our nuclear-powered warships to the Government of Australia. Officials of the Government of Australia would, therefore, be appropriate sources for inquiry.

25. Advice from the US Navy attaché, Canberra to the Department of Defence, 20 October 1988 (Evidence, p. 1300.48). Advice previously given to the Committee by ANSTO was to the same effect (Evidence, p. 443.463). For earlier press reports of the US view that specific safety plans are not required for occasional visits see; 'Further call for Burke to detail plans', West Australian, 19 July 1986; 'Crisis plan not needed - U. S.', West Australian, 22 July 1986, p. 14.

removal: no distinction was made between differing reactor power levels.[26]

Environmental Monitoring

6.26 The United States Navy currently 'conducts environmental monitoring in harbors frequented by its nuclear-powered ships'.[27] The inference is that monitoring is not regarded as necessary for ports used only occasionally. The Committee has not been able to locate any information that contradicts this inference. Civilian agencies have also monitored ports in the United States used frequently by United States nuclear powered warships. These 'agencies generally have not considered monitoring of all places used by nuclear powered warships necessary since the surveys performed have found no environmental concern'.[28]

Bar on Visits to Some Cities?

6.27 A few submissions suggested that nuclear powered warships were banned from visiting some major cities in the United States for safety reasons. New York and Boston were mentioned.[29] In response to a similar suggestion made in a Perth

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26. Evidence, p. 443.463 (ANSTO). See also Evidence, p. 1300.48 (Department of Defence).
27. US, Department of the Navy, Environmental Monitoring and Disposal of Radioactive Wastes from U. S. Naval Nuclear Powered Ships and their Support Facilities 1987, (NT-88-1, February 1988), p. 19. This report is part of an annual series. In the year covered by it, 1987, monitoring was done at 23 berth areas within 14 harbours. Within Pearl Harbour, for example, 3 separate areas were monitored. All harbours were within US territory. In previous years, the US Navy has monitored bases used by it in other countries; in the 1960's Rota in Spain and Holy Loch in Scotland were monitored: US Congress, Joint Committee on Atomic Energy, Naval Nuclear Propulsion Program - Hearing, 26 January 1966, p. 71.
28. US, H of R, Committee on Armed Services, Subcommittee on Procurement and Military Nuclear Systems, Naval Nuclear Propulsion Program - 1984: Hearing on H. R. 5263, 28 February 1984, p. 201, Appendix D ('Discussion of Allegations Contained in Article "The Nuclear Navy") (Evidence, p. 1300.68).
29. e.g. see the submissions from the Victorian Government, p. 6; Miss E. Ruzicka, p. 6; Australian Nuclear Free Zones Secretariat, p. 2; United Associations of Women. p. 1.

newspaper in 1986, the United States consulate in Perth provided a detailed response.[30] This stated that legally any US warship can visit any US port at any time. While for many ports there has been no operational requirement for nuclear powered vessels to visit, such visits had been made to Long Island and to Earle, New Jersey near New York.[31] Examples were given of other ports in major metropolitan areas in the United States which had received visits from nuclear powered warships.[32] Port visits apart, some United States nuclear powered warships have their home ports in or near major cities, such as Oakland and San Diego.[33] In addition, the nuclear powered merchant ship, NS Savannah, was a frequent visitor to New York in the 1960's.[34]

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30. 'No New York ban on N-warships', West Australian, 22 July 1986.
31. See to the same effect US, H of R, Committee on Armed Services, Sub-committee on Military Installations and Facilities, Civil Defense Aspects of the Three Mile Island Nuclear Accident - Hearings, 14 June 1979, p. 239 (Dr J. P. Wade, Department of Defense). With respect to visits to Boston, the nuclear powered cruiser USS Bainbridge was commissioned at Boston Navy Yard: 'U. S. Commissions Nuclear Cruiser', New York Times, 10 September 1961, section 5, p. 11. For the 1962 goodwill visit to Boston of the nuclear powered aircraft carrier USS Enterprise see N. Polmar and T. B. Allen, Rickover, (Simon and Schuster, New York, 1982), p. 625.
32. See also for example US, H of R, Committee on Foreign Affairs, Sub-committee on Asian and Pacific Affairs, Security Treaty between Australia, New Zealand, and the United States - Hearing, 18 March 1985, p. 171 (P. Wolfowitz, State Department and J. A. Kelly, Department of Defense): no ports in the US which Navy needs to visit that it cannot - nuclear powered ships visit all kinds of ports, including those in heavily populated areas.
33. See US, Department of the Navy, Environmental Monitoring and Disposal of Radioactive Wastes from U. S. Naval Nuclear Powered Ships and their Support Facilities 1987, (NT-88-1, February 1988), pp. 40-41 for a list of ports frequented. See also A. M. Brown and R. O'Rourke, 'Ports for the Fleet', US Naval Institute, Proceedings, May 1986, p. 140, for a complete list of US Navy homeports as at 31 July 1985. Four nuclear powered surface ships are listed as being homeported at Alameda on San Francisco Bay and two more at San Diego. For an earlier list of examples, see Australia, Environmental Considerations of Visits of Nuclear Powered Warships to Australia, (May 1976), para. 66 (Evidence, p. 147).
34. e.g. 'The Savannah, First Atom-Powered Merchant Ship, Gets Noisy Welcome', New York Times, 3 June 1964, p. 1 (berthed at pier at W44th Street, Manhattan); 'Tests of Savannah May Be Her Last', New York Times, 16 April 1967, p. 80 (berthed at pier at W44th Street, Manhattan for safety inspection, including tests involving entry into reactor compartment); 'A Nuclear Fleet For Cargo Urged', New York Times, 20 April 1968, p. 66 (W44th Street berth used).

6.28 There was a view held by some officials in the United States in the late 1950's that goodwill visits were not sufficiently important to warrant the risk involved in visits to ports in populated areas.[35] The Committee has not been able to discover any evidence that this view survived in official quarters once the safety record of nuclear powered warships was clearly demonstrated.[36]

OTHER COUNTRIES

Nuclear Powered Warships

6.29 United States nuclear powered warships visit over 150 ports around the world.[37] The Committee has been unable to discover any country that does not permit port visits[38] by these

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35. See US Congress, Joint Committee on Atomic Energy, Naval Reactor Program and Polaris Missile System - Hearing, 9 April 1960 for extracts from correspondence from the Advisory Committee on Reactor Safeguards (p. 17) and Dr Edward Teller (p. 37) to this effect, and for testimony by Vice Admiral H. G. Rickover that he supported the instructions issued by the Chief of Naval Operations that there must be an actual military or national necessity before a nuclear ship can go into a populated harbour (p. 19). For the way in which Rickover's view was effectively overruled see N. Polmar and T. B. Allen, Rickover, (Simon and Schuster, New York, 1982), pp. 622-25. The issue was noted by the Australian press: e.g. Sydney Morning Herald, 16 June 1961, p. 1, 'Visiting Atom Submarine "Defied Order"'; ibid., 17 June 1961, p. 3, 'U. S. Pledge on Atom Submarine'.
36. cf. N. Polmar and T. B. Allen, Rickover, (Simon and Schuster, New York, 1982), p. 625: in referring to a 1962 goodwill visit to Boston by the USS Enterprise the authors state: 'but in other years other ships did not always go where the Navy wanted them to go'. No information is given as to which years or places are referred to.
37. US, H of R, Committee on Appropriations, Subcommittee on Energy and Water Development, Energy and Water Development Appropriations for 1989 - Hearings, 23 March 1988, p. 1331 (Admiral K. R. McKee).
38. This is not to say that visits are permitted to all ports in a given country. For example, it appears that the Turkish Government will not permit visits to Istanbul by the nuclear powered USS Nimitz, although visits elsewhere in Turkey are permitted: US, H of R, Committee on Armed Services, Subcommittee on Procurement and Military Nuclear Systems, Naval Nuclear Propulsion Program - 1988 - Hearing on H. R. 1748, 26 February 1987, p. 7 (Congressman Skelton).

vessels on the sole basis that the risk of a reactor accident is too great. New Zealand is a possible exception.[39] Other countries mentioned as exceptions either do not appear to ban visits,[40] or

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39. The rationale for the current New Zealand ban on nuclear powered vessel visits is unclear. It appears to be linked to the ban on nuclear weapons capable warships, which in turn is linked to concerns about nuclear war and the nuclearisation of the South Pacific. The possibility of a reactor accident in a New Zealand port does not appear to have been a major element. See S. McMillan, Neither Confirm Nor Deny: The Nuclear Ships Dispute between New Zealand and the United States, (Allan & Unwin, Wellington, 1987), pp. 38–40. See also US, H of R, Committee on Foreign Affairs, Subcommittee on Asian and Pacific Affairs, Security Treaty between Australia, New Zealand, and the United States – Hearing, 18 March 1985, p. 170 (P. Wolfowitz, State Department and J. A. Kelly, Department of Defense): prior to imposing the ban New Zealand had not sought information on US safety procedures and precautions relating to its nuclear powered warships, nor had it sought to explore with the US ways in which safety concerns might be overcome. The explanation given for the ban in David Lange, 'New Zealand's Security Policy', Foreign Affairs, Summer 1985, vol. 63(5), pp. 1010–13 makes no reference to reactor safety.

40. e.g. in 1985, retired US Rear Admiral E. Carroll stated that France continued to ban visits: US, H of R, Committee on Foreign Affairs, Subcommittee on Asian and Pacific Affairs, Security Treaty between Australia, New Zealand, and the United States – Hearing, 18 March 1985, p. 61. But a US State Department witness said this was incorrect: ibid., p. 166. In 1976 it was explained that the then inability to visit arose because 'France has internal government regulations which establish conditions we cannot agree to without surrendering the traditional concept of sovereign immunity for warships': US, H of R, Committee on Appropriations, Subcommittee on the Department of Defense, Department of Defense Appropriations for 1977 – Hearings, 31 March 1976, p. 299 (Admiral H. G. Rickover).

do not clearly do so on the ground of reactor safety.[41] The issue of Suez canal transits is also unclear, with transits having to be negotiated on a case-by-case basis.[42]

6.30 However, the United States has not sought to make port visits to all possible countries.[43] It may be that if visits were

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41. e.g. C. Ewald, 'Book Review of R. E. White, Nuclear Ship Visit Policies and Ship Visit Data for 55 Countries, (SANA, Auckland, 1988)', SANA Update (Scientists Against Nuclear Arms Australia Newsletter), November 1988, No. 67, p. 7: the People's Republic of China has a strong policy of not allowing nuclear-powered ship visits. But the reviewer does not indicate if the policy rests on safety grounds. The Chinese Embassy in Canberra responded to the Committee's request for information by stating that China 'had not yet developed any safety and emergency plans for visits of nuclear powered vessels', but did not indicate that there was a ban on such visits: letter of 25 November 1986. See also R. E. White, The New Zealand Ship Ban: Is Compromise Possible?, (Working Paper No. 40, Peace Reasarch Centre, Australian National University, Canberra, 1988), pp. 4-5: China, Egypt, and the Solomon Islands do not permit port entry to nuclear powered ships. This statement is based on information provided to the author by diplomatic representatives of China and Egypt in New Zealand and from the Soloman Islands' Ministry of Foreign Affairs. In all three cases the ban is linked to a similar ban on nuclear weapons capable vessels, and no reason is given by the author for the bans. He makes the point with respect to vessel-visit policies that there may well be a difference between officially stated policy and what actually occurs. One illustration given is that US nuclear powered warships visited Egyptian ports in 1985, despite the apparent official ban on visits (pp. 6 and 10). See also p. 9, where it is noted that China's apparent official policy of not allowing visits may not apply in practice to prevent specific visits.
42. US, H of R, Committee on Appropriations, Subcommittee on Energy and Water Development, Energy and Water Development Appropriations for 1988 - Hearings, 11 March 1987, pp. 890-91 (Admiral K. R. McKee). See also the Times (London), 31 October 1977, p. 1, 'Suez Barred to nuclear submarine': HMS Dreadnought refused passasge.
43. cf. US, H of R, Committee on Appropriations, Subcommittee on Energy and Water Development, Energy and Water Development Appropriations for 1989 - Hearings, 23 March 1988, p. 1331:

    Mr J. T. Myers: How many others [in addition to New Zealand] have denied us port access?
    Admiral McKee: It is hard to say because we have not asked everybody in the world to let us come in, but I believe the only place where there is a national policy against the visit of nuclear-powered ships is there. There are several islands in the South Pacific that have banded together to create nuclear-free zones, but we have visited some of those, not all. There are periodic stand-offs that come along. They say, well maybe not now. But eventually it works.

sought they would be refused on safety grounds.[44] Alternatively, visits may not be sought because the host country's conditions for visits are not acceptable.[45] It is also possible that some countries permit visits because they see the benefits outweighing major concerns about safety.

Nuclear Powered Merchant Ships

6.31 During the 1960's and 1970's the nuclear powered merchant ships NS Savannah and NS Otto Hahn visited a large number of ports in a large number of countries.[46] Although there are no reports of any nuclear-related safety problems occurring during any of these visits, safety studies were made and contingency plans were drawn up in respect of at least some of the ports visited.

6.32 The Committee examined only a small sample of the literature relating to these studies and plans. The overseas plans were based on port visits, it apparently being accepted

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44. e.g. the question of visits to Swedish ports by civilian or military nuclear powered vessels has not arisen since 1964. Hence the Government has not had reason to consider whether visits should be permitted: letter from the Swedish Embassy, Canberra to Senator McIntosh, 15 December 1986.
45. e.g. Denmark permits nuclear powered vessel visits subject to stringent conditions, including the provision of technical information which would permit the Danish authorities to evaluate the safety-related standards of the vessel. 'Experience has shown that countries that have expressed a wish for a visit to Danish ports of their nuclear-powered vessel have not in practice felt able to meet the necessary conditions': letter from the Danish Embassy, Canberra to Senator McIntosh, 17 February 1987. No nuclear powered vessel has visited a Danish port since the NS Savannah in 1964; ibid.
46. Figures of 107 ports in 40 countries are given in D. McMichael and H. Bianchi, 'Port Entry of Nuclear Ships: Differences, Procedures and Conditions' in Organisation for Economic Cooperation and Development, Nuclear Energy Agency, Symposium on the Safety of Nuclear Ships: Proceedings, Hamburg, 5-9 December 1977, (OECD, Paris, 1978), p. 407. The NS Otto Hahn visited populated ports such as Rotterdam, Southampton, Lisbon, Cape Town, Buenos Aires, and Rio de Janeiro: W. Boulanger, 'Legal Aspects of Nuclear Merchant Ships' in ibid., p. 530.

that there was no need to plan for accidents occurring at sea.[47] The Committee's examination indicated that Australian planning is within the bounds of what was considered necessary overseas, after making allowance for the difference between naval and merchant vessels.[48] Australian planning tends towards the conservative (ie. more safety-oriented) end of the spectrum.

6.33 Dutch planners, for example, envisaged an evacuation zone radius which might extend to 600 metres. But there was no equivalent to the Zone 2 in Australian plans. The planners based their plans on a contained accident, but assumed a higher leak rate from containment than the ship's designers.[49]

6.34 South African plans provided for a 600 metre zone for immediate evacuation, with people immediately outside this zone being issued with potassium iodate tablets, warned to stay indoors, etc.[50] Monitoring for radiation was required throughout the visit, with readings taken every hour near the ship.[51]

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47. C. J. van Daatselaar, 'Arrangements for and Experience with the Visits of the Nuclear Ship "Otto Hahn" to the Harbours of Rotterdam and Vlaardingen in the Netherlands' in Organisation for Economic Cooperation and Development, Nuclear Energy Agency, Symposium on the Safety of Nuclear Ships: Proceedings, Hamburg, 5-9 December 1977, (OECD, Paris, 1978), p. 405 ('At a distance of 5 miles from the coast the risk to population will be negligible ...'); M. Kuramoto, 'Some Considerations on the Safety of Nuclear Ships' in ibid., p. 461 (accident in the open sea 'would have no consequence on the population at large').
48. On overseas planning, see for example the general discussion in R. O'Neil, 'Port Interface Requirements' in Organisation for Economic Co-operation and Development, Nuclear Energy Agency, Symposium on the Safety of Nuclear Ships: Proceedings, Hamburg, 5-9 December 1977, (OECD, Paris, 1978), pp. 71-87.
49. C. J. van Daatselaar, 'Arrangements for and Experience with the Visits of the Nuclear Ship "Otto Hahn" to the Harbours of Rotterdam and Vlaardingen in the Netherlands' in Organisation for Economic Cooperation and Development, Nuclear Energy Agency, Symposium on the Safety of Nuclear Ships: Proceedings, Hamburg, 5-9 December 1977, (OECD, Paris, 1978), p. 406.
50. J. O. Tattersall, 'The Position of a Host Country in Receiving Nuclear Ships' in Organisation for Economic Cooperation and Development, Nuclear Energy Agency, Symposium on the Safety of Nuclear Ships: Proceedings, Hamburg, 5-9 December 1977, (OECD, Paris, 1978), p. 478.
51. ibid., p. 474.

Australian guidelines call for monitoring only once daily.[52] In both cases there is provision for alarm monitors which will automatically indicate the occurrence of an accident.

6.35 The safety scheme for Southampton provided for a 600 yard evacuation and exclusion zone, with little need seen for measures beyond this zone.[53] For example, potassium iodate tablets were to be issued only to persons within the 600 yard zone.[54]

6.36 The safety scheme for Wellington similarly focuses almost all its protective measures, including evacuation, within a 600 metre zone around the accident.[55] Provision is made for a prohibition on the consumption of foodstuffs in the downwind sector out to 1,000 metres from the accident site.

CONCLUSIONS

6.37 Australian contingency plans are more stringent than the arrangements for warships thought necessary by the United Kingdom and the United States. Based upon comparison with a small sample of overseas plans relating to nuclear powered merchant ship visits, Australian plans are clearly at the more stringent end of the spectrum.

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52. Department of Defence, Environmental Radiation Monitoring during Visits of Nuclear Powered Warships to Australian Ports: Requirements, Arrangements and Procedures, (May 1988), para. 3.1.1.
53. Southampton Special Safety Scheme for Visits of Nuclear Merchant Ships reproduced in Organisation for Economic Cooperation and Development, Nuclear Energy Agency, Symposium on the Safety of Nuclear Ships: Proceedings, Hamburg, 5-9 December 1977, (OECD, Paris, 1978), p. 427-53. See p. 428 (health hazard beyond 600 yards 'most ulikely'), p. 429 (600 yard exclusion distance), p. 438 (ban consumption of foodstuffs within 880 yards and take action to ensure that warning is given to all persons), and p. 439 (arrange testing of milk samples from farms up to 5 and a half miles down wind of the accident site).
54. ibid., p. 429.
55. New Zealand, Wellington Regional Civil Defence Plan for a Nuclear Powered Vessel Visit to the Port of Wellington, (1983), para. 8 (Evidence, 1147).

CHAPTER 7

ASSESSING THE VALIDITY OF THE REFERENCE ACCIDENT

INTRODUCTION

7.1 The concept of the reference accident was explained in chapter 2.[1] It was noted that current planning is based on the premise that the worst accident that needs to be planned for is a contained core meltdown. The design and significance of containment was discussed in chapter 4.[2] In particular it was explained that a 'contained' accident may not be totally contained, but may involve slow leakage to the atmosphere.

7.2 In chapter 3 it was explained that the principal point made by those submissions opposed to the adequacy of current contingency planning was that the reference accident should be an uncontained rather than a contained core meltdown.[3] Some of the technical matters relevant to this and related issues were addressed in chapter 4. The remaining matters are considered in this chapter.

7.3 The Committee did not consider that it had the resources to carry out a full-scale risk assessment of its own. Instead, it critically reviewed the adequacy of the assessment carried out by the Australian Nuclear Science and Technology Organisation (ANSTO)[4] for the Department of Defence in the early 1970's. The

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1. See para. 2.17.
2. See paras. 4.20-4.23 and 4.63-4.78.
3. See paras. 3.16-3.17
4. As already noted, ANSTO is the successor to the Australian Atomic Energy Commission, which provided the original assessment. For simplicity, 'ANSTO' is used throughout.

method ANSTO used to assess the risk and derive the reference accident was outlined in chapter 2.[5] It was described in some detail in ANSTO's submission.[6] This description follows closely the wording of the relevant paragraphs of the 1974 environmental impact report on nuclear powered warship visits.[7]

7.4 The view of ANSTO and the Department of Defence is, as already noted, that an uncontained accident is so unlikely that it is not appropriate for the purposes of contingency planning. This conclusion is entitled to some weight simply because it is the conclusion of those in Australia having the most information and the greatest expertise on the subject and being based on a detailed examination of the issues.[8] But clearly the conclusion acquires greater weight, to the extent that the assessment that led to it is available for critical public examination.[9]

ANSTO'S ASSESSMENT

Need to Revise the Original Assessment?

7.5 Before reviewing the assessment in some detail both as to accident likelihood and accident consequences, it is helpful to deal with the argument that the assessment is out of date. A number of submissions suggested that, even if it was adequate at the time it was done, it is no longer so due to the increased knowledge of reactor accident risks gained in the last 15

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5. See para. 2.17.
6. Submission from ANSTO, Attachment 1, pp. 1-11 (Evidence, pp. 247-57).
7. Department of Defence, The Environmental Impact of Visits by Nuclear Powered Warships to Australia, (July 1974), paras. 35-79.
8. Note that AIRAC has not attempted to assess the likelihood of an accident, but has focused on assessing the consequences were an accident to occur: Evidence, p. 742 (AIRAC).
9. cf. submission from Mr R. Bolt, p. 9 (Evidence, p. 959), where the ANSTO assessment, as presented in the 1976 Environmental Considerations report, is criticised for not disclosing the sources and methods upon which its conclusions rest.

years.[10]

7.6 Little in the way of detailed argument was provided. Rather there seemed to be a general assumption that scientific developments since 1974 had in some unspecified way invalidated the original work. It was suggested that, as a result of the accidents at Three Mile Island and Chernobyl, experts were now more pessimistic about reactor safety than in the early 1970's.[11] It followed on this view that the original ANSTO assessment should be revised to take into account this alleged increase in the perceived risk.

7.7 The Committee put this view to ANSTO. The response was twofold. First, there had been no major scientific developments that would cause the revision of the original assessment. In particular, ANSTO stated that their assessment leading to the adoption of the current reference accident was not invalidated by their study of the 1979 reactor accident at Three Mile Island.[12]

7.8 Second, there had been developments which would allow refinement of some of the calculations that led to the assessment, but these would not invalidate the overall result. Regarding these calculations, Mr Donald McCulloch of ANSTO told the Committee:

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10. e.g. see the submissions from Mr K. G. Blake, p. 4; State School Teachers' Union of WA (Inc.), p. 1.
11. e.g. see the submission from Mr R. Bolt, p. 7 (Evidence, p. 957); and Evidence, p. 582 (Prof W. J. Davis). It should be noted that it is difficult to find evidence that any perception of increased risk that there may have been about civil reactors following the Three Mile Island accident also extended to naval reactor safety: e.g. see para. 4.134 above. Moreover the expert (as opposed to popular) view is by no means unanimous that there has been any major increase in the assessment of risk regarding civil reactors: e.g. see US, Nuclear Regulatory Commission, Reactor Risk Reference Document, (NUREG-1150 (draft), NRC, Washington, 1987), p. ES-6: current risk estimates show no particular trend when compared with those from previous risk analyses, except that the estimates from the 1975 Reactor Safety Study often appear to be near the higher-risk end of the currently accepted range of estimates.
12. Evidence, pp. 433.448, 1268-69 (ANSTO).

My judgment is that were they now undertaken it might be possible, while still remaining conservative and being certain one's results were remaining conservative, to perhaps make less conservative assumptions regarding some of the parameters which were used in the analysis.[13]

7.9 As a result of ANSTO'S present view, the Committee considered it appropriate to evaluate the assessment made in 1974.

ANSTO's Methodology

7.10 ANSTO's method of assessment was the orthodox one of estimating the likelihood of a range of reactor accidents. The possibility of reactivity accidents, start-up faults, loss of power supplies, and fuel handling accidents were considered and found to be low or non-existent. The maximum credible accident was considered to be a loss of coolant accident. Confidential information available to ANSTO led it to conclude that the containment design catered for this accident, and only slow leakage to the atmosphere would result from it. 'Any release into the atmosphere beyond that associated with this accident must involve either coincidental failure or sub-standard performance of the containment.'[14]

7.11 Ways in which either of these might occur were then examined in some detail. Scenarios considered were ship collision, pressure vessel failure, deterioration of containment in service (including the possibility of violation of operating procedures), shock waves within the containment from sources such as hydrogen explosions, flying debris within the containment, and melt-through by molten fuel. ANSTO explained why it thought each of these was either not possible or was of sufficiently low probability that it could be discounted.

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13. Evidence, p. 371 (ANSTO). See Evidence, pp. 443.48 and 1300.01, where ANSTO note aspects of their assessment on which revision could be done. See also the 'Revised Accident Model' discussed below, para. 7.17.
14. Submission from ANSTO, Attachment 1, p. 4 (Evidence, p. 250).

7.12 In comparing contained to uncontained accidents, ANSTO used the concept of mean annual severity. This is a measure of the amount in Curies per reactor per year of iodine-131 that would be released in a defined accident. It is obtained by multiplying the accident likelihood (measured in accidents per reactor year) by the accident consequences (measured in Curies of iodine-131 that would be released from that accident).

7.13 The mean annual severity of the current reference accident was calculated by ANSTO to be less than 0.1 Curies of iodine-131 per reactor per year.[15] The mean annual severity of one type of uncontained accident, a massive pressure vessel failure leading to simultaneous breach of containment, was calculated as 0.01 Curies of iodine-131 per reactor per year.[16] This is one-tenth the mean annual severity for the reference accident. The greater consequences of the uncontained accident

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15. Submission from ANSTO, Attachment 1, p. 4, (Evidence, p. 250). The result was derived from the amount of iodine-131 expected to be released in the first 12 hours following an accident (1000 Curies), multiplied by the likelihood of a contained accident (1 in 10,000 reactor years). The figures are the same as those used by the British authorities in relation to a contained submarine reactor accident: UK, Parliamentary Debates (Commons), 6th series, vol. 112, Written Answers, 20 March 1987, cols. 634-35 (Evidence, p. 1300.19). ANSTO also supplied figures for the iodine-131 release that are based on more conservative (ie. safety-oriented) assumptions (see Evidence, p. 443.449). On this basis, releases are estimated of 1875 Ci of I-131 in the first 12 hours following the reference accident, and of a similar amount in the following 12 hours. Recalculation of the mean annual severity using this 24-hour total gives likelihood (1 : 10,000) x consequences (3750 Ci) = 0.375 Ci of I-131 per reactor per year.
16. Submission from ANSTO, Attachment 1, p. 8 (Evidence, p. 254). The likelihood is put at 1 : 10,000,000 per reactor year, and the consequences at 100,000 Curies of I-131 released. The figure used by ANSTO for the amount released is the same as that used by the British authorities: see previous footnote. The British authorities, however, put the likelihood of an uncontained accident at 1 in 1,000,000 reactor years. ANSTO did not use this figure as they regarded it as including considerations that are only relevant during visits to homeports/dockyards, where reactor repairs and maintenance may be carried out, containment breached, etc. ANSTO derived the figure of 1 in 10,000,000 from its consideration of what would be required to cause gross containment failure during a visit to an Australian port, when reactor repairs, etc are not permitted: see ibid., especially p. 8 (Evidence, p. 254).

are outweighed by its lesser likelihood, giving a lower overall figure.

7.14 ANSTO did not claim to have quantified the likelihood of all the possible contained or uncontained accidents. Numerical mean annual severity calculations were made for only two uncontained accident scenarios.[17] In other cases quantitative calculations were replaced by qualitative assessments of the unquantified factors. Nonetheless its conclusions were the same for other uncontained accident possibilities: their mean annual severity would always be less that that of the current reference accident.[18]

Conservatism of the Assessment

7.15 Throughout its assessment ANSTO made conservative (ie. pessimistic or risk enlarging) assumptions about safety where it considered reliable estimates could not be made. Overlapping with this were other conservative assumptions. It was assumed that there would be no operator intervention to minimise an accident sequence once it commenced, and that failures would, if they occurred, be total.[19] For example, any serious failure of the coolant circuit was assumed to lead to a core meltdown.[20] Particular points of conservatism identified by ANSTO relating to accident consequences were that the reference accident assumes:

- a much higher fraction of the fission product inventory available for release from the reactor compartment than experience would indicate is probable;
- unfavourably stable atmospheric conditions [ie. minimal wind] for dispersion of the release; and
- impracticably long duration (12 hours) of

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17. See the submission from ANSTO, Attachment 1, p. 8 (pressure vessel failure causing containment breach) and p. 9 (LOCA and violation of containment integrity by operator breach of procedure) (Evidence, pp. 254 and 255).
18. Submission from ANSTO, Addendum, p. 1 (Evidence, p. 379).
19. Evidence, pp. 742-43 (AIRAC).
20. Evidence, p. 1272 (ANSTO).

unchanged wind direction into the most populated sector from commencement time of release.

Together, these conservative assumptions, which are extremely unlikely in practice all to occur simultaneously and in conjunction with the reactor accident itself, mean that the consequences estimated for this reference accident are in general scale (but not necessarily in detail) likely to be closer to those which might arise from an uncontained, rather than a contained, loss of coolant accident.[21]

A More Realistic Assessment?

7.16 The Australian Ionising Radiation Advisory Council (AIRAC) noted the conservatism of ANSTO's assessment and thought it 'desirable to have a more realistic assessment'.[22] At AIRAC's request ANSTO produced such an assessment. The Committee requested and was provided with a copy of this. ANSTO described the assessment as a 'Revised Accident Model'.[23]

7.17 The main differences between the current reference accident and the revised model are as follows:

- the amount of iodine-131 it is assumed would be released

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21. Submission from ANSTO, Addendum, p. 2 (Evidence, p. 380).
22. Evidence, p. 743 (AIRAC). In this context 'more realistic' meant in effect a less serious accident: Evidence, pp. 1275-76 (ANSTO). In New Zealand, a reference accident was developed in the 1970's which is broadly similar to that devised by the Australian authorities: see NZ, Atomic Energy Committee, New Zealand Code or Nuclear Powered Shipping, (AEC500, 1981 edn.), paras. 5.2 - 5.5. It appears that this has since been reassessed. See A. C. McEwan, 'Health Physics Aspects of Nuclear Issues in New Zealand over the Last Decade', Australasian Physical & Engineering Sciences in Medicine, April-June 1986, vol. 9(2), p. 79:

    A more recent assessment suggests that the AEC500 reference accident is an unlikely outcome for a core meltdown event. It is more probable secondary containment would reduce the airborne release of volatiles to much smaller values.

23. ANSTO, 'Visits by Nuclear Powered Warships: Revised Accident Model' (June 1986). The complete document is reproduced in Evidence, pp. 1300.23-31. It explains the revisions made and documents the reasons for each change.

has been reduced from 25% of the total present in the reactor to 2.5%. This reduction is based on studies done since the 1979 Three Mile Island accident of proportions that would be released following accidents.[24]

- the allowance made for the other radioiodines that would be released is reduced from 2.0 times the iodine-131 dose to 1.4 times. This reduction is based on criteria put forward by the Medical Research Council in the United Kingdom.

- a reduction in the containment leakage rate from 1.5% per day constant to 1% initially, reducing in a linear fashion by a factor of 10 over the 24-hour period. The reduction is based on an assumption that the containment will not leak more rapidly that its design specification permits. Credit is also taken for the reduction over time in containment pressure (ie. the pressure that forces the radioactive material out of the containment).

- a reduction in radiation doses received of 2-3 times due to use of a different airborne dispersion model. A model recommended in 1982 by the United States Nuclear Regulatory Commission has been used instead of the model used in the calculation of the current reference accident.

7.18 The description of the revised accident model included graphs showing the reduction in consequences. ANSTO noted:

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24. As an indication that the revised accident model nonetheless retains very conservative (ie. safety-óriented) assumptions, ANSTO noted that studies indicate that pre-Three Mile Island estimates of the release of iodine-131 are overestimates by a factor of 10 to 1,000: ANSTO, 'Visits by Nuclear Powered Warships: Revised Accident Model', (June 1986), para. 4 (Evidence, p. 1300.24). ANSTO adopted the lowest end of this range in its revised accident model, reducing iodine-131 release by only a factor of 10.

> Individual thyroid doses at the perimeter of Emergency Planning Zone 1 (600m) are reduced by a factor 70 for the revised accident relative to the reference accident, and whole body doses by a factor 7.5. Collective thyroid dose would be reduced by a factor 70 for the revised accident relative to the reference accident.[25]

7.19 The Committee considered what regard it should have to the revised accident model, compared to the current reference accident. The Committee noted that neither AIRAC (who asked for the revised model) nor ANSTO (who produced it) had advised the Committee that current plans should be altered to take into account the revised accident model.[26]

7.20 The revised accident model appeared to the Committee to be based on a combination of two factors: an intention to use less safety-oriented (ie. less conservative) parameters, and the results of improved scientific knowledge since the 1974 assessment was done. At least to the extent that it is based on the latter, it could be argued that the revised accident model should replace the current reference accident.

7.21 The Committee considers that the current reference accident can continue to be used. It saw no need to investigate the revised accident model in order to determine if it should be used instead. The Committee's conclusion rests on two grounds. One related to the use of any reference accident for overall risk assessment and for berth assessment; the other related to its use as a basis for detailed contingency planning.

7.22 First, with regard to overall risk assessment and berth assessment, the Committee took the view that, for the purposes of its inquiry, it did not matter if the reference accident was over-cautious. For example, the effect of this on berth assess-

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25. ANSTO, 'Visits by Nuclear Powered Warships: Revised Accident Model', (June 1986), para. 16 (Evidence, p. 1300.27).
26. cf. Evidence, p. 1276 (ANSTO).

ment is that berths that might be assessed as safe using the revised accident model might not be approved if the current reference accident is used. But this apparently causes no practical difficulties, given the number of berths that are or could be approved under the current reference accident.

7.23 The second of the Committee's reasons relates to the model's possible use as a basis for detailed planning. For this purpose, the choice of an unnecessarily safety-oriented reference accident may have detrimental consequences should an accident occur. It was in this context that AIRAC raised the issue of the appropriateness of the current reference accident.[27]

7.24 The concern is that the detail of planning for the more serious accident (the current reference accident) may lead to incorrect or less than optimal responses should a less serious accident (e.g. the revised accident model) occur. For example, use of the current reference accident results in an emphasis in post-accident monitoring on the detection of radioiodines. The revised accident model gives a far smaller role to radioiodines. Planning based on this model might require a different focus in post-accident monitoring.

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27. Evidence, p. 743 (AIRAC).

7.25 The Committee recognised the validity of the concern.[28] The Committee considered, however, that the concern could be met by ensuring that the detail of planning was sufficiently flexible to cope with both the reference accident and with less serious accidents, such as the revised accident model. In general terms, the current planning is flexible in this regard.[29] Particular aspects are indicated in the discussion of the details of planning.[30]

EVALUATION OF ANSTO'S ASSESSMENT

Logical Probabilities

7.26 As a matter of logic an uncontained reactor core accident has to be considered less likely than a contained one.[31]

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28. The issue extends more widely than a choice between the current reference accident and the revised accident model. With regard to land-based reactors it has been suggested that it is inappropriate to base the detail of accident contingency planning on a single reference accident. See for example, US, Report of the President's Commission on the Accident at Three Mile Island, The Need for Change: The Legacy of TMI, (Washington, 1979), Recommendation F(2)(a):

    > No single plan based on a fixed set of distances and a fixed set of responses can be adequate. Planning should involve the identification of several different kinds of accidents with different possible radiation consequences. For each such scenario, there should be clearly identified criteria for the appropriate responses at various distances ... .

    cf. International Atomic Energy Agency, Planning for Off-Site Response to Radiation Accidents in Nuclear Facilities, (Safety Series No. 55, IAEA, Vienna, 1981), para. 2.03:

    > emergency planning should be based upon the technical assessment of the potential consequences, time-factors, and release characteristics of various classes of accidents with different possible radiation consequences.

29. Evidence, pp. 1300.47-48 (Department of Defence).
30. See paras. 8.42, 8.127 and 8.136-8.137.
31. Evidence, p. 662 (Dr T. P. Speed); p. 1269-70 (ANSTO). Contrast the submission from People for Nuclear Disarmament, p. 3 (Evidence, p. 1305), where it is claimed that what is in effect an uncontained accident is 'a much more likely scenario'. When a representative of the group appeared before the Committee he did not support the view in the submission: (Evidence, p. 1325).

If the core accident is independent of the containment breach then two independent events have to occur together to produce an uncontained core accident. It is more plausible that the accident and the breach are related. But even so the occurrence of the two events together is less likely. Not all events that might breach the containment (e.g. ship collisions) will invariably cause an accident to the reactor core. Equally, not all accidents that might occur to the core will necessarily cause a breach of containment (e.g. the 1979 Three Mile Island core meltdown accident).

7.27 But this logical point means little unless some indication can be given of how much less likely an uncontained core accident is than a contained one. In paragraph 3.28 it was noted that the British Government has given the relevant figures for its nuclear powered submarine reactors. These indicate that an uncontained accident is one hundred times less likely than the 1 : 10,000 per reactor year chance of a contained accident. The Committee put this ratio of the likelihood of contained versus uncontained accidents to ANSTO. In response, ANSTO said it regarded the British 1 : 100 ratio as a believable figure for naval reactors.[32]

7.28 ANSTO also made clear the fact that it had not independently verified the figure, nor had it seen the British documentation setting out the process which led to the figure. The Committee was no better placed. Therefore the Committee thought it prudent not to place too great a reliance on the British figure as such.

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32. Evidence, pp. 1270-71. The question was put and answered in general terms. In footnote 16 in this chapter it is noted that figures giving a ratio of the liklihood of a contained to an uncontained reactor accident of 1 : 1000 are used by ANSTO in relation to an Australian port visit. Because no reactor repairs necessitating breach of containment are permitted during these visits, ANSTO regards the likelihood of an uncontained accident as lower than during a visit to a homeport/dockyard, where such repairs may occur.

Views in Submissions

7.29 No submission provided detailed justification for regarding an uncontained accident as sufficiently probable to warrant using it as the reference accident. This was no doubt in part due to the limited information in the public domain on the design and operation of naval reactors. In addition, none of the authors of these submissions claimed any expertise in naval reactor design.

7.30 A further handicap was the fact that there has never been a core accident that breached containment in either a commercial power reactor[33] or a western naval reactor. There are no precedents to serve as guides. Because there has never been an accident involving core damage to a western naval reactor, naval reactor containment has never been tested by an accident.

7.31 While all these factors are understandable, the effect of the submissions was to leave the Committee with little more than vague suggestions as to how serious accidents were likely to happen and why containment was likely to prove ineffective. There was no measure of agreement in the submissions opposed to the current reference accident as the basis of planning on what scenario or scenarios would lead to an uncontained accident. One view put in submissions was that those making submissions were entitled to assume lack of effective containment. It was for those who advocated planning based on a contained accident to show that containment existed and would be effective.[34]

7.32 The arguments in submissions relating to the perceived flimsiness of containment on warships and other design features were considered in chapter 4. The conclusions reached were that

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33. The reactor involved in the 1986 accident at Chernobyl lacked a complete containment structure.
34. e.g see supplementary submission from Prof W. J. Davis, p. 2 (Evidence, p. 617.002); submission from the Australian Quaker Peace Committee, p. 2.

there were no technical reasons for regarding the containment for United States and British warship reactors as any less adequate for naval-size reactors than the larger containment is for correspondingly larger land-based reactors.

7.33 No submission or witness appearing before the Committee provided information which explicitly challenged any part of ANSTO's assessment in any detail. Nor were any plausible accident scenarios identified that ANSTO had entirely omitted to consider. Instead the Committee was presented with general statements that one or more of the scenarios considered by ANSTO was a likely route to an uncontained accident. For example, Senator Vallentine provided to the Committee a comment made to her by Dr Richard Webb:

> I am very much interested in the official claims (as you stated them) that the core could even suffer melting and still cause no danger to the public. Off hand; I think such claims are mere words, which cannot possibly be supported by experiments, as full scale reactor destructive experiments would be needed to establish just what would really happen in an accident.[35]

7.34 Since full-scale destructive testing is never likely to be done, proof is never going to be available to this standard.[36] Similarly, no amount of expert opinion obtained by the Committee would prove convincing according to this standard.

7.35 Another approach taken in submissions was to give little regard to technical considerations and instead simply say that human error would be the cause of the uncontained accident. Speaking at a sufficient level of generality, it is no doubt true

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35. Letter from Dr R. E. Webb to Senator J. Vallentine, 29 April 1988, p. 2. The wording as read to the Committee by Senator Vallentine and appearing in Evidence at p. 1218 differs in some respects from that of the original letter.
36. cf. 'Sandia puts the pressure on containments', Nuclear Engineering International, March 1987, p. 26, which describes tests using scale models to test containment integrity for commercial reactors.

to say that human error is the cause of many accidents. But no precise suggestions were made on how human error would turn a contained accident into an uncontained one.[37] It is possible to speculate on how human error might lead to a meltdown. But it is far less easy to see how, a meltdown having occurred, human error could then cause the containment to fail, unless the error occurred at the containment design, manufacture or inspection stage.

7.36 A further possibility is that the human error impacts on the accident frequency, not on the containment failure directly. For example, assume containment failure occurs in, say, one in ten core accidents. Assume further that risk assessors do not give due weight to human error as a cause of accidents, and this leads to an under-estimation of core accident likelihood by a factor of ten. On these arbitrarily chosen figures, the result is that the likelihood of the uncontained core accident would be the same as the original (erroneous) estimate for the contained core accident. If it was originally accepted that planning was required for the latter, it follows that, on the corrected estimate, planning should now be required for the uncontained accident.

7.37 This argument was not put explicitly in any submission.[38] Clearly it is equally applicable to any core accident cause that has been under-estimated, not just human error. Equally, its persuasiveness depends on the closeness of the ratio of the likelihood of uncontained to contained accidents. If the ratio is large (say 1 : 1,000) then a large under-estimation of core accidents is necessary to enable the likelihood of the uncontained accident to approach the original assessment for the contained accident. Assuming adequate assessment (a matter considered below), a large under-estimation is less likely than a small one. The naval reactor safety record to date also gives no support to any suggestion that a large (or

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37. cf. Evidence, pp. 392-93 (ANSTO): low probability of operator action having this effect should the reference accident occur.
38. cf. submission from Mr R. Bolt, p. 10 (Evidence, p. 960), where the point was made in a somewhat different context.

indeed any) under-estimation is likely.

Completeness

7.38 The Committee noted the expert view that it is impossible to guarantee absolutely that all relevant factors have been taken into consideration in a reactor risk assessment.[39] The Committee asked ANSTO if it was confident that its assessment was accurate in the sense that all relevant factors had been given appropriate weight. ANSTO responded:

> If we had not been satisfied on the basis of our judgments and experience that this was likely to be the case, we would not have provided this advice to the Department of Defence in the first place.[40]

MATTERS RELATING TO ACCIDENT LIKELIHOOD

Introduction

7.39 It is convenient in considering further points relating to ANSTO's assessment to separate accident likelihood from accident consequences. As a check on the completeness of the factors considered by ANSTO that might lead to a significant accident the Committee compared ANSTO's assessment with the types

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39. e.g. UK, Department of Energy, Sizewell B Public Inquiry: Report of Sir Frank Layfield, (HMSO, London, 1987), para. 28.86:

> It was generally agreed that there could be no guarantee that all relevant initiating faults and accident sequences would be identified in an accident probability analysis.

40. Evidence, p. 376 (ANSTO). See also Evidence, p. 391 (ANSTO):

> Any probabilistic assessment of reliability must contain a factor of engineering judgment, which depends on the experience and ability of the people who are making the assessment. That is always true, but ... in general, a large number of factors come into play in arriving at an overall figure for reliability and it is unlikely that an error in any one of them will produce a significant influence on the final result.

of scenarios evaluated in risk assessments relating to commercial reactors.

7.40 The Committee acknowledges that such a comparison can provide no more than a partial check due to the differences between commercial and naval reactors. The object of the comparison was twofold. Primarily it was to determine if what were regarded as plausible accident scenarios for commercial reactors had been considered in the ANSTO assessment. Secondly, these other assessments provided an occasional means of spot-checking the ANSTO assessment on points of detail.

7.41 To take the latter point first, where comparison was possible the ANSTO assessment seemed to be consistent as to method and compatible as to results. For example, the evaluation of the possibility of coolant pipe breaks in the Sizewell B report proceeds on similar lines and comes to broadly similar conclusions to the ANSTO assessment.[41] The assessment by ANSTO of the possibility of pressure vessel failure is compatible with other studies.[42]

7.42 The comparison in order to determine if ANSTO had omitted any plausible scenarios revealed that the depth and sophistication of examination given to particular scenarios varied considerably. This was true not only as between the ANSTO

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41. UK, Department of Energy, Sizewell B Public Inquiry: Report of Sir Frank Layfield, (HMSO, London, 1987), paras. 28.29–28.48. cf. submission from ANSTO, Attachment 1, pp. 3-4 (Evidence, pp. 249-50).
42. e.g. US, Nuclear Regulatory Commission, Reactor Safety Study: An Assessment of Accident Risks in U. S. Commercial Nuclear Power Plants, (WASH-1400, NRC, Washington, 1975), para. 5.3.2.4; NZ, Atomic Energy Committee, New Zealand Code for Nuclear Powered Shipping, (AEC500, 1981 edn.), para. 5.6. See also J. G. Waddington and A. Wright, 'Safety Criteria for a Canadian Nuclear Icebreaker' in Organisation for Economic Cooperation and Development, Nuclear Energy Agency, Symposium on the Safety of Nuclear Ships: Proceedings, Hamburg, 5-9 December 1977, (OECD, Paris, 1978), p. 360.

assessment and others but also amongst other assessments.[43]

7.43 However, the comparison did not disclose any broad omissions of scenarios which the Committee regarded as having major significance. For example, the Sizewell B report identified four principal ways in which events inside the containment might lead to containment failure.[44] None of these has been omitted from consideration in the ANSTO assessment.[45] The focus by ANSTO on a loss of coolant as the key element conforms with the focus in other studies.[46]

7.44 Without attempting to canvass all the scenarios that ANSTO considered or could have considered, the Committee makes the following selective comments on some of them.

Fire or Weapon Accidents

7.45 The ANSTO assessment did not address the risk of a

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43. The major assessments of land-based reactors used as points of reference were US, Nuclear Regulatory Commission, Reactor Safety Study: An Assessment of Accident Risks in U. S. Commercial Nuclear Power Plants, (WASH-1400, NRC, Washington, 1975); US, Nuclear Regulatory Commission, Reactor Risk Reference Document, (NUREG-1150 (draft), NRC, Washington, 1987); and UK, Department of Energy, Sizewell B Public Inquiry: Report of Sir Frank Layfield, (HMSO, London, 1987). The APS Study Group, 'Report to the American Physical Society of the study group on radionuclide release from severe accidents at nuclear power plants', Reviews of Modern Physics, July 1985, vol. 57(3)(part II) was also useful. The safety assessments in relation to nuclear powered merchant ships that are summarised or discussed in Organisation for Economic Cooperation and Development, Nuclear Energy Agency, Symposium on the Safety of Nuclear Ships: Proceedings, Hamburg, 5-9 December 1977, (OECD, Paris, 1978) were also useful.
44. UK, Department of Energy, Sizewell B Public Inquiry: Report of Sir Frank Layfield, (HMSO, London, 1987), para. 29.15.
45. Submission from ANSTO, Attachment 1, pp. 4-11 (Evidence, pp. 250-57).
46. e.g. APS Study Group, 'Report to the American Physical Society of the study group on radionuclide release from severe accidents at nuclear power plants', Reviews of Modern Physics, July 1985, vol. 57(3)(part II), p. S28:

> the accidents that are expected to lead to the possibility of an appreciable source term (i.e., those in which a substantial amount and wide variety of types of radioactive material are released to the environment) are all postulated to involve a system failure that results in loss of water from the primary system.

reactor accident due to the warship catching fire. However the risk of radioactive release from a warship fire appears to be very low.[47] The ANSTO assessment also did not consider the risk of a reactor accident resulting from a weapon accident. This risk was raised with ANSTO by the Committee. The Committee was told that the presence of weapons would not increase the risk of reactor failure.[48] It appears that this conclusion is based on the assumption that the weapons are in safe storage during visits.[49]

Sabotage and Terrorism

7.46 Other risks not addressed by ANSTO in the material supplied to the Committee were those of sabotage or terrorism.[50] These have been addressed by Australian authorities, but the

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47. See para. 5.38 for references to fires that have occurred on nuclear powered warships. See also Australia, Environmental Considerations of Visits of Nuclear Powered Warships to Australia, (May 1976), para. 37 (Evidence, p. 133):

> Fires could not result in damage to the reactor of sufficient severity to cause release of radioactivity unless they occurred within the reactor compartment. Such damage is not credible because of:
> a. the lack of combustible material in these areas to support a fire of the necessary intensity; and
> b. the elaborate measures, both structural and procedural, taken to prevent the outbreak and spread of fire in warships.

See similarly NZ, Atomic Energy Committee, New Zealand Code for Nuclear Powered Shipping, (AEC500, 1981 edn.), para. 5.8. For nuclear powered merchant ships, see UK, Department of Industry, Second Report on the Nuclear Ship Study, (HMSO, London, 1975), para. 100:

> it is considered that the greatly reduced use of oil fuel in machinery spaces and the nature of reactor containment give confidence that present fire protection and extinguishing systems could ensure an appropriate standard of fire safety.

48. Evidence, pp. 425-27 (ANSTO). See also NZ, Atomic Energy Committee, New Zealand Code for Nuclear Powered Shipping, (AEC500, 1981 edn.), para. 5.9.
49. The safety features relating to weapon storage are discussed in paras. 11.71-11.81.
50. cf. submissions from Mr R. Addison, p. 6; Greenpeace Australia (NSW) Ltd, p. 29; Esperance Nuclear Awareness, p. 1; Milton-Ulladulla People for Peace, p. 3; Assoc Prof P. Jennings, p. 1; Scientists Against Nuclear Arms (Tas), p. 6 (Evidence, p. 825); Medical Association for the Prevention of War (NSW), p. 3.

conclusions remain classified.[51] As far as the Committee was able to discover, there have been no reports of either incidents of significant sabotage[52] or of terrorist actions relating to nuclear powered warships. ANSTO did consider the possibility of a crew member compromising containment integrity by unauthorised opening of airlocks. The possibility was regarded as small,[53] but was evaluated from the point of view of an accident rather than intentional sabotage.

7.47 Quantitative risk assessments relating to land-based reactors have not considered the possibility of sabotage in any detail because, as the 1975 Reactor Safety Study noted:

> no convincing way could be found to estimate the probability of acts of sabotage directed at any target. However, the study believes that nuclear power plants would be difficult to sabotage in the sense of creating an

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51. One of the deletions on security grounds from the copy supplied to the Committee of the Department of Defence's, The Environmental Impact of Visits by Nuclear Powered Warships to Australia, (July 1974) is that of paras. 80 and 81 dealing with (it appears) terrorism and sabotage.
52. This is not to say that there have not been incidents relating to the nuclear reactor, but which have not caused or threatened to cause any radiation hazard. See for example 'Ship's Nuclear Plant Forced to Shut Down', Washington Post, 3 March 1986, p. D2: disgruntled sailor stopped cooling pump without permission, forcing the shutdown of one of the two reactors on the USS Bainbridge. The press report notes the incident caused no danger to any equipment and no safety problem. It also implies that this type of incident had occurred previously. See also Rear Admiral E. J. Carroll jr (USN Ret.), 'Nuclear Trojan Horse', New York Times, 8 August 1983, p. A17: 'Sabotage occurs even on United States warships'; Department of Defence, The Environmental Impact of Visits by Nuclear Powered Warships to Australia, (July 1974), para. 34(f): 'One case of minor sabotage in a nuclear warship undergoing maintenance in a US Dockyard has been reported but no cases are known involving an operational warship in a US or foreign port'.
53. Submission from ANSTO, Attachment 1, p. 9 (Evidence, p. 255). cf. US, Nuclear Regulatory Commission, Reactor Risk Reference Document, (NUREG-1150 (draft), NRC, Washington, 1987), p. 1-6, with respect to commercial reactors:

    > Because of the experience gained in U. S. plant operation and existing regulatory requirements and industry practices, it is believed that the likelihood of severe core damage caused by the intentional violation of procedures is small.

accident with large public consequences ...[54]

7.48 In other words, while unlikely, it is conceivable that a saboteur could initiate a reactor accident by, say, causing a ship collision or shutting off the reactor coolant pumps. But the accidents that would result from collisions and coolant pump failures have been taken into account in the general risk assessment.[55] To this limited extent the risk of sabotage is not a separate head of risk.

7.49 The question of a terrorist attack relating to nuclear weapons is considered in chapter 13. The Committee has no reason to consider the risk of terrorist action relating to a naval reactor any greater than that with respect to a nuclear weapon. If anything, reactors are perhaps a less inviting target because they lack the symbolism of nuclear weapons.

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54. US, Nuclear Regulatory Commission, Reactor Safety Study: An Assessment of Accident Risks in U. S. Commercial Nuclear Power Plants, (WASH-1400, NRC, Washington, 1975), section 1.9. See also APS Study Group, 'Report to the American Physical Society of the study group on radionuclide release from severe accidents at nuclear power plants', Reviews of Modern Physics, July 1985, vol. 57(3)(part II), p. S51; UK, Department of Energy, Sizewell B Public Inquiry: Report of Sir Frank Layfield, (HMSO, London, 1987), para. 28.85 ('It was common ground that the probabilities of accidents caused or aggrivated by war or sabotage could not usefully be estimated.'); Nuclear Regulatory Commission, Reactor Risk Reference Document, (NUREG-1150 (draft), NRC, Washington, 1987), p. 2-1:

> The risk of sabotage has not been included in the results of this report. It is the staff's opinion that the likelihood of a specific threat is very dependent on the changing political and social climate. The applicability of historical data pertaining to a threat of sabotage to a nuclear plant in the future is less obvious than for hardware data or information on human error probabilities.

55. cf. APS Study Group, 'Report to the American Physical Society of the study group on radionuclide release from severe accidents at nuclear power plants', Reviews of Modern Physics, July 1985, vol. 57(3)(part II), p. S51: '... the accident scenario after initiation [by sabotage] could conceivably (and probably would) resemble some of those which have already been analyzed in PRA's, given the large number of scenarios with multiple system failures that have been investigated'.

Hydrogen or Steam Explosions

7.50 A number of submissions referred to the possibility of hydrogen or steam explosions, either generally or as matters on which the 1974 assessment might have been rendered suspect by later scientific developments.[56] It was not clear to the Committee why submissions took this view: inappropriate comparisons to the Three Mile Island and Chernobyl accidents appear to have been a factor.[57] Nonetheless, the Committee put the possibilities to ANSTO, even though they had been to some extent addressed in ANSTO's original submission.[58] The response was:

> The primary containment design specification allows for internal pressures due ... to the hydrogen which might be generated by metal-water reactions under accident conditions. Specific reference to design allowance for steam explosions has not been located. However, the conditions under which such an explosion might conceivably occur are closely analogous to those necessary for

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56. e.g. submissions from Prof W. J. Davis, pp. 14-15 (Evidence, pp. 461-62; Mr R. Addison, p. 6; Medical Association for the Prevention of War (Vic), p. 2. See also Evidence, p. 617 (Prof W. J. Davis).
57. A summary of experiments on these issues in the commercial reactor context done at Sandia National Laboratories in the US quotes a researcher:

    > We've defined a safety threat that appears to be more likely than the classic China Syndrome scenario of molten core melting through the basement. That threat is the interaction of structural concrete and molten core debris following a LOCA and the subsequent generation of heat and explosive hydrogen.

    'Sandia puts the pressure on containments', Nuclear Engineering International, March 1987, p. 28 (Dr J. Walker, emphasis added). This scenario cannot occur in naval reactors due to the absence of structural concrete. The same source also states:

    > We now believe that steam explosions are more likely to occur than we thought several years ago. However, the conditions required to produce a steam explosion with sufficient energy to fail containment may be more difficult to achieve than was originally thought.

    See similarly APS Study Group, 'Report to the American Physical Society of the study group on radionuclide release from severe accidents at nuclear power plants', Reviews of Modern Physics, July 1985, vol. 53(3)(part II), p. S98: likelihood of steam explosion large enough to fail containment considered by most investigators to be much smaller than assumed in 1975 Reactor Safety Study and regarded as impossible by a few. Again the context is commercial, not naval, reactors.
58. Submission from ANSTO, Attachment 1, p. 10 (Evidence, p. 256).

> hydrogen/air/steam explosions [considered in the original submission] ... It is reasonable to expect that, as for the hydrogen/air/steam explosion, any steam explosion could only occur within the reactor vessel. Similar attenuation mechanisms for the resulting shockwaves would therefore apply, and provide the same measure of protection for the integrity of the primary containment.[59]

7.51 The Committee acknowledges that a degree of scientific uncertainty exists with respect to hydrogen and steam explosions in reactors following core accidents. The Committee regards ANSTO's assessment of the likelihood of these types of explosions breaching containment as being consistent with what it understands to be the predominant scientific view.[60]

Melt Through to the Sea

7.52 A number of submissions put to the Committee the possibility that, following an accident leading to core meltdown, the molten core would melt its way through the bottom of the

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59. Evidence, p. 443.462 (ANSTO).
60. cf. US, H of R, Committee on Science and Technology, Subcommittee on Energy Research and Production, Nuclear Powerplant Safety Systems - Hearings, 24 May 1979, p. 1071 (Admiral H. G. Rickover): a hydrogen explosion was not a credible threat in the Three Mile Island context. Note also the following exchange (pp. 1071-72):

    Mr Anthony: Going back to your own personal operation [ie. the US Naval Nuclear Propulsion Program], what has been the naval experience with a hydrogen bubble that would create the possibility of a hydrogen gas explosion?
    Admiral Rickover: We have never had anything like it. The next question would be what if we did? That is a good question. I can anticipate that but our system is such that the hydrogen would not have formed. That is the way we operate.
    Mr Anthony: You feel that your safety and your training would have been such that you would not have had the water contamination that apparently is existing at Three Mile Island?
    Admiral Rickover: Yes, sir; I do firmly feel that. ...

    The Admiral then elaborates on the basis for his confidence.

pressure vessel and the containment into the sea.[61] One concern is the contamination that this would cause.[62] Another is that when the molten core comes into contact with the sea water a large steam explosion might result.[63]

7.53 Senator Vallentine told the Committee that, according to a 1973 United States Navy reactor disaster control plan, the 'Navy found that the melt-down could go right down through the ship spilling hot radioactive materials to the bottom of the harbour ...'.[64] When the Committee tried to obtain a copy of the plan, it became clear that Senator Vallentine had not seen the plan she purported to quote from. She in fact was quoting from a booklet authored by a New York peace activist.[65] It would seem that this author had not seen the plan either but was relying on an account in a Honolulu newspaper.[66] The journalist who wrote this account did not purport to have seen the plan, but had interviewed one of its authors. The statement about the melt through is not presented in this account as part of the plan, but as the view of the interviewee, a former shift supervisor in the radiological controls section at Pearl Harbour naval base. The knowledge of reactor design possessed by the interviewee is not stated. The Committee did not regard it as prudent to rely on this source.

7.54 ANSTO informed the Committee that they had examined the

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61. Submission from People for Nuclear Disarmament, p. 3 (Evidence, p. p. 1305). See also Evidence, p. 1330 (People for Nuclear Disarmament). Dr R. Webb raised the possibility of melt-through in a letter to Senator J. Vallentine (Evidence, p. 1362), although, as he stated that he did not know if US naval reactors had containment (Evidence, p. 1361), he is presumably not in a position to reach worthwhile conclusions on the possibility.
62. Submission from Mr R. Addison, p. 6.
63. Submissions from Albany Peace Group, p. 3; Senator J. Vallentine, p. 6 (Evidence, p. 1049). See also Evidence, pp. 1219-20 (Senator J. Vallentine).
64. Evidence, p. 1217 (Senator J. Vallentine).
65. S. A. Sahaydachny, Nuclear Trojan Horse: The Navy's Plan to Base Nuclear Weapons in New York Harbor, (Riverside Church Disarmament Program, New York, 1985), p. 46 (Evidence, p. 1185).
66. Honolulu Star-Bulletin, 18 June 1979, p. A2, 'Pearl Harbor's Nuclear Sub Risks Discussed'.

possibility of a breach of containment by molten fuel. On the basis that there would be insufficient decay heat available in a submarine's reactor, it had 'concluded that melt-through of the hull will not occur'.[67]

7.55 The Committee notes that ANSTO's conclusion with respect to submarines is consistent with the position for nuclear powered merchant ships.[68] However, for surface ship reactors, where the containment is not in direct contact with the sea, the hull forms an additional barrier.[69] The analysis leading to ANSTO's conclusion is conservative in that it makes no allowance for counter-measures (e.g. flooding the reactor compartment) during the time it would take the molten core to melt through.

7.56 The Committee did not understand ANSTO to be claiming that melt-through was physically impossible. Determination of this would require detailed knowledge of, among other things, the structure of the pressure vessel and the hull, and whatever else lay between the hull and the bottom of the pressure vessel.

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67. Submission from ANSTO, Attachment 1, p. 11 (Evidence, p. 257).

68. e.g. W. Vinck and others, 'Technical Safety Problems in Nuclear Naval Propulsion as Related to Port Entry Conditions' in International Atomic Energy Agency and others, Proceedings of the Symposium on Nuclear Ships, Hamburg, 10-15 May 1971, (GKSS, Hamburg, 1971), p. 145, with reference to marine reactors up to 100 Mw(t) in power:

> the after heat in the molten masses of fuel and cladding would probably not be such as to jeopardize integrity of the pressure vessel and subsequently of the containment.

Direct comparisons between naval and land-based reactors on this point are not valid. But it is worth noting that concern about melt-thorough on the latter (the 'China syndrome') only became a major concern as reactor size increased. e.g. see US, Nuclear Regulatory Commission, Reactor Safety Study: An Assessment of Accident Risks in U. S. Commercial Nuclear Power Plants, (WASH-1400, NRC, Washington, 1975), pp. 26-27:

> In early power reactors the power level was about one tenth that of today's large reactors. It was thought that core melting in those low power reactors would not lead to melt-through of the containment. Further, since the decay heat was low enough to be readily transferred through the steel containment walls to the outside atmosphere, it could not overpressurize and fail the containment. ... However, as reactors grew larger, ... it became likely that a molten core could melt through the thick concrete containment base into the ground.

69. Submission from ANSTO, Attachment 1, p. 11 (Evidence, p. 257).

Variables such as the recent operating history of the reactor and the time since it was shut down would also have to be considered. If worst-case assumptions are made on all points on which firm information is lacking, the possibility of melt-through cannot be shown to be impossible under all conceivable circumstances.

7.57 It is important, however, to keep this conclusion in perspective. First, the conclusion that the scenario cannot be shown to be impossible is based on the limited information available. If more comprehensive information was available the conclusion might alter. Therefore, it should not be taken for granted that melt-through is physically possible.

7.58 Secondly, the scenario is based on a series of unlikely events.[70] There must be a melt down. No effective countermeasures against melt-through are taken either at the design stage or following the accident. The vessel has been running at or near full power for some time immediately prior to, or at the time of, the accident. The likelihood of these events coming together is logically less likely that of a melt down alone. It is because of this that ANSTO concludes that, for practical purposes, the overall scenario can be discounted.

7.59 The Committee finds no reason to differ from this conclusion. The Committee explained in paragraph 3.14 that it does not accept that planning is required for all physically possible accidents, irrespective of their likelihood.

Human Error

7.60 The fact that a number of submissions relied partly or wholly on human error as an accident cause has already been noted. The Committee asked ANSTO the extent to which it had considered the possibilities of human error in making its

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70. See the submission from ANSTO, Attachment 1, p. 11 (Evidence, p. 257) where some of the improbabilities are noted.

assessment. ANSTO told the Committee that it lacked relevant information on the detailed design and operating procedures of naval reactors. It had made a judgment that the incidence of errors with naval reactors was unlikely to be higher than that with commercial reactors.[71]

7.61 In evaluating this judgment, the Committee had regard to the attention paid in the United States Naval Nuclear Propulsion Program to training of reactor operators, to development of safe operating procedures, and to designing reactors so as to minimise the scope for operator error.[72] In the light of this attention, the Committee considered ANSTO's judgment to be reasonable.[73]

7.62 On the basis of its judgment, ANSTO considers that 'a reasonable allowance has been made for human operating errors' in arriving at its reference accident.[74] The Committee did not understand ANSTO to be claiming to have done more than this. Overseas reactor risk assessments relating to land-based reactors have not made allowance for human error with any precision, and

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71. Evidence, p. 375 (ANSTO).
72. On these see paras. 4.115-4.120 and 4.138-4.140. See also UK, Department of Energy, Sizewell B Public Inquiry: Report of Sir Frank Layfield, (HMSO, London, 1987), para. 47.44:

> I considered two main indicators of the adequacy of the CEGB's [the electricity board's] case on human factors: first, the Board's managerial arrangements for recruiting, training and providing instructions for operators, and second, whether human factors had been properly integrated with the engineering design.

73. cf. Evidence, p. 834 (Scientists Against Nuclear Arms): three factors identified as contributing to human error are ignorance, apathy, and institutional blindness. It would seem from the material referred to in chapter 4 on the training, etc of US naval reactor operators and the regard for safety that each of these three factors would have minimal effect on Navy reactor safety, compared to, say, civil reactors.
74. Evidence, p. 391 (ANSTO).

probably cannot do so.[75]

7.63 Human error may lead to marine risks such as collision, which in turn lead to reactor risks. One study identified 14 causes of error in merchant marine safety. The majority related to factors such as fatigue, excessive alcohol use, boredom, and a high level of calculated risk.[76] It seems reasonable to assume that these factors would be present to a lesser degree on a warship than the average merchant ship. The fact that alcohol is not permitted on United States warships supports this assumption.[77]

Collisions

7.64 The ANSTO assessment included the possibility of a reactor accident resulting from a collision involving the warship.[78] It was considered that a collision of sufficient

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75. e.g. see J. N. O'Brien and C. M. Spettell, Uses of Human Reliability Analysis Probabilistic Risk Assessment Results to Resolve Personnel Performance Issues that Could Affect Safety, (NUREG/CR-4103, Brookhaven National Laboratory for the Nuclear Regulatory Commission, October 1985), p. 5: 'To date, the human risk component in safety system reliability has been analyzed in only a peripheral manner in PRAs, even though 40 to 50% of all system failures are reported to involve human error'. See also UK, Department of Energy, Sizewell B Public Inquiry: Report of Sir Frank Layfield, (HMSO, London, 1987), para. 47.43: it was common ground during the inquiry that human error is difficult to model adequately in accident probability analysis.
76. US, National Research Council, Human Error in Merchant Marine Safety, (June 1976) discussed in J. Deck, 'Application of Risk Assessment to Nuclear Merchant Ship Safety' in Organisation for Economic Cooperation and Development, Nuclear Energy Agency, Symposium on the Safety of Nuclear Ships: Proceedings, Hamburg, 5-9 December 1977, (OECD, Paris, 1978), p. 67.
77. Contrast Evidence, p. 1201 (Senator J. Vallentine): concern regarding intoxicated crew members returning from shore leave.
78. Submission from ANSTO, Attachment 1, pp. 5-6 (Evidence, pp. 251-52); Evidence, pp. 396-97 (ANSTO). cf. D. J. Morris and R. Strong, 'A Role for Probabilistic Methods in Nuclear Ship Safety' in Organisation for Economic Cooperation and Development, Nuclear Energy Agency, Symposium on the Safety of Nuclear Ships: Proceedings, Hamburg, 5-9 December 1977, (OECD, Paris, 1978), p. 195: a sample calculation 'indicates that, without collision protection, a release of fission products due to collision is 10 times more likely than a release caused by a major spontaneous primary circuit leak. Similar probabilities arise for grounding ...'. The calculations relate to merchant ships.

severity to damage a reactor was unlikely in ports, where speed limits are low.[79] The Australian Department of Defence described as a 'virtual impossibility' the likelihood of reactor damage following a low-speed collision.[80] The Committee, noting that the Department lacked detailed design information on nuclear powered warships, asked it to explain the basis of its view.

7.65 The Department replied:

> The judgement about the consequences of a ship collision involving an NPW is based on the Defence Department's very considerable expertise in warship design and construction, and ship engineering in general. Further, it has long been known that marine reactor compartments for the US Navy are designed and constructed to particularly high standards of strength and integrity. ... the reactor plant containment and shielding required to minimize radiation outside of the reactor also provide strong protection for the reactor plant from external impact. We can be confident of that fact without having access to NPW design specifications.[81]

The Committee noted that the absence of reactor damage in the numerous collisions involving nuclear powered warships tends to confirm that reactors are robust enough to survive substantial collision impacts without damage.[82]

7.66 ANSTO regarded the risk from collision as higher in port approaches, where speeds are greater than in ports. Its assessment considered that this risk could be reduced to an acceptable level by the imposition of navigational controls. The adequacy of

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79. Contrast the submission from Mr R. Bolt, p. 8 (Evidence, p. 958), where collision with a wharf while docking is given as a possible cause of a reactor accident.
80. Second supplementary submission from the Department of Defence, p. 19 (Evidence, p. 238.274).
81. Evidence, p. 1300.52 (Department of Defence). The Department noted that ANSTO, in making its original assessment of the effect of collisions, 'possessed significant information on the design of NPWs from confidential sources': ibid.
82. See the references to collisions in para. 5.38.

the controls currently imposed[83] is discussed in paragraphs 8.16-8.21.

7.67 The assessment noted that a collision of sufficient severity to breach a submarine's reactor would almost certainly sink the submarine. A similar conclusion is also made in the context of British plans.[84] The sinking would release radionuclides from the damaged reactor core to the sea rather than the atmosphere. This form of release presents a much lower risk to population.[85]

7.68 The Committee noted that sophisticated attempts have been made to assess the risk of reactor damage from a collision involving a nuclear powered merchant ship.[86] The Committee found it beyond its resources to attempt any detailed quantitative assessment of the collision risk for nuclear powered warships visiting Australia.

7.69 The basic data on vessel collisions in Australian ports are not centrally held and are not in uniform format. Collisions involving small vessels would need to be excluded from the data base, as these would not be relevant to the severity of impact needed to damage a reactor. Judgments would have to be made as to

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83. OPSMAN 1 (2nd edn.), para. 201(c)-(d), (Evidence, p. 49).
84. UK, Ministry of Defence, Liverpool Special Safety Scheme for Visits to Liverpool by Nuclear Powered Submarines, (April 1986), para. 13.
85. Submission from ANSTO, Attachment 1, p. 5 (Evidence, p. 251). See also J. B. Montgomery and C. R. Jordan, 'Impact of Nuclear-Related Safety Requirements on the Design of Merchant Ships' in Organization for Economic Cooperation and Development, Nuclear Energy Agency, Symposium on the Safety of Nuclear Ships: Proceedings, Hamburg, 5-9 December 1977, (OECD, Paris, 1978), p. 377: 'If a nuclear vessel sinks, the immediate danger from radiation is eliminated. Water is a good shielding material'.
86. e.g. see V. U. Minorsky and others, 'Ship Accident Studies' in Organisation for Economic Cooperation and Development, Nuclear Energy Agency, Symposium on the Safety of Ships: Proceedings, Hamburg, 5-9 December 1977, (OECD, Paris, 1978), pp. 95-101. The Safety Assessment for the NS Savannah concluded conservatively that the risk of collision with enough energy to breach both containment and the primary circuit was 7 in 100,000 during one year of continuous operation: cited in D. W. Crancher, 'Problems Faced by Host Nations in Accepting Visits by Nuclear Powered Merchant Ships' in ibid., p. 497.

which collisions were serious enough to warrant inclusion in the data base. Allowance would have to be made for the navigational controls imposed during nuclear powered warship visits, and for differing traffic volumes and geography at different ports. Additionally, the higher levels on warships of manning, training, equipment (such as radar), and manoeuvrability compared to most merchant ships would have to be taken into account.

7.70 Despite the absence of any quantitative assessment of the collision risk, the Committee could see no reason to regard the ANSTO assessment of this risk as inappropriate.

Grounding

7.71 The ANSTO assessment did not address the possibility of a ship running aground, although other studies have.[87] In the extreme case, grounding may lead to the total wreck of the ship. Short of this the main hazard is the loss of condenser cooling water supply if the tide ebbs and leaves the intake above sea level. Not all ports visited have a sufficient tidal range to make this probable. If it occurs, cooling water can be provided from a pump aboard another vessel without difficulty.[88]

Assessment Applicable to All Visiting Warship Types?

7.72 The Committee noted that much of the recent work on reactor risk assessment has pointed out the need to focus on specific designs. In other words, it is not satisfactory to evaluate one or two designs within the same generic type and then

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87. e.g. see V. U. Minorsky and others, 'Ship Accident Studies' and H. A. Agena, 'Effects of Ship Casualties on Reactor Safety and Marine Reactor Design' both in Organisation for Economic Cooperation and Development, Nuclear Energy Agency, Symposium on the Safety of Nuclear Ships: Proceedings, Hamburg, 5-9 December 1977, (OECD, Paris, 1978), pp. 92-95 and 133 respectively. The studies relate to merchant ships.
88. See UK, Ministry of Defence, Liverpool Special Safety Scheme for the Visits to Liverpool by Nuclear Powered Submarines, (April 1986), Annex 2B, para. 3.

apply the results across all reactors of the type.[89]

7.73 The Committee put this point to ANSTO with respect to its assessment. ANSTO responded by saying that its assessment had been conservatively derived to cover the generic class of naval reactors: 'It is not likely that any ship visiting an Australian port would not be covered by that assessment'.[90]

7.74 The Committee lacked the detailed design information necessary to confirm this. However, it notes both the relatively high degree of similarity between the reactors aboard visiting warships,[91] and the degree to which conservatism has been built into the ANSTO assessment.[92] ANSTO's view appeared reasonable in the light of these factors.

Conclusions on Accident Likelihood

7.75 The Committee accepts ANSTO's view that the likelihood of a contained accident is remote. The Committee is not able to attach any precise figure to the likelihood. This is both because all the necessary information is not available to it and because it does not consider precise calculations to be possible in assessing the likelihood of such rare and complex events. The Committee, however, has not identified any basis for considering the British figure of no greater than 1 : 10,000 reactor years to

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89. This is a theme of US, Nuclear Regulatory Commission, Reactor Risk Reference Document, (NUREG-1150 (draft), NRC, Washington, 1987). See also APS Study Group, 'Report to the American Physical Society of the study group on radionuclide release from severe accidents at nuclear power plants', Reviews of Modern Physics, July 1985, vol. 57(3)(part II), pp. S11-12: in the 1975 Reactor Safety Study, the risk of the chain of events that occurred in the 1979 Three Mile Island accident was calculated by reference to a Westinghouse PWR reactor at the Surry power station to have a probability of 1 in 100,000 years. Had the same assessment methodology been applied to the Babcock and Wilcox PWR reactor at Three Mile Island it would have predicted a frequency of occurrence of once in 300 years.
90. Evidence, p. 1274 (ANSTO).
91. See para. 4.137 on the higher degree of standardisation amongst naval reactors compared to civil reactors.
92. See above, para. 7.15.

be anything other than a conservative estimate.

7.76 For reasons discussed earlier in this chapter, an uncontained accident is logically less likely than a contained accident. Again the Committee is not in a position to quantify how much less likely. But all the information available to it relating to naval reactor containment and possible scenarios by which that containment might be breached to permit a large airborne release of radioactivity suggests that an uncontained accident is much less likely again than an already unlikely contained accident.

MATTERS RELATING TO ACCIDENT CONSEQUENCES

Introduction

7.77 As already indicated, ANSTO accepted that uncontained accidents would have greater consequences than the current reference accident. However, it considered that the difference would not be as great as one might suspect, due to the very conservative assumptions it had made on the consequences of the reference accident. Moreover, the likelihood of uncontained accidents was much less than the already remote likelihood of contained accidents. Taking both these factors into account, the overall risk (the mean annual severity[93]) of an uncontained accident was less in ANSTO's view than that of the contained accident currently used as the reference accident.[94]

7.78 In the previous section the Committee accepted as reasonable ANSTO's evaluation of factors relating to accident likelihood. In view of this, the Committee did not consider it necessary to examine accident consequences in great detail.

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93. See para. 7.12.
94. Submission from ANSTO, Addendum, p. 1 (Evidence, p. 379).

Rather, what the Committee looked for were indications that ANSTO's assessment was incorrect with regard to consequences to the degree necessary to make the overall risk of the uncontained accident exceed that currently estimated for the reference accident.

7.79 ANSTO did not provide a detailed tabulation of the consequences of an uncontained accident in such a way as to enable a simple comparison with the consequences of the current reference accident. A simple comparison may not be all that realistic. Most submissions treated contained and uncontained accidents as distinct, easily-defined categories. Apart from noting that 'contained' does not mean totally contained, the Committee has to this stage of its report adopted a similar approach.

7.80 More realistically, there is a continuous spectrum of possible containment failures in terms of both time and quantity. The containment may fail instantly or only hours after the onset of the accident. The failure may range from a slow leak to a large hole. The method and timing of containment failure is regarded for land-based reactors as critical for the size of accident consequences.[95] For example, late failure or slow leakage allows time for radioactive decay and for deposition of aerosols within the containment and, for a marine reactor, towing the vessel to a remote anchorage. If there is failure with a large hole, the gases would leave in a puff and release much, if not all, of the aerosols suspended in the containment atmosphere.[96]

7.81 In short, it would be necessary to define what is meant

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95. See APS Study Group, 'Report to the American Physical Society of the study group on radionuclide release from severe accidents at nuclear power plants', Reviews of Modern Physics, July 1985, vol. 57(3)(part II), pp. S92-95.

96. ibid., p. S95, which notes that 'large' in this context for commercial land-based reactors means over 10 square metres.

by an uncontained accident before its consequences could be rigorously compared to those of the contained accident defined for the purposes of the current reference accident. For example, Professor Jackson Davis provided the Committee with a sophisticated analysis of accident consequences. This was based on methodology accepted in the United States,[97] and on the assumption that there was no reactor containment.[98] He calculated that 1% of the non-volatiles would be released, compared to ANSTO's assumption of nil release of non-volatiles following its (contained) reference accident.[99]

7.82 ANSTO regarded the 1% figure as credible only if there were to be a complete and instantaneous loss of containment. If this is correct,[100] Professor Davis's figure is not consistent with his own assumptions. He assumes that there is no containment as such but then treats the 'reactor vessel' as 'containment'. As a result, he assumes a slow leakage (4 hours duration) from this reactor vessel/containment to the atmosphere, rather than an instantaneous release.[101]

7.83 This underlines the point that there can be various types of uncontained accidents. Within the category of uncontained accidents, it is very much a conservative or 'worst case' assumption to postulate the absence of even weak containment. It assumes in effect that the reactor is floating on a raft, rather than contained in a warship's hull. Nonetheless,

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97. See the submission from Prof W. J. Davis, pp. 93-122 (Evidence, pp. 540-69) where the methodology used by him is defined in detail.
98. Evidence, pp. 604 and 617.002 (Prof W. J. Davis).
99. Submission from Prof W. J. Davis, p. 60 (Evidence, p. 507); Evidence, p. 443.454 (ANSTO).
100. See para. 7.99, where it is noted that Prof Davis did not seem to challenge ANSTO's view.
101. Submission from Prof W. J. Davis, p. 59 (Evidence, p. 506). The reference to 'reactor vessel' would appear to mean the pressure vessel surrounding the core. But it is conceivable that 'vessel' means 'hull'. If so, some allowance is being made for the fact that the warship's hull would be in some accident scenarios a barrier of sorts to the instantaneous release to the atmosphere from the reactor even if the hull is not designed to be 'containment' in the technical sense.

ANSTO used this conservative assumption as the basis for what comparative data it supplied.

The Source Term

7.84 In order to assess the consequences of an accident involving release to the atmosphere it is necessary to establish the inventory of radioactive materials available to be released. These materials are the fission products formed either by fission, or by the subsequent radioactive decay of the materials formed by fission. The radioactive isotopes so formed are broadly classified into one of three groups: gaseous, volatile, or non-volatile.[102]

7.85 The quantity of each isotope present depends on factors such as the reactor size, fuel used, length of time since refuelling, and the reactor operating conditions. Further factors requiring consideration govern what quantities of which fission products will remain in the fuel elements or the reactor pressure vessel following an accident.

7.86 The quantity of radionuclides available for release to the atmosphere is referred to as the source term. This is obtained by multiplying the fission product inventory by the proportion released. As the United States Nuclear Regulatory Commission has observed:

> The determination of the radioactive source term that would be released following severe accidents is perhaps the most difficult and

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102. e.g. APS Study Group, 'Report to the American Physical Society of the study group on radionuclide release from severe accidents at nuclear power plants', Reviews of Modern Physics, July 1985, vol. 57(3)(part II), p. S4. For a more sophisticated method of classification see ibid., p. S15.

uncertain area of risk analysis.[103]

7.87 In evaluating accident consequences it is important to distinguish two possible grounds of criticism. One relates to the degree to which containment would be breached. The other accepts the reference accident leakage rate but argues that the ANSTO assessment of the types of radionuclides released is nonetheless incorrect in some respect. Almost all the arguments made in submissions focused on the first of these grounds: that is they rejected the current reference accident. Because the Committee has accepted the degree of integrity of reactor containment underlying the adoption of the reference accident, it is necessary to deal only with the second ground.

7.88 While simplifying assumptions had to be made about many factors in estimating the source term,[104] ANSTO's assumptions appear conservative. It assumed a substantially greater release from the fuel elements via the pressure vessel than Professor Davis, for example.[105] ANSTO's assessment of the release from the core as far as the containment was in effect a worst case one. For this reason it is not surprising that it was not criticised in those submissions expressing opposition to ANSTO's overall conclusions. There seemed to be only one point of disagreement with ANSTO's assumptions on this matter. This related to the passing from the reactor core to the reactor compartment of non-

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103. US, Nuclear Regulatory Commission, Reactor Risk Reference Document, (NUREG-1150 (draft), NRC, Washington, 1987), p. ES-14. For a survey of the uncertainties involved in assessing source terms and other aspects of land-based reactor accident consequences, together with the assumptions commonly made, see Organisation for Economic Cooperation and Development, Nuclear Energy Agency, International Comparison Study on Reactor Accident Consequence Modeling, (OECD, Paris, 1984).

104. See Evidence, pp. 381-83, 398-400, 443.449, 443.453-54, 443.458-60 for some of the assumptions made by ANSTO. cf. submission from Prof W. J. Davis, 55-61 (Evidence, pp. 502-08) for some of the simplifying assumptions made by him.

105. Evidence, p. 601 (Prof W. J. Davis); p. 443.454 (ANSTO).

volatiles,[106] and is discussed later in this chapter.

Focus on Iodine

7.89 Rather than deal in detail with all the possible types of radionuclides that might be released, ANSTO made simplifying assumptions.[107] It focused principally though not exclusively on the release of radioiodine.[108] In focusing on radioiodine, ANSTO followed accepted regulatory practice, as Professor Davis

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106. The ability of different species of radioactive substances to escape from damaged fuel rods via the pressure vessel and containment to the atmosphere largely depends on their volatility: see for example, APS Study Group, 'Report to the American Physical Society of the study group on radionuclide release from severe accidents at nuclear power plants', Reviews of Modern Physics, July 1985, vol. 57(3)(part II), p. S112. See ibid., p. S62 for a description of the ways in which various species of radionuclides are retained within the core and pressure vessel, and thus never reach the containment.

107. Although many hundreds of nuclides are produced in a reactor, many are regarded as not significant in assessing off-site accident consequences because of their relatively small inventory, short half-life, or low radio-biological hazard. See D. J. Alpert and others, 'Relative Importance of Individual Elements to LWR Accident Consequence Estimates Assuming Equal Release Fractions', Nuclear Safety, January 1987, vol. 28(1), p. 78. This article notes that the 1975 Reactor Safety Study considered only 54 radionuclides to be of significance. Other studies cited have considered 60. All these studies relate to land-based commercial reactors. cf. ANSTO, Radiation Monitoring Handbook for Visits by Nuclear Powered Warships to Australian Ports, (ANSTO, Lucas Hights, NSW, 1985), para. 6.3 (Evidence, p. 340), which lists 45 radionuclides as being of importance; submission from Prof W. J. Davis, pp. 58-59 (Evidence, pp. 505-06), who lists 52 radionuclides, but then makes the further simplifying assumption that during a port visit radionuclides with half-lives of less than one day can be eliminated from consideration. By further selecting only those radionuclides making the major contribution to health detriment, Professor Davis arrives at a total of 15: ibid., pp. 60-61 (Evidence, pp. 507-08).

108. Evidence, pp. 381-87. See also ANSTO, Radiation Monitoring Handbook for Visits by Nuclear Powered Warships to Australian Ports, (ANSTO, Lucas Heights, NSW, 1985), p. 5 (Evidence, p. 299); para. 7.12 above on the calculation of the mean annual severity.

agreed.[109] Any radioactive iodine released is particularly significant because it is readily retained by the body if inhaled or ingested and concentrates in the thyroid gland.[110]

7.90 The treatment of iodine in ANSTO's assessment can be criticised as being too conservative in the light of present scientific knowledge. ANSTO in 1974 made what were then conservative assumptions about the amounts of iodine-131 available for release to the environment in the event of an accident. In particular, it was assumed that iodine would be released from the fuel and transported as a gas without change of chemical form.

7.91 Following the 1979 accident at Three Mile Island it became apparent that this assumption could lead to a considerable overestimate of iodine release. In contrast to the 0.1%[111] of the total iodine inventory assumed to be released in the reference accident, it is estimated that only 0.00003% of the radioiodine inventory escaped during the Three Mile Island accident.[112]

7.92 It is now widely accepted that pre-Three Mile Island assessments of radioiodine release from accidents at commercial

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109. Evidence, p. 614. See also the submission from the Medical Association for the Prevention of War (Vic), p. 1: of the material in a reactor, 'the most important biologically is radioactive iodine'. cf. APS Study Group, 'Report to the American Physical Society of the study group on radionuclide release from severe accidents at nuclear power plants', Reviews of Modern Physics, July 1985, vol. 57(3)(part II), pp. S17-18:

> The current studies of the source term have tended to concentrate their attention on iodine, cesium, and to a modest extent tellurium. ...it is apparent that, if released in sufficiently large quantities, some of the relatively low volatility or nonvolatile fission products and actinides might also contribute to consequences.

110. OPSMAN 1 (2nd edn.), para. 120(b) (Evidence, p. 48). See also ANSTO, Radiation Monitoring Handbook for Visits by Nuclear Powered Warships to Australian Ports, (ANSTO, Lucas Heights, NSW, 1985), p. 5 (Evidence, p. 299); Evidence, p. 1018 (ARL/NHMRC).

111. Submission from ANSTO, Addendum, p. 4 (Evidence, p. 382). Note that the figure relates to the leakage to the atmosphere from the containment, not to the release from the core to the containment.

112. Evidence, p. 443.465 (ANSTO).

reactors were greatly over-estimated.[113] ANSTO considers it reasonable to assume that the physico-chemical factors that led to the much lower than predicted iodine-131 release at Three Mile Island would also generally apply in a naval reactor accident.[114] The amount of the iodine release in ANSTO's revised accident model reflects this view, being only one-tenth of the amount allowed for in the current reference accident.[115]

7.93 It seems clear that, by adhering to its 1974 assumptions regarding the release of radioiodine, ANSTO's assessment has become very conservative indeed in this respect. The Committee took into account the need, noted in paragraph 7.25, to make a more realistic assessment for evaluation of some aspects of detailed planning.

Omission of Other Radionuclides

7.94 A few submissions questioned the appropriateness of ignoring some other radionuclides in focusing on iodine.[116]

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113. e.g. see C. Norman, 'Assessing the Effects of a Nuclear Accident', Science, 5 April 1985, vol. 228, p. 31. See ibid., p. 33, where it is noted that the factors that led to a lower than predicted release of radioiodine also apply to fission products such as cesium and tellurium. See also APS Study Group, 'Report to the American Physical Society of the study group on radionuclide release from severe accidents at nuclear power plants', Reviews of Modern Physics, July 1985, vol. 57(3)(part II), p. S127.

114. Evidence, p. 433.466 (ANSTO). cf. APS Study Group, 'Report to the American Physical Society of the study group on radionuclide release from severe accidents at nuclear power plants', Reviews of Modern Physics, July 1985, vol. 57(3)(part II), p. S127, where three factors are identified as responsible for the lowering of source term estimates since the 1975 Reactor Safety Study: the recognition that containments are stronger than was assumed; the inclusion in the modeling of previously neglected physical and chemical phenomena that lead to the retention of fission products; and allowance for additional mechanisms such as ice beds, suppression pools, and auxiliary buildings. The second of these is by and large applicable to naval reactors. The degree of applicability of the first and third is not clear, in the absence of detailed design information on naval reactors. The only factor identified which might operate to raise source term estimates is the release of radionuclides due to core-concrete interaction: ibid., p. S127. This factor is not present for naval reactors.

115. See para. 7.17 on the revised accident model. In providing this model ANSTO documented the reason for the reduction.

116. e.g. submission from the Albany Peace Group, pp. 1-2.

Professor Davis told the Committee that by ignoring some other radionuclides in the way that it did ANSTO's assessment understated the effect of its reference accident 'by perhaps an order of magnitude or two'.[117]

7.95 The Committee asked ANSTO to comment on this. The response pointed to a number of what ANSTO regarded as defects and errors in the calculations made by Professor Davis.[118] In particular, it said that he had seriously overstated the extent to which non-volatiles would be released following the reference accident.

7.96 In its 1974 assessment ANSTO allowed for the release of 1% of the solid fission products.[119] Professor Davis defined certain types of radionuclides that would be released in much the same way as ANSTO. He then allowed for the release of 1% of 'all other radionuclides' - presumably most or all of which are the non-volatiles.[120]

7.97 ANSTO, however, criticised this assumption by Professor Davis: 'without an instantaneous and complete loss of containment the 1% value assumed by Davis for non-volatiles is too high ...'.[121] The Committee sought clarification from ANSTO on what appeared to be a change in its view since 1974. ANSTO responded by saying that it had in fact changed its view, and that its current view was correct. The basis of the change stemmed from

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117. Evidence, p. 614. See also p. 615.
118. Evidence, pp. 443.457-59, 743, 1277, 1280, 1282.
119. Department of Defence, The Environmental Impact of Visits by Nuclear Powered Warships to Australia, (July 1974), para. 127.
120. Submission from Prof W. J. Davis, pp. 60 and 96 (Evidence, pp. 507 and 543.
121. Evidence, p. 443.454 (ANSTO).

work done as long ago as 1967 in the United States.[122]

7.98 The Committee notes that, even if the original ANSTO assessment was incorrect, it leads to an over-estimation of accident consequences, and therefore does not affect the orientation towards safety built into the calculations leading to the adoption of the reference accident.[123]

7.99 In his response to ANSTO's criticism, Professor Davis apparently abandoned his own criticism of ANSTO premised on the validity of the current reference accident in favour of what had always been his primary argument, viz. that an uncontained accident should be the basis of planning.[124] Accordingly, the Committee did not pursue the point.

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122. Letter from ANSTO, 15 July 1988 (Evidence, p. 1300.01). This letter referred the Committee to F. G. May, Source Term & Behavioural Parameters for the HIFAR Loss of Coolant Accident, (ANSTO, Lucas Heights, NSW, 1987). This paper and the US data underpinning it, however, are based on molten fuel consisting of uranium and aluminium. The fuel cladding in naval reactors is almost certainly an alloy of zirconium, not aluminium. The melting point of zircalloy used in civil reactors is nearly three times that of uranium-aluminium. For this reason the relevance of the paper and data to naval reactors is unclear.

123. On the uncertainty, with respect to land-based reactors, in estimating the size of the release of non-volatiles, see Organisation for Economic Cooperation and Development, Nuclear Energy Agency, Nuclear Accident Source Terms: Report by an NEA Group of Experts, (OECD, Paris, 1986), p. 19:

> The non-volatile fission and activation products are believed to be nearly totally retained in the melt, at least till the time of vessel failure. The experimental release data for these elements are rather limited, so that determination of escape fractions is relatively uncertain but these values are all quite low.

See also Organisation for Economic Cooperation and Development, Nuclear Energy Agency, International Comparison Study on Reactor Accident Consequence Modeling: Summary Report to CSNI by an NEA Group of Experts, (OECD, Paris, 1984), p. 29: in a 'benchmark accident release' developed to reflect the largest releases postulated in accident assessments relating to land-based light water reactors, figures of 0.03% and 0.003% are used for the release fractions of groups of non-volatiles.

124. Evidence, pp. 617.001-04. See especially p. 617.002, where the assumption about the fraction of non-volatiles that would be released is justified by reference to the Chernobyl reactor accident. This was of course an uncontained accident. ANSTO apparently took the view that Prof Davis had abandoned his argument premised on a contained accident: Evidence, p. 1282 (ANSTO).

7.100 The Committee notes that at least one study has cautioned that the effects of some radionuclides have been neglected in assessing possible accident consequences.[125] The Committee put this view to ANSTO. The Committee took the response to mean that ANSTO was using conservative values (in pre-Three Mile Island terms) for radioiodine as an alternative to using realistic values for radioiodine and at the same time including the effect of other significant radionuclides.[126]

7.101 Moreover, some of these radionuclides are of more significance if exposure occurs over a relatively long period of time than to brief exposure. The focus on those whose effects arise from brief exposure is more appropriate in the context of planning the initial post-accident response.[127] The response for other radionuclides, whose significant effects occur only if exposure is over a long period, can be postponed until accurate monitoring has provided guidance on appropriate remedial measures.[128]

7.102 Both these points seem as applicable to an uncontained accident as to a contained one. On this basis, the fact that

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125. See APS Study Group, 'Report to the American Physical Society of the study group on radionuclide release from severe accidents at nuclear power plants', Reviews of Modern Physics, July 1985, vol. 57(3)(part II), pp. S18 and S19.

126. Evidence, pp. 398-99 (ANSTO).

127. Evidence, pp. 400-01 (ANSTO).

128. Evidence, pp. 443.459-60 and 1300.01 (ANSTO). It is important to note that effective countermeasures may avoid the health effects that arise due to long-term exposure. In the submission from Prof W. J. Davis, pp. 74 and 77 (Evidence, pp. 521 and 524) casualties from a reactor accident are calculated using assumptions that there would be no evacuation (or other countermeasures such as vessel removal) during the first day, the first week or the first year after the accident. Also the assumptions for the longest period appear to make no allowance for the effect of weathering on deposited radionuclides, or for the effect of any clean-up operations. The realism of these assumptions, and hence the results obtained by using them, are open to serious question. This would be true even in the context of a health/environmental assessment of the overall effects of an accident. In the context considered by the Committee, the adequacy of contingency planning to respond to an accident, the focus on immediate and short-term effects and necessary countermeasures is appropriate.

Professor Davis considered a wider range of radionuclides than ANSTO[129] loses much of its apparent significance.

Reactor Size Used in ANSTO's Assessment

7.103 The Committee noted that where ANSTO's original assessment relied on specific input figures, the figures often related to British nuclear powered submarines. The reactor on these submarines has a power output of about 40 Mw(t).[130] Yet the ANSTO assessment is used as the basis for allowing port entry to vessels having a reactor size up to 100 Mw(t). The Committee was concerned that any conclusions based on data relating to a 40 Mw(t) reactor might not be valid for reactors up to 100 Mw(t).

7.104 The main impact of the different reactor sizes would be on calculating the size of their respective source terms following an accident. In fact there is no indication that ANSTO's use, in some parts of its assessment, of the smaller reactor size has led to any overall underestimation of the source term. As already noted, a number of factors has to be considered in calculation of a source term, of which reactor size is only one. Assumptions made with respect to other factors, primarily that relating to the operating level at the time of the accident, operate to overstate the source term. The net effect is to give a larger source term than that, for example, calculated by Professor Davis using a 100 Mw(t) reactor as a starting point.[131]

Conclusions on Source Terms

7.105 It was clear to the Committee that any attempt to

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129. Evidence, p. 613 (Prof W. J. Davis).
130. e.g. see Department of Defence, The Environmental Impact of Visits by Nuclear Powered Warships to Australia, (July 1974), para. 21: 'attention in this document has been directed mainly to' 40 Mw(t) reactors; submission from ANSTO, Addendum, p. 3 (Evidence, p. 381): release calculations based on the inventory of 40 Mw(t) reactor. ANSTO made separate calculations for reactors over 100 Mw(t), ie. for Nimitz-class aircraft carrier visits.
131. Evidence, p. 443.453 (ANSTO).

calculate with precision the consequences of a reactor accident involves considerable uncertainties. Highly complex calculations are required and many simplifying assumptions have to be made. ANSTO acknowledged that its 1974 estimates contain elements that are either not logical or could usefully be revised.[132]

7.106 But as far as the Committee can determine, re-estimation using different assumptions or treating particular radionuclides in different ways would not lead to any more pessimistic view of consequences. The ultra-conservative (with respect to present scientific knowledge) assumptions on radioiodine would appear to negate any over-optimistic (ie. risk understating) assumptions that might inadvertently be part of the overall estimation.

Atmospheric Dispersion and Population Exposure

7.107 Once source terms have been calculated the atmospheric dispersion, ground deposition, inhalation by humans, and so forth all have to be calculated in order to determine the ultimate effects of the accident. These calculations are, like source term calculations, complex and require many simplifying assumptions to be made. Submissions did not raise any issues with respect to ANSTO's assessment on these matters.[133] The Committee is aware of no evidence suggesting that this assessment is insufficiently safety-oriented. There is some evidence, however, in the form of the revised accident model to suggest that it is overly safety-oriented.[134]

Allowance for Countermeasures

7.108 The comparison by ANSTO between the consequences of a

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132. e.g. see Evidence, pp. 443.458 and 1300.01 (ANSTO) for the treatment of tellurium; para. 7.17 above for the 'Revised Accident Model'.
133. e.g. see Evidence, p. 613, where Prof Davis agrees that many of the ANSTO assumptions on dispersion are similar to his.
134. See para. 7.17 for the difference in airborne dispersal models used in the current reference accident and the revised accident model.

contained and an uncontained accident made no allowance for countermeasures. In both cases, once the accident occurred the differing estimated amounts of iodine-131 were treated as being free to cause harm. In the view of the Committee, the effect of this is to introduce an extra element of conservatism into the assessment of the reference accident when comparing it with an uncontained accident.

7.109 The occurrence of the contained accident would allow time for the warship to be towed away. Alternatively, or additionally, people could be evacuated or take shelter in the time available. In contrast, a sudden and catastrophic failure of containment immediately following a core meltdown would not permit mitigating actions to be taken in time.[135] On this point a conservatively-assessed reference accident is being compared by ANSTO to a realistically-assessed uncontained accident.

EFFECTS OF POPULATION EXPOSURE.

Introduction

7.110 The international radiological community and national governments set reference levels below which exposure of people to radiation should be kept. Three sets of levels are used: a low level for general population exposure, a higher level for occupational exposure, and, in some countries, a still higher level for exposure during an emergency or accident.[136] While

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135. cf. UK, Ministry of Defence, Liverpool Special Safety Scheme for Visits to Liverpool by Nuclear Powered Submarines, (April 1986), para. 24(c): sheltering is an inappropriate countermeasure following the rapid release of short duration which would follow the postulated uncontained accident. ANSTO pointed out to the Committee (Evidence, p. 1296) that it is unlikely that an uncontained accident would result in a short-duration release, and where it did not, countermeasures would be worthwhile. See also para. 7.80 on the differing types of uncontained accident.

136. Australia, Environmental Considerations of Visits of Nuclear Powered Warships to Australia, (May 1976), pp. 21-22 (Evidence, pp. 138-39).

there is now reasonable agreement on the expected consequences to people of exposure to doses above 10 rad (0.1 Gray), there is substantial uncertainty for very low doses.[137] As a result, internationally or nationally set reference levels are open to revision.

7.111 A potential revision is not relevant to the choice between a contained and uncontained accident. Whatever levels are chosen apply equally to both types of accident and are used to translate the consequences of whatever measure of exposure results into health effects. Revision would, however, be relevant to aspects of current planning. Distances at which particular response measures may be required, and the time within which any response should be taken, are determined in part on the basis of the emergency reference levels.

International Changes to Reference Levels

7.112 The International Commission on Radiological Protection (ICRP) is considered the authoritative international body for recommending reference levels for exposure to radiation. The most recent comprehensive set of ICRP-recommended levels dates from 1977. A process of revision is now underway within the ICRP and the United Nations Scientific Committee on the Effects of Atomic Radiation. This is based on a reassessment of the effect of the 1945 atomic bombings of Hiroshima and Nagasaki.[138] It appears that there will be a reduction in some aspects of the levels. Any new levels recommended by the ICRP are not expected to be issued until 1990.[139] Some national radiation standards have been altered as an interim measure in anticipation of expected ICRP

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137. APS Study Group, 'Report to the American Physical Society of the study group on radionuclide release from severe accidents at nuclear power plants', Reviews of Modern Physics, July 1985, vol. 57(3)(part II), p. S15.
138. Evidence, p. 1019 (ARL/NHMRC).
139. Evidence, pp. 1019-20 (ARL/NHMRC).

changes.[140]

7.113 The emergency reference levels used in conjunction with the reference accident were those recommended for general radiation protection purposes in 1973 by the National Health and Medical Research Council (NHMRC).[141] The Committee inquired if there was any need to alter these levels. Dr Keith Lokan of the NHMRC told the Committee that the 1973 levels did deserve to be looked at again and the NHMRC had formed a working party to do this.[142] However, there would be a long process of consultation with the States and others before any changes were recommended.

7.114 The Committee considered if there was any need to alter planning now, in anticipation of any changes that might be made.[143] Mr Donald McCulloch of ANSTO told the Committee that he considered it would be 'a bit presumptuous' to make alterations now, in advance of the expert bodies' conclusions.[144] It was not, in his view, an inevitable conclusion that plans would need to be altered.[145] The Committee agrees with this view.

Exposure As Low As Reasonably Achievable (ALARA)

7.115 An argument was put to the Committee based on the assumption, generally accepted in the interests of being conservative, that there is no threshold dose below which

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140. e.g. for the UK see 'NRPB ups radiation risk estimates', Nuclear Engineering International, January 1988, p. 2. See also Evidence, pp. 1022-23 (ARL/NHMRC) for the position in the Federal Republic of Germany and the United States.

141. Evidence, p. 1017 (ARL/NHMRC). Extracts from the NHMRC's 1973 Recommendations are set out in Evidence, pp. 149-55. The 1977 ICRP recommendations were adopted by the NHMRC in 1980: Evidence, p. 1021 (ARL/NHMRC). But no changes to the reference levels used for planning purposes resulted.

142. Evidence, pp. 1017 and 1018. (ARL/NHMRC).

143. See Evidence, pp. 1023-24 (ARL/NHMRC) for the way in which changes would affect the current contingency plans.

144. Evidence, p. 1294 (ANSTO).

145. The anticipatory changes made in the UK affect general and occupational exposure levels, but not it seems emergency levels.

exposure to radiation is harmless. On this view it is incorrect to say that persons further away from the accident, and thus receiving less than the reference level dose, suffer no harm.[146]

7.116 The ICRP has derived three principles from the assumption that there is no threshold dose. These can be summarised as:

- the need for justification of the practice creating the risk of exposure, that is, no practice involving radiation hazards should be adopted unless it produces a positive net benefit;
- the optimisation of radiation protection, that is, all exposures should be kept as low as reasonably achievable, with economic and social factors being taken into account (the ALARA principle); and
- the limitation of exposure of individuals, that is, taking steps to ensure that doses received do not exceed recommended limits.[147]

7.117 At the risk of over-simplification, the argument is that the focus in current planning has been on the third of these principles. Little regard has been had to the ALARA principle,[148] except perhaps in the indirect sense that there has been a good deal of conservatism (ie. exaggeration of risk) in the analysis leading up to the application of the recommended limits. No formal regard, it is argued, has been paid to the first principle.

7.118 In effect, application of the first principle would

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146. See for example the submission from Scientists Against Nuclear Arms (WA) and Medical Association for the Prevention of War (WA), p. 3 (Evidence, p. 789).
147. See for example Organisation for Economic Cooperation and Development, Nuclear Energy Agency, Implications of Nuclear Safety Requirements for the Protection of Workers in Nuclear Facilities, (OECD, Paris, 1988), p. 10.
148. cf. Evidence, pp. 1021-22 (ARL/NHMRC).

require the Committee to conduct a risk-benefit assessment of the value of the ship visits. The Committee considers that its terms of reference preclude it from doing this.

CONCLUSIONS

7.119 The Committee accepts the overall conclusions of ANSTO's assessment as to both accident likelihood and accident consequences. The Committee has been unable to find any reason to justify the substitution of an uncontained accident for the current contained accident as a reference accident.

CHAPTER 8

CURRENT PLANNING - GENERAL ISSUES

DISCHARGE OF RADIOACTIVE WASTES

8.1 Australian contingency plans for visiting nuclear powered warships deal with the possibility of radioactive waste discharge as well as the possibility of reactor accidents. The sources of radioactive wastes from naval nuclear reactors were described in chapter 4. The United States Navy's apparently excellent record since the early 1970's on waste discharges was discussed in chapter 5. The United States Navy considers that there is no need for monitoring for waste discharges during port visits of the type made to Australia.[1]

8.2 The United States has provided an assurance with respect to its warships visiting foreign ports that:

> No effluent or other waste will be discharged from the ship which would cause a measurable increase in the general background radio-activity of the environment.[2]

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1. 'U. S. Navy Statement on the Safety of Operations of U. S. Nuclear Powered Warships', January 1987 (Evidence. p. 238.242). The US Navy does, however, conduct environmental monitoring in locations where repair or maintenance on reactors is carried out: ibid.
2. 'Standard Statement', para. 2(a) (Evidence, p. 1078). The Department of Defence told the Committee that 'no discharge of radioactive waste is permitted in Australian waters': Evidence, p. 238.291. The Committee noted that Australian legislation prohibiting the discharge of radioactive waste does not apply to visiting warships. The Committee asked the Department to explain its statement in the light of this. In doing so, the Department referred to the 'Standard Statement', not to any Australian prohibition: Evidence, p. 1300.50. No exact figure has been set to define what would constitute the 'measurable increase' referred to in the 'Standard Statement': ibid.

The United Kingdom has provided a similar assurance.[3]

8.3 Compared to a reactor core meltdown, the harm caused by an accidental discharge of radioactive waste would be minimal, as noted in chapter 4.[4] This, taken together with the safety record and the assurances from the United States and the United Kingdom, suggests that there is little need to continue monitoring specifically for waste discharges.

8.4 The Committee considers, however, that the monitoring for radioactive waste discharges should continue in those places where reactor accident monitoring is required. It provides useful reassurance, and also an independent check if allegations are made that there has been a discharge of radioactive waste. The cost is relatively modest.[5]

REACTOR ACCIDENTS - ADEQUACY OF CURRENT CONDITIONS OF ENTRY

Introduction

8.5 In the previous chapter the Committee accepted that the reference accident used by the Department of Defence provided an appropriate basis upon which to evaluate the need for planning for nuclear powered warship visits. In this chapter the Committee considers whether plans are needed for individual ports. It also deals with issues relating to the detail of the current contingency planning, focusing primarily on matters dealt with in Commonwealth documents and hence common to all ports receiving visits. In the next two chapters, the focus is mainly on the

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3. UK 'Standard Statement', para. 2(a) (Evidence, p. 1300.16).
4. Para. 4.30.
5. Department of Defence, Environmental Radiation Monitoring during Visits of Nuclear Powered Warships to Australian Ports: Requirements, Arrangements and Procedures, (May 1988) indicates what resources are required for routine monitoring.

details of the plans relating to individual ports.

Purpose of Visits

8.6 The six conditions under which entry is currently permitted to visiting nuclear powered warships are set out in full in paragraph 2.20. Condition (a), that the purpose of visits is not to be for fuel handling or reactor repairs, is briefly considered in paragraphs 2.58-2.59, and found to be appropriate.

Liability, Indemnity and Assurances

8.7 Condition (b) refers in part to arrangements covering liability and indemnity. The Committee has not made recommendations on these matters. In part this is because the Committee regards aspects of the present arrangements as adequate. In part it is because comprehensive treatment of the issues involved would take the Committee well beyond its terms of reference.

8.8 Relevant material on liability and indemnity is, however, set out in Appendix 4. As this material indicates, an Australian seeking damages for radiation exposure for injuries alleged to have been caused by radiation following a reactor (or weapon) accident occurring on a visiting warship is subject to essentially the same rules in relation to matters such as the level and burden of proof as one seeking compensation from a local defendant for radiation or chemical exposure in, say, the work place.[6]

8.9 It might be argued, for example, that these legal rules of general application are inadequate to cope with the special difficulties facing a person seeking to prove that exposure many years before to a low level of radiation or a toxic substance caused their present injury. This broad issue of possible law reform lies well beyond the scope of the Committee's inquiry.

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6. Foreign States Immunities Act 1985.

8.10 As an alternative, it might be argued that a special set of procedural/evidentiary rules should apply where the injury allegedly arose from an accident involving the reactor (or nuclear weapon) on a visiting warship. The result would be to place a person seeking compensation in relation to a radiation accident involving a visiting warship in a more advantageous position that one in an similar accident involving, say, the Commonwealth's reactor at Lucas Heights or a work-place accident involving a private employer. Tentatively at least, the Committee can see no justification for such discrimination.

8.11 The other element of condition of entry (b) is the requirement for 'provision of adequate assurances relating to the operation and safety of the warships while they are in Australian waters'.

8.12 The Department of Defence regards the standard statements of assurances[7] from the United States and United Kingdom as meeting this requirement.[8] The assurances relating to the non-discharge of radioactive waste, and to the independent review of the reactor safety aspects of design, crew training and operating procedures have already been referred to.[9] The assurances relating to accident notification, salvage responsibility, radiation monitoring, and compensation are referred to below.[10]

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7. These statements are set out in full in Evidence, pp. 1078-79 (US) and p. 1300.16 (UK).

8. Evidence, pp. 183-84 (Department of Defence). Other information from the US Government can also be regarded as providing assurances. See for example 'U. S. Navy Statement on the Safety of Operations of U. S. Nuclear Powered Warships', January 1987 (Evidence, pp. 238.241-43); the annual USN environmental monitoring reports relating to US nuclear powered warships (see Evidence, pp. 238.295-316 for an extract from the report for 1984); and testimony over the years by US Navy officers before US Congressional Committees (e.g. US, H of R, Committee on Science and Technology, Subcommittee on Energy Research and Production, Nuclear Powerplant Safety Systems, 24 May 1979, pp. 888-917 (Admiral H. G. Rickover)). Other relevant information has also been made available by the UK authorities, either publicly or in confidence to Australian authorities.

9. See para. 4.29 and para. 4.36, footnote 39.

10. See paras. 8.105, 9.91, 10.103 and Appendix 4, para. A4.7.

8.13 A key element in the assurances is the statement that reactor safety aspects of design, crew training and operating procedures 'are as defined in officially approved manuals'.[11] The statements of assurances also certify that the safety precautions and procedures followed in connection with nuclear powered warship operations in their country of origin will be strictly observed in foreign ports.

8.14 The Committee recommends in paragraph 9.55 that additional assurances be sought relating to multi-reactor vessels. Subject to this, the Committee regards the statements of assurances as fulfilling that part of condition of entry (b) which requires adequate assurances relating to operation and safety. The Committee can see no advantage in attempting to have the assurances made part of a formal agreement between Australia and the country to which the warship belongs.

8.15 A further issue examined by the Committee was whether it is satisfactory to rely on assurances rather than on the sort of inspection and safety assessments required by many countries for visits by nuclear powered merchant ships.[12] The Committee considers that it is. Assurances rather than inspections are accepted for visits by conventional warships.[13] As far as the Committee was able to discover, no country currently receiving visits by nuclear powered warships requires a formal safety assessment or inspection as a condition of entry.

Controls on Navigation

8.16 No issues were put to the Committee relating to conditions (c) and (d), which require navigational controls on the visiting warship and on other shipping in the vicinity.

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11. US 'Standard Statement', para. 1 (Evidence, p. 1078). See similarly the UK 'Standard Statement', para. 1 (Evidence, p. 1300.16).
12. See para. 3.37 on these requirements.
13. See para. 3.38.

Condition (c) does not distinguish between movement of vessels in ordinary circumstances and movement following an accident. Strictly interpreted, condition (c) would prohibit the movement of an accident-stricken vessel at night or during conditions where visibility is poor. The Committee assumes that the condition is not intended to apply to vessel removal following an accident. The wording, however, could usefully be clarified to put the matter beyond doubt.

8.17 The Committee noted that the British safety plan for Liverpool requires provision of tugs to escort visiting nuclear powered submarines in some circumstances, as a precaution against collision and stranding.[14] No equivalent provision is made in either the Australian conditions of entry, the Commonwealth documentation covering visits, or the plans for specific ports.

8.18 However, the Department of Defence told the Committee:

> In Australia, tug services are requested for all movements of visiting warships. Additionally, visiting NPWs are provided with escort vessels.[15]

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14. UK, Ministry of Defence, Liverpool Special Safety Scheme for Visits to Liverpool by Nuclear Powered Submarines, (April 1986), paras. 26 and 36. See also NZ, Atomic Energy Committee, New Zealand Code for Nuclear Powered Shipping, (AEC500, 1981 edn.), para. 2.3: 'nuclear-powered submarines are to be accompanied by surface escort vessels (provided by the appropriate Port authorities) whenever they move within the harbour'.
15. Evidence, p. 1300.56 (Department of Defence). It is conceivable that a visiting nuclear powered warship at anchor could experience difficulties due to the onset of stormy weather, dragging anchor, etc. Tugs do not stand by around the clock so as to be in a position to provide assistance in such cases. AIRAC suggested in 1984 that anchor drag was a particular problem for submarines at one of the approved anchorages at Darwin: AIRAC, 'Review of Safety and Monitoring Arrangements for Visits by Nuclear Powered Warships', p. 4 (Evidence, p. 755). The VSP(N) responded by stating, in part, that 'prudent seamanship dictates that in the event of a navigationally hazardous situation developing, the (submarine) would weigh and re-anchor ...': quoted in AIRAC, 'Follow-up Actions on Report of Visits to Hobart/Darwin/Brisbane', p. 4 (Evidence, p. 764). The inference from this, and from the use of escort vessels/tugs for nuclear powered vessels entering and leaving ports, is that prudent seamanship would equally ensure that a tug was placed on stand-by if it was likely to be required by a vessel at anchor due to the onset of bad weather, etc.

8.19 The Committee also noted that the British safety plan for Liverpool requires that 'hazardous cargo of any description is not to be dealt with at adjoining berths during the stay in port' of a nuclear powered submarine.[16] Again no equivalent provision is made in either the Australian conditions of entry, or the plans for specific ports.

8.20 The Committee understands, however, that the Department of Defence considers a provision on hazardous cargo unnecessary in plans relating to nuclear powered vessel visits. This is because the necessary safety is provided by the individual port authorities' general controls on use of berths for hazardous cargo. Under these controls, the vessel carrying the hazardous cargo would not be permitted to use a berth in the vicinity of one being used by a visiting nuclear powered vessel. The Committee, however, lacked firm evidence that controls were in place and were observed at all ports receiving visits where adjacent hazardous cargo handling might occur.[17]

8.21 Accordingly, the Committee RECOMMENDS that: <u>either</u> the Visiting Ships Panel (Nuclear) obtain confirmation that, for each port receiving visits, adequate controls exist to prevent hazardous cargo being dealt with in the vicinity of visiting nuclear powered warships; <u>or</u> that a provision to prevent this be added to the general conditions of entry.

Vessel Removal

8.22 Condition (e), capability to remove the vessel following

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16. UK, Ministry of Defence, <u>Liverpool Special Safety Scheme for Visits to Liverpool by Nuclear Powered Submarines</u>, (April 1986), para. 37(a).
17. The issue of hazardous-cargo vessels at Darwin's Iron Ore Wharf when a nuclear powered warship is berthed at the Stokes Hill Wharf has been examined. The conclusion was that 'the distance between the wharves is in excess of 400 m and the presence of such vessels whilst an NPW is berthed at Stokes Hill is not considered to present an unacceptable hazard': letter from the Director, Nuclear Plant Safety Unit, AAEC to the Secretary, VSP(N) 25 June 1981.

an accident, raised no issues of principle. However, the precise wording of the condition, the ability to give practical effect to it, and its contribution to mitigating the effects of an accident all proved contentious. These matters are addressed in chapter 9.

Operating Safety Organisation

8.23 Condition (f) requires that an operating safety organisation must exist for the port being visited. A widespread view in those submissions that addressed the point was that condition (f) should be amended to require additionally that an approved accident contingency plan exist. This raises two issues: whether there is a practical need to have a plan, and, if so, whether the condition of entry should formally require that the plan be in existence.

EXTENT OF THE NEED FOR ACCIDENT PLANS

Introduction

8.24 It was noted in chapter 6 that both the United Kingdom and the United States appear to take the view that no specific accident contingency planning is required for ports receiving the occasional, goodwill-type, visits from nuclear powered warships that are made to Australia.[18] It was noted in chapter 5 that there has never been any accident, incident, event or happening involving damage to a United States or British naval reactor core during a port visit that resulted in any significant release of radiation.

8.25 Taken together with what is known about the safety features of the design and operation of visiting nuclear powered

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18. See paras. 6.4 and 6.24.

warships,[19] these points could lead to a possible conclusion that the current accident contingency planning is redundant.

8.26 This conclusion was not advocated in any government or non-government submission to the Committee. For this reason, and because the Committee regarded a safety-oriented approach as prudent, the Committee rejected the conclusion that no contingency arrangements were necessary.

8.27 The following sections of this chapter discuss the extent to which the Committee considers that contingency arrangements should be required. In reaching its conclusions, the Committee did not investigate the question of the cost of formulating, maintaining and carrying out the arrangements.[20]

Ports and Anchorages for which Arrangements are Required

8.28 The area that would be affected by the reference accident on a visiting warship is limited. The area may, for a particular berth or anchorage, contain neither residents nor temporary population such as workers, tourists, etc. The primary purpose of contingency planning is to protect people from the consequences of a reactor accident. Where there are no people, there is logically no need to have any contingency arrangement to protect population in the event of an accident.

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19. See chapter 4 in the context of discussing the differences between land-based and naval reactors.
20. But see Evidence, p. 1033 (ARL): cost to the Australian Radiation Laboratory of its role in monitoring is about $5,000 to $10,000 per year. In the 1985-86 financial year ANSTO was allocated $50,000 for 'warship monitoring - fares, travelling allowance and freight': Department of Resources and Energy, Estimates of Expenditure 1985-86: Explanatory Notes, (August 1985), p. 77. In the following year, when fewer visits occurred, the corresponding amount was $25,000: Department of Resources and Energy, Estimates of Expenditure 1986-87: Explanatory Notes, (August 1986), p. 72. Other costs are incurred for equipment purchase, training, salaries, etc. On the possible costs imposed by the requirement that there be navigational controls on other shipping during nuclear powered warship movements, see the submission from the Victorian Government, p. 4.

8.29 The Committee accepts this logic. The characteristics of the area visited, not simply the fact of a visit, should also govern the need for contingency arrangements.

8.30 The key question then becomes what characteristics does a berth or anchorage have to have in order that no operating safety organisation or plan is needed. In the Committee's view, this may best be answered not with a single set of characteristics, but by a sliding scale. For example, as the size of the potentially affected population decreases, the need for specific contingency planning may be reduced. The general police or emergency services procedures may, for example, be considered adequate to evacuate a small number of people, and hence specific and detailed provision in a port safety plan may be unnecessary.

8.31 It is necessary, in the Committee's view, to distinguish between the requirement for specific port safety plans for nuclear powered warship visits, and the requirement that adequate safety arrangements exist for the visits. The latter requirement may, in the geographical and other circumstances of a particular port, be able to be met to a greater or lesser extent by safety plans not specifically directed at nuclear powered warship visits. It may also be able to be met in some circumstances in the absence of any plan at all, by relying on the general capability of police and other emergency personnel.

8.32 The Department of Defence has acted in a way that accords with this view. Visits to an anchorage at Jervis Bay have taken place without a specific contingency plan. As the anchorage used was at least 2.2 kilometres from the nearest permanent public habitation,[21] the normal emergency plan for the naval base, HMAS CRESWELL, was considered adequate by the Depart-

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21. The anchorage is about 1.5 km north east of the jetty at HMAS CRESWELL, about 2.5 km from Jervis Bay Village, and about 3 km south east of Hyam Point. The anchorage is in NSW, not ACT, waters. The waters are subject to RAN control, however, under the Control of Naval Waters Act 1918.

ment.[22] Similarly, visits took place without a specific contingency plan to an anchorage near Albany which was at least 2.2 kilometres from the nearest permanent residence. The adoption of the general features of the Gage Roads/HMAS STIRLING arrangements was considered sufficient by the authorities.[23]

8.33 It could be argued, however, that this view on the need for a specific plan has not been adopted consistently. For example, there is no permanent habitation within 2.2 kilometres of any of the anchorages used in Gage Roads off Fremantle. There is minimal likelihood of many people being temporarily in the area as it is almost entirely water.[24] Nonetheless a specific contingency plan has been prepared for these anchorages.

8.34 Before making detailed comments on the current contingency arrangements, the Committee wishes to state what it regards as a basic principle. This is that the contingency arrangements for all ports receiving visits should be based on consistent application of a common standard. In applying the standard to different ports, allowance of course has to be made for different geography, population density, etc. Regard has also to be given to whether the State/Territory responsible for a particular plan

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22. Second supplementary submission from the Department of Defence, p. 13 (Evidence, p. 238.268). See also Department of Home Affairs and Environment, Visits by Nuclear Powered Warships to Australian Ports: Report on Radiation Monitoring during 1983, (DHAE, Canberra, 1984), p. 11, in respect of a 36-hour visit in 1983 by USS Sea Dragon to Jervis Bay:

> The Emergency Planning Zone perimeter for the vessel at the designated anchorage encompassed only Commonwealth property and the only buildings within the Zone were those associated with the Royal Austrlian Naval College. The standing emergency arrangements and procedures at the College for fire protection were considered to be adequate for emergency response within the College and provision was made at the Lucas Heights Research Laboratories of the Australian Atomic Energy Commission in Sydney for emergency personnel and equipment to be available on call.

23. Second supplementary submission from the Department of Defence, p. 12 (Evidence, p. 238.267).
24. Western Australia, State Emergency Service, Western Australian Port Safety Scheme for the Visits of Nuclear Powered Warships to Fremantle and Cockburn Sound, (1986), para. 924.

has chosen to create a plan that is more extensive than that required by the common standard. However, after allowing for these matters, if a plan is deemed necessary for Gage Roads, then a plan should also exist for Jervis Bay and Albany.

Emergency Planning Zones - Basic Features

8.35 One method of evaluating the characteristics of berths and anchorages that may lead to a requirement for plans to be in place is by use of emergency planning zones. The figure of 2.2 kilometres in the three examples in the previous section derives from the size of the second of the standard emergency planning zones currently used by Australian planners. The Committee examined whether the sizes of these zones are appropriate, both because they form a key element in the current plans and because they provide a basis for deciding for which places plans are required.

8.36 Three concentric emergency planning zones have been formulated, centred on the vessel and based on the predicted consequences of the reference accident.[25] They are used for both berth assessment and accident response purposes.[26] Use of zones in this way is an orthodox method of planning for radiation accidents.[27]

8.37 The Department of Defence described the zones as follows:

> Zone 1. A designated area close to the NPW within which protective measures will be implemented automatically upon notification of a reactor accident and within which the port or

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25. Submission from the Department of Defence, p. 5 (Evidence, p. 10).
26. OPSMAN 1 (2nd edn.), Chapter 4, Annex B, para. 1 (Evidence, p. 93).
27. e.g. see International Atomic Energy Agency, Basic Safety Principles for Nuclear Power Plants: A Report by the International Nuclear Safety Advisory Group, (Safety Series No. 75-INSAG-3, IAEA, Vienna, 1988), para. 275.

dockyard authorities or, in the case of an emergency, the designated Operations Officer, can exercise full control over all personnel. For planning purposes Zone 1 should be approximately 600 metres in radius. There would be no restriction on workers, etc, entering the Zone in the normal course of their duties, provided their presence, functions and whereabouts are known to the authorities and they are subject to immediate control. Residence of members of the general public would, except in unusual circumstances, be excluded from Zone 1, but residence of official personnel, night watchmen, etc, might be acceptable on condition they would be evacuated from the area immediately if an emergency were to arise.

Zone 2. Represents the area at risk from inhalation hazards, ie, the plume exposure pathway, and includes Zone 1. The zone boundary represents the limit at which it may be necessary to implement protective measures to prevent radiation doses from inhalation from exceeding the individual dose criteria. Generally, the countermeasures would be less urgent than in Zone 1 and priority would be given to downwind sections where the hazards would be greatest.

Zone 3. Represents the area at risk with respect to ingestion hazards, ie, foodstuffs, milk, water and agricultural contamination, and includes Zones 1 and 2.[28]

Zone Sizes - 'Standard' Zones

8.38 The sizes of these Zones are derived from the current reference accident, taking into account what radionuclides would be released from that accident, the rate of leakage to the atmosphere, atmospheric dispersion mechanisms, and the meteorological characteristics of the ports. It would be possible to determine specific values for these factors based on the characteristics of each class of visiting vessel and of each port visited. If this were done, the size of the Zones would vary from

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28. Submission from the Department of Defence, pp. 5-6 (Evidence, pp. 10-11). The same text is set out in ANSTO, 'Basis of Berth Assessment', (August 1986), para. 2 (Evidence, p. 259).

port to port, and according to the type of visiting vessel.

8.39 In practice, the Department of Defence and the Australian Nuclear Science and Technology Organisation (ANSTO) have used the same values for all currently-approved ports and vessel types, with two exceptions (discussed below). Using these 'standard' values, the calculated maximum zone sizes are: Zone 1 - 600 metres; Zone 2 - 2.2 kilometres; and Zone 3 - several kilometres.[29] Two points should be made regarding these Zone sizes.

8.40 First, the application of the same values to different ports results in extra-safe values being applied in respect of some situations. For example, the planners assume that there could be a period of extreme atmospheric stability, and hence that any radioactive plume would remain concentrated rather than dispersed. It should be explained that plume concentration presents a greater hazard than dispersal. Exposure to radiation at doses exceeding the emergency reference levels will occur most rapidly if the plume remains concentrated.[30] Widespread dispersal by strong winds minimises or eliminates the possibility of individuals being exposed to such doses.

8.41 Atmospheric stability is less likely at, say, Gage Roads off Fremantle than at, say, Hobart.[31] Measured on this factor alone (and hence artificially), what is safe for the latter becomes even safer for the former. On the same one-dimensional (and hence artificial) basis considering only reactor power

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29. OPSMAN 1 (2nd edn.), Chapter 4, Annex B, para. 6 (Evidence, p. 94). Contrast ANSTO, Radiation Monitoring Handbook for Visits by Nuclear Powered Warships to Australian Ports, (ANSTO, Lucas Heights, NSW, 1985), p. 5 (Evidence, p. 299): with respect to the inhalation hazard, 'persons outside zone 1, up to several kilometres from the NPW, could ... be at risk from exposure to radioiodines' (emphasis added). This appears to be incorrect as it is inconsistent with all the other information received by the Committee from ANSTO and the Department of Defence.
30. Evidence, p. 1297 (ANSTO). See also Evidence, p. 238.288 (ANSTO).
31. Department of Defence, The Environmental Impact of Visits by Nuclear Powered Warships to Australia, (July 1974), paras. 204 and 220.

levels, a visit by a submarine is safer than that of a cruiser. The plans cater for the size of reactor aboard the latter, and hence include an added margin of safety when the smaller reactor of some visiting submarines is present.

8.42 Secondly, for the purpose of responding to an accident that has actually occurred, the boundaries and circular shape of Zones 2 and 3 are not fixed. The actual sizes and shapes of the Zones will vary inwards from these maximums according to the severity of the accident and the meteorological conditions existing at the time. They will be determined by measurement of radiation and contamination levels following an accident.[32]

8.43 The Zone sizes set out above are practical rather than theoretical maximums. Safety-oriented assumptions are made by the planners as to the degree of atmospheric dispersion that could take place. While it is highly unlikely that all these assumptions would be exceeded together in practice, it is not physically impossible.[33] The Committee was given no reason to regard the assumptions as anything other than adequately safety-oriented.[34]

Zone Sizes - 'Non-Standard' Zones

8.44 There are at present only two places for which Commonwealth planners[35] have used other than 'standard' values. These are the approved berth at Macquarie Wharves, Hobart and one of the approved anchorages at Gage Roads off Fremantle.[36] The

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32. Submission from the Department of Defence, p. 6 (Evidence, p. 11). The submission refers to Zones 1 and 2 but clearly this is a typographical error: see OPSMAN 1 (2nd edn.), Chapter 4, Annex B, para. 5 (Evidence, p. 94).
33. Evidence, p. 238.288 (Department of Defence); p. 411 (ANSTO).
34. cf. the Committee's conclusion in paragraph 3.14 that planning should not be based on the worst physically possible case.
35. See para. 8.50 for the variation made by Tasmanian planners in relation to the primary anchorage in the Derwent near Hobart.
36. The anchorage is that marked 'D' on the chart reproduced in Evidence, p. 1128.

parameter relating to vessel removal time has a 'standard' maximum value of 24 hours.[37] This value has been altered to three and a half hours for the Hobart berth,[38] and two hours for the Gage Roads anchorage.[39] For the Gage Roads anchorage, the parameter relating to reactor size has also been altered to permit the anchorage to be used by vessels having a reactor power output greater than 100 Mw(t).[40]

8.45 The effect of altering these parameter values is to alter the size of the Zone 2 used in each case for emergency planning. For the berth at Hobart, the Zone 2 size is reduced to

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37. OPSMAN 1 (2nd edn.), para. 201 (Evidence, p. 49). The period of 24 hours has been chosen as a time limit so as to avoid a second period of continuous atmospheric inversion. Under this condition the air remains extremely stable, and therefore airborne contaminants remain concentrated while they drift slowly away from their source. This condition is expected to be most intense on calm cloudless nights - hence the value of setting a time limit that avoids the possibility of two nights exposure. See Department of Defence, <u>The Environmental Impact of Visits by Nuclear Powered Warships to Australia</u>, (July 1974), para. 129; submission from ANSTO, Addendum, p. 5 (Evidence, p. 383); Evidence, p. 1297 (ANSTO). Note that the berth that was once approved at Melbourne had a vessel removal time specified of 5 hours: OPSMAN 1 (original edition, 1981), Chapter 3, Annex B. The berth at Melbourne is no longer approved for use by visiting nuclear powered warships.
38. Second supplementary submission from the Department of Defence, p. 7 (Evidence, p. 238.262). See also the Hobart Safety Scheme, paras. 320 and 325(b). A part of the requirement is that the removal 'proceed away from the berth at a minimum speed of 3 knots [5.56 km/h]': letter from the the Director, Regulatory Bureau, AAEC to the Secretary, VSP(N), 18 April 1985, (AAEC (SP)/R7, Supplement 1, Addendum 1), p. 2. This speed is calculated on the basis that, once the vessel is more than 5 km from the wharf, radiation from it will no longer make a significant contribution to the total doses received by those in the vicinity of the wharf. These doses are the critical ones in the overall assessment of the berth: ibid., p. 1.
39. Evidence, p. 443.469 (ANSTO). See also the WA Port Safety Scheme, para. 925. In the second supplementary submission from the Department of Defence, p. 7 (Evidence, p. 238.262) the time is stated as 3 hours, but this is incorrect.
40. The only vessels currently visiting within this category are the US Nimitz-class aircraft carriers.

1.2 kilometres from the 'standard' 2.2 kilometres.[41] The effect of reducing the removal time allowed at Gage Roads is also to reduce the size of Zone 2. But this reduction is more than offset by the effect of the increase in the reactor-size parameter, so that the net effect is to increase the Zone 2 size to 3.5 kilometres.[42] In neither place has the alteration of parameters led planners to alter the size of Zone 1.

Appropriateness of the Zone Sizes

8.46 No detailed argument based on the reference accident was put to the Committee that the 'standard' Zone sizes were too small. In contrast, the implications of ANSTO's revised accident model[43] were that the Zone sizes might well be able to be reduced by a considerable amount without sacrificing safety.

8.47 The reasons were set out in paragraphs 7.21-7.25 why the Committee considers that its inquiry should, in resolving questions of this kind, refer to the current reference accident rather than the revised accident model. On this basis, the Committee considers that the 'standard' Zone sizes are appropriate.

8.48 The acceptability of the variations used for the berth at Hobart and the anchorage at Gage Roads depends on whether the

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41. Hobart Safety Scheme, paras. 320 and 325(b). Using 'standard' parameter values for this berth, the 1973 berth assessment concluded that the number of people for whom countermeasures would be required following a reference accident was too large to be acceptable, and unrestricted use of the berth could not be recommended: ANSTO, Assessment of Berths for Operational Use by Nuclear Powered Warships in Australian Ports: Supplement No. 1: Macquarie Wharf and Anchorage, Hobart, (AAEC (SP)/R7, Supp. 1, September 1973), p. 6. As indicated in Addendum 1 to this assessment (18 April 1985), p. 2, the effect of reducing the time allowed for vessel removal is to reduce considerably the number of people for whom countermeasures could be required following a reference accident at the berth.
42. Evidence, p. 238.288 (Department of Defence); p. 443.469 (ANSTO).
43. See para. 7.17 for a description of this model.

requirement of vessel removal within the reduced time allowed can be met in practice. The subject of vessel removal is discussed in chapter 9. The conclusion reached there is that the shorter removal times are feasible.[44] Therefore, the Committee considers the Gage Roads anchorage and Hobart berth variations acceptable.

8.49 The Committee noted that it would be possible to specify shorter vessel removal times for berths or anchorages where the 24-hour limit currently applies. Provided assurances could be obtained that the shorter times could be met, Zone 2 sizes could be reduced in the same way as has been done for the berth at Hobart.

8.50 This has been done by the Tasmanian authorities with respect to the primary anchorage in the Derwent near Hobart. Although the berth was assessed using 'standard' values and found to be suitable, the Hobart Safety Scheme proceeds on the basis that a three and a half hour removal time applies.[45] This reduces the area in which planning for countermeasures such as evacuation is required (ie. the Zone 2) to 1.2 kilometres. It also simplifies the Hobart Safety Scheme, as planning parameters are the same for the berth as for the primary anchorage. On the other hand, the reduced time allowed for vessel removal places greater stress on the arrangements for early-warning monitoring and post-accident vessel removal.

8.51 The fact that 'standard' parameters have not been varied in this or some other way at places other than one of the Gage

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44. See paras. 9.78 and 9.80.
45. Hobart Safety Scheme, paras. 320 and 325(b) and Chapter 8, Annex C.

Roads anchorages and at Hobart reflects a choice by planners.[46] The Committee does not regard the differing approaches taken at different ports as a matter for criticism.

8.52 A further issue relates to the size of Zone 1. It may not be immediately obvious why, where alteration of a parameter value leads to an alteration in the size of Zone 2, there is no corresponding alteration in the size of Zone 1. However, the basis of calculating the size of Zone 1 is not the same as for Zone 2, and as a result the size of the two Zones are not directly linked.

8.53 The size of Zone 2 is determined by the time taken for a person to receive an exposure to radiation in excess of the emergency reference level at a given distance from the reference accident.[47] The size of Zone 1 reflects the fact that it is an area in which immediate protective measures such as evacuation will be taken. These measures will be taken before the results of post-accident monitoring are known.

8.54 The 600 metre radius of Zone 1 has been chosen so as to allow at least an hour following the reference accident for the fact of a radiation leak and its significance to be determined, for radiation monitoring to be started, and for the activation of

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46. For example, 'standard' parameters have been used in relation to the approved berths at Darwin. The population distribution within Zone 2 is such that the criteria for berth approval can be met, using the 'standard' 24-hour vessel removal time. This results in a Zone 2 of 2.2 km. Had the authorities wished to have a smaller Zone 2, and hence reduced the area in which planning for protective measures would be required, they could have examined the feasibility of allowing a maximum of less than 24 hours for vessel removal. If an assurance could have been obtained from the RAN that a vessel removal time of, say, three hours was feasible, the size of the Zone 2 could have been reduced considerably.

47. See the graphs contained in ANSTO, 'Visits by Nuclear Powered Warships: Revised Accident Model', (June 1986), figs. 1-3 (Evidence, pp. 1300.26, 1300.30-31). Although the graphs have been drawn to illustrate the differences between the current refernece accident and the revised accident model, they also illustrate the way in which receipt of a radiation dose at the emergency reference level is related to the duration of exposure and the distance from the source of the radiation.

the emergency organisation. Only if the maximum time allowed for vessel removal were to be set at less than 1 hour would reduction in vessel removal time affect the size of Zone 1.

Extent of Planning Required

8.55 To summarise the discussion so far, the Committee has accepted that there should be contingency arrangements for at least some of the places that nuclear powered warships might visit in Australia; that the extent and nature of the arrangements should be determined by the characteristics of each place visited; and that the planning Zones currently used provide an appropriate measure of the types of responses required at differing distances from the accident site.

8.56 It follows from this that the Committee accepts that the accident response measures identified as appropriate for each Zone define the degree of organisation and planning required for that zone. For example, in the case where no people are within 2.2 kilometres of a berth or anchorage, there is no need to contemplate measures to protect against the inhalation hazard. If no people are expected to be in an anchorage's Zone 1, there is no need to contemplate measures to achieve immediate evacuation of the Zone.

8.57 Where there are eventualities, defined by reference to one of the Zones, that need to be taken into account the question arises whether a formal written plan is required in all cases to cater for them. The Committee does not consider that this is required. In some situations the eventualities that would have to be catered for would be too simple to require specific planning. An example would be the evacuation of a handful of people, which could be achieved under general police or emergency services procedures.

8.58 In other situations, the eventualities could be avoided by measures put in place for the duration of the visit. For example, if the only people likely to be in Zones 1 and 2 are recreational land-users, it might be more practical to exclude them from the area during the visit. This would avoid the need to consider protective measures if an accident occurred. Specific visit operational orders can be used to achieve this result without any need for a standing plan.[48]

8.59 Visits are only permitted to approved berths and anchorages. The criteria for approval give the result that berths and anchorages are not used where population distribution and related factors are such as would prevent effective evacuation from Zones 1 and 2.[49] In other words, situations in which effective, workable plans would be difficult to devise are avoided by withholding berth or anchorage approval.[50] However, if the most difficult situations are avoided and there is no need for plans for the simplest situations, it can be argued that there is a middle range of situations where the actions required would be sufficiently complex to benefit from planning.

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48. On the role of Visit Operation Orders/Instructions, see para. 2.34.

49. Submission from the Department of Defence, pp. 6-7 (Evidence, pp. 11-12) sets out the criteria, which operate by reference to doses of radiation to the thyroid gland due to exposure to radioactive iodine.

50. This has occurred with respect to Sydney. A 1978 study found:

> The suitability of the berths proposed for nuclear-powered warships in Sydney Harbour rests on an ability to
> . Remove a stricken vessel from the proposed berths clear of Sydney Heads within four hours of a Reference Accident
> . Evacuate residents nearest to the berths within two hours of a Reference Accident.

NSW, Report of the Interdepartmental Committee on Visits of Nuclear-Powered Warships to New South Wales Ports, (March 1978), para. 6.1. An additional constraint was the lack of an appropriate remote anchorage to which a vessel could be removed following an accident: Australia, Visits of Nuclear Powered Warships to New South Wales Ports, (September 1977), para. 54. While all these constraints were in theory able to be overcome by suitable accident contingency planning, the implementation of the required planning would have imposed severe practical problems and allowed little margin for the unexpected. As a result, the decision was made that the proposed berths should not be approved: second supplementary submission from the Department of Defence, p. 5 (Evidence, p. 238.260).

8.60 Alternatively, it can be argued that the berth and anchorage assessment criteria should be altered so as to prevent visits in this middle range of situations. This alternative would exclude several of the berths presently used: for example the Zone 2, the area at risk from inhalation hazards, for the approved berth at Darwin's Stokes Hill Wharf takes in much of the city's central business district. The Committee sees no need to prevent visits to berths and anchorages which, with appropriate accident contingency planning, can accommodate visits safely.

8.61 This still leaves the question of whether the existence of a plan for what the Committee has referred to as berths or anchorages in the middle range of risk should be made a formal condition of entry.

8.62 At present the responsibility for the preparation of an effective safety plan lies with the relevant State or Territory government in respect of ports under their control.[51] The Commonwealth encourages the preparation of plans,[52] and provides technical advice and other assistance where required.[53] In addition, the Natural Disasters Organisation, an agency within the Defence Portfolio, has the responsibility for confirming that a completed safety plan is in existence.[54]

8.63 The existence of an effective port safety plan is not a

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51. OPSMAN 1 (2nd edn.), paras. 322 and 402 (Evidence, pp. 67 and 69).
52. Second supplementary submission from the Department of Defence, p. 4 (Evidence, p. 238.259).
53. OPSMAN 1 (2nd edn.), para. 403 (Evidence, p. 69).
54. Second supplementary submission from the Department of Defence, p. 14 (Evidence, p. 238.269). Contrast OPSMAN 1 (2nd edn.), para. 314(b)(1) (Evidence, p. 64) where the NDO's function is listed as 'confirming the availability of the Port Safety Organisation', rather than of the plan for the port. It appears that, while OPSMAN 1 only imposes its stated requirement, the requirement to confirm the existence of a plan arises from the arrangements under which the Natural Disasters Organisation operates.

formal condition of entry.[55] The Committee understands, however, that the Visiting Ships Panel (Nuclear) does not currently approve visits unless it is satisfied that the visit could take place safely.[56] In practice, this means that, for those ports which the VSP(N) considers a specific plan to be necessary, visits will not be approved unless an appropriate plan exists.

8.64 The Committee considers that this practice should be put on a formal basis. Accordingly, the Committee RECOMMENDS that an additional condition of entry be introduced. This should require the existence of a specific safety plan for those ports where the Visiting Ships Panel (Nuclear) considers that a specific plan is necessary to ensure safety in the event of an accident.

8.65 If the lack of State/Territory plans were to impede essential Commonwealth Government requirements, the Commonwealth should implement its own plan using its powers under the Constitution.

REMOTE ANCHORAGES

Criteria

8.66 With the exception of Jervis Bay, the approval of berths and anchorages at each port has been accompanied by the approval of one or more remote anchorages to which a vessel can be removed following an accident. (As noted above, visits to Jervis Bay are made only to an anchorage remote from civilian residential areas.) The Department of Defence's criteria for remote anchorage

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55. Second supplementary submission from the Department of Defence, p. 4 (Evidence, p. 238.259).
56. Contrast the first supplementary submission from the Department of Defence, section 6B (Evidence, p. 238.251):

> Were further NPW visits to be made to Victoria, it would be a matter for the Victorian authorities to decide what depth of planning it should undertake ... [for the visits].

approval are that the anchorage should:

(a) have complete isolation from all populated areas for a radius of 1.5Km;

(b) be surrounded by a further zone 5Km in radius, from which the population could be evacuated if desired; and

(c) be outside normal navigation routes.[57]

The basis for the size of these two zones was provided to the Committee by ANSTO.[58]

Adequacy of the Criteria

8.67 No detailed or documented argument was put to the Committee that the criteria used for assessing the suitability of remote anchorages were incorrect or inappropriate. However, it appears that the 1.5 kilometre radius of the isolation zone was and is intended to be 1.6 kilometres.[59]

8.68 The Committee RECOMMENDS that the zone of complete isolation around a remote anchorage be specified as 1.6 kilometres.

8.69 The Committee was told by ANSTO that the 5 km zone of possible evacuation is now recognised as giving a very wide margin of safety. A 1987 assessment considered in detail the possible doses resulting over 10 days from the continuing leakage of radionuclides from the reactor containment to the atmosphere

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57. Submission from the Department of Defence, p. 7 (Evidence, p. 12); ANSTO, 'Basis of Berth Assessment', (August 1986), para. 7 (Evidence, p. 260).
58. Evidence, pp. 433.466-68 (ANSTO).
59. The appropriate distance was in the early 1970's regarded as 1 mile: Department of Defence, The Environmental Impact of Visits by Nuclear Powered Warships to Australia, (July 1974), para. 154. In the explanation ANSTO provided to the Committee a distance of '1.6 km (1 mile)' is used for the exclusion zone: Evidence, p. 443.467.

following the reference accident.[60] Conservative (ie. safety-oriented) assumptions were made.

8.70 The result of the assessment:

> suggests that evacuation might be required by the NHMRC recommendations [on emergency reference levels] out to 1.6 km or so, if no action were taken to reduce the rate of release of radioactive material from a stricken vessel at a remote anchorage, but not out to 5 km, and thus supports the 1972 decision that an exclusion zone of 1 mile and a low population zone of 3 miles would provide adequate protection from exposure to airborne material.[61]

DIVISION OF RESPONSIBILITIES BETWEEN GOVERNMENTS

8.71 Under present arrangements, the responsibility for different aspects of contingency planning is allocated to either Commonwealth or State/Territory authorities.[62] The plans relating to visits to specific ports, and the Commonwealth's umbrella document, OPSMAN 1, set out the division explicitly and in

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60. ANSTO, 'Visits by Nuclear Powered Warships: Radiological Consequences of Releases from Remote Anchorages', (August 1987). This assessment also considered the effects of releases over a 20-day period and canvasses an alternative scenario in which leakage is from the (primary) containment to adjacent machinery compartments. On some vessels at least, these compartments are designed to act as secondary containment (see para. 4.63 above). The scenario hypothesises that a warship commander might wish to vent the machinery spaces to the atmosphere in a single 'puff', so as to reduce the radiation hazard to crew having a need to enter. From the assessment it can be seen that the scenario can be safely accommodated within the existing remote anchorage criteria, save in the unrealistic case where the voluntary release is made in an instantaneous way and at a time when the wind speed, direction, etc are least favourable to safety. In this worst-case situation some evacuation could be required beyond 5 km from the vessel: ibid., p. 3 and Appendix, paras. 9-10.
61. Evidence, p. 443.468 (ANSTO). The reference to the 1972 decision appears to be to the decision formally reported in Department of Defence, The Environmental Impact of Visits by Nuclear Powered Warships to Australia, (July 1974), para. 154.
62. See para. 2.32.

detail.[63]

8.72 The authors of a few submissions criticised what they saw as confusion over the division of responsibilities between the authorities.[64] However, the examples provided were based on inquiries made to State officials in respect of ports that do not receive visits. No examples of confusion of roles or responsibilities in the contingency plans for ports currently receiving visits were brought to the Committee's attention.[65]

8.73 The governments of the Northern Territory and of the States which currently receive visits indicated to the Committee that they considered the present division satisfactory.[66] Similarly, none of the Commonwealth agencies who made submissions to, or appeared before, the Committee indicated that the division of responsibilities operated to prevent effective contingency arrangements.

8.74 During visits to Tasmania and Western Australia, members of the Committee examined the way the divided responsibilities would be exercised. They found no basis on which to conclude that the division of shared responsibilities between Commonwealth and State authorities would cause problems in the event of a reactor

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63. e.g. OPSMAN 1 (2nd. edn), paras. 306-308, 315-323, 402-403 (Evidence, pp. 62, 64-68, 69); WA Port Safety Scheme, Part 2; Brisbane Port Safety Plan, paras. 316-334; Darwin Port Safety Plan, Chapter 7; Hobart Safety Scheme, Chapter 5. See also HMAS STIRLING Sub-Plan, paras. 1301(5)-(8) and Annexes A-C.
64. e.g. submissions from Illawarra People for Nuclear Disarmament, pp. 1-2; Australian Nuclear Free Zones Secretariat, p. 4.
65. When Senator Vallentine appeared before the Committee she asserted that in the WA Port Safety Scheme there were 'contradictions' in the setting out of duties under the Scheme: Evidence, pp. 1226-27. Senator Vallentine undertook to provide details to support this claim. However, in providing follow-up information she did not identify any specific provisions of the Scheme which were contradictory: letter from Senator J. Vallentine, 19 August 1988.
66. Submissions from the Northern Territory Government, p. 2; the Tasmanian Government, p. 5. The submissions from the Queensland and Western Australian Governments did not suggest that they regarded the division as unsatisfactory.

accident. Commonwealth authorities appreciate the necessity of maintaining good relations with their State or Territory colleagues so as to ensure contingency planning operates effectively.[67]

CURRENCY OF BERTH AND ANCHORAGE APPROVALS

8.75 An approved berth or anchorage may cease to comply with berth assessment criteria due to changes in the use made of adjacent land. The Committee was concerned that there seemed to be no mechanism to ensure that relevant changes in land use were drawn to the attention of the Visiting Ships Panel (Nuclear).[68] This creates the risk that use would inadvertently be made of a berth or anchorage which no longer met the assessment criteria.

8.76 The Committee considers that some formal mechanism should be put in place to ensure that this does not happen. The simplest mechanism appears to be to employ the local land-use planning system. The fact that an approved berth or anchorage exists and the area covered by its emergency planning Zone 2 would be noted on the local land-use plan. Provision would be made for the Visiting Ships Panel (Nuclear) to be notified automatically when a building or development application affecting the area was lodged with the planning authority.

8.77 The Committee did not investigate the practicality of

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67. Second supplementary submission from the Department of Defence, p. 15 (Evidence, p. 238.270).
68. Evidence, pp. 414-15, 1284-91. The Department of Defence told the Committee that the VSP(N) had set up a procedure under which each port receiving ship visits was checked every 18 months to ensure that it continued to meet berth assessment criteria (p. 1288). The Department also said that only rarely would an approval be affected by subsequent land development, and that in one case where this has happened, Townsville, steps have been taken by the VSP(N) to both reassess the port and to ensure that no visit occurs until its continuing suitability is confirmed: Evidence, p. 1300.43 (Department of Defence).

this mechanism in any detail. It may be that it is not possible or practical in respect of one or more ports. In this case, and if no alternative mechanism can be used, the Committee considers that the possibility of changed land use should be investigated before each visit. For berths and anchorages at ports where visits are expected to be rare, it may be more cost-effective to inspect before each visit than to use the town planning mechanism.

8.78 Accordingly, the Committee RECOMMENDS that use be made of local land-use planning procedures to ensure that any change in land use that would affect an approved berth or anchorage is automatically notified to the Visiting Ships Panel (Nuclear). Where this method, or an effective substitute, is not possible or practical, approved berths and anchorages should be reassessed by the Visiting Ships Panel (Nuclear) before each visit to ensure changed land use has not affected their status.

8.79 The Committee is aware that changes in land-use have raised questions as to the continuing validity of the original berth assessments for Port Adelaide and Townsville. The Committee RECOMMENDS that no visits by nuclear powered vessels take place to either Port Adelaide or Townsville until the berths have been re-assessed to ensure that changed land use has not affected their status.

AVAILABILITY OF INFORMATION ABOUT PLANNING

Availability of the Plans

8.80 The current contingency arrangements are set out in a series of Commonwealth documents, in addition to the individual port safety plans. The documents were briefly described in chapter 2. It was noted that relevant Commonwealth documents are available on enquiry to members of the public.[69] The Committee considers it essential that this availability continue. The Committee would not object to charges being levied for the supply of copies of the documents, provided the level of charges is no higher than that necessary to cover the cost of copying and handling.

8.81 Of the four State/Territory plans, the Queensland plan relating to Brisbane, and the Western Australian plan for Cockburn Sound/Gage Roads are publicly available. The plans for Darwin and Hobart are not. In contrast, emergency plans devised by State and Territory authorities for other major accidents and for natural disasters are generally available for public inspection.[70]

8.82 The Committee is not aware of any publicly stated reason why the Darwin plan has been withheld. The Tasmanian Government has provided two grounds in respect of the Hobart plan: that the plan contains confidential telephone numbers and confidential details of the Police Department and other organisations;[71] and that details of the plan would be misrepresented by those opposed to visits.[72]

8.83 In relation to the first ground, the Committee considers that any reasonable concern that knowledge of the contents of plans could be misused by hoaxers or others could readily be met by the release of an edited version of the plan. Telephone numbers, passwords and similar operational details could be

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69. See also Evidence, p. 1300.49 (Department of Defence): the relevant Commonwealth 'documents are unclassified and publicly available. Subject to resources they should be disseminated widely.'
70. Evidence, p. 1300.45 (Department of Defence).
71. Tasmania, Assembly, Debates, 30 September 1986, p. 2869. See also ibid., 22 July 1986, p. 2223.
72. Tasmania, Assembly, Debates, 9 December 1987, pp. 5488-89 and 25 August 1988, p. 2487.

masked out.[73] With regard to the second ground, the Committee considers that a secret plan is more open to be misrepresented than one that is available to the public.

8.84 The Committee notes that, according to a media report on 4 October 1988, the Tasmanian Minister for Emergency Services has stated that a brochure would be distributed to the public before the next visit to Hobart by a nuclear powered warship.[74] The brochure would detail what action to take in the event of a reactor accident. The Committee cannot comment on the extent to which the proposed brochure is an adequate substitute for a publicly available plan for Hobart, as the brochure is not yet available.

8.85 The Committee RECOMMENDS that, where there is a State/Territory contingency plan relating to nuclear powered warship visits to a particular port and the plan is not publicly available, the Commonwealth should:

(a) advise the State/Territory that it is desirable that the plan be publicly available;

(b) allow a reasonable time for editing the plan so as to remove any sensitive information (such as passwords or telephone numbers) which might otherwise inhibit its release; and

(c) withhold approval for visits to any port for which the plan is not publicly available after this time.

8.86 The Committee regards the question whether copies of a

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73. As noted in Chapter 2, the copy of the Hobart Safety Scheme that was provided to the Committee had the security-sensitive details removed. This does not prevent the reader from evaluating the overall adequacy of the scheme. Nor does it prevent local residents, etc. from understanding what might be expected of them in the unlikely event that an accident occurs.

74. 'State nuclear mishap plan "inadequate"', Mercury (Hobart), 4 October 1988. See also Tasmania, Assembly, Debates, 5 October 1988, p. 3169: Ministerial undertaking to have details of the plan published.

plan should be available without charge as one to be decided by the government responsible for the plan. Any access charges, however, should relate to the reasonable costs of copying and handling only.

8.87 Two submissions criticised paragraph 801 of the WA Port Safety Scheme,[75] which provides:

> No information in respect of any aspect of the Port Safety Scheme may be released to the public or the media without the authority of the Chairman, State Counter Disaster Advisory Committee.[76]

8.88 As the WA Port Safety Scheme is publicly available, this paragraph is not in fact being used to prevent access. Given that this is the case, the Committee considers that the wording of paragraph 801 could be modified, so as to remove the basis for any perception that the authors of the Scheme are intent on preventing public access to it.[77]

Availability of Information Relating to Accidents and Planning

8.89 Judging by the submissions received by the Committee, few of those interested in the issues relating to ship visits were aware of all the relevant Commonwealth documents. While a number of submissions referred to the 1976 Environmental

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75. Submissions from Scientists Against Nuclear Arms (WA) and Medical Association for the Prevention of War (WA), pp. 6-7 (Evidence, pp. 792-93); Mr K. G. Blake, p. 3.
76. Because of the nexus between the two plans, this statement also is made in the HMAS STIRLING Sub-Plan, para. 1315(1).
77. cf. the wording of the equivalent paragraph, 1201, in the Hobart Safety Scheme: 'During the visit of an NPW no aspect of the Safety Scheme that has not previously been released to the public is to be divulged'. A better method might be to separate out the security-sensitive information into a separate annex or annexes, and indicate that only these need to be kept confidential. This was in fact done with the copy of the Hobart Safety Scheme that was provided to the Committee. The two sections containing this type of information were deleted from the copy provided. An alternative method is to indicate by marginal annotation on a paragraph-by-paragraph basis which information may not be divulged.

Considerations document, few gave any indication that they had seen ANSTO's 1985 Radiation Monitoring Handbook, the annual reports of radiation monitoring relating to nuclear powered warship visits, or OPSMAN 1. Many concerns put to the Committee were not based on full information of the details of current arrangements.

8.90 The Committee hopes that one result of its inquiry will be to increase awareness of these documents, which contain much information essential to an overall understanding of the procedures, precautions and plans that relate to visits. The Committee considered, however, that more could usefully be done to increase the public's opportunity to have access to the relevant documentation.

8.91 Accordingly, the Committee RECOMMENDS that the Visiting Ships Panel (Nuclear) ensure that a set of the Commonwealth planning documents is placed in each State and Territory Library, and, outside capital cities, in the main public library of each port approved to receive visits from nuclear powered warships. Further, the deposited material should be kept up to date.

8.92 Late in its inquiry, the Committee was told by the Department of Defence that it was preparing public information documents on warship visits for wide distribution, and that media releases are issued for each visit by a nuclear powered warship.[78] The Department also told the Committee that it supported the concept of making appropriate officers available for public presentations on visits by allied warships.[79]

8.93 The Committee regards activities of this kind as

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78. Evidence, p. 1300.49 (Department of Defence). As new documents are written or existing ones extensively rewritten, they are reproduced in microfiche form for wide distribution to libraries. See OPSMAN 1 (2nd edn.), para. 323 (Evidence, p. 68) on the issuing of media releases by the Department.

79. Evidence, p. 1300.49 (Department of Defence).

constructive. The Committee would wish to encourage both Commonwealth and State/Territory authorities to do more to ensure that knowledge of the procedures, precautions and plans relating to visits is widely available. One useful step would be to include in media releases relating to specific visits an indication that information kits have been deposited in a library at the port.

Distribution of Information Leaflets

8.94 The Committee considered whether further steps should be required to ensure that those who may be required to take protective measures following an accident are informed beforehand of what may be involved. The Committee's attention was drawn to a one-page information leaflet issued by the New Zealand civil defence authorities in connection with the visit by the nuclear powered USS Haddo to Auckland in 1979.[80] A number of submissions suggested that some type of leaflet should be distributed locally prior to each nuclear powered warship visit.[81]

8.95 Leaflet distribution to residents is not relevant to all ports currently receiving visits.[82] Only Darwin and Hobart have significant numbers of people resident within Zone 2, which is the limit of the area of inhalation hazard following the reference accident. For approved anchorages at Gage Roads off Fremantle for example, the Zone 2's are almost entirely water and there are no residents.[83]

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80. The leaflet is reproduced in Evidence at p. 1170.
81. Submissions from B. Lebbing, p. 1; Ms S. Taylor, p. 1; Senator J. Vallentine, p. 12 (Evidence, p. 1055); H. H. Somer, p. 4. See also, with respect to land-based reactor accidents, International Atomic Energy Agency, Planning for Off-Site Response to Radiation Accidents in Nuclear Facilities, (Safety Series No. 55, IAEA, Vienna, 1981), p. 59:

    a simple information leaflet or brochure should be prepared and distributed in advance, and periodically to residents close to the [nuclear] facility ... outlining some basic aspects of the emergency response plan and simple straightforward emergency instructions.

82. Evidence, p. 1300.46 (Department of Defence).
83. WA Port Safety Scheme, para. 924.

8.96 The response, if any, required in Zone 2 is determined by the results of monitoring after the accident. It would be difficult to set out in leaflet form beforehand useful advice to members of the general public on how they should respond. The 1979 Auckland leaflet to which the Committee was referred relates only to evacuation, etc. from a 600 metre zone (ie. the equivalent of Zone 1 in the Australian plans). This reflects the fact that New Zealand plans were based on more limited accident consequences than Australian plans.[84]

8.97 Few members of the general public are expected to be present in Zone 1. There may, at some ports, be considerable numbers of port workers. At HMAS STIRLING, a considerable number of naval personnel may be on the base. But more direct methods than distributing leaflets to the public are available to ensure that these groups are informed of emergency response procedures for Zone 1. The Committee would regard consultation and liaison with port unions, for example, as more effective.

8.98 The Committee would not wish to discourage any State or Territory that regarded distribution of an information leaflet as appropriate for a particular port. But the Committee does not consider that leaflet distribution should be made a precondition for visits to ports, even where there are residents within Zone 2. The Committee noted that the British port safety plans available to it do not require leaflet distribution. Nor is it a requirement or practice followed generally in the context of Australian plans for non-nuclear hazards.[85]

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84. e.g. see NZ, Wellington Regional Civil Defence Plan for a Nuclear Powered Vessel Visit to the Port of Wellington, (1983), para. 8 (Evidence, pp. 1147-48).

85. Evidence, p. 1300.46 (Department of Defence): 'apart from areas such as Darwin which are prone to cyclone emergencies, it is very rare for the general public to receive documentation on disaster reaction procedures'.

Reporting on Radiation Monitoring during Visits

8.99 As noted in Chapter 2, between 1976 and 1986 the Commonwealth department having responsibility for the environment reported annually on the results of radiation monitoring during visits.[86] In 1986, the responsibility for reporting was transferred to the Department of Defence.

8.100 It was evident that the Department of Defence was regarded by the authors of a number of submissions as being a partisan advocate of continued visits by nuclear powered warships. On this view, the transfer to Defence from a department concerned with the environment might be seen as lessening the independence of the reporting.

8.101 The Committee put this view to the Australian Ionising Radiation Advisory Council (AIRAC) and the Department of Defence. The Committee was told that there was minimal risk of loss in the independent reporting of monitoring due to the change. This was because of the large number of organisations, with different policy and program objectives, involved in the monitoring program.[87]

8.102 The Committee accepts this explanation.

MONITORING TO PROVIDE ACCIDENT NOTIFICATION

Introduction

8.103 The Commonwealth provides guidelines for the carrying out of routine environmental monitoring, of monitoring to detect

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86. See para. 2.31: in no case has any release of radioactive material or infringement of Australian public health standards been reported.
87. Letter from Cdre N. J. Stoker, Chairman of the VSP(N), 26 April 1988, p. 3 (Evidence, p. 706.718); Evidence, p. 748 (AIRAC).

a reactor accident, and of post-accident monitoring.[88] The detailed instructions for carrying out monitoring are also contained in a Commonwealth document.[89] Because monitoring is governed by a single set of guidelines and instructions, it is conducted in a uniform way for all Australian ports that receive visits from nuclear powered warships.

Basic Methods

8.104 Accident response can only commence once the relevant authorities are aware that an accident has happened. A communications link is established routinely with a visiting warship in order to permit direct communication, including notification of an accident by its commander.[90]

8.105 Some submissions expressed a concern that the warship commander would fail to provide the earliest possible notification of a reactor accident.[91] The United States Government has provided an assurance that notification will occur 'immediately in the event of an accident involving the reactor of the warship during a port visit'.[92] The Committee has no cogent reason to

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88. See para. 2.29.
89. ibid.
90. Information supplied at briefings to Coommittee members by WA Officials, 1 February 1988; Tasmanian officials, 21 March 1988. See also the submission from the Tasmanian Government, p. 3; Evidence, p. 436 (ANSTO).
91. e.g. submissions from Scientists Against Nuclear Arms (WA) and Medical Association for the Prevention of War (WA), p. 6 (Evidence, p. 792); Senator J. Vallentine, p. 16 (Evidence, p. 1059).
92. US 'Standard Statement', para. 2(c) (Evidence, p. 1078). See also the UK 'Standard Statement', para. 2(c) (Evidence, p. 1300.16) for a similar assurance. The Committee was also referred to the notification provisions of the 1986 multilateral Convention on Early Notification of a Nuclear Accident: second supplementary submission from the Department of Defence, p. 10 (Evidence, p. 238.265). This Convention applies to 'any nuclear reactor wherever located': article 1(2)(a). For reference to the text of the Convention and the question of its applicability to an accident in an Australian port, see below, para. 13.48.

doubt this.[93]

8.106 Continuous early warning monitoring is used for the duration of each visit. It is designed to provide independent notice of the occurrence of any accident of sufficient severity to threaten a major release of fission products to the environment. Concern was expressed that this monitoring would not provide sufficiently quick notification.[94]

8.107 The basis of the concern was not explained, but it appeared to rest on the assumption that early warning monitoring operated by detecting the release of radionuclides to the atmosphere. In fact, the early warning monitoring is for gamma radiation penetrating through the vessel's hull.[95] This radiation would follow any major release of fission products from the reactor core to the containment.[96] Signals from the monitors are relayed automatically to a recorder and alarm located at a continuously staffed monitoring post. Detection is not dependent on airborne release to the environment,[97] and hence not dependent on wind speed and direction bringing the release towards monitors.

8.108 Detection is, however, dependent on sufficiently strong gamma radiation reaching the monitor. The Committee considered three factors which might inhibit effective monitoring: the

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93. See the second supplementary submission from the Department of Defence, p. 16 (Evidence, p. 238.271) for reasons (apart from legal obligation) which, in the Department's view, make it unrealistic to assume a vessel commander will fail to notify an accident. See also the submission from the Tasmanian Government, p. 3 on the cooperative attitude shown by visiting US warship commanders and their willingness to comply with requests by Tasmanian officials.
94. Submission from Scientists Against Nuclear Arms (WA) and Medical Association for the Prevention of War (WA), p. 6 (Evidence, p. 792).
95. Evidence, pp. 238.290, 238.293 (ANSTO). On the early warning monitoring arrangements see Department of Defence, Environmental Radiation Monitoring during Visits by Nuclear Powered Warships to Australian Ports: Requirements, Arrangements and Procedures, (May 1988), Part 2, para. 4.1.
96. Evidence, p. 238.294 (ANSTO).
97. Evidence, p. 238.293 (ANSTO).

possibility that line-of-sight between the monitor and the vessel would be obstructed; the possibility of fully effective biological shielding around the reactor; and the distance at which the early warning monitors are located from the vessel.

Obstructions between the Vessel and the Monitor

8.109 One of the factors that may cause erroneous readings on early warning monitors is the interposition of large objects between the vessel and the monitor. AIRAC suggested that cargo containers stacked on the wharf used for nuclear powered vessel visits to Brisbane might have this effect.[98]

8.110 The Committee is satisfied that monitoring personnel understand the importance of ensuring that monitors are always in line-of-sight of the vessel, both at Brisbane[99] and generally.[100] Monitoring procedures for berths are satisfactory in this regard. The additional problems encountered in ensuring line-of-sight monitoring with respect to anchorages are noted in paragraph 8.124.

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98. AIRAC, 'Review of Safety and Monitoring Arrangements for Visits by Nuclear Powered Warships', p. 8 (Evidence, p. 759). Another example relates to the alleged radiation incident during the visit by USS Swordfish to Sasebo, Japan in May 1968. The basis for the allegation was a monitor reading taken from a small boat about 100 metres from the vessel. US authorities investigated the allegation and rejected it. One reason for doing so was that, according to the investigators, at the time of the reading a US Navy repair ship was between the vessel and the monitor, masking completely the one from the other. Moreover, on the repair ship welding equipment was being operated in direct view of the monitor. See US Congress, Joint Committee on Atomic Energy, Naval Nuclear Propulsion Program - 1971 - Hearing, 10 March 1971, p. 83 (Vice Admiral H. G. Rickover).

99. AIRAC, 'Follow-up Actions on Report of Visits to Hobart/Darwin/ Brisbane', p. 9 (Evidence, p. 769).

100. e.g. see the instructions in Department of Defence, Environmental Radiation Monitoring during Visits of Nuclear Powered Warships to Australian Ports: Requirements, Arrangements and Procedures, (May 1988), Part 2, para. 4.1.

Effect of Biological Shielding

8.111 In paragraph 4.20, it was explained that in addition to having containment, naval reactors are enclosed to some extent in biological shielding. The primary function of the latter is to ensure operator safety during normal reactor operation. For single reactor vessels (ie. submarines) the shielding is not such as would prevent detection of gamma radiation through the hull following a reactor accident that could release fission products to the containment.[101]

8.112 As indicated in the next chapter, the Department of Defence is confident that a multi-reactor vessel will be able to proceed to a remote anchorage under its own power following an accident to one of its reactors. This suggests that the shielding on multi-reactor vessels is sufficient to at least sharply reduce penetration by gamma radiation of the surroundings of the stricken reactor. The early warning monitoring, on the other hand, relies on gamma radiation penetrating through the containment, the shielding, and the hull so as to be detected by the monitors located outside the vessel.

8.113 In other words, the more effective the shielding the more credible vessel removal under its own power is, and the less likely it is that early warning monitoring will be effective. Conversely, if early warning monitoring is regarded as likely to be effective, doubt must exist as to the vessel removal under its own power. The Committee lacked the information necessary to resolve this issue conclusively. However, for the reasons given in paragraph 9.54 in the context of vessel removal, the Committee considered it likely that a multi-reactor vessel would remain operable following an accident to one of its reactors.

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101. e.g. see UK, Ministry of Defence, Liverpool Special Safety Scheme for Visits to Liverpool by Nuclear Powered Submarines, (April 1986), paras. 8 and 18; Evidence, p. 238.292 (ANSTO).

8.114 It followed that the Committee had some doubt on the extent to which early warning monitoring of multi-reactor vessels would be effective. The question is one of degree: the weaker the radiation penetrating the hull, the less likely the monitoring will be effective, especially if the monitoring device is at some distance from the hull. Moreover, there is not necessarily a conflict between external monitoring and continued vessel operability. Shielding could be arranged so as to protect those on board, without at the same time protecting those alongside the vessel. The Committee, however, lacked firm information that this was the case.

8.115 In summary, the Committee cannot confirm that early warning monitoring of a surface vessel would be effective in providing immediate notification of the escape of fission products into the containment.

Distance between Vessel and Monitor

8.116 There is no difficulty in locating monitoring equipment sufficiently close to a vessel at a berth. However, the range of the monitors is limited. According to ANSTO, it 'has been estimated to be about 600 metres for the reference accident source term'.[102] For this reason, land-based monitoring equipment would not provide effective early warning of an accident on a

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102. ANSTO, Radiation Monitoring Handbook for Visits by Nuclear Powered Warships to Australian Ports, (ANSTO, Lucas Heights, NSW, 1985), p. 10 (Evidence, p. 304). See also Evidence, p. 433 (ANSTO). Contrast the statement in the WA Port Safety Scheme, p. 10A-3: 'the gamma-radiation [through the hull] should be readily detectable out to several kilometres'. This statement is also made in OPSMAN 1 (original edition, 1981), p. 3E1-2, but not in later editions: see OPSMAN 1 (Revision 1, 1986), Chapter 4, Annex A, paras. 17-21 (Evidence, pp. 88-89).

vessel anchored a kilometre or more from shore.[103]

8.117 Monitoring equipment has nonetheless sometimes been sited more than this distance from the vessel.[104] In these cases, immediate initiation of protective measures could only have occurred if the vessel's commander had provided notification of the accident.[105] Moreover, this absence of constant early warning monitoring does not appear to conform to the Department of Defence's radiation monitoring requirement, which does not differentiate between berths and off-shore anchorages.[106]

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103. The statement in the text may not be precisely accurate for the reactors on Nimitz-class aircraft carriers, as these are several times larger than the reactor size used to calculate the reference accident source term. Equally, if the reactor is smaller than that used to calculate the source term, the effective monitoring distance will presumably be less than the 600 metre distance based on the reference accident source term. Additionally, the calculation of the reference accident source term has been safety-oriented, using 'worst-case' assumptions for the amount of the release from the reactor into the containment. Any calculation of the range of a detector based on the conservatively-calculated source term would over-state the range unless a 'realistic' source term was substituted for this purpose. In effect, in order to maintain an overall safety-orientation in planning, the size of the release to the containment should be under estimated for the purpose of assessing the efficacy of accident-detection monitoring equipment.

104. For example, during visits to Gage Roads the fixed gamma radiation monitoring equipment has been located in the Port Authority Tower, Fremantle: e.g., Department of Arts, Heritage and Environment, Visits by Nuclear Powered Warships to Australian Ports: Report on Radiation Monitoring during 1985, (DAHE, Canberra, 1986), p. 5 (Evidence, p. 353). This is about 4 km from the anchorage used for Nimitz-class vessels. As further examples, for the 1985 visit of USS Pogy to an anchorage off Darwin the equipment was sited on shore 1.2 km away: ibid, pp. 6-7 (Evidence, pp. 354-55); during the 1982 visit by USS Truxtun to an anchorage in the Derwent near Hobart the equipment was located 1.5 km away at Kangaroo Bluff: Department of Home Affairs and Environment, Visits by Nuclear Powered Warships to Australian Ports: Report on Radiation Monitoring during 1982, (DHAE, Canberra, 1983), para. 6.1. Neither of these annual monitoring reports indicates any awareness that the equipment was ineffective for the purpose of early warning in the position used.

105. AIRAC, 'Review of Safety and Monitoring Arrangements for Visits by Nuclear Powered Warships', p. 5 (Evidence, p. 756).

106. OPSMAN 1 (2nd edn.), Chapter 4, Annex A, para. 17 (Evidence, p. 88); Department of Defence, Environmental Radiation Monitoring during Visits of Nuclear Powered Warships to Australian Ports: Requirements, Arrangements and Procedures, (May 1988), Part 2, para. 4.1: 'a facility to provide early warning of a reactor accident is required'.

8.118 The Committee noted, however, that during the 36-hour visit of USS Sea Dragon to an anchorage at Jervis Bay in 1983 no early warning monitoring was undertaken.[107] This suggested that the Department of Defence took the view (on this occasion at least) that early warning monitoring was not necessary for visits to anchorages where few members of the public are likely to be within Zones 1 and 2.

8.119 The main aim of the monitoring is to provide an immediate signal for the evacuation of Zone 1.[108] In the situation where land-based early warning is ineffective, there would be no residents, port workers, etc. to evacuate. The only immediate concern would be for any fishermen, pleasure craft users, etc. who might be afloat in the vicinity of the vessel.

8.120 After evacuation of Zone 1, accident notification would be required in order to commence protective measures for Zone 2. The major concern in this context is the anchorage at Gage Roads off Fremantle approved for use by vessels having a reactor power

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107. Department of Home Affairs and Environment, Visits by Nuclear Powered Warships to Australian Ports: Report on Radiation Monitoring during 1983, (DHAE, Canberra, 1984), p. 11, describes other monitoring for the visit. The implied rationale for no early warning monitoring was the isolated nature of the anchorage: ibid.

108. Evidence, p. 433 (ANSTO). See also Department of Defence, Radiation Monitoring at Australian Ports Visited by Nuclear Powered Warships, (Revision 1, DoD, Canberra, 1986), Part 1, para. 8: an early warning system is provided to enable timely remedial action to be taken at berths, where significant numbers of workers could be within Zone 1; Department of Defence, Environmental Radiation Monitoring during Visits of Nuclear Powered Warships to Australian Ports: Requirements, Arrangements and Procedures, (May 1988), Part 1, para. 2.2.1: early warning monitoring is linked to the need 'to protect the health of members of the public in the vicinity of the berth'. Both of these documents discuss the rationale in relation to berths, making no mention of anchorages in this context.

output greater than 100 Mw(t).[109] The anchorage has a 2-hour vessel removal time when used by this class of vessel.[110]

8.121 The Visiting Ships Panel (Nuclear) undertook to AIRAC to provide it with a paper on the issue of early warning monitoring for off-shore anchorages.[111] It appears that this has not been done. As a result, the Committee was not able to say how necessary or practical the VSP(N) considered the use of monitors mounted on a separate monitoring vessel for early warning at those anchorages where land-based monitors would be ineffective in this role.[112]

8.122 The Committee considered that the use of ship-borne monitors in this role is only necessary in either of two cases. The first is where people are likely to be on the water close to

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109. The concern arises on the assumption that the warship commander would not only fail to notify Australian authorities of an accident but would also fail to remove the warship until directed by those authorities. The possibility was raised in a few submissions that the warship commander might try to conceal the reactor accident: e.g. see the submission from Senator J. Vallentine, p. 16 (Evidence, p. 1059). However, on this hypothesis it would be in the interest of the commander to remove the vessel as quickly as possible. Vessel-removal would generally offer the best prospect of concealing the fact that a reactor accident had occurred which might create a radiation hazard beyond the immediate vicinity of the vessel. Due to the potential weather and sea conditions at Gage Roads, multi-reactor vessels are the only nuclear powered vessels that anchor there in practice. The ability of a multi-reactor vessel, following an accident to one reactor, to use its remaining reactor(s) is discussed in the next chapter. Subject to the points made there, and assuming the commander was intent on concealing the accident, the warship could be immediately taken to sea on its remaining reactor(s).

110. Where a 24-hour removal time exists, decisions about vessel-removal are less time-critical.

111. AIRAC, 'Follow-up Actions on Report of Visits to Hobart/Darwin/Brisbane', p. 6 (Evidence, pp. 766).

112. When USS Enterprise visited the Quarantine Anchorage, Hobart in 1976 HMAS BASS was stationed near it throughout the visit to provide a monitoring base: Department of Environment, Housing and Community Development, Report on Environmental Radiation Monitoring During Visits to Australian Ports by Nuclear Powered Warships in 1976, (DEHCD, Canberra, 1977), para. 3.4. The RAN vessel, TV NEPEAN, was anchored near the USS Long Beach to facilitate monitoring during the latter's visit to an anchorage near Melbourne in 1976: ibid., para. 3.5. Rough weather limited the effectiveness of this monitoring at Melbourne: ibid.

the visiting vessel (e.g. for a regatta). Use in this situation could be rendered unnecessary by excluding people from entering the area in which immediate protective measures would be required in the event of an accident.[113] The second is where a short time is specified for vessel removal.[114]

8.123 The Committee RECOMMENDS that where land-based monitoring is too remote from an anchorage to provide early warning of an accident, ship-borne early warning monitoring be required in two cases: first, when the specified vessel removal time is less than 24 hours, and, secondly, when adequate measures cannot be made to ensure that people are not in the vicinity of the vessel.

8.124 Where ship-borne monitoring is used, problems may arise in ensuring that it remains in line-of-sight to the vessel being monitored. The interposition of a transiting vessel would not cause difficulties, due to the brief time it might screen the monitor. A different problem may arise if the vessel is anchored or moored in such a way that it can swing with the effect of wind and tide.

8.125 The reactors are located near the midships region of the vessel. Viewed along the length of the vessel from the bow or stern, the structure of the vessel provides a measure of

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113. cf. the prohibition on traditional ship's open days for nuclear powered warships, so as to prevent the possibility of a large number of visitors being aboard the visiting vessel in the event of an accident: OPSMAN 1 (2nd edn.), para. 311 (Evidence, p. 63).

114. 'Specified' in this context includes the situation for the Hobart primary anchorage, where the short removal time is not specified in the anchorage assessment/conditions of entry but is voluntarily adopted by the Tasmanian authorities in order to reduce the size of Zone 2: see para. 8.50.

shielding. It appears from the data supplied by ANSTO,[115] that early warning monitoring might not be effective if the monitor was end-on to the bow or stern. To be effective, it seems to the Committee that the ship-borne monitor would need to be able to reposition itself relative to its target. This would add to the complexity of the monitoring task, although the problems would not be insuperable.

False Alarms

8.126 The Committee examined whether timely notification would be delayed by a need to check an alarm to ensure that it was not due to faulty equipment or some other extraneous cause.[116] The Committee was told that redundancy in the monitoring system would reduce the impact of any equipment fault. Moreover, it would be possible within 15 minutes to determine if an alarm was false or real, independently of any information provided by the vessel

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115. ANSTO, Radiation Monitoring Handbook for Visits by Nuclear Powered Warships to Australian Ports, (ANSTO, Lucas Heights, NSW, 1985), p. 20, (Evidence, p. 314) gives an isodose contour chart for gamma radiation through the hull. A dose of 5000 mSv alongside the reactor compartment reduces to less than 1 mSv end-on to the bow or stern. See also the 'Supplement to the Safety Scheme for Visits of Nuclear Powered Warships to Tasmania: Royal Hobart Hospital Arrangements', p. 2: using caesium-137 as a benchmark gamma emitter, a 5.3 cm thickness of steel between the source and the subject would have the effect of reducing the radiation received to a tenth of the unattenuated dose rate.

116. cf. Department of Home Affairs and Environment, Visits by Nuclear Powered Warships to Australian Ports: Report on Environmental Radiation Monitoring during 1980 and Amendments to (Environmental Radiation) Monitoring Guidelines, (DHAE, Canberra, 1981), para. 5.2.1, describes some of the false alarms at HMAS STIRLING, WA experienced

> due to minor equipment malfunction, electrical interference and in some cases it is believed due to stray radio frequency interference. Installation of permanent monitoring equipment will shortly be completed at HMAS Stirling which should alleviate this problem.

Permanent monitoring detectors have now been installed: HMAS STIRLING Sub-Plan, para. 1306(3).

commander.[117]

OTHER MONITORING

Monitoring for Airborne Contamination

8.127 In addition to early warning monitoring, monitoring has a critical role in guiding the accident response by plotting the size, direction and extent of dispersal of any release of airborne contamination. Data from monitoring assists in choosing the appropriate protective measures to be implemented. Monitoring also has a longer term role in guiding decisions relating to possible decontamination requirements, re-occupation of any evacuated areas, and resumption of any suspended activities such as the use of farm products and foodstuffs from the area around the site of the accident.[118]

8.128 It was questioned whether all this monitoring would be effective due to lack of standardisation of units of measurement, equipment and procedures, and due to insufficient equipment and trained personnel.[119] The basis of the doubt was comment made at a 1982 seminar which considered measures for protecting the Australian public from ionising radiation.[120]

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117. Evidence, p. 434 (ANSTO). See ANSTO, Radiation Monitoring Handbook for Visits by Nuclear Powered Warships to Australian Ports, (ANSTO, Lucas Heights, NSW, 1985), pp. 12-13 (Evidence, pp. 306-07), which describes the steps necessary before an 'alarm' becomes a 'confirmed alarm'. For the steps in the context of a specific plan, see WA Port Safety Scheme, para. SP B15.

118. See Department of Defence, Environmental Radiation Monitoring During Visits of Nuclear Powered Warships to Australian Ports: Requirements, Arrangements and Procedures, (May 1988), Part 2, paras. 4.2.1 and 4.3 for details of these uses of monitoring.

119. Submission from Scientists Against Nuclear Arms (WA) and Medical Association for the Prevention of War (WA), p. 5 (Evidence, p. 791).

120. Report of Proceedings of a Study on the Protection of the Australian Public from Ionising Radiation: 8-12 November, 1982, (Australian Counter Disaster College, Mt Macedon, Vic, 1983). See particularly pp. 7-10, 82, 117, 223-24 and 225.

8.129 Much of the seminar comment was not relevant to a naval reactor accident. The seminar focused heavily, though not exclusively, on the aftermath of a nuclear war. The range of equipment and trained personnel required to meet this situation would clearly be far greater that for a single naval reactor accident. Available personnel and equipment, civil and military, would be used in a far more ad hoc way than in the planned response to a naval reactor accident.[121]

8.130 The equipment for warship early warning monitoring and for immediate post-accident monitoring is all provided by the Commonwealth.[122] Most items are held by ANSTO, and are made available at a port receiving a visit.[123] The concern put to the Committee that there was insufficient monitoring equipment in Perth and none at Albany incorrectly assumed that local sources were to be relied on.[124]

8.131 No current comprehensive list is available to the Committee of the monitoring equipment that the authorities regard as the minimum needed. However, earlier and partial lists indicate that the number of items required for routine and

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121. e.g. see the seminar comment (p. 9) that the planning for nuclear powered ship visits had led to some improvements applicable to responses to other radiation emergencies. ANSTO provides training to RAN and State personnel on the operation of the specific monitoring equipment: Department of Defence, Visits by Nuclear Powered Warships to Australian Ports: Report on Radiation Monitoring during 1986, (DoD, Canberra, 1988), Part II, paras. 14-15. This assists in ensuring that all concerned operate to a common standard.
122. OPSMAN 1 (2nd edn.), Chapter 4, Annex A, para. 33 (Evidence, p. 92).
123. ibid. The remaining equipment is held by the RAN.
124. Submission from Scientists Against Nuclear Arms (WA) and Medical Association for the Prevention of War (WA), p. 6 (Evidence, p. 792).

immediate post-accident monitoring is small.[125] No information was put to members of the Committee during their inspection visits to Tasmania and Western Australia that suggested deficiencies, either in the kind or amounts of equipment specified, or in the actual provision of that equipment by the Commonwealth during visits. No submission based on knowledge of the relevant documentation suggested deficiencies.

8.132 The Commonwealth documentation suggests that the number of personnel required to carry out monitoring is small.[126] As with equipment, however, there is no comprehensive list available to the Committee setting out precise numbers of persons and the precise skills they require. Again as with equipment, no deficiencies with regard to personnel and their training came to light during inspection visits by members of the Committee, or in a documented form in submissions.

8.133 Not all portable items of monitoring equipment

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125. OPSMAN 1 (original edition, 1981), Chapter 3, Annex E, Appendix 1, para. 2.2.3. This paragraph has been carried across into the WA Port Safety Scheme, p. 10A-5, but no equivalent appears in the more recent editions of OPSMAN 1. Department of Science and the Environment, Report and Guidelines on Environmental Radiation Monitoring during Visits to Australian Ports by Nuclear Powered Warships, (DSE, Canberra, 1979), Annex A, para. 2.2.3, lists 11 items as comprising the equipment for the immediate program of radiation monitoring. The 1988 version of these guidelines contains no equivalent list. It provides instead that equipment lists are to be set out in the Radiation Monitoring Handbook when the revised edition is prepared: Department of Defence, Environmental Radiation Monitoring during Visits of Nuclear Powered Warships to Australian Ports: Requirements, Arrangements and Procedures, (May 1988), p. 10. Australia, Environmental Considerations of Visits of Nuclear Powered Warships to Australia, (May 1976), Annex C, paras. 37 and 39 (Evidence, pp. 169-70) lists the minimum equipment required for routine and emergency monitoring. ANSTO, Radiation Monitoring Handbook for Visits by Nuclear Powered Warships to Australian Ports, (ANSTO, Lucas Heights, NSW, 1985), p. 47 (Evidence, p. 341) lists a 'typical NPW mobile monitoring kit inventory'.

126. ANSTO, Radiation Monitoring Handbook for Visits by Nuclear Powered Warships to Australian Ports, (ANSTO, Lucas Heights, NSW, 1985), pp. 9-10 (Evidence, pp. 303-04).

operate on the international system (SI) units of measurement,[127] which is the system of units used in the Australian planning documentation. The monitoring instructions, however, make provision for the conversion of readings from non-SI equipment to SI units before reporting results.[128] The United States Navy does not use SI units for radiation monitoring.[129] The Committee did not envisage major problems arising from this, as the planned radiation monitoring response that would immediately follow an accident does not rely on non-Australian resources.

8.134 After the initial phases, response to a major accident is also planned initially to involve ANSTO resources in the main.[130] It is recognised, however, that it might also involve Australian resources not specifically identified in the plans.[131] Overseas assistance presumably might also be accepted. But this stage of the response would not be time-critical. There would be time to resolve problems (if any) relating to unfamiliar equipment or units of measurement.

8.135 The Committee considers that there is sufficient monitoring equipment available, that there are sufficient trained personnel to use the equipment, and that no confusion is likely to arise due to the differing systems of units used by the equipment.

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127. SI is an abbreviation of the French name for the international system of units, Le Système International d'Unités, which is gradually replacing units previously used. See the table at the end of the Glossary for a list of SI and corresponding older units for measuring radiation.

128. ANSTO, Radiation Monitoring Handbook for Visits by Nuclear Powered Warships to Australian Ports, (ANSTO, Lucas Heights, NSW, 1985), p. 16 (Evidence, p. 310).

129. ibid., p. 38 (Evidence, p. 332).

130. OPSMAN 1 (2nd edn.), Chapter 4, Annex I, para. 4 (Evidence, p. 113) sets out the extra equipment and personnel to be supplied.

131. ibid., Annex A, para. 29 (Evidence, p. 91). See also Evidence, p. 238.319 (Department of Defence).

Calibration of Instruments

8.136 The Committee noted that, following the 1979 reactor accident at Three Mile Island, various kinds of portable survey equipment were used, none of which was calibrated for the low energies of xenon-133 which in fact predominated in the radiation plume.[132] This is an illustration of how planning for the more serious accident may prove deficient if a more limited radiation release actually occurs.

8.137 The Committee found that this potential problem is avoided under Australian arrangements. One of the monitoring devices used during each visit, a gamma spectrometer,[133] is capable of identifying all the radionuclides in an air sample. Based on the results of using this device, appropriate equipment is available which can, if necessary, be brought into use. In practice, it appears to the Committee that any re-calibration would only be necessary where, as at Three Mile Island, only minimal amounts of the radioiodines were released.

Thermoluminescent Dosemeters

8.138 Thermoluminescent dosemeters (TLD's) are devices containing a type of film which is sensitive to ionising radiation.[134] The devices are exposed and, when subsequently analysed in a laboratory, indicate the amount of radiation

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132. A. P. Hull, 'Critical Evaluation of Radiological Measurements and of the Need for Evacuation of the Nearby Public during the Three Mile Island Incident', International Atomic Energy Agency, Current Nuclear Power Plant Safety Issues: Proceedings of an International Conference Organized by the International Atomic Energy Agency, Stockholm, 20-24 October 1980, (IAEA, Vienna, 1981), p. 86.
133. ANSTO, Radiation Monitoring Handbook for Visits by Nuclear Powered Warships to Australian Ports, (ANSTO, Lucas Heights, NSW, 1985), pp. 15 and 23-27 (Evidence, pp. 309 and 317-21) refers to the use of the gamma spectrometer. The references made to 'laboratory measurement' (e.g. ibid., p. 14) refer to use of a test facility set up for the duration of each visit using moveable equipment assembled for the occasion.
134. See Evidence, pp. 238.317-18 (Department of Defence) for a more detailed description.

received during the period of exposure. During each nuclear powered warship visit to an Australian port, TLD's are exposed at a number of locations in the vicinity of the vessel. The locations are determined jointly by authorities of the Commonwealth and of the State/Territory receiving the visit.[135] The particular TLD's used are identical to those used as personal monitors by radiation workers.[136]

8.139 Following a ship visit, the TLD's are returned to the Australian Radiation Laboratory for assessment of the doses received. The TLD's provide an additional means of confirming whether or not there has been a radiation accident with consequences for the environment during the visit.

8.140 In some plans overseas, TLD's are used to assist in immediate post-accident decision-making.[137] The Australian Radiation Laboratory told the Committee that 'in the event of an accident the TLD's would be replaced at the termination of the accident'.[138] The Committee understood from this, and from the time taken to process the TLD's,[139] that the TLD's were not intended to be used to guide decision-making on the implementation of protective measures during the period immediately following a reactor accident. Instead, the TLD's would be used

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135. Department of Defence, Environmental Radiation Monitoring during Visits of Nuclear Powered Warships to Australian Ports: Requirements, Arrangements and Procedures, (May 1988), Part 2, para. 3.1.2. For maps showing the TLD locations used for particular visits to Gage Roads/Cockburn Sound, Darwin, Hobart and Brisbane, see Evidence, pp. 361-64.

136. Submission from the Australian Radiation Laboratory, p. 4 (Evidence, p. 1008).

137. e.g. see R. Raufer and R. Flessner, 'Off-site emergency planning exercises in Illinois', Nuclear Engineering International, February 1984, p. 41: after an accident

> radiation measurements are made with portable radiation detection equipment and thermoluminescent dosimeters (TLDs). The TLDs give a good measurement of the time-integrated dose, in support of population dose projections.

138. Submission from the Australian Radiation Laboratory, p. 4 (Evidence, p. 1008).

139. The fact that the TLD's would have to be returned to the Australian Radiation Laboratory at Melbourne for assessment would prevent their being used as speedy guides to post-accident decision-making.

after an accident was over to provide evidence of the total dose accumulated at each TLD location.

8.141 The Committee accepts this as satisfactory, as it considers the other radiation monitoring methods adequate to guide decision-making immediately following an accident.

METEOROLOGICAL INFORMATION

8.142 In addition to the results of radiation monitoring, weather information would be needed to guide decision-makers in the immediate post-accident phase. Information about wind speed, direction, etc., will help assess the extent and effects of airborne contamination.[140]

8.143 In 1984, an AIRAC working group noted during an on-site inspection of arrangements for Hobart that there 'was an apparent lack of appreciation of the role which the Meteorological Bureau could play under emergency conditions'.[141] Provision has, however, been made for the use of smoke generators to assist in monitoring wind conditions.[142] AIRAC was unable to confirm that planning now has due regard for the assistance available from the Meteorological Bureau.[143] However, it was clear to members of the Committee during the inspection they made at Hobart in March 1988 that those involved in the implementation of the plan had a good appreciation of the importance of data relating to wind and weather.[144]

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140. OPSMAN 1 (2nd edn.), Chapter 4, Annex A, para. 27 (Evidence, p. 90).
141. AIRAC, 'Review of Safety and Monitoring Arrangements for Visits by Nuclear Powered Warships', p. 3 (Evidence, p. 754).
142. ibid., p. 2 (Evidence, p. 753); Hobart Safety Scheme, paras. 1311(c) and 1423(4)(d).
143. AIRAC, 'Follow-up Actions on Report of Visits to Hobart/Darwin/Brisbane', p. 3 (Evidence, p. 763).
144. See also Hobart Safety Scheme, Chapter 4, Annex A, para. 27, and para. 514.

8.144 The only other issue relating to weather information to come to the Committee's attention was also raised by AIRAC. This related to inadequate wind force measuring equipment at the approved berths at the Fisherman Island Container Terminal, Brisbane.[145] Again AIRAC was unable to confirm that remedial action had been taken.[146]

8.145 The Committee RECOMMENDS that the Visiting Ships Panel (Nuclear) confirm that the wind force measuring equipment at the approved berths at Fisherman Island, Brisbane is now adequate.

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145. AIRAC, 'Review of Safety and Monitoring Arrangements for Visits by Nuclear Powered Warships', p. 7 (Evidence, p. 758).

146. AIRAC, 'Follow-up Actions on Report of Visits to Hobart/Darwin/Brisbane', p. 8 (Evidence, p. 768).

CHAPTER 9

CRITICISMS OF CURRENT PLANS - PART I

FORMAT OF PLANS

Introduction

9.1 Many submissions criticised the detail of current contingency plans for the accidental release of ionising radiation from a visiting nuclear powered warship. Much of the criticism, however, was inconsistent with the reference accident upon which the plans are based. The Committee found it unnecessary to deal with this category of criticism because the Committee has concluded that the current reference accident is an appropriate basis for planning.

9.2 This chapter and chapter 10 deal with the arguments put to the Committee that, even if the reference accident is an appropriate basis, the plans for Australian ports based on it are nonetheless deficient in one or more respects. The port plans examined were those for Gage Roads/Cockburn Sound in Western Australia, Brisbane, Darwin, and Hobart.[1] Plans for other ports, to the extent that plans exist, were not examined in detail because the ports do not currently receive visits.

Same Standard as for Non-Nuclear Accident Planning

9.3 Contingency plans for a reactor accident aboard a visiting warship will have to be designed to deal with the unique

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1. See paras. 2.36, 2.37, 2.39, 2.41 and 2.42 for the full titles, dates, etc of these plans.

features of reactor accidents. One point of comparison for the Committee in evaluating the Australian plans was overseas planning for reactor accidents.[2]

9.4 A second possible point of comparison was planning for non-nuclear accidents. A conspicuous omission in submissions criticising the detail of the plans under examination was any attempt to substantiate the criticism by reference to plans relating to other, non-nuclear, contingencies. By inference, it was suggested that the plans subject to the Committee's inquiry should conform to different standards from plans for other accidents or for natural disasters.

9.5 The Committee considers that in principle there is no reason why this should be so. Matters such the degree of detail and complexity in plans; the scale and frequency of exercises; the degree of public participation in exercises; the public availability of plans; and publicity measures regarding the content of plans and actions to be taken by the public if the accident occurred should be guided by the experience gained from planning for other types of accidents and emergencies. The Committee takes the view that the same general criteria should apply to both nuclear and non-nuclear accident contingency planning.

Degree of Detail Required

9.6 Senator Vallentine described the WA Port Safety Scheme as 'not a safety scheme at all, but rather a huge rendez-vous plan'.[3] The Committee, without accepting this as an accurate description of the particular plan, acknowledged that the comment

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2. For a general checklist on what should be contained in a plan to deal with a reactor accident see International Atomic Energy Agency, Basic Safety Standards for Radiation Protection, (1982 edn., IAEA, Vienna), para. A.IV.614.
3. Submission from Senator J. Vallentine, p. 10 (Evidence, p. 1053).

raised a general issue. This was the extent to which plans should be expected to go beyond ensuring that appropriate experts are present at appropriate locations, and should state in any detail what the experts are supposed to do.

9.7 The distinction can be made clearer by use of a simplified example relating to post-accident responses in Zone 2. One possibility is that the plan is required to do no more than provide that suitably equipped monitoring groups are present with appropriate communication links established, and state that the implementation of any countermeasures would be made on the advice of these groups. A second approach would have the plan state how the groups should go about monitoring, where they should take readings, how often, with what equipment, what the consequences of any particular level of readings should be in terms of counter-measures, and so forth.

9.8 Clearly if the first approach is adopted there must be a sound basis for thinking that the personnel have the necessary expertise and that the sorts of things that they are being asked to do are practicable. But the basis for this does not have to be in the plan itself. The Committee saw the issue, in effect, as being whether a port safety plan was required to be a comprehensive, free-standing document, or whether it could be something less than this. The Committee accepted the latter as more appropriate.

9.9 The Committee has identified specific problems in the plans. But it has done so only after reading them in the light of information contained in other, Commonwealth, documents. Allowance has also been made for the expertise of those required to act under the plans. To return to the example just given, a radiation expert equipped with the information set out in the monitoring handbook[4] and the monitoring guidelines[5] does not, in the Committee's view, need specific direction from a port safety plan. It is enough that the plan links the expert's presence into other elements of the plan.[6]

9.10 One consequence of adoption of this view is that the Committee does not consider that port safety plans should be written so as to serve a general educational or informative role. The plans need only to be operational guides for those expected to implement them. It is not a valid ground of complaint, in the Committee's opinion, that the plans for specific ports fail to provide all the detail and background information a lay reader might wish. Educational needs can be addressed in ways other than by requiring voluminous safety plans.[7]

Style and Length of Plans

9.11 One submission described the WA Port Safety Scheme as 'lengthy, repetitious and tedious - and thus confusing, which a report on such an important matter has no right to be'.[8] As to the Scheme being tedious, the Committee leaves it for readers to decide. It merely notes that it does not consider that safety plans should provide exciting reading.

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4. ANSTO, Radiation Monitoring Handbook for Visits by Nuclear Powered Warships to Australian Ports, (ANSTO, Lucas Heights, NSW, 1985).
5. Department of Defence, Environmental Radiation Monitoring during Visits of Nuclear Powered Warships to Australian Ports: Requirements, Arrangements and Procedures, (May 1988).
6. See also Evidence, p. 1300.46 (Department of Defence):

   > While port safety plans for NPW visits allocate responsibilities to the appropriate authorities, they allow that those authorities are competent to implement the most appropriate procedures ... .

7. See paras 8.89-8.93.
8. Submission from Scientists Against Nuclear Arms (WA) and Medical Association for the Prevention of War (WA), p. 2 (Evidence, p. 788), See also the submission from People for Nuclear Disarmament, p. 5 (Evidence, p. 1307): the WA plan 'is difficult to read and does not have the clear, easy to follow procedural advice necessary for an emergency document'. No examples of difficult passages are given to support this view, nor is it explained why the step-by-step procedures set out in parts 3-5 of the plan are not easy to follow.

9.12 The Committee does not consider that Australian contingency plans are excessively lengthy. The WA Port Safety Scheme is a few pages longer than the 57 pages of the corresponding British plan for Liverpool.[9] Unlike the Liverpool plan, however, the WA plan deals with two locations, Gage Roads and Cockburn Sound, and with two classes of vessel, those having reactors rated at more than 100 Mw(t) and others with smaller reactors. The British plan for the naval dockyard at Devonport is nearly 40 pages longer that the WA plan.[10]

9.13 In response to a question from the Committee, the Department of Defence stated:

> In comparison with other types of emergency plans, the WA port safety plan is more complex than some (eg cyclone response plans) and less complex than others (eg HAZMAT plans).[11]

The Committee noted that the WA plan is, for example, only a few pages longer than the Australian Capital Territory disaster plan.[12]

9.14 The particular evidence cited for the claim of repetition is the overlap between Parts 3, 4 and 5 of the WA Port Safety Scheme.[13] These parts respectively set out the standing procedures for visits to HMAS STIRLING, for visits to Gage Roads anchorages by vessels having reactors smaller than 100 Mw(t), and for visits by vessels with larger reactors. While there is consi-

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9. UK, Ministry of Defence, Liverpool Special Safety Scheme for Visits to Liverpool by Nuclear Powered Submarines, (April 1986).
10. UK, Ministry of Defence, Devonport Public Safety Scheme, (1982 edn.).
11. Evidence, p. 1300.46 (Department of Defence). HAZMAT plans deal with accidents involving hazardous materials such as chemicals.
12. Department of Territories and Local Government, ACT Disasters Plan, (AGPS, Canberra, 1984). If its sub-plan is taken into account, the ACT plan is considerably longer than the WA Port Safety Scheme: see Department of Territories, ACT Welfare Plan : Sub-plan of the ACT Disaster Plan, (AGPS, Canberra, 1986).
13. Submission from Scientists Against Nuclear Arms (WA) and Medical Association for the Prevention of War (WA), p. 2 (Evidence, p. 788).

derable duplication in this approach, the Committee recognises that this has operational advantages. The accident, if it occurs, will require only one of the three Parts to be acted upon. The Part acted upon will be free of irrelevant references to matters which apply only to other locations or another class of vessel.[14]

9.15 Senator Vallentine questioned what she saw as the complexity of the WA Port Safety Scheme:

> While meticulous in designating each agency's responsibilities, the plan raises numerous questions about whether anything so complicated could work as a coordinated whole at a time when demarcation disputes could spell tragedy.[15]

9.16 During a visit to Western Australia, members of the Committee put this type of criticism to State Emergency Service officials. The Committee members were told that experience from exercises had shown that the scheme was not too complicated. It worked well, and the command structure was very clear.[16]

9.17 Based on this response, and on comparisons with other port safety plans[17] and other emergency plans, the Committee does not consider the WA Port Safety Scheme to be complicated in a way

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14. To some extent, a similar explanation applies to the considerable duplication that exists between the various parts of the Hobart Safety Scheme. The intention appears to be that those required to operate a particular part or sub-part of the scheme need only direct their attention to that part. The evacuation plan (Chapter 14), for example, has been written as a stand-alone plan. As a result it contains much information that is also contained in other parts of the scheme.
15. Submission from Senator J. Vallentine, pp. 10-11 (Evidence, pp. 1053-54).
16. Information supplied at briefing to Committee members by WA officials, 1 February 1988.
17. e.g. UK, Ministry of Defence, Liverpool Special Safety Scheme for Visits to Liverpool by Nuclear Powered Submarines, (April 1986), Annex 3B, lists 17 'authorities responsible for public safety' in relation to the plan. The WA Port Safety Scheme, table of contents, p. vi, lists 16 authorities as having responsibilities under the plan. While the comparison can be no more than approximate due to differing government structures, it indicates that the number of organisations involved in the WA plan is not unusually large.

that would hinder its effective implementation.

Relationship to Other Documents

9.18 The Committee noted that the Parts 9 and 10 of the WA Port Safety Scheme contain mostly background information. There is some duplication as between Part 9 and Part 10.[18] The Parts taken together largely duplicate information provided in other, Commonwealth Government, documents. Some economy of effort could be achieved if the Scheme simply incorporated the relevant extracts from these other documents, perhaps as an appendix.

9.19 In addition to achieving economies, this would ensure that the content of the Scheme does not inadvertently diverge from that of Commonwealth Government documents. For example, the author of Part 10 of the Scheme drew heavily on the original (ie. 1981) edition of OPSMAN 1. Later editions of OPSMAN 1 have been produced and minor discrepancies now exist between the Commonwealth and Western Australian background information.[19]

9.20 Duplication leading to divergence is not limited to the WA Port Safety Scheme. For example, the plans for Brisbane, Darwin, Hobart and Western Australia all contain descriptions of the general hazards due to reactor accidents. The descriptions

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18. e.g. the purposes of radiation monitoring are described in para. 908 and again, in different words, in paras. 1007 and 1011.
19. For example, the WA Port Safety Scheme, p. 10A-6 duplicates OPSMAN 1 (original edition, 1981), Chapter 3, Annex E, Appendix 1, para. 2.4 in setting out three countermeasures that could be taken following an accident. OPSMAN 1 (2nd edn.), para. 121 lists four countermeasures: sheltering is the additional one. The WA Port Safety Scheme itself lists four, including sheltering, at p. 9-4. For a further discrepancy, relating to the effectiveness of gamma radiation monitoring equipment, see chapter 8 footnote 102. In the Hobart Safety Scheme, Chapter 4 and its Annex A duplicate to a considerable extent the content of the Commonwealth's document setting out radiation monitoring requirements, arrangements, etc. They are based on the 1986 edition of the Commonwealth document, and the same potential as with the WA Port Safety Scheme exists for discrepancies to occur as the document is updated. In May 1988 the Commonwealth issued an updated version of the document, although the changes are only minor.

give about 100 metres as the limit of the severe hazard due to gamma radiation through the hull of the vessel following a reactor accident.[20] Commonwealth documentation states the limit as being 30 metres.[21] Again, the Committee considers that incorporation of a Commonwealth document containing background information of this sort is the appropriate solution.

9.21 The Committee RECOMMENDS that the Commonwealth Government produce a document containing all the necessary scientific background on naval nuclear reactors; the nature of the potential hazards resulting from accidents involving the reactors which the plans have to address; and other background information which is common to all the plans. The document should be suitable for incorporation in, or attachment to, individual port safety plans.

Lack of Standard Format

9.22 The current plans for Australian ports are not identical in format, or in their detailed provisions. The Department of Defence has taken the view that a standard format for such plans is not feasible, because of the differing State and Territory legislation under which the organisations responsible for accident response operate.[22]

9.23 The Committee accepts that the plans should reflect uniform objectives, and that, in the abstract, there is much to be said for attempting to achieve these goals through uniform format and content. However, the Committee acknowledges the

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20. Paras. 109, 305, 404 and 903 respectively. Para. 1406 of the Hobart Safety Scheme states that gamma radiation 'could present a hazard close to (say within 200 metres of) the vessel' (emphasis added). If this is intended to refer to gamma radiation through the hull, it is inconsistent with the 100-metre distance given in para. 305 of the scheme.
21. Australia, Environmental Considerations of Visits of Nuclear Powered Warships to Australia, (May 1976), para. 39 (Evidence, p. 134); ANSTO, Radiation Monitoring Handbook for Visits by Nuclear Powered Warships to Australian Ports, (ANSTO, Lucas Heights, NSW, 1985), p. 4 (Evidence, p. 298).
22. OPSMAN 1 (2nd edn.), para. 446 (Evidence, p. 81).

practical difficulties involved in attempting to impose either a uniform format or uniform detailed contents, except in relation to background information on the hazards of radiation accidents, and matters where the Commonwealth has the responsibility for a particular response measure. It became clear to members of the Committee during inspection visits to Western Australia and Hobart that planned responses to a naval reactor accident would draw considerably on procedures, organisational structures and personnel used for the responses to other types of accidents.

9.24 In the Committee's view, an effective response to a naval reactor accident is obtained by having the plan conform where possible to locally accepted ways of responding to emergencies.

PROTECTIVE MEASURES FOLLOWING AN ACCIDENT

9.25 One protective measure that may be taken following a marine reactor accident is to move the vessel to a more remote berth or anchorage, or out to sea. Other standard protective measures in response to reactor accidents are evacuation, the use of iodine as a prophylactic, sheltering, and personal measures such as respiratory protection and protective clothing.[23]

9.26 Following an accident, a choice from among the available protective measures would have to be made in the light of the actual situation. To the extent that one measure can be relied upon to work, alternative measures are not required. In the Committee's view, the aim of the planning should be to ensure that measures that may plausibly be required in the event of an accident are available, without wasteful and costly redundancy.

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23. International Atomic Energy Agency, Planning for Off-Site Response to Radiation Accidents in Nuclear Facilities, (Safety Series No. 55, IAEA, Vienna, 1981), pp. 9-10.

9.27 The use of any protective measure incurs costs and risks. An International Atomic Energy Agency safety guide points out:

> As a general principle it will be appropriate to implement protective measures only when their social cost and risk will be less than those resulting from the radiological exposure that would be avoided. In many cases this is a very difficult decision.[24]

Australian port safety plans acknowledge this point.[25]

VESSEL REMOVAL

Appropriateness of the Removal Option

9.28 The Victorian Government argued:

> the assumption that moving a vessel in distress is a desirable strategy must be seriously questioned. The fact that radioactive material is being discharged argues strongly against moving the vessel and would hamper, if not entirely prevent, any efforts to minimise the spread of radioactive materials.[26]

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24. ibid., p. 11. See pp. 15-27 for an indication of the types of costs and risks attached to implementing each of a wide range of protective measures. For further detail on the difficulties of post-accident decision making see International Atomic Energy Agency, Techniques and Decision Making in the Assessment of Off-Site Consequences of an Accident in a Nuclear Facility, (Safety Series No. 86, IAEA, Vienna, 1987), pp. 147-54.
25. Brisbane Port Safety Plan, para. 313; Darwin Port Safety Plan, para. 510; Hobart Safety Scheme, Chapter 4, Annex A, para. 31; WA Port Safety Scheme, para. 920.
26. Submission from the Victorian Government, p. 6. See also the submissions from Coalition Against Nuclear Armed & Powered Ships, p. 3 (Evidence, p. 1375); Senator J. Vallentine, p. 14 (Evidence, p. 1057); Scientists Against Nuclear Arms (Tas), pp. 5-6 (Evidence, pp. 824-25); Scientists Against Nuclear Arms (ACT), p. 4 (Evidence, p. 782). See also Evidence, p. 610 (Prof W. J. Davis).

9.29 This view appears to be based on a misunderstanding of when vessel removal would be most useful and what it seeks to achieve. The reason why exposure to radiation at doses exceeding the emergency reference levels will occur most rapidly if the plume remains concentrated was explained in paragraph 8.40. The aim of vessel removal is to assist dispersion, and to avoid all the radioactive material remaining concentrated in a place where it will lead to individual doses approaching or exceeding the emergency reference levels.

9.30 This point is relevant also to concerns expressed about the difficulty of towing in rough seas and stormy weather,[27] and to the fact that towing capability is required to be able to cope with moderate sea conditions (up to sea-state 3) only.[28] Seas sufficiently rough to hamper vessel removal will almost certainly be accompanied by winds sufficiently strong to eliminate the need for removal.

9.31 A further concern was the perceived need to remove an accident-stricken vessel from HMAS STIRLING, at the southern end of Cockburn Sound, northwards through a dredged channel towards Fremantle in order to reach the open sea. Senator Vallentine told the Committee:

> a vessel berthed at HMAS Stirling with a damaged reactor would have to be towed up the channel in order to be moved out to open sea. This narrow channel is the only entry and exit from the naval base. Any vessel being towed through it would pollute the entire coastal strip as it went, as well as contaminate Rottnest Island as it headed out to open sea.[29]

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27. Submissions from Mr J. R. Budge, p. 1; Mrs L. Van Geloven, p. 4.
28. OPSMAN 1 (2nd edn.), para. 432 (Evidence, p. 77).
29. Submission from Sentor J. Vallentine, p. 14, (Evidence, p. 1057). See also the submission from Mr R. Bolt, p. 12 (Evidence, p. 962); Evidence, pp. 920 and 932-34 (Mr M. Lynch): at p. 920 a similar type of criticism is made of the route to the remote anchorage at Hobart.

9.32 This argument overlooks the fact that there are two approved remote anchorages and a remote berth towards the southern end of Cockburn Sound.[30] Assuming a stricken vessel needed to be moved at all, it would not need to be moved up the channel in order to reach an approved remote location. Any decision to move the vessel to sea rather than one of these locations would take weather conditions into account.

9.33 If the accident occurred to a multi-reactor vessel at HMAS STIRLING and the decision was made to move it out to sea, the Department of Defence expect it would be moving at its normal transit speed up the channel by means of its undamaged reactor.[31] This would maximise dispersal, and therefore minimise the hazard.

9.34 Even a slow-moving vessel under tow following the reference accident would not pose a significant hazard to the populated areas to the east of the channel from HMAS STIRLING to the open sea. As indicated in paragraphs 8.37 and 8.53, the maximum distance for which protective measures are required following the reference accident is calculated by the Australian Nuclear Science and Technology Organisation (ANSTO) at 2.2 kilometres, based on 12-hour exposure of an individual to the resulting radiation. The dredged channel does not come closer than about 4 kilometres to the mainland. The vessel being removed, because it is moving, will not create this type of 12-hour exposure for any fixed position 2.2 kilometres away.

9.35 The Committee does not regard as valid the criticism that vessel removal is an unsound option which, if employed, would be bound to increase rather than decrease the radiation hazard to the public. It does not follow, of course, that it

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30. OPSMAN 1 (2nd edn.), Chapter 2, Annex A (Evidence, p. 52). These locations have been criticised on the basis that they are closer to Perth and Fremantle than the primary berths and anchorages at HMAS STIRLING: submission from Mr R. Addison, p. 9. All the remote locations, however, are over 10 km from the southern part of Fremantle.
31. Evidence, p. 1296 (Department of Defence).

would necessarily be appropriate to exercise the option in all circumstances.

9.36 In examining the adequacy of the arrangements for vessel removal, the Committee took into account that vessel removal was only one of the protective measures available. It is not the case that, if vessel removal fails, all options will be exhausted and that as a result planners have to be absolutely certain vessel removal will work.

9.37 It is unlikely but conceivable that vessel removal would not be possible in a situation where it was otherwise regarded as desirable, and as a result the vessel would remain afloat at its berth or anchorage. In this case options would exist for implementation of other protective measures, particularly evacuation. These measures might need to be implemented over a wider area than Zone 2, but this would only be necessary in the period beginning more than 24 hours after the accident.[32] This period after the accident would permit the arrangements for the wider measures to be made, in the highly unlikely event that they were required.

The Removal Decision

9.38 The Committee obtained advice from the Attorney-General to the effect that Australian authorities have the legal power to order a visiting warship to leave port following a reactor accident.[33] The Commonwealth has delegated to the relevant State or Territory Government the decision-making on whether and when

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32. As noted in para. 9.34, the Zone 2 size is based on 12-hour exposure. But, put simply, the meteorological model used to calculate dispersion assumes something approaching worst-case conditions will only apply during 12 hours in any 24-hour period, due to the change in conditions that occurs normally between day and night times. If the action referred to in the text is required, it will only be after at least this 24-hour period.
33. Letter of Advice from the Attorney General, the Hon Lionel Bowen, to the Committee, 3 April 1987. See also the second supplementary submission from the Department of Defence, p. 11 (Evidence, p. 238.266).

to order removal, and whether to a remote anchorage or to sea.[34]

9.39 OPSMAN 1 states:

> Under certain circumstances it may be advisable for the NPW to remain at the berth or anchorage following a reactor accident. The decision on whether or not to request removal of the vessel would be made after consideration of the relative risks posed to members of the public and to personnel engaged in the removal operation.[35]

9.40 Factors identified by the Department of Defence as relevant to the removal decision include the character and severity of the accident; the amount, type and expected duration of the release of fission products; plume altitude; and meteorological factors.[36] The Department told the Committee that, while a removal decision could possibly be made almost immediately following an accident, 'perhaps more realistically, a decision could be made within a couple of hours'.[37]

9.41 The WA Port Safety Scheme sets out standing procedures to be implemented in the event of an accident. The Committee had difficulty in following these procedures as they related to the decision to remove a vessel from any of the anchorages at Gage Roads off Fremantle. The procedures appear to require that if the accident is notified by the warship's commander, an immediate

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34. OPSMAN 1 (2nd edn.), para. 425 (Evidence, p. 75). See also the second supplementary submission from the Department of Defence, pp. 6 and 11 (Evidence, pp. 238.261 and 268.266). The Western Australian Government is given the power to make removal decisions for vessels at HMAS STIRLING: HMAS STIRLING Sub-Plan, para. 1313(1). No specific plan exists for Jervis Bay, leaving it unclear to the Committee who would make removal decisions in respect of visits there.
35. OPSMAN 1 (2nd edn.), para. 425 (Evidence, p. 75).
36. Second supplementary submission from the Department of Defence, pp. 9-10 (Evidence, pp. 238.264-65).
37. ibid., p. 10 (Evidence, p. 238.265).

removal instruction will be issued.[38] If the accident is detected by early warning monitoring, there appears to be no provision for directing immediate removal. The Committee could see no reason why, if immediate removal is appropriate in one case, it should not be equally appropriate in the other.

9.42 The Committee RECOMMENDS that the wording of the WA Port Safety Scheme be clarified on the question of whether vessel removal procedure differs according to whether the accident is notified by the vessel commander or detected by early warning monitoring.

9.43 A further issue is the fact that the removal decision is to be made (in the one case at least) automatically and immediately. This appears difficult to reconcile with the Department of Defence's view, quoted above from OPSMAN 1, that removal decisions need to be made on a case-by-case basis after considering actual circumstances.

9.44 It may be that there are berths and anchorages whose characteristics are such that a presumption can be made by the decision-maker that immediate and automatic removal would be the appropriate response to any plausible accident scenario. If so,

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38. WA Port Safety Scheme, para. SP B16 occurs immediately under the heading 'Alarm Raised by Nuclear Powered Warship', and provides that the Fremantle Port Authority 'is to immediately direct the nuclear powered warship to an approved remote anchorage or to sea'. The immediately preceeding procedures are under the heading 'Alarm Raised by Monitoring Equipment', and the last of these, SP B15, provides that in the event of a confirmed alarm 'procedures SP B17 to SP B27 will be implemented'. This suggests that SP B16 is not to be implemented, a suggestion reinforced by the heading above SP B16. However, it is possible that this is not what is intended. Under the general heading 'Emergency Procedures', SP B12 provides that following an alarm from the early warning monitoring equipment 'SP B13 to SP B27 will be implemented'. Thus SP B16, the direction to remove, would be implemented on receipt of an alarm as well as on notification by the warship commander. This reading would involve duplication of instructions, as the other elements in SP B16 are also provided for in SP B13. All these procedures relate to vessels with reactors of less than 100 Mw(t) anchored at Gage Roads. The Scheme's provisions for other vessels using Gage Roads are the same in the present context: see SP C13 - SP C17.

there is obvious merit in identifying these and planning accordingly so as to avoid the time required for decision-making following an accident.

9.45 It may also be that the Gage Roads anchorages fit this description. For one of these anchorages, that approved for use by vessels having a reactor power output greater than 100 Mw(t), it is a condition of entry that there be a capability to remove the vessel within two hours of an accident. It may be that, both for this anchorage and for all other Gage Roads anchorages, the automatic and immediate removal decision required by the WA Port Safety Scheme is appropriate, and the position as stated in OPSMAN 1 is at best incomplete. If not, the removal provisions in the WA Port Safety Scheme are inappropriate.

9.46 The Committee RECOMMENDS that the Visiting Ships Panel (Nuclear) develop guidelines to assist decision-makers in determining under what circumstances vessel removal is appropriate. In particular, the guidelines should indicate under what circumstances and at what ports automatic removal following an accident would be appropriate.

Types of Vessels to be Towed

9.47 The condition of entry currently requires towing capability only for vessels not capable of moving under their own power. The Department of Defence takes the view that all multi-reactor warships[39] are capable of moving under their own power, even if one reactor is disabled.[40] Therefore, OPSMAN 1 states

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39. All US nuclear powered surface vessels have two reactors except for the USS Enterprise, which has eight. To avoid cumbersome expression in the discussion in the text, twin-reactor vessels only are discussed. But the points discussed apply equally to the USS Enterprise. All US nuclear powered submarines are powered by single reactors, apart from the USS Triton, which was decommissioned in 1969. All British nuclear powered vessels have only single reactors.
40. Second supplementary submission from the Department of Defence, pp. 7 and 9 (Evidence, pp. 238.262 and 238.264).

that the requirement for a towing capability to be available is limited to single reactor vessels (ie. to submarines).[41]

9.48 This limitation was questioned in submissions on two grounds; that the accident to one reactor might also have disabled the other,[42] and that the delay caused by the need to bring an undamaged reactor up to steaming condition was undesirable.[43]

9.49 The Committee noted that the condition of entry as originally formulated in 1974 did not distinguish between vessels capable of moving under their own power and other vessels.[44] The distinction first formally appeared with the 1981 revision of the conditions of entry.[45]

9.50 The Department of Defence did not indicate to the Committee that it had received any formal assurance from the United States Navy that its multi-reactor vessels would always be able to proceed to sea under their own power in the event of a reactor accident. Rather, the Department's confidence in this regard appeared to be based on the fact that warship designers allow for independent operation of duplicated equipment, such as propulsion plant, in order to cope with battle damage, mechanical

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41. OPSMAN 1 (2nd edn.), para. 422 (Evidence, p. 75). Visiting nuclear powered submarines have auxiliary diesel propulsion, but the Department of Defence considers this may not be powerful enough for vessel removal under adverse tide, wind, etc. conditions, and that towing assistance is therefore a prudent safety measure: second supplementary submission from the Department of Defence, p. 9 (Evidence, p. 238.264). This is a further illustration of the conservatism used in planning for visits.
42. Submissions from Mr R. Addison, p. 9; Mrs L. Van Geloven, p. 4. See also the criticism for the same reason in HR, Hansard, 8 December 1982, p. 3079 (Mr G. Scholes); letter from Senator J. Vallentine to the Committee, 19 August 1988, p. 3.
43. Submission from Mr K. G. Blake, pp. 4-5.
44. Department of Defence, The Environmental Impact of Visits by Nuclear Powered Warships to Australia, (July 1974), para. 143. See also Australia, Environmental Considerations of Visits of Nuclear Powered Warships to Australia, (May 1976), para. 12(e), (Evidence, p. 121).
45. OPSMAN 1 (original edn., 1981), para. 104. See also the conditions of entry as set out in HR, Hansard, 8 December 1982, pp. 3078-79.

breakdowns and accidents.[46]

9.51 While the Committee accepts that independent operation would be a design objective, it lacks information on the extent to which it has been achieved. Clearly it is possible to imagine accident scenarios in which damage occurs to both reactors on a twin-reactor vessel, yet leaves the vessel afloat. The damage to the second reactor may not pose a radiation hazard but may nonetheless leave it unserviceable.

9.52 Logically, the probability of such accidents has to be less than that of an accident which leaves one reactor serviceable. On the information available to the Committee, it is not possible to conclude that such accidents are not credible for planning purposes. In other words, the Committee has insufficient information to conclude that there is no need for any requirement that a towing capability be available.

9.53 A second type of scenario does not involve damage to the second reactor. It focuses on the possibility that the radiation hazard from the accident to the first reactor is such that the crew cannot safely access the reactor controls or machinery spaces needed to move the vessel using the second reactor. The hazard might arise from inhalation of radionuclides, from gamma radiation penetrating through bulkheads and shielding, or both.

9.54 Again the principle of designing for independent operation would suggest that biological shielding around each reactor and ventilation arrangements are adequate to prevent this result. This suggestion is reinforced by the fact that, as merchant ship designs indicate, adequate shielding is technically

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46. Second supplementary submission from the Department of Defence, p. 9 (Evidence, p. 238.264). cf. HR, Hansard, 8 December 1982, p. 3079 (Mr G. Scholes), where criticism was made of the failure of the then Government adequately to explain the reason why it considered that movement by means of the second reactor would always be possible.

feasible within a surface ship's hull.[47]

9.55 The Committee RECOMMENDS that the Department of Defence seek information and assurances from the United States Navy that, with respect to its multi-reactor vessels:

(a) the likelihood of a reactor accident leaving one without propulsion power is not sufficiently credible to require planning; and
(b) the biological shielding and ventilation arrangements are adequate to permit the continued operation of the vessels following the reference accident occurring to one reactor.

If adequate information and assurances are not obtained, the Committee RECOMMENDS that condition (e) of the conditions of entry be amended to require the provision of a towing capability during visits by multi-reactor warships.

9.56 A third scenario relates to the start-up time for the second reactor. During an extended port visit only one reactor on a multi-reactor vessel may be operating. Some delay would occur before a shut-down reactor would be available to provide propulsion power for the vessel. The Committee lacks information on the minimum time necessary to start a naval reactor that has been shut-down for some time, but it may be measured in hours

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47. e.g. US, Department of Commerce, Maritime Administration, Competitive Nuclear Merchant Ship Program - Preliminary Safety Analysis Report, (MA-940-02, April 1974), Tables 15-11 and 15-13. These tables indicate the dose that a person would receive on the bridge, on the main deck, and in the control room following a contained reactor accident on a proposed 312 Mw(t) nuclear powered bulk carrier. The figures are given for thyroid, whole-body, and beta skin doses over 2 hours and over 30 days. All of the doses are well below Australian emergency reference levels. The composition of the source term is the same as that used for ANSTO's reference accident.

rather than minutes.[48]

9.57 Australian authorities plan, however, on the basis that the second reactor is not completely shut down during visits to berths or anchorages where a short removal time is specified. There is, as far as the Committee can discover, no formal arrangement explicitly to this effect. However, condition (e) of the conditions of entry requires that:

> there must be a capability to remove the vessel, either under its own power or under tow, to a designated safe anchorage or a designated distance to sea, within the time frame specified for the particular berth or anchorage, and in any case within 24 hours, if an incident should occur.[49]

9.58 The Australian authorities apparently rely on the fact that the commander of a visiting multi-reactor vessel is made aware of this requirement to be able to leave within the specified time. The commander is also made aware that no towing capability is provided for post-accident departure, and hence the requirement has to be able to be met using the vessel's second reactor alone. The authorities rely on the commander following standard operating procedure in keeping the second reactor on the vessel in a state of readiness sufficient to comply with the requirement.

9.59 The Committee RECOMMENDS that the Department of Defence

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48. N. Polmar and T. B. Allen, Rickover, (Simon and Schuster, New York, 1982), p. 425: 'it takes several hours and considerable electricity to restart a [US naval] reactor after it has been closed down'. Although put in general terms, this statement was made in the context of discussing the time needed to restart the reactor on a single-reactor vessel. It may be that starting a second reactor when one is already operating is a speedier process. One standard text gives as a typical start-up time from complete shutdown for a commercial land-based reactor a time of 13 hours, although this is much reduced if the reactor has only been shut down for a few hours: F. J. Rahn and others, A Guide to Nuclear Power Technology, (Wiley, New York, 1984), p. 498.
49. OPSMAN 1 (2nd edn.), para. 201(e) (Evidence, p. 49). See also ibid., para. 422 (Evidence, p. 75).

confirm that condition of entry (e) is interpreted by the commanders of visiting warships having more than one reactor as requiring that a second reactor be kept in a sufficient state of readiness to be used for post-accident vessel removal. If the Department is unable to confirm this, the Committee RECOMMENDS that condition (e) be reworded to make this state of readiness a condition of entry for multi-reactor warships.

9.60 A further issue relating to towing of multi-reactor vessels was whether one or more tugs might be required to assist in manoeuvring, rather than supplying prime motive power. In 1983 for example, the nuclear powered USS Texas collided with a wharf when leaving Brisbane.[50] Two commercial tugs which would normally have been used were not assisting due to a union ban, although an army tug was present. The damage was not serious enough to prevent the ship's departure.

9.61 Clearly the need for tugs to assist with manoeuvring would vary according to the characteristics of the berth, and to the state of the weather and tide at the time. The Department of Defence told the Committee of the position in relation to the ordinary (ie. not post-accident) movements of visiting nuclear powered warships:

> Australian procedures for tug assistance of NPWs and for NPW escort reflect current practice abroad. In Australia, tug services are requested for all movements of visiting warships. Additionally, visiting NPWs are provided with escort vessels.[51]

9.62 As tug assistance is considered appropriate for all ordinary port movements of nuclear powered warships, it appears to the Committee that provision for similar assistance to be given quickly should be made for post-accident movements. It is

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50. Courier-Mail, 20 July 1983: 'Wharf Bill to Govt'; Sydney Morning Herald, 20 July 1983, p. 2, 'A Brisbane souvenir - deep in the stern of Texas'.
51. Evidence, p. 1300.56 (Department of Defence).

unclear to the Committee, however, if the assistance is essential or merely useful.

9.63 Therefore, the Committee RECOMMENDS that the Department of Defence determine if assistance from one or more tugs would be essential to effect the speedy removal from any approved berth of a multi-reactor vessel with a damaged reactor, and, if so, require as a condition of entry for the visit that the necessary assistance be available during visits to that berth.

Preparing the Vessel for Removal

9.64 A VSP(N) study into aspects of vessel removal following an accident noted:

> The operations involved in removing a NPW include casting off, slipping an anchor or slipping from a buoy, attaching the tow line, towing and securing at a remote location. All of these operations could, if necessary, be undertaken by RAN personnel, however the cooperation of the NPW crew will be necessary to slip the anchor of a vessel being removed from an anchorage.[52]

9.65 The study indicates that the operations required of Royal Australian Navy personnel can all be carried out without exposure of individuals to radiation in excess of recommended levels. The Committee was concerned that the option of vessel removal as a protective measure following an accident depended on actions by that vessel's crew in the case of an anchored vessel. This occurs because the vessel's winch must be used to raise the anchor, or the anchor cable parted inboard of the slip securing the cable to the vessel in order to release the anchor.

9.66 The concern was not that the warship crew will dispute

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52. Department of Defence, VSP(N), Report on the Protection of Personnel Engaged in the Removal of Nuclear Powered Vessels Following a Reactor Accident, (18 May 1984), para. 6.

the necessity for vessel removal. Rather it was that the action of slipping the anchor might involve a severe radiation hazard to the vessel's crew involved. On investigation, the Committee found that this was not a valid concern.

9.67 It appears reasonable to assume that, if a multi-reactor vessel is expected to be able to depart following an accident by using its undamaged reactor, its crew could also raise (or, if necessary, cast loose) its anchor. Even if the expectation relating to vessel removal is incorrect (on which see the discussion in the previous section), the size of multi-reactor vessels (ie. surface ships) means that approaching the anchor release slip from on board would not be exceptionally hazardous.

9.68 For both surface ships and submarines, the length and bulk of the vessel would provide shielding for a person on the bow from the direct gamma radiation dose,[53] even in the unlikely event that reactor shielding was inadequate to protect persons closer to the reactor. The risk from inhalation also needs to be considered. The distance of the anchor release point from the reactor would, however, also allow time for crew members to release or raise an anchor without exceeding recommended levels of radiation exposure, even in the unlikely event that they

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53. On submarines, the anchor slip point is outside the pressure hull, which would provide further shielding.

lacked respiratory protective equipment.[54]

9.69 Moreover, the Committee understands that the Australian authorities have required and been given assurances by the United States Navy that its crew members will always release or raise the warship's anchor if vessel removal is required.[55]

Time Allowed for Removal - 'Standard' Berths

9.70 Once a decision to remove a vessel has been made, time will be needed to accomplish the removal. One of the conditions of entry to Australian ports by visiting nuclear powered warships is that:

> there must be a capability to remove the vessel ... within the time frame specified for the particular berth or anchorage, and in any case within 24 hours, if an incident should

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54. Department of Defence, VSP(N), Report on the Protection of Personnel Engaged in the Removal of Nuclear Powered Vessels Following a Reactor Accident, (18 May 1984), Annex A, para. 10:

> calculations indicate that, at a distance of 50 m down-wind from the reactor compartment, ie. at the bow or the stern, a thyroid dose of 3 Sv would be accumulated by an unprotected person in seven minutes due to the inhalation of radioactive iodine, and in 28 minutes at a distance of 100 m. (Note: 3 Sv is the emergency reference level for thyroid dose requiring urgent evacuation of adult members of the public.) The corresponding whole body dose rates from gamma radiation due to direct exposure have been calculated to be 0.04 Sv/h at 50 m and 0.012 Sv/h at 100 m [emergency reference level for whole body dose = 0.1 Sv].

Some of the figures tend to overstate exposure as they are based on an assumption that the exposed individuals will be down-wind of the reactor. In typical circumstances, a vessel at anchor will swing down-wind from its anchor. Crew members releasing the anchor will be up-wind of the reactor. In light winds, strong currents, tides, etc. it is possible that the wind direction will not determine the ships's position relative to its anchor. If such a situation were to occur, the VSP(N) figures would be more realistic, as they would be if there was no wind at all.

55. Information supplied at briefings to Committee members by RAN officers at HMAS STIRLING, 2 February 1988; Tasmanian officials, 21 March 1988.

occur.[56]

9.71 The effect of allowing up to 24 hours for removal at 'standard' berths and anchorages gave rise to concern that arrangements for towing might be such that removal would not be able to be achieved for almost 24 hours after the accident.[57] Members of the Committee found the condition, and its paraphrase in OPSMAN 1, unclear in this regard.[58] In practice, the Committee was assured, the removal capacity would be available in a lot less than 24 hours in those places where no time less than 24 hours had been specified.[59]

9.72 The Committee noted that the original (ie. 1974) environmental assessment relating to visits stated as one of the general conditions of entry: 'tugs or other suitable towing craft must be available within one hour of a request'.[60] This condition of entry did not appear in the amended conditions of entry published in 1981.[61] The Committee was not told why the condition of entry had been deleted.

9.73 The Committee considered three options relating to the time allowed for the provision of a towing capability at 'standard' berths:

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56. OPSMAN 1 (2nd edn.), para. 201(e) (Evidence, p. 49). See also ibid., para. 422 (Evidence, p. 75). The time refers to the time by which the vessel must be moved to a point where its contribution to the radiation dose received by a person at the original accident site becomes insignificant. In other words, a period is added to the time when towing commences in order to cater for the radiation caused at the original site by the vessel after it has begun to move away.
57. e.g. see the submission from Mr R. Bolt, p. 5 (Evidence, p. 955); letter from Mr M. Lynch, 23 March 1988, p. 2 (Evidence, p. 915).
58. Evidence, pp. 1297-99. For the paraphrase, see OPSMAN 1 (2nd edn.), para. 422 (Evidence, p. 75).
59. Evidence, pp. 1297-1300 (Department of Defence); p. 443.452 (ANSTO).
60. Department of Defence, The Environmental Impact of Visits by Nuclear Powered Warships to Australia, (July 1974), para. 143. See also Australia, Environmental Considerations of Visits of Nuclear Powered Warships to Australia, (May 1976), para. 12(f), (Evidence, p. 121).
61. OPSMAN 1 (original edn., 1981), para. 104. See also the conditions of entry as set out in HR, Hansard, 8 December 1982, pp. 3078-79.

- retention of the current wording of condition (e) as it relates to the timing of vessel removal and with the meaning as explained to the Committee by the Department of Defence;
- a recommendation that the condition be reworded to put beyond doubt that towing facilities are required to be made available as soon as possible after an accident, rather than merely within the 24 hours specified for vessel removal for berth assessment purposes; and
- a recommendation that the requirement that a towing capability be available within one hour of a request be reinstated as a condition of entry.

9.74 The reinstatement of such an entry condition would do no more than require what the Committee was told was the existing practice. On the other hand, reinstatement would formally require an extra margin of safety that is not now apparently regarded as necessary by the Department of Defence and ANSTO. Even with a 24-hour period specified, the other elements of the plans are designed to provide adequate safety.

9.75 The Committee RECOMMENDS that condition (e) of the conditions of entry be reworded to put beyond doubt that towing facilities are required to be made available as soon as possible after an accident, rather than merely within the maximum time of 24 hours specified for vessel removal for berth assessment purposes.

Time Allowed for Removal - 'Non-Standard' Berths

9.76 In chapter 8 it was noted that variations from what the Committee called 'standard' parameter values for calculating the consequences of the reference accident applied in respect two places. These were the berth and anchorage at Hobart, and an anchorage at Gage Roads off Fremantle. The 24-hour period allowed for vessel removal was reduced to three and a half hours for the former and two hours for the latter. The Committee concluded that the variations were only acceptable if an assurance could be given that these removal times could be met.[62] The need for this assurance in relation to the berth at Hobart is particularly acute due to the relatively large population in the Zone 2 for the berth.[63]

9.77 The Hobart berth may be used by either single or multi-reactor vessels. Members of the Committee were told at a briefing and inspection in Hobart that the three and a half hours allowed for vessel removal could be met without difficulty: the maximum time to have a towing vessel available would be 45 minutes.[64] The Hobart Safety Scheme provides that, for single-reactor vessels, 'a tug or towing vessel will be on standby for the duration of the visit'.[65] A similar arrangement was made for the only visit to date of a multi-reactor vessel to the berth, although neither the scheme nor the conditions of entry formally require this.[66]

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62. See para. 8.48.
63. See ANSTO's Addendum 1 (18 April 1985) to the original (September 1973) assessment for the berth, p. 2:

> Data presented in the 1973 assessment shows that the residential and transient populations close to Macquarie Wharf are larger than for any currently approved NPW berth in Australia. ... A major factor in the acceptance of NPW berths is the feasibility of implementing countermeasures within the necessary timescale following an accident. For the Macquarie Wharf [berth] the contingency response requirements remain [after taking into account the effect of the reduction in time allowed for vessel removal] more demanding than for any other approved Australian NPW berth and it is recommended that Tasmanian authorities are consulted regarding the feasibility of these requirements, as identified in this assessment, prior to VSP(N) consideration of approval.

The Addendum recommends that approval for the berth 'should only be granted if firm assurances can be obtained' that vessel removal can be achieved within the allowed time, and evacuation of Zone 1 within 1 hour and Zone 2 within 4 hours can be accomplished.
64. Information supplied at briefing to Committee members by Tasmanian and RAN officials, 21 March 1988.
65. Para. 320.
66. Information supplied at briefing to Committee members by Tasmanian and RAN officials, 21 March 1988.

9.78 The Committee considers acceptable the reduction to a maximum of three and a half hours in the time allowed for vessel removal from the Hobart berth and anchorage.[67]

9.79 The reduction in the removal time limit for the Gage Roads anchorage applies only when it is used by vessels having reactors with a power output greater than 100 Mw(t). These vessels, Nimitz-class aircraft carriers, all have two reactors. Therefore the planners expect them to be able to be removed following an accident by means of the undamaged reactor.

9.80 The Committee made recommendations above in relation to the removal of multi-reactor vessels.[68] Subject to implementation of these recommendations, the Committee considers acceptable the reduction to two hours in the time allowed for vessel removal from the Gage Roads anchorage when it is used by vessels having reactors with a power output greater than 100 Mw(t).

Availability of Towing Vessel

9.81 OPSMAN 1 provides:

> The RAN has the responsibility to make arrangements for the provision of towing facilities for NPWs. These may be civil or RAN vessels, manned by civilian or Naval personnel. The RAN, with ANSTO assistance, has the responsibility for developing and maintaining specific training and procedures for personnel engaged in NPW towing operations. The RAN will also provide appropriate equipment which is in the Department of Defence inventory.[69]

9.82 In one submission it was suggested that the removal responsibility should rest with the country to which the vessel

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67. See para. 9.120, however, where the Committee recommends for other reasons that the approval for the berth be withdrawn.
68. See paras. 9.55, 9.59 and 9.63.
69. See OPSMAN 1 (2nd edn.) para. 424 (Evidence, p. 75).

belonged.[70] Members of the Committee were told by Western Australian officials that the escort vessels which normally accompany a nuclear powered aircraft carrier during visits could be used to tow the carrier if it was disabled.[71] However, the United States Navy does not name a specific ship as a towing vessel during a visit.[72]

9.83 In any event, there have been many single-vessel visits. It would, in the Committee's opinion, add to the complications of planning if the foreign country was required to arrange for local towing services to be available in such cases. Australian authorities are better placed to arrange any towing service required, including as it does the need to train and equip the personnel involved and integrate their actions into the overall response. In addition, it is regarded internationally as normal for the host country to provide towing services for visiting warships.

9.84 A number of submissions questioned whether a towing vessel's crew would agree to tow the stricken vessel on the day.[73] In the Committee's view, generalised assertions that emergency personnel would not carry out their role in an emergency are difficult to sustain.[74] Moreover, the authors of the submissions appear to be overestimating the risk to the crew

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70. Submission from Scientists Against Nuclear Arms (WA) and Medical Association for the Prevention of War (WA), p. 13 (Evidence, p. 799).
71. Information supplied at a briefing to Committee members by WA State Emergency Service officials at Fremantle, 1 February 1988.
72. Information supplied at briefing to Committee members by RAN officers at HMAS STIRLING, 2 February 1988.
73. e.g. submissions from Scientist Against Nuclear Arms (WA) and Medical Association for the Prevention of War (WA), p. 13 (Evidence, p. 799); Assoc Prof P. Jennings, p. 3; Senator J. Vallentine, p. 14 (Evidence, p. 1057).
74. See for example I. G. C. Gilmore, 'Education for Action - The Official Sector' in J. Oliver (ed.), Response to Disaster, (Centre for Disaster Studies, James Cook University, Townsville, Qld., 1980), p. 83:

    Individuals and organizations which are charged with, or accept the responsibility for, action on the community's behalf in emergencies and disasters usually show remarkable capacity to cope with the demands of crisis situations.

    Several examples are given from Australian disaster responses.

of a towing vessel.

9.85 ANSTO assessed the radiation doses to tug crews and concluded that the vessel removal could be undertaken without individual doses exceeding the appropriate emergency reference level.[75] The Department of Defence told the Committee:

> On each occasion a vessel is assigned for possible towing operations, an officer from the ANSTO briefs the crew on nuclear related precautions. In addition, tug crews are briefed on the method to be used when towing the particular NPW involved.[76]

9.86 The 1986 edition of OPSMAN 1 provided: 'a member of the Radiation Monitoring Group will be onboard the towing vessel to monitor radiation and advise the master'.[77] An amendment made in

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75. Evidence, p. 443.452 (ANSTO). See OPSMAN 1 (2nd edn.), Chapter 4, Annexes E and G (Evidence, pp. 101 and 104-07) for precautions to be taken and special clothing to be worn by tug crews. See also ANSTO, Radiation Monitoring Handbook for Visits by Nuclear Powered Warships to Australian Ports, (ANSTO, Lucas Heights, NSW, 1985), p. 20 (Evidence, p. 314): isodose contour chart is given for gamma radiation dose rates, showing that the gamma radiation hazard is negligible for those approaching from within a 30 degree angle of the bow or stern of the stricken vessel. See also Department of Defence, VSP(N), Report on the Protection of Personnel Engaged in the Removal of Nuclear Powered Vessels Following a Reactor Accident, (18 May 1984), Annex A, paras. 6-9 for calculations of the doses that would be received by the crew of a towing vessel. The total radiation dose received is estimated at about 0.11 Sieverts, which compares with an emergency reference level for whole body dose of 0.10 Sv. The total of 0.11 Sv is made up of doses received during casting off the warship's moorings and attaching a towing line (0.03 Sv), manoeuvring it clear and towing it away (0.05 Sv), and securing the warship following the removal (0.03 Sv). It is noted that the first of these three operations could be undertaken by a shore party, in which case any exposure received would not accrue to the towing vessel crew. Also options exist both to change the entire crew of the towing vessel and to rotate the functions of individuals, should the original crew or an individual receive exposures approaching the emergency reference levels during the course of vessel removal.
76. Second supplementary submission from the Department of Defence, p. 8 (Evidence, p. 238.263). See also Department of Defence, Visits by Nuclear Powered Warships to Australian Ports: Report on Radiation Monitoring during 1987, (DoD, Canberra, 1988), Part II, para. 7: talks on radiation safety given by ANSTO to crew members of RAN tugs which are designated for post-accident NPW removal duties.
77. OPSMAN 1 (Revised edn.), para. 429 (Evidence, p. 77).

1988 removed this statement.[78] The Committee was told that the reason for the deletion was that it had been decided that the presence of a person having the degree of expertise required to be a member of the radiation monitoring group was not necessary. Performance of the monitoring task requires only a relatively low level of training. Arrangements have been made for a member of the towing vessel crew or some other person to receive sufficient training to carry out the necessary monitoring.

9.87 The Committee does not consider inappropriate the substitution of a less expert person. It considers, however, that OPSMAN 1 should reflect the substituted requirement, rather than make no provision on the point. Accordingly, the Committee RECOMMENDS that it be a requirement that a person sufficiently trained to conduct radiation monitoring be on board a vessel designated for emergency towing following a reactor accident.

9.88 The Department of Defence told the Committee that Hobart is the only port currently receiving visits 'where Naval towing resources are not necessarily programmed to coincide with a NPW visit'.[79] Undertakings have been given by civilian tug operators in Hobart to provide tugs in an emergency.[80]

9.89 The Committee concludes that the current plans relating to the arrangements to provide emergency towing services in the unlikely event that they should be required are adequate. The Committee notes the announcement by the Government on 18 October 1988 that it proposed to purchase further tugs for the Royal

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78. OPSMAN 1 (2nd edn.), para. 429.

79. Second supplementary submission from the Department of Defence, p. 8 (Evidence, p. 238.263). For, example, the Committee was told that the Navy would provide a towing vessel at Albany should a visit be made there: information supplied at briefing to Committee members by WA officials, 1 February 1988. Contrast P. Gilding, 'The Darwin Plan', SANA Update (Scientists Against Nuclear Arms Australia Newsletter), September 1988, No. 65, p. 5, where it is incorrectly assumed that civilian tugs and crews would be responsible for vessel removal in Darwin.

80. Second supplementary submission from the Department of Defence, p. 8 (Evidence, p. 238.263).

Australian Navy.[81] The purchase of these tugs will improve an already satisfactory situation with respect to vessel removal arrangements for nuclear powered warships.

Action Following Removal

9.90 Criticism was made of the fact that Australian plans make no detailed provision for what is to happen to the vessel once it has been removed to a remote anchorage or to sea.[82]

9.91 Calculations of radiation dose levels from a vessel at a remote anchorage have been made on the assumption that the vessel will remain there until the tenth day following the accident.[83] Removal to an even more remote anchorage or to sea is considered by planners as a further option.[84] The United States and the United Kingdom have undertaken the responsibility to salvage or otherwise make safe any of their nuclear powered warships which might be incapacitated in a foreign port.[85]

9.92 The Committee does not regard it as either necessary or practical for plans to detail the long-term disposal arrangements for a stricken vessel. There would be adequate time after an accident to make these arrangements, which would be dependent on the characteristics of the particular vessel, accident, and location.

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81. Senate, Hansard, 18 October 1988, p. 1519.
82. Letter from Mr M. Lynch, 23 March 1988, p. 2 (Evidence, p. 915).
83. Evidence, p. 443.467 (ANSTO). See also the Appendix to ANSTO, 'Visits by Nuclear Powered Warships: Radiological Consequences of Releases from Remote Anchorages', (August 1987) which includes calculations for the period from 11 to 20 days after the accident.
84. Evidence, p. 443.467 (ANSTO).
85. US 'Standard Statement', para. 2(d) (Evidence, p. 1079). For the equivalent United Kingdom statement, see Evidence, p. 1300.16.

EVACUATION

Introduction

9.93 The Department of Defence view is that in Zone 1 protective measures such as evacuation should be taken immediately and automatically on receipt of a confirmed alarm.[86] Evacuation from Zone 2 is an option available to be exercised should the inhalation hazard spread beyond Zone 1. Because the outer limit of Zone 2 represents the maximum scope of the inhalation hazard, no evacuation measures would be required beyond this in the first 24 hours following an accident, according to the planners.

9.94 The adequacy of evacuation arrangements has to be assessed with regard to the characteristics of specific berths and anchorages. As a general point, the Committee noted that traditional open days, where the general public are allowed on board, are not permitted for visiting nuclear powered warships.[87] Hence the need to evacuate large numbers of visitors will not arise.

9.95 A general criticism sometimes made of emergency planning is that it presumes the public will respond rationally and will follow orders, directions and advice.[88] The Committee is prepared to assume that Australian planners have had sufficient experience with human behaviour in emergencies to have made realistic

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86. Submission from the Department of Defence, p. 5 (Evidence, p. 10). See also Evidence, p. 1300.49 (Department of Defence).
87. OPSMAN 1 (2nd edn.), paras. 311-12 (Evidence, p. 63). Visits by individually identified and escorted groups are permitted: ibid.
88. e.g. see S. L. Cutter, 'Emergency Preparedness and Planning for Nuclear Power Plant Accidents', Applied Geography, 1984, vol. 4, p. 239.

allowance for its variability.[89] No evidence was put to the Committee to suggest otherwise.[90]

9.96 However, a sub-set of this general criticism relates specifically to nuclear reactor accident responses. It is based on the response to the 1979 nuclear reactor accident at Three Mile Island. The experience in the United States has been that people directed to evacuate from non-nuclear emergencies have often failed to do so.[91] Following the Three Mile Island accident, advice to evacuate was given only in relation to pregnant women and preschool children within a 5-mile (8-km) radius of the accident site. Nonetheless, a large number of

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89. cf. Evidence, p. 1300.47 (Department of Defence):

> Police and emergency services should take these matters into account in their procedures. It is not the function of port safety plans to lay down procedures for the Services. Each Service has its own procedures for responding to these kinds of contingencies.

90. A number of submissions assumed mass panic might occur in a number of accident scenarios, some relating to nuclear weapons rather than reactors: see the submissions from Balmain People for Nuclear Disarmament, p. 7; Mrs L. Van Geloven, p. 5; Movement Against Uranium Mining, p. 2; Medical Association for the Prevention of War (NSW), p. 3; Mr K. G. Blake, p. 3; Miss E. Ruzicka, p. 2; People for Nuclear Disarmament, pp. 5-6 (Evidence, pp. 1307-08). No evidence was provided to support the assumption. Contrast J. Oliver, 'An Overview and Commentary on the Workshop, Human Behaviour in Disaster' in Department of Defence, Natural Disasters Organisation, Report of Proceedings of a Research Workshop on Human Behaviour in Disaster in Australia, 25-27 April 1984, (Australian Counter Disaster College, Mt Macedon, Vic., 1985), p. 10:

> The general community, and indeed many counter-disaster personnel, hold popular beliefs, which researchers consider at variance with the truth such as panic, looting, anti-social behaviour, inability to think or plan after disaster. (citation omitted)

See also R. R. Dynes, 'The Accident at Three Mile Island: The Contribution of the Social Sciences to the Evaluation of Emergency Preparedness and Response' in D. L. Sills and others (eds.), Accident at Three Mile Island: The Human Dimensions, (Westview, Boulder, Col., 1982), p. 126: there was fear of mass panic as the accident developed but:

> those images of panic, which were widely perceived, contrasted with the available social science literature and with what actually happened as a result of the TMI accident.

91. In D. J. Zeigler and J. H. Johnson, 'Evacuation Decision-Making at Three Mile Island' in A. Blowers and D. Pepper (eds.), Nuclear Power in Crisis: Politics and Planning for the Nuclear State, (Nichols, New York, 1987), p. 275 figures of 10 to 50 per cent are given as the typical under-response to evacuation warnings.

others, both within this area and outside it, evacuated.[92]

9.97 From this experience some researchers have argued that planning for a nuclear emergency should be different from that for a non-nuclear emergency.[93] Those evacuating without direction to do so may block evacuation routes on which the planned evacuation depends. Planned evacuation times may be rendered unrealistic. Other arrangements for evacuation and the reception of evacuees may be unable to cope with the unexpected numbers.

9.98 Even in its United States context,[94] the argument that responses will differ in nuclear and non-nuclear emergencies rests essentially on a single example. The literature suggests that the evacuation response to the Three Mile Island accident may well be explicable by factors specific to that accident. In particular, it seems that the fact that various officials were expressing conflicting views on the seriousness of the accident suggested to many that it would be prudent to assume the worst

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92. ibid., p. 274 states that 50 times as many evacuated as were advised to evacuate. See also D. J. Zeigler and J. H. Johnson, 'Evacuation Behavior in Response to Nuclear Power Plant Accidents', Professional Geographer, May 1984, vol. 36(2), p. 208, where numbers somewhat smaller than 50 times are suggested. A survey reported in the latter paper and based on evacuation intentions of those living near a reactor in New York State suggests that their evacuation behaviour would be similar to that which actually occurred after Three Mile Island: ibid., p. 213.

93. D. J. Zeigler and J. H. Johnson, 'Evacuation Decision-Making at Three Mile Island' in A. Blowers and D. Pepper (eds.), Nuclear Power in Crisis: Politics and Planning for the Nuclear State, (Nichols, New York, 1987), p. 275. The reasons given (ibid.) for the different response to nuclear accidents are:

> because people perceive the radiation hazard differently, because they cannot see or sense the hazard agent itself, because they fear the carcinogenic and transgenerational consequences of radiation exposure, and because they have no way of evaluating the veracity of official information. (citation omitted)

94. In the Australian context, the Department of Defence told the Committee that there is no evidence to suggest a greater over-reaction to a nuclear emergency than to a non-nuclear emergency: Evidence, p. 1300.46. But the value of its view is limited because the Department said it was unaware of the US literature on the over-reaction to the Three Mile Island accident: ibid.

and to evacuate.[95]

9.99 Evacuation planning in the United States and the United Kingdom has not been altered to reflect the particular response which occurred after the Three Mile Island accident.[96] Moreover, the unforeseen response which occurred after the Three Mile Island accident did not cause major problems.

9.100 The only Australian ports currently visited where significant evacuation of the general public might be directed in the 24 hours following the reference accident are Darwin and Hobart. There seems to the Committee no reason why unexpected evacuation in either of these places, if it occurs, should seriously hinder the evacuation of those directed to evacuate. The possibility of unexpected evacuation occurring, however, does emphasis the need for the safety plans for Darwin and Hobart to be publicly available.

9.101 The Committee does not consider that the argument on unforeseen evacuation applies so as to invalidate current planning for naval reactor accidents in Australian ports.

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95. C. B. Flynn, 'Reactions of Local Residents to the Accident at Three Mile Island' in D. L. Sills and others (eds.), Accident at Three Mile Island: The Human Dimensions, (Westview, Boulder, Col., 1982), pp. 52-54; S. L. Cutter, 'Emergency Preparedness and Planning for Nuclear Power Plant Accidents', Applied Geography, 1984, vol. 4, pp. 239-40; M. K. Lindell and V. E. Barnes, 'Protective Response to Technological Emergency: Risk Perception and Behavioral Intention', Nuclear Safety, October-December 1986, vol. 27(4), p. 457. However, this last paper notes (p. 466) there is:

> a growing literature that suggests that the overresponse at TMI resulted as much from prior public perceptions of the risks of a nuclear power-plant accident as it did from the confusing and conflicting information disseminated during the TMI-2 crisis.

The authors of this paper conclude (p. 466) that additional research is needed to improve understanding of evacuation behaviour.

96. D. J. Zeigler and J. H. Johnson, 'Evacuation Decision-Making at Three Mile Island' in A. Blowers and D. Pepper (eds.), Nuclear Power in Crisis: Politics and Planning for the Nuclear State, (Nichols, New York, 1987), p. 275.

Western Australia

9.102 For approved anchorages at Gage Roads off Fremantle, the area taken in by their respective Zone 2's is almost entirely water. The evacuation plan caters for any people who may be on the end of the North and South Moles and for clearance of small craft from the area.[97]

9.103 At HMAS STIRLING, the Zone 1 for two berths includes part of the base. For none of the berths or anchorages does the Zone 2 include civilian residential areas. Evacuation requirements extend only to the base and craft in adjacent waters. Plans cater for this in a thorough way.[98]

9.104 Members of the Committee examined the arrangements for both Gage Roads and HMAS STIRLING during a visit to Western Australia and considered them satisfactory.

Brisbane

9.105 All the approved berths are at Fisherman Islands, near the mouth of the Brisbane River. The Zone 2's for the berths furthest upstream include part of the small suburb of Myrtletown on the opposite bank of the river, but these berths have never been used. The three visits to date have all been to berths at the Container Terminal. These are well away from residential areas, so evacuation plans have to cater for only port workers, those on ships at the port, and any recreational users of the surrounding area.

9.106 The Port of Brisbane Safety Plan notes that Zone 1 will be evacuated immediately on confirmation of an accident, that the State Radiation Officer is responsible for provision of advice on

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97. WA Port Safety Scheme, para. 604.
98. HMAS STIRLING Sub-Plan, p. 13-11; WA Port Safety Scheme, para. 605.

the necessity for and scope of evacuation, and that the Queensland police will assist with evacuation as required.[99] But the Plan makes no detailed provision for evacuation. For example, there is no provision for establishment of a decontamination control zone, exit from which would be monitored so as to avoid spreading contamination.[100] Nor is provision made for how port workers or those on other ships in the port would be notified of the need to evacuate.[101]

9.107 In the report of the Australian Ionising Radiation Advisory Council (AIRAC) on its 1985 on-site review of the Brisbane arrangements it was recommended that the Plan make provision for evacuation.[102] AIRAC was assured that nuclear powered warships would not be allowed to berth if passenger liners were expected to be at adjacent berths, although there was no formal requirement to this effect. AIRAC recommended that:

> because of the difficulty of rapid evacuation of persons from a liner in an emergency, this requirement be explicitly stated in the Safety Plan for the Port of Brisbane.[103]

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99. Paras. 109, 329(h), 330(d).
100. cf. ANSTO, Report of the Committee of Inquiry into a Fire which Occurred on 18 March 1987 in a Radioisotope Processing Cell, Building 54 at the Lucas Heights Research Laboratories, (ANSTO, Lucas Heights, NSW, 1987), p. 3: one fire crew left the scene without first having been monitored, and it was necessary for an ANSTO officer equipped with a portable radiation monitor to go to the fire station to carry out monitoring of the crew and their equipment. No contamination was detected.
101. Contrast UK, Ministry of Defence, Liverpool Special Safety Scheme for Visits to Liverpool by Nuclear Powered Submarines, (April 1986), para. 57(b): Terminal Manager responsible for sounding all fire alarms in the area, and arranging orders by word of mouth and radio for evacuation of all personnel; para. 58(a): police to tour area making loudhailer announcements to reinforce steps taken by Terminal Manager; para. 58(f): police to notify masters of ships within 550 metres of the accident site; standard-form instructions (as set out in Annex 3E) to be delivered to masters; prior arrangements for foreign vessels made with the ships' agents, to obviate any language difficulties at the time of accident notification.
102. AIRAC, 'Review of Safety and Monitoring Arrangements for Visits by Nuclear Powered Warships', p. 7 (Evidence, p. 758).
103. ibid, p. 6 (Evidence, p. 757). Visiting passenger vessels berth at the Container Terminal.

9.108 The Visiting Ships Panel (Nuclear) agreed with both these recommendations and referred them to the Queensland authorities.[104] The Plan has not yet been modified in regard to either of them. No visits to Brisbane, however, have taken place since 1985.

9.109 The Committee RECOMMENDS that no visits to berths at Fisherman Islands, Brisbane be approved until adequate, documented, provisions are made: either for the evacuation of port workers, persons on ships in the vicinity, and tourists and other recreational land users likely to be within the inhalation hazard zone (Zone 2); or for avoiding the presence of such persons during a visit by a nuclear powered warship. Additionally, the Committee RECOMMENDS that the approved berths up-stream (ie. closer to Brisbane) of the ones currently used at the Container Terminal not be used until adequate, documented, provisions are made for the evacuation of residents from within the Zone 2's for the berths.

Darwin

9.110 Darwin has two approved primary anchorages and two approved berths. The Zone 2 for the more southerly anchorage takes in no residential areas and almost no land area at all. The Zone 2 for the other anchorage extends into part of the central business and residential area of the city. The Zone 2's for the two berths extend even further into this area. The business district lies just beyond Zone 1 for both berths.

9.111 The Darwin Port Safety Plan makes no provision for evacuation beyond noting that it is an available countermeasure

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104. AIRAC, 'Follow-up Actions on Report of Visits to Hobart/Darwin/Brisbane', pp. 7, 9 (Evidence, pp. 767, 769). In contrast, when the Committee asked the Department of Defence why Australian port safety plans made no detailed provision for dealing with crews aboard vessels berhted adjacent to a visiting NPW, the response indicated no dissatisfaction with existing arrangements: Evidence, p. 1300.45.

and making the police responsible for such evacuation as may be directed by the Counter Disaster Controller.[105] In its submission the Northern Territory Government told the Committee that the police prepare evacuation plans for each nuclear powered warship visit.[106]

9.112 For Zone 1, the Port Safety Plan provides for implementation of countermeasures following notification of an accident,[107] but not specifically for evacuation. This does not conform to the view of the Department of Defence that Zone 1 evacuation should be an immediate and automatic accident response.

9.113 The Committee takes the view that the Plan should contain detailed provision for immediate evacuation from Zone 1 and for possible evacuation from Zone 2. Accordingly the Committee RECOMMENDS that no visits be permitted to the northern approved anchorage or to either of the approved berths at Darwin until detailed provision is made in the Darwin Port Safety Plan for evacuation of the relevant Zones 1 and 2.

Hobart

9.114 At Hobart, one primary anchorage and one berth have been approved. As explained in Chapter 8, the Zone 2 for both the

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105. Paras. 509 and 717. cf. P. Gilding, 'The Darwin Plan', SANA Update (Scientists Against Nuclear Arms Australia Newsletter), September 1988, No. 65, p. 5, where the lack of adequate evacuation plans is criticised as 'a particularly serious omission', given the proximity of the central business district to the approved berths.

106. Submission from the Northern Territory Government, p. 2. Because the Committee has not seen these plans, it is not aware of the extent to which they cater for passengers and crews of vessels that may be berthed adjacent to the visiting warship. cf. letter from the Chairman of the VSP(N) to the Darwin Harbourmaster, 14 July 1981, referring to the intention to use Stokes Hill Wharf, Darwin for visits by nuclear powered warships:

> We note that it is intended to use the same berth for passenger vessels and the AAEC [now ANSTO] has recommended, as a condition of approval, that passenger vessels and NPWs do not visit concurrently.

107. Para. 513(a).

berth and the anchorage have been reduced to 1.2 kilometres, due to the effect of the shorter vessel removal times adopted.[108] No land lies within Zone 1 for the anchorage. Some residential areas on the eastern side of the Derwent lie within its Zone 2. There is only one residence, that of a caretaker, within the Zone 1 for the berth, which is at Macquarie Wharves.[109] Zone 2 for the berth includes part of the central business district and some residential areas to the west.

9.115 The Hobart Safety Scheme includes a free-standing sub-plan entitled 'Plan for the Limited Evacuation of Hobart'. This sets out detailed provisions covering all aspects of evacuation, including matters such as notification of the need to evacuate, traffic control measures, provision of transport, the registration of evacuees, security of evacuated premises, welfare measures for evacuees, and a series of measures relating to the re-occupation of evacuated areas. Based on its 1984 on-site review, AIRAC made the general comment that 'no problems were identified in the ability of the [State emergency] organisation to respond to an NPW emergency'.[110]

9.116 During their visit to Hobart in March 1988, members of the Committee were told by local officials that an estimated 22,000 people work in the central business district. These people could be evacuated within 20 minutes using usual transport means,

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108. See paras. 8.45 and 8.50.
109. Hobart Safety Scheme, Chapter 8, Annex A, para. 1(l). The berth approval does not specify any particular berth at the Wharves, although they extend in an 'L' shape for over 1 km. Distances cited in the text have been measured from No. 4 berth, which was used for the visit of the USS Long Beach in 1987. The Hobart Safety Scheme describes the berth to be used as 'Macquarie No. 4/5 Wharf': Chapter 8, Annex A, para. 1(a).
110. AIRAC, 'Review of Safety and Monitoring Arrangements for Visits by Nuclear Powered Warships', p. 2 (Evidence, p. 753).

such as buses and private cars.[111] An agreement has been reached with the relevant union that buses will continue to operate during an emergency.

9.117 The Committee noted that the nearest part of Royal Hobart Hospital is about 900 metres from the approved berth. In its on-site investigation in December 1984, AIRAC noted the presence of the Hospital. It commented: 'the local topography is such that valley winds under inversion conditions should ensure minimum risk to the hospital sector'.[112]

9.118 The Committee noted that a supplement to the Hobart Safety Scheme describes the response measures that would be taken to protect those in the hospital following a reactor accident. The Committee had some doubts as to the adequacy of these measures. For example, the scheme and the supplement suggest that there is no arrangement to fully evacuate the hospital.[113]

9.119 The Committee considers, however, that irrespective of the merits of the particular plan, it is undesirable to have a major public hospital within the Zone 2 for any berth or anchorage. Evacuation could be the most appropriate accident response in this Zone, notwithstanding that other measures such as

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111. cf. ANSTO's Addendum 1 (18 April 1985) to the Hobart berth assessment (September 1973), pp. 2-3: approval for use of the berth at Macquarie Wharf 'should only be granted if firm assurances can be obtained to the effect that', amongst other things, organisation and plans are in place 'such that people at the Zone 1 boundary can be moved within 1 hour and at the Zone 2 boundary within 4 hours'. The times derive from the period needed under 'worst-case' meteorological conditions to exceed the emergency reference level for the limiting radiation dose, which is the individual dose to the child thyroid (150 rem). See also the Hobart Safety Scheme, para. 1415, which notes that under less disadvantageous meteorological conditions the limiting times would be about 12 hours for Zone 1, and 2 days for Zone 2.

112. AIRAC, 'Review of Safety and Monitoring Arrangements for Visits by Nuclear Powered Warships', p. 1 (Evidence, p. 752).

113. Hobart Safety Scheme, para. 1413 states that the hospital 'may be exempted from the evacuation' of Zone 2. The supplement indicates that measures will be taken to decrease the number of people who might otherwise be in the hospital (p. 1), and limited evacuation will be considered (p. 7).

sheltering may also be effective. There is no shortage of berths and anchorages in Australia either approved or meeting approval criteria. The Committee considers there is no justification for incurring the extra risk, small though it may be, in allowing visits to any berth or anchorage where a major hospital lies within Zone 2.

9.120 The Committee RECOMMENDS that the berth approval for Macquarie Wharves, Hobart be rescinded. Further, the Committee RECOMMENDS that no approval be given to any berth or anchorage where a major hospital lies within the zone in which evacuation may be required (ie. Zone 2) following an accident.

9.121 In relation to the approved primary anchorage, evacuation arrangements are required for the area within Zone 2 on the eastern side of the Derwent. The Zone 2 for the anchorage extends about 300 metres from the shoreline into the suburb of Bellerive. The evacuation sub-plan which forms part of the Hobart Safety Scheme makes no specific provision for the evacuation of this small area,[114] although its general features could no doubt be utilised.

9.122 The Committee RECOMMENDS that no visits be made to the primary approved anchorage in the Derwent near Hobart until adequate, documented, provisions are made for evacuation of residents and others from within 1.2 km (ie. Zone 2) of the anchorage.

Jervis Bay

9.123 The only anchorage approved at Jervis Bay is in effect a remote anchorage. The Zone 1 for the anchorage contains no land

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114. Contrast the provision made for the small area of the eastern shore suburb of Rosny, which lies within the Zone 2 for the berth at Macquarie Wharves: Hobart Safety Scheme, Chapter 14, Annex B, Sector A, and the references earlier in the Chapter to this Sector.

area. There are no public residences within Zone 2,[115] although Zone 2 does cover part of the Navy base, HMAS CRESWELL. The Committee has not examined the standard emergency plan for non-nuclear contingencies at the base. However, it is prepared to accept that it is adequate to cater for the evacuation of naval personnel and others who may be on the base.[116]

9.124 The Committee notes, however, that there are populated areas in close proximity to HMAS CRESWELL. The Committee RECOMMENDS that before further visits are permitted to Jervis Bay there should be an examination of whether contingency planning for evacuation and other countermeasures in respect of areas outside HMAS CRESWELL is required. This examination should include consideration of the need for liaison with New South Wales authorities.

Other Ports

9.125 The Committee did not examine the question of evacuation in relation to other ports which have approved berths or anchorages but which do not receive visits (e.g. Townsville), or, as at Albany, have received visits only to anchorages some distance from shore. The Committee considers, however, that recommendations made in this chapter should be applied to any plans that may be written for other Australian ports.

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115. Second supplementary submission from the Department of Defence, p. 13 (Evidence, p. 238.268).

116. Other elements that might be required in a comprehensive port safety plan for Jervis Bay have been provided, notwithstanding the absence of such a plan. See, for example, on provision for post-accident monitoring in relation to the 1983 visit of USS Sea Dragon, Department of Home Affairs and Environment, Visits by Nuclear Powered Warships to Australian Ports: Report on Radiation Monitoring during 1983, (DHAE, Canberra, 1984), p. 11. Standard arrangements for environmental monitoring were implemented: ibid.

USE OF STABLE IODINE AS A PROPHYLACTIC

Introduction

9.126 A number of biological measures are possible to prevent the body's absorption, and to reduce its retention, of radio-nuclides.[117] But with one possible exception they are not, it seems, practical to undertake on a large scale and also have only limited effectiveness.[118] The possible exception is the use of stable iodine as a blocking agent.

9.127 The use of stable iodine as a protective measure has been controversial in the United States in relation to large land-based reactors. Potentially it can be used for emergency

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117. e.g. See D. V. Becker, 'Reactor Accidents: Public Health Strategies and Their Medical Implications', Journal of the American Medical Association, 7 August 1987, vol. 258(5), p. 650:

> Ingestion of Prussian blue (ferric ferrocyanide) can reduce the body burden of cesium radionuclides by half to one third, while intake of aluminum hydroxide gels slows absorption of strontium isotopes. Therapy with diuretics may help to increase excretion of some soluable elements ... Once radioiodine is taken into the thyroid ... its retention can be shortened somewhat by administration of antithyroid agents such as thionamides ... Similarly, thyroidal discharge of radioiodine-labeled thyroid hormone can be accelerated by the injection of bovine thyroid-stimulating hormone.

See also R. A. F. Cox, 'Nuclear Emergencies: Medical Preparedness', British Journal of Radiology, 1987, vol. 60(720), p. 1181, which states, with reference to civil nuclear reactor sites in the UK:

> Other preparations are available on site in the event of an intake of radioactive material. These include Gaviscon granules, which are an antacid containing aluminium combined with alginates, which reduce the intake of strontium 90.

118. ibid. See also International Atomic Energy Agency, Principles for Establishing Intervention Levels for the Protection of the Public in the Event of a Nuclear Accident or Radiological Emergency, (Safety Series No. 72, IAEA, Vienna, 1985), p. 17 (use of stable iodine 'is the only intervention which is practically applicable for protection against internal irradiation caused by the intake of radionuclides'). The use of Prussian blue on patients who received high doses of radiation at Chernobyl proved ineffective: R. E. Linnemann, 'Soviet Medical Response to the Chernobyl Nuclear Accident', Journal of the American Medical Association, 7 August 1987, vol. 258(5), p. 639.

workers, for those evacuating from Zone 1, and for the general population beyond Zone 1. The controversy has focused almost entirely on its use in relation to the last of these groups, who would at most be exposed only to relatively low doses of radiation.[119] This also was seen by the Committee as the major issue in relation to Australian plans.

Role of Stable Iodine

9.128 As noted in chapter 7, the radioiodines have been regarded as the most significant in the immediate post-accident period of those radionuclides likely to be dispersed following a reactor accident. In this context, the iodine isotope of major concern is I-131.[120] As this isotope has a half-life of 8 days, it dispersion is not of long-term concern. When iodine, radioactive or otherwise, is inhaled or ingested it accumulates in the thyroid gland.

9.129 It has long been recognised that saturation of the thyroid with stable iodine blocks the uptake and concentration there of radioiodine.[121] Iodine in the form of potassium iodide (KI) or potassium iodate (KIO_3) is an effective blocking

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119. ie. doses below those likely to cause acute effects.
120. ANSTO, Radiation Monitoring Handbook for Visits by Nuclear Powered Warships to Australian Ports, (ANSTO, Lucas Heights, NSW, 1985), p. 5 (Evidence, p. 299); D. G. Crocker, 'Nuclear Reactor Accidents - The Use of KI as a Blocking Agent against Radioiodine Uptake in the Thyroid - A Review', Health Physics, June 1984, vol. 46(6), p. 1268.
121. For references to the relevant scientific literature, see for example R. A. Meck and others, 'Criteria for the Administration of KI for Thyroid Blocking of Radioiodine', Health Physics, February 1985, vol. 48(2), p. 143; E. Sternthal and others, 'Suppression of Thyroid Radiodine Uptake by Various Doses of Stable Iodide', New England Journal of Medicine, 6 November 1980, vol. 303(19), p. 1083. Contrast submissions from People for Nuclear Disarmament, pp. 4-5 (Evidence, pp. 1306-07); Mr K. G. Blake, p. 4. Both expressed doubts as to the blocking effect, but cited no scientific literature in support of the doubts. Note that the administration of stable iodine is also said to increase the rate of urinary excretion of I-131 iodide atoms, and thus decreases the whole-body radiation dose: D. V. Becker, 'Reactor Accidents: Public Health Strategies and Their Medical Implications', Journal of the American Medical Association, 7 August 1987, vol. 258(5), p. 651.

agent.[122] The iodate form made into tablets is preferred for emergency issue because the tablets may be stored for longer periods without deterioration.[123] There seems to be little dispute that doses of 100 milligrams of stable iodine are the appropriate size for adults, although smaller doses would be almost as effective.[124]

9.130 Iodine that enters the body is quickly taken up by the thyroid. The effectiveness of taking stable iodine as a blocking agent is optimum if it is taken before exposure to radio-iodine,[125] and decreases rapidly with time after exposure. For a single exposure to radioiodine:

> a substantial benefit (e.g., a block of 50 percent) is attainable only during the first 3 to 4 hours after acute exposure. If initial administration is delayed beyond this, the usefulness of potassium iodide will be limited and little benefit can be expected after 10 to

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122. International Atomic Energy Agency, Planning for Off-Site Response to Radiation Accidents in Nuclear Facilities, (Safety Series No. 55, IAEA, Vienna, 1981), p. 16; D. G. Crocker, 'Nuclear Reactor Accidents - The Use of KI as a Blocking Agent Against Radioiodine Uptake in the Thyroid - A Review', Health Physics, June 1984, vol. 46(6), p. 1273.
123. ibid. See also Evidence, p. 1031 (ARL/NHMRC): iodate form lasts more than 10 years; UK, Parliamentary Debates (Commons), 6th series, vol. 99, Written Answers, 12 June 1986, col. 304: tests show iodate tablets still in good condition after 20 years. In the US, because use of the iodate form would have required lengthy procedures to acquire Food and Drug Administration approval, the already-approved iodide form has been used: Protection of the Thyroid Gland in the Event of Releases of Radioiodine: Recommendations of the National Council on Radiation Protection and Measurements, (NCRP Report No. 55, NCRP, Washington, 1977), p. 23. The US literature therefore discusses potassium iodide rather than iodate.
124. D. V. Becker, 'Reactor Accidents: Public Health Strategies and Their Medical Implications', Journal of the American Medical Association, 7 August 1987, vol. 258(5), pp. 651-52. When made up as KI, 100 mg of stable iodine become a 130 mg tablet.
125. 'The Use of Iodine as a Thyroidal Blocking Agent in the Event of a Reactor Accident: Report of the Environmental Hazards Committee of the American Thyroid Association', Journal of the American Medical Association, 3 August 1984, vol. 252(5), 660.

12 hours for a single exposure.[126]

9.131 It is clear from this that, if use of stable iodine as a protective measure is to be an option, the iodine must be stockpiled ready for prompt use. Arrangements to distribute and administer it quickly following an accident would need to be in place. For planning purposes two levels of decision arise: whether use of stable iodine should be an available option; and, if so, whether the option should be exercised in a given situation in preference to alternative protective measures.

9.132 The Committee noted that the Commonwealth has not provided formal or comprehensive guidance to State/Territory planners on the use, if any, to be made of stable iodine as a protective measure. However, it appears that work on the preparation of such guidelines is well advanced, and it is intended that the guidelines be available about the middle of 1989. The Committee has seen a draft of these, but, given their draft status, does not consider it appropriate to comment on them.

Health Benefits and Risks

9.133 Although stable iodine is undoubtedly an efficient

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126. US, Department of Health and Human Services, Food and Drug Administration, Background Material for the Development of the Food and Drug Administration's Recommendations on Thyroid-Blocking with Potassium Iodide, (DHHS, Rockville, Md., 1981), pp. 2-4. cf. International Atomic Energy Agency, Techniques and Decision Making in the Assessment of Off-Site Consequences of an Accident in a Nuclear Facility, (Safety Series No. 86, IAEA, Vienna, 1987), p. 161:

> If administered before the intake, the protection factor is nearly 100%, and it is about 90% if administered at the time of inhalation. Thereafter, protection decreases quickly, and a block of about 50% is attainable if administration is about six hours after inhalation.

See also D. V. Becker, 'Reactor Accidents: Public Health Strategies and Their Medical Implications', Journal of the American Medical Association, 7 August 1987, vol. 258(5), p. 651:

> the protective effect decreases to 85% by one hour after the radioiodine exposure. Potassium iodide given three hours later reduces the uptake to only 50% of control value, and after six hours KI no longer has a significant protective effect.

blocking agent, the extent to which it is an effective protective measure following a reactor accident has been questioned by researchers in the United States.[127]

9.134 It is generally accepted in the scientific literature that the scientific data on any harmful effects to the thyroid of internal (ie. due to inhalation or ingestion) exposure to low doses of radioiodines are inadequate.[128] While it is widely agreed that the incidence of serious or life-threatening effects due to internal exposure to low-doses is likely to be small, there is no agreement among experts on just how small.[129]

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127. D. C. Aldrich and R. M. Blond, 'Radiation Protection: An Analysis of Thyroid Blocking' in Current Nuclear Power Plant Safety Issues: Proceedings of an International Conference Organized by the International Atomic Energy Agency, Stockholm, 20-24 October 1980, (IAEA, Vienna, 1981), vol. 2, p. 76. The authors stress both the medical/scientific uncertainties and the many assumptions that underlie their conclusion.

128. See for example B. Shleien and others, 'Recommendations on the Use of Potassium Iodide as a Thyroid Blocking Agent in Radiation Accidents: An FDA Update', Bulletin of the New York Academy of Medicine, December 1983, vol. 59(10), pp. 1012-14; T. E. Hamilton and others, 'Thyroid Neoplasia in Marshall Islanders Exposed to Nuclear Fallout', Journal of the American Medical Association, 7 August 1987, vol. 258(5), p. 635.

129. See for example, Committee on Public Health of the New York Academy of Medicine, 'Resolution Concerning the Stockpiling of Potassium Iodide in New York City in the Event of a Nuclear Accident', Bulletin of the New York Academy of Medicine, June 1981, vol. 57(5), p. 396 (few good data on the carcinogenicity of ^{131}I in humans); US, H of R, Committee on Interior and Insular Affairs, Subcommittee on Oversight and Investigations, Emergency Preparedness for Radiological Accidents: the Issue of Potassium Iodide, 5 March 1982, p. 7 (F. von Hippel), pp. 11-12, 14-16 (Dr R. S. Yalow); S. Wolfe and C. LaCheen, 'Potassium Iodide Policy', Science, 1982, vol. 218, p. 6; F. von Hippel, 'Potassium Iodide for Thyroid Protection', ibid., p. 1174: 'The Use of Iodine as a Thyroidal Blocking Agent in the Event of a Reactor Accident: Report of the Environmental Hazards Committee of the American Thyroid Association', Journal of the American Medical Association, 3 August 1984, vol. 252(5), p. 659; R. A. Meck and others, 'Criteria for the Administration of KI for Thyroid Blocking of Radioiodine', Health Physics, February 1985, vol. 48(2), pp. 142-43. A recent survey comments:

> radiation from ^{131}I has not been demonstrated to cause thyroid cancer in humans - but, there is no reason to believe that it does not have a carcinogenic potential:

D. V. Becker, 'Reactor Accidents: Public Health Strategies and Their Medical Implications', Journal of the American Medical Association, 7 August 1987, vol. 258(5), p. 650.

9.135 Opinions vary among experts on the likely incidence of medical side-effects from the administration of a single dose of stable iodine. It is agreed that possible temporary discomfort has to be considered.[130] There are, however, few reliable data on which to base an estimate of the occurrence of more serious side effects,[131] although the experience following the 1986 Chernobyl accident may eventually assist in this regard.[132] Those who have examined the issue consider that the incidence of serious side

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130. The concern is not primarily medical, but that people who have taken stable iodine may, unless warned, confuse its side effects with the effects of exposure to radiation and panic as a result: D. G. Crocker, 'Nuclear Reactor Accidents - The Use of KI as a Blocking Agent against Radioiodine Uptake in the Thyroid - A Review', Health Physics, June 1984, vol. 46(6), p. 1277.

131. See for example, Committee on Public Health of the New York Academy of Medicine, 'Resolution Concerning the Stockpiling of Potassium Iodide in New York City in the Event of a Nuclear Accident', Bulletin of the New York Academy of Medicine, June 1981, vol. 57(5), p. 397; J. Wolff, 'The Use of Iodides in Protection against Radioactive Iodine', incorporated in US, H of R, Committee on Interior and Insular Affairs, Subcommittee on Oversight and Operations, Emergency Preparedness for Radiological Accidents: The Issue of Potassium Iodide, 5 March 1982, at pp. 171-73; 'The Use of Iodine as a Thyroidal Blocking Agent in the Event of a Reactor Accident: Report of the Environmental Hazards Committee of the American Thyroid Association', Journal of the American Medical Accociation, 3 August 1984, vol. 252(5), p. 660.

132. The distribution of potassium iodide in the Soviet Union following the accident led to minor side effects only, with none requiring medical attention. Severe iodine reactions requiring medical treatment occurred to 17 of the 10 million recipients of potassium iodide in Poland: R. E. Linnemann, 'Soviet Medical Response to the Chernobyl Nuclear Accident', Journal of the American Medical Association, 7 August 1987, vol. 258(5), p. 641. This paper is based on preliminary data relating to the accident response.

effects is likely to be small.[133]

9.136 Despite the uncertainties on both benefits and risks, it is generally considered in the scientific literature that above a minimal level of exposure the benefits for an exposed population of taking stable iodide outweigh the risks of side effects.[134] There is disagreement, however, on the question of how high the exposure level has to be before measures to protect the thyroid

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133. e.g. US, Department of Health and Human Services, Food and Drug Administration, Background Material for the Development of the Food and Drug Administration's Recommendations on Thyroid-Blocking with Potassium Iodide, (DHHS, Rockville, Md., 1981), p. 4 (number of severe reactions 'is unknown but is expected to be low'); R. A. Meck and others, 'Criteria for for the Administration of KI for Thyroid Blocking of Radioiodine', Health Physics, February 1985, vol. 48(2), pp. 143-45 (1 life-threatening, 3 other serious reactions, estimated per million person-regimens for KI doses); V. E. Archer, 'In Accidents, Give KI Promptly', Health Physics, December 1985, vol. 49(6), p. 1312 (for healthy adults, risk from a single 130 mg dose of KI 'is essentially zero'). For a higher estimate based on some of the same (admittedly inadequate) data see Dr R. S. Yalow's testimony in US, H of R, Committee on Interior and Insular Affairs, Subcommittee on Oversight and Operations, Emergency Preparedness for Radiological Accidents: The Issue of Potassium Iodide, 5 March 1982, p. 12 ('incidence of seriously adverse reactions that we might expect is 6 in 10,000' persons using KI) and pp. 139, 166. cf. International Atomic Energy Agency, Principles for Establishing Intervention Levels for the Protection of the Public in the Event of a Nuclear Accident or Radiological Emergency, (Safety Series No. 72, IAEA, Vienna, 1985), p. 23 (administration of stable iodine as a protective measure has been accepted by many national authorities as constituting only a small risk to the individual).

134. See for example, B. Shleien and others, 'Recommendations on the Use of Potassium Iodide as a Thyroid-Blocking Agent in Radiation Accidents: An FDA Update', Bulletin of the New York Academy of Medicine, December 1983, vol. 59(10), p. 1012; R. A. Meck and others, 'Criteria for the Administration of KI for Thyroid Blocking of Radioiodine', Health Physics, February 1985, vol. 48(2), pp. 144-45. These and other papers reaching a similar conclusion note the uncertainty of the data on which it is based.

should be considered.[135]

Distribution Issues

9.137 Some commentators have suggested that use of stable iodine might create a false sense of security,[136] although there appears to be no empirical evidence on the point.[137] Stable iodine has the potential to protect only against radioiodines, not other radionuclides that would be present following a reactor accident. Persons who have taken stable iodine may, it is argued by these commentators, mistakenly consider it unnecessary to take other protective measures, such as evacuation.

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135. See for example, 'The Use of Iodine as a Thyroidal Blocking Agent in the Event of a Reactor Accident: Report of the Environmental Hazards Committee of the American Thyroid Association', Journal of the American Medical Association, 3 August 1984, vol. 252(5), p. 659 (intervention levels as high as 500 rad (5 Gy) have been realistically proposed) and p. 661 (Committee suggested levels of 100 rad (1 Gy) for adults and 50 rad (0.5 Gy) for children and pregnant women); D. V. Becker, 'Reactor Accidents: Public Health Strategies and Their Medical Implications', Journal of the American Medical Association, 7 August 1987, vol. 258(5), p. 652 (US regulatory authorities have favoured levels in the 10 to 25 rad (0.1 to 0.25 Gy) range); US, Federal Emergency Management Agency, 'Federal Policy on Distribution of Potassium Iodide Around Nuclear Power Sites for Use as a Thyroidal Blocking Agent', Federal Register, 24 July 1985, vol. 50(142), p. 30,259: Food and Drug Administration guidance

> states that risks from the short term use of relatively low doses of KI for thyroidal blocking in a radiation emergency are outweighed by the risks of radioiodine induced thyroid nodules or cancer at a projected dose to the thyroid gland of 25 rem [which can be equated to 0.25 Gy] or greater.

The action level for Soviet authorities at Chernobyl was 30 rem to the child thyroid: R. F. Mould, Chernobyl: The Real Story, (Pergamon, Oxford, 1988), p. 124.

136. e.g. US, H of R, Committee on Interior and Insular Affairs, Subcommittee on Oversight and Investigations, Emergency Preparedness for Radiological Accidents: The Issue of Potassium Iodide, 5 March 1982, p. 3 (Dr E. W. Fowinkle), p. 36 (J. C. Villforth, Department of Health and Human Services); R. A. F. Cox, 'Nuclear Emergencies: Medical Preparedness', British Journal of Radiology, 1987, vol. 60(720), p. 1181.

137. Soviet physicians are reported as having found that the distribution of potassium iodide at Chernobyl in 1986 had a positive psychological effect on the population: R. E. Linnemann, 'Soviet Medical Response to the Chernobyl Nuclear Accident', Journal of the American Medical Association, 7 August 1987, vol. 258(5), p. 641.

9.138 As public controversy in the United States has indicated, distribution of stable iodine poses problems.[138] The following points have been argued in that debate. If stable iodine is distributed beforehand to households, offices, etc. there is a risk that it will have become mislaid by the time it is needed, which may be decades later. Extra quantities have to be distributed to cater for visitors. A small risk exists that the quantity distributed will be taken by mistake or accident. If an accident occurs, it is argued that many people will take the tablets unnecessarily and in the absence of instructions to do so. This will incur the small risk of side effects for no compensating benefit. It is debatable how far public education campaigns can overcome some of these perceived problems.

9.139 If pre-accident distribution is not made, distribution will have to be done from stockpiles after the accident. Speedy distribution would be essential. In the United Kingdom, police are reported to be reluctant to be responsible for distribution.[139] There is evidence from the United States to indicate that distribution is unlikely to be anything like fully effective in reaching people.[140] In addition, distribution involves people

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138. The points made in this paragraph are drawn from testimony in US, H of R, Committee on Interior and Insular Affairs, Subcommittee on Oversight and Investigations, Emergency Preparedness for Radiological Accidents: The Issue of Potassium Iodide, 5 March 1982, pp. 1-46. See also D. V. Becker, 'Physiological Basis for the Use of Potassium Iodide as a Thyroid Blocking Agent: Logistic Issues in its Distribution', Bulletin of the New York Academy of Medicine, December 1983, vol. 59(10), pp. 1006-08.

139. R. A. F. Cox, 'Nuclear Emergencies: Medical Preparedness', British Journal of Radiology, 1987, vol. 60(720), p. 1181.

140. Exercises carried out in Tennessee were successful in reaching only 54% of the target population, despite considerable effort and cost: D. V. Becker, 'Physiological Basis for the Use of Potassium Iodide as a Thyroid Blocking Agent: Logistic Issues in its Distribution', Bulletin of the New York Academy of Medicine, December 1983, vol. 59(10), p. 1007. For New York City, the view has been expressed that 'it is unlikely that ... distribution will be efficient in the critical hour or two necessary to to minimise radiation': Committee on Public Health of the New York Academy of Medicine, 'Resolution Concerning the Stockpiling of Potassium Iodide in New York City in the Event of a Nuclear Accident', Bulletin of the New York Academy of Medicine, June 1981, vol. 57(5), p. 398.

moving about in the open, thereby risking increased exposure.[141]

9.140 It has been argued in the United States that, irrespective of how distribution occurs, consideration has to be given to what medical assistance will be available to persons suffering an adverse reaction. Additional issues relate to what advice should accompany the distribution of stable iodine and the form the advice should take. Matters on which advice would be relevant include the efficacy of taking stable iodine, the risks, and the medical conditions which, if present, make iodine use inadvisable are all. In Australia, unlike the United States, the cost of the tablets to be distributed is not a significant issue.[142]

9.141 Based on the reference accident, the outer limit of the area at risk from inhalation hazards and for which countermeasures would be necessary in Australia is 2.2 kilometres. There is no need to plan for distribution of stable iodine in areas beyond this distance. This makes distribution problems much more manageable than for large land-based reactors with correspondingly larger inhalation-hazard zones.

9.142 In the United States one aspect of the stable iodine

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141. Committee on Public Health of the New York Academy of Medicine, 'Resolution Concerning the Stockpiling of Potassium Iodide in New York City in the Event of a Nuclear Accident', Bulletin of the New York Academy of Medicine, June 1981, vol. 57(5), p. 398.

142. No Australian costs have been obtained. US costs are of the order of ten cents per tablet, though if child-proof containers or other special packaging is required this cost will increase: US, H of R, Committee on Interior and Insular Affairs, Subcommittee on Oversight and Investigations, Emergency Preparedness for Radiological Accidents: The Issue of Potassium Iodide, 5 March 1982, p. 4 (Dr E. W. Fowinkle), p. 38 (R. W. Krimm, Federal Emergency Management Agency). The cost of distribution has been a significant issue in the United States because of the short (2 yr) shelf-life of the iodide form approved for use in that country. Having to re-establish any stockpile every 2 years has influenced decision-making: e.g. Committee on Public Health of the New York Academy of Medicine, 'Resolution Concerning the Stockpiling of Potassium Iodide in New York City in the Event of a Nuclear Accident', Bulletin of the New York Academy of Medicine, June 1981, vol. 57(5), p. 399.

controversy has been whether credible scenarios can be found to justify reliance on it as a general protective measure. Alternative protective measures will often, arguably always, be both available and more effective.

Use of Alternative Protective Measures

9.143 The time necessary for radioiodine to be ingested through the food chain following a nuclear accident allows controls on foodstuffs, particularly milk,[143] to be put in place as an effective countermeasure.[144] On this basis, if stable iodine is to be an available protective measure, it will be required only as a counter to the inhalation hazard.

9.144 For this hazard, evacuation and sheltering are regarded by planners as standard alternative protective measures. In the United States, Federal authorities have taken the view that these alternatives are more effective protective measures for the general public in the event of a reactor accident, and that the

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143. The effect of cows grazing on contaminated pasture is to concentrate radioiodine in their milk over the following 24 hours. Therefore pasture receiving contamination at levels that would not directly pose a hazard to humans may result in the production of hazardous milk: see ANSTO, Radiation Monitoring Handbook for Visits by Nuclear Powered Warships to Australian Ports, (ANSTO, Lucas Heights, NSW, 1985), p. 6 (Evidence, p. 300).

144. e.g. International Atomic Energy Agency, Planning for Off-Site Response to Radiation Accidents in Nuclear Facilities, (Safety Series No. 55, IAEA, Vienna, 1981), p. 16. See ANSTO, Radiation Monitoring Handbook for Visits by Nuclear Powered Warships to Australian Ports, (ANSTO, Lucas Heights, NSW, 1985), p. 41 (Evidence, p. 335) for the action guide to protecting the thyroid from the ingestion hazard.

use of stable iodine is at best of marginal value.[145] The view of State authorities in the United States varies.[146]

9.145 This view relates to land-based reactors. It rests in part on the distribution problems and the risk of side effects identified above. It also rests on the fact that use of stable iodine can at best mitigate only some of the effects of exposure to radionuclides. Other protective measures will also be required. If evacuation is used, it will generally have the effect of removing the need for measures relating specifically to radioiodines. If effective sheltering is used, it would have the result of reducing exposure, possibly to a level below the

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145. US, H of R, Committee on Interior and Insular Affairs, Subcommittee on Oversight and Investigations, Emergency Preparedness for Radiological Accidents: the Issue of Potassium Iodide, 5 March 1982, pp. 33, 40 (B. K. Grimes, Nuclear Regulatory Commission); US, Federal Emergency Management Agency, 'Federal Policy on Distribution of Potassium Iodide Around Nuclear Power Sites for Use as a Thyroidal Blocking Agent', Federal Register, 24 July 1985, vol. 50(142), p. 30,258:

> The Federal position with regard to the predistribution or stockpiling of potassium iodide for use by the general public is that it should not be required. ... While valid arguments may be made for the use of KI, the preponderance of information indicates that a nationwide requirement for the predistribution or stockpiling for use by the general public would not be worthwhile.

146. B. Shleien and others, 'Recommendations on the Use of Potassium Iodide as a Thyroid Blocking Agent in Radiation Accidents: An FDA Update', Bulletin of the New York Academy of Medicine, December 1983, vol. 59(10), p. 1017: State emergency plans in the United States deal with supply as follows:

> stockpile for use by emergency workers: 31 States;
> stockpile for public use, but no predistribution: 6 States;
> predistribute to public living near reactor site: 1 State;
> adopted a position not to use for anyone: 4 States; and
> adopted a position not to use for general public only: 5 States.

The United Kingdom has stockpiled but not predistributed, while Sweden has predistributed to those living near reactor sites: ibid.

emergency reference level for thyroid exposure.[147]

9.146 The main challenges to this view rest on concern about an uncontained accident, and situations in which evacuation is not a viable alternative measure. These criticisms are not relevant in the present context. The Committee has accepted that planning should be based on a contained accident. It has also accepted that evacuation would be an effective protective measure.

9.147 The view that stockpiling or pre-distribution is not warranted becomes even more persuasive in the Australian context, when allowance is made for the additional protective measure of vessel removal.

9.148 Accordingly, the Committee considers that there is no need to plan for stable iodine distribution to the general public as a protective measure.[148]

Distribution Plans in Western Australia

9.149 None of the berths or anchorages in Gage Roads/Cockburn Sound is within 2.2 kilometres of the mainland. The WA Port

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147. US, H of R, Committee on Interior and Insular Affairs, Subcommittee on Oversight and Investigations, Emergency Preparedness for Radiological Accidents: the Issue of Potassium Iodide, 5 March 1982, p. 40 (B. K. Grimes, Nuclear Regulatory Commission):

> if one plans to take evacuation or sheltering measures that will reduce doses by a factor of two or three for sheltering, or substantially more if the population was evacuated, then one should not assume that the same dose will occur [to the thyroid].

148. This conclusion would be reinforced if the Committee had chosen to base its assessment on ANSTO's revised accident model rather than the reference accident (see paras. 7.17–7.25). One of the differences between the revised model and the reference accident is the much lower quantity of radioiodines released from the revised model. If planning were to be based on this model and yet there were to be widespread distribution of stable iodine to the general public it might lead to wide unnecessary use of the iodine. This in turn would incur the small risk of side effects without any corresponding benefit.

Safety Scheme provides under these circumstances 'that except in the most unusual circumstances, there will be no requirement for the distribution of potassium iodate tablets'.[149] The Scheme, however, makes provision for iodate tablet distribution to households,[150] notwithstanding that no need for distribution is identified in terms of the current reference accident.[151]

9.150 The Committee considers this provision for stable iodine distribution to be unnecessary, in view of the distance from the mainland of the berths and anchorages currently used. This point applies to these berths and anchorages, and is additional to the general grounds put forward above. The Committee notes that Western Australian officials have been advised by their Commonwealth counterparts that the distribution plans are unnecessarily broad.[152]

9.151 The Committee considers that the breadth of the plans for stable iodine distribution could result in the public becoming confused as to the maximum extent of the area in which protective measures would be required.[153] This could not only cause unnecessary anxiety relating to warship visits, but could also lead to inappropriate responses by the public (e.g. unnecessary evacuation) in the event of an accident.

9.152 The Committee RECOMMENDS that the Western Australian

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149. Para. 701.
150. Paras. 702-710 and Annexes A, B and C to Part 7.
151. See footnote 149 above on the effect of substituting ANSTO's revised accident model.
152. Information supplied at a briefing to Committee members by WA officials, 1 February 1988.
153. A number of submissions considered the WA Port Safety Scheme's provision for stable iodine distribution impracticable or unworkable: see for example the submissions from Assoc Prof P. Jennings, p. 3; Albany Peace Group, p. 2; Mr K. G. Blake, p. 4; State School Teachers' Union of WA (Inc.), p. 2; Mrs L. Van Geloven, p. 5; Scientists Against Nuclear Arms (WA) and Medical Association for the Prevention of War (WA), pp. 11-12 (Evidence, pp. 797-98); People for Nuclear Disarmament, p. 5 (Evidence, p. 1307). The provision in the Scheme may have contributed to this view because it raises the possibility of distribution over an indeterminate area.

planners delete their provision for distribution of potassium iodate tablets to the general public beyond Zone 2.

Emergency Workers and Evacuees from Zone 1

9.153 The discussion in this section has focused so far on distribution to the general public. At least some authorities that consider such distribution unnecessary accept that the availability of stable iodine for emergency workers is desirable.[154] Evacuation and sheltering may not be realistic options for these persons, and they are more likely to be exposed to radiation and in larger doses. Moreover, they are few in number, thereby eliminating the logistical problems relating to distribution. They are able to be monitored for side effects relatively easily. Finally, they are under the supervision of persons with experience in radiation protection, and therefore unlikely to take the stable iodine unnecessarily or to overestimate the degree of protection that it provides.

9.154 These reasons also apply to those evacuating from Zone 1. Accordingly, the Committee considered the need to provide for the administration of stable iodine to emergency personnel and to those evacuating from Zone 1.

Duration of Administration of Stable Iodine

9.155 Before considering the individual plans, it is convenient to consider a criticism that was made of the WA Port Safety Scheme plan to distribute one tablet only per person.

> There is no obvious explanation for the Western Australian authorities' decision to distribute one tablet per person. Literature in Australia and the US recommends daily administration for three to ten days. A single

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154. e.g. US, Federal Emergency Management Agency, 'Federal Policy on Distribution of Potassium Iodide Around Nuclear Power Sites for Use as a Thyroidal Blocking Agent', Federal Register, 24 July 1984, vol. 50(142), p. 30,258. See also footnote 146 above.

tablet is ineffective for continuous protection.[155]

9.156 No Australian literature was cited in support. The single United States source cited dealt with both continuous exposure to radioiodine over a number of days and a brief exposure.[156] The criticism failed to make clear whether the objection was to a failure to plan for continuous exposure, or to the adequacy of a single dose of stable iodine in response to a brief exposure.

9.157 Given the provision in plans relating to vessel removal and evacuation, the Committee sees no need to plan for continuous exposure. The issue of the adequacy of a single dose as a response to a brief exposure is less clear-cut. The blocking effect of a single dose of stable iodine lasts for over 24 hours but not, it seems, for as long as 48 hours.[157] Most radioiodine taken into the body and blocked from entering the thyroid is

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155. M. Boyes, 'Iodine distribution after nuclear accidents', (Intercept Foundation Ltd Information Dossier No. 3, Sydney, 1988), p. 2.

156. US, Department of Health and Human Services, Food and Drug Administration, Background Material for the Development of the Food and Drug Administration's Recommendations on Thyroid-Blocking with Potassium Iodide, (DHHS, Rockville, Md., 1981), p. 4.

157. Committee on Public Health of the New York Academy of Medicine, 'Resolution Concerning the Stockpiling of Potassium Iodide in New York City in the Event of a Nuclear Accident', Bulletin of the New York Academy of Medicine, June 1981, vol. 57(5), p. 397. cf. 'The Use of Iodine as a Thyroidal Blocking Agent in the Event of a Reactor Accident: Report of the Environmental Hazards Committee of the American Thyroid Association', Journal of the American Medical Association, 3 August 1984, vol. 252(5), p. 660 ('blockade with a single 100-mg dose of iodide lasts between 24 and 48 hours'); J. Wolff, 'The Use of Iodides in Protection against Radioactive Iodine', incorporated in US, H of R, Committee on Interior and Insular Affairs, Subcommittee on Oversight and Investigations, Emergency Preparedness for Radiological Accidents: The Issue of Potassium Iodide, 5 March 1982, p. 171 (duration of the block from a single dose 'is between 24-48 hours'); E. Sternthal and others, 'Suppression of Thyroid Radioiodine Uptake by Various Doses of Stable Iodide', New England Journal of Medicine, 6 November 1980, vol. 303(19), p. 1086 ('recovery of the thyroid radioiodine uptake that follows a single dose of iodide occurs within a few days').

excreted over the subsequent 48 hours.[158] If blocking ceases before excretion is complete, thyroid uptake of the remaining radioiodine will be possible.

9.158 To ensure that blocking continues until excretion is substantially complete, the official view in the United States at the Federal level is that stable iodine should be taken daily for at least 48 hours after the last exposure following an accident involving a land-based reactor.[159] Medical experts support this view.[160] But it has been argued that, for blocking the uptake from a brief exposure, the initial dose of stable iodine is the only important one.[161] In the United Kingdom, planning assumes that only a single administration of stable iodide will be necessary.[162]

9.159 The Committee was not in a position to determine if continued daily administration of stable iodine following a brief exposure was a counsel of perfection or a matter of practical significance.

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158. US, Department of Health and Human Services, Food and Drug Administration, Background Material for the Development of the Food and Drug Administration's Recommendations on Thyroid-Blocking with Potassium Iodide, (DHHS, Rockville, Md., 1981), p. 4. Contrast ANSTO, Radiation Monitoring Handbook for Visits by Nuclear Powered Warships to Australian Ports, ANSTO, Lucas Heights, NSW, 1985), p. 5 (Evidence, p. 299): excretion of radioiodine not taken up by the thyroid occurs within 24 hours.

159. US, Federal Emergency Management Agency, 'Federal Policy on Distribution of Potassium Iodide Around Nuclear Power Sites for Use as a Thyroidal Blocking Agent', Federal Register, 24 July 1985, vol. 50(142), p. 30,259.

160. e.g. D. V. Becker, 'Reactor Accidents: Public Health Strategies and Their Medical Implications', Journal of the American Medical Association, 7 August 1987, vol. 258(5), p. 651. However, many writers who discuss the period over which stable iodine should be administered fail to separate the effect of lingering external exposure from the effect of a single internal exposure.

161. J. A. Martin, 'Potassium Iodide: Predistribution or Not? The Real Emergency Preparedness Issue', Health Physics, August 1985, vol. 49(2), p. 287.

162. 'Reactor Accidents: Iodine Supplements?', Lancet, 26 February 1983, vol. 1(8322), p. 452. The UK port safety plans seen by the Committee make provision for only a single dose of 2 tablets per adult, 1 per child and 1/2 per infant. The iodine content of the tablets is not stated in the plan but differs from the tablets held in Australia.

9.160 Therefore, the Committee RECOMMENDS that the Government seek advice to determine if there is a practical need to administer stable iodine for several days, rather than as a single dose, in order to provide continued blocking of thyroid uptake of radioiodine following a brief exposure. The Committee RECOMMENDS that, if the advice received by the Government states that administration over several days is required, plans relating to stable iodine distribution be amended accordingly.

Provisions for Stable Iodine in Australian Plans

9.161 Provision is made for the taking of stable iodine by radiation monitoring personnel,[163] and the crew of a vessel placed on standby for emergency towing duty.[164] No detailed provision is made in the port-specific plans as to the mechanics of supplying tablets to shore parties, who may be required to approach the stricken vessel, or to other emergency workers. Nor is detailed provision made for administration to those evacuating from Zone 1. The Darwin plan, for example, merely notes that stable iodine distribution is a responsibility of the local Department of Health and Community Services.[165]

9.162 In this respect the plans compare unfavourably with the Liverpool Safety Scheme. This Scheme provides for positioning, before the vessel's arrival, of set quantities of stable iodine

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163. ANSTO, Radiation Monitoring Handbook for Visits by Nuclear Powered Warships to Australian Ports, (ANSTO, Lucas Heights, NSW, 1985), pp. 10, 21, 47 (Evidence, p. 304, 315, 341).
164. OPSMAN 1 (2nd edn.), para. 433 (Evidence, p. 77).
165. Para. 715(b). See similarly the Brisbane Port Safety Plan, para. 329(c); WA Port Safety Scheme, para. 226(b). The HMAS STIRLING Sub-Plan notes the utility of stable iodine tablets but does not state who is responsible for distribution or how distribution would be done. The Hobart Safety Scheme, para. 1114 states that tablets held at the Emergency Operations Centre 'will be available for administration if considered necessary'. See also ibid., para. 1316. Members of the Committee who visited Hobart in March 1988 were told that, due to the short distances involved, it was planned to distribute the tablets to evacuees from Zone 1, vessels within Zone 1, etc. by foot from the Centre.

tablets with the decontamination unit, the fire brigade, the safety officer's team, and each of the pedestrian or vehicle access points to the berth.[166] Provision is also made for tablets to be in place for distribution to masters and crews of other vessels in the vicinity. Explanatory leaflets are supplied. All those evacuating the area are to be given tablets, as are any emergency or essential staff entering.[167]

9.163 The Committee considers this level of detailed provision to be appropriate for adoption in Australian plans in relation to berths (as opposed to anchorages more than 600 metres from shore). Accordingly, the Committee RECOMMENDS that visits not be approved to berths unless detailed provisions are in place to ensure that those evacuating the surrounding Zone 1 and emergency personnel entering the Zone 1 are able to be supplied with stable iodine.

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166. UK, Ministry of Defence, Liverpool Special Safety Scheme for Visits to Liverpool by Nuclear Powered Submarines, (April 1986), p. 2-10.
167. ibid., pp. 3-4 - 3-6.

CHAPTER 10

CRITICISMS OF CURRENT PLANS - PART II

SHELTERING

10.1 Sheltering provides protection against external radiation from the plume and from surface deposition, as well as inhalation of airborne contamination.[1] The shielding effect against direct radiation from the passing plume depends heavily on the mass of material between the source and the person. For example, a wooden framed house with no basement will afford little protection, while the basement of a large office building will afford virtually total protection from this source.[2]

10.2 Protection against inhalation depends on the rate of ventilation of the building used as shelter. By turning off ventilation fans and air conditioners, and closing doors and windows before the plume arrives a reduction of up to 90 per cent in the inhalation dose can be achieved.[3] A further reduction can be achieved by measures such as placing layers of moist newspaper or cloth in the chinks of doors and windows.[4]

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1. ANSTO, Radiation Monitoring Handbook for Visits by Nuclear Powered Warships to Australian Ports, (ANSTO, Lucas Heights, NSW, 1985), p. 42 (Evidence, p. 336).
2. ibid. See also International Atomic Energy Agency, Planning for Off-Site Response to Radiation Accidents in Nuclear Facilities, (Safety Series No. 55, IAEA, Vienna, 1981), p. 13.
3. ANSTO, Radiation Monitoring Handbook for Visits by Nuclear Powered Warships to Australian Ports, (ANSTO, Lucas Heights, NSW, 1985), p. 42 (Evidence, p. 336).
4. International Atomic Energy Agency, Planning for Off-Site Response to Radiation Accidents in Nuclear Facilities, (Safety Series No. 55, IAEA, Vienna, 1981), p. 14.

10.3 It is widely accepted that sheltering has a role to play in terms of reactor accidents generally.[5] In the Australian context, consideration of sheltering as a protective measure is relevant primarily where large numbers of residents, office workers, etc. are likely to be within Zone 2, and timely evacuation may present difficulties. Sheltering may be most effective if used as an interim countermeasure, pending evacuation.[6] The evacuation might await either the passing of the radioactive plume or the putting in place of, say, transport arrangements that minimise the possibility of exposure during the evacuation.[7]

10.4 Of the ports currently visited, only in Hobart and Darwin are large numbers of people likely to be within Zone 2.[8] In both places the authorities are confident that rapid evacuation can be effected. While the Hobart Safety Scheme caters

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5. e.g. ibid., p. 15.
6. See, for example, the Hobart Safety Scheme, para. 1113(b), which sets out, as an option, an instruction to shelter as an interim protective measure pending evacuation.
7. e.g. International Atomic Energy Agency, Planning for Off-Site Response to Radiation Accidents in Nuclear Facilities, (Safety Series No. 55, IAEA, Vienna, 1981), p. 19:

> Evacuation requires time, and in some circumstances it may not be feasible during the early phase of the accident. During that stage only relatively small communities can be efficiently evacuated in a timely fashion. ... If evacuation is envisaged during the passage of the plume, it is possible that higher doses might be received by the evacuees than if they were kept in shelter. In addition, it must also be remembered that the time scale for mobilizing vehicles is long, and it may prove impossible to evacuate before the plume arrives.

See also R. P. Gale, 'Immediate Medical Consequences of Nuclear Accidents: Lessons from Chernobyl', Journal of the American Medical Association, 7 August 1987, vol. 258(5), p. 625: the response to the Chernobyl accident: indicated that immediate evacuation is not always desirable.

> In the case of Pripyat, evacuation was postponed until buses could be assembled, escape routes selected to avoid the path of the radioactive plume, and a polymer film sprayed on ground surfaces to reduce the likelihood of inhalation of radio-active dust. The efficacy of this strategy is indicated by by the fact that the population of Pripyat received a lower average radiation dose than individuals living at consider-ably greater distance from the power station.

8. See the consideration of evacuation in the previous chapter, where a distinction is drawn between evacuation of a central business district and of a major public hospital.

for the use of sheltering,[9] it appears that the authorities in Darwin see no need to consider making detailed provision. The latter position is similar at HMAS STIRLING, where the number of people potentially affected is smaller.

10.5 The Committee accepts that, compared to vessel removal or evacuation, sheltering will often be a less effective counter-measure. The Committee is concerned, however, that the current plans give such limited recognition to the use of sheltering, even as an interim measure pending evacuation.[10] In particular, the Committee considers that insufficient guidance is given to those required to direct the accident response as to when to recommend that the option of sheltering be adopted.

10.6 Accordingly, the Committee RECOMMENDS that the Department of Defence advise the authorities responsible for the individual port safety plans of the need for the plans to contain specific criteria to assist post-accident decision-makers in deciding if sheltering should be adopted as a countermeasure in the particular circumstances prevailing.

PERSONAL PROTECTIVE MEASURES

10.7 Special respiratory protection equipment and protective

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9. cf. the Hobart Safety Scheme, paras. 1113(b), 1204(b) and 1315, and Chapter 12, Annex C which relate to the use of sheltering as an option. The supplement to the scheme, which relates to protective measures to be taken at the Royal Hobart Hospital, also caters for sheltering.

10. cf. A. P. Hull, 'Critical Evaluation of Radiological Measurements and of the Need for Evacuation of the Nearby Public during the Three Mile Island Incident' in Current Nuclear Power Plant Safety Issues: Proceedings of an International Conference Organized by the International Atomic Energy Agency, Stockholm, 20-24 October 1980, (IAEA, Vienna, 1981), vol. 2, p. 94:

> It seems unwise to condition emergency authorities and the public to think almost exclusively in terms of evacuation, as the only available effective and/or most desirable protective measure in the event of a major release from a power reactor.

clothing offer protection against airborne and deposited contamination. But mass distribution of such items and training in their correct use is not a feasible accident response. However, as an International Atomic Energy Agency safety guide indicates, simple respiratory protection:

> may be provided by the use of handkerchiefs, soft absorbent paper products, clothing and other items which can be used to cover the mouth and nostrils. The public can be advised to use such simple items while proceeding to take shelter, and possibly during sheltering. Similar precautions could be recommended while members of the public were being evacuated from a contaminated area.[11]

10.8 The plans for Australian ports make no explicit provision for giving advice to the public on this simple protective measure.[12] The assumption appears to be the same as that relating to sheltering: the effectiveness of evacuation will be such that alternative, less-effective, countermeasures do not need to be planned in detail.

10.9 The Committee noted that the British plan for Liverpool does not make provision for individuals to be advised of the means of achieving respiratory protection. The Committee, however, suggests that advice on simple means of respiratory protection should be given in association with advice to evacuate or to take shelter. The plans should cater for this.

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11. International Atomic Energy Agency, Planning for Off-Site Response to Radiation Accidents in Nuclear Facilities, (Safety Series No. 55, IAEA, Vienna, 1981), p. 22. A table on p. 21 gives the degree of respiratory protection provided by common household and personal items.
12. cf. ANSTO, Radiation Monitoring Handbook for Visits by Nuclear Powered Vessels to Australian Ports, (ANSTO, Lucas Heights, NSW, 1985), p. 43 (Evidence, p. 337), which provides general information on the efficacy of simple measures of respiratory protection.

10.10 The Australian port-specific plans note the possible need for controls on milk and other foodstuffs following a reactor accident.[13] However, no specific provision is made for how or by whom the controls would be implemented except, to some extent, in the Hobart Safety Scheme.[14] In this respect the plans compare unfavourably with the Liverpool Port Safety Scheme.[15]

10.11 The Liverpool Scheme allocates responsibility for arranging and implementing any ban considered necessary on harvesting, sale or consumption of foodstuffs, including locally caught fish. All dairy farms within 9 kilometres of the berth are required to be identified. Provision is made for the collection of milk samples and the place where they will be analysed is identified. Responsibility is also allocated for the collection and disposal of contaminated milk, and the provision of replacement stocks of uncontaminated milk.[16]

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13. WA Port Safety Scheme, paras. 906-07; Darwin Port Safety Plan, paras. 407, 408 (noting that the majority of dairy products are imported from outside the region), 509; Brisbane Port Safety Plan, paras. 112-13; Hobart Safety Scheme, paras. 308, 309, 1407(d) and 1466.
14. The Hobart Safety Scheme, para. 509.
15. UK, Ministry of Defence, Liverpool Special Safety Scheme for Visits to Liverpool by Nuclear Powered Submarines, (April 1986), para. 64.
16. The arrangements set out in UK, Ministry of Defence, Devonport Public Safety Scheme, (1982 edn.), Part 11, are even more detailed. Measures of the kind described in the text are specified in greater detail. Also, pre-addressed envelopes are prepared for all milk producers/retailers and occupiers of other agricultural holdings within 9 km of the berths. Draft letters relating to the consequences of a reactor accident on foodstuffs have been prepared, and arrangements made for delivery of letters in an emergency. Drafts of messages to be broadcast to farmers, etc are included in the plan. The possibility of using police vehicles with loudhailers is also included. Provision is made for the possible ban on consumption of fruit, vegetables and free range eggs produced within 1.5 km of the berth. At the date of the plan a survey had shown only one registered farmer within this radius. Provision is made for amendments to the plan at intervals of not more than 3 months, and a positive check that its details are still correct is required once a year. It should be recalled that Devonport is a submarine base and reactor repairs are done there.

10.12 The Committee considered if provision in Australian plans should be at a similar level of detail. The argument against doing so is that the measures are not ones that need to be taken within minutes, or even the first few hours, following an accident. For example, milk sampling would only be required to begin 24 hours after an accident.[17] On this view, there would be time after the accident to arrange countermeasures in Zone 3. Given the generally non-agricultural nature of the land within 9 kilometres (to use the British figure) of currently approved berths and anchorages, the countermeasures would not be extensive.

10.13 The Committee accepts this view. It does not consider that more extensive planning for countermeasures in Zone 3 is required.

REDUCING THE HAZARD AT SOURCE

10.14 In the abstract, an obvious response to a reactor accident is to try to reduce its consequences by halting or reducing the release of radionuclides from the vessel. In practice, of course, this is not easily achieved. It seemed to the Committee that one possibility worth exploring was the use of spray drenching with water. Given that radioiodine and some other fission products are soluble, the continuous spraying of the vessel, either using its own equipment[18] or from fire-fighting tugs or dock-side fire hoses, might be expected to significantly reduce the releases to the atmosphere.

10.15 The Committee put the possibility of spraying to ANSTO,

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17. UK, Ministry of Defence, Devonport Public Safety Scheme, (1982 edn.), section 1103.
18. Many modern surface ships designed for combat are fitted with devices to spray the exterior of the ship, in order to minimise the effect of sailing through the fallout from a nuclear detonation.

who responded:

> ANSTO officers are not aware of any evidence on the efficacy of water sprays in reducing releases in the event of accidents in nuclear submarines or of any other external action which would reduce releases to atmosphere. Removal of the stricken vessel to a remote anchorage is seen as the most effective means of reducing onshore exposures.[19]

10.16 The Committee accepts that vessel removal is the most effective protective measure. Nonetheless, the Committee considers that the efficacy of water spraying should be investigated further. Spraying has the potential to supplement other protective measures.

10.17 The Committee RECOMMENDS that the Department of Defence and ANSTO investigate whether water-spray drenching of an accident-stricken vessel would provide a useful supplementary protective measure.

EXERCISES

Introduction

10.18 It is generally accepted by planners that the holding of exercises and drills makes a valuable contribution towards ensuring that emergency plans will work if required.[20] The Australian Ionising Radiation Advisory Council (AIRAC) has recommended that exercises play a regular part in the contingency

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19. Evidence, p. 443.450 (ANSTO).
20. e.g. Department of Defence, Natural Disasters Organisation, Australian Counter Disaster Handbook, (Australian Counter Disaster College, Mt Macedon, Vic, 1980), para. 13.19; International Atomic Energy Agency, Emergency Preparedness Exercises for Nuclear Facilities: Preparation, Conduct and Evaluation, (Safety Series No. 73, IAEA, Vienna, 1985), p. 3.

planning for nuclear powered warship visits.[21] The Visiting Ships Panel (Nuclear) agreed with this recommendation.[22] The VSP(N) has provided a 'standard exercise' to assist the States and the Northern Territory in meeting their responsibilities to respond effectively in the unlikely event of an accident.[23]

10.19 At the same time exercises may be costly to run and depend on the contributions and goodwill of volunteers. The issues considered by the Committee were the scope of exercises, particularly the extent to which members of the public should be involved, and the frequency of exercises. The Committee did not have the opportunity to observe an exercise.

Scope

10.20 The Committee was told that exercises in Western Australia and in Hobart have involved the command and control structure of the respective plans, but have not involved the general public.[24] The same appears to be true in the other Australian ports receiving visits.[25] Failure to involve members

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21. AIRAC, 'Review of Safety and Monitoring Arrangements for Visits by Nuclear Powered Warships', p. 5 (Evidence, p. 756).
22. AIRAC, 'Follow-up Actions on Report of Visits to Hobart/Darwin/ Brisbane', p. 6 (Evidence, p. 766).
23. Second supplementary submission from the Department of Defence, p. 15 (Evidence, p. 238.270). See also ANSTO, Radiation Monitoring Handbook for Visits by Nuclear Powered Warships to Australia, (ANSTO, Lucas Heights, NSW, 1985), p. 10 (Evidence, p. 304) for details on who is responsible for testing various aspects of the plans, and for a set of test data for use in exercises.
24. Information supplied at briefings to Committee members by WA officials, 1 February 1988; Tasmanian officials, 21 March 1988.
25. See the second supplementary submission from the Department of Defence, pp. 15-16 (Evidence, p. 238.270-71), where it is said that the scope of exercise activations involves among other things:

    > actual deployment of the radiation monitoring teams, relay of exercise monitoring reports, plotting and reactions. This latter segment is not blatantly public, so as to avoid any public inconvenience but it does ensure that teams are trained to a satisfactory operational level and the AAEC [now ANSTO] supplied equipment is performing to specification.

of the public in exercises was criticised in some submissions.[26]

10.21 Exercises involving the public are not normally held in Australia for other types of emergency plans. The Committee was given no reason why the plans that were the subject of its inquiry should be treated differently in this regard.

10.22 Only in Darwin and Hobart would the occurrence of the reference accident lead to a possible need for many members of the public to take protective measures in the first 24 hours after an accident. This is due to the relative isolation from populated areas of the berths and anchorages used elsewhere. Even in Darwin and Hobart, the numbers affected within Zones 1 and 2 are relatively small. In contrast, the number of people who might be required to take protective measures following a land-based reactor accident in the United States is much larger.[27] For this reason, the Committee does not regard requirements relating to exercises for these reactors[28] as directly relevant to Australian port safety plans.

10.23 The Committee does not regard the failure of exercises to involve the general public as a valid ground of criticism.

10.24 A further issue was whether the exercises that are held are sufficiently detailed, even accepting that they should stop

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26. e.g. see the submissions from Assoc Prof P. Jennings. p. 3; Senator J. Vallentine, p. 11 (Evidence, p. 1054); People for Nuclear Disarmament, pp. 5-6 (Evidence, pp. 1307-08); Ms S. Taylor, p. 1.
27. The inhalation hazard zone for planning purposes for US land-based commercial reactors has been set at 10 miles (16 km): 10 Code of Federal Regulations 50.47(16)(c)(2). This compares with the 2.2 km Zone 2 used in Australian planning for the much smaller naval reactors.
28. The requirements are set out in 10 Code of Federal Regulations 50, Appendix E, Part IV(F). The required exercises are graded, with a 'full participation' exercise being required as part of the initial licensing process and at least once every 7 years thereafter. A full particpation exercise is defined as including licensee, State and local government personnel in sufficient numbers to verify the capability to respond to the accident scenario. The scope of the exercise shall be such 'as is reasonably achievable without mandatory public participation'.

short of public involvement. The representative of the Natural Disasters Organisation (NDO) on the Visiting Ships Panel (Nuclear) expressed the view in 1986:

> The operational element of the VSP(N) has long felt that the State/Territory exercises have failed to adequately test their operations room staffs but the fundamental problem has been and remains the fact that such procedures remain a State/Territory responsibility. In short, we can propose courses of action or content of exercises but we cannot direct.[29]

10.25 The NDO representative outlined a very detailed 'standard exercise', which involved measures 'to a point just short of causing alarm to the public', and suggested it be put to State/Territory planners.[30] The Committee noted that AIRAC did not recommend that exercises be held in this depth, although it endorsed the holding of exercises.[31] The organisations with the central role in implementing the port safety plans, the State/Territory emergency services, are regularly involved in responding to emergencies of various kinds. It might be argued that their general expertise obviates the need for very detailed exercises specifically relating to the port safety schemes.

10.26 The Committee RECOMMENDS that no visit to a port be allowed unless the Visiting Ships Panel (Nuclear) is satisfied, after consultation with the relevant State/Territory planners, that the safety plan for that port has been exercised in sufficient depth to demonstrate its adequacy and efficacy.

Frequency

10.27 The view has been taken by Tasmanian planners that there

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29. 'Standard Exercise for Use at All Cleared Ports/Anchorages Immediately Prior to an NPW Visit', (undated paper presented to VSP(N) on 7 August 1986), para. 4.
30. ibid., para. 7.
31. ibid., para. 3; AIRAC, 'Review of Safety and Monitoring Arrangements for Visits by Nuclear Powered Warships', p. 5 (Evidence, p. 756).

is no necessity to hold exercises until just prior to a visit.[32] Exercises are generally held at other ports in conjunction with visits also.[33] This accords with the recommendation in OPSMAN 1:

> State/Territory authorities should conduct exercise activations of their Port Safety Organisations prior to the visit of a NPW, especially where those visits are infrequent or when key personnel change.[34]

10.28 There is no requirement in either the Commonwealth documentation or the port-specific plans to hold exercises at set intervals. The Committee noted that the frequency of exercises in relation to land-based reactors in the United States is closely regulated, with the least detailed level of exercise being required at least once a year.[35] For land-based reactors generally, the International Atomic Energy Agency suggests that the interval between major exercises should be not less than 12

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32. Information supplied at briefing to Committee members by Tasmanian officials, 21 March 1988. See also the submission from the Tasmanian Government, p. 4.
33. In 1982 for example, a training exercise was held in February in Western Australia involving Commonwealth and State officials; in April in Brisbane to coincide with a visit; and in May in Hobart, again in conjunction with a visit: Department of Home Affairs and Environment, Visits by Nuclear Powered Warships to Australian Ports: Report on Radiation Monitoring during 1982, (DHAE, Canberra, 1983), pp. 6, 7 and 9. Other reports in this annual series note exercises held during the reporting year. In a paper prepared by the Natural Disasters Organisation representative on the VSP(N) for presentation to it on 7 August 1986, 'Standard Exercise for Use at All Cleared Ports/Anchorages Immediately Prior to an NPW Visit', it is noted (para. 1):

    > Since the resumption of NPW visits in 1976 it has been standard practice to conduct a radiation monitoring exercise immediately prior to a visit, with the aim of:
    > a. verifying the serviceability of both fixed and mobile radiation monitoring equipment; and
    > b. exercising the State/Territory radiation monitoring teams, Radiation Officer and S/TES operations team in response to a simulated controlled release of radioactive material to atmosphere.
34. OPSMAN 1 (2nd edn.), para. 447 (Evidence, p. 81).
35. 10 Code of Federal Regulations 50, Appendix E, Part IV(F)(2). This requirement relates to the licensee's emergency plan. Less frequent exercises are required for emergency plans involving off-site use of State and local government resources.

months or more than 36 months.[36]

10.29 The Committee sees no need for a requirement for exercises at fixed periods. Unlike land-based reactors, for a naval reactor the time in which an accident may occur is limited to the period of the visit. There is, in the Committee's view, no reason to maintain a readiness to respond to an accident when no visits are due.[37] Visits are notified sufficiently far in advance to permit any necessary refresher exercise to be held before the vessel arrives.[38]

10.30 It does not appear to the Committee that the need to hold exercises with sufficient frequency has been neglected. Nonetheless, the Committee considers that there be formal requirements imposed, so as to ensure a satisfactory frequency of exercises. The Committee considers that the requirement to hold an exercise should take account of both the period since the last exercise and any change in key personnel since than.

10.31 Accordingly, the Committee RECOMMENDS that no visit to a port be allowed unless, immediately before the visit, there has been an exercise of the port safety organisation. No exercise should be required, however, if an exercise has been held at the port during the previous 12 months, and there has been no change in key personnel since that exercise.

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36. International Atomic Energy Agency, Emergency Preparedness Exercises for Nuclear Facilities: Preparation, Conduct and Evaluation, (Safety Series No. 73, IAEA, Vienna, 1985) p. 7.
37. cf. the Clyde area public safety scheme, which covers areas in Scotland around bases used by US and UK nuclear powered vessels, is exercised four times a year, with a major field exercise held every three years: UK, Parliamentary Debates (Commons), 6th series, vol. 140, Written Answers, 10 November 1988, col. 303. Vessel presence at the bases would be much higher than at Australian ports, which receive only occasional visits.
38. OPSMAN 1 (2nd edn.), para. 310 (Evidence, p. 63) states that public notification is usually given 10 days prior to a visit. But State/Territory Governments are notified when the visit request is made and of the decision on the request: ibid., para. 301 (Evidence, p. 60).

10.32 The WA Port Safety Scheme provides for a Port Nuclear Safety Panel and states:

> The functions of the panel are to handle all the routine arrangements relating to the Port with respect to nuclear powered warship visits. This includes:
> a. maintaining a communications link between the ship(s) and the Western Australian State Emergency Service,
> b. provid[ing] an officer to assist the officer-in-charge of Zone 1 responsible for the evacuation of the zone should it be necessary.
> The Port Nuclear Safety Panel is required to meet, at the discretion of the Chairman, prior to and following the visit of a nuclear powered warship.[39]

10.33 Senator Vallentine informed the Committee that she had been told by the Director of the Western Australian State Emergency Service that the WA Port Nuclear Safety Panel did not meet either before or after the 18-24 July 1986 visit to Western Australia by three United States nuclear powered surface ships.[40] Senator Vallentine put the argument that if the Chairman of the Panel did not think it appropriate that it meet on that occasion, it must be doubted if it would ever meet at all.

10.34 In addition, the Committee had difficulty understanding the concept of a Panel that is required to meet, yet whose chairman has a discretion on whether the meeting should take place.

10.35 The Committee sought further information from the chairman of the Panel, the Director of the Western Australian State Emergency Service, who replied:

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39. WA Port Safety Scheme, paras. 208-09.
40. Letter from Senator J. Vallentine, 19 August 1988, p. 2.

> I cannot recall specific details of my discussions with Senator Vallentine, however my records show that the Port Nuclear Safety Panel met, prior to the ships' arrival, on 2 July, 1986 and again on 28 July, 1986 following the ships' departure.[41]

10.36 On the matter of discretionary meetings, the Director explained:

> The discretion permitted the Chairman of this panel in calling for meetings is based on the fact that the frequency of visits, and thus the familiarity of panel members with the arrangements required, allowed the Chairman to co-ordinate these matters by telephone, without having to assemble members for what has become routine for each visit. This, however, is only likely if the visit is by a single ship like a submarine or similar class vessel.[42]

10.37 The Committee does not consider the existence of a discretion on this basis to be inappropriate. However, the Committee considers that the wording of the Scheme could usefully be amended to make clear the reason for, and scope of, the discretion.

10.38 Senator Vallentine also drew the Committee's attention to what she regarded as a further example of lack of preparedness in practice. The WA Port Safety Scheme, paragraph SP B5, states in part: 'The availability of essential equipment, services and documentation at the State Emergency Operations Centre is to be confirmed prior to the visit'. Senator Vallentine said that her discussions in 1986 with the State Emergency Service Director and

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41. Letter from the Director, WA State Emergency Service, 16 December 1988, p. 1. The Director also noted that, while the Panel had operational responsibilities, another body, the WA Visits Co-ordinating Committee, had planning responsibility. Because it has no operational responsibilities:

    > there is therefore no need for the WA Visits Co-ordinating Committee to meet prior to each visit. Not withstanding the above, the WA Visits Co-ordinating Committee usually meets once or twice a year and whenever a situation dictates, to examine particular issues and ensure the currency of the scheme.

42. ibid.

Deputy Director indicated that this confirmation did not occur in practice.[43] Neither person, for example, could tell her how much protective clothing was available or where it was located.

10.39 The Committee noted in paragraphs 8.131-8.132 that the documentation relating to visits does not contain complete lists of the personnel or equipment required to carry out monitoring. Similarly, there is no comprehensive list in any of the available documentation of those for whom protective clothing would be required.[44]

10.40 The Director of the Western Australian State Emergency Service informed the Committee that approximately 25 sets of protective clothing for use in relation to the WA Port Safety Scheme are held at HMAS STIRLING by the Navy for issue prior to each visit.[45] The Director noted that protective clothing is

> only required for those persons likely to be involved in directly dealing with the ship concerned ... [such as] the crew of the navy tugs, navy shore parties, fire fighters, and the Police crew of water craft likely to be involved in securing the surrounds of a ship at anchorage, or in movement during an incident.[46]

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43. Letter from Senator J. Vallentine, 19 August 1988, p. 2.
44. OPSMAN 1 (2nd edn.), Chapter 4, Annexes F and G (Evidence, pp. 102-03) deal with the protective clothing for shore parties and towing vessel crews. ANSTO, Radiation Monitoring Handbook for Visits by Nuclear Powered Warships to Australian Ports, (ANSTO, Lucas Heights, NSW, 1985), p. 47 (Evidence, p. 341) lists the protective clothing required by a mobile radiation monitoring team.
45. Letter from the Director, WA State Emergency Service, 16 December 1988, p. 2.
46. ibid.

DECONTAMINATION

Introduction

10.41 Criticisms were made in submissions of the current plans for what was seen as insufficient provision for decontamination.[47] Decontamination requirements following an accident can be placed under two headings: immediate decontamination of persons, vehicles, etc. evacuating from close to the vessel, and longer term decontamination of areas affected by deposition from the airborne plume.

Decontamination of Persons

10.42 ANSTO's Radiation Monitoring Handbook states:

> Personal decontamination is necessary only in the case of detected or suspected skin contamination. In general, ordinary shower facilities are adequate. If large numbers of people are involved and showering is not feasible, the careful removal of outer garments followed by the washing of hands, face and possibly hair could be sufficient. Personal decontamination can be of prime importance for some people who were outdoors under the plume, as contamination of the skin and especially of the hair may contribute a large dose.[48]

10.43 The Handbook recommends that decontamination of Zone 1

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47. e.g. submissions from Prof W. J. Davis, pp. 82-85 (Evidence, pp. 529-32); Esperance Nuclear Awareness, p. 1; Scientists Against Nuclear Arms (WA) and Medical Association for the Prevention of War (WA), p. 13 (Evidence, p. 799). See also letter from Mr M. Lynch, 23 March 1988, p. 2 (Evidence, p. 915).
48. ANSTO, Radiation Monitoring Handbook for Visits by Nuclear Powered Warships to Australian Ports, (ANSTO, Lucas Heights, NSW, 1985), p. 44 (Evidence, p. 338). During a 1987 fire at ANSTO's Lucas Heights research laboratories 4 persons were contaminated by radiation. 'All contamination was quickly removed by washing with soap and water': ANSTO, Report of the Committee of Inquiry into a Fire which Occurred on 18 March 1987 in a Radioisotope Processing Cell, Building 54 at the Lucas Heights Research Laboratories, (ANSTO, Lucas Heights, NSW, 1987), p. 3.

evacuees 'will be arranged, as necessary and with advice from the RMG [Radiation Monitoring Group], by the officer in charge of zone 1'.[49] The Handbook also states that contamination control points should be defined during the planning stages of a visit. The points should be near Zone 1, and are usually located at port security control points. They should be equipped with a hose or other water facilities for use in decontamination of persons and vehicles leaving the area.[50]

10.44 Of the plans examined by the Committee, only the HMAS STIRLING Sub-Plan meets the criteria in the Handbook. It designates the shower block required to be used as a personnel decontamination station, with provision made for loan of clothing to those who have been decontaminated.[51] There is also a requirement that controls be exercised over vehicles departing Zone 1, until they have been cleared of contamination.[52] The Committee considered that, if provisions are to be required (on which see below), the decontamination provisions in this plan provide a general model for other Australian plans.

10.45 For Gage Roads off Fremantle, there is little need for decontamination points: the anchorages are several kilometres off shore and no land lies within any of the Zone 1's. The WA Port Safety Plan does not require decontamination of any small craft or those on board who may have been close to, and downwind of, the vessel.

10.46 The Hobart Safety Scheme requires that civilian evacuees from the vessel be held at named control points in order to be checked for radioactive contamination: 'further actions will be as required' by the State Radiation Officer.[53] There is no

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49. ibid., p. 13 (Evidence, p. 307).
50. ibid., p. 28 (Evidence, p. 322).
51. Para. 1310(12).
52. Paras. 1310(13) and 1310(15).
53. Hobart Safety Scheme, para. 1115. See also ibid., paras. 1305(d), 1306(h), 1311(b) and 1316.

provision for monitoring and decontaminating other evacuees from Zone 1. The Committee was told that adequate showering facilities existed near the only alongside berth used, which is at Macquarie Wharves.[54] The Tasmanian Government also informed the Committee that a decontamination unit was available to treat members of the public if required.[55]

10.47 The plans for Brisbane and Darwin make no provision for personal decontamination of those evacuating from Zone 1. In both cases it is possible that significant numbers of port workers and others will be in the Zone 1's for the berths used.

10.48 On the need for personal decontamination provisions in the plans, the Radiation Monitoring Handbook states:

> It is anticipated that contamination control would only be needed in rare circumstances and at a later stage of the reference accident.[56]

10.49 The Committee was unclear, as a result of this, to what extent planning for personal decontamination measures ought to be required. If the planned immediate evacuation of Zone 1 is successful, at most only a handful of persons would be present at a later stage of the accident to become contaminated. These persons, all presumably emergency personnel, would not require a control point and mass decontamination facility. Their limited requirements could be met without need for specific provision in the plans.

10.50 If, contrary to the view in the Radiation Monitoring Handbook, measures were required at the outset of the accident, it is unlikely that personnel monitoring could be organised in

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54. Information supplied at briefing to Committee members by Tasmanian officials, 21 March 1988.
55. Submission from the Tasmanian Government, p. 4.
56. ANSTO, Radiation Monitoring Handbook for Visits by Nuclear Powered Warships to Australian Ports, (ANSTO, Lucas Heights, NSW, 1985), p. 28 (Evidence, p. 322).

time to deal with the immediate evacuees from Zone 1. The absence of monitoring facilities is perhaps not critical if decontamination facilities are available, as a worst-case assumption can be made and all evacuees decontaminated.

10.51 However, a delay could be expected in organising anything more than rudimentary decontamination facilities, except at berths where shower blocks existed near the exits as part of the ordinary port facilities. To hold the evacuees at the control point near the Zone 1 perimeter, pending the arrival of mobile decontamination facilities, might result in increased exposure to airborne contamination.

10.52 Because the Committee lacks the information to state confidently that personal decontamination would not be required, it concludes that provision should be made for it in all the Australian plans.

10.53 The Committee RECOMMENDS that port safety plans for alongside berths include arrangements, such as those existing for HMAS STIRLING, for the monitoring of evacuees from Zone 1, and for the decontamination of those found to be contaminated. For anchorages, where the Zone 1 comprises no land area, the Committee RECOMMENDS that the plans require that advice be given to those who might be within Zone 1 and downwind of the vessel of the need to take decontamination measures.

10.54 The advice could be passed via marine radio, public broadcasts, police water patrols or other means. No decontamination facilities need to be specifically provided, given the ready availability of water for washing.

Other Decontamination

10.55 In addition to a possible need to decontaminate those near the vessel at the time of the accident, a need may also arise to deal with contaminated areas. The extent of this latter need can only be determined by radiation monitoring carried out following the accident. The radiation monitoring guidelines make provision for this to be done.[57] The Radiation Monitoring Handbook provides details on how the monitoring and subsequent decontamination is to be done.[58]

10.56 The Committee does not consider that plans should be required to contain detailed provision for surface decontamination. Until monitoring has defined the scope of any need to decontaminate there is little specific provision that could be usefully included in plans. The necessary monitoring facilities are provided for. Other requirements for a decontamination program could be met from locally available resources and personnel without the need for prior planning. Given the characteristics of the reference accident, the extent of any decontamination required is not likely to be major.

ROLE OF FIREFIGHTERS

Introduction

10.57 The Committee was made aware that some firefighters considered that they have been inadequately trained for what they

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57. Department of Defence, Environmental Radiation Monitoring during Visits of Nuclear Powered Warships to Australian Ports: Requirements, Arrangements and Procedures, (May 1988), pp. 8-9. For an earlier version of these provisions see Evidence, pp. 289-90.
58. ANSTO, Radiation Monitoring Handbook for Visits by Nuclear Powered Warships to Australian Ports, (ANSTO, Lucas Heights, NSW, 1985), pp. 18, 28-29, 45 (Evidence, pp. 312, 322-23, 339). For further detail on decontamination procedures see International Atomic Energy Agency, Manual on Decontamination of Surfaces, (Safety Series No. 48, IAEA, Vienna, 1979).

assumed would be their role following a reactor accident.[59] The Committee wrote to relevant unions in June 1988 seeking their views. The unions in Tasmania and Western Australia did not respond. Replies from other unions supported the claims of inadequate training.[60]

10.58 In order to determine the merits of this claim, it was necessary for the Committee to determine in what ways fire-fighters might be involved, based on the reference accident. One possible role relates to post-accident decontamination. Fire-fighters might also be involved in dealing with the accident directly if it involved a fire on the vessel.

Decontamination Role

10.59 The HMAS STIRLING Sub-Plan makes no provision for civilian firefighters to be involved at any stage of a reactor accident. Although the WA Port Safety Plan similarly makes no provision, members of the Committee were told by officials that the fire brigade might be used to assist with decontamination.[61] The Brisbane Safety Plan provides that the Metropolitan Fire Brigade is responsible for the 'normal firefighting role, and assistance with decontamination of any affected surfaces'.[62] The plans for Darwin and Hobart do not refer to firefighters.

10.60 The Committee noted that the NSW Fire Brigade is assigned a role in decontamination under the safety plan for the

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59. Evidence, p. 1388 (Coalition Against Nuclear Armed & Powered Ships); p. 1395 (Senator McMullan); submission from the NSW Fire Brigade Employees' Union, p. 7; 'Firemen want nuclear accident plan for US ships', Advertiser (Adelaide), 20 October 1986, p. 3.
60. Submission from the NSW Fire Brigade Employees' Union, p. 7; letter from the United Firefighters' Union (Vic), 21 July 1988; letter from the Australian Fire Service Unions, 1 August 1988; United Firefighters Union (Qld), 4 August 1988.
61. Information supplied at briefing to Committee members by WA officials, 1 February 1988.
62. Para. 332.

ANSTO reactor at Lucas Heights near Sydney.[63] The NSW Fire Brigade Employees' Union told the Committee that its members had not been provided with radiation decontamination training, nor the special equipment it regarded as necessary for the task.[64] The plan, however, indicates that no special training is required, and any special items of equipment required will be supplied by ANSTO.[65]

10.61 This appeared to the Committee to apply also in the context of the plans which form the subject of this inquiry,[66] although the plans are not explicit on the point. Some equipment needed, such as respirators and protective clothing, is part of the standard equipment of firefighters.[67] Other items, such as dosemeters and special cleaning fluids, could readily be supplied at the site.

10.62 There is no reason why the surface decontamination measures with which firefighters are expected to be involved will be urgent. Once any required evacuation has been completed, the immediate threat to health ceases. The need to avoid inconvenience and to permit general entry to the evacuated area govern the speed with which decontamination must be done. Equipment

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63. ANSTO, APTCARE-Lucas Heights: A Plan to Cope with Accidents at the Research Establishment of the Australian Atomic Energy Commission, Lucas Heights, NSW, (ANSTO, Lucas Heights, NSW, 1986), para. 303.4.
64. Submission from the NSW Fire Brigade Employees' Union, p. 7.
65. ANSTO, APTCARE-Lucas Heights: A Plan to Cope with Accidents at the Research Establishment of the Australian Atomic Energy Commission, Lucas Heights, NSW, (ANSTO, Lucas Heights, NSW, 1986), Annex I, para. 3.
66. cf. First supplementary submission from the Department of Defence, Part 6B (Evidence, p. 238.251): in response to the criticism that the Australian Defence Force has no training in decontamination, the Department of Defence stated that the plans do not envisage any direct role by the ADF in decontamination, and that decontamination would be coordinated by, and draw on the expertise of, ANSTO.
67. Submission from the NSW Fire Brigade Employees' Union, p. 8. See also ANSTO, Report of the Committee of Inquiry into a Fire which Occurred on 18 March 1987 in a Radioisotope Processing Cell, Building 54 at the Lucas Heights Research Laboratories, (ANSTO, Lucas Heights, NSW, 1987), p. 6: NSW Fire Brigade fire appliances which attended the fire were equipped with protective clothing for fire personnel should it have been needed.

required to be delivered from ANSTO stores at Lucas Heights near Sydney would be available in less than 12 hours even at the more distant ports such as Darwin and HMAS STIRLING in Western Australia.[68]

10.63 Therefore, there would be adequate time to ensure that all were appropriately equipped and that any required system of radiation exposure control was in place. Radiation experts would be on hand to direct activities to ensure that they were conducted in a safe manner. For these reasons, the Committee considers that it is unnecessary to provide specific training to firefighters with respect to any role that they might have in post-accident surface decontamination measures.

Firefighting Role

10.64 A fire may occur on a nuclear powered vessel without necessarily involving the reactor. The scenarios leading to the reference accident do not require fire as its cause. If the reference accident occurred, there is no reason why a fire would be expected to result. Therefore the need to plan for fire-fighting in a radioactive environment is much smaller than the already very small likelihood of the reference accident occurring.

10.65 It appeared to the Committee that there is a need for a system of radiation exposure control to be in place to ensure that firefighters do not exceed recommended exposure levels. But apart from this, fighting a fire in a radioactive environment appeared to be similar to fighting fires in other situations where respiratory protection and protective clothing needed to be

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68. OPSMAN 1 (2nd edn.), Chapter 4, Annex I details the arrangements to achieve this, including the use of facilities at Sydney airport and an RAAF transport aircraft from Richmond RAAF base: 'these arrangements should make the resources available, eg in HMAS STIRLING within 10 hours'.

worn.[69] Civilian firefighters would not need to be self-sufficient in radiation exposure control, as the plans provide for radiation monitoring experts to be present. Although Australian planning is not dependent on them, members of the vessel's crew would also probably be available to provide expert direction.

10.66 Moreover, naval vessels possess their own firefighting equipment and their crews are trained in fighting fires on board the particular vessel. Civilian firefighters lack the same degree of specialised knowledge and training. Therefore, it appeared to the Committee that civilian firefighters would not be expected to lead, or probably even to play a subordinate role in, the response to a fire on a nuclear powered warship.

10.67 The firefighters' unions did not refer to any occasion on which their members had been called on to deal with a fire on a visiting naval vessel. The Committee is not aware of any such occasion. Although the Brisbane Port Safety plan refers to fire-fighters carrying out their normal firefighting role, it is not clear that this role includes fighting fires on visiting war-ships. The other Australian port safety plans make no provision for civilian firefighters to have a fire fighting role.

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69. For a general textbook dealing with firefighting in the presence of radiation hazards, see L. Whitman, Fire Safety in the Atomic Age, (Nelson-Hall, Chicago, 1980). For the lessons learned from firefighting in 1986 at Chernobyl, see Organisation for Economic Cooperation and Development, Nuclear Energy Agency, Chernobyl and the Safety of Nuclear Reactors in OECD Countries: Report by an NEA Group of Experts, (OECD, Paris, 1987), p. 64. See also International Atomic Energy Agency, Summary Report on the Post-Accident Review Meeting on the Chernobyl Accident: Report by the International Nuclear Safety Advisory Group, (IAEA, Vienna, 1986), p. 11: in regard to Chernobyl, 'fighting fires in a nuclear power plant with an added large scale radiological hazard was an entirely new experience'. The particular difficulties experienced in firefighting at Chernobyl are noted ibid., pp. 44-45. One, burning graphite, would not be present on a visiting warship. Another, lack of equipment to place firefighters on the roof of the reactor building, is also not relevant to warship visits. Other issues noted, such as the need for fire-fighting robots, are also more relevant to the scale of the Chernobyl accident than the much smaller scale of any accident that could occur on a visiting warship. The report also notes the need for lightweight clothing for both heat and radiation protection.

10.68 For all these reasons, the Committee does not envisage any need for civilian firefighters to receive specialist training to deal with fires aboard visiting nuclear powered warships. However, the Committee considers that the correctness of this view should be confirmed (see paragraph 10.70).

10.69 If it is correct, the Committee considers that the wording of the port safety plans could usefully be amended so as to make clear that civilian firefighters are not expected to play a primary role in dealing with the highly unlikely event of a combination of a fire and reactor radiation hazard aboard a visiting warship. If it is not correct, either generally or in respect of a particular port, the Committee considers that civilian firefighters should receive any necessary training for the role assigned to them in the relevant plan.

10.70 Accordingly, the Committee RECOMMENDS that the Department of Defence, based on consultation with the navies of the countries to which the visiting warships belong, provide guidance to State/Territory planners on the planned role of civilian firefighters in the highly unlikely event of a combined fire and radiation hazard on a visiting nuclear powered warship. The Department should attempt to ensure that plans make clear either the role that civilian firefighters have, or the fact that they have no role, as the case may be. If the role requires specialist training and equipment, these should be provided as part of the plans.

PUBLIC INFORMATION FOLLOWING AN ACCIDENT

Introduction

10.71 Issues relating to the availability of plans and provision of information prior to nuclear powered warship visits were discussed in chapter 8. The occurrence of any nuclear accident or incident, however trivial, can be expected to create intense media and public interest.[70] The same is true of a false alarm or rumour that an accident has occurred.

10.72 It is important, in the Committee's view, that plans are in place to respond to the expected demand for information.[71] The provision of timely and accurate information will play a major role in allaying unnecessary concerns and assisting in an orderly implementation of any protective measures that might be required.

10.73 For example, a report into a fire at ANSTO's Lucas Heights Research Laboratories (LHRL) noted that ANSTO:

> has acknowledged that procedures implemented on the occasion of the fire at LHRL on 18 March 1987 did not cope adequately with providing information to the media and the general public. One consequence which resulted in widespread criticism, especially from local residents, was that credible information was not available to the public to counterbalance the alarmist media reports which were broadcast within minutes of the call to the NSW Fire Brigade. Apart from the unnecessary alarm among local residents, a further more general consequence was the inaccurate impressions throughout Australia and internationally that there had been a major reactor incident.[72]

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70. See for example ANSTO, Public Information during Incidents at Lucas Heights Research Laboratories, (ANSTO, Lucas Heights, NSW, 25 March 1987), p. 2, for the initial sensationalised and inaccurate treatment by the electronic media of a minor fire at Lucas Heights on 18 March 1987. The fire did not involve the reactor at the site.
71. cf. T. P. Haire, 'Emergency Preparedness in the Central Electricity Generating Board: Development of Emergency Procedures Following the Three Mile Island Accident' in International Atomic Energy Agency, Operational Safety of Nuclear Power Plants: Proceedings of an International Symposium, Marseilles, 2-6 May 1983, (IAEA, Vienna, 1984), vol. 2, p. 392:

    > The accident at Three Mile Island emphasized the need for the rapid, clear, reliable and authoritative issue of information to the public.
72. ANSTO, Public Information during Incidents at Lucas Heights Research Laboratories, (ANSTO, Lucas Heights, NSW, 25 March 1987), p. 1.

10.74 It appeared to the Committee that experts agree it is desirable that post-accident information should be provided to the public as far as possible through a single information centre.[73] In order that this centre retain credibility it must be in a position to provide accurate, timely and authoritative statements, and to respond to questions. In this context, journalists have said that:

> it was important to have a spokesman who both understood the technicalities and was able to explain them to the media. Ideally, this spokesman should not himself be involved in operational aspects, so that his main role could be that of a communicator.[74]

10.75 The Department of Defence has stated that port safety plans should include draft messages and instructions to the public relating to an accident.[75] After insertion of the

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73. e.g. International Atomic Energy Agency, Planning for Off-Site Response to Radiation Accidents in Nuclear Facilities, (Safety Series No. 55, IAEA, Vienna, 1981), p. 59; 'Panel: Informing the Public' in International Atomic Energy Agency, Current Nuclear Power Plant Safety Issues: Proceedings of an International Conference, Stockholm, 20-24 October 1980, (IAEA, Vienna, 1981), vol. 1, pp. 354-56; J. Scanlon and others, 'Coping with the Media in Disasters: Some Predictable Problems', Public Administration Review, January 1985, vol. 45(S), p. 126. See also ANSTO, Public Information during Incidents at Lucas Heights Research Laboratories, (ANSTO, Lucas Heights, NSW, 25 March 1987), p. 4: as one of the actions to be implemented following the unsatisfactory public information response to the 18 March 1987 fire at Lucas Heights, 'a permanently equipped public information facility will be constructed for use on all occasions when there is a high demand for public information'. It is stated that the facility will have multiple dedicated PABX extensions, TV and radio to permit monitoring of media reporting of the course of incidents, and word processing facilities to assist in the rapid preparation of media releases: ibid., pp. 4-5.
74. 'Panel: Informing the Public' in International Atomic Eneregy Agency, Current Nuclear Power Plant Safety Issues: Proceedings of an International Conference, Stockholm, 20-24 October 1980, (IAEA, Vienna, 1981), vol. 1, p. 356.
75. OPSMAN 1 (2nd edn.), Chapter 4, Annex H, para. 8(d) (Evidence, p. 110). This requirement is generally recognised as being an appropriate one. e.g. see International Atomic Energy Agency, Planning for Off-Site Response to Radiation Accidents in Nuclear Facilities, (Safety Series No. 55, IAEA, Vienna, 1981), p. 58. See also, for example, the prepared messages in UK, Ministry of Defence, Liverpool Special Safety Scheme for Visits to Liverpool by Nuclear Powered Submarines, (April 1986), Annex 2A.

appropriate factual information, these can be released to the media with a minimum of delay.

Provisions in the Plans

10.76 Measured against these criteria, the Australian port safety plans make inadequate provision for public information following an accident.

10.77 Of the existing plans, the WA Port Safety Scheme sets out reasonably detailed requirements relating to public information.[76] The media liaison office, to which all public inquiries are to be directed, is located at the State Emergency Operations Centre. The staffing, duties, and message-release authority of the office are all defined. The Hobart Safety Scheme contains similar provisions.[77] Members of the Committee who inspected the Centres in February and March 1988 were satisfied with the range of facilities available for providing public information.

10.78 The HMAS STIRLING Sub-Plan makes no provision for public information following an accident. It is unclear if it is intended that the WA Port Safety Scheme provisions apply with regard to this aspect of any accident that occurs at HMAS STIRLING.[78] The Committee considers that this lack of clarity should be remedied.

10.79 The Committee had no information on how the demand for public information would be met following a nuclear powered warship accident at the approved anchorage at Jervis Bay. The anchorage at Jervis Bay is sufficiently far from shore and from

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76. Paras. 801-07.
77. Paras. 1201-1210 and 1456-59.
78. The inference is that they do not, as para. 1315 duplicates that part of the provisions of the WA Port Safety Scheme (paras. 801-02) that relates to information in routine, non-emergency, situations. If all the provisions of the WA Port Safety Scheme (ie. paras. 801-07) were intended to apply to HMAS STIRLING there would be no need to duplicate two of them.

heavily populated areas to render unnecessary all the elements of planning required for berths such as those at, say, Hobart or Darwin.[79] However, this does not, in the Committee's view, diminish the need for planning to meet the post-accident demand for public information.

10.80 The Brisbane Port Safety Plan makes no detailed provision for public information, nor does it state that provision is made in some other, more general, counter-disaster plan.[80]

10.81 The Darwin Port Safety Plan provides: that the Territory Counter Disaster Controller has responsibility to authorise dissemination of information; that only information which is authorised by this person is to be released to the media; and that 'the Protocol and Public Relations Unit, Department of the Chief Minister is the official source of all media and public information'.[81] No indication is given of the location of the information distribution point, of where press briefings will be held, etc.[82]

10.82 None of the plans examined makes provision for anyone with expertise in either nuclear reactors or radiation to be on

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79. See above, paras. 9.123-9.124, for the Committee's conclusions to this effect.
80. The table forming Annex A to Chapter 4 of the Plan allocates to the Executive Officer, State Counter-Disaster Organization and Director, State Emergency Service the function of co-ordinating the release of public information following an alarm. However, the narrative describing the roles of these officers and their organisations (paras. 325-27) does not refer to the provision of public information. An inference might be made that any procedures of the organisations relating to information provision in regard to disasters generally would also apply to a nuclear powered warship accident.
81. Paras. 1101-03.
82. However, the Committee is aware that the relevant personnel possess considerable experience gained in cyclone emergencies in providing public information relating to emergencies.

hand to brief the media.[83] The Committee considers this unsatisfactory, although it understands that in the event of an accident one of the functions of the Commonwealth technical adviser[84] would be to assist in the provision of public information. The Committee also recognises that State and Territory emergency services personnel have considerable experience in providing public information in non-nuclear accidents and emergencies.

10.83 No provision is made in the port safety plans for input from, or coordination with, media liaison activities by the Commonwealth or the country to which the warship belongs. Of the plans examined, only that for Hobart contains draft media releases.[85]

10.84 The Committee considers it important that the various authorities, civil and military, of the foreign government are in a position to present a coordinated response to the public, and that this response is also coordinated with the response by Australian authorities.

10.85 Because of the widespread assumption in the community that all nuclear powered vessels visiting Australia carry nuclear weapons, the Committee considers it important that one of the

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83. cf. T. P. Haire, 'Emergency Preparedness in the Central Electricity Generating Board: Development of Emergency Procedures Following the Three Mile Island Accident' in International Atomic Energy Agency, Operational Safety of Nuclear Power Plants: Proceedings of an International Symposium, Marseilles, 2-6 May 1983, (IAEA, Vienna, 1984), vol. 2, p. 395:

> The TMI accident emphasized the importance of accurate determination of the radiation dose received by members of the public. The widespread public concern and the demand for information on the level of dose received showed that it would be necessary to have precise figures available with the necessary assurance on the small effect of low doses in order to recover and retain public confidence.

84. See for example, the WA Port Safety Scheme, para. 213(c), the Darwin Port Safety Plan, para. 704(f), the Brisbane Safety Plan, para. 324 and the Hobart Safety Scheme, para. 319 on the provision of a Comonwealth Technical Adviser. The adviser is a senior radiation specialist.
85. Hobart Safety Scheme, Chapter 12, Annexes A-E.

officials assigned to provide public information following a reactor accident be sufficiently well-informed to make credible statements on the nuclear weapon safety position also. In practice, the media may not regard as accurate statements on either the technical aspects of the reactor accident or the risk to nuclear weapons which will be assumed to be on board, unless the statements are made or endorsed by a spokesperson for the foreign country.[86]

10.86 The Committee noted that, in United States nuclear weapon accident plans intended to apply in other countries, detailed provision is made for a coordinated public information response.[87] As part of this, provision is made for holding of joint United States/host-country news conferences, and for the demarcation of the public information roles of the United States military and the United States embassy in the host country.[88] The Committee had no information on United States or British plans relating to provision of public information following a reactor accident on one of their vessels while in a foreign port.

10.87 The Committee RECOMMENDS that the Department of Defence confirm that, with regard to the public information response to a reactor accident on a visiting warship, measures are in place to ensure:

(a) that the response of Commonwealth bodies, the State/Territory concerned, and the country to which the warship belongs be coordinated through a single information centre;

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86. As noted in chapter 13, the policy of neither confirming nor denying the presence of nuclear weapons would not limit the provision of information, as one of the standard exceptions to that policy permits the presence of nuclear weapons to be confirmed or denied when necessary to allay public alarm: see paras. 13.44-13.45.

87. e.g. see US, Department of Defense, Directive No. 5230.16 (Nuclear Accident and Incident Public Affairs Guidance) (Encl 3), 7 February 1983, p. 2.

88. e.g. US, United States European Command, USCINCEUR CONPLAN 4367-87-Response to Nuclear Accidents/Incidents within the Theater, 1987, pp. F-1 - F-6.

(b) that technical expertise about naval reactors, nuclear weapons, radiation effects and safety measures be available to that information centre; and

(c) that before visits are approved these public information measures be in place.

10.88 The Committee has no firm view on whether it is essential to have media statements prepared beforehand. The Committee would expect that issue to be resolved by the Department of Defence as part of the steps taken to coordinate the State/Territory, Commonwealth, and foreign country roles in the public information response.

10.89 The Committee noted that the public information provisions in the safety plan (APTCARE) for ANSTO's Lucas Heights Research Laboratories are broadly similar to the more detailed provisions in some of the current port safety plans.[89] The APTCARE provisions were tested by the fire that occurred at Lucas Heights on 18 March 1987. A subsequent report recommended:

> that the emergency information provisions of APTCARE be reviewed by the State Authorities in conjunction with AAEC [now ANSTO]. The experiences of 18 March 1987 suggest that the procedures outlined in the APTCARE document (p. 28) cannot cope with the level of information demand which could be expected.[90]

10.90 The Committee is concerned that the public information arrangements under at least some of the plans subject to its inquiry may be similarly deficient in relation to the volume of inquiries that might be received. Members of the Committee who inspected the facilities at the Tasmanian and Western Australian

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89. See ANSTO, APTCARE-Lucas Heights: A Plan to Cope with Accidents at the Research Establishment of the Australian Atomic Energy Commission, Lucas Heights, NSW, (ANSTO, Lucas Heights, NSW, 1986), Annex E, Appendix 2.

90. ANSTO, Public Information during Incidents at Lucas Heights Research Laboratories, (ANSTO, Lucas Heights, NSW, 25 March 1987), p. 6.

State Emergency Service headquarters and considered them suitable in this regard.[91] But the Committee did not inspect the facilities in all places receiving visits.

10.91 Accordingly, the Committee RECOMMENDS that the Department of Defence ensure that the report on the inadequacies of the public information provisions of APTCARE are drawn to the attention of State/Territory planners, together with the results of the review of these provisions in APTCARE. Further, the Department should ensure that the planners incorporate in their plans all relevant lessons of the public information response at Lucas Heights following the 18 March 1987 fire there.

FOREIGN COUNTRY INVOLVEMENT IN ACCIDENT RESPONSE

Introduction

10.92 The Committee noted that a 1984 report by a subcommittee of the Visiting Ships Panel (Nuclear) on post-accident vessel removal concluded:

> There is a total lack of knowledge of the contingency procedures that the United States authorities (both internal and external to the NPW) would implement in the event of a reactor incident. ... Recommendations contained in this Report may be found in practice to be incompatible with mutually co-operative efforts to resolve an incident.[92]

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91. For example, the Tasmanian State Emergency Service telephone equipment has the ability to automatically transfer calls from an overloaded switchboard to another number at, say, the Police Operations Room. Plans have been made to ensure that this Room remains operational following an accident even though it is in an area (Zone 2) that might require evacuation: Hobart Safety Scheme, Chapter 14, Annex D, para. 3.
92. Department of Defence, VSP(N), Report on the Protection of Personnel Engaged in the Removal of Nuclear Powered Vessels Following a Reactor Accident, (18 May 1984), paras. 19 and 21.

10.93 The need to integrate the actions of the foreign country to which the warship belongs with those of Australian authorities has already been considered in two contexts. One relates to the provision of public information.[93] The other concerns the requirement that an anchored warship's crew release its anchor to permit post-accident vessel removal.[94] The Committee considered if the need to integrate contingency procedures extended to other aspects of planning.

10.94 Under the current demarcation in contingency planning, the warship's crew are responsible for actions required to be taken on board the vessel. Australian plans cater for all responses required elsewhere, including vessel removal.[95]

Appropriateness of the Current Planning Demarcation

10.95 The Department of Defence informed the Committee that it is not the practice of the United States to devise integrated plans with countries hosting visits.[96] The Department expressed the view that it would be inappropriate for the foreign country to which the warship belonged to prepare detailed plans to respond to a reactor accident in an Australian port. Planning that extended beyond the warship itself would intrude on Australia's sovereign responsibility to coordinate the accident response in one of its ports.[97] The Committee regards this view as correct.

10.96 The Committee could foresee difficulties if the warship's crew were to be integrated into Australian planning in ways that required them to act under the direction of Australian authorities. In addition, it would not be possible to predict in

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93. Paras. 10.83-10.87.
94. Paras. 9.64-9.69.
95. e.g. see Evidence, p. 1300.44 (Department of Defence).
96. Evidence, p. 1300.43 (Department of Defence).
97. First supplementary submission from the Department of Defence, Part 4 (Evidence, p. 238.245).

advance how many of the crew would be available and what expertise the particular members who were available would have. The visiting warships have differing crew sizes. More importantly, the events of an accident may have killed or injured some of the crew, or made their presence essential on board the vessel itself.

10.97 The Committee considers that there are sufficient Australian resources to operate the Australian plans in the period immediately after the accident. Therefore the Committee could see no need to integrate the warship's crew into those plans. The current demarcation of spheres of planning responsibility is, in the Committee's view, appropriate from the perspectives of Australian sovereignty and effective use of resources.[98]

Potential for Conflict between Uncoordinated Plans?

10.98 However, the issue remains whether lack of knowledge by local planners of the contingency arrangements applying on the warship would reduce the effectiveness of the local response. The lack of knowledge arises because, according to the Australian Department of Defence, 'the USN has advised that it is forbidden under the Atomic Energy Act from discussing the details of its emergency response procedures'.[99]

10.99 Australian authorities have adopted two types of measures to reduce the likelihood of conflict. The first is to make sure that the content of the local port safety plan is made known to the commander of each visiting warship.[100] No formal, written assurance has been obtained from the United States Navy that the responses outlined in these plans will not conflict with the planned response on the warship. However, informal assurances

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98. Evidence, p. 1300.44 (Department of Defence): it is not clear that integration of plans would result in savings in Australian resources and costs.
99. Evidence, p. 1300.43 (Department of Defence).
100. ibid.

have been given that there is no conflict between the two sets of planned responses.

10.100 The second means adopted to prevent conflicting accident responses is to ensure that visiting warship commanders are aware of the need for co-operation, and that a communication channel exists to facilitate post-accident co-operation.[101]

10.101 As a result of these measures, the Department of Defence told the Committee that:

> there is virtually no risk that the independent accident reactions of the crew of a visiting NPW and those of local authorities/services will lessen the effectiveness of each.[102]

10.102 The Committee accepted this view, both because the current demarcation of planning responsibilities minimises the likelihood of conflict and because of the other steps taken to avoid conflicting accident-responses.

Possible Overlap in Monitoring Arrangements

10.103 The Committee noted that the standard statements of assurances by both the United States and United Kingdom provide in respect of a visit by one of their nuclear powered warships:

> During the period of the visit, the personnel of the nuclear-powered warship will be responsible for radiological control on board the ship and for environmental monitoring in its immediate vicinity.[103]

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101. ibid.

102. Evidence, p. 1300.44 (Department of Defence). The Department also noted that 'the planned efficient communication between the NPW and the controller of the local safety organisation would minimise the scope for confusion'.

103. US, 'Standard Statement', para. 2(b) (Evidence, p. 1078). See also the virtually identical UK statement, para. 2(b) (Evidence, p. 1300.16).

10.104 These assurances are addressed to any country that receives a visit, not specifically to Australia. The Committee notes that, independently of this, environmental monitoring in the vicinity of the vessel during port visits is undertaken by Australian personnel.

COMPENSATION ISSUES

Introduction

10.105 A number of legal issues would confront someone seeking compensation for injury to their person or property resulting from a reactor accident aboard a visiting warship. The issues, which are referred to in more detail in Appendix 4, include questions of proof, the standard of liability, and the steps required to recover compensation from a foreign country either through the courts or through administrative means.

10.106 The port safety plans are, in the Committee's view, operational documents designed to guide the immediate response to an accident should it occur. The Committee does not consider that the broader legal issues relating to compensation of individuals for injuries received ought to be addressed in these plans. Moreover, for the reasons given in chapter 8, the Committee has not made recommendations on these issues. However, the Committee did consider the issues of record keeping and a possible register of those present in the vicinity of the accident as these matters related directly to planning.

10.107 Resolution of subsequent legal claims will be greatly assisted if accurate records of the course of the accident and of the accident response are made and retained. This is because there may be a long latency period before an injury caused by exposure to a low dose of radiation becomes apparent. Compensation claims may need to be considered many years after the accident. The main matter of concern to individuals is that a record should be made of their presence at particular locations, of the level of radiation at those locations, and of the fact of being advised to evacuate, being monitored, or undergoing decontamination.

Present Provisions

10.108 The port plans make little explicit provision for recording personal details and movements. The general absence in the current plans of detailed provisions on evacuation and decontamination was noted earlier in this chapter. It follows that on the whole the plans make no provision for record keeping in respect of these activities.

10.109 An exception to these comments is the HMAS STIRLING Sub-Plan, which notes the general importance of keeping adequate records and particularises categories of activities which efforts must be made to record.[104] In addition, ANSTO's Radiation Monitoring Handbook states that, in the context of making provision for decontamination, the names and addresses of all contaminated persons, together with details of the contamination, must be recorded by the team surveying those leaving Zone 1 following an accident.[105]

Proposed Changes

10.110 The Department of Defence told the Committee that it regarded provision for the listing of people possibly exposed to

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104. See also the Hobart Safety Scheme, para. 1314(d) (register of civilians evacuated from the vessel) and para. 1427 (register of evacuees referred to the designated assembly areas, to enable queries from friends and relatives to be answered).

105. ANSTO, Radiation Monitoring Handbook for Visits by Nuclear Powered Warships to Australian Ports, (ANSTO, Lucas Heights, NSW, 1985), p. 28 (Evidence, p. 322).

higher than normal radiation doses as an option for inclusion in the individual port safety plans by those responsible for the individual plans.[106] The Committee considers that all the Australian plans should be required to facilitate record keeping of this nature.

10.111 The Committee acknowledges that in the immediate aftermath of a serious accident precise record keeping may present difficulties. The Committee noted that the Natural Disasters Organisation has developed a computer-based system called the 'National Registration and Inquiry System'. This is designed to assist in locating and keeping track of persons following large-scale accidents and natural disasters.[107] The Committee understands that the system is sufficiently flexible to be used for keeping records of persons' presence at or near the scene of a reactor accident on a visiting warship, together with information on any exposure to radiation they received, decontamination undergone, etc.

10.112 Therefore, the Committee RECOMMENDS that steps be taken to make better provision in the port safety plans for the making and long-term keeping of records of individuals' presence in the vicinity of the vessel at the time of an accident, of the levels of radiation to which they might have been exposed, and of any evacuation or decontamination which they may have undergone. In particular, the Committee RECOMMENDS that the Natural Disasters Organisation's 'National Inquiry and Registration System' be examined with a view to using it to provide a means of recording and preserving this information.

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106. Evidence, p. 1300.45 (Department of Defence).

107. See Department of Defence, Natural Disasters Organisation, Australian Counter Disaster Handbook, (Australian Counter Disaster College, Mt Macedon, Vic., 1980), chapter 12, for details. Under the system record-keeping can be either manual or computer-based. The manual version is used as a matter of routine by emergency services. The computerised version, which is more appropriate to large-scale disasters, was last used as part of the response to the 1983 Ash Wednesday bushfires.

10.113 In relation to civil nuclear installations, in the United Kingdom a system has been devised under which members of the general public can register the fact that they were in the area affected by a nuclear reactor accident.[108] The aim is to provide a source of evidence of this fact so as to assist the individual in the event that he or she wishes to bring a claim for compensation years after the event. The register is no more than a source of evidence. It does not prevent other evidence being brought to disprove the material set out in the register.[109] But, in the absence of other evidence, the facts as set out in the register would prevail.

10.114 Although the legislation requiring this system does not apply to ship-borne reactors, the United Kingdom authorities plan to use the system following a reactor accident to a Royal Navy submarine in a United Kingdom port. Registration forms would be distributed through local post offices.

10.115 The Committee considered whether a similar system would be useful in Australia, and if so, whether it should be a State/Territory or Commonwealth scheme. On balance, the Committee does not consider that a scheme of this type should be required. In the United Kingdom a scheme existing for other reasons is extended to apply to submarine reactor accidents. In Australia, the scheme would need to be specifically devised in respect to warship visits.

10.116 Unlike in the position in the United Kingdom where the scheme applies to civil reactors, a scheme of this type has not been judged necessary in relation to the Commonwealth's own nuclear reactor at Lucas Heights, NSW. An element of discrimination might be seen to arise if the Commonwealth were to

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108. The Nuclear Installations Act 1965 (UK), s. 23 provides the basis for the system, with details contained in subordinate legislation.

109. Nuclear Installations Act 1965 (UK), s. 23(1): '... registration in respect of any person shall be sufficient evidence of his presence within that area during that period unless the contrary is proved ...'.

facilitate compensation claims against a foreign country in a way that it is not prepared to do for claims against itself.

10.117 The more significant reasons why the Committee does not consider a registration scheme should be required relate to the limited benefits it would achieve. As already noted registration operates as no more than a source of proof. In the absence of the registration scheme individuals will still have available other means of establishing the facts that would be evidenced by registration.

10.118 Many of the individuals most likely to have been exposed to radiation will have been recorded under the improved record keeping recommended above. Others, including many emergency personnel and port workers, would be able to rely on employment or similar records. Any individual concerned about their possible exposure can always make an appropriately witnessed written record of their whereabouts for possible use as evidence in years to come.

CHAPTER 11

NUCLEAR WEAPONS - BACKGROUND

NEED FOR SAFETY PLANS

Differing Views

11.1 The absence of specific plans for dealing with a nuclear weapon accident in an Australian port was noted in chapter 2. The Department of Defence does not consider as credible the risk of nuclear detonation during a visit to an Australian port. It considers:

> the risks of even the worst credible nuclear weapons accident on a visiting warship are extremely low. It would not be sensible for emergency planners to attempt to develop plans to deal with every emergency that may conceivably, but not credibly, arise. ... we consider that it would be ... unrealistic to prepare in detail for a nuclear weapon accident on a warship making a routine port call. The general plans for dealing with disasters in our ports and harbours would be appropriate to deal with the initial phase of any major nuclear weapons accident ... The additional requirements of a nuclear weapons accident - such as radiation monitoring equipment and personnel trained in use of that equipment - would need to be obtained from Commonwealth authorities and perhaps also from the other government involved but there is no reason to believe that this would involve major problems of coordination or that undue delays would be encountered in making those resources available. The task of cleaning up after any nuclear weapons accident would moreover be one in which prompt assistance would be forthcoming from the country on whose

vessel the accident occurred.[1]

11.2 In contrast, the Victorian Government suggested greater precautions might be justified for visits by nuclear armed warships.[2] The majority of non-government submissions that addressed the issue considered that the current position underestimated the risk, that is, the likelihood of and/or consequences of a nuclear weapon accident, and hence underestimated the need for specific planning.

11.3 In its submission, the Australian Ionising Radiation Advisory Council (AIRAC) stated its belief that appropriate control and emergency procedures should be in place for ports visited by nuclear weapons capable vessels.[3] However, AIRAC stressed that it had not calculated the probability of a nuclear weapon accident in an Australian port or developed a reference accident.[4] Rather it was suggesting that a series of accident scenarios should be constructed and examined to determine the probability of their occurrence.[5]

The Committee's Methodology

11.4 In order to assess whether the absence of specific contingency plans was acceptable, it was necessary for the Committee to consider the types of accidents which might occur. The concepts of risk assessment, 'credible accident' and 'reference accident' were discussed in chapters 3 and 7 in the context of reactor accidents. The Committee considered these concepts and the general approach it adopted in relation to reactor accidents to be equally applicable to assessing the risk

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1. Submission from the Department of Defence, pp. 26-27 (Evidence, pp. 31-32. Note also the second supplementary submission from the Department of Defence, pp. 24-25 (Evidence, pp. 238.279-80); Senate, Hansard, 2 May 1986, p. 2292 and 27 September 1988, pp. 753-54.
2. Submission from the Victorian Government, pp. 6-7.
3. Submission from AIRAC, p. 6 (Evidence, p. 700).
4. Evidence, pp. 714, 721, 725 (AIRAC).
5. Evidence, p. 713, (AIRAC).

of nuclear weapon accidents.

11.5 Hence, to assess the overall risk, and thereby establish the need for contingency planning, the Committee considered both accident likelihood and accident consequences. In assessing accident likelihood, the Committee considered both the historical record of accidents involving nuclear weapons and the theoretical means by which an accident might happen.

11.6 After considering the adequacy of the information available to the Committee, the remainder of this chapter summarises the information available to the Committee on: the types of nuclear weapons likely to be aboard visiting warships; the hazards posed by the plutonium in these weapons; the safety-related features of the design and storage of the weapons; and the accident record for nuclear weapons. Based on this information, chapter 12 deals with hypothetical accident scenarios involving nuclear weapons on board visiting warships.

11.7 While the Committee's general approach to assessing the risk of both weapon and reactor accidents is the same, the range of hypothetical accidents differs. For reactor accidents, the Department of Defence and its advisers assessed the likelihood and consequences of a range of scenarios. The reference accident which resulted from this assessment indicated to the authorities that there was a need for contingency planning and provided a basis upon which to plan. A consistent view in submissions opposed to the current position was the need to plan for a more serious reactor accident.

11.8 In contrast, assessment of weapon accident scenarios has led the Department of Defence to the conclusion that there is no accident whose combination of likelihood and consequences (ie. risk) requires specific contingency planning. In other words, the Department's assessment has not led to a reference accident being developed in respect of nuclear weapons.

11.9 In submissions opposing this conclusion, there was no single alternative position clearly put forward. This again was in contrast to the case with regard to planning for nuclear powered warship visits. Rather the Committee was presented with scenarios ranging from nuclear detonation through to simple loss of an intact weapon in a sunken vessel. There was considerable focus on fire and non-nuclear explosion as credible risks. However, there were differing views in the submissions on whether planning should be based on the separate occurrence of fire or non-nuclear explosion, or on their combined effect.

Information available to the Committee

11.10 Given official secrecy on nuclear weapons, the adequacy of the information available to the Committee was a threshold issue in its consideration of the risk of a nuclear weapon accident. Adequate information is essential in the use of either the historical method or the theoretical method of assessing accident likelihood.[6]

11.11 In respect of the historical safety record, considerable official data are available on United States Navy nuclear weapons accidents and incidents. The Committee is aware of the criticism that the data may well be less than comprehensive.[7]

11.12 The Committee considers that even if the official figures are incomplete they provide a useful guide to the types of accidents that have occurred. It is improbable that a nuclear detonation has been omitted, because the consequences of such a detonation would almost certainly have become public knowledge.

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6. The methods are not mutually exclusive: see paras. 3.20, 3.22.
7. e.g. see the submissions from Prof W. J. Davis, p. 52 (Evidence, p. 499); Greenpeace Australia (NSW) Ltd, p. 18. See also Stockholm International Peace Research Institute, World Armament and Disarmament: SIPRI Yearbook 1977, (MIT Press, Cambridge, Mass., 1977), pp. 53-54; S. Talbot, 'The H-Bombs Next Door', The Nation (USA), 7 February 1981, p. 144.

Moreover, the type of less serious accidents most relevant in the present context, magazine fires and chemical explosions while in port, are relatively difficult to conceal.[8] Official statistics are therefore unlikely to be deficient in this regard, even if it is true that other types of accidents are under-reported.

11.13 In respect of the second method, rigorous theoretical assessment of the likelihood of an accident involving a nuclear weapon requires precise knowledge of, among other things, the design and construction of the weapon, and the way in which it is maintained and stored. The amount of information available to either the Australian Government or the Committee on these matters is limited.[9]

11.14 There is much publicly available information relating to civilian nuclear powered merchant ships and land-based reactors which can, if used judiciously, assist in filling the gaps in public information relating to naval reactors. There are no corresponding sources for nuclear weapons, as there are obviously no civilian devices employing the physical principles, design and technology of nuclear weapons.

11.15 The Department of Defence pointed out to the Committee:

> As a non-nuclear weapons state that is party to the Nuclear Non-Proliferation Treaty, Australia has undertaken not to manufacture or otherwise acquire nuclear weapons and not to seek or receive any assistance in their manufacture.[10] These undertakings mean that the Government's direct knowledge of nuclear weapons design and construction is necessarily

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8. cf. Evidence, p. 712 (AIRAC).
9. e.g. see the second supplementary submission from the Department of Defence, p. 23 (Evidence, p. 238.278).
10. Treaty on the Non-proliferation of Nuclear Weapons, Washington/ London/Moscow, 1 July 1968, (Australia, Treaty Series, 1973, No. 3), article 2.

limited.[11]

11.16 Nonetheless the Department considered that:

> a good deal of reliable information is available about safety standards and procedures applied in the relevant NATO countries to nuclear weapons manufacture, handling and storage. This information is sufficient for the Government to be assured not only that the risk of a nuclear weapon accident during a visit to an Australian port by a foreign warship is extremely low, but also that the consequences of any such accident would be localised rather than widespread and would not pose a major health hazard to the Australian population.[12]

11.17 The Committee accepts that the lack of information available to it makes any formal, comprehensive risk assessment by the Committee impossible.[13] The Commonwealth Government is clearly in no better position. Some submissions argued that a necessary precondition to visits by nuclear armed vessels is that all relevant data should be available to Australian authorities. On this view, visits should only be permitted following the outcome of a full, independent risk assessment by Australian authorities or, in default, by making the most safety-directed or

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11. Submission from the Department of Defence, p. 22 (Evidence, p. 27). See also the second supplementary submission from the Department of Defence, p. 23 (Evidence, p. 238.278), and the submissions from AIRAC, p. 5 (Evidence, p. 699); Australian Radiation Laboratory p. 5 (Evidence, p. 1009); ANSTO, p. 5 (Evidence, p. 243).
12. Submission from the Department of Defence, pp. 22-23 (Evidence, pp. 27-28).
13. cf. submission from Prof W. J. Davis, p. 52 (Evidence, p. 499); Evidence, pp. 590-95 (Prof W. J. Davis), and pp. 726-27 (AIRAC). Note also the view of the Department of Defence (Evidence, p. 1300.58):

    > The statistical probability of either an accident involving a naval nuclear weapon that is in secure stowage or an accidental explosion in the magazine of a conventionally armed warship do not appear susceptible to calculation.

conservative estimates of risk.[14]

11.18 The Committee does not accept this view. In many other situations the Australian Government does not conduct its own independent safety assessment, but instead relies on the good faith of, or assurances from, other governments. Examples are visits by conventional warships and military aircraft.[15]

11.19 The Committee considers that the information available to it, while imperfect, does not prevent it making an assessment of the likelihood of an accident involving a nuclear weapon on board a visiting warship.

11.20 Australian authorities are better informed on accident consequences: that is on matters such as radiation dispersal mechanisms, the health and environmental effects of radiation, and the remedial measures required.[16] The Australian Radiation Laboratory, an agency within the Health portfolio, informed the Committee that it could acquire the facilities needed to deal with an accident involving the rupture of a nuclear warhead, if required to do so and subject to funding.[17] The Australian Ionising Radiation Advisory Council indicated that it would be available to examine appropriate control and emergency procedures if requested to do so.[18]

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14. Submission from Scientists Against Nuclear Arms (ACT), p. 2 (Evidence, p. 780). See also the submissions from the Medical Association for the Prevention of War Australia (NSW), p. 4; Milton-Ulladulla People for Peace, p. 3; Scientists Against Nuclear Arms (Tas), p. 2 (Evidence, p. 821).
15. cf. Australia, Environmental Considerations of Visits of Nuclear Powered Warships to Australia, (May, 1976), p. 7 (Evidence, p. 124).
16. Submission from ANSTO, p. 1 (Evidence, p. 243: See also pp. 417-18).
17. Submission from the Australian Radiation Laboratory, p. 5 (Evidence, p. 1009).
18. Submission from AIRAC, p. 5 (Evidence, p. 699).

TYPES AND NUMBERS OF NUCLEAR WEAPONS ABOARD WARSHIPS

Weapon Types

11.21 It is highly unlikely that warships carrying ballistic (ie. strategic or inter-continental) missiles will visit Australia.[19] As a result of official secrecy, there are no concise official data on the size of the United States Navy's stockpile of theatre (ie. non-strategic or tactical[20]) nuclear weapons, on the numbers of weapons of each type in the stockpile, or on the number aboard any particular ship.[21] However, a considerable amount of information on the United States Navy's theatre nuclear weapons has become public in piecemeal fashion over the years, largely in reporting to the United States Congress and its various committees. Commentators are able to state with some confidence the types and characteristics of nuclear weapons deployed by the United States Navy. The published data on British and French naval nuclear weapons are less comprehensive.

11.22 The following table sets out what is believed by commentators to be the United States Navy's theatre nuclear weapons arsenal. Because of the nature of the sources on which it is based, the figures in the table should be treated as a guide rather than a precise statement.

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19. See para. 2.51.
20. On this division between strategic and theatre nuclear weapons, see for example W. Arkin, The Nuclear Arms Race at Sea, (Neptune Papers, No. 1, Greenpeace/Institute of Policy Studies, Washington, 1987), p. 5. The Tomahawk cruise missile has, for the limited purpose of the Committee's report, been treated as a theatre weapon. For some other purposes, it might possibly be more appropriately classed as strategic, given its long range.
21. The US regards as classified the percentage of its naval vessels that actually have nuclear weapons on board: US, H of R, Committee on Foreign Affairs, Subcommittee on Asian and Pacific Affairs, Security Treaty between Australia, New Zealand, and the United States - Hearing, 18 March 1985, p. 179 (J. A. Kelly, Department of Defense).

US Naval Theatre Nuclear Weapons[22]

Weapon system	War-head	Yield (kt)	No. in stockpile	Year 1st deployed	Period produced
Carrier aircraft bombs	B43 B57 B61	1000 1-20 1-345	{1000	1960 1964 1975[23]	1960s 1960s 1968 on
Terrier surface to air missiles	W45	1	285	1958	unknown: now ceased
Anti-submarine rockets(ASROC)	W44	1	575	1961	1960s
Submarine rockets (SUBROC)	W55	1-5	285[24]	1965	1964-74
Tomahawk sea-launched cruise missiles (SLCM)	W80	5-150	150	1984	current

11.23 British and French theatre nuclear naval arsenals appear to be confined to bombs capable of being delivered by carrier-based aircraft and anti-submarine warfare helicopters.[25] The

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22. Sources: T. B. Cochran and others, Nuclear Weapons Databook, Volume 1: U.S. Nuclear Forces and Capabilities, (Ballinger, Cambridge, Mass., 1984); Stockholm International Peace Research Institute, World Armaments and Disarmament: SIPRI Yearbook 1987, (OUP, Oxford, 1987) Table 1.2; the Bulletin of the Atomic Scientists, June 1988, vol. 44(5), p. 56. There are minor variations in the data given by these several sources, with considerable differences regarding weapon yields. For consistency, all yields have been taken from the last named source. Omitted from the table are land-based, long-range maritime surveillance aircraft capable of deploying B57 nuclear depth bombs, because they are not relevant to the Committee's inquiry.
23. Date taken from the Bulletin of the Atomic Scientists, June 1988, vol. 44(5), p. 56, where it is noted that non-naval versions of the B61 were first produced in 1966.
24. Bulletin of the Atomic Scientists, June 1988, vol. 44(5), p. 56 gives this total of 285, with the annotation 'scheduled for retirement in 1989'. Recent Congressional testimony stated that the SUBROC has already been taken out of service: US, H of R, Committee on Appropriations, Subcommittee on Energy and Water Development, Energy and Water Development Appropriations for 1989 - Hearings, 23 March 1988, p. 1326 (Admiral K. R. McKee).
25. Stockholm International Peace Research Institute, World Armaments and Disarmament: SIPRI Yearbook 1987, (OUP, Oxford, 1987), pp. 25 and 30; UK, Secretary of State for Defence, Statement on the Defence Estimates 1986, (Cmnd. 9763-1, HMSO, London, 1986), vol. 1, p. 28.

number of nuclear warheads is relatively small.[26]

Number of Weapons on Each Visiting Warship

11.24 The Committee did not regard the issue of the number of weapons which may be on board a visiting warship as being of major significance in its inquiry because, in this limited context, it was prepared to make 'worst-case' assumptions.[27] If a given risk arises with each weapon, it follows that the total risk increases as the number of weapons that are on board any one visiting vessel increases. In the Committee's view, its conclusions on nuclear weapons remain valid even if the maximum design load of weapons were to be on board each visiting nuclear weapons capable warship.

11.25 The Committee considers it useful briefly to note two factors which, while by no means conclusive, suggest that the number of nuclear weapons entering Australian ports may be lower than often assumed by those opposing the present position on contingency planning. One concerns the relationship between the number of launchers for a particular weapon on a vessel, the size of the overall stockpile of that weapon, and the number (if any) of that type of weapon likely to be on board the vessel. The second factor is the distinction between nuclear weapons capable and nuclear weapons certified warships. In the majority of the submissions made to the Committee neither of these factors was

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26. Stockholm International Peace Research Institute, World Armaments and Disarmament: SIPRI Yearbook 1987, (OUP, Oxford, 1987), p. 25 states that some sources put the maximum number of British tactical nuclear warheads at 105 (25 depth bombs, 80 gravity bombs). The equivalent French total is given as 40: ibid., p. 30. D. Campbell, 'Too Few Bombs to go Round', New Statesman, 29 November 1985, p. 10 claims that the Royal Navy has only 25 tactical nuclear weapons. See also S. Gregory, 'The Command and Control of British Tactical Nuclear Weapons', Defense Analysis, 1988, vol. 4(1), p. 49: total stockpile for all British armed services is only about 120 tactical nuclear weapons.

27. Many submissions suggested that the Committee should make assumptions of this kind. See for example, submissions from Scientists Against Nuclear Arms (ACT), p. 6 (Evidence, p. 784); Senator J. Vallentine, p. 18 (Evidence, p. 1061).

considered, and they are often overlooked in public discussion.[28]

11.26 In relation to the first of these factors, assertions were put to the Committee that, for example, 'there could be as many as 200 nuclear warheads on board a US battlegroup',[29] and that 'hundreds of new tactical nuclear weapons are deployed on ships visiting Australia'.[30] One of the accident scenarios put to the Committee by Professor Jackson Davis rests on the assumption that there would be 100 nuclear weapons on a visiting nuclear weapons capable warship.[31]

11.27 The delivery systems for theatre nuclear weapons are often capable of also delivering a non-nuclear version of the same weapon.[32] There is no necessary correlation between the number of launchers on a vessel and the number of nuclear

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28. It may in some contexts be unnecessary to make any distinction between nuclear weapons capable and certified warships. For example, in estimating war-fighting potential, the distinction might be largely irrelevant, as capable ships may be able to be rapidly certified. The distinction is, however, of significance for peacetime visits to Australian ports.
29. Submission from Senator J. Vallentine, p. 20 (Evidence, p. 1063).
30. Submission from Greenpeace Australia (NSW) Ltd, pp. 31-32. See also the submission from Mr R. Addison, p. 1. cf. Tasmania, Assembly, Debates, 9 December 1987, p. 5580 (Dr R. Brown): 120 nuclear weapons would be aboard aboard the cruiser USS Long Beach when it visited Hobart.
31. Evidence, p. 593.
32. For example, the US Navy as at March 1986 planned the eventual deployment on 91 surface vessels and 107 submarines of 3994 Tomahawk missiles, of which 758 were planned to be the nuclear version: Stockholm International Peace Research Institute, World Armaments and Disarmament: SIPRI Yearbook 1987, (OUP, Oxford, 1987), p. 14. See also US, H of R, Committee on Armed Services, Defense Department Authorization and Oversight - Hearings on H. R. 1872, 13 March 1985, p. 519 (Rear Admiral S. Hostettler): from the perspective of launch devices, the nuclear and non-nuclear versions of Tomahawk

    missiles are identical, and so there is no difference in the magazines. You can put any nuclear round in any hole of a box launcher or any torpedo tube. You can put the conventional varient in the same launcher or tube, so they are completely interchangeable.

    Modifications are made, however, to the firing software, safety devices, etc. in order to ensure nuclear weapon safety and surety: ibid.

weapons, if any, that are carried.[33] For example, one recent source states that there are 575 ASROC [anti-submarine rocket] warheads in the United States nuclear stockpile which are deployed on 159 nuclear capable surface vessels.[34] Assuming these figures are correct, they give an average of less than four warheads per vessel, yet the vessels are mainly equipped with 8-tube ASROC launchers.[35] A similar situation exists with the nuclear version of Tomahawk missiles.[36]

11.28 This position does not appear to prevail for all vessel/weapon types. For example one source gives figures of 900 United States nuclear weapons capable carrier-borne aircraft with 1000 nuclear weapons stockpiled for them.[37] The only weapon for which there appear clearly to be more weapons carried than there

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33. Contrast Tasmania, Assembly, Debates, 23 September 1986, p. 2593 and 25 September 1986, p. 2863 for suggestions that the USS Missouri carries 32 nuclear weapons. This is apparently based on it having 32 Tomahawk missile launchers. In J. Handler and W. M. Arkin, Nuclear Warships and Naval Nuclear Weapons: A Complete Inventory, (Neptune Papers, No. 2, Greenpeace/ Institute of Policy Studies, Washington, 1988), p. 44 it is stated that the 'nominal nuclear-armed TOMAHAWK (TLAM/N) loading is eight per ship' for the USS Missouri and the other ships of the same class.
34. J. Handler and W. M. Arkin, Nuclear Warships and Naval Nuclear Weapons: A Complete Inventory, (Neptune Papers, No. 2, Greenpeace/Institute of Policy Studies, Washington, 1988), p. 8.
35. ibid. Tables on pp. 44-50 indicate that no vessel carries more than three ASROCs with nuclear warheads. In order to reconcile the numbers, it appears necessary to assume that some nuclear ASROCs are stored on land, being refurbished, etc.
36. For example, in 1986 there were 21 US attack class submarines which were certified to carry the nuclear version of the Tomahawk, with some having capacity for 8 missiles, others for 20: N. Friedman, 'US Naval Weapons and Combat Systems Development in 1986', in US Naval Institute, Proceedings, May 1987, p. 90. The total number of Tomahawk nuclear warheads then believed to be in the US Navy stockpile, 110, would have been insufficient to utilise all these launchers, quite apart from the Tomahawk launchers on surface vessels. For the submarines having capacity for 8 missiles, one source states that 'two of the eight nominally are nuclear-armed': J. Handler and W. M. Arkin, Nuclear Warships and Naval Nuclear Weapons: A Complete Inventory, (Neptune Papers, No. 2, Greenpeace/ Institute of Policy Studies, Washington, 1988), p. 40, note 16.
37. Stockholm International Peace Research Institute, World Armaments and Disarmament: SIPRI Yearbook 1987, (OUP, Oxford, 1987), Table 1.2. But compare R. Fieldhouse, 'Nuclear Weapons at Sea', Bulletin of the Atomic Scientists, September 1987, vol. 43(7), p. 22 where figures of 1500 nuclear bombs stockpiled for 900 carrier-borne aircraft are given.

are launchers on board is the Terrier missile.[38]

11.29 The calculations in the previous two paragraphs, and many similar ones made by commentators,[39] assume that all or most of the stockpile of each nuclear weapon type is deployed at sea. This assumption may not be valid. Reportedly official figures, leaked to the media in 1983, showed that, for example, less than half the Terrier missiles in the stockpile were deployed on ships.[40]

Nuclear Weapons Capable and Nuclear Weapons Certified

11.30 A significant proportion of the United States fleet is

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38. J. Handler and W. M. Arkin, Nuclear Warships and Naval Nuclear Weapons: A Complete Inventory, (Neptune Papers, No. 2, Greenpeace/Institute of Policy Studies, Washington, 1988), p. 46: a total of 189 Terrier missiles nominally carried amongst a total of 21 cruisers. The cruisers have either 1 or 2 twin rail-launchers, and each ship has a nominal loading of 9 missiles: ibid., p. 44, note 34. The ratio of misslies to launchers is said to be similar for Terrier-armed destroyers: ibid., p. 48.
39. e.g. ibid., uses the concept of 'nominal' loads of nuclear weapons carried aboard particular vessel-types. The figures often, though not always, appear to be obtained by dividing the total assumed stockpile of a particular weapon by the number of vessels equipped to deploy that weapon.
40. 'Report to Congress Provides Figures for Nuclear Arsenal', New York Times, 15 November 1983, p. A15. The figures for Terrier are 135 at sea of a total of 290; for ASROC, 350 of 575; and SUBROC 175 of 285. All the US Navy's 720 nuclear bombs are listed as being deployed at sea. Weapons deployed at sea may not all be stored on combat vessels. In J. R. Hill, Arms Control at Sea, (Routledge, London, 1989), p. 115 it is claimed that many of the US theatre nuclear weapons held at sea are stored on underway replenishment vessels.

said to possess nuclear weapons capability.[41] However, before any United States vessel having this capability is permitted to actually carry nuclear weapons, it must undergo a costly process to gain and maintain certification to deploy nuclear weapons.[42] This involves crew training, proficiency and inspection, as well as provision for armed guards and other safety and security features.[43]

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41. Commentators differ as to the precise proportion. For example, Rear Admiral E. J. Carroll jr USN (Ret.) in 1986 gave a figure of 'approximately 85%': US, H of R, Committee on Armed Services, Subcommittee on Military Installations and Facilities, Hearings on H. R. 4181 to Authorize Certain Construction at Military Installations for FY 1987, 26 February 1986, p. 143. A figure of 70% is given in J. Handler and W. M. Arkin, Nuclear Warships and Naval Nuclear Weapons: A Complete Inventory, (Neptune Papers, No. 2, Greenpeace/Institute of Policy Studies, Washington, 1988), p. 1. A table in Bulletin of the Atomic Scientists, September 1988, vol. 44(7), p. 64 shows a total of 284 US vessels as being nuclear capable. As US fleet size is not far short of its one-time goal of a 600-ship Navy, this equates to about 50% of the total fleet. For figures in submissions on the percentage of nuclear capable vessels of the total US vessels visiting Australia, see above, para. 2.3. To be meaningful in the context of port visits to Australia, ballistic-missile submarines would need to be excluded from any calculation, as these do not visit.
42. To avoid possible confusion, note that this certification process relates to the vessel. The nuclear weapons are also certified by the design laboratories as to their safety and other characteristics: US, H of R, Committee on Foreign Affairs, Subcommittee on Arms Control, Proposals to Ban Nuclear Testing - Hearings and Markup on House Joint Resolution 3, 8 May 1985, p. 85 (D. Kerr, Los Alamos National Laboratory).
43. e.g. see US, H of R, Committee on Armed Services, Defense Department Authorization and Oversight - Hearings on H. R. 1872, 13 March 1985, p. 532 (Rear Admiral S. Hostettler). This describes the procedures relating to the naval nuclear version of the Tomahawk missile, but the procedures appear to be standard for all naval nuclear weapons. Before the missile is loaded, ships have to undergo Nuclear Weapons Acceptance Inspections (NWAI) which verify that security requirements such as alarms, armed guards, and the 2-man rule are in place.

> In order to insure each surface ship is properly trained and ready to safely operate with and employ Tomahawk, a certification program has been implemented. Prior to loading a nuclear Tomahawk, in addition to an NWAI, each ship must receive a Tomahawk Safety/Material certification which verifies the Tomahawk weapon system installation is correct and meets safety requirements. It also certifies the ability of the ship crew to operate and maintain the system. Subsequently, a demanding Tactical Qualifiaction Evaluation is conducted with the ship underway to verify individual and team proficiency ... When all these examinations are passed successfully, the ship is certified for Tomahawk operations. Periodic re-examinations are conducted throughout the operating cycle. (ibid., pp. 532-33)

11.31 There appears no reliable information on what proportion of nuclear weapons capable vessels are certified at any one time.[44] Given the expense and inconvenience of the certification process, it may be that not all are certified.[45] On the other hand, these same factors suggest that once a vessel has been certified, it actually carries nuclear weapons.[46]

Age of the Weapons

11.32 As indicated in the table earlier in this chapter, a number of the types of nuclear warheads which may be aboard visiting United States warships are of 1950's and 1960's design

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44. Greenpeace claimed that each of the four US warships to visit Sydney for the 1988 Bicentennial Naval Review was nuclear weapon certified: 'A hundred Hiroshimas in harbour: Greenpeace', Sydney Morning Herald, 24 September 1988, p. 4. The claim was reported as being based on publicly available documents and documents obtained using the US Freedom of Information Act.
45. e.g. J. Handler and W. M. Arkin, Nuclear Warships and Naval Nuclear Weapons: A Complete Inventory, (Neptune Papers, No. 2, Greenpeace/Institute of Policy Studies, Washington, 1988), p. 33, note 99:

    > As of December 1987, of the 98 SSNs [ie. US attack class submarines], 51 have been, or are shortly being, converted to a Tomahawk SLCM [sea launched cruise missile] capability, but only 31 of these 51 are Tomahawk certified submarines. (emphasis in original)

    For Sturgeon class attack submarines, although '19 are listed as TOMAHAWK-capable, only six submarines are TOMAHAWK-certified as of December 1987': ibid., p. 40, note 16. The authors note that the numbers change from month to month as submarines enter overhauls, undergo conversions, new submarines are commissioned, etc: ibid., p. 33, note 99. Many of the reasons why a capable vessel might not certified at a given time would not be relevant to vessels on extended deployment, such as those visiting Australia.
46. cf. Andrew Mack, head of the Peace Research Centre at the Australian National University, quoted in 'A hundred Hiroshimas in harbour: Greenpeace', Sydney Morning Herald, 24 September 1988, p. 4:

    > You don't go to the considerable trouble of certifying a ship which is nuclear capable unless you intend it to carry nuclear weapons. A great deal of paperwork is involved and there has to to be provision for people trained and certified to handle nuclear weapons.

and manufacture.[47] The designs of the older weapons incorporate fewer safety features than those of the later weapons.[48] These safety features are noted later in this chapter.

11.33 The nuclear warheads of earlier design are being phased out of service and being replaced with later designs,[49] or in some cases with non-nuclear weapons.[50] Moreover, there has been some retrofitting of safety features to older weapons.[51] Nonetheless older weapons such as Terrier missiles and ASROC's may be on United States warships visiting Australian ports.

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47. cf. US, Senate, Committee on Armed Services, Department of Defense Authorization for Appropriations for FY 1988/1989 - Hearings (Part 4), 31 March 1987, p. 2469 (Dr R. B. Barker): 'the [US] Navy tactical nuclear weapons stockpile is probably the oldest fraction or close to the oldest fraction' of the current US nuclear stockpile.

48. See para. 11.105 for the argument, made in the arms control context, that older nuclear weapons are nonetheless sufficiently safe. See also US, Senate, Committee on Armed Services, Subcommittee on Arms Control, FY 1981 Department of Energy Authorization for National Security Programs, 28 April 1980, p. 75 (Dr M. Sparks, Sandia Laboratories): noting the desirability of modernising the stockpile:

> Now I don't want to mislead you. The old weapons are as safe as they have ever been and they are very, very safe, but we now have new design capabilities and new requirements.

The reasons why the USN stockpile has not been completely modernised are varied, and not all relate to safety. But on safety grounds, the need to modernise is a relatively low priority as the risk of an accident is regarded as relatively low compared to that relating to some other types of nuclear weapons. See para. 11.94, footnote 142, for example, on the reason why PAL's are not fitted to US Navy tactical nuclear weapons.

49. See, for example, the table in Bulletin of the Atomic Scientists, June 1988, vol. 44(5), p. 56.

50. e.g. it appears as if the replacement for submarine launched rockets (SUBROCS), which have nuclear warheads, is the non-nuclear version of the Sea Lance anti-submarine weapon, as the US Congress has declined to approve funding for a nuclear version of the Sea Lance: J. Handler and W. M. Arkin, Nuclear Warships and Naval Nuclear Weapons: A Complete Inventory, (Neptune Papers, No. 2, Greenpeace/Institute for Policy Studies, Washington, 1988), p. 8. See also 'US Navy is quietly phasing out short-range N-missiles', the Age, 1 May 1989, p. 8: SUBROC, Terrier and the nuclear version of the ASROC to be phased out of use by about 1991.

51. See for example US, H of R, Committee on Armed Services, Subcommittee on Procurement and Military Nuclear Systems, National Defense Authorization Act for FY 1988/1989 - H. R. 1748 - Hearings, 24 February 1987, pp. 67, 68 (Dr R. Barker, Department of Defense): B61 bombs have been retrofitted with insensitive high explosive; enhanced electrical safety devices can be fitted as modifications very easily.

POTENTIAL HAZARDS OF NUCLEAR WEAPONS

Nuclear Detonation

11.34 Clearly the most serious hazard that needs to be considered in relation to a nuclear weapon is that of accidental nuclear detonation.

Plutonium Hazards

11.35 Most nuclear weapons in the United States stockpile, and all presently in development, contain plutonium.[52] Nuclear detonation apart, the potential for serious consequences from a nuclear weapon accident arises mainly due to the presence of plutonium.[53] The Committee was told that it would be appropriate in the context of such an accident to focus its inquiry on plutonium.[54]

11.36 A nuclear reactor accident could result in the release and dispersal of a wide variety of fission products, many of which emit gamma and beta radiation. In a nuclear weapon accident, so long as there is no nuclear detonation, the primary radiological hazard is from plutonium dispersal. Sufficient quantities of beta/gamma radiation to pose a significant health problem will not be present.[55]

11.37 Plutonium-239, the primary isotope used in nuclear

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52. US, Departments of Defense and Energy, Nuclear Weapons Surety: Annual Report to the President 1984, p. I-6.
53. Evidence, p. 733 (AIRAC). See also US, Defense Nuclear Agency, Nuclear Weapons Accident Response Procedures Manual, (Washington, 1984), p. 79: 'plutonium is considered the most significant radiological hazard associated with an accident involving nuclear weapons containing plutonium'.
54. Evidence, p. 733 (AIRAC).
55. US, Defense Nuclear Agency, Nuclear Weapons Accident Response Procedures Manual, (Washington, 1984), p. 3. See also Evidence, pp. 732-33 (AIRAC).

weapons, has a half-life of over 24,000 years. This was a matter of considerable concern to many of those making submissions because they believe plutonium dispersal has the potential to 'not only affect this generation, but generations to come'.[56]

11.38 Plutonium-239 is radioactive, emitting alpha radiation. This has such a low penetrating power that it is strongly absorbed by air and is incapable of penetrating clothing or the outer layer of unbroken skin. Normally alpha emitters can cause harm only if they are inhaled, ingested, or absorbed into the blood stream (e.g. through a wound).[57] The presence of an emitter of alpha radiation in the body has the potential to cause malignant change. It is clear that the toxicity of plutonium is related solely to its radioactivity.[58]

11.39 The Committee was told that if plutonium comes into

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56. Submission from Senator J. Vallentine, p. 30 (Evidence, p. 1073). See also for example submissions from People for Nuclear Disarmament, p. 4 (Evidence, p. 1306); Ms A. Tubnor, p. 2.
57. US, Defense Nuclear Agency, Nuclear Weapons Accident Response Procedures Manual, (Washington, 1984), p. 3. See also Royal Commission into British Nuclear Tests in Australia, Report, (Parl. Paper No. 483/1985), vol. 2, pp. 574–78.
58. G. A. Williams and others, 'Plutonium Contamination at Maralinga', Chemistry in Australia, April 1987, vol. 54(4), p. 122; J. C. Nenot and H. Metivier, 'Biological Behaviour and Toxicology of Plutonium and Trans-plutonics', Inorganica Chimica Acta, 1984, vol. 94, p. 167. The latter gives a useful balance to some of the more alarmist statements made to the Committee on the toxicity of plutonium (p. 165):

    > The toxic properties of this element are known more than for any other poison. Paradoxically, since its discovery in December 1940 ... no unquestionable direct relationship, 40 years later, has been established between its toxicity and human death. ... all of the knowledge acquired on its toxicity comes from animal experiments. Any extrapolation to man is always subject to controversy.

    Although the sample is too small to support firm conclusions, a group of 26 men contaminated by plutonium during World War II, mainly by inhalation, have had a subsequent medical profile no different to other Americans and have had a mortality rate below the national average (p. 168). For a controversial view that the hazards from plutonium have been overstated, see B. L. Cohen, 'The Myth of Plutonium Toxicity' in K. O. Ott and B. I. Spinrad (eds.), Nuclear Energy: A Sensible Alternative, (Plenum, New York, 1985), pp. 355–65.

contact with water, no immediate significant hazard results.[59] Nor is there any hazard to marine life as plutonium is not an element that accumulates within biota (ie. marine, animal and plant life) to any degree.[60] Plutonium dispersal resulted from the crash onto sea ice near Thule, Greenland in 1968 of a plane containing nuclear weapons. Studies were made by Danish scientists of the marine environment. Concentrations of plutonium were found in samples of marine life but not at levels that posed any hazard to higher animals or persons.[61]

11.40 The toxic effects of plutonium depend on its particle size, chemical form and isotopic composition. Within limits, the smaller the particles, the greater the danger they present. Large pieces of plutonium are unlikely to be absorbed, ingested or inhaled, and so present little radiological hazard. Plutonium in the form of contaminated fragments, such as might result from an explosion, does not represent an inhalation hazard unless 'over a period of time, surface degradation (e.g. rusting of steel), releases particles of plutonium of respirable size'.[62] It is for this reason that an accident scenario involving the aerosolisation of plutonium is considered to be the most hazardous weapon accident short of nuclear detonation.[63]

11.41 A number of submissions portrayed the plutonium hazard in terms more dramatic than instructive. For example, the Peace

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59. Evidence, p. 717 (AIRAC).
60. Evidence, p. 718 (AIRAC).
61. A. Aarkrog, 'Radio-Ecological Investigations', USAF Nuclear Safety, 1970, vol. 65(1) part 2, p. 79; A. Aarkrog, 'Further Studies of Plutonium and Americium at Thule, Greenland', Health Physics, January 1984, vol. 46(1), pp. 29-44.
62. G. A. Williams and others, 'Plutonium Contamination at Maralinga', Chemistry in Australia, April 1987, vol. 54(4), p. 124.
63. US, General Accounting Office, Nuclear Weapons: Emergency Preparedness Planning for Accidents Can Be Better Coordinated, (GAO/NSIAD-87-15, February 1987), p. 50: US Department of Defense and Department of Energy officials believe that airborne contaminants present the primary health risk following a nuclear weapon accident, and 'the greatest danger to the public from plutonium would be inhalation of aerosolized particles during passage of a cloud created by fire or HE detonation, though the chance of this happening is low'.

Squadron (Sydney) assumed the smallest weapon to contain 5 kg of plutonium and stated:

> Given a uniform distribution of the 5 kg of plutonium over the Sydney area, and a lethal inhaled dose of .001 g, this would be sufficient to kill 142% of the population of Sydney in a 'worst case' accident involving a single nuclear weapon of the smallest size.[64]

This ignores the fact that there is no possible mechanism of achieving this sort of uniform distribution.[65]

11.42 Any calculation of the degree of dispersal of plutonium and its eventual internalisation by humans is very complex because of the large number of variables that need to be considered. Some of these are the amount of plutonium in the weapon(s); the weather at the time of the accident and subsequently; the particle size dispersed; and the population density and topography of the area affected. These and other

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64. Submission from the Peace Squadron (Sydney), pp. 4-5. See also for example the submission from Scientists Against Nuclear Arms (Tas), p. 4 (Evidence, p. 823); Scientists Against Nuclear Arms (ACT), p. 5 (Evidence, p. 783). cf. Evidence, p. 869 (Scientists Against Nuclear Arms).
65. cf. R. K. Mullen, 'Mass Destruction and Terrorism', Journal of International Affairs, 1978, vol. 32(1), p. 82. This deals with a scenario of a terrorist attempting to cause mass deaths through plutonium dispersal, not a weapon accident. The following comments, however, have some relevance:

> Making some extremely simplistic calculations, and extrapolating directly from the animal data, it may be shown that milligram quantities of insoluable reactor grade plutonium, deposited in the pulmonary region of the human lung, will cause a short-term fatality in that individual so exposed. Such calculations do not, however, take into consideration any of the previously mentioned physical factors which tend to degrade the performance of any aerosol; the environmental factors which affect the time and space occupancy characteristics of any aerosol; the physiological factors which require an aerosol to possess certain characteristics if it is to be effective; and other factors which make any attempt to cause numbers of short-term fatalities from a plutonium aerosol, an undertaking of great uncertainty. ... Frequently seen statements that small quantities of plutonium, dispersed into undefined environments, in some undefined manner, and made without consideration of the problems involved in creating an aerosol, much less those of maintaining its integrity once discharged from the aerosol generator, causing thousands of deaths, are simply incredible.

factors such as the effect of a particular dose on a particular person and the psychological effects of possible exposure need to be considered when calculating the consequences of various nuclear weapon accident scenarios involving plutonium dispersal.

Non-Radiological Hazards

11.43 Most concerns put to the Committee about a nuclear weapon accident related to the potential radiological hazards. However, other hazards could also exist,[66] including, for example pieces of unexploded high explosive thrown out in a detonation of conventional explosive. But these hazards are identical to those arising from conventional munitions aboard Australian or visiting warships, unless insensitive high explosive[67] is involved. No information was brought to the Committee's notice that suggests insensitive high explosive is more dangerous in a non-nuclear accident than conventional explosive.

11.44 If there is a fire involving a nuclear weapon toxic hazards may result from poisonous substances that might be included in the weapons, such as beryllium, lithium, lead and plastics.[68] While the Committee does not wish to play down the hazards that these substances might pose, it considers that the hazards are within the range of those encountered in industrial accidents. As such they do not provide the basis for requiring special contingency plans for nuclear weapons.[69]

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66. See for example, Evidence, pp. 732 and 734 (AIRAC).
67. See para. 11.55 on the use of insensitive high explosive.
68. US, Defense Nuclear Agency, Nuclear Weapons Accident Response Procedures Manual, (Washington, 1984), pp. 113-14. See also New York City, Mayor's Emergency Control Board, Staten Island Homeport Plan, (Draft, June 1988) pp. 15-16: 'There are no toxic hazards from conventional HE [high explosive] or propellants used in naval weapons'.
69. See para. 12.68, for the Committee's recommendation with respect to Australian port plans for dealing with general shipping accidents, including those involving hazardous cargo.

SAFETY FEATURES

Safety Design[70]

11.45 Those involved in designing, handling and storing nuclear weapons are, of course, well aware of the harm that might result from a nuclear weapon accident. Extensive precautions are taken to avoid any accident.[71] Two major factors relevant to assessing accident likelihood are the design of the nuclear weapons and the way in which they are stored in warships visiting Australia.

11.46 United States nuclear weapons are designed, maintained and stored 'so as to incorporate maximum safety consistent with operating requirements'.[72] The arming, fusing and safing features

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70. For the physics and basic design of nuclear weapons, see for example Joint Committee on Foreign Affairs and Defence, Disarmament and Arms Control in the Nuclear Age, (Parl. Paper No. 337/1986), pp. 189-195; T. B. Cochran and others, Nuclear Weapons Databook, Volume 1: U.S. Nuclear Forces and Capabilities, (Ballinger, Cambridge, Mass., 1984), chapter 2.
71. e.g. see US, General Accounting Office, Nuclear Weapons: Emergency Preparedness Planning for Accidents Can Be Better Coordinated, (GAO/NSIAD-87-15, February 1987), p. 55: 'prevention of accidents is paramount in D[epartment] o[f] D[efense] and DoE[nergy] nuclear weapon programs ...'.
72. US, General Accounting Office, Observations on Navy Nuclear Weapon Safeguards and Nuclear Weapon Accident Emergency Planning, (GAO/NSIAD-85-123, 29 July 1985), Appendix 1, p. 5. Safety is achieved by compliance with four safety standards, requiring positive measures to:
    - prevent nuclear weapons involved in accidents or incidents, or jettisoned weapons, from producing a nuclear yield;
    - prevent deliberate prearming, arming, launching, firing, or releasing of nuclear weapons except upon execution of emergency war orders or when directed by competent authority;
    - prevent inadvertent prearming, arming, launching, firing, or releasing of nuclear weapons in all normal and credible abnormal environments; and
    - ensure adequate security of nuclear weapons.

    A positive measure is a design feature, safety device, or procedure that exists solely or principally to provide nuclear system safety: ibid. For an indication of how these standards were given effect with regard to the Tomahawk missile, see ibid., p. 6. The standards are also set out in US, H of R, Committee on Armed Services, Subcommittee on Military Installations and Facilities, Civil Defense Aspects of the Three Mile Island Nuclear Accident - Hearings, 14 June 1979, p. 218 (Department of Defense).

vary from weapon to weapon. Not all the details are publicly available, but the following description relating to a nuclear bomb gives an idea of what is involved in, and of the meaning of, terms such as 'prearming' and 'arming' in relation to a specific weapon.[73]

> With bombs, preflight operations include prearming by insertion of arming plugs, removal of safing wires that prevent closure of release switches, and connection of 'pull-out wires' that pull out when the bomb falls from the plane, activating the switches. Prior to release, the pilot activates a reversible arm-safe switch. After release all functions are automatic. An environmental sensing device monitors a number of different 'environments' that can be duplicated only in the flight of the bomb: close-to-zero gravity accelerations (that is, free fall), changes in barometric pressure, and deceleration caused by deployment of a parachute to slow the bomb's descent. Timers are used in some cases to ensure that these environments occur in the proper sequence and time frame. Arming and safing features ensure that a weapon is in a proper and safe trajectory before arming is completed and fuzing can occur.
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> Fuzing ... components include altitude-measuring devices ... or inertial devices that measure a distance along a trajectory. ... Pressure sensitive switches (hydrostats) are used in depth bombs for subsurface bursts in water.[74]

11.47 Other weapons have similar devices, all of which have to

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73. These terms, and the term 'un'armed', can only be given a precise meaning by reference to the design of a specific weapon. For a general definition of 'unarmed', see Evidence, p. 1254 (Department of Defence).

74. D. R. Cotter, 'Peacetime Operations: Safety and Security' in A. B. Carter and others, Managing Nuclear Operations, (Brookings Institution, Washington, 1987), pp. 43-45.

operate as intended to produce a nuclear detonation.[75] For example, 'a sea-launched cruise missile will experience a period of acceleration for a known period of time. Unless this acceleration occurs, the weapon cannot be detonated.'[76]

11.48 A major concern for nuclear weapon designers has been to ensure safety in the event the weapon is involved in a crash, fire, or other accident. A declassified part of a 1984 report to the United States President on nuclear weapons safety states:

> Our modern ... weapon electrical systems are designed with multiple safety features so that in accident environments (fire, crash, lightning, etc.), selected components necessary for arming and fuzing are reliably destroyed before the safety devices fail.[77]

11.49 The Department of Defence told the Committee:

> In the case of fission weapons, high voltage detonators are used which do not contain any sensitive primary explosives. This ensures that individual detonators will not function unless the correct high voltage pulse is

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75. See for example US, H of R, Committee on Armed Services, Subcommittee on Military Installations and Facilities, Civil Defense Aspects of the Three Mile Island Nuclear Accident - Hearings, 14 June 1979, p. 219 (Dr J. P. Wade, Department of Defense):

    > Special safety features include electrical, mechanical, and environmental devices specifically designed for each nuclear weapon or nuclear weapon system. Failure of one of those safety features will cause the weapon to remain nonoperable: that is, there would be no nuclear explosion. For each weapon, these safety features are included in a sequence of steps which must be accomplished for the weapon to operate.

76. D. Caldwell, 'Permissive Action Links for Sea-Based Nuclear Weapons?', NATO's Sixteen Nations, February/March 1988, vol. 33(1), p. 48.
77. US, Departments of Defense and Energy, Nuclear Weapons Surety: Annual Report to the President 1984, p. I-4. Declassified parts of this report were released under the US Freedom of Information Act. In the passage quoted a word or words after 'modern' was deleted on security grounds from the released document. For details of some of these features, see for example D. R. Cotter, 'Peacetime Operations: Safety and Security' in A. B. Carter and others, Managing Nuclear Operations, (Brookings Institution, Washington, 1987), pp. 45-46. A schematic diagram, ibid., p. 47, indicates how one of the safety devices, the 'weak link - strong link', works.

> supplied; they will not function from static discharge or stray electric currents.[78]

11.50 Nuclear weapons contain chemical high explosive as part of the trigger mechanism.[79] Safety features have been incorporated into modern nuclear weapons to prevent nuclear detonation in the unlikely event that the chemical explosive detonates. The Australian Department of Defence informed the Committee it was not aware of:

> any evidence to dispute the advice we have been given that, in a nuclear weapons accident - even one involving detonation of its conventional explosives - it would be almost impossible for the materials in the nuclear weapon to form a critical mass to cause fission or fusion of a measurable nuclear yield.[80]

11.51 The United States Departments of Defense and Energy jointly reported in 1984:

> United States nuclear warheads are currently designed to be inherently one-point safe. This means that if the high explosive surrounding the nuclear material were somehow detonated in a localized region, there is less than one chance in one million that there would be a nuclear yield exceeding four pounds trinitro-

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78. Submission from the Department of Defence, p. 24 (Evidence, p. 29). cf. US, H of R, Committee on Armed Services, Subcommittee on Procurement and Military Nuclear Systems, National Defense Authorization Act for FY 1988/1989 - H. R. 1748 - Hearings, 24 February 1987, p. 63 (Dr R. Barker, Department of Defense): for a weapon employing insensitive high explosive, 'it takes energy akin to a lightening bolt to cause the intended initiation of the high explosive. It will not detonate in violent accidents.' Contrast the concerns of Senator J. Vallentine on the possible effects of stray electric currents, etc: Evidence, p. 1209.
79. In simplistic terms, a nuclear weapon can be thought of as a sphere with the nuclear material in the centre, surrounded by conventional explosive. The function of the latter is to compress the nuclear material into a critical mass. Unless all the explosive is detonated at precisely the right time, the weapon will be blown apart rather than compressed and no critical mass will be formed.
80. Second supplementary submission from the Department of Defence, p. 24 (Evidence, p. 238.279).

toluene (TNT) equivalent.[81]

Knowledge of whatever methodology and data were used to arrive at the figure of 1 in 1 million is not publicly available.[82]

11.52 The Committee was referred to a passage in an article which critically evaluated the definition of one-point safe:

> This definition allows for nuclear yields with less than four pounds of TNT equivalent and/or lesser probabilities. Not all nuclear weapons incorporate 'one-point safe' design, allowing the possibility that nuclear yields may exceed four pounds with a higher probability than one in one million.
>
> While US officials insist that such events are highly unlikely, such statements are strictly meaningless since it is impossible to predict precisely either the origin or the sequence of events in a real accident.[83]

11.53 The Committee does not accept this claim that statements as to accident likelihood are 'meaningless'. The Committee sees nothing illogical in accepting an accident likelihood as small even though it is not possible to define precisely all the elements in all possible accident scenarios involving the weapon. In any event, the premise for the scenarios raised is a chemical explosion, itself a very unlikely event for reasons set out below. Moreover, the Committee notes that there has never been any reported partial nuclear detonation involving a United States

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81. US, Departments of Defense and Energy, Nuclear Weapons Surety: Annual Report to the President 1984, p. I-4. See also US, H of R, Committee on Armed Services, Subcommittee on Military Installations and Facilities, Civil Defense Aspects of the Three Mile Island Nuclear Accident - Hearings, 14 June 1979, pp. 219, 226, 236 (Department of Defense).
82. See para. 12.14, footnote 19 on probability figures in the context of the risk of nuclear detonation. For a brief description of what is publicly known of tests conducted to determine if specific weapon designs were one-point safe, see S. Fetter, 'Stockpile Confidence under a Nuclear Test Ban', International Security, Winter 1987/88, vol. 12(3), pp. 136-38.
83. L. Zarsky and others, 'Nuclear Accidents', Current Affairs Bulletin, June 1986, vol. 63(1), p. 10 (Evidence, p. 813).

weapon.[84]

11.54 The Committee inquired as to the effect of a nuclear yield of less than the equivalent of 4 pounds of TNT. It was told by the Australian Ionising Radiation Advisory Council (AIRAC) that the health hazard as a result of a fission of this size would be 'extraordinarily small'.[85] AIRAC said that the dose rate from the fission products would be about one hundredth of the background level.[86]

11.55 The use of insensitive chemical high explosive[87] as a trigger device in modern nuclear weapons is an additional safety feature in these weapons. A report to the United States President in 1984 noted:

> The possibility of an accidental or deliberate detonation of a nuclear weapon's chemical high explosives, with resultant dispersal of plutonium as a hazardous aerosol, can be

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84. 'U.S. Nuclear Weapons Accidents', Strategic Digest, November 1981, vol. 11(11), p. 921.
85. Evidence, p. 740 (AIRAC).
86. Evidence, p. 739 (AIRAC).
87. For the tests an explosive has to pass in order to meet US Department of Energy (DOE) criteria for insensitive high explosive, see R. J. Slape, IHE Material Qualification Tests: Description and Criteria, (MHSMP-84-22, Mason & Hanger - Silas Mason Co. Inc., Amarillo, Tex., June 1984). These tests include dropping, application of friction and of sparks, burning and heating, firing projectiles containing IHE at armour plate, and bullet-impact tests. See also R. R. McGuire and R. P. Guarienti, DOE Hazard Classification for Insensitive High Explosives, (UCRL-91420, Lawrence Livermore Nat. Lab., Livermore, Calif., August 1984), p. 2:

    > [IHE] is truly insensitive to impact, friction, spark, or thermal stimulus under any reasonable confinement condition. Only high amplitude shocks induce detonation and we have not found sustained lower level reactions. ... [But] we are speaking about materials that are by definition mass detonable explosives. They will detonate if the proper high amplitude shock pulse is provided. Therefore, if they are stored, handled, or transported in conjunction with more sensitive materials that could supply that pulse, they must be counted as hazard class 1.1. ... It is only when they are stored alone or with other IHE's that they can be considered as insensitive.

    This paper also summarises how the claim that 'there is no reasonable probability of the accidental delivery of sufficient energy to cause initiation' of IHE (p. 2) is verified: pp. 2-5.

> essentially eliminated for most scenarios by use of new formulations of high explosive, developed by the Department of Energy weapons laboratories. These formulations, called insensitive high explosive, have been used in all but one nuclear weapon to enter the stockpile since 1980...[88]

11.56 The Committee recognises that older nuclear weapon designs contain fewer safety features and that some of these weapons are probably still deployed.[89] The Committee has been unable to determine if any weapons which are not designed to be one point safe are likely to be on board warships visiting Australia. The additional hazard posed by older weapon designs will diminish as they are progressively withdrawn from service. It appears as if all will have been withdrawn by the middle of the 1990's.[90]

11.57 Very little detailed information appears to be publicly known about the design and safety features of British and French nuclear weapons.[91]

Points Made in Submissions

11.58 Submissions received by the Committee generally

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88. US, Departments of Defense and Energy, Nuclear Weapons Surety: Annual Report to the President 1984, p. II-7. The declassified part of the report does not identify the weapon which does not contain IHE. It appears as if it is the W88 warhead for the Trident II strategic missile: 'Nuclear Notebook', Bulletin of the Atomic Scientists, May 1988, vol. 44(4), p. 55. Retrofitting of weapons with IHE is possible only if the weapon design permits the replacement of the earlier HE with the bulkier IHE, as was the case with the B-61 bomb: US, H of R, Committee on Armed Services, Sub-committee on Procurement and Military Nuclear Systems, National Defense Authorization Act for FY 1988/1989 - H. R. 1748 - Hearings, 24 February 1987, p. 67 (Dr R. Barker, Department of Defense). There does not appear to be any indication that the nuclear warheads of Terrier missiles, ASROC's or SUBROC's have been retrofitted with IHE.
89. cf. supplementary submission from AIRAC, p. 5 (Evidence, p. 705).
90. See para. 11.33.
91. e.g. see UK, Parliamentary Debates (Commons), 6th series, vol. 128, 4 March 1988, Written Answers, col. 730: it is British Government policy not to comment on arrangements which exist to prevent unauthorised use of nuclear weapons.

acknowledged the presence of the various safety features built into nuclear weapons but sometimes suggested that these are not as reliable as claimed. For example, one submission stated that for a nuclear weapon to detonate:

> a sequence of electrical and mechanical procedures must be undertaken. None are immune to tampering. All can be accidentally activated, by operator error, by improper test procedures, or during simulations and war games. Electronic safety mechanisms can always be overcome by determined experts ... there seems to be no technical reason why a nuclear explosion should not occur by accident, or deliberately. Human error or human interference is the most likely cause.[92]

11.59 The Committee does not accept that in any practical sense it is correct to say that 'safety mechanisms can always be overcome'. Such statements appear to ignore the publicly available data on the sophistication of safety devices and procedures. The passage quoted also ignores the fact that simulations, war games, tests or other procedures which could give rise to operator error are not carried out during visits to Australian ports, and that weapons are held in safe storage during such visits (see below).

11.60 The Peace Squadron (Sydney) claimed that they had 'information about US weapons accidents where five out of six safety devices on nuclear weapons have failed', although no details were provided.[93] The Committee is otherwise aware of only one accident about which such a claim has been made. This related to a nuclear bomb dropped in 1961 when a B-52 bomber experienced structural failure during a flight over North Carolina.

11.61 The official view remains that the bomb was unarmed and that there was no chance of nuclear detonation, although the

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92. Submission from Scientists Against Nuclear Arms (WA) and the Medical Association for the Prevention of War (WA), p. 10 (Evidence, p. 796).
93. Submission from the Peace Squadron (Sydney), p. 6.

veracity of this view is a matter of dispute.[94] In any event, the type of weapon involved was not deployed by the United States Navy (and hence could not have been on a warship visiting an Australian port), was not in safe storage at the time, and is no longer in active service.[95]

Safe Storage Regulations

11.62 Accidents are less likely to occur to weapons when they are held in safe storage. Australia has no written agreement with the United States that there will be no handling of nuclear weapons in Australian ports.[96] Nor has it sought any such agreement.[97] The Department of Defence informed the Committee that it saw no need for a written agreement in view of the procedures that the United States is known to follow.[98] It also stated that there was no evidence to suggest that any of the NATO countries fail to observe fully all the safety procedures relating to their armaments while their vessels are in port.[99]

11.63 These procedures relate to both nuclear and non-nuclear weapons.[100] They stipulate that weapons must be in secure storage during port visits, and this precludes any handling of the

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94. G. Hanauer, 'The Story Behind The Pentagon's Broken Arrows', Mother Jones, April 1981, pp. 23-28; 'U. S. Nuclear Weapons Accidents', Strategic Digest, November 1981, vol. 11(11), pp. 931-32. For a well-documented view that the source of the 'five out of six switches' claim, Dr Ralph Lapp, has key parts of his information incorrect, see: R. L. Miller, Under the Cloud: The Decades of Nuclear Testing, (Free Press, New York, 1986), pp. 321, 520.
95. Note also the comment of the Center for Defense Information on the accident that 'as a result of the ... accident many new safety devices were placed on U. S. nuclear weapons and the Soviets were encouraged to do the same': 'U. S. Nuclear Weapons Accidents', Strategic Digest, November 1981, vol. 11(11), p. 932 (reprinted from CDI's Defense Monitor, 1981, vol. 10(5)).
96. Second supplementary submission from the Department of Defence, p. 26; Evidence, pp. 1252 and 1300.56 (Department of Defence).
97. Evidence, pp. 1252-53 and 1300.56 (Department of Defence).
98. Evidence, pp. 1253 and 1300.56-57 (Department of Defence).
99. Second supplementary submission from the Department of Defence, pp. 23-24 (Evidence, pp. 238.278-79).
100. Evidence, p. 1300.56 (Department of Defence).

weapons.[101] The Department of Defence holds copies of the United States and British instructions relating to storage of conventional explosives. It has obtained information informally which is sufficient to enable it to say with confidence that the instructions relating to nuclear weapons are more stringent.[102]

11.64 In response to questions put by the Committee, the Minister for Defence, the Hon Kim Beazley, stated:

> the US has confirmed to us that in all routine peacetime circumstances, US naval weapons are securely and safely stowed in an unarmed condition where they are protected from fire and electrical activity. The US Navy's safety procedures take full account of the risks arising from sources of electromagnetic radiation as well as unauthorised access being gained to nuclear weapons ... [T]he nuclear material in modern nuclear weapons is kept together with the other components of the weapon at all times. This does not however affect the possibility that a nuclear weapon accident might occur or that an accidental nuclear detonation might eventuate.[103]

The Committee accepts this assurance.

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101. Second supplementary submission from the Department of Defence, pp. 26 and 29 (Evidence, pp. 238.281 and 238.284). For discussion of the meaning of safe and secure storage, see Evidence, pp. 1254-55 (Department of Defence).

102. Second supplementary submission from the Department of Defence, pp. 29-30 (Evidence, pp. 238.284-85).

103. Letter from the Minister for Defence, 18 July 1988 (Evidence, p. 1257.01). See also Evidence, pp. 1255-57 and 1300.56 (Department of Defence). On separate storage, contrast the submission from the Department of Defence, p. 23 (Evidence, p. 28): 'it is normal practice to store arming mechanisms in a separate magazine from the weapons themselves', and as long as this separation is maintained accidental arming and nuclear fission cannot occur. In the earliest nuclear weapons, the fissile material was stored apart from the rest of the weapon, and only inserted as part of the arming process. Later weapons did not use the concept of insertable nuclear components as a safety device. The concept has been revived in the 1980's and development work done on it: see US, Departments of Defense and Energy, Nuclear Weapons Surety: Annual Report to the President 1984, p. II-22. It appears that no decision has been made to re-employ insertable nuclear components as a safety device in US weapons: S. Fetter, Towards a Comprehensive Test Ban, (Ballinger, Cambridge, Mass., 1988), p. 39.

11.65 The Committee considered that, in view of this, little would be achieved by seeking a formal written agreement relating to the storage of weapons during visits.[104] Even if such an agreement were could be obtained, it is unlikely that the United States would permit Australian officials to verify compliance by inspecting weapons storage.[105] The point was put to the Committee that the value of any agreement or condition on safe storage would be limited unless Australian authorities are able and prepared to monitor compliance.[106]

11.66 The Committee considered it important that weapons should be placed in safe storage in the vessel at a point clear of the Australian coast.[107] For example, an accident just outside Sydney Heads might affect almost as many people as one at a berth at Garden Island Dockyard.

11.67 The Committee noted, however, the Minister for Defence's statement (quoted above) that the storage arrangements applied 'in all routine peacetime circumstances', not just as ships enter port.[108] The Department of Defence also stated to the Committee

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104. New York City's draft nuclear weapon accident plan in relation to US Navy ships that may be homeported at Staten Island lists as one of the 'assumptions made in planning for emergencies' that 'it is Navy policy during normal peacetime conditions that naval weapons systems will not be armed in port or near New York Harbor': New York City, Mayor's Emergency Control Board, Staten Island Homeport Plan, (Draft, June 1988), p. 47. The need to make this assumption suggests that New York City was unable to obtain any formal written agreement from the US Navy relating to weapon arming. The statements in Evidence, pp. 1317-18 (People for Nuclear Disarmament) on this point are based on an earlier draft of the Staten Island plan.

105. Evidence, pp. 1254 and 1300.57 (Department of Defence). The Department of Defence told the Committee (p. 1300.57):

> in that the Australian Government respects the policy of the US to neither confirm nor deny the presence or absence of nuclear weapons on board visiting warships, we would not seek access to weapon magazines.

106. Letter from Mr P. Hayes, 10 February 1987, p. 1.

107. Evidence, pp. 216-17.

108. Letter from the Minister for Defence, 18 July 1988 (Evidence, p. 1257.01); Evidence, p. 1300.56 (Department of Defence).

that:

> Standard naval procedures provide that missiles and other such weapons should not be removed from their storage or prepared for launch until they are about to be used. For training purposes, dummy weapons and warheads are employed. The Department of Defence is confident that in all routine peacetime circumstances naval nuclear weapons are kept in an unarmed securely stowed condition. ... Given that naval nuclear weapons are always securely stowed in an unarmed condition, there is no need to consider securing them at particular distances from ports, or seeking agreements to do so.[109]

11.68 Both this and the quotation in paragraph 11.64 from the response of the Minister for Defence state that the storage conditions apply in 'all routine peacetime circumstances'. The concept was not defined. In chapter 2, the Committee noted that it had confined its inquiry to visits occurring at a time when neither Australia nor the country to which the warship belonged was engaged in hostilities. This approach, and the use of the concept of 'routine peacetime circumstances', were challenged in a submission from Mr Peter Hayes:

> why assume peacetime operations? Warships are made for crisis and war, not peacetime. 'Peacetime' is not a military concept, at least not an American military concept (it doesn't appear in the official U. S. DOD dictionary of military terms). Nuclear weapons and warships are built to be used in seconds, minutes and hours. 'Peacetime' in the nuclear

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109. Evidence, p. 1300.57 (Department of Defence).

era means permanent mobilization for war.[110]

11.69 The Committee notes that, contrary to this claim, 'peacetime' is a concept used by the United States Department of Defense,[111] and does appear in its official dictionary.[112] The concept plays a key role in the draft nuclear weapon accident plan prepared for Staten Island, New York.[113] Additionally, if weapons can quickly be moved from safe storage to readiness for

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110. Submission from Mr P Hayes, p. 3. See similarly P. Hayes and others, 'Nuclear Weapon Accidents: Are we ready?', Current Affairs Bulletin, September 1988, vol. 65(4), p. 27. Both sources refer to the official US system of defence readiness conditions (Defcons). The apparent inference is that, unless the phrase 'routine peacetime circumstances' can be defined in terms of Defcons, it lacks meaning, or at least lacks precision. There are five Defcons, ranging from Defcon 5 (normal peacetime position) to Defcon 1 (forces deployed for imminent combat): see generally B. G. Blair, 'Alerting in Crisis and Conventional War' in A. B. Carter and others, Managing Nuclear Operations, (Brookings Institution, Washington, 1987), pp. 77–113. It is not obvious how a statement intended for the public would gain in meaning or clarity by referring to the Defcon system, which is itself imprecise as far as the public are concerned. See for example S. D. Sagan, 'Nuclear Alerts and Crisis Management', International Security, Spring 1985, vol. 9(4), p. 100: 'it is difficult to outline with any degree of precision the preparations that take place under the five DEFCONs for three reasons': variations among US commands, threats faced, planned missions and weapon systems; 'the gradations of the system have been greatly altered over time' due to new communications and weapons systems, and new strategic threats; and 'most importantly, the precise details of the DEFCON system are, with good reason, kept highly classified'.

111. For an example chosen at random, see US, H of R, Committee on Armed Services, Defense Department Authorization and Oversight - Hearings on H. R. 1872, 8 March 1985, p. 282 (Prepared Statement of Lt Gen R. K. Saxer, Director, Defense Nuclear Agency): 'To increase weapon survivability and security once they [ie. land-based tactical nuclear weapons] leave peacetime storage, DNA is developing a secure and surviviable weapons container' (emphasis added).

112. US, Joint Chiefs of Staff, Department of Defense Dictionary of Military and Associated Terms, (JCS Pub 1, 1 June 1987, Washhington), p. 274. Although the word 'peacetime' is not defined, the phrases 'peacetime force material assets', 'peacetime force material requirement' and 'peacetime material consumption and losses' are defined. Moreover, the stated purpose of the dictionary is 'to supplement standard English-language dictionaries' (p. i), rather than to replace them.

113. New York City, Mayor's Emergency Control Board, Staten Island Naval Homeport Plan, (Draft, June 1988), p. 47: one of the assumptions on which the plan rests is that:

> it is Navy policy during normal peacetime conditions that naval weapons systems will not be armed in port or near New York Harbor, ... (emphasis added).

use, there is no need to remove them from storage in advance. This would appear, again contrary to Mr Hayes's claim, to reduce rather than increase the likelihood of nuclear weapon handling during any port visits which coincide with moments of international tension.

11.70 Mr Hayes cited no evidence of any United States practices or instructions indicating that the handling of nuclear weapons in an Australian port would occur during a time of heightened tension short of hostilities.[114] (In chapter 12, the reasons are set out why the Committee regards as unconvincing the hypothetical weapons handling scenario he advances.) Nor is the Committee aware of any evidence of this kind.[115]

Magazine Safety

11.71 There is no reason to assume that the possibility of a fire or conventional explosion in a nuclear weapon magazine is any greater that in a magazine used for conventional munitions. The concern for nuclear weapon safety might indicate that it is less.

11.72 Conventional magazine safety features include automatic spraying and flooding facilities (which can be remote controlled), carbon dioxide fire fighting systems and highly trained and

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114. Neither did Mr P. Gilding, who stated in his submission, (p. 8 (Evidence, p. 1341):

> If there were a developing crisis (which may not involve Australia and in fact may be opposed by Australia) it is possible there would be weapons handling in port if the ship were called to a trouble spot from Australian territory.

115. The reference by the Department of Defence to 'routine' peacetime circumstances was not intended to refer to differing levels of alert that forces might be placed on. Rather it was intended to address the case where a nuclear armed vessel might experience propulsion failure, non-nuclear accident, etc. requiring, for example, de-ammunitioning at sea prior to entering a port for dry-docking.

exercised crew.[116] Magazines on conventionally armed warships are often located below the ship's waterline, so flooding can take place even if there is a failure of the ship's pumping system.

11.73 The Committee is not aware of any publicly available data on fires or explosions in magazines, conventional or nuclear, aboard United States warships.[117] Due to the difficulty of concealing a fire that leads to an explosion it seems to be reasonable to suggest that the occurrence of such fires would become public knowledge. The absence of data is at least an indication that there have been few if any fires or explosions.

11.74 The Royal Australian Navy has been unable to find any record of accidents involving magazines holding conventional weapons in its ships while in port:[118] 'nor are any explosions known to have occurred in the magazines of conventionally armed warships for many years'.[119] The Department of Defence informed the Committee:

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116. Submission from the Department of Defence, p. 26 (Evidence, p. 31). See also Evidence, pp. 212-13 (Department of Defence). It should be noted that two warship types used by the Royal Australian Navy, the FFG and DDG, are of US design. As a result, the RAN has detailed knowledge of US magazine design and safety features as they relate to magazines for conventional weapons on these types of vessel: second supplementary submission from the Department of Defence, p. 29 (Evidence, p. 238.284).

117. cf. New York City, Mayor's Emergency Control Board, Staten Island Naval Homeport Plan, (Draft, June 1988), p. 36:

> There has never been an explosive accident involving weapons in storage aboard a modern [US] Navy warship. The only explosive occurrences for weapons in storage aboard Navy ships have been as a result of wartime hostilities.

No source is given for this statement. G. W. Schiele, 'Letting Our Bridges Burn', US Naval Institute, Proceedings, December 1988, p. 125 states:

> According to [US] Navy statistics, from 1973 to 1983 there were an average of 148 fires per year on ships and on land, with fire losses in each of those years averaging almost $19 million. ... Losses from shipboard fires in 1985 totaled $35 million.

The source of the statistics is not identified, nor is any breakdown given on the types of fires (e.g. on land, at sea, on ships undergoing refits, on ships in port) or on the cause or location of shipboard fires.

118. Supplementary submission from AIRAC, p. 5 (Evidence, p. 705). See also Evidence p. 596 (Senator Hamer); pp. 711-12 (AIRAC); p. 1257 (Department of Defence).

119. Evidence, p. 1300.58 (Department of Defence).

> Empirical evidence demonstrates that major fires in the magazines of modern warships simply do not happen. This is because of the effectiveness of the safety features designed and built into them.[120]

11.75 One indication of the safety of modern warship magazines is the incidents involving British ships during the 1982 Falklands campaign.[121] HMS Sheffield was hit by a missile, caught fire, burned for over four hours before being abandoned, and ultimately sank. HMS Glamorgan was similarly hit and the resulting fire took about three hours to bring under control. HMS Ardent and HMS Coventry were hit by bombs and sank, the former after burning for many hours. In none of these cases did the

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120. Second supplementary submission from the Department of Defence, p. 23 (Evidence, p. 238.279). See also Australia, Environmental Considerations of Visits of Nuclear Powered Warships to Australia, (May 1976), p. 16 (Evidence, p. 133):

> the risk of explosion of weapons is made extremely remote by elaborate safety features built into the design of weapons and weapon magazines and strict regulations for weapon handling. The efficacy of these arrangements has been demonstrated over the decades by the lack of any known explosion in peace time in the magazine of a warship in the fleets of any of the major powers.

The safety of warship magazines was also stressed to Committee members by RAN officers at a briefing in Sydney on 14 March 1988. Some submissions regarded the explosion aboard a USSR submarine in the Atlantic on 4 October 1986 as casting doubt on claims of magazine safety: e.g. submissions from Scientists Against Nuclear Arms (Tas), p. 2 (Evidence, p. 821); Mr K. Blake, p. 2. However, the explosion occurred during operational deployment, not a port visit; occurred to a ballistic missile, yet these are not stored in magazines in the same way as smaller nuclear weapons and are not brought into Australian ports; occurred to a liquid-fuelled missile, while the only weapons likely to be brought into an Australian port use (safer) solid fuel; and occurred in a Navy of whose operating safety standards litle is publicly known. Moreover, no radiation hazard from the weapon's warhead was reported to have resulted.

121. The details in the text are taken from D. Brown, The Royal Navy and the Falklands War, (Leo Cooper, London, 1987), pp. 141-44, 192-96, 198, 202, 209-10, 222-23.

ship's main magazines explode.[122] HMS Antelope was hit by a bomb which exploded during an attempt to defuse it. The ship caught fire and eventually the magazines exploded. On HMS Argonaut, an unexploded bomb penetrated the forward magazine, where two Seacat missiles detonated, starting a major fire.

11.76 A further indication of magazine safety is provided by the missile attack on the USS Stark in May 1987.[123] In the resulting intense fires, which lasted over 18 hours, temperatures were high enough to melt parts of the decking and superstructure. A principal fire main was severed. The forward missile magazine was flooded as a safety precaution and no weapons or ammunition exploded.

11.77 The Committee considered whether newer types of weapon storage arrangements might be less safe than traditional warship magazines. In other words, the Committee was concerned with what types of storage were considered to be 'safe' in the context of the understandings that exist regarding safe storage.[124]

11.78 From the published information it seems as if there are three broad types of nuclear weapon storage for surface ships. All also apply to conventional weapons/warheads. One involves the equivalent to traditional munitions magazines, in a well protected part of the ship and often below the waterline.[125]

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122. If the dubious claim is true that some British ships in the Falklands campaign carried nuclear weapons, the lack of any reported nuclear incident from the battle damage and losses can be seen as providing further evidence of the safety of these weapons. On the presence of nuclear weapons, see for example New Scientist, 24 March 1983, p. 834 for a claim that they were aboard both HMS Sheffield and HMS Coventry. For what now seems to be the more widely accepted view that they were not aboard any of the ships, see S. Gregory, 'The Command and Control of British Tactical Nuclear Weapons', Defense Analysis, 1988, vol. 4(1), p. 44.
123. US, H of R, Committee on Armed Services, Report on the Staff Investigation into the Iraqi Attack on the USS Stark, June 1987, p. 26.
124. Evidence, pp. 1254-55.
125. The way in which this can be used for a nuclear-capable missile such as ASROC can be seen from the diagrams in Jane's Weapon Systems 1987-88, (Jane's, London, 1987), pp. 512-13.

11.79 A second type of system involves armoured box launchers. These can be used for nuclear capable Tomahawk missiles. It would seem from the information available to the Committee that the weapons are stored in the self-contained launchers, which remain on deck: there is no separate magazine.[126] The Committee was told that storage within these box launchers is within the meaning of safe storage: the boxes provide a similar level of security to below-deck magazines.[127]

11.80 The third type of system, the vertical launch system (VLS), first became operational in 1986 for launching Tomahawk missiles.[128] The VLS is used on both surface ships and submarines,[129] and it is planned to extend the system to launch ASROC's. The system consists of a honeycomb of cells whose tops are almost flush with the open deck. An individual missile is shipped in a steel canister and the unit is loaded into a cell where it remains while on board. The canister serves as protection during shipping and as a vertical launcher rail when in the cell. Hatch covers close off the cell tops.[130] A deluge system is fitted, with individual controls for each canister in

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126. T. B. Cochran and others, Nuclear Weapons Databook, Volume 1: U.S. Nuclear Forces and Capabilities, (Ballinger, Cambridge, Mass., 1984), p. 264.

127. Evidence, p. 1255 (Department of Defence). See also US, General Accounting Office, Observations on Navy Nuclear Weapon Safeguards and Nuclear Weapon Accident Emergency Planning, (GAO/NSIAD-85-123, 29 July 1985), Appendix 1, p. 9: 'the armoured box launcher includes fire suppression systems that automatically activate ...'.

128. Jane's Weapon Systems 1987-88, (Jane's, London, 1987), p. 514. Unless otherwise indicated, all data on the VLS has been taken from this source. For a schematic diagram of an installed VLS see Aviation Week and Space Technology, vol. 127(19), 9 November 1987, p. 3.

129. The VLS on SSN-688 class submarines is external to the vessel's presssure hull: US, H of R, Committee on Armed Services, Subcommittee on Seapower and Strategic and Critical Materials, National Defense Authorization Act for FY 1988/1989 - H. R. 1748 - Hearings, 10 March 1987, p. 307 (Admiral B. DeMars).

130. The VLS has to be robust in order to ensure that when one missile is fired, missiles in adjoining cells are not affected by the heat and blast of the rocket motor. For a dramatic photograph of these effects as a missile is launched, see M. Hura and D. Miller, 'Cruise Missiles: Future Options', US Naval Institute, Proceedings, August 1986, p. 48.

the event of accidental motor ignition and a separate sprinkler system operates in other spaces in the cluster of cells.[131]

11.81 On the basis of the information provided to it, including some provided at an in camera hearing, the Committee considered box launchers and the VLS to be no less safe in the context of its inquiry than more traditional magazines. On the same basis the Committee was satisfied that the storage arrangements for theatre nuclear weapons launched from submarines' torpedo tubes are compatible with traditional magazine safety standards.

Effect on Magazine Safety of Dry-Docking the Vessel

11.82 The Committee notes that the issue of dry-docking a nuclear weapons capable warship was considered in late November 1983. The possibility was raised that HMS Invincible would undergo repair at Garden Island, Sydney. The British Government ultimately decided for operational reasons that it would not have the repair done in Australia.[132]

11.83 In response to debate on the issue, in February 1984 the Minister for Defence, Mr Gordon Scholes, announced that each request to visit for repairs involving a nuclear weapons capable vessel:

> would have to be considered on its own merits taking into account technical and safety factors, and the strategic and operational circumstances obtaining at the time.[133]

For example, a vessel's fire fighting and magazine flooding

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131. The fire protection system 'is pressurized with 64 gallons of fresh water at 225 pounds per square inch followed by up to 1,370 gallons of sea water per minute as required': S. B. Moorhead, 'The Latest in Ship Weapon Launchers - the Vertical Launching System', Naval Engineers Journal, April 1981, vol. 93(2), p. 95.
132. Senate, Hansard, 15 December 1983, p. 3831.
133. Defence News Release, No. 31/84, 26 February 1984, p. 2.

mechanisms might normally draw on sea water, and hence depend on the vessel being afloat. It would be necessary to determine that an alternative water supply (e.g. connection to shore fire-fighting pressure mains) was available and provided an adequate substitute.

11.84 In January 1989, the Minister for Defence responded to an inquiry from the Committee on whether guidelines existed to allow or preclude dry-docking of a nuclear weapons capable warship. The Minister stated:

> if the condition of a visiting allied warship deteriorated to the point that it needed to be docked, the Australian Government would make docking facilities available subject to the normal safety guidelines. ... The Royal Australian Navy's guidelines provide for the de-ammunitioning of warships, but also permit docking for external repairs without de-ammunitioning under particular conditions. Those conditions include the type of repairs involved, the likely duration of the docking, the location of the area under repair (in relation to the weapon magazines) and the fire-fighting facilities available to the dock. This approach is consistent with the Government's assessment of the safety standards of allied nuclear weapon technology and armament storage.[134]

11.85 The Minister's reply also indicated that docking for which de-ammunitioning would be required would be possible:

> for any docking requirements it would not be necessary on principle for allied warships to declare the nature of their armaments beyond an assurance that de-ammunitioning had occurred (perhaps at sea to a sister ship) should that be required.[135]

11.86 The Committee noted that this policy places visiting

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134. Letter from the Hon K. C. Beazley, 22 January 1989. See also, HR, Hansard, 11 October 1988, p. 1324.
135. ibid.

warships on the same footing as Australian warships, save for the location of de-ammunitioning (if required). The policy does not require disclosure of the presence or absence of nuclear weapons.

11.87 The Committee had no concern about the policy as it applied to a de-ammunitioned ship. By definition, the visit would not be one by a nuclear armed ship.

11.88 For a vessel that has not been de-ammunitioned, dry-docking may be possible without loss of safety. The nature of the repairs (e.g. to a rudder) may involve no disconnection of safety systems and no activities in or near magazines. With regard to fire safety, the Minister for Defence informed the Committee:

> all ships when dry docked are fitted out for fire-fighting. In particular, the ship's fire main is pressurised from a shore-supplied fire main. In the event of a fire in modern ships, the magazines may be flooded and sprayed directly through the fire main. In older ships, magazines are sprayed through the ship's fire main and flooded through bonnets which are fitted to the hull over the normal inlet point that allows flooding at sea. These bonnets are connected to, and pressurised by, the shore-supplied fire main.
>
> These normal fire-fighting precautions would not need to be varied in the case of nuclear weapons capable warships.[136]

11.89 The Committee also notes that the Treaty of Rarotonga, which establishes the South Pacific nuclear free zone and to which Australia is a party, does not restrict the dry-docking of nuclear weapons capable vessels.[137]

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136. Letter from the Minister for Defence, 11 April 1989.
137. ibid. See also HR, Hansard, 5 June 1986, p. 4622. For the text of the Treaty of Rarotonga, 6 August 1985, especially Article 5(2), see International Legal Materials, 1985, vol. 24, p. 1442. Australia ratified the Treaty on 11 December 1986.

11.90 The Committee RECOMMENDS that no dry-docking of nuclear weapons capable vessels be permitted unless either the vessel has been de-ammunitioned outside Australia or it can be guaranteed that the level of safety is at least as high as that for vessels berthed alongside a wharf, as is the normal practice.

Personnel Reliability

11.91 Concern was expressed to the Committee that errors or malicious acts by crew members dealing with nuclear weapons could pose a hazard.[138] Possibilities mentioned ranged from deliberate sabotage through drug or alcohol induced incompetence to simple human error. Reference was made to what was regarded by some as the large number of United States personnel assigned to duties related to nuclear weapons who have been found to be unreliable.

11.92 The issue of potentially unreliable staff was considered in a 1984 report to the United States President, which stated:

> Individuals assigned to designated positions are formally certified upon a favourable medical evaluation, an interview by the certifying official, and the acquisition of required security clearances. Once accepted for a nuclear weapons-related assignment, each person is continually observed/evaluated to assure that the highest reliability standards are maintained. There were 103,832 Department of Defense personnel certified in the program in 1984. Of that number only 3,766 or 3.63 per cent were decertified. Since 1975, the number of persons decertified annually has been relatively low and constant, averaging about

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138. e.g. see the submissions from the Manly Warringah Peace Movement, p. 2; Scientists Against Nuclear Arms (WA) and Medical Association for the Prevention of War (WA), p. 10 (Evidence, p. 796); the Victorian Government, pp. 2-3. See also Evidence, pp. 1199-1201 (Senator J. Vallentine).

4.5 per cent per year.[139]

11.93 The figures on staff removal from weapons programs can be seen as a cause for concern. In the view of the Committee, they are better seen as the application of very stringent standards to ensure that errors or deliberate malicious acts do not occur.[140] These standards are reinforced by stringent safety training and inspections, including inspections by an agency independent of the United States Navy.[141]

11.94 Equally important in the context of Australian port visits is the fact that nuclear weapons are in safe storage during the visits. This appears to the Committee virtually to

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139. US, Departments of Defense and Energy, Nuclear Weapons Surety: Annual Report to the President 1984, p. I-16. In the period 1975-1984 33% were decertified for drug abuse, 21% for psychological, behavioural or physical aberrations and 9% for alcohol abuse: see H. L. Abrams, 'Human Instability and Nuclear Weapons', Bulletin of the Atomic Scientists, January 1987, vol. 43(1), p. 36. See also 'Nuclear Notebook', Bulletin of the Atomic Scientists, July 1988, vol. 44(6), p. 55:

> During 1987, 2,524 nuclear workers lost their bomb credentials. Of these, 892 were bounced out of the program for alcohol or drug abuse (267 for cannabis use), and another 1,632 'decertified' for psychological or emotional instability, insubordination, criminal behavior, negligence of [sic] duty, or 'poor attitude'. At the end of 1987, 94,321 persons were in the PRP [Personnel Reliability Program], down almost 24,000 since 1979.

140. As an illustration of the thoroughness of the US Navy's procedures relating to nuclear weapons, see the detailed instructions in US, Department of the Navy, Loading and Underway Replenishment of Nuclear Weapons, (NWP 14-1 (Rev. C), August 1983). Most of the procedures detailed in this document are not directly relevant to Australian port visits, where nuclear weapons handling does not occur. But they indicate the extreme care taken to reduce to an absolute minimum the chance of human error in relation to the handling and storage of nuclear weapons.

141. e.g. see US, H of R, Committee on Armed Services, Defense Department Authorization and Oversight - Hearings on H. R. 1872, 13 March 1985, pp. 532-33 (Rear Admiral S. Hostettler), for a description of the training, inspections, etc. that are involved in a US Navy crew gaining and retaining their certification to handle nuclear armed Tomahawk missiles. On the nuclear safety rules as they apply in the US Pacific Command, see USCINCPACINST S8110.4C (8 May 1984), Appendix A ('Nuclear Safety Rules'). On the inspection system designed to ensure that the rules are adhered to, see US, Departments of Defense and Energy, Nuclear Weapons Surety: Annual Report to the President 1984, pp. I-16 - I-19: measures include short-notice inspections and surveillance of service-conducted inspections by the Defense Nuclear Agency.

eliminate the possibility of simple human error causing a nuclear weapon accident. It also greatly reduces the scope for malicious acts. The design of storage, fusing and firing procedures ensures that no one person can perform all the steps to bring about nuclear detonation (the 'two-man rule').[142]

11.95 For these reasons the Department of Defence considered the possibility of significant sabotage extremely implausible.[143] The Committee accepts this assessment.

THE ACCIDENT RECORD

Introduction

11.96 One way of assessing the effectiveness of the safety measures taken in the design and storage of nuclear weapons is to examine the accident record. The authors of many submissions

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142. T. B. Cochran and others, Nuclear Weapons Databook, Volume 1: U.S. Nuclear Forces and Capabilities, (Ballinger, Cambridge, Mass., 1984), p. 30. One type of device designed to prevent unauthorised use of a US nuclear weapon is a 'premissive action link' (PAL). This consists of mechanical and/or electronic coded locks. Units having custody of a weapon do not have the code; it would be received if the need arose from one authorised to to order use of the weapon: see generally D. Caldwell, 'Permissive Action Links', Survival, May/June 1987, vol. 29(3), pp. 224-26. The US Navy's limited use of PAL's is described in Vice Admiral G. Millar USN (Ret.), 'Who Needs PALs?', US Naval Institute, Proceedings, July 1988, p. 52:

> The Navy employs use-control devices such as the PAL on nuclear weapons stored ashore or during logistic moves, but not on nuclear weapons on board ships. ... The weapons [on ships] are in secure spaces under heavy guard ... with the weapons in the possession of U. S. personnel who have been strictly screened for reliability. The storage sites - the ships themselves - are well protected and secure. Some Army and Air Force weapons may be more accessible to elements intending mischief; PALs for those weapons are necessary. There does not seem to be such an urgent requirement for the Navy.

Another reason the US Navy does not use PAL's is due to the concern that communication difficulties might prevent the unlocking code from being received by a ship at sea: 'Accidental Nuclear War: A Rising Risk?', Defense Monitor, 1986, vol. 15(7), p. 2.

143. Evidence, pp. 1264-65 (Department of Defence).

referred to what they claimed were the large number of accidents that have occurred involving nuclear weapons, particularly those of the United States.[144] The Committee examined this claim critically in the light of the available information.

United States Definitions

11.97 United States nuclear weapon reporting criteria distinguish between accidents and incidents, a point not appreciated by many of those who made submissions. A nuclear weapon accident is defined by the United States Department of Defense as:

> An unexpected event involving nuclear weapons or their radiological components that results in:
> - A nuclear detonation.
> - Radioactive contamination.
> - The nonnuclear detonation or burning of a nuclear weapon or its radiological components.
> - The accidental or unauthorized launching, firing or use by U.S. Forces (or U.S. supported allies) of a nuclear weapon that can cause the outbreak of war.
> - Seizure, theft, loss (including jettisoning), or destruction of a nuclear weapon or its radiological component.
> - A public hazard, actual or implied.[145]

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144. e.g. see the submissions from the Victorian Government. p. 3; the Peace Squadron (Sydney), p. 6; Greenpeace Australia (NSW) Ltd, Part 3; Assoc Prof P. Jennings, p. 1; Scientists Against Nuclear Arms (Townsville), p. 2 (Evidence, p. 776); Albany Peace Group, p. 1; Inner City People for Nuclear Disarmament, p. 1; Concord, Burwood & District Peace Group, p. 2; Campaign for International Cooperation and Disarmament, p. 1; Balmain People for Nuclear Disarmament, p. 4; Mr R. Bolt, p. 16 (Evidence, p. 966); Scientists Against Nuclear Arms (WA) and Medical Association for the Prevention of War (WA), p. 9 (Evidence, p. 795); Action for World Development (Townsville Group), p. 1; Northside Peace Group, p. 1; Mrs L. Van Geloven, p. 6; Coalition Against Nuclear Armed & Powered Ships, p. 6 (Evidence, p. 1378); People for Peace, p. 1; Scientists Against Nuclear Arms (Tas), p. 2 (Evidence, p. 821); Ms A. Tubnor, p. 4; Friends of the Earth, p. 1; Prof W. J. Davis, p. 52 (Evidence, p. 499).
145. US, General Accounting Office, Nuclear Weapons: Emergency Preparedness Planning for Accidents Can Be Better Coordinated, (GAO/NSIAD-87-15, February 1987), pp. 13-14.

11.98 Nuclear weapon incidents are defined to include matters such as:

> unexpected events involving nuclear weapons, test and training weapons, dummy bomb units, nuclear weapon facilities, components or associated test and handling equipment that do not fall in the nuclear weapon accident categories.[146]

Absence of Accidental Nuclear Detonations

11.99 A recent review of United States Department of Defense documents by the General Accounting Office:

> showed that despite severe stresses imposed on nuclear weapons involved in accidents, there has never been an inadvertent US nuclear detonation.[147]

The United States stockpile averaged over 25,000 nuclear warheads

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146. ibid., p. 15. The category of incidents has, since 1974, been sub-divided into 'significant incidents' and 'incidents'. Prior to 1974, the former were part of the category 'nuclear weapon accident or significant incident'. As set out in US, Naval Weapons Evaluation Facility, Summary of Navy Nuclear Weapon Accidents and Incidents (1975, 1976 & 1977 Supplement), (NWEF Report 1070-2, Albuquerque, NM, 1978), p. 2, the definition of a 'nuclear weapon significant incident' (code named 'Bent Spear') is:

> An unexpected event involving war reserve nuclear weapons or nuclear components which does not fall into the category of a nuclear weapon accident but:
> 1. Results in evident damage to a nuclear weapon or nuclear component to the extent that major rework, complete replacement, or examination or recertification by the ... [Department of Energy] is required; or
> 2. Requires immediate action in the interest of safety or which may result in adverse public reaction (national or international) or premature release of information; or
> 3. Has such potential consequences as to warrant the informational interest or action of the Chief of Naval Operations (Naval Command Support Center).

147. US, General Accounting Office, Observations on Navy Nuclear Weapon Safeguards and Nuclear Weapon Accident Emergency Planning, (GAO/NSIAD-85-123, 29 July 1985), p. 4.

in each year from 1962 to 1983.[148] The safety record therefore rests on a large base and, for that reason, is statistically significant.

11.100 The absence of inadvertent nuclear detonation is also significant in view of what is known of the abnormal stresses experienced by some United States nuclear weapons. For example, in the most recent accident, which occurred in 1980:

> an Air Force Titan II missile exploded in an Arkansas silo. Though exposed to an explosion, the reentry vehicle containing a nuclear warhead was recovered intact and no radiological material was released.[149]

11.101 United States nuclear weapons were accidentally dropped from aircraft over Spain in 1966 and Greenland in 1968. Others in the 1950's were in severe aircraft fires, conventional explosions, and in one case were in a storage bunker into which an aircraft crashed.[150] A United States naval aircraft carrying a nuclear weapon was lost overboard from an aircraft carrier at sea in December 1965. United States nuclear weapons capable warships

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148. T. B. Cochran and others, Nuclear Weapons Databook, Volume 1: U.S. Nuclear Forces and Capabilities, (Ballinger, Cambridge, Mass., 1984), p. 15.

149. US, General Accounting Office, Nuclear Weapons: Emergency Preparedness Planning for Accidents Can Be Better Coordinated, (GAO/NSIAD-87-15, February 1987), p. 52. Although less well documented, it appears that on 4 October 1986 the liquid fuel in a ballistic missile on a Soviet submarine in the Atlantic exploded, but no nuclear detonation resulted: Jane's Defence Weekly, 11 October 1986, p. 759.

150. 'U. S. Nuclear Weapons Accidents', Strategic Digest, November 1981, vol. 11(11), pp. 924-30. This is a reprint of an article which first appeared in the Center for Defence Information's Defense Monitor, 1981, vol. 10(5). The article consists of an introduction and unclassified summaries on each of the 32 US nuclear weapon accidents, prepared by the US Department of Defense; and a commentary on each accident and conclusions, prepared by the independent, Washington-based Center for Defense Information. The US Defense Department material in the article is also incorporated in US, H of R, Committee on Appropriations, Subcommittee on Energy and Water Development, Energy and Water Development Appropriations for 1987 - Hearings, 17 March 1986, pp. 1469-87.

are reported to have been involved in collisions and fires.[151] In no case has nuclear detonation resulted.

United States - Less Serious Accidents

11.102 According to the most recent information on United States nuclear weapon accidents available to the Committee,[152] as of January 1986 there have been 32 accidents. Of these, 31 occurred before 1969 and the remaining one in 1980. As already noted, none of the 32 nuclear weapon accidents resulted in a nuclear detonation. However, 10 released radiological material in the immediate vicinity of the accident and two resulted in a broader dispersal of radiological material from the accident site.

11.103 The two most serious radiological releases both involved the detonation of the conventional explosive in the weapons. In none of the 32 reported accidents was there widespread airborne plutonium dispersal as a result of fire, although over half of the accidents did involve fire.[153] For some of these, the publicly available information does not make clear the extent of radiation dispersal, if any, or whether the fissile material in the weapon was plutonium.

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151. Stockholm International Peace Research Institute, World Armaments and Disarmament: SIPRI Yearbook 1977, (MIT Press, Cambridge, Mass., 1977), chapter 3; S. Gregory and A. Edwards, A Handbook of Nuclear Weapon Accidents, (Bradford School of Peace Studies, Bradford, 1988), chapter 4. See also paras. 5.38-5.39 above on non-nuclear accidents to nuclear powered warships. Many of these are also relevant to the issue of nuclear weapon safety as most of the nuclear powered vessels involved were also nuclear weapons capable, and therefore may have had nuclear weapons on board.
152. US, General Accounting Office, Nuclear Weapons: Emergency Preparedness Planning for Accidents Can Be Better Coordinated, (GAO/NSIAD-87-15, February 1987), pp. 14-16, 52-53. The text, paras. 11.102-11.106 is based on this source, unless otherwise indicated.
153. Figure taken from the accident summaries in 'U. S. Nuclear Weapons Accidents', Strategic Digest, November 1981, vol. 11(11), pp. 924-30. With some early models of nuclear weapons a capsule containing the plutonium or enriched uranium was kept apart from the weapon for safety purposes during most operations. In the reports of some accidents it is unclear if the nuclear capsule was involved in the fire or only the weapon, which in its safety state contained only natural (not enriched) uranium.

11.104 Where information is available it indicates that severe fires do not lead to plutonium dispersal.[154] For example, an aircraft carrying four nuclear weapons caught fire and crashed near Thule, Greenland in 1968. The conventional explosive in the four weapons exploded on impact, scattering the plutonium into the fire. A small amount of plutonium became airborne but the total amount of the plutonium dispersed in this way outside the immediate crash site was considered of no biological significance.[155]

11.105 The accidents resulting in plutonium dispersal all occurred before 1969.[156] This fact, and the limited number and scope of the earlier accidents, have been used by some commentators to argue that even the older nuclear weapons which incorporate less safety features are nonetheless sufficiently safe so as to preclude the need to continue nuclear testing in

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154. e.g. S. Glasstone (ed.), The Effects of Nuclear Weapons, (Rev. edn., USAEC, Washington, 1962), p. 667, which is based on access to classified information and which notes:

> In the few instances in which aircraft containing nuclear weapons have burned, the fissionable material melted and was left on the ground as slag. In this condition, oxides will form on the surface and may become airborne if disturbed, e.g., by the wind, to become an inhalation hazard.

155. H. L. Gjorup and others, 'Investigation and Evaluation of Contamination Levels', USAF Nuclear Safety, 1970, vol. 65(1) part 2, pp. 59–60. A further example, referred to in submissions, involved a BOMARC missile at McGuire Air Force Base, New Jersey in 1960. The missile's fuel caught fire and the warhead was destroyed in the fire, although the high explosive did not detonate. Contamination was limited to an area immediately beneath the weapon and an adjacent elongated area about 100 ft (30 m) long, caused by drain-off of firefighting water: 'U. S. Nuclear Weapon Accidents', Strategic Digest, November 1981, vol. 11(11), p. 931. This report does not state positively that the fissile material in the warhead was plutonium. Controversy arose in 1985 over whether the area of contamination had been understated: e.g. New York Times, 10 July 1985, p. B2, 'Old Missile Site at McGuire Is Still Tainted, Kean Says'. The US Defense Department maintained its view as to the size of the area contaminated.

156. US, Departments of Defense and Energy, Nuclear Weapons Surety: Annual Report to the President 1984, p. I-6.

order to enhance weapon safety.[157] The point is made in the context of some United States authorities' claims that continued nuclear testing is needed, in part, for this reason, and that therefore a complete nuclear test ban is undesirable.

11.106 The majority of the 32 accidents involved weapons systems no longer in the United States inventory, and occurred during Air Force flights,[158] a point seldom acknowledged by those making submissions.[159] Only three of the accidents related to the Navy. None of the Navy accidents involved a ship while in port or near civilian populations, and none released radioactivity or resulted in severe weapon damage. None of the 32 accidents occurred in circumstances which would arise during a port visit to Australia.

United States - Incidents

11.107 The United States Navy reported 630 nuclear weapon incidents between January 1965 and December 1985, of which 266 involved an actual nuclear weapon.[160] Sixty-six of the incidents involving a nuclear weapon occurred on Navy surface ships in port but none of these involved damage to nuclear components. None of the Navy nuclear weapon accidents or incidents resulted from ship

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157. e.g. J. C. Mark, 'The Purpose of Nuclear Test Explosions', and Paul C. Warnke, 'A Nuclear Test Ban and the Prevention of Nuclear Weapon Proliferation', both in J. Goldblat and D. Cox (eds.), Nuclear Weapon Tests: Prohibition or Limitation?, (OUP, Oxford, 1988), pp. 36 and 327 respectively. In the same context, see also S. Fetter, Toward a Comprehensive Test Ban, (Ballinger, Cambridge, Mass., 1988), p. 58: 'Although the degree of nuclear safety in early designs [of US nuclear weapons] was not as high as it is now, there was an acceptable margin of safety'.
158. 'U. S. Nuclear Weapons Accidents', Strategic Digest, November 1981, vol. 11(11), p. 922.
159. e.g. Scientists Against Nuclear Arms (Tas), p. 2 (Evidence, p. 821) stated in referring to these accidents: 'It must be emphasised that ... all accidents are, prospectively, a possible cause of a major disaster in Australian waters'.
160. The figures presented in Evidence, p. 215 by the Department of Defence suggest that the total of 630 is made up of 2 accidents and 628 incidents.

collision.[161] None occurred in Australian ports or waters.[162]

11.108 The full details of these accidents and incidents are not publicly available. From information that is publicly available,[163] it appears that the majority of incidents can fairly be described as trivial.[164] Some apparently involved matters such as scratched paint or a bent fin on training weapon simulators and flat tires on nuclear weapons carriers.[165] Others involved false

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161. cf. US Congress, Joint Committee on Atomic Energy, Subcommittee on Military Aplications, Proliferation of Nuclear Weapons - Hearing, 10 September 1974, p. 18 (E. R. La Rocque, Rear Admiral USN (ret.)): minor collision in harbour in Malta, in which a US destroyer was hit 'right on the spot where we had some nuclear weapons'. Either this was so trivial that it was not included in Navy records as a nuclear weapon incident, the publically disclosed records are incomplete, or the incident happened before 1965.
162. Senate, Hansard, 14 November 1986, p. 2360.
163. The main sources of information are US, Naval Weapons Evaluation Facility, Summary of Navy Nuclear Weapon Accidents and Incidents 1965 through 1972, (NWEF Report 1070, Albuquerque, NM, 1973); the 1973/1974 Supplement to the Summary, (NWEF Report 1070-1, Albuquerque, NM, 1975); and the 1975, 1976 & 1977 Supplement, (NWEF Report 1070-2, Albuquerque, NM, 1978). The Summary and Supplements were all released under the US Freedom of Information Act, but with extensive deletions having been made in order to protect classified information.
164. Note also that the reported totals include a number of occurrences involving conventional versions of nuclear weapons. They were not required to be reported. They were included, however, as 'the equipment involved is also used with nuclear weapons and a similar accident/incident involving a nuclear weapon could have serious results': US, Naval Weapon Evaluation Facility, Summary of Navy Nuclear Weapon Accidents and Incidents 1965 through 1972, (NWEF Report 1070, Albuquerque, NM, 1973), p. 1.
165. Evidence, p. 215 (Department of Defence); Senate, Hansard, 16 September 1986, p. 481 and 24 September 1986, p. 754. A list of 7 nuclear incidents during 1976-77 was reportedly released by the US Defense Nuclear Agency: M. Kunstel and J. Albright, 'Vandals at Robins Damage Nuclear-Armed Bomber', Atlanta Journal and Constitution, 5 February 1978, incorporated in US, H of R, Committee on Appropriations, Subcommittee on Military Construction Appropriations, Military Construction Appropriations for 1979 - Hearings, 23 February 1978, p. 157-59. Three of the incidents related to the US Navy: 'a Navy unit stored a weapon for 10 days outside the approved storage boundaries, but within a military base'; 'a Navy unit tipped on its side a container with a nuclear weapon in it, damaging the container, but not the weapon'; and 'a Navy unit said slight damage was done to a weapon when a crane operator swung the weapon into a barge during loading operations. No hazard to personnel was reported'. None of these incidents is relevant to warship visits to Australian ports.

alarms caused by faulty monitoring equipment.[166]

11.109 Viewed in this way, the United States Navy's safety record is much less serious than mere citation of the number of incidents would suggest. Yet most of the submissions that referred to the number of incidents recorded appeared not to be aware of the basis of the record-keeping.

11.110 The significance of the number is further reduced from the perspective of port visits to Australia if what is known of the causes of the incidents is taken into account. One commentator noted in relation to the United States Navy's nuclear weapon safety record:

> The major causes of accidents and incidents are personnel error and equipment failure. ... The most frequent type of accident [sic] involves the flooding of nuclear weapons by improper activation of sprinkler systems, rough seas, etc. Other incidents occur during handling and transportation, storage, in assembly or disassembly during maintenance operations, or during testing operations. Some incidents reportedly involve the actual or technical 'inadvertent release' of a nuclear weapon.[167]

11.111 The Committee notes that, of all these causes, only a few of those relating to storage can occur when the weapons are

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166. e.g. US, Naval Weapons Evaluation Facility, Summary of Navy Nuclear Weapon Accidents and Incidents (1975, 1976 & 1977 Supplement), (NWEF Report 1070-2, Albuquerque, NM, 1978), p. 4:

> During 1974 one DULL SWORD [ie. reported nuclear weapon incident] was caused by faulty radiac equipment in which the alarm sounded when no radiation was present. In 1975 four such incidents were reported ... No incidents were reported in 1976 that were caused by the malfunctioning of radiac equipment. However, in 1977 two such incidents occurred ... .

167. I. Y. Lind, 'Summary of Navy Nuclear Weapon Accidents and Incidents 1965-1977', (mimeo, Honolulu, 1986) pp. 4-5. In this comment, the term 'accident' is clearly not being used with the meaning defined by the US Navy (quoted above at para. 11.97).

in secure storage during a port visit,[168] and those that could occur, such as flooding, do not lead to a radiation hazard. Many submissions which referred to the United States safety record failed to appreciate this. For example, one submission referred to events likely to make an accident possible in an Australian port as being:

> moving nuclear weapons between ships in or near ports; helicopter airlift of nuclear weapons; dropping of missiles by mistake; shipping of nuclear weapons back to the U.S. by aircraft from aircraft carriers in port.[169]

All these activities are inconsistent with the safe storage in which nuclear weapons are held during visits to Australian ports.

British Accident Record

11.112 Official information is less readily available on

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168. The breadth of the US Navy's category of 'storage' for incident reporting purposes should be noted. The category used in US, Navy Weapons Evaluation Facility, Summary of Navy Nuclear Weapon Accidents and Incidents 1965 through 1972, (NWEF Report 1070, Albuquerque, NM, 1973), is defined (at p. 28) to include:

> accidents/incidents that occur while the weapon or component is in permanent storage, such as in a magazine or igloo; or temporary storage, such as on a transport vehicle overnight. Accidents/ incidents that occur during transportation or other movement when the vehicle or equipment is temporarily stopped (rest stops in convoy, step control in a handling system, pauses during strike down, etc.) also would fall into this category.

169. Submission from Greenpeace Australia (NSW) Ltd, p. 31. See also the submission from Mr R. Bolt, p. 16 (Evidence, p. 966), which noted that the weapon which appeared to be the most accident-prone was ASROC, and said that ASROC's are frequently carried by US warships visiting Australia. It seems that one major reason why ASROC is the most accident-prone is because it 'is handled more frequently than other surface-launched weapons and is large, heavy, and awkward to handle on a ship that is pitching and rolling': US, Navy Weapons Evaluation Facility, Summary of Navy Nuclear Weapon Accidents and Incidents (1973/1974 Supplement), (NWEF Report 1070-1, Albuquerque, NM, 1975), p. 98. The name of the weapon to which this extract refers was deleted on security grounds from the copy released under the US FOI Act. However, according to I. Y. Lind, 'Summary of Navy Nuclear Weapon Accidents and Incidents 1965-1977', (mimeo, Honolulu, 1986), p. 3, the weapon referred to is the ASROC. Whichever weapon is being referred to, this reason given for the high incident rate is not relevant to visits to Australian ports, when the weapons are in safe storage.

accidents or incidents relating to British nuclear weapons than to those of the United States.[170] In 1982, the British Government said that there had 'never been any incident involving a British nuclear weapon leading to its loss or to the dispersal of radioactive contamination'.[171] In 1987, a British Parliamentary question asked how many incidents there had been in the previous ten years involving nuclear warheads, 'in which the accidental discharge of radioactive material was narrowly averted'. The response was that there had been none in that period involving United States or United Kingdom weapons in the United Kingdom.[172]

Conclusions Based on Accident Records

11.113 The Committee acknowledges that, as a matter of strict logic, the fact that a particular type of accident has not occurred in the past does not prove that it will not happen in the future. The Committee, however, regards the United States Navy's nuclear weapon safety record as having considerable significance. The record is based on a large number of weapons over a long period of time in a wide variety of circumstances,

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170. One unofficial list of incidents involving British nuclear weapons, Stockholm International Peace Research Institute, World Armament and Disarmament: SIPRI Year Book 1977, (MIT Press, Cambridge, Mass., 1977), p. 77, lists only 5 incidents, none involving nuclear weapons of the kinds likely to be aboard a British warship visiting Australia. S. Gregory and A. Edwards, A Handbook of Nuclear Weapon Accidents, (U. of Bradford School of Peace Studies, Bradford, 1988), pp. 156-60, list 17 alleged incidents, most involving aircraft or bases and none of relevance to port visits to Australia. In assessing the accuracy of these lists, it should be noted that both state that HMAS Hobart carried missiles with nuclear warheads in the late 1960's. Even the most elementary research would have indicated that it has never been suggested that Australia was at any time a nuclear weapon state.

171. UK, Parliamentary Debates (Commons), 6th series, vol. 28, Written Answers, 23 July 1982, col. 340. See also ibid., vol. 119, Written Answers, 17 July 1987, col. 676; and vol: 128, 23 February 1988, col. 134: there has never been an accident involving damage to, or release of radioactivity from, a nuclear weapon in the UK, and neither has there been any malfunction of systems associated with such a weapon which could have posed a hazard to servicemen or to members of the public.

172. UK, Parliamentary Debates (Commons), 6th series, vol. 123, Written Answers, 30 November 1987, col. 439.

often much more demanding than those encountered during a port visit.

11.114 The Committee concludes that the known accident/incident records of the United States and British Navies do not demonstrate that a risk arises during port visits by vessels from these navies of sufficient magnitude to warrant contingency planning for a nuclear weapon accident.

11.115 However, as noted in paragraph 2.8, officers within the Department of Defence have prepared a draft document outlining possible procedures which might be required to respond to a nuclear weapon accident in an Australian port. The draft has no formal status or official approval, and the Committee has not had access to it.

11.116 The Committee considers that it would be useful for work to continue on this document, and that the necessary Departmental decision-making procedures be carried out to give the document official status and approval.

11.117 Accordingly, the Committee RECOMMENDS that the Department of Defence continue work on the current unofficial draft document outlining possible procedures for responding to a nuclear weapon accident in an Australian port, with a view to producing an officially approved document. The document should then be made available to the public, in the interests of better informing the community on appropriate response procedures.

CHAPTER 12

NUCLEAR WEAPON ACCIDENT SCENARIOS

INTRODUCTION

12.1 In the previous chapter it was noted that submissions opposed to the current position presented to the Committee a range of accident possibilities, with little agreement on which should provide the basis for assessing the need for contingency planning. For the purposes of its inquiry, the Committee considered the risks in three groups: nuclear detonation; accidents which would produce particles of plutonium of a size able to be inhaled; and accidents involving dispersal of plutonium in larger pieces.

RISK OF NUCLEAR DETONATION

Views in Submissions

12.2 Few of the submissions which criticised the absence of planning for nuclear weapon accidents indicated that the risk of accidental nuclear detonation could be regarded as so small as not to justify specific contingency planning.[1] Other submissions focused on accidents less serious than nuclear detonation without

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1. But see submissions from the Peace Squadron (Sydney), pp. 7-8 (plutonium dispersal by fire is the 'worst case' accident for planning purposes); Mr R. Bolt, p. 20 (Evidence, p. 970) (one-point detonation accident should be the basis of planning). See also Evidence, p. 921 (Mr M. Lynch): 'not that anybody is suggesting an accidental [nuclear] detonation'; pp. 597-98 (Prof W. J. Davis): nuclear detonation not considered possible.

expressly stating that nuclear detonation was not a credible event.[2]

12.3 Some submissions argued that, when nuclear weapons were involved, any possible accident, no matter how remote, should be taken into consideration:

> While naval authorities will tell us that the chance of...[an accidental nuclear detonation] occurring is very slim, they do not deny it is possible. Therefore, mathematical probability says it is likely to happen, given sufficient time. It is therefore this, the worst scenario, that must be addressed by any safety procedures.[3]

12.4 The Committee, as discussed in chapter 3, has adopted the orthodox approach to risk assessment, which distinguishes credible from other physically possible events. Because arguments of the type quoted are inconsistent with this approach, the Committee does not accept them. In the Committee's view, planning is appropriate only for credible accidents, not for all physically possible accidents irrespective of their likelihood.[4]

12.5 Other submissions suggested that predictions by nuclear planners had proven false in the past:

> Chernobyl, Three Mile Island, and the recent sinking of a Soviet submarine and indeed, the US Navy's accident record all PROVE that no matter how remote the risk, nuclear accidents

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2. e.g. see the submissions from the Victorian Association for Peace Studies, p. 3; Assoc Prof P. Jennings, p. 1; Dr B. Ewald, p. 3; Scientists Against Nuclear Arms (NSW), p. 2 (Evidence, p. 804); People for Nuclear Disarmament, p. 3 (Evidence, p. 1305); Senator J. Vallentine, p. 21 (Evidence, p. 1064).
3. Submission from Balmain People for Nuclear Disarmament, p. 3. See also for example the submissions from the Coalition Against Nuclear Armed & Powered Ships, pp. 6-7 (Evidence, pp. 1378-79); Derwent Valley Peace Group. p. 3.
4. See para. 3.14.

do happen.[5]

12.6 The claim was also made that the fact that a particular type of accident has not yet happened does not mean that it never will: there has to be a first time.[6] It was also put to the Committee that, as the consequences of a nuclear weapon accident would be so catastrophic, it would be prudent to eliminate the small probability that one would occur.[7] The Victorian Government submission suggested:

> There must always be a very small but real risk of nuclear detonation through either a sequence of technical faults or human error, or through an act of fanaticism by one or more of the ship's crew ...[8]

12.7 In contrast to these views, Eugene J. Carroll, formerly a rear admiral in the United States Navy and subsequently a strong critic of many aspects of nuclear weapons and strategy in his capacity as deputy director of the Center for Defense Information in Washington, considered that 'there is no credible possibility of accidental detonation of a nuclear weapon'.[9] The Australian former nuclear scientist, Sir Mark Oliphant, was quoted as having said recently that the probability of an accidental nuclear detonation 'is almost exactly zero'.[10]

Official Views

12.8 The view of the Department of Defence is that:

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5. Australian Nuclear Free Zones Secretariat, p. 3 (emphasis in original). See also the submissions from Scientists Against Nuclear Arms (Townsville), p. 2 (Evidence, p. 776); Epping & District Peace Group, p. 2.
6. e.g. submission from Mrs M. J. Holmes, p. 1.
7. Submission from Scientists Against Nuclear Arms (WA) and Medical Association for the Prevention of War (WA), p. 9 (Evidence, p. 795).
8. Submission from the Victorian Government, pp. 2-3.
9. E. J. Carroll, 'Nuclear Trojan Horse', New York Times, 8 August 1983, p. A17.
10. 'Sir Mark Oliphant says N-ships safe', Advertiser (Adelaide), 19 October 1988, p. 1.

> If we take into account the fact that any accidents to nuclear weapons are extremely unlikely to occur when those weapons are in secure storage, as would be the case during visits by US warships, the actual risk of a nuclear detonation during a visit to an Australian port by a US warship becomes infinitesimally small.[11]

12.9 On 24 September 1986, Senator Evans, as Minister representing the Minister for Defence, told the Senate:

> the Government is satisfied that the standards required by the North Atlantic Treaty Organisation countries, including France, in respect of nuclear weapons safety, coupled with the precautions taken on board visiting warships, effectively preclude the possibility of accidental nuclear detonation.[12]

12.10 The Australian Ionising Radiation Advisory Council (AIRAC) reviewed information on nuclear weapon safety features supplied to it by the Department of Defence. On the basis of this information it:

> concluded that the extensive safety precautions make identification of a likely cause of an accidental nuclear detonation difficult.[13]

AIRAC stated that it believed the possibility of a nuclear detonation occurring accidentally to be 'exceedingly small'.[14]

12.11 The position of the United States Navy with regard to planning for nuclear weapon accidents is:

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11. Submission from the Department of Defence, p. 24 (Evidence, p. 29).
12. Senate, Hansard, 24 September 1986, p. 754. See similarly HR, Hansard, 30 May 1984, p. 2397; ibid., 23 August 1985, p. 458; Senate, Hansard, 2 May 1986, p. 2292.
13. Supplementary submission from AIRAC, p. 4 (Evidence, p. 704).
14. Evidence, p. 707 (AIRAC). See also p. 708 where the Chairman of AIRAC gave his personal view that the possibility of such a detonation was 'negligible' and 'almost impossible'.

> The possibility of a nuclear weapon accident affecting the civilian population is virtually nil, nonetheless we plan for the worst possible, though unlikely, case. Even in worst case there is no danger of nuclear explosion.[15]

12.12 The United States General Accounting Office has reported that according to United States Departments of Defense and Energy sources:

> the probability of an accidental detonation of a nuclear weapon warhead is virtually non-existent because extensive safety precautions have been taken in the design, handling, storage, and maintenance of weapons.[16]

The view of the British Government is similar.[17]

12.13 In 1979, a representative of the United States Department of Defense stated:

> we still require that under normal environmental situations that the probability for a nuclear weapon detonation to occur through an accident is less than 1 in 1 billion. In the most extreme cases, like a fire, we maintain a

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15. US, H of R, Committee on Armed Services, Subcommittee on Military Installations and Facilities, Hearings on H. R. 1409 to Authorize Certain Construction at Military Installations for FY 1986, 27 March 1985, p. 432 ('Response to a Nuclear Weapon Accident on a Navy Ship').
16. US, General Accounting Office, Nuclear Weapons: Emergency Preparedness Planning for Accidents Can Be Better Coordinated, (GAO/NSIAD-87-15, February 1987), p. 16. See also US, General Accounting Office, Observations on Navy Nuclear Weapon Safeguards and Nuclear Weapon Accident Emergency Planning, (GAO/NSIAD-85-123, 29 July 1985), p. 5: 'Department of Energy studies indicate that the possibility of an accidental nuclear explosion while transporting or storing nuclear weapons is so remote as to be virtually nonexistent'.
17. UK, Parliamentary Debates (Lords), 5th series, vol. 466, 10 July 1985, cols. 190 and 191: 'there is no prospect of an atomic bomb-type explosion occurring by accident or mistake' and 'the prospect of an accidental discharge of a nuclear weapon is very remote indeed'.

probability of less than 1 in 1 million.[18]

12.14 The Committee has not had access to the methodology or the data used to produce these risk estimates or underlying the official assurances. Assuming that formal risk assessments have been made,[19] the input to the assessments would of necessity include highly classified details of weapon design. It follows, therefore, that assurances from the Australian Government are based to a considerable extent on assurances given to it by United States and British sources, not on its own independent assessment.[20]

Effect of Nuclear Reactor Accident

12.15 Some visiting warships may be both nuclear powered and nuclear armed. No plausible scenario has been put to the Committee whereby an accident involving the reactor could lead to a nuclear detonation of the weapon.[21]

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18. US, H of R, Committee on Armed Services, Subcommittee on Military Installations and Facilities, Civil Defense Aspects of the Three Mile Island Nuclear Accident - Hearings, 14 June 1979, p. 224. See also Evidence, p. 1261 (Department of Defence).
19. It may be that quantified assessments have only been made for the newer weapons: cf. US, H of R, Committee on Armed Services, Subcommittee on Procurement and Military Nuclear Systems, National Defense Authorization Act for FY 1988/1989 - H. R. 1748 - Hearings, 24 February 1987, p. 69 (Dr R. Barker, Department of Defense): for the probability of an older nuclear weapon's conventional explosive detonating by accident:

    > it is difficult, if not impossible, to assign a number of [sic] the probability in an accident environment. We still believe it is quite low, some place between one in ten to the third or one in ten to the sixth, but because of the nature of the design, we cannot quantify it, we cannot do the tests which make us feel comfortable in providing a number. The modern devices are such that we can tell you indeed it is at least as good as one in a million and maybe better.

    Since the nuclear detonation requires the prior detonation of the conventional explosive, it would seem to follow that where the latter cannot be quantified, neither can the former. The ambit of the category of weapons for which quantification is not possible was deleted from the published transcript on security grounds.
20. Second supplementary submission from the Department of Defence, pp. 22-23 (Evidence, pp. 238.277-78).
21. cf. Evidence, p. 425 (ANSTO).

Conclusions - Nuclear Detonation

12.16 The Committee found no reason to disagree with the official view that the risk of accidental nuclear detonation is so small that there is no need to have specific plans for this contingency. The Committee reached its conclusion on the basis of what is publicly known about the safety features in the design of nuclear weapons; the fact that warheads and explosives are officially stated to be held in safe storage during port visits; the integrity of that storage; the absence of any accident to date leading to nuclear detonation; and the absence in submissions made to it of any credible scenario which would result in nuclear detonation during a port visit.

12.17 Having reached this conclusion the Committee did not find it necessary to assess the effects of a nuclear detonation. Nor was it necessary to consider what sort of planning would be required in order to deal with these effects.

ACCIDENT CAUSING DISPERSAL OF PLUTONIUM PARTICLES

Introduction

12.18 The hazards from plutonium were discussed in the previous chapter, in particular the hazard from inhalation of plutonium particles. The Committee therefore examined the possibility of accidents leading to this result. It appeared to the Committee that the expert view was that the plutonium in a weapon could, in an accident, be rendered into particles capable of inhalation by one of two means. These were fire and/or conventional explosion.[22]

Effect of Fire

12.19 Even if a nuclear weapon is involved in an intense, prolonged fire, only a small proportion of the plutonium will be turned into a form in which it can be inhaled. The United States Departments of Defense and Energy reported in 1984:

> The experimental efforts of the Department of Energy study of plutonium dispersal under various fire scenarios have been completed. The conclusions of the study are that in a fuel fire approximately 0.1 percent of the plutonium mass is aerosolized and that nearly all of this aerosol is respirable. The worst-case fuel fire would aerosolize up to only one percent. The results of this joint study correlate quite well with other tests and studies on the aerosolization of plutonium.[23]

12.20 AIRAC told the Committee it accepted the accuracy of these conclusions.[24]

12.21 One purpose of the British nuclear 'Minor Trials' conducted at Maralinga, South Australia in the late 1950's and early 1960's was to assess the degree of plutonium dispersal from an accident involving a nuclear weapon. The Committee was told

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22. e.g. see US, General Accounting Office, Nuclear Weapons: Emergency Preparedness Planning for Accidents Can Be Better Coordinated, (GAO/NSIAD-87-15, February 1987), p. 16 (views of US Defense and Energy Department officials); UK, Parliamentary Debates (Commons), 6th series, vol. 149, Written Answers, 20 March 1989, col. 477. See also US, Defense Nuclear Agency, Nuclear Weapons Accident Response Procedures Manual, Washington, 1984), p. 3: if the conventional explosive in a nuclear weapon

    > explodes ... there may be extensive radiological contamination. A fire, while less serious than an explosion may also give rise to substantial contamination.

23. US, Departments of Defense and Energy, Nuclear Weapons Surety: Annual Report to the President 1984, p. II-25.
24. Evidence, p. 725 (AIRAC). Contrast the submission from Prof W. J. Davis, p. 18 (Evidence, p. 465) and his Evidence, p. 591, where it is assumed that 100% of the plutonium is aerosolised in a shipboard fire. No scientific evidence or argument is provided by Prof Davis to support his assumption. Nor is the Committee aware of any.

that the dispersal from tests designed to simulate an intense petrochemical fire was limited to an area with a maximum dimension across the perimeter of 200 metres.[25] Only a very small percentage of the material was dispersed into the air.[26]

12.22 The Committee noted that it appears that the plutonium would have to remain subject to the intense fire for a considerable period in order to produce significant aerosolisation.[27] One accident scenario, that put to the Committee by Professor W. J. Davis, postulated significant aerosolisation by assuming that the weapon would remain in the fire for three hours.[28]

Effect of Conventional Explosion

12.23 The United States General Accounting Office found that officials of the United States Departments of Defense and Energy:

> believe the most probable health and safety hazards from a nuclear weapon accident are the detonation of conventional explosives and the

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25. Evidence, p. 719 (AIRAC). See also Evidence, p. 418 (ANSTO); J. L. Symonds, A History of British Atomic Tests in Australia, (AGPS, Canberra, 1985), p. 502.
26. J. L. Symonds, A History of British Atomic Tests in Australia, (AGPS, Canberra, 1985), p. 501. Each of the two tests involved burning a 7.6 cm long rod of plutonium. The total plutonium present was 405.4 g, of which an estimated 395 g was returned to Britain after the tests: ibid., p. 556. See also Evidence, pp. 706.708 ff for a now declassified extract from the UK Atomic Weapons Research Establishment report on the Vixen A trials in 1959 from which Dr Symonds drew his information. In the first test, dispersal by fire was about 1%. In the second test, material was not collected for two days after the fire. About 3% was dispersed by the combined effects of the fire and then the wind during the two day period. It is important to note that the Maralinga tests were not designed to model an accident to a weapon in a warship magazine. The results do not reflect the extent to which plutonium dispersal might be reduced by deposition inside the magazine and inside the hull of the warship.
27. UK, Atomic Energy Authority, Atomic Weapons Research Establishment, AWRE Report No. T 15/60: Vixen A Trials, (AWRE, Aldemaston, 1961), pp. 11-12 (Evidence, pp. 706.711-12) indicates the temperatures (725-860 degrees Celsius) and times (20-30 minutes) involved.
28. Submission from Prof W. J. Davis, p. 18 (Evidence, p. 465). In giving an alternative scenario involving 100 warheds in a fire (Evidence, p. 593), no indication was given that the assumed duration of the fire was altered.

release of plutonium particles ...[29]

12.24 AIRAC also regarded a conventional explosion as a key factor:

> the dispersion to substantial distances involves a chemical explosion which disperses the plutonium. Fire may be the initiating event of a chemical explosion; collision may be the initiating event of the fire. But the essentiality of it is that you have to have a chemical explosion that disperses the plutonium, not only in order to get it dispersed, but in order to open up the magazine or whatever to the atmosphere. So the chemical explosion is a strong prerequisite right through the AIRAC submission.[30]

12.25 AIRAC described to the Committee the process by which a conventional explosion would convert some of the plutonium present into an aerosol:

> the casing fails - we are talking of a time sequence of nanoseconds or less - and what you really do is squirt out molten plutonium into the atmosphere. ... [This] will generate an awful lot of very small particles that are inhalable and that will travel quite large distances.[31]

12.26 A theoretical model used to predict plutonium dispersal

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29. US, General Accounting Office, Nuclear Weapons: Emergency Preparedness Planning for Accidents Can Be Better Coordinated, (GAO/NSIAD-87-15, February 1987), p. 53. See also New York City, Department of Health, Bureau for Radiation Control, Radiation Aspects of Emergency Plan for Proposed Homeport, Navy Battleship Surface Action Group, Stapleton, Staten Island, (17 March 1988), p. 3, referring to naval nuclear weapon hazards:

    > Without specific information on the nuclear ordnance components, we view the principal accident in terms of possible health consequences as the result of unintended detonation of the conventional high explosive in the neighborhood of the fissionable capsule resulting in airborne dispersion of plutonium-239.

30. Evidence, p. 718 (AIRAC).
31. Evidence, p. 724 (AIRAC). It was experiments leading to this type of effect that resulted in the widespread contamination from the Maralinga trials: ibid., pp. 723-24.

following a nuclear weapon accident assumes that the detonation of the weapon's conventional explosive could result in twenty per cent of the plutonium being aerosolised in respirable sized particles.[32] Once in aerosol form, the assumptions and calculations used in the model indicate that this plutonium could be distributed over a significant area.[33]

12.27 However, the model uses very much worst case assumptions: the percentages of plutonium dispersed have been smaller in tests and actual accidents, and the statistical confidence level in the model is regarded as low.[34] In addition, the model, which is not directed specifically to shipboard accidents, makes no allowance for the percentage of plutonium particles that might be trapped within the ship.[35] Nonetheless, the plutonium dispersal achievable through the detonation of the weapon's conventional explosive poses a serious possible hazard.

12.28 In the aircraft accident which occurred in 1966 at Palomares, Spain the high explosive in two nuclear weapons

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32. US, General Accounting Office, Nuclear Weapons: Emergency Preparedness Planning for Accidents Can Be Better Coordinated, (GAO/NSIAD-87-15, February 1987), p. 52, referring to studies using the US Department of Energy's Atmospheric Release Advisory Capability system. Respirable size is defined as being 10 microns or less.

33. ibid., p. 51 contains a diagram indicating that the downwind dispersal of quantities sufficient to require respirator protection or evacuation could extend for about 2 kilometres. See also Evidence, pp. 718, 720, 723-4 (AIRAC) on the extent of plutonium dispersion following detonation of the conventional explosive in a nuclear weapon.

34. ibid. In contrast to the model's assumption of 20%, a study done by Sandia National Laboratories suggested that the fraction aerosolized in respirable form might be in the range of 1 to 10%: cited in New York City, Department of Health, Bureau for Radiation Control, Radiation Aspects of Emergency Plan for Proposed Homeport, Navy Battleship Surface Action Group, Stapleton, Staten Island, (17 March 1988), p. 16.

35. US, H of R, Committee on Armed Services, Subcomittee on Military Installations and Facilities, Civil Defense Aspects of the Three Mile Island Nuclear Accident - Hearings, 14 June 1979, p. 235 (Dr J. P. Wade, Department of Defense): in the scenario modelled

> the accident happens while the weapon is on a hard concrete surface and occurs under adverse meteorological conditions. In real life, such an accident could occur while a weapon was being moved from one location to another, within a military installation, or being loaded into an airplane.

detonated when they hit the ground, dispersing plutonium. The furthest point at which plutonium was detected above the level of natural background radiation was a about one and a half kilometres from the point of detonation.[36] Contaminated soil was removed from 2.3 hectares for shipment to the United States, with other areas less seriously contaminated being treated at the site.[37]

Committee's Focus on Accident Likelihood

12.29 The Committee was prepared to assume for the purpose of its inquiry that an intense fire of some duration involving a nuclear weapon on a visiting warship, or the detonation of the conventional explosion of that weapon, might have serious consequences.[38] The Committee focused its attention on the means by which such a fire or conventional explosion might occur, in order to determine its likelihood.

12.30 The Committee notes that in taking this approach it did not follow the approach taken by many of the submissions opposing

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36. US, H of R, Committee on Armed Services, Subcomittee on Military Installations and Facilities, Civil Defense Aspects of the Three Mile Island Nuclear Accident - Hearings, 14 June 1979, p. 236 (Maj Gen J. K. Bratton, Department of Energy).
37. US, Defense Nuclear Agency, Technology and Analysis Directorate, Palomares Summary Report, (DNA, 1975), p. 65. On the effectiveness of the clean-up and the limited extent to which contamination still gives rise to concern, see E. Iranzo and others, 'Air Concentrations of 239Pu and 240Pu and Potential Doses to Persons Living Near Pu-Contaminated Areas in Palomares, Spain', Health Physics, April 1987, vol. 52(4), p. 460; New York Times, 28 December 1985, p. 2, 'Where H-Bombs Fell, Spaniards Still Worry'. The official view is that no one received exposure in excess of international safety levels as a result of the accident: New York Times, ibid., citing the Spanish Nuclear Energy Board; US, H of R, Committee on Armed Services, Subcommittee on Military Installations and Facilities, Civil Defense Aspects of the Three Mile Island Nuclear Accident - Hearings, 14 June 1979, p. 227 (Maj Gen R. Cody, Defense Nuclear Agency).
38. Submissions by Prof W. J. Davis and Scientists Against Nuclear Arms (NSW) provided calculations which, using different values, gave differing figures for the numbers of additional cancers which would be caused by a nuclear weapon accident on a ship in Sydney. The Committee did not consider it necessary to investigate the accuracy of the calculations or the assumptions underlying them.

the current position. These submissions tended to focus in some detail on the consequences of a nuclear weapon accident, without giving equally detailed consideration to how any such accident might occur. The Committee considered that it was more efficient to focus on how accidents having those consequences might occur. If it can be concluded that the likelihood of occurrence is very small, there is no need to explore further some of the difficult issues that relate to accident consequences.

Possible Scenarios

12.31 The reported safety characteristics of the insensitive high explosive used as a trigger in modern nuclear weapons are such that the Committee can find no accident scenario which takes account of these characteristics that would lead to its detonation. Therefore, in looking for a means by which a nuclear weapon's conventional high explosive might be detonated, the Committee was considering only those older weapons not fitted with insensitive high explosive.[39]

12.32 The view of the Department of Defence is that 'credible hypothetical nuclear weapon accident scenarios on visiting warships are really very hard to envisage'.[40] Compared to the reference accident relating to naval reactors, the Department's view is that 'the chance of a nuclear weapons accident would be very much less than the chance of an accident involving a dynamic system, like a reactor system' on a visiting warship.[41] Because the weapon is in a passive state, the Department did not regard it as plausible to regard the weapon as the source of the events leading to the weapon burning or its conventional explosive detonating.[42]

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39. See paras. 11.33 and 11.55-11.56 on the types of weapons which may not use insensitive high explosive.
40. Evidence, p. 1258 (Department of Defence).
41. Evidence, p. 1262 (Department of Defence).
42. Evidence, p. 1259 (Department of Defence).

12.33 The Committee considered this view to be sound. Accordingly, as the weapons are on a warship, it looked at ways in which the warship rather than the nuclear weapon could become the victim of fire or explosion which might then affect the weapon. Ship collision is one initiating factor which obviously has to be considered.

Collision

12.34 A number of submissions referred in general terms to vessel collision as the initiator of a nuclear weapon accident.[43] The Department of Defence examined the possibility of a nuclear weapon accident resulting from a collision - a possibility it regarded as 'conceivable as distinct from credible'.[44]

12.35 AIRAC, on its own initiative and on the basis of information supplied by the Department of Defence,[45] attempted to define some hypothetical accidents.[46] It did so as an interim step towards defining the most probable accident involving a nuclear weapon. AIRAC came to the view that in order to produce an immediate and serious radiation hazard the accident would have to involve a collision followed by a fire and conventional

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43. e.g. submissions from Scientists Against Nuclear Arms (Townsville), p. 1 (Evidence, p. 775); Scientist Against Nuclear Arms (Tas), pp. 3-4 (Evidence, pp. 822-23); Balmain People for Nuclear Disarmament, p. 3; Port Adelaide Environmental Protection Group, p. 2; Mr R. Addison, pp. 1 and 2.
44. Evidence, p. 1259 (Department of Defence). In P. Hayes and others, 'Nuclear Weapons: Are we ready?', Current Affairs Bulletin, September 1988, vol. 65(4), p. 26 it is incorrectly stated that Defence regarded the collision scenario as one of 'only two credible scenarios' involving a nuclear weapon in Australia.
45. Evidence, pp. 737-38 (AIRAC).
46. It is evident that some of those following the course of the inquiry have not appreciated the distinction between hypothetical accidents and a reference accident used as a basis for planning: see, for example, the submission from Mr P. Gilding, p. 5 (Evidence, p. 1338). Hypothetical accidents are the input to the risk evaluation process: a reference accident is one possible outcome of that process. The assumption that the Department of Defence has not evaluated hypothetical accidents does not follow from the fact that it has not arrived at a reference accident for nuclear weapons.

explosion.[47]

12.36 The Committee notes that AIRAC's scenario requires that three separate events occur in sequence. In order to evaluate the scenario, it has to be asked how likely is a collision, how likely is that collision to cause a fire, and how likely is the fire to cause the conventional explosive to detonate. If each of these events is unlikely, the probability of their all occurring together is even less likely.

12.37 The difficulty of accurately establishing the likelihood of a warship being involved in a collision in an Australian port was noted in relation to nuclear powered warships in chapter 7. In the present context, the Committee noted that, while special navigational controls apply in relation to the port movements of nuclear powered warships, no specific controls apply to the movements of nuclear weapons capable vessels.

12.38 The Victorian Government suggested that controls similar to those applicable to nuclear powered warships ought to be applied to nuclear weapons capable vessels.[48] But it provided no supporting argument based on collision probability. Nor did it explain how it considered that a collision would lead to a radiation hazard from a nuclear weapon that was in safe storage on board, or how likely it considered this in comparison to a collision-induced reactor accident.

12.39 The Department of Defence has taken the view that there

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47. Supplementary submission from AIRAC, pp. 4-5 (Evidence, pp. 704-05); Evidence, pp. 708-09 (AIRAC). Although AIRAC set out this scenario in a measure of detail, it did not rule out other accident scenarios that might be developed: Evidence, pp. 709 and 713.
48. Submission from the Victorian Government, p. 4.

is no need to impose special speed limits on visiting warships.[49] It has preferred to leave the matter of appropriate limits to the individual port authorities and relies on warships observing these limits.[50] For Sydney for example, the limits are 12 knots (22 km/h) from the Heads to Bradley's Head and 10 knots (18.5 km/h) from there to the Harbour Bridge.[51]

12.40 A collision occurring at the relatively low speeds maintained in ports and port approaches is unlikely to affect weapons stored in the vessel's magazines, which for safety reasons are located away from the more vulnerable parts of the ship. The Committee received no information suggesting that a United States warship has been in a serious collision while entering or leaving an Australian port.[52] As noted in the previous chapter, none of the United States Navy's 630 reported nuclear weapon accidents or incidents in the period 1965-1985 resulted from ship collision.

12.41 As part of its collision-fire-conventional-explosion scenario, AIRAC canvassed the possibility that the firefighting capability of a warship could be rendered inoperative due to the vessel being involved in a collision which also caused a fire in

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49. A surface warship would need to be the struck rather than striking ship for the maximum weapon accident likelihood to arise. If it was the striking ship the impact would probably be on its bow, well away from magazines and in a place where the prospect of localising a fire would be good. Thus the speed of other vessels in the vicinity is more important than the speed of the surface warship. This is less true for submarines, whose weapons may be stored near the bow.
50. cf. Evidence, pp. 1291-93 (Department of Defence) relating primarily to nuclear powered warships.
51. Evidence, p. 1292 (Department of Defence).
52. The attention of the Committee was drawn to collisions such as that of the USS Texas with a wharf in Brisbane in 1983: see, for example, the submissions from Friends of the Earth, p. 1; Mr P. Gilding, p. 7 (Evidence, p. 1340). But in the context of the scenarios under consideration this type of accident can fairly be regarded as insignificant: see Evidence, pp. 1393-94. Mr Peter Hayes, in a letter to Senator McIntosh, 10 February 1987, p. 1 stated that there had been a collision between a US aircraft carrier and a RAN destroyer in Sydney Harbour in the 1960's. The Department of Defence informed the Committee that they had no record of this.

the magazine.[53] The possibility of the collision and fire occurring as independent events at the same time is logically far less probable.

12.42 Collision might cause flooding rather than fire.[54] This would be particularly likely if the warship was a submarine. Even a collision that started either a magazine fire or a fire capable of spreading to a magazine might well not detract from the fire-fighting capability on the vessel.[55] This is especially true in that the magazine can be flooded or smothered even though the vessel has lost all power.[56]

12.43 The Committee was told by the Department of Defence that, given magazine safety systems, 'the risk of a major sustained fire in as well protected part of a warship as its magazine does stretch credibility very far'.[57] Thus, even if the AIRAC scenario proceeds from a collision to ship fire, it is difficult to find a mechanism by which the fire could affect the magazine so as to cause the nuclear weapon's conventional explosive to detonate.

12.44 As an alternative to the AIRAC scenario, the collision may impact directly on the magazine without causing a fire, but with sufficient force to trigger the conventional explosive of a nuclear weapon. The need to ensure that the weapons can withstand the shock of routine handling, stormy seas, launching or, for bombs, aircraft take-off and landing, indicates that they must be robustly designed. The location of magazines in well-protected parts of ships also reduces the likelihood of this scenario eventuating. The absence of collision-induced nuclear weapon accidents is as relevant to this scenario as to other collision scenarios.

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53. Evidence, pp. 709-10 (AIRAC).
54. Evidence, p. 709 (AIRAC); p. 1259 (Department of Defence).
55. Evidence, p. 709 (AIRAC); p. 1259 (Department of Defence).
56. cf. Evidence, p. 1260 (Department of Defence).
57. Evidence, p. 1259 (Department of Defence).

Collision - Committee's Conclusion

12.45 The Committee is unable to find a credible scenario in the context of an Australian port visit in which a collision would lead to either a sustained fire in a warship magazine or to the detonation of a nuclear weapon's conventional explosive.

Fire

12.46 The Department of Defence canvassed the possibility of a nuclear weapon accident caused by fire because it had been raised by others, but did not itself consider the scenario credible.[58] The Department gave as reasons for its conclusion the safety features of magazines and the procedures governing weapons storage combined with the safety features in nuclear weapon design.[59]

12.47 As noted in the previous chapter, the Department of Defence considers and the Committee accepts that all weapons will be safely stored during a port visit. None of the submissions postulating an accident involving a fire provided any detail of how such a fire might occur in a magazine, or of how the plutonium might be directly exposed to the fire. Given the record of safety of warship magazines under combat conditions it difficult to postulate a credible cause in port in peacetime for a fire starting in a magazine, let alone burning for the three hours required by Professor Davis's accident scenario.[60]

12.48 The magazine safety record, together with the safety features of magazines is such that the Committee is unable to postulate a credible means by which a fire could start in a magazine without some external triggering event.

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58. Second supplementary submission from the Department of Defence, p. 24 (Evidence, p. 238.279).
59. Submission from the Department of Defence, p. 26 (Evidence, p. 31).
60. Submission from Prof W. J. Davis, p. 18 (Evidence, p. 465).

12.49 The alternative is to consider the possibility of a fire which starts outside the magazine, and spreads to it. The cause may be external to the vessel. One cause, collision, has already been considered. The Department of Defence canvassed the scenario of a large aircraft crashing onto the warship and causing a fire. It was considered that this appeared 'to be an extremely remote possibility',[61] which the Department did not consider credible.[62]

12.50 The Committee agrees with this assessment. To be considered credible, a scenario of this type has to contend not only with the unlikelihood of the initiating event, but also with the ship's general firefighting capability and the fire protection built into magazines. In particular a credible means to overcome the ability to flood or smother magazines by passive means has to be found in order that the overall scenario be credible. Scenarios can be imagined in which the ship might be

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61. Evidence, p. 1259 (Department of Defence). cf. submission from Mr R. Addison, p. 12, where it is assumed that a visiting aircraft carrier would have aircraft landing and taking off while berthed in Australian port and that one of the vertical takeoff aircraft crashes through the flight deck into the nuclear weapons magazine which is assumed to be directly underneath. This scenario gives no reason for assuming that the magazine is located in such an exposed place, nor that the flight deck is so thinly constructed as to be unable to survive such an obvious hazard as an aircraft crashing on to it.

62. Evidence, p. 1260 (Department of Defence). In assessing Brisbane's suitability for visits by nuclear powered warships the possibility of an aircraft crashing onto the warship was examined, due to the proximity of Brisbane Airport to the berths approved for visits: ANSTO, Assessment of Berths for Operational Use by Nuclear Powered Warships in Australian Ports: Supplement No. 6, The Container Terminal, Fisherman Islands, Brisbane, (March 1982), p. 3 (Evidence, p. 264). The assessment concluded:

> it is estimated that the probability of an accident of sufficient severity to penetrate the reactor compartment and cause damage to reactor safety systems is about 10^{-9} for an NPW visit of one week's duration. This accident therefore does not contribute significantly to the total risk of a reactor accident at an NPW berthed at the Container Terminal.

Because the risk of aircraft crashes are generally highest near busy airports, the likelihood of a crash onto a visiting warship would generally be lower at ports other than Brisbane as major airports are further away from the berths used. The new Brisbane Airport was formally opened in 1988. ANSTO considers that the move to the new airport does not alter the risk sufficiently to affect its conclusion on total risk made with respect to the old airport.

massively damaged, so as to impair all firefighting capability. But the likelihood of this happening without either sinking or extensively flooding the vessel appears small.

12.51 Other causes external to the vessel are physically possible but, when examined, no more credible. A fire starting on a wharf to which the vessel was moored, an explosion on shore throwing burning debris onto the warship, an oil spill on the water catching fire and drifting to the vessel, another vessel catching fire and drifting towards the warship, and many other scenarios can be imagined. But all both involve rare events and allow time for actions by the warship's crew to prevent the fire affecting any nuclear weapons on board. Even if the warship cannot be moved, there would be time to flood the magazines.

12.52 It is possible to imagine a fire starting on the warship but outside the magazine. The precautions taken on warships suggest that the possibility is limited. Fuel storage tanks and other inflammables are not located close to magazines. But the problem still remains of how the fire would overcome the ship's firefighting ability and magazine safety measures. Fires have occurred on warships of the relevant navies in peacetime, but they have not caused explosions in magazines.[63]

Fire - Committee's Conclusion

12.53 The Committee is unable to find a credible scenario in the context of an Australian port visit in which a fire could start and could continue in a warship magazine for the necessary time at the necessary intensity to cause the dispersal of respirable-sized plutonium outside the vessel.

Effect of a Reactor Accident

12.54 Most nuclear powered warships are also nuclear weapons

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63. See paras. 11.73-11.74 on magazine safety records.

capable. The possibility of a reactor accident leading to a weapon accident has to be considered. The Committee was prepared to assume that any nuclear weapons that might be on board would not be stored immediately adjacent to the reactor(s). A reactor accident is itself an unlikely event for the reasons discussed earlier in the report. There is no obvious mechanism by which even a meltdown in the reactor compartment should have any impact on weapons located in magazines some distance away.

Accident during Weapon Transfer

12.55 One nuclear weapon accident scenario was canvassed in an article by Mr Peter Hayes and others in the September 1988 issue of Current Affairs Bulletin. The premise for the scenario was that nuclear weapon handling could occur between United States warships in an Australian port during a time of heightened tension between the super-powers.[64] Although the Committee did not accept this premise, it did consider the scenario. The accident postulated is one in which a helicopter being used to transfer a nuclear weapon crashes on land, explodes and burns with the result that the casing of the weapon is cracked and the

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64. P. Hayes and others, 'Nuclear Weapon Accidents: Are we ready?', Current Affairs Bulletin, September 1988, vol. 65(4), p. 27. Two apparently separate scenarios are presented. The one labeled 'A' involves no more than an increased number of ship visits to Australia following an increase in super-power tension in the Indian Ocean region. It is difficult to see how this increases the hazard markedly, unless an assumption is made that it is only in times of tension that visiting US vessels carry nuclear arms. While this assumption may be correct, the Committee adopted a 'worst case' assumption that nuclear weapons may be aboard during other visits (see para. 11.24). So, in terms of the Committee's approach, scenario 'A' adds nothing to what is assumed to be the risk. Another possibility is that the increased risk arises from the possibility of the vessels becoming targets. This is inconsistent with the focus of the article, which is on accidents. It may be that scenario 'A' is not intended to be a free-standing scenario, but is merely an element in scenario 'B'. This was the case in an earlier, draft, version of the article attached to the submission from Mr P. Hayes.

plutonium burns.[65]

12.56 The Committee considers that, in addition to its premise, this scenario contains many unlikely events. For example, it requires that two (or more) United States warships with compatible weapons systems be in an Australian port at the moment when the super-power tension increases.[66] Periods of the requisite degree of tension are very rare.[67] The chance of one coinciding with the warships' presence is even less likely, given the infrequency of multiple-ship visits to Australian ports.

12.57 The scenario requires a need to transfer nuclear depth

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65. ibid. The relevant part of the scenario, premised on hightened super-power tension, reads (p. 27):

> The commanders of two US destroyers visiting Sydney consult with each other. They know that a Soviet submarine is waiting offshore for their departure. One destroyer has a full complement of nuclear anti-submarine depth bombs which it needs to share with the other so that it can fulfil its mission of protecting an American aircraft carrier steaming south from the North Pacific. It may also need them to destroy the Soviet submarine. The commanders are advised that there are no agreements with Australia forbidding them to ship these bombs from one ship to the other using helicopters - the fastest and easiest means of cross-decking the weapons. A helicopter makes the run across the wharves. On its third run, the motor sputters and stops. The chopper falls to the wharf and explodes. In the fire, the casing of a nuclear bomb is cracked and the plutonium burns. ...

66. If the period of tension had been running for any length of time, the the trans-shipment of weapons would presumably have taken place at sea or in a homeport.

67. In his submission, one of the authors of the article criticises the use by Australian authorities of the allegedly undefined concept of 'normal peacetime circumstances' ; submission from Mr P. Hayes, p. 3. Yet the article gives no definition of a 'crisis between the superpowers' which 'could result in non-routine crisishandling of nuclear weapons' (p. 27). Thus, it is not possible to say on how many days since nuclear weapons were first deployed such a state of crisis has existed. If only the core period of the 1962 Cuban missile crisis and the brief period of hightened super-power confrontation during the 1973 Arab-Israel war qualify as times of crisis in the relevant sense, then the number of days would average much less that one per year.

bombs.[68] This requirement is inconsistent with the virtually unanimous view of those opposing visits. On this view, vessels certified to carry nuclear weapons always do so. If this view is correct, there would never be a need to trans-ship weapons during port visits. Thus the scenario rests on the proposition that the view held by many commentators is incorrect.[69]

12.58 The weapons transfer envisaged by the scenario would seem likely to breach numerous United States Navy safety rules relating to the mechanics of transferring nuclear weapons,[70] unless there is provision to waive these rules in times of tension. The scenario requires that a helicopter be used as a transfer means, rather than placing the ships side-by-side and handling the weapons across. Further, the helicopter is required to experience an engine failure such that it is prevented from making a controlled descent or landing on water rather than a

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68. It should be noted that according to a recent unofficial catalogue of what nuclear weapon-types are believed to be carried on board which US ship-types, destroyers do not carry the 'anti-submarine depth bombs' postulated (p. 27) by the scenario: see J. Handler and W. M. Arkin, Nuclear Warships and Naval Nuclear Weapons: A Complete Inventory, (Neptune Papers, No. 2, Greenpeace/Institute of Policy Studies, Washington, 1988), pp. 14 and 48 (destroyers may carry Terrier missiles, ASROC's and Tomahawk missiles, depending on the class of destroyer). A vessel deploying depth bombs might be expected to also carry a helicopter capable of transporting them, as helicopter-delivery is one of the means of dropping the bombs. The scenario may be referring to ASROC's, whose warheads are sometimes called depth bombs. But ASROC's are not capable of being launched from helicopters, so a helicopter on an ASROC-carrying vessel could not be assumed to be routinely capable of transporting ASROC's.

69. More accurately, the position should be stated in terms of each visit. The scenario increases in plausibility (on this point) in proportion to the percentage of the total visits by nuclear-certified vessels which are visits with no nuclear weapons on board.

70. US, Department of the Navy, Loading and Underway Replenishment of Nuclear Weapons, (NWP 14-1, (Rev. C), August 1983) sets out the rules and conditions under which weapons transfers may occur between ships at sea or between a shore facility and a support ship. It seems reasonable to assume that similar conditions would apply to transfers between two combat vessels in a foreign port. For example, only specially approved equipment may be used to transfer nuclear weapons (pp. 1-3, 5-9); only certain helicopter types are to be used for transfers, and then only by specially trained crews (p. 5-1); and only explosives-loading anchorages may be used if the transfer takes place in a port that is not a US naval weapons station, etc. (p. 2-1).

wharf. There would, of course, be no need for it to fly over land at all in order to accomplish its mission.

12.59 There has never been a United States nuclear weapon accident during helicopter trans-shipment. If the scenario is correct in saying that this mode of transfer is the fastest and easiest, the implication arises that it has been frequently done in the past. Therefore, the absence of any accident to date is statistically significant in terms of evaluating the likelihood of the scenario.

12.60 The scenario requires that the impact of the crash both crack the weapon casing and cause a fire. Given that the weapon is designed to be dropped from a plane or helicopter into the water, it cannot be assumed that the crash of the helicopter would crack the weapon casing. Nor can it be assumed that the fire will be of sufficient intensity or duration to aerosolise much, if any, plutonium.

12.61 This examination of the scenario does not purport to be exhaustive.[71] But the Committee considers that enough has been shown to establish three points. Firstly, although no step in the scenario is physically impossible, all the steps have a probability of occurrence that is less than one, in many cases vastly less. The second point derives from the mathematical rules for establishing the likelihood of a multi-step scenario. These require that the probability of each step or factor be multiplied together. Even the crudest calculation for the scenario in question indicates that multiplying the very unlikely by the

71. Comment on the likelihood of the super-powers reacting as set out in the scenario and preparing to start a nuclear war by using nuclear weapons off Sydney Heads would take the Committee well beyond its terms of reference. It should not be assumed, however, that the Committee would accept as valid these kinds of assumptions in the scenario.

unlikely gives an exceedingly small overall likelihood.[72]

12.62 The third point to emerge from consideration of the weapon transfer scenario is that, even if the fact that all weapons would be in safe storage during port visits is disregarded, credible accident scenarios do not become easy to sustain.

Conclusions - Plutonium Dispersal Accidents

12.63 The most serious accidents short of nuclear detonation are those involving fire and conventional explosion. The Committee does not consider that scenarios involving any of these accidents during a port visit in which weapons are held in safe storage are credible. Specific contingency planning and monitoring for such accidents are not, in the Committee's view, necessary.

12.64 In order to avoid misunderstanding, it should be noted that the accident scenarios considered in the previous sections do not represent all those that the Committee considered. Rather, in order to avoid an excessively lengthy report, the Committee

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72. The authors of the scenario do not claim to have made any calculation of the the likelihood that it would eventuate, although they claim it is credible (p. 27). Without pretending to include all factors, or to be using anything other than very rough figures and rounding those used, the likelihood of particular elements of the scenario might be as follows: of a period of tension, 1 : 11,000 days (10 days during the last 30 years - ie. some days during the Cuban missile crisis and 1973 Arab-Israel War); of 2 US ships with compatible weapons-systems being in an Australian port together, 1 : 10 days; of one having excess nuclear weapons, the other lacking the weapons (ie. of a need to transfer), 1 : 3 times; of transfer being done by helicopter, 1 : 2 times; of the crash during transfer, 1 : 10,000 transfers; of the crash being onto land rather than water, 1 : 10 crashes; and of the crash causing an intense fire, cracked weapon casing, etc., 1 : 10 crashes. Multiplying these probabilities together gives a likelihood for the scenario of 1 : 660,000,000,000. If 6 transfers are assumed to occur on the one occasion, the overall figure must be divided by 6. Given the rough, often arbitrary, figures used, several zeros could be removed (or added) to the final figure through the selection of of different values. The aim in making the calculation is not produce any precise result, but rather to illustrate the sort of process that has to be gone through before any scenario can be said to be credible.

has only included in it those scenarios most often discussed in submissions, or which are commonly suggested as being worthy of serious consideration.

OTHER ACCIDENTS

12.65 In addition to the scenarios already considered, other accidents involving nuclear weapons can be postulated which would, if they occurred, have less serious consequences. If a collision leads to the loss of the weapon, either inside a sunken vessel or otherwise, no nuclear hazard will result provided the weapon is recovered intact. Recovery from the shallow water of a port or port approaches should present little difficulty. Other accidents to the vessel but not involving any break in the weapon casing will likewise produce no radiation release.

12.66 If a collision or some other event (however improbably) ruptures the weapon casing, the fissile material would be exposed, and perhaps broken into large pieces. There would be little or no dispersal off the vessel. More importantly, there would be no immediate danger of aerosolisation,[73] which is, as explained above, the most serious nuclear weapons hazard and the one most requiring immediate response.

12.67 In other words, accidents less serious than those involving aerosolisation are sufficiently akin to ordinary shipping accidents not to require specific nuclear weapon accident contingency planning.[74] The Committee considers, however, that the public interest would be assisted if knowledge of current plans to deal with shipping accidents in ports,

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73. Evidence, p. 1261 (Department of Defence).
74. See also para. 11.44.

especially those relating to hazardous cargoes, was more widely available.[75]

12.68 Accordingly, the Committee RECOMMENDS that the Commonwealth Government confirm that the State and Northern Territory Governments have adequate plans to deal with shipping accidents involving hazardous cargoes in their ports. The Commonwealth should encourage the States and Northern Territory to make these plans public where this is not already the case.

GENERAL CONCLUSION

12.69 While accidents of the kind noted in paragraphs 12.65 and 12.66 may be more credible than those discussed earlier in the chapter, the consequences were they to occur are limited. Accidents of this kind are sufficiently similar to ordinary shipping accidents to be dealt with under the general port safety plans which currently exist.

12.70 Accidents involving plutonium dispersal in respirable form, and accidental nuclear detonation are, in the Committee's view, sufficiently unlikely as not to warrant specific contingency planning.

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75. In para. 11.117 it was recommended that the Department of Defence complete development of, and officially adopt and make public, a planning procedures document relating to nuclear weapon accidents. It may be that this document will assist in improving community awareness of the plans for dealing with shipping accidents in Australian ports.

CHAPTER 13

NUCLEAR WEAPON ACCIDENTS - OTHER MATTERS

TERRORIST ATTACK

Introduction

13.1 A number of submissions referred to the possibility of a terrorist attack on a visiting nuclear weapons capable warship.[1] None suggested what might motivate such an attack, or attempted to justify the possibility by reference to what is known of terrorists, their motives and their actions. Only one suggestion was made to the Committee as to the form that a terrorist attack might take: the firing of a shoulder-launched anti-tank weapon at the nuclear warhead of a Tomahawk missile in its armoured box launcher on the deck of the USS Missouri.[2]

13.2 A radiation release deliberately caused by terrorists would not, strictly speaking, be within the phrase 'accidental release' in the Committee's terms of reference. Nonetheless, the Committee considered the possibility. It did so under four headings: history, possible motives, possible methods, and possible consequences. It is impossible to consider all possible scenarios in detail and the Committee did not attempt to do this. Rather,

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1. e.g see submissions from the Peace Squadron (Sydney), p. 3; Esperance Nuclear Awareness, p. 1; H. H. Somer, p. 2; State School Teachers' Union of WA (Inc.), p. 2; Victorian Government, p. 3; Senator J. Vallentine, p. 23 (Evidence, p. 1066); Dr C. Hughes, p. 9; Ms C. Jordan, p. 1; Darwin Combined Port Unions, p. 1. See also Evidence, pp. 984-85 (Mr R. Bolt); p. 1201 (Senator J. Vallentine).
2. Submission from the Peace Squadron (Sydney), p. 5. One of the authors of this submission, Mr P. Gilding, repeated the suggestion in his personal submission, p. 8 (Evidence, p. 1341). The same suggestion was made in Evidence, p. 1202 (Senator J. Vallentine).

its aim was to indicate briefly the reasons supporting its belief that the risk of serious damage or contamination to an Australian port from terrorism involving a nuclear weapon is minimal.

History

13.3 The history of terrorism suggests that an attack on a nuclear weapon is remote. Commentators who do not consider enough is done to ensure safety in nuclear matters nonetheless acknowledge this: 'no terrorists, either operating independently or with state backing, are known to have attempted major acts of nuclear violence';[3] and 'there has never been a verified attempt by outsiders to attack a nuclear weapons site'.[4] The occurrence of any type of terrorist attack in Australia has been far lower than many other parts of the world. There seems no reason to expect this to change in the foreseeable future. As a general proposition, terrorists have not used high technology methods of

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3. International Task Force on Prevention of Nuclear Terrorism, 'The Task Force Report' in P. Leventhal and Y. Alexander (eds.), Preventing Nuclear Terrorism, (Lexington, Lexington, Mass., 1987), p. 11. The Report considers, however, that 'navy tactical [nuclear] weapons are vulnerable to use by terrorists if successfully seized': ibid., p. 17. The Task Force was a non-government initiative with multinational membership. The US, Departments of Defense and Energy, Nuclear Weapons Surety: Annual Report to the President 1984, p. III-2 refers to terrorist threats that were not deemed credible enough to warrant a full response or which on investigation were found not to involve nuclear materials.
4. W. M. Arkin, 'Nuclear Security: The Enemy May Be Us', Bulletin of the Atomic Scientists, November 1983, vol. 39(9), p. 5. The submission from Victorian Government, p. 3 claims that there have been a few nuclear terrorist incidents but does not identify them. In the US, the FBI had investigated more than 70 nuclear threats of various types up to 1986. Of these, the Nuclear Emergency Search Team (NEST) was involved in 20, all but one of which proved to be a hoax. The one exception involved the theft of 150 lbs of low-enriched uranium by a disgruntled employee: Washington Times, 26 August 1986, p. 5, 'Scientists seek nuclear weapons'. The NEST is part of the response capability for threats where the response may involve locating nuclear material, such as a stolen or home-made nuclear weapon.

destruction to anything like their potential.[5]

Possible Motives

13.4 The motive for a terrorist attack on a nuclear weapon in an Australian port is difficult to conceive. Those opposed to nuclear weapons are unlikely to use those weapons as a means of causing harm.[6] Even if this view is incorrect, the greatest impact would be gained by attacking a weapon in a country where they are based with the hope of securing the termination of the basing agreement. The halting of port visits in a country that receives only occasional port visits would presumably be a less significant achievement, and therefore a much lower priority for anti-nuclear terrorists prepared to use nuclear violence.

13.5 An attack with the aim of seizing a ship-borne nuclear weapon is implausible because, quite apart from the guards and other security precautions, the weight of the weapons would

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5. e.g. R. K. Mullen, 'Mass Destruction and Terrorism', Journal of International Affairs, 1978, vol. 32(1), p. 87:

> One may ... look in vain for even modest use of portable missile launchers which have been around for decades. ... The numbers of incidents where rocket launchers are employed are rare, no matter in what terrorist cause they may be used. Moreover, their rate of use remains relatively constant. One therefore observes that the level of terrorist violence has remained over the years relatively static; only the frequency of incidents has increased in the past decade.

Although the Committee has not researched the point extensively, this appears to be as true now as when it was written. See for example Atlanta Journal and Constitution, 22 May 1988, p. 7, 'Experts: U. S. vulnerable to new, high-tech terrorists': US ambassador-at-large for counterterrorism, Paul Bremner, cited as saying that terrorists rely mainly on technologies of the past (pistols, hand grenades, and machine guns); when confronted with harder targets, terrorists have tended to switch targets rather than upgrade technologies.

6. See for example B. M. Jenkins, 'Is Nuclear Terrorism Plausible?' in P. Leventhal and Y. Alexander (eds.), Nuclear Terrorism: Defining the Threat, (Pergamon-Brassey's, Washington, 1986), p. 28:

> Terrorist groups in Western Europe have demonstrated their opposition to the deployment of new nuclear missiles, but they have done so with the traditional terrorist tactics of bombings and assassinations.

preclude them being readily removed from ships.[7] For one determined to seize a nuclear weapon, a relatively portable battlefield tactical nuclear weapon would appear to offer a more plausible prospect for easy removal.

13.6 The safety devices in the newer weapons would preclude them being detonated and therefore seizure would be relatively pointless.[8] A group with the sophisticated skills necessary to attempt a seizure with some prospect of success might well consider it easier and less risky to build their own weapon. Seizure of a weapon for hostage or ransom purposes seems implausible; there are far softer targets available for these

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7. for example, it takes a trained crew working on an open deck some 15 minutes to load each of the 1,300-plus kg missiles into its cell in the Vertical Launch System of a US surface vessel: P. W. Stiles, 'An Alternative to VLS UnRep', US Naval Institute, Proceedings, December 1987, p. 130 (currently 11 hours to load 44 missiles; best planned improvement will achieve only 6.2 missiles per hour). The launch weight of an ASROC is about 435 kg: Jane's Weapon Systems 1987-88, (Jane's, London, 1987), p. 571. See also N. Polmar, The American Submarine, (Patrick Stephens, Cambridge, UK, 1981), p. 139 for a photograph of 6.4 m, 1800 kg SUBROC being loaded aboard a US submarine: this indicates how difficult it would be to remove the weapon unless the terrorists had full control of the vessel and its surroundings for a considerable period. Detaching warheads from their launch vehicles would lessen the weight and size problems, but would require time, technical skill, and knowledge of the means of detachment.

8. Even the older weapons would have only a limited value. See L. Norman, 'Our Nuclear Weapon Sites: Next Target of Terrorists?' in A. R. Norton and M. H. Greenburg (eds.), Studies in Nuclear Terrorism, (G. K. Hall, Boston, 1979), p. 89, quoting a Defense Department source:

> The old ones might be taken apart by someone with expertise and he might be able to separate the pieces and reconstruct them. He could not detonate the bomb itself, however, because he would have to know the precise voltages and the necessary settings for that bomb.'

If the aim of the siezure is to remove the fissile material and repackage it in a home-made device, a further difficulty arises. The cruder the bomb, the more fissile material is required for a given size result. It is unlikely that terrorists could reproduce the very precise geometries and detonation pattern of the original weapon, so that it might well not give them enough fissile material to make a workable substitute.

purposes.[9]

13.7 It has been observed that 'simply killing a lot of people has seldom been a terrorist objective. ... terrorists want a lot of people watching, not a lot of people dead'.[10] There are, of course, exceptions to this, but these have generally involved killing across racial, ethnic or religious lines.[11] Any victims of terrorist-created plutonium dispersal in an Australian port would not constitute, even approximately, a single racial, etc. group. It is hard to see what public sympathy would be gained by causing such indiscriminate harm.

13.8 The indiscriminate nature of the harm would also militate against a possible aim of killing United States personnel aboard the warship in retaliation for United States actions elsewhere in the world. Because the plutonium would probably be dispersed away from the ship, only those personnel on

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9. cf. International Task Force on Prevention of Nuclear Terrorism, 'The Task Force Report' in P. Leventhal and Y. Alexander (eds.), Preventing Nuclear Terrorism, (Lexington, Lexington, Mass., 1987), p. 14: 'it is difficult to think of a demand that could be used to justify an act of nuclear violence'. This appears to refer to a nuclear detonation. See also R. K. Mullen, 'Mass Destruction and Terrorism', Journal of International Affairs, 1978, vol. 32(1), p. 85: the more that scenarios involving nuclear weapons used to hold governments or cities hostage by threatening mass destruction are examined, 'the more unlikely a proposition they seem to become'.

10. B. M. Jenkins, 'Is Nuclear Terrorism Plausible?' in P. Leventhal and Y. Alexander (eds.), Nuclear Terrorism: Defining the Threat, (Pergamon-Brassey's, Washington, 1986), p. 28 (emphasis in original). See also ibid., p. 29 (terrorists have had the (non-nuclear) means to kill large numbers of people for many years, yet few have done so); G. Wardlaw, Political Terrorism: Theory, Tactics and Counter-Measures, (CUP, Cambridge, 1982), p. 177 ('Although much popular writing on terrorism portrays terrorists as unscrupulous, insane and having an insatiable lust for blood, this is far from the truth'); ibid., p. 178 ('it seems that most terrorist groups do not see the killing of a few people ... as counter-productive, but have to date assessed the massacre of many people as being either out of proportion to their ends ... or counter-productive to their cause ...').

11. cf. International Task Force on Prevention of Nuclear Terrorism, 'The Task Force Report' in P. Leventhal and Y. Alexander (eds.), Preventing Nuclear Terrorism, (Lexington, Lexington, Mass., 1987), p. 13:

> most terrorists operating within their own borders would be inhibited from engaging in actual nuclear violence out of fear of losing popular support for their cause.

the open deck would be at immediate risk.

13.9 A motiveless attack might be suggested, that is, one not designed to achieve any rational objective. However, organising any potentially damaging attack on a visiting warship would require a degree of ability and intelligence. The expert view tends to be that 'psychotic individuals most strongly motivated to commit acts of nuclear terrorism would be the least able to carry them out'.[12]

Possible Methods

13.10 Methods present as many difficulties as motives. For the only scenario offered to the Committee, the anti-tank weapon attack, the weapon would have to be acquired, together with ammunition and training in its use. None are readily available in Australia. Many terrorists, particularly the more sophisticated ones, operate with some degree of foreign government support. But any sponsoring government might be reluctant to provide the weapons for a nuclear-related attack on a United States warship. Government sponsorship

> in itself might lead to caution in the employment of weapons of mass destruction, since such employment could very likely precipitate countermeasures of such severity as to topple any government associated with the act.[13]

13.11 Finding a secure launch site will present further

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12. J. M. Post, 'Prospects for Nuclear Terrorism: Psychological Motivations and Constraints' in P. Leventhal and Y. Alexander (eds.), Preventing Nuclear Terrorism, (Lexington, Lexington, Mass., 1987), p. 93. It is for this reason that examples of individuals running amok with firearms are not, in the view of many experts, regarded as plausible in relation to what would need to be planned for an attack on a visiting nuclear weapons capable warship to have any reasonable prospect of resulting in plutonium dispersal. Contrast the submission from Scientists Against Nuclear Arms (WA) and the Medical Association for the Prevention of War (WA), p. 10 (Evidence, p. 796).
13. R. K. Mullen, 'Mass Destruction and Terrorism', Journal of International Affairs, 1978, vol. 32(1), p. 85.

problems. Absence of security measures in the vicinity of the vessel could not be taken for granted.[14] Information that a particular vessel will be visiting may not be released until shortly before its arrival, limiting the opportunity for an overseas group to travel to Australia and establish themselves in time to launch an attack. The berth or mooring to be used may not be known until the time of arrival or very shortly before.[15] The visiting warship may be in port for only a short time, and if on a swing mooring will from time to time alter its position in relation to a fixed site on shore, increasing the targeting problem.

13.12 For reasons given earlier, it is highly unlikely that many Tomahawks in box launchers on a visiting warship would carry nuclear warheads, even if the vessel is carrying nuclear weapons.[16] The attackers are unlikely to have the opportunity to launch too many projectiles before a response is forthcoming. So the chance of hitting a launcher containing a nuclear warhead is much reduced. This, of course, would sharply reduce the incentive to mount the attack in the first place. Moreover, unless the terrorists had details of the armour on the launchers, they could not be sure that their projectiles could penetrate it, especially if they could not be confident of striking the armour at a ninety-degree angle.

13.13 The Committee is not suggesting that these and other difficulties make the mechanics of the proposed scenario absolutely impossible. However, on the basis of the above type of

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14. cf. Evidence, p. 1300.58 (Department of Defence): 'Consideration is routinely given by the relevant Australian authorities to the possibility of terrorist activity'.
15. Although nuclear powered warships may only use approved berths, whose location is public knowledge, there is no similar restriction on the berths that may be used by conventionally powered vessels that are nuclear weapons capable.
16. See para. 11.27 on the ratio of nuclear to non-nuclear Tomahawk missiles in the stockpile and on the lack of externally visible differences between the nuclear and conventional versions of the missiles, and also between their launchers.

analysis, the Committee does not share Senator Vallentine's view that a successful attack of the type suggested would be 'fairly easy' to mount.[17]

13.14 Other possible attack scenarios suffer from equal or greater obstacles. The policy of 'neither confirm nor deny' means that terrorists could not be certain if any nuclear weapons were on board a visiting vessel, and hence and hence could not be certain that there was anything to attack. It might be thought that the presence of nuclear weapons is most likely on a large vessel such as an aircraft carrier. But equally, the precise storage location on a large vessel would be essential information, yet is not readily available.

13.15 Storage in below-deck magazines renders the problem of attack more difficult without first boarding the vessel. Unauthorised boarding of visiting warships would not be a simple matter.[18] Particularly on larger warships, there is defence in depth against intruders reaching sensitive locations.[19] The United States Navy has anticipated terrorist attacks,[20] so the terrorists would have to expect a prepared defence and counter-

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17. Evidence, p. 1202 (Senator J. Vallentine).
18. For example, two peace protesters who attempted an unauthorised boarding of the USS Carl Vinson when it was anchored in Gage Roads reportedly found themselves surrounded by marines armed with automatic weapons: West Australian, 26 April 1985, 'Protest men reach carrier'. While no doubt the boarding attempt was more symbolic than in earnest, it does illustrate that access to visiting warships is not simple. See also Lt Cdr C. Staszak, USNR, 'Extra: Terrorists Attack USN Ship', US Naval Institute, Proceedings, June 1986, p. 35 for a description of current US Navy doctrine on the defence of its ships against terrorist attack while in port. He notes the doctrine is designed to deal with those seeking to disable the ship or steal its weapons. He criticises its ability to cater for 'an enemy whose objective is simply to kill or a sophisticated threat with a well-developed plan for executing a coordinated attack'.
19. Lt Cdr C Staszak, USNR, 'Extra: Terrorists Attack USN Ship', US Naval Institute, Proceedings, June 1986, p. 35.
20. e.g. Washington Post, 24 August 1987, p. 1, 'Navy Stages Commando Raids To Expose Its Security Flaws' (scenarios tested included a speedboat based attack on a nuclear powered/weapons capable submarine in a Japanese port); Detroit News, 22 February 1988, p. 3, 'Navy holds rehearsals to battle terrorists' (exercises simulating terrorist attacks on USS Enterprise in San Diego, including suicide-plane attack).

measures. The weapons are protected by armed guards and alarm systems.[21] All these factors would make the success of an attack aimed at seizing a nuclear weapon unlikely.[22]

13.16 As a general conclusion on methods, there are clearly less uncertain and less difficult methods of causing a lot of damage than attacking a nuclear weapon on board a visiting warship.[23] If the aim of the terrorists was simply to kill a number of United States personnel without regard to bystander casualties, there are easier ways of achieving this objective.

Possible Consequences

13.17 The consequences, assuming that the suggested attack was carried out, would not necessarily be severe. Those raising the risk of terrorism tended to be those who assumed that an incident involving a nuclear weapon would almost certainly cause mass casualties. Terrorists may share the Committee's more realistic assessment.

13.18 For the suggested scenario of an attack on a Tomahawk missile, the prospect of nuclear detonation is virtually eliminated by the safety features discussed in chapter 11. The

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21. e.g. see US, H of R, Committee on Armed Services, Defense Department Authorization and Oversight - Hearings on H. R. 1872, 13 March 1985, pp. 519 and 532 (Rear Admiral S. Hostettler).
22. cf. Evidence, p. 1300.58 (Department of Defence):

    The Department of Defence considers the guarding and other precautions taken by the nuclear weapon states to ensure the security of their nuclear weapons make it extremely unlikely that a terrorist group would be able to seize any nuclear weapons wherever they might be located.

23. International Task Force on Prevention of Nuclear Terrorism, 'The Task Force Report' in P. Leventhal and Y. Alexander (eds.), Preventing Nuclear Terrorism, (Lexington, Lexington, Mass., 1987), p. 14:

    there are a number of options for escalating violence before they [ie. terrorists] approach a nuclear threshold. Nuclear systems are but one among the high-technology options available to terrorists. Chemical and biological systems, for example, offer terrorists effective methods of threatening to kill or actually killing large numbers of people.

nuclear warheads used on Tomahawk missiles contain insensitive high explosive.[24] For the reasons noted earlier, it is doubtful if, even in the event of a direct hit by an anti-tank projectile on the armoured box launcher, the warhead's insensitive high explosive would detonate.[25] If the projectile managed somehow to ignite the missile's propellant, it does not follow that the warhead would be damaged.[26]

Conclusions

13.19 In the light of its consideration of the possibility of terrorist actions, the Committee found no reason to alter the conclusions set out at the end of the previous chapter.

WEAPON ACCIDENT PLANNING IN OTHER COUNTRIES

General Plans

13.20 A number of submissions noted that accident-response exercises for nuclear weapon accidents had taken place in the United States. Typical comments were:

> If the risk of accident is so remote, why does the U.S. military engage in simulated Nuclear Weapon Accident Exercises (Nuwax)?[27]

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24. US, Departments of Defense and Energy, Nuclear Weapons Surety: Annual Report to the President 1984, p. II-7.
25. See para. 11.55.
26. For example, a Titan II missile exploded in its Arkansas silo in 1980 but the warhead was recovered intact. Reportedly, a missile fuel fire in a Soviet submarine in the Atlantic in October 1986 caused the loss of the submarine, but no radiological releases from the missile's warhead were reported.
27. Submission from Coalition Against Nuclear Armed & Powered Ships, p. 6 (Evidence, p. 1378). See also submissions from Greenpeace Australia (NSW) Ltd, p. 33; Mr R. Bolt, p. 17 (Evidence, p. 967). Contrast the submission from the Medical Association for the Prevention of War (Vic), p. 2: US Navy failure to hold further NUWAX exercises suggests that it regards a nuclear weapon accident as very unlikely.

> Although the WA state government does not consider the chances of a weapons accident high enough to warrant contingency planning, the US Government obviously does, as is evidenced by its NUWAX exercises.[28]

13.21 Many submissions made reference to an article in the June 1986 issue of Current Affairs Bulletin which described the NUWAX exercises.[29] Reference was also made in the article to instructions issued in 1981 by the Commander in Chief of the United States Pacific Fleet.[30] These required nuclear armed vessels to establish a nuclear casualty medical team to respond to accidents involving detonation of the high explosive components of a nuclear weapon. Authors of submissions argued that if the United States considered it necessary to prepare for a naval nuclear weapon accident, so should Australia.

13.22 The Committee notes that the United States Navy, together with the Department of Defense, has 'a comprehensive plan to respond to a nuclear weapon accident'.[31] Britain also maintains detailed secret contingency plans for nuclear weapon accidents,[32] and regularly holds nuclear weapon exercises.[33]

13.23 The Department of Defence responded to the arguments based on the existence of plans in the nuclear weapon countries by pointing out:

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28. Submission from People for Nuclear Disarmament, p. 3 (Evidence, p. 1305).
29. L. Zarsky and others, 'Nuclear Accidents', Current Affairs Bulletin, June 1986, vol. 63(1), pp. 4-11 (Evidence, pp. 807-14).
30. ibid., p. 10 (Evidence, p. 813).
31. US, H of R, Committee on Armed Services, Subcommittee on Military Installations and Facilities, Hearings on H. R. 1409 to Authorize Certain Construction at Military Installations for FY 1986, 27 March 1985, p. 432 ('Response to a Nuclear Weapon Accident on a Navy Ship'). The plan is not specific to any particular port. Nor is it linked to any single accident accident scenario: 'it fits a broad range of events from a minor scratch to a massive fire' (ibid.). The plan as described appears to apply only in the US, but this may be because the description was prepared in response to a request relating to a possible accident within the US.
32. UK, Parliamentary Debates (Commons), 6th series, vol. 112, 20 March 1987, Written Answers, col. 635.
33. ibid., vol. 119, 15 July 1987, col. 1133.

> The NUWAX series of exercises, and the issues and problems which they have raised, all relate to accidents which might possibly occur in NATO countries, but which have no relevance to the safety aspects of visits by nuclear weapons capable warships to Australia. For example, NUWAX 79 simulated the crash of a USAF bomber carrying a nuclear weapon; NUWAX 81 simulated the collision of a light aircraft with a US Army Helicopter transporting a nuclear weapon; and NUWAX 83 simulated the crash of a USN Helicopter carrying a Navy nuclear weapon. The command and control and security issues involved in a nuclear accident on land in a host country are more complex than those for any conceivable nuclear weapons accident on a visiting warship.[34]

13.24 Countries involved with the manufacture, testing, transport, or handling of nuclear weapons, and whose forces may deploy with such weapons, require specific plans to cope with possible accidents. In the view of the Committee, it does not follow from the plans that exist in nuclear weapons countries and in relation to other countries in which the weapons are stored that ports visited by vessels in which nuclear weapons are held in secure storage also need specific safety plans. The level of emergency preparedness in Australian ports needs to be based on the risk that exists in these ports.

13.25 According to the Department of Defence, the lack of any detailed contingency plans in Australia is:

> fully consistent with the practice of other countries which accept visits by warships from the nuclear weapons states. As far as we are aware, no other countries make specific plans to deal with nuclear weapons accidents involving port calls by visiting warships.[35]

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34. First supplementary submission from the Department of Defence, section 4 (Evidence, p. 238.245). See also Senate, Hansard, 24 September 1986, p. 754. Australia had two observers at NUWAX 83: Evidence, p. 228 (Department of Defence). Australia has not taken part in combined nuclear weapon accident exercises with the US, nor have any such exercises been proposed: Senate, Hansard, 29 May 1987, p. 3269.
35. Submission from the Department of Defence, p. 28 (Evidence, p. 33).

No submission identified any national government whose policy controverted this statement.[36]

The New York Nuclear Weapon Accident Draft Plan

13.26 The Committee's attention was drawn to the draft plan prepared under the direction of the municipal authorities in New York City.[37] The need for consideration of nuclear weapon accident planning arose from the Navy's decision to homeport a nuclear weapons capable battleship group in New York harbour near Stapleton, Staten Island. It did not arise from nuclear weapons capable warship visits of the type made to Australia.[38] A decision to move to dispersed basing of major fleet units has led to plans to use other ports near large population centres as homeports for nuclear weapons capable surface ships.[39] In none of the other proposed homeports does there appear to be any official

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36. The Committee understands that Canada, and quite possibly other countries, have general radiological emergency plans which make reference to a nuclear weapon on an aircraft, ship or vehicle as one of the possible sources of an accident required to be dealt with under the plan.
37. New York City, Mayor's Emergency Control Board, Staten Island Naval Homeport Plan, (Draft, June 1988). The original draft (March 1988) was significantly revised. It should be noted that the municipal authorities in New York have control of many functions such as fire and police services that in Australia are carried out by State/Territory governments.
38. Occasional visits by nuclear weapons capable US Navy ships have taken place to New York over the years without, as far as can be determined from this distance, any serious suggestion that accident contingency plans be prepared. e.g. Coalition for an Nuclear-Free Harbor, No Safe Harbor: The Consequences of a Nuclear Weapon Accident in New York Harbor, (New York, March 1988) focuses on the need for planning entirely in the context of the homeport proposal, and does not consider the question of occasional goodwill-type visits.
39. As at early 1987, the homeporting plan had four major components:
    - a battleship battle group in Staten Island, New York;
    - a carrier battle group in Everett, Washington;
    - a battleship battle group, carrier battle group, and other ships in the Gulf ports of Ingleside (Corpus Christi) and Galveston, Texas; Lake Charles, Louisiana; Gulfport and Pascagoula, Mississippi; Mobile, Alabama; and Pensacola and Key West, Florida;
    - an expanded battleship surface action group in San Francisco and Long Beach, California; and Pearl Harbour, Hawaii:

    US, H of R, Committee on Armed Services, Subcommittee on Military Installations and Facilities, National Defense Authorization Act for FY 1988/89 - H. R. 1748 - Hearings, 18 March 1987, p. 621 (Department of the Navy).

proposal that nuclear weapon accident contingency plans be prepared.

13.27 For New York, there appear to be two major public issues: the need for a publicly available document explaining the degree of risk of a nuclear weapon accident, and the need for a contingency plan to deal with an accident of this kind. The Committee accepts that the first of these needs exists also in Australia. It hopes that this report will in large measure fulfil the need here.

13.28 Viewed from this perspective, the draft Staten Island plan consists of two parts: a 'hazard profile' (pp. 11-46), and a plan to deal with the identified hazard (pp. 47-106, supported by 13 appendices). Before considering the plan, the Committee's concerns as to its authorship and status should be noted.

13.29 The plan does not indicate the sources upon which its hazard profile is based. It was put to the Committee that the plan was the work of 'the United States authorities who clearly have a lot more information available to them' than the Australian Government and, by inference, the Committee.[40] In fact, the plan was reportedly written by a New York City police inspector.[41] It is not a United States Government document. Nor does it appear to be a document approved or endorsed by the United States Navy.[42] As a result, it was not clear how much weight the

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40. Evidence, p. 1317 (People for Nuclear Disarmament).
41. Staten Island Advance, 1 April 1988, p. 1, 'Evacuation plan is prepared by city, just in case ...' describes a person who is 'a deputy inspector in the Police Department and deputy director of the city Office of Emergency Management' as the 'author of the draft'.
42. See para. 6.24 above. One of the appendices to the Plan is New York City, Department of Health, Bureau for Radiation Control, Radiation Aspects of Emergency Plan for Proposed Homeport, Navy Battleship Surface Action Group, Stapleton, Staten Island, (17 March 1988). This states (p. 1):

    Though certain classified information designated as secret/confidential data has been made available to us, this has not influenced our assumptions or planning in any material way. The assumptions are our own and have neither been confirmed nor denied by the federal agencies involved except where indicated.

Committee should place on statements made in the profile.[43]

13.30 Many of the points made in the Plan's 'hazard profile' accord with information that the Committee has obtained independently. But the Committee thought it prudent to adopt a cautious attitude towards those statements for which no independent confirmation was available.

13.31 Among the points made in the hazard profile are:

- the profile addresses only hazards relating to weapons while in storage aboard ships, when it is assumed that the weapons will not be armed (p. 12);

- the probability of an accidental nuclear detonation 'is at or near zero and considered to be virtually a non-existent hazard' (p. 18), and is not addressed in the contingency plan;[44]

- two accident scenarios are modelled: the total non-nuclear detonation of a weapon's high explosive, and the complete burning of the weapon in a fire (p. 24), with the former regarded as the more serious (pp. 39-40);

- plutonium contamination from an accident will likely be confined to an area within 2,000 feet (610 metres) and down wind of the accident site (p. 26);

- plutonium contamination through ingestion or through absorption via an open wound is much less likely to be significant than inhalation,

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43. e.g. the profile states: 'There has never been an explosive accident involving weapons in storage aboard a modern Navy warship' (p. 36). If this is based on official US Navy information, it is clearly entitled to be treated as having greater weight than if it rests on the whatever public records were available to the profile's author.

44. cf. the plan prepared by the Oahu (Hawaii) Civil Defense Agency for nuclear weapon accidents at Pearl Harbour Navy facilities and Hickham Air Force base states that the nuclear detonation of a weapon in storage or transit 'is sufficiently unlikely as not to be considered as a possibility for planning purposes': quoted in 'Oahu CD has evacuation plan on file', Honolulu Advertiser, 18 March 1985, p. B1. The plan covers weapon storage areas on land and accidents during weapon transportation, as well as accidents involving weapons on ships based at Pearl Harbour or visiting there. It also covers reactor accidents on the warships.

which 'is by far the most likely scenario which could result in a life-threatening internal radiation exposure in an accident'(pp. 22-23);

- hazards of electromagnetic radiation to ordinance present 'a negligible problem' for nuclear weapons in storage (p. 31);
- 'seizure or theft [of a nuclear weapon] are not considered a viable occurrence' (p. 27);
- the threat from terrorism is regarded as 'greatly reduced' because of the safety design of the weapons and the security surrounding their storage (p. 40); and
- the profile does not treat as significant the differences in safety between older and modern nuclear weapons.

13.32 The hazard profile rather surprisingly contains no discussion of how a nuclear weapon accident might be initiated. For example, there is no examination of how a fire might start or how it would overcome the safety features of weapon magazines. Nor is there any examination of how the weapon's conventional explosive might be accidentally detonated.

13.33 The hazard profile's overall conclusion is:

> Because of the designed in nuclear weapon safety features, the possibility of a nuclear weapon accidental nuclear detonation is negligible. Because of the enhanced Navy safeguards and safety procedures, the possibility of any other kind of nuclear weapon accident is greatly reduced (p. 36).

13.34 In the light of this, it might be thought surprising that the draft plan was written. The explanation for this is to be found in the wording of the New York City Board of Estimates Resolution of 1 October 1987. This required that a plan be prepared at the same time as the hazard profile (p. 7). In other words, the decision that a plan is necessary is not based on the hazard profile, but was made at the same time as the decision that a hazard profile should be prepared. Moreover, the most recent information available to the Committee indicates that the draft plan has not been, and possibly may never be, officially adopted.[45]

13.35 In view of this the Committee regarded the draft plan as an indication of what a nuclear weapon accident response plan might contain. But it regarded the existence of the draft plan as no evidence at all that such a plan is necessary for Australian ports.

Nuclear Capable Warship Bans in United States Ports

13.36 A few submissions suggested that United States cities, such as New York and Boston, had banned visits by nuclear weapons capable warships on safety grounds.[46] United States port visits by warships are under the jurisdiction of the United States Government and are not affected by any bans which local authorities may attempt to impose.[47] There are no ports in the United States which its Navy wishes to visit with nuclear weapons capable or nuclear powered vessels that it cannot do so.[48]

Conclusions

13.37 The Committee did not consider that the existence of planning by nuclear weapon countries, or by New York City, for

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45. 'Board Delays Vote On S. I. Navy Port', New York Times, 1 October 1988, section 1, p. 32: agreement to 'postpone indefinitely' a vote on the plan by the New York City Board of Estimates, at the request of the mayor.
46. e.g. submissions from Miss E. Ruzicka, p. 6; United Associations of Women, p. 1; Medical Association for the Prevention of War Australia (Vic), p. 1; Australian Nuclear Free Zones Secretariat, p. 2.
47. HR, Hansard, 29 November 1985, p. 4265.
48. US, H of R, Committee on Foreign Affairs, Subcommittee on Asian and Pacific Affairs, Security Treaty between Australia, New Zealand, and the United States - Hearing, 18 March 1985, p. 171 (J. A. Kelly, Department of Defense). For an example of a visit to New York, see 'Amid Salutes, Reagan Reviews Armada', New York Times, 5 July 1986, p. 26 (nuclear weapons capable battleship, aircraft-carrier and cruiser visit).

nuclear weapon accidents provided a persuasive basis for altering the conclusion set out at the end of the previous chapter. This conclusion was that there was no need for specific contingency planning for a nuclear weapon accident in an Australian port.

OTHER ISSUES

13.38 A number of issues related to the aftermath of a nuclear weapons accident were raised in submissions. Because of the conclusions reached by the Committee in this and the previous chapter on the improbability of such an accident, it is not necessary to deal with these issues. In many cases, however, the concern with regard to these issues was based on factual misunderstandings and the Committee considered that it would be useful to clarify some of these misunderstandings.

Scope of Contingency Plans

13.39 A number of submissions argued that plans similar to those now in place for nuclear powered warship visits should operate during visits by nuclear weapons capable vessels. For example, the absence of radiation monitoring during visits by the latter vessels was criticised.[49]

13.40 As the Australian Ionising Radiation Advisory Council noted, even if a nuclear weapon accident is thought to be a credible risk, contingency planning would need to be different from, and not necessarily as elaborate as, that now in place for nuclear powered warship visits.[50] For example, the Committee was told that there would be no point in continuous monitoring of

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49. Submissions from Senator J. Vallentine, p. 21 (Evidence, p. 1064); Ms A. Tubnor, p. 2; the Peace Squadron (Sydney), p. 15; Mr R. Bolt, p. 20 (Evidence, p. 970); Scientists Against Nuclear Arms (Tas), p. 5 (Evidence, p. 824).
50. Evidence, pp. 730-31 (AIRAC).

vessels because there would be no radiological warning of a weapon accident. Towing arrangements would not be needed because a weapon accident would involve a single rather than continuing release of hazardous material. Distribution of stable iodine tablets would be unnecessary because there would be no fission products released from the sorts of accidents likely to be found credible.[51]

Notification of Accidents

13.41 Some submissions questioned whether, in the light of the policy of neither confirming nor denying the presence of nuclear weapons, the United States Navy would inform Australian authorities of a nuclear weapon accident occurring in an Australian port.[52] It was stated that United States Naval instructions were in the event of an accident to maintain secrecy as long as possible.[53] Reference was made to the 1966 aircraft

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51. Contrast the submission from Mr R. Bolt, p. 20 (Evidence, p. 970), where it is assumed that the fission from a one-point detonation would create sufficient radioiodine to make stable iodine tablet distribution of some use.
52. e.g. see submissions from Scientists Against Nuclear Arms (Tas), p. 4 (Evidence, p. 823); Mr R. Bolt, p. 20 (Evidence, p. 970); Greenpeace Australia (NSW) Ltd, p. 32; People for Nuclear Disarmament, p. 5 (Evidence, p. 1307); Scientists Against Nuclear Arms (WA) and the Medical Association for the Prevention of War (WA), p. 9 (Evidence, p. 795).
53. Submissions from Balmain People for Nuclear Disarmament, p. 5; Inner City People for Nuclear Disarmament, pp. 1-2; Illawarra People for Nuclear Disarmament, p. 4; Scientists Against Nuclear Arms (NSW), pp. 1-2 (Evidence, p. 803-04); Scientists Against Nuclear Arms (Townsville), p. 2 (Evidence, p. 776).

accident at Palomares, Spain,[54] where the Committee was told that it was four days after the accident before local residents were informed of the contamination hazard. Submissions also referred to an article which stated:

> Even in an accident, the US will stick to its neither-confirm-nor-deny policy about the presence of nuclear weapons. Indeed, US officials may even purposely issue false public information to divert attention from the shipment of damaged nuclear components - a practice for which the participants in the 1983 Nuwax exercise were criticised.[55]

13.42 The Committee does not draw the conclusion that a practice acknowledged to be deficient as the result of an

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54. A few of the submissions referring to the Palomares accident appeared to rely on R. Lorente, 'The Nuclear Accident at Palomares', Peace Studies, June/July 1986, pp. 31-32. See for example the submissions from Scientists Against Nuclear Arms (NSW), p. 2 (Evidence, p. 804); Ms A. Weate and Ms L. Beacroft, p. 6. This is a polemical rather than a balanced account of the accident, however, and it contains major inaccuracies and misrepresentations. For example, contrary to other official and unofficial accounts of the accident, the author asserts that two bombers, not one, crashed in addition to the tanker aircraft, and that eight bombs were lost, not four. He asserts that 'for several weeks, the authorities concealed the fact that the B52 bombers had carried nuclear bombs'. Yet the media on the fourth day after the accident were reporting the admission by the US Defense Department that nuclear weapons were aboard: e.g. New York Times, 21 January 1966, p. 3 , 'U. S. Confirms Loss of Unarmed A-Bombs'. Lorente refers to events on the third day after the crash (ie. 20 January) and states: 'not until much later were steps initiated to provide compensation'. According to the official account, authorisation for making compensation payments was given on 19 January, with the first payment being made on 24 January: US, Defense Nuclear Agency, Technology and Analysis Directorate, Palomares Summary Report, (DNA, 1975), p. 154.
55. L. Zarsky and others, 'Nuclear Accidents', Current Affairs Bulletin, June 1986, vol. 63(1), p. 8 (citation omitted, emphasis in original, Evidence, p. 811). See also for example, submissions from Senator J. Vallentine, p. 28 (Evidence, p. 1071); Scientists Against Nuclear Arms (ACT), p. 5 (Evidence, p. 783); Australian Nuclear Free Zones Secretariat, p. 5. See also the Age, 22 March 1985, p. 3, 'US might cover up nuclear accidents abroad: claim'. For a rebuttal of this claim see the Age, 23 March 1985, p. 14, 'US would tell of N-accident: air marshal'.

exercise nonetheless continues to be the standard.[56] Moreover, it does not follow from a simulated accident response in the United States that a similar response would occur if an accident happened in an Australian port because of the international aspect.[57]

13.43 With respect to the Palomares accident, there was delay in publicly acknowledging the existence of a radiation hazard, in part due to the concerns of the Spanish Government.[58] There was no delay in informing the Spanish Government.[59] There appears to have been no delay in informing either the Danish Government or local residents about the accident in 1968 at Thule, Greenland.[60]

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56. See for example the US Defense Nuclear Agency's training material for nuclear weapon accident-response instruction, which was released in 1985 under the US Freedom of Information Act, and described in the letter accompanying it as 'current': letter from the Defense Nuclear Agency to Mr Peter Hayes, 28 February 1985, p. 1. One of the slides states the basic policy of neither confirming nor denying the presence of nuclear weapons. The following slide states (emphasis in original):

    Exceptions to the Basic Policy
    Confirm the presence of nuclear weapons when:
    1. There is clear danger to public safety
    2. There is public alarm
    And do it as quickly as possible!

    The next slide quotes an unnamed 'European Ambassador, 1985' as saying:

    What you say, and how quickly you say it, are crucial to maintaining your credibility in an emergency situation like this.

    For additional material published since the last NUWAX exercise, see US, Defense Nuclear Agency, Nuclear Weapons Accident Response Procedures Manual, (Washington, 1984), Section 10, including the requirement that 'the public must be notified immediately in the event their safety or welfare is endangered' by a nuclear weapon accident (p. 120).
57. e.g. the 1984 instructions issued by the US Pacific Command state that 'confirmation [of the presence of nuclear weapons] will be made promptly when protective actions in the interest of public safety must be taken': USCINCPACINST S8110.4C (8 May 1984), p. 4D2 (emphasis added). These instructions would apply to an accident on a US warship in an Australian port.
58. US, Defense Nuclear Agency, Technology and Analysis Directorate, Palomares Summary Report, (DNA, 1975), pp. 183-88.
59. ibid., p. 18.
60. O. J. Sundstrom, 'The Thule Affair', USAF Nuclear Safety, 1970, vol. 62(1) part 2, p. 6; R. O. Hunziker, 'The Commander's Point of View', ibid., pp. 13-16.

13.44 The references in submissions to United States instructions to maintain secrecy are to the United States Defense Nuclear Agency's Nuclear Weapons Accident Response Procedures Manual issued in 1984. This manual is intended specifically for use for accidents occurring in the US and its territories and possessions, although the manual states that parts of it may be appropriate in other locations.[61] The manual cites a Department of Defense (DOD) directive to the effect that:

> in general, it is DOD policy to neither confirm nor deny the presence of nuclear weapons at a specific location. The on-scene commander is authorized to invoke two exceptions. First, confirmation of the presence of a nuclear weapon is required when public safety is endangered. Second, the on-scene commander may confirm or deny the presence of the weapon, as necessary, to allay public alarm. No other variations from DOD policy are authorized.[62]

13.45 United States Department of Defense directions applicable to accidents outside United States territory allow on-scene commanders the same latitude in confirming the presence of nuclear weapons but require additionally that the host government

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61. 'Portions of the manual may also be appropriate for use by DOD elements ... in responding to overseas and in-port shipboard radiological accidents' (p. 1).
62. p. 2 (emphasis in original).

concur in any announcement.[63]

13.46 The Committee has satisfied itself that communication links and delegation of authority established for each warship visit ensure that there would be no delay on the part of the Australian Government in concurring in any accident announcement.

13.47 Media reports in mid-1987 based on a document obtained by a research group in the United States, Nautilus Pacific Research, claimed that United States naval commanders in the Pacific had been ordered to remove evidence in case of a nuclear weapon accident and treat it as one involving conventional explosive.[64] However, the relevant United States document does

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63. US, Department of Defense, Directive No. 5230.16 (Nuclear Accident and Incident Public Affairs Guidance) (Encl 3), 7 February 1983, p. 2. Instructions issued by the US Navy Pacific Command are to the same effect and clearly distinguish between what is appropriate in the United States or its territories and what is appropriate in other areas: declassified portion of USCINCPACINST S8110.4C (8 May 1984) released under the US Freedom of Information Act, pp. 4D1-4D2. See also HR, Hansard, 18 February 1988, p. 359; and the US Navy directions applicable to a US nuclear weapon involved in an accident or incident in the Philippines, obtained under FOI and reproduced in part in R. G. Simbulan, The Bases of Our Insecurity, (BALAI Fellowship, Manila, 1983), Appendix 5:

> official confirmation of the presence of such weapon may be made when it will have significant value in conjunction with with public safety or as a means of reducing or preventing wide-spread public alarm.

See similarly the declassified parts, also released under FOI, of US, United States European Command, USCINCEUR CONPLAN 4367-87-Response to Nuclear Accidents/Incidents within the Theater, 1987, p. F-2. This plan also provides for the concurrence of the host government to be obtained for any public announcement confirming or denying the presence of nuclear weapons in the accident, for joint US/host news conferences, and joint information dissemination to the media: pp. F-2 and F-3.

64. e.g. see the Australian, 24 August 1987, p. 6, 'US order to remove nuclear mishap clues'. See also earlier press reports based on the same document: e.g. Canberra Times, 9 July 1987, pp. 1, 15, 'US nuclear accident planning revealed'; the Age, 9 July 1987, 'Paper reveals US plan for N-accident in Australia'.

not clearly support the claim.[65] The claim was put to the Australian Government in the form of a Parliamentary Question. The Government responded:

> Contrary to the implication in the question, the procedures which are set out in the instruction are not designed to conceal the fact of a nuclear weapon accident from the Government of any country in which such an accident might occur. The instruction specifically directs nominated US Government representatives to coordinate accident response arrangements with the host Government. The instruction stipulates that accidents that do not entail a radiation hazard should be handled in the same way as accidents involving conventional weapons. The objective is to provide responses suitable to the level of accident, and to avoid undue public alarm.[66]

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65. The relevant part of the instruction, USCINCPACINST S8110.4C of 8 May 1984, Appendix C, para. 2(f), reads:
    (3) In the event a nuclear weapon accident/significant incident occurs:
    (a) Comply with the notification procedures covered in paragraph 3 below [relating to notification of various US officials].
    (b) Release only that information to the public which is authorized in accordance with Appendix D to this enclosure [which allows the presence of nuclear weapons to be confirmed]
    (c) Implement nuclear weapon accident/significant incident control procedures. If possible, the accident or significant incident should be treated as an accident or incident involving conventional high explosives, i.e., the procedures applied should not exceed the minimum required by the existing conditions.
    (d) Ensure safety of personnel.
    (e) Recover or remove, if at all practicable, all evidence of the nuclear weapon accident or significant incident as expeditiously as possible.
    (f) Maintain effective control at all times.
66. HR, Hansard, 18 February 1988, p. 359. In P. Hayes and others, 'Nuclear Weapon Accidents: Are we ready?', Current Affairs Bulletin, September 1988, vol. 65(4), p. 26 the original claim is repeated, the authors being apparently unaware that the Australian Government had responded to it. In reading the US instruction, it is important to keep in mind the breadth of the definitions of 'accident' and 'significant incident': see above, paras. 11.97–11.98. Events falling within these definitions do not necessarily involve a release of radioactive material from a weapon.

13.48 The international Convention on Early Notification of a Nuclear Accident does not apply to nuclear weapons accidents.[67] All five nuclear weapons countries have indicated, however, that they would notify within the framework of the convention any nuclear weapon accident which has, or might have, radiological safety significance for another country.[68] In indicating this, the United States stated that such notification represented a reaffirmation of its existing policy.[69]

13.49 In 1985, the Australian Government stated that 'working level procedures' required the commanders of visiting United States and British warships to notify the appropriate Australian authority immediately in the event of a nuclear weapon accident.[70]

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67. See article 1(2) of the convention. The text of the convention is set out in International Legal Materials, 1986, vol. 25, pp. 1370-1376. Australia ratified the convention on 22 September 1987. The US and Britain have stated that they will apply the convention pending their formal ratification of it: see ibid., p. 1394.
68. The texts of the statements by China, France, UK, US and USSR are set out in International Legal Materials, 1986, vol. 25, p. 1394. An accident only gives rise to an obligation to provide notification under the convention if it 'has resulted or may result in an international transboundary release that could be of radiological safety significance for another state': article 1(1). On a strict interpretation, it could be argued that an accident in an Australian port would lack this transboundary effect, and thus the convention is not relevant. The notification in 1986 (see next footnote) suggests that the focus will be on the words 'could be of ... significance' and notifications will be made so as to allay concerns. But the correctness of this suggestion remains to be seen.
69. On 4 and 6 October 1986, the USSR notified within the convention framework an explosion of the fuel of a nuclear missile on one of its nuclear powered submarines in the Atlantic and the subsequent sinking of the vessel: International Atomic Energy Agency press release, PR 86/37, 8 October 1986. This was presumably done in the spirit of the convention, which did not enter into force until 27 October 1986. Media reports immediately after the sinking of a Soviet submarine in international waters north of Norway on 7 April 1989 indicated that notification was made direct to the Norwegian and other governments, without using the convention framework. However, the sinking was reportedly not nuclear-related.
70. HR, Hansard, 23 August 1985, p. 458. See also Senate, Hansard, 14 November 1986, p. 2360: the commanding officer of a visiting warship would immediately notify a weapon accident to the local port authorities, naval or civil, having responsibility for general emergencies arising in that port.

13.50 A Parliamentary question in 1987 asked, in part, whether United States Navy commanders were obliged to inform Australian authorities of an accident in Australian territory in all cases, or only when the Australian public was deemed at risk. In response, the Government stated that the obligation arose in all cases.[71] The answer did not set out the basis of this obligation.[72]

13.51 In view of the above factors, the Committee does not consider that the United States would fail to notify Australian authorities of any nuclear accident in Australian territory.

Control at the Scene of an Accident

13.52 The Committee accepts that for safety reasons there would have to be control on access to, and removal of possibly contaminated material from, an accident site. A number of submissions raised the possibility that United States personnel would attempt to create around a nuclear weapon accident site some sort of extraterritorial zone from which Australians would

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71. HR, Hansard, 18 February 1988, p. 359.
72. It appears that the basis is an assurance given to the Australian Government in 1976 by the United States. In referring to this assurance, Senator Ray, on behalf of the Minister for Defence, described it as the same kind of assurance as that given by the US to Canada, New Zealand and other allies: Senate, Hansard, 12 October 1988, p. 1258. A document released under New Zealand's Official Information Act states that the assurances to Canada and New Zealand take the form of the US 'Standard Statement' relating to nuclear powered ships, modified to apply to nuclear weapons: memo to the NZ Minister of Foreign Affairs from the Secretary of Foreign Affairs, 9 August 1976, paras. 6 and 8. The 'Standard Statement' in its unmodified form states: 'the appropriate authorities of the host government will be notified immediately in the event of an accident involving the reactor of the warship during a port visit': para. 2(c) (Evidence, p. 1078). Presumably in its modified form the assurance refers to nuclear weapons that may be on board.

be excluded.[73] Those expressing concern in submissions were apparently basing their concern on past NUWAX exercises and on the Defense Nuclear Agency manual referred to earlier in this chapter.[74] As noted in that context, neither are directly

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73. e.g. see submissions from Greenpeace Australia (NSW) Ltd, p. 32; Epping & District Peace Group, p. 2; Assoc Prof P. Jennings, p. 1; Miss E. Ruzicka, p. 7; Scientists Against Nuclear Arms (Townsville), p. 2 (Evidence, p. 776); the Peace Squadron (Sydney), p. 9; Illawarra People for Nuclear Disarmament, p. 4; Victorian Association for Peace Studies, p. 3; Women's International League for Peace and Freedom (SA), p. 3; Senator J. Vallentine, p. 28 (Evidence, p. 1071); Ms A. Weate and Ms L. Beacroft, p. 9; New South Wales Fire Brigade Employees' Union, p. 12.

74. The media in September 1987 (e.g. 'Nuclear "plot": US accused', the Age, 26 September 1987) reported a claim that US control would be established over US weapon accident sites, irrespective of the country in which they occurred. The claim was based on instructions of the US Navy European Command, which, while applicable to the UK, did not apply to Australia. UK Department of Defence officials were reported as denying that the applicable US-UK contingency agreements for nuclear weapon accident response compromised UK sovereignty. For a similar denial see UK, Parliamentary Debates (Commons), 6th series, vol. 121, Written Answers, 2 November 1987, col. 601. The relevant contingency arrangements are classified and the UK Government has declined to make them public: ibid., vol. 123, Written Answers, 2 December 1987, col. 593. They would appear to resemble the arrangements which could arise pursuant to Article 20 of the Agreement between Australia and the United States of America concerning the Status of United States Forces in Australia, Canberra, 9 May 1963 (Australia, Treaty Series, 1963, No. 10). This provides that, in respect of bases or areas of which US forces have exclusive occupation, the US may, after consultation with the Australian Government, designate parts of the bases or areas as places which only personnel authorised by the local US commander may enter. In L. Beacroft and A. Walton, '"Broken Arrows": Who Pays?', Australian Society, May 1987, p. 35, it is claimed that this agreement gives the US 'exclusive control over the core of the contaminated area' after a weapon accident. The article of the agreement claimed to have this effect is not identified by the authors, and the claim is clearly incorrect.

applicable to events occurring in Australia.[75]

13.53 The United States Department of Defense has acknowledged to the Australian Department of Defence that:

> the establishment of such an area outside the US and its territories 'would appear to violate the sovereignty of the host nation, and be inconsistent with both international law and well established US policy'.[76]

13.54 The Department of Defence told the Committee:

> As a sovereign nation Australia would control and coordinate the response to any weapons accidents in one of its ports. This right of the host nation is acknowledged in Article 3(a) of CANARE [the international Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency[77]]. We

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75. Reference was also made to an incident at St Mawgan air base in Britain: see the submission from Mr P. Gilding, p. 25 (Evidence, p. 1358); Evidence, p. 1215 (Senator J. Vallentine). The incident, undated, was reported in the Independent (London), 15 July 1987, p. 1, 'Atomic dust used in training'. As reported, RAF firemen responding to a fire alarm at a part of the base used to store US nuclear weapons found their way barred by armed US servicemen. The report does not indicate if there was in fact a fire. The British Government stated in reference to the incident that it was entirely satisfied with the US/UK forces liaison and co-operation for nuclear accidents in the UK: UK, Parliamentary Debates (Commons), 6th series, vol. 119, 15 July 1987, col. 1135. See also ibid., Written Answers, 17 July 1987, col. 676. In a related response, the British Government declined to state if British emergency services had a right of access to US nuclear weapon storage sites, saying only that there was 'full liaison' with local emergency services: ibid., vol 120, Written Answers, 23 July 1987, col. 390. The roles and responsibilities of the US and UK with regard to a US nuclear weapon accident in the UK are governed by special arrangements: ibid., vol. 121, Written Answers, 2 November 1987, col. 607. A strong inference arises that the exclusive US control reportedly exercised at St Mawgan was in accord with these arrangements. This cannot be verified as the documents setting out the special arrangements are classified: ibid., vol. 123, Written Answers, 2 December 1987, col. 593. But the incident seems of limited relevance to Australia, save that it shows the strict physical security that surrounds US nuclear weapons.
76. Second supplementary submission from the Department of Defence, p. 27 (Evidence, p. 238.282), quoting an unidentified source.
77. For the text of the convention see International Legal Materials, 1986, vol. 25, pp. 1377-1386. Australia ratified this convention on 22 September 1987. The UK and US have both signed but not yet ratified the convention.

> would call on the US to provide promptly all the assistance that the responsible Australian authorities might require, but the extent and nature of this assistance would alter from port to port and in accordance with the specific circumstances of the accident.[78]

13.55 The Committee does not consider it objectionable that overseas personnel assist Australian officials in providing control and monitoring at an accident site. Spanish police controlled the site of the 1966 United States nuclear weapon accident at Palomares, Spain, although site examination and monitoring appears to have been done by United States personnel.[79] At the site of a similar accident in 1968 at Thule, Greenland site examination and monitoring was undertaken by Danish and United States teams working in close co-ordination.[80]

13.56 United States instructions relating to nuclear weapon accidents in its European Command make it amply clear that any accident response by United States forces will be within the framework of international law (including any agreements with the host state) and the law of the host state.[81] For example, the instructions state as a planning assumption that 'displacement, movement, and control of the civilian populace will be performed by host government authorities'.[82]

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78. Second supplementary submission from the Department of Defence, p. 28 (Evidence, p. 238.283).
79. US, Defense Nuclear Agency, Technology and Analysis Directorate, Palomares Summary Report, (DNA, 1975), pp. 18 and 27. It is important to note that responsibilities in relation to accident response were allocated by treaty between Spain and the United States; measures to take charge of and remove the damaged aircraft and its technical equipment were the responsibility of the United States authorities: ibid., p. 18.
80. The Danish Thule Committee, 'Evaluation of Possible Hazards', USAF Nuclear Safety, 1970, vol. 65(1) part 2, pp. 8-11.
81. US, United States European Command, USCINCEUR CONPLAN 4367-87-Response to Nuclear Accidents/Incidents within the Theater, 1987, Annex G.
82. ibid., p. G-3.

Conclusions

13.57 The Committee is confident that the relevant Australian authorities would be notified promptly of any nuclear weapon accident or significant incident occurring on a United States vessel in an Australian port. The Committee is equally confident that measures taken in response to any such event would not compromise Australian sovereignty.

13.58 The Committee has not considered these matters in relation to an nuclear weapon accident involving a British or French vessel. But it is aware of no basis for believing that its conclusions would be any different for such accidents.

Graham Maguire
(Chairman)

APPENDIX 1

INDIVIDUALS AND ORGANISATIONS

WHO MADE WRITTEN SUBMISSIONS TO THE COMMITTEE

	Submission Number
ACTION for World Development (Townsville Group), Townsville, Qld.	51
ADDISON, Mr R., Adelaide, SA.	23
ALBANY Peace Group, Albany, WA.	15
ALLEN, Ms K., Scarborough, Qld.	44
AUSTRALIAN Conservation Foundation (Adelaide Chapter), Adelaide, SA.	13
AUSTRALIAN Council of Churches, Sydney, NSW.	93
AUSTRALIAN Ionising Radiation Advisory Council, Canberra, ACT.	90
AUSTRALIAN Nuclear Free Zones Secretariat, Sydney, NSW.	63
AUSTRALIAN Nuclear Science & Technology Organisation, Menai, NSW (formerly the Australian Atomic Energy Commission).	70
AUSTRALIAN Peace Committee (NSW), Sydney, NSW.	65
AUSTRALIAN Peace Committee (SA), Adelaide, SA.	50
AUSTRALIAN Quaker Peace Committee, O'Connor, ACT.	30
AUSTRALIAN Radiation Laboratory, Yallambie, Vic.	94
BALMAIN People for Nuclear Disarmament, Balmain, NSW.	39
BLAKE, Mr K.G., Shenton Park, WA.	17
BOCQUET, Mr H., Port Melbourne, Vic.	12
BOLT, Mr R., Richmond, Vic.	43
BRUEN, Mrs E., South Perth, WA.	14
BUDGE, Mr J.R., Nedlands, WA.	33
CAMPAIGN for International Cooperation & Disarmament, Melbourne, Vic.	34
CHERNOBYL Collective of the Canberra and South-East Region Environment Center Inc, Canberra, ACT.	31
COALITION Against Nuclear Armed & Powered Ships, Melbourne, Vic.	68
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APPENDIX 2

WITNESSES WHO APPEARED AT PUBLIC HEARINGS

Australian Nuclear Science and Technology Organisation
(formerly Australian Atomic Energy Commission)

Mr Desmond Robert Davy, Chief, Environmental Science Division
Mr John Maitland Rolland, Head, Technical Secretariat
Mr Donald Basil McCulloch, Leader, Nuclear Analysis Section
Mr James Edward Cook, Senior Principal Research Scientist, Regulatory Bureau
Mr Paul Neville Michael Wright, Health and Safety Division Officer

Australian Radiation Laboratory/National Health and Medical Research Council

Dr Keith Henry Lokan, Director

Australian Ionising Radiation Advisory Council

Professor Ralph Whaddon Parsons, Chairman
Dr Desmond Robert Davy, Member
Dr Richard John Petty, Member
Dr Gilbert Brian Tucker, Member

Bolt, Mr Richard

Coalition Against Nuclear Armed and Powered Ships

Mr Leslie Richard George Taylor

Davis, Professor William Jackson

Department of Defence

Mr Ross Kenneth Thomas, Special Adviser, Strategic and International Policy Division
Commodore Ian MacDougall, Director-General, Joint Operations and Plans
Commodore Nigel John Stoker, Director General, Joint Operations and Plans

Commander Bryan Damien Hunt, Joint Planning Staff
Lieutenant Commander Ernest Thomas James, Secretary, Visiting Ships Panel (Nuclear)
Mr Robin Arthur George Herron, Natural Disasters Organisation

Lynch, Mr Michael

People for Nuclear Disarmament

Mr Paul Gilding

Scientists Against Nuclear Arms

Dr Geoffrey Frederick Davies, President, Australian Capital Territory Branch
Dr Lindsay Thomas Matthews, Member, Western Australian Branch/Member, Medical Association for the Prevention of War (WA)
Professor William Alan Runciman, Committee Member, Australian Capital Territory Branch

Speed, Dr Terence

Vallentine, Senator Jo

APPENDIX 3

VISITS TO AUSTRALIAN PORTS BY NUCLEAR POWERED WARSHIPS 1976-1988

1976

Dates	Vessel	Type	Port
14-19 August	USS Snook	submarine	HMAS Stirling, WA
7-13 Sept	USS Truxtun	cruiser	Melbourne
14 Sept	USS Truxtun	cruiser	Jervis Bay
29 Oct-5 Nov	USS Enterprise	aircraft carrier	Hobart
30 Oct-6 Nov	USS Long Beach	cruiser	Melbourne

1977

No visits

1978

Dates	Vessel	Type	Port
5-10 March	USS Queenfish	submarine	Melbourne
7-12 July	USS Bainbridge	cruiser	Darwin
7-12 August	USS Enterprise	aircraft carrier	Gage Roads, WA
7-12 August	USS Long Beach	cruiser	Gage Roads, WA
7-12 August	USS Truxtun	cruiser	HMAS Stirling, WA

1979

Dates	Vessel	Type	Port
19-27 April	USS Tunny	submarine	HMAS Stirling, WA
20-25 Oct	USS Bainbridge	cruiser	HMAS Stirling, WA
20-25 Oct	USS Pintado	submarine	HMAS Stirling, WA
24-29 Oct	USS Gurnard	submarine	Melbourne

1980

Dates	Vessel	Type	Port
26 Mar-2 Apr	USS Haddock	submarine	HMAS Stirling, WA
1-7 April	USS Los Angeles	submarine	HMAS Stirling, WA
16-21 May	USS Guardfish	submarine	HMAS Stirling, WA
18-25 July	USS Puffer	submarine	HMAS Stirling, WA
25-30 July	USS Baton Rouge	submarine	HMAS Stirling, WA
14-20 August	USS Tautog	submarine	HMAS Stirling, WA
6-11 Sept	USS Groton	submarine	HMAS Stirling, WA
12-17 Sept	USS Permit	submarine	HMAS Stirling, WA
10-17 Nov	USS Omaha	submarine	HMAS Stirling, WA
16-22 Dec	USS Haddo	submarine	HMAS Stirling, WA
23-29 Dec	USS Philadelphia	submarine	HMAS Stirling, WA

1981

Dates	Vessel	Type	Port
6-11 Feb	USS Memphis	submarine	HMAS Stirling, WA
27 Feb-Mar 6	USS Gurnard	submarine	HMAS Stirling, WA
15-22 April	USS Cavalla	submarine	HMAS Stirling, WA
20-27 May	USS Pintado	submarine	HMAS Stirling, WA
29 May-3 June	USS Bluefish	submarine	HMAS Stirling, WA
6-13 July	USS Los Angeles	submarine	HMAS Stirling, WA
8-13 July	USS Cincinnati	submarine	HMAS Stirling, WA
11-17 Aug	USS Haddock	submarine	HMAS Stirling, WA
25-31 Aug	USS California	submarine	HMAS Stirling, WA
23-30 Sept	USS New York City	submarine	HMAS Stirling, WA
5-12 Oct	USS Bremerton	submarine	HMAS Stirling, WA
22-28 Oct	USS Flasher	submarine	HMAS Stirling, WA
30 Nov-7 Dec	USS Aspro	submarine	HMAS Stirling, WA

1982

Dates	Vessel	Type	Port
29 Jan-5 Feb	USS Tautog	submarine	HMAS Stirling, WA
10-17 Feb	USS Puffer	submarine	HMAS Stirling, WA
23 Feb-1 Mar	USS Truxtun	cruiser	HMAS Stirling, WA
19-26 Mar	USS Sea Horse	submarine	HMAS Stirling, WA
29 Apr-5 May	USS Truxtun	cruiser	Brisbane
8-13 May	USS Truxtun	cruiser	Hobart
14-21 June	USS Cavalla	submarine	HMAS Stirling, WA
26 Jul-2 Aug	USS Indianapolis	submarine	HMAS Stirling, WA
11-18 Oct	USS San Francisco	submarine	HMAS Stirling, WA
16-23 Nov	USS Jacksonville	submarine	HMAS Stirling, WA

1983

Dates	Vessel	Type	Port
30 Dec-6 Jan	USS Omaha	submarine	HMAS Stirling, WA
20-26 Jan	USS Enterprise	aircraft carrier	Gage Roads, WA
20-26 Jan	USS Bainbridge	cruiser	HMAS Stirling, WA
20-26 Jan	USS Los Angeles	submarine	HMAS Stirling, WA
27 Jan-4 Feb	USS Sea Dragon	submarine	Hobart
12-14 Feb	USS Sea Dragon	submarine	Jervis Bay
31 Mar-7 Apr	USS Drum	submarine	HMAS Stirling, WA
6-13 May	USS Guitarro	submarine	HMAS Stirling, WA
1-7 July	USS Carl Vinson	aircraft carrier	Gage Roads, WA
1-7 July	USS Texas	cruiser	HMAS Stirling, WA
1-7 July	USS Phoenix	submarine	HMAS Stirling, WA
14-19 July	USS Texas	cruiser	Brisbane
18-25 Aug	USS Texas	cruiser	Hobart
29 Aug-1 Sep	USS Texas	cruiser	Albany
9-16 Sept	USS Boston	submarine	HMAS Stirling, WA
20-24 Sept	USS Boston	submarine	Hobart
5-12 Dec	USS William H. Bates	submarine	HMAS Stirling, WA

1984

Dates	Vessel	Type	Port
1-8 Feb	USS New York City	submarine	HMAS Stirling, WA
4-11 May	USS Tunny	submarine	HMAS Stirling, WA
22-27 June	USS Long Beach	cruiser	HMAS Stirling, WA
18-25 Sept	USS Corpus Christi	submarine	HMAS Stirling, WA
28 Sep-5 Oct	USS Aspro	submarine	Darwin
1-5 Nov	USS Dallas	submarine	Albany
6-12 Nov	USS Dallas	submarine	HMAS Sterling, WA

1985

Dates	Vessel	Type	Port
31 Jan-7 Feb	USS Indianapolis	submarine	HMAS Stirling, WA
11-17 March	USS Pogy	submarine	Darwin
16-20 April	USS Texas	cruiser	Hobart
19-26 April	USS Carl Vinson	aircraft carrier	Gage Roads, WA
24-29 April	USS Texas	cruiser	Brisbane
3-9 May	USS Puffer	submarine	HMAS Stirling, WA
19-24 July	USS California	cruiser	HMAS Stirling, WA
16-22 Sept	USS Jacksonville	submarine	HMAS Stirling, WA
31 Oct-7 Nov	USS Lapon	submarine	HMAS Stirling, WA
21-27 Dec	USS Portsmouth	submarine	HMAS Stirling, WA

1986

Dates	Vessel	Type	Port
29 Jan-4 Feb	USS Tautog	submarine	HMAS Stirling, WA
18-24 July	USS Enterprise	aircraft carrier	Gage Roads, WA
18-24 July	USS Arkansas	cruiser	HMAS Stirling, WA
18-24 July	USS Truxtun	cruiser	HMAS Stirling, WA
19-27 Dec	USS Carl Vinson	aircraft carrier	Gage Roads, WA

1987

Dates	Vessels	Type	Port
12-19 Dec	USS Long Beach	cruiser	HMAS Stirling, WA
23-30 Dec	USS Long Beach	cruiser	Hobart

1988

no visits

Sources: the annual reports on radiation monitoring. Dates for visits vary in minor respects in some cases from dates given in Senate, Hansard, 8 May 1985, pp. 1573-1581. The latter also lists a visit by USS Los Angeles to Cockburn Sound, WA between 15-22 February 1983, which is not listed in the 1983 annual report.

APPENDIX 4

BACKGROUND NOTE ON COMPENSATION ISSUES

PREPARED BY THE COMMITTEE SECRETARIAT

Introduction

A4.1 This note addresses legal issues relating to compensation for injury and loss caused by a reactor or nuclear weapon accident on a visiting warship. The threshold issue is determining the most suitable avenue for bringing compensation claims. Within whatever avenue is chosen issues arise with respect to: proving causation; the standard of liability to be applied; and possible time limits for the bringing of claims. Only with respect to the standard of liability is there a formal difference between weapon and reactor accidents with respect to the issues discussed in this note.

Views in Submissions

A4.2 As an accident involving a nuclear weapon or warship reactor has never happened in Australia, it is not surprising that a number of submissions express uncertainty as to the legal arrangements that would apply to those seeking compensation for injuries suffered in such an accident.[1] Others exhibit misconceptions, such as that United States acceptance of nuclear weapon accident liability is contingent on it retaining control of the emergency,[2] or that individuals cannot sue a foreign government

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1. See for example the submissions from the Peace Squadron (Sydney), p. 14; Greenpeace Australia (NSW) Ltd, pp. 34-35.
2. Submission from Chernobyl Collective of the Canberra and South-East Region Environment Centre, p. 3. No basis was provided for the statement. As a speculation, it may have been based on a misreading of article 20 of the 1963 Australia-United States status of forces agreement: see chapter 13 footnote 74.

in an Australian court.[3]

A4.3 The United States Congress, in Public Law 93-513 in 1974,[4] accepted absolute or strict liability[5] with respect to accidents involving its nuclear powered warship reactors. The British Government 'has provided a unilateral assurance to Australia on reactor accident liability comparable to that given by the United States'.[6] There does not appear to be any equivalent assurance issued by the French Government, although this point ought to be confirmed with the French authorities before it is stated unequivocally.

A4.4 Concern is expressed in submissions over the formal

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3. Submission from Senator J. Vallentine, p. 27 (Evidence, p. 1070).
4. US Public Law 93-513 (1974), codefied at 42 USC 2211.
5. Acceptance of absolute or strict liability means that the plaintiff would be relieved of the need to show that the accident was caused by the fault or negligence of the United States Government or those for whose acts it was legally responsible: US Senate Report No. 93-1281, (Public Law 93-513), U. S. Code Congressional and Administrative News, 1974, p. 6365. The acceptance of absolute liability does not extend to cases arising from combat or civil insurrection (PL 93-513) or to those who intentionally caused the accident (Senate Report No. 93-1281: ibid., p. 6366). To avoid possible confusion with the law setting ceilings on the liability of civil reactor operators in the United States, the following passage from the Senate Report No. 93-1281, which accompanied PL 93-513 should be noted.

> The Resolution [which became PL 93-513] avoids mentioning any particular dollar ceiling on the amount of U. S. liability. It is important to be flexible on this so that domestic needs are not governed by practice in other countries. A specific sum would serve only as a target, and the U. S. Government has stated that it will take care of whatever damage its ships cause.

6. Senate, Hansard, 14 March 1986, p. 1096. The British Government has stated with respect to a reactor accident:

> in the unlikely event of such an accident it would be our policy to pay compensation, subject to parliamentary approval of the necessary funds, for personal injury, death or damage to or loss of real or personal property proved to have resulted from the accident. Certain exceptions would have to be made. For example, such compensation would not necessarily be paid for damage or injury arising in the course of any armed conflict or civil disturbance, nor would compensation be paid to a person or his personal representatives or dependants, who intentionally caused the nuclear reactor accident ... .

UK, Parliamentary Debates (Commons), 5th series, vol. 913, Written Answers, 15 June 1976, col. 99.

difference in the standard of liability as between weapon and reactor accidents.[7] Criticism is made of provisions in the Australia-United States Status of Forces Agreement (SOFA)[8] which provide that in nominated circumstances Australia would bear a proportion of the compensation costs due to an accident involving United States forces in Australia even though those forces were alone responsible for the accident.[9] Submissions note that it may be difficult to prove the cause of a radiation-induced illness, especially if a long time has elapsed between exposure to the radiation and the manifestation of symptoms.[10]

AVENUES FOR CLAIMING COMPENSATION

Official Statements

A4.5 In March 1986, the Government repeated its earlier statement relating to weapon accident compensation claims:

> Any claims for compensation resulting from a nuclear weapons accident would be dealt with through diplomatic channels in accordance with customary procedures for settlement of claims under generally accepted principles of law and equity. In the case of the United States, settlement of claims would take place in accordance with Article 12 of the Agreement between Australia and the US concerning the status of US Forces in Australia.[11]

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7. Submissions from the Medical Asociation for Prevention of War Australia (Vic), p. 1; Victorian Association of Peace Studies, p. 3; Mr M. Lynch, p. 5 (Evidence, p. 878).
8. Agreement between Australia and the United States of America concerning the Status of United States Forces in Australia, Canberra, 9 May 1963, (Australia, Treaty Series, 1963, No. 10).
9. Supplementary submission from Ms A. Weate and Ms L. Beacroft, p. 10; submission from Senator J. Vallentine, p. 27 (Evidence, p. 1070).
10. e.g. submissions from Ms A. Weate and Ms L. Beacroft, p. 6; Senator J. Vallentine, p. 26 (Evidence, p. 1069); the Peace Squadron (Sydney), p. 18.
11. Senate, Hansard, 14 March 1986, p. 1096 repeating a statement made in HR, Hansard, 23 August 1985, p. 458.

A4.6 A year later the Government modified the last sentence of this statement, saying instead that the 1963 SOFA 'contains provisions regarding claims arising from the activities of United States forces in Australia'.[12] Australia has no SOFA with the United Kingdom or with France.

A4.7 For reactor accident compensation claims relating to their respective warships, the United States and United Kingdom 'Standard Statements' both state that claims 'will be dealt with through diplomatic channels in accordance with customary procedures for the settlement of international claims under generally accepted principles of law and equity'.[13]

Government to Government Claims

A4.8 It is helpful to distinguish between the avenues open to an aggrieved individual to seek compensation and those open to the Australian Government to seek damages from the foreign country to which the warship belonged. The latter category of compensation might include any sums that the Australian Government had spent in compensation to individuals.

A4.9 The Committee might choose not to address the issue of inter-government compensation, regarding it as beyond the scope of its inquiry. It should be noted that warship visits are seen as beneficial to both the sending and receiving countries by the governments concerned. It is not inconsistent with this premise that both governments share the burden of providing compensation for accidents relating to the visits.

A4.10 The Victorian Government submission raises the issue of the present lack of contingency arrangements under which the Commonwealth would indemnify a State in respect of costs incurred by the State arising from a nuclear accident involving a visiting

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12. Senate, Hansard, 26 March 1987, p. 1389.
13. Evidence, p. 1079 (US) and p. 1300.16 (UK).

warship.[14] The Committee might also choose not to consider this issue. Investigation and resolution of compensation issues arising between the States and the Commonwealth would involve broad questions of policy going well beyond the Committee's terms of reference.

Individual Claims

A4.11 Individual compensation claims can be brought in a number of ways, either through the courts or administratively.

A4.12 First, the claim could be brought in the Supreme Court or a lower court of the State or Territory in which the accident occurred. It would be brought as an action for tort causing death or personal injury to a person and/or loss or damage to tangible property.[15] The foreign country would be immune to a claim where the only type of harm alleged was economic loss unconnected with physical injury or damage.[16] Australian law would apply. The terms of the Australia-United States SOFA would not affect the

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14. Submission from the Victorian Government, p. 4. See also the submission from Greenpeace Australia (NSW) Ltd, p. 34 (liability of State bodies).
15. Foreign States Immunities Act 1985, s. 13 read with the Judiciary Act 1903, s. 39.
16. Ability to recover for economic loss (e.g. cost of delay to a ship due to port closure during the emergency arising from the accident) would be uncertain even in an ordinary accident caused by an Australian: see for example D. F. Partlett, 'Economic Loss and the Limits of Negligence', Australian Law Journal, February 1986, vol. 60(2), pp. 73-76. On the reason for excluding foreign states from whatever liability might otherwise exist in respect of economic loss unconnected with physical harm to the plaintiff, see Australian Law Reform Commission, Foreign State Immunity, (AGPS, Canberra, 1984), p. 68. Note that under the British policy relating to reactor accidents (see para. A4.3) there would be no compensation for such economic loss.

litigation.[17] Legislation permitting ship owners to limit their liability in respect of shipping accidents does not apply to visiting naval vessels.[18]

A4.13 Secondly, the claim could be brought in the appropriate court of the foreign country concerned. The prospects of obtaining compensation in this way depend to some extent on the laws of the country, and differ as between the United States and Britain.

A4.14 The aftermath of the Bhopal chemical disaster in 1984 indicates how assistance from the legal profession in the United States can be made readily available on a contingency fee basis to those wishing to bring claims against a United States defendant following a disaster.[19] Similar assistance might be expected for Australians wishing to litigate their claims for compensation in United States courts following a nuclear accident involving a United States warship. However, from the limited research done in preparing this note it appears that obtaining compensation in United States courts would be problematical, at least for a weapon-related claim. This is because the United States has immunity from suit in its own courts except where the immunity has been waived by legislation. The general statute providing for waiver does not apply to 'any claim arising in a foreign

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17. In Australia treaties do not form part of the local law unless they have been made to do so by legislation. The Australia-US SOFA has been given legislative effect with respect to civil claims only in minor respects: see the Defence (Visiting Forces) Act 1963, s. 17. There does not appear to be any equivalent to the World War II regulation that provided that the Commonwealth stand in the stead of the United States as defendant in civil litigation relating to visiting US forces: cf. National Security (Claims against the Commonwealth in Relation to Visiting Forces) Regulations, No. 193 of 1943, r. 4(1).
18. Navigation Act 1912, ss. 3, 332(2).
19. The disaster occurred on 3 December 1984 at Bhopal, India. The first lawsuit was filed in a US court on 7 December, with other suits being filed in the following weeks: Keesing's Contemporary Archives, March 1985, vol. 131, p. 33468.

country'.[20]

A4.15 Other legislation permits actions to be brought in United States courts having Admiralty jurisdiction for 'damages caused by a public vessel of the United States'.[21] It seems reasonable to assume that a naval reactor accident would fall within this. It would depend to some extent on the particular facts whether a particular nuclear weapon accident on board a United States vessel came within this phrase. The meaning of the phrase has been much litigated in the United States in a number of contexts, none involving nuclear weapons.[22]

A4.16 A further hurdle for the plaintiff bringing a weapon

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20. Federal Tort Claims Act, 28 USC 2680(k). Any argument that an accident aboard a US warship in an Australian port or territorial waters occurred in the United States for the purpose of this Act would be unlikely to succeed: cf. Meredith v United States 330 F.2d 9 (1964): US Embassy in Bangkok is a 'foreign country' for purpose of the Federal Tort Claims Act. It should also be noted that the status of forces agreement between the US and Australia presumably applies as part of US law, pursuant to the general US constitutional provision giving treaties domestic legal effect. The consequences of this (if any) have not been explored in this note. Article 12(7)(a) of the 1963 SOFA provides:

> Claims shall be filed, considered and settled or adjudicated in accordance with the laws and regulations of Australia with respect to claims arising from the activities of Australia's own armed forces.

It might be that a US Court would interpret this provision as not merely a choice of law provision but rather as one denying it any jurisdiction over a claim brought in respect of damages suffered in relation to a US warship in Australia and to which the provisions of Article 12(7) apply. Among other matters, Article 12(7) does not apply to 'any claim arising out of or in connection with the navigation or operation of a ship ... other than claims for death or personal injury' to civilians: Art. 12(7)(f).

21. Public Vessels Act, 46 USC 781. The action may only be brought by a foreign national if the law in that national's country would permit a US citizen to bring an action in the courts of the foreign country in respect of the same type of claim as is being brought in the case; in other words, reciprocity is required: 46 USC 785. Australian law meets this test: Judiciary Act 1903, ss. 56, 64; Shaw Savill and Albion Co. Ltd. v The Commonwealth, (1948) 66 Commonwealth Law Reports 344.

22. It is clear that the phrase extends beyond damage directly inflicted by the vessel (e.g. by collision) to that caused by crew negligence: Canadian Aviator Ltd. v United States 324 US 215 (1945). The Extension of Admiralty Jurisdiction Act, 46 USC 740, obviates what would otherwise be a bar to Admiralty jurisdiction, that is when the negligent act occurs on a vessel but the resulting damage to the plaintiff occurs on land.

accident claim arises due to the ability of the United States to limit the monetary amount of its liability for shipping accidents in the same way as ordinary ship owners.[23] Limitation to $420 per gross ton[24] is available, but only where the accident happened without the 'privity or knowledge' of the owner.[25] Because the issue has never been litigated, it is not clear how this test would apply to a nuclear weapon accident.[26] The effect of the United States acceptance of absolute liability for its warship reactor accidents appears to be that limitation would not be available in suits arising from such accidents.[27]

A4.17 The Crown in right of the United Kingdom (ie. the British Government) does not have immunity in its own courts in respect of tort actions brought by foreign nationals arising out of British warship accidents occurring in foreign ports.[28] However, the question of the circumstances under, and extent to, which the British Government could or would limit its monetary

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23. Public Vessels Act, 46 USC 789. See for example a recent case not involving nuclear materials: Empresa Lineas Maritimas Argentinas S. A. v United States 730 F.2d 153 (1984).
24. 46 USC 183(b)-(c).
25. 46 USC 183(a).
26. There is a large body of case law on the meaning of 'privity or knowledge', none directly related to nuclear accidents. In 1960, the US Attorney General noted that it could be argued that as a matter of law a nuclear reactor accident could never happen without the 'privity or knowledge' of the vessel's owner: Opinions of the Attorney General, 1961-74, vol. 42, pp. 15-16.
27. See US Senate Report No. 93-1281, (Public Law 93-513), U. S. Code Congressional and Administrative News, 1974, p. 6366: in the event of a non-nuclear accident to a US nuclear powered warship, the ordinary Admiralty rules relating to exemptions and limitations would be available to the United States Government.
28. Crown Proceedings Act 1947 (UK), s. 2(1). See for example The Norwhale [1975] 2 All England Reports 501: action arising from the sinking of a barge in Fremantle harbour allegedly caused by the negligent operation of the British aircraft carrier, HMS Eagle.

liability in such an action would need to be considered.[29]

A4.18 A third avenue for those seeking compensation would be to ask the Australian Government to take up their claims with the foreign country. The Australian Government would negotiate through diplomatic channels for settlement. There is at least one precedent for settling radiation damage claims in this way.[30] The

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29. Given the UK Government's policy on liability for its warship reactor accidents, it would presumably not seek to limit its liability in a suit relating to such an accident. In broad terms, the ability to limit liability is the same with respect to naval as to merchant vessels: Crown Proceedings Act 1947 (UK), s. 5(1) as amended by the Merchant Shipping Act 1979 (UK), s. 19, Schedule 5, para. 3. The latter Act provides that the relevant rules shall be those contained in the 1976 international Convention on Limitation of Liability for Maritime Claims, modified as provided for in s. 17(2). Article 3(d) of the Convention states that the rules of the Convention do not apply to 'claims against the shipowner of a nuclear ship for nuclear damage'. 'Nuclear ship' is not defined. It presumably refers to a nuclear powered ship, but not to a conventionally powered, nuclear armed ship. If this is correct, the British Government could not rely on the legislation in order to limit its liability for a reactor accident. However, the right to limit would appear to be open in relation to a nuclear weapon accident, assuming the accident was sufficiently linked to the operation of the vessel for limitation to arise in the first place. The facts of a particular accident might negate the right to limit liability: for example, if the accident occurred due to the fault of the owner as defined in Article 4 of the Convention.
30. See Japanese Annual of International Law, 1959, vol. 3, p. 107, (Japan demanded compensation for radiation injuries suffered by its fishermen from a US nuclear test at Bikini Island on 1 March 1954; following negotiations the US agreed to pay $US2m.) Such diplomatic settlements are open to the criticism that they are arrived at through negotiation and compromise, rather than the normal winner-take-all result of arbitration or litigation: e.g. see Evidence, p. 581 (Prof W. J. Davis); submission from the Australian Nuclear Free Zones Secretariat, p. 6, which 'most certainly puts no trust in "normal diplomatic channels" to make adequate reparation'. cf. the submission from Ms A. Weate and Ms L. Beacroft, p. 8: 'it is doubtful if there is any customary [international] law governing reparation in cases of serious pollution such as nuclear damage'. This claim is repeated in L. Beacroft and A. Walton, '"Broken Arrows": Who Pays?', Australian Society, May 1987, p. 35. The sole source cited in support of the claim does not discuss radiation damage. The claim fails to distinguish the legal issues arising out of transfrontier pollution as a byproduct of normal industrial, irrigation, etc activities of private individuals from those due to an accident, moreover one involving a warship and occurring within the country seeking compensation, and hence lacking a transfrontier element.

Australia-United States SOFA would provide a framework.[31] In any large-scale accident it is likely that a special claims settlement procedure would be agreed, possibly with an ad hoc tribunal to resolve contested issues.[32]

A4.19 As a fourth avenue, those seeking compensation could make their claims directly on an administrative level to the foreign country concerned. These countries have an interest in maintaining goodwill and the continuation of warship visits. It cannot be assumed that they would fail to settle genuine claims. The opposite assumption is arguably more realistic.[33]

A4.20 This last method of compensation was used for nearly all claims arising from the United States nuclear weapon accident at Palomares, Spain in 1966.[34] The procedure involved a relatively informal statement of claim to a local office set up for the purpose by the United States. Claims were vetted administratively by United States personnel with local assistance, and justified claims were settled on the spot. Provision was made for emergency payments, pending settlement.

A4.21 One opinion of the Palomares settlement suggested that

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31. This framework has not had to stand the test of a large-scale disaster. In respect of the claims that have been brought, it is said that 'there have been very few problems': H. B. Connell, 'Australian Defence Arrangements' in K. W. Ryan (ed.) International Law in Australia (2nd edn., Law Book Co., Sydney, 1984) p. 245, n. 2.

32. To prevent such an agreed settlement procedure from being outflanked by individual actions in Australian courts, the Australian Government has the power to bar such actions if the agreed procedure so requires: Foreign States Immunities Act 1985, s. 42(2)-(4).

33. US Executive Order 11918 (1 June 1976), pursuant to Public Law 93-513, empowers the Secretary for Defense to authorise payment of claims as part of administrative claims settlement arising from a reactor accident on a US warship. With respect to nuclear weapon accidents, see Senate, Hansard, 29 September 1988, p. 1014: the Australian 'Government is confident that the US Government would promptly settle any proper claim for damage in the highly unlikely event of a nuclear weapon accident in an Australian port'.

34. The claims settlement is described in detail in US, Defense Nuclear Agency, Technology and Analysis Directorate, Palomares Summary Report, (DNA, 1975), pp. 149-181.

the particular procedure adopted was not the most appropriate and that administrative settlement pursuant to an international agreement was to be preferred.[35] The authors of an evaluation of the accident response concluded that the 'Palomares claims program was lengthy and caused considerable personal and political friction, both in Spain and in the United States'.[36]

A4.22 In July 1983, the USS Texas collided with a wharf in Brisbane, damaging the wharf. A claim for compensation for the damage was made to the United States Government on the administrative level. The claim was paid in full, with settlement occurring 22 months after the accident.[37] In September 1988, the USS Berkeley collided with a launch in Cairns during berthing. A claim for compensation has been made administratively by the launch-owner. It appears that the United States has accepted liability, although the amount of damages has yet to be settled.[38]

Conclusions

A4.23 There are good grounds on which the Committee could conclude that following any major accident a special claims settlement procedure would be established to meet the specific needs of claimants. Further, it would not appear to be useful to attempt to establish this procedure in advance. Such a procedure would probably be out of date if the need to use it ever arose. It might also not be optimum for the features of the particular accident.

A4.24 If the belief is incorrect that a specific procedure would be instituted following a major accident, it is nonetheless clearly arguable that existing avenues give plaintiffs adequate

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35. ibid., p. 180; the opinion is that of a senior US official involved in the Palomares settlement.
36. ibid.
37. Senate, Hansard, 12 December 1988, p. 4007.
38. ibid.

opportunity to pursue their claims.

CAUSATION AND LIMITATION PERIODS

A4.25 In order to succeed in a compensation claim, a plaintiff has to show that exposure to radiation for which the defendant was responsible caused the plaintiff's injury. For prompt or acute effects this presents no particular difficulty. However, for late effects (ie. years after the event) due to exposure to low doses the position may be different. In many cases, the most that scientific evidence can show is that the exposure increased the probability that the illness would result. But the statistical correlation between exposure and illness may be too low to support a verdict that the exposure caused the illness. Moreover, plaintiffs may have difficulty in proving in court the actual level of radiation to which they were exposed.

A4.26 A related difficulty may arise due to the general legal requirement that a claim be brought within a limited period after the illness was capable of being diagnosed. The late effects of exposure to radiation may remain undiagnosed after they are capable of being diagnosed. When diagnosis is eventually made the limitation period may have expired, although there is generally some provision allowing courts a discretion to extend the time.[39] This difficulty is not removed by any acceptance of a standard of

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39. The position both on when the limitation period starts to run and on any discretion of courts to extend differs between each jurisdiction in Australia: see generally Western Australia, Law Reform Commission, Report on Limitation and Notice of Actions: Latent Disease and Injury, (Project No. 36, part 1, October 1982), pp. 15-17, 47-62. In respect to the accident at Palomares, Spain in 1966, Spanish law appears to be the law governing compensation claims. This law is reported to provide a 20 year period for bringing claims, which commences from the time when the accident occurred. The local population were reported in 1985 to be concerned that they would have no avenue for compensation should cancer cases attributable to the accident become manifest after the 20 year period had expired: New York Times, 28 December 1985, p. 2, 'Where H-Bombs Fell, Spaniards Still Worry'.

strict liability.[40]

A4.27 Any problems that there may be in these respects are not unique to the type of radiation exposure which may result from an accident involving a nuclear powered or armed vessel. Nor are they unique to radiation exposure of any type. The same points may arise in litigating any of what are sometimes referred to as toxic torts, that is torts involving injuries with long latency periods and possibly caused by exposure to relatively low doses of a drug, chemical or radiation.[41]

A4.28 It can be argued that no special rules should apply to these issues as they relate to visiting warships. Rather the ordinary Australian law should apply in a way that does not discriminate against foreign countries. It would arguably not be appropriate for the Committee to address in its report the adequacy of the ordinary Australian law in such a broad area.

STANDARD OF LIABILITY

Introduction

A4.29 To recover in law generally, it may not be sufficient for the plaintiff to show a causal link between the harm suffered

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40. It should be noted that, conceptually, the issue of the applicability of a limitation period is independent of the issue of the applicable standard of liability. Acceptance of absolute liability by the US for US warship reactor accidents does not mean that these accident claims are not subject to a limitation period. The Senate Report No. 93-1281, relating to Public Law 93-513, notes that amongst the subsidiary matters it leaves to executive discretion is the question of a limitation period. The Report envisages that a limitation period for the submission of claims would be applied, but does not specify the period. Executive Order 11918 (1 June 1976) provides rules for some of the matters the Law leaves to executive discretion, but does not deal with the length of the limitation period.
41. e.g see D. A. Farber, 'Toxic Causation', Minnesota Law Review, 1987, vol. 71, pp. 1226-28.

and the act or omission of the defendant. As a general rule, the plaintiff must also show that the defendant's act or omission was negligent. Matters of both law and fact are involved in showing this. It must be shown that the law imposes a particular standard on persons in a position such as that of the defendant. It must also be shown that on the facts the defendant's conduct fell short of this standard.

A4.30 Proof of this factual element may pose difficulties following a warship accident, not least because all of the relevant technical information will be exclusively in the defendant's possession. A standard of strict liability, rather than liability based on negligence, is generally understood as meaning that the plaintiff is relieved of the burden of having to show that the defendant was negligent.

A4.31 It was pointed out earlier in this note that both the United States and the United Kingdom accept that a test of strict liability will apply to accidents involving the reactor on one of their warships. It is not clear that the absence of formal acceptance of a similar standard with respect to nuclear weapon accidents would disadvantage plaintiffs greatly in practice.

A4.32 On the particular facts, evidence of negligence may be clear. Alternatively, the foreign country may concede the issue.[42] It might be motivated a general desire to preserve port access rights in other countries by not being seen to be taking refuge in technical legal issues in an attempt to avoid liability. On the particular facts, it might also be motivated by a wish to avoid disclosure of classified or embarrassing

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42. cf. in a brief to the New Zealand Minister of Foreign Affairs from his Department dated 17 August 1976, the Department commented:

> it is inconceivable that the United States would act other than generously in meeting claims in the remote eventuality of an accident involving a nuclear weapon on board a visiting American warship.

The document was released under New Zealand's Official Information Act in June 1987.

information relating to weapon design or handling procedures.

A4.33 The general law of negligence in Australia includes a principle described by the Latin phrase res ipsa loquitur, which can be loosely translated as 'the event speaks for itself'.[43] Under this principle the law allows the fact that the accident has occurred to be evidence that the defendant was negligent. The plaintiff is relieved of the normal burden of specifying and proving the particular negligent act or acts of the defendant which caused the accident. The onus is on the defendant to show an absence of negligence on its part.

A4.34 The principle of res ipsa loquitur applies where an accident occurs that would not ordinarily be expected to occur in the absence of negligence. A further requirement is that the defendant must have been in control of the situation so as to create an inference that the negligence was that of the defendant. Both these requirements could be met if a nuclear weapons accident occurred on a warship under the control of its crew.

A4.35 The effect of the applicability of res ipsa loquitur is that a plaintiff suing under Australian law in respect of a nuclear weapon accident would, depending on the facts and assuming the defendant put in issue the standard of liability, often not be disadvantaged in practice by the formal absence of a strict liability standard. The likelihood of any disadvantage could only begin to be estimated once a credible accident sceanrio or scenarios had been determined.

A4.36 For claims taken up through the diplomatic channel, it would be open to Australia to agree with the other country to apply a strict liability (or some other) standard. In the absence of agreement the standard imposed by public international law is

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43. See generally F. A. Trindade and P. Cane, The Law of Torts in Australia, (OUP, Melbourne, 1985), pp. 351-356.

likely to be one of strict liability,[44] again assuming that the issue of whether negligence led to the accident is in issue.

A4.37 It should be noted that any agreement between the nuclear weapons country and Australia that the standard should be one of strict liability would not be effective of itself to make that standard applicable in an action brought under Australian law. It might well be, however, that that country would feel morally or politically obliged not to plead its case in such a way as to require the plaintiff to prove more than would be called for under the strict liability standard.[45] That standard would apply where the claim was brought subject to the agreement through the diplomatic channel. It would also apply as part of the law of the foreign country if made part of that law, as has been done in the United States in respect of warship reactor accidents.

A4.38 It is obviously better to have a clear agreement that the relevant standard for nuclear weapon accidents is one of strict liability, although the practical effect of the statement might not be major. Other countries have sought assurances that the applicable standard of liability for weapon accidents was to be the same as that for reactor accidents.

A4.39 In 1976, the United States Government referred the Government of Spain to the provision with respect to reactor accidents and gave:

> its further assurances that it will endeavor, should the need arise, to seek legislative authority to settle in a similar manner claims for bodily injury, death or damages to or loss of real or personal property proven to have resulted from a nuclear incident involving any other United States' nuclear component giving

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44. See generally I. Brownlie, Principles of Public International Law, (3rd edn., Clarendon, Oxford, 1979), pp. 436-40.

45. cf. the accident involving the USS Berkeley in Cairns in September 1988, in which it seems that the US has not disputed liability although the amount of compensation has been an issue: see para. A4.22.

rise to such claims within Spanish territory.[46]

A4.40 The New Zealand and Canadian Governments appear to have obtained amendment of the United States 'standard statement' relating to nuclear powered warships so that it also covers nuclear weapons aboard visiting United States warships.[47] This unilateral assurance appears with respect to compensation to provide no more than that claims will be dealt with through diplomatic channels. It makes no specific reference to the standard of liability to be applied in evaluating claims.[48] The Australian Government has obtained a similar assurance, the exact terms of which remain classified.[49]

A4.41 The view that only limited disadvantage might be caused by the absence of formal acceptance by the United States of absolute liability for its nuclear weapon accidents has been noted. In the past there apparently has been some reluctance on the part of the United States to entering into any agreement involving such formal acceptance. In view of these points, it could be argued that there is little merit in Australia expending scarce diplomatic capital attempting to secure a formal acceptance.

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46. Note of 24 January 1976 from the United States Ambassador to the Spanish Minister of Foreign Affairs, accompanying the Treaty of Friendship and Cooperation between Spain and the United States of America, United Nations Treaty Series, 1976, vol. 1030, p. 124. The Spanish reply of the same date states that the Spanish Government accepts the contents of the Note 'and trusts in a broad application of its provisions': ibid., p. 126.
47. Brief from the New Zealand Department of Foreign Affairs to its Minister, 9 August 1976, p. 2 and 17 August 1976, p. 1. Both documents were released in response to an access request under New Zealand's Official Information Act.
48. The revised versions of the 'standard statements' given to Canada and New Zealand have not been sighted by the Committee secretariat. The statements in the text are based on the secondary sources cited in the previous footnote.
49. Senate, Hansard, 12 October 1988, p. 1260.

INSURANCE POLICIES

A4.42 A number of submissions noted that insurance policies on property in Australia exclude, by means of a standard clause, cover in respect of all types of nuclear accidents.[50] It was asserted that the exclusion was as a result of the way in which insurance companies had assessed the risk.

A4.43 The Insurance Council of Australia (ICA) has informed the Committee that this type of exclusion from standard cover was not directly related to visits by nuclear powered or armed warships. The insurance industry had not carried out any assessment of the risks of such visits. The reason for the exclusion was 'to bring the Australian market into line with other insurance markets and to ensure compatibility in reinsurance and treaty arrangements effected on a global basis'.[51] Although insurers are free to offer non-standard cover for nuclear risks, to the best of the ICA's knowledge none do so in Australia.

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50. e.g. Scientists Against Nuclear Arms (Tas), p. 6 (Evidence, p. 825); Mr K. Colbung, p. 3; Senator J. Vallentine, p. 25 (Evidence, p. 1068); Mrs E. Bruen, p. 1; Greenpeace Australia (NSW) Ltd, p. 34. See also Evidence, p. 924 (Mr M. Lynch). The regulations made under the Insurance Contracts Act 1984 provide for the exclusion, from various types of 'standard cover' policies, of libility in respect of damage resulting from:

    the use, existence or escape of nuclear weapons material, or ionizing radiation from, or contamination by radioactivity from, any nuclear fuel or nuclear waste from the combustion of nuclear fuel.

    Statutory Rules 1985, No. 162, r. 15(d)(iii), which relates to home contents insurance. Similar provisions in these Rules relate to insurance for home buildings, sickness and accident, consumer credit, and travel.
51. Letter from the Insurance Council of Australia, 1 July 1988.

ADDITIONAL STATEMENT
by
SENATOR HAMER

The Report correctly establishes that a ship, possibly nuclear armed, is no greater a threat when in dry dock than it would be alongside at a nearby wharf.

However, I consider the Report does not deal adequately with the industrial relations problems of dry-docking ships which may be, accurately or inaccurately, described as carrying nuclear weapons. In recent years we have had examples of this with HMS Invincible and HMS Edinburgh. I believe that foreign ships which might be nuclear armed would not be prepared to take the risk of being dry-docked in Australia for minor repairs, because of the danger that once in dock they would in effect be hostages to militant Australian trade unions. The fact that the unions would be behaving absurdly, in view of the fact that if the risks were real their aim surely should be to get rid of the ship as quickly as possible, would unfortunately not mean they might not take such action; and the risk of them doing so would be a strong disincentive for foreign warships to be dry-docked here, and if dry-docking for emergency repairs to (say) the steering or propulsion systems is known to be impracticable in Australia, foreign warships may be reluctant to come here at all.

The Navy has, in recent years, endeavoured to establish bases for its operational ships which are clear of civilian manned dockyards, and which are manned exclusively by Naval personnel, and are not therefore subject to industrial disruption and blackmail. HMAS Stirling in Western Australia, and the new fleet base at Woolloomooloo are examples of this.

Nevertheless there is a clear gap in the campaign to make operational ships immune to militant industrial campaigns.

Operational ships, during their tour of duty - typically four years - between dockyard refits, may nevertheless require to be dry-docked, either for inspection or for minor repairs. These repairs could probably be performed by Naval personnel, but the dock itself in Sydney - the Captain Cook dock - is operated by civilian personnel, who are subject to trade union discipline and political objectives. The number of men concerned in operating the dry-dock is probably not more than 20, but they could render an operational warship non-operational.

The problem is even more acute for visiting warships which may be nuclear armed. The recent fiasco of the visit to Melbourne by the aircraft carrier HMS Ark Royal and her accompanying supply ship, demonstrates this. After that fiasco, when the maritime unions refused to provide tugs for the berthing of the ships, the Minister for Defence took action to provide Naval-manned tugs which I understand will be in service by the end of the year. I believe, for exactly the same reason, the Government should take over the operation, with uniformed disciplined personnel, of the dry-docking facilities in the Captain Cook dock in Sydney, so that those facilities are always available for the operational ships of the RAN, and for visiting warships.

It is quite unacceptable that the operation of our fleet, and the willingness of the warships of our friends and allies to visit this country, should be in the hands of militant unions whose motives and behaviour may have nothing to do with the national interest.

I accept that the Captain Cook dock, at Garden Island, Sydney, has two roles - to provide emergency dry-docking facilities for operational warships (including visiting foreign warships) and also to be used during the refits of our own ships, when the ships are being overhauled by civilian dockyard personnel. I also accept that with the commercialisation of Garden Island, the Captain Cook dock may be an important commercial asset of the dockyard in seeking non-Naval income. Nevertheless I think, of these two roles, the operational availability of our fleet is the overriding one and that therefore the dry-docking facilities, like the berthing facilities at the fleet base at Woolloomooloo, should be under direct Naval control.

David Hamer
Senator for Victoria

SENATE

A DISSENT FROM THE REPORT OF THE STANDING COMMITTEE ON FOREIGN AFFAIRS, DEFENCE AND TRADE

Reference: The adequacy of current contingency planning by Federal and State authorities to deal with the accidental release of ionizing radiation from visiting nuclear powered or armed vessels in Australian waters and ports.

SENATOR IRINA DUNN

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Preface

In dissenting from the conclusions and recommendations of the majority report I have not attempted to include all of the issues raised by the large number of submissions with concerns about the safety of visiting nuclear-powered and nuclear-armed warships. Beside many well-developed arguments there is much disputed material in these submissions, including matter that is anecdotal, officially denied, or differentially interpreted by official sources. I have chosen to concentrate upon the evidence - largely from official sources - that was accepted by the Committee in the preparation of the majority report and have confined my discussion - as far as possible - within the ambit of the terms of reference.

Furthermore, I have not sought to identify every point of disagreement with the majority report; this could have produced a dissenting report as bulky and impenetrable as the majority report itself. It has been my intention to concentrate on the evidence and arguments that I consider basic to the Committee's enquiry and to make this dissenting report as brief and accessible as possible.

For the sake of economy I shall refer to the majority report as "the Report" and the remaining members of the committees of the thirty-fourth and thirty-fifth Parliaments as "the Committee".

I have appended three extracts from the Hansard evidence to this dissent. The first (Appendix 1) is part of the submission of the Australian Atomic Energy Commission, now the Australian Nuclear Science and Technology Organisation (ANSTO), dealing with "mean annual severity" calculations which I have included for the convenience of readers following my argument on these calculations.

The extracts in Appendix 2 are two samples of evidence under cross-examination by the Committee - in both cases the Committee of the thirty-fourth Parliament. I have included Dr Speed's evidence because I feel many of his pertinent comments and observations have been ignored by the Report and also because he is an expert witness with an obvious ability to translate technical concepts into a form that lay readers can understand. The second extract in Appendix 2 is the cross-examination of Professor Jackson Davis which refers to some basic issues not often mentioned in the Report. Readers of this part of the evidence may notice that the discussion is - at the beginning - quite spirited and I should explain that Professor Davis' appearance was preceded by extensive media reports forecasting his evidence, which may have coloured the attitude of Committee members towards him.

Both of these extracts, especially the latter, have theatrical qualities that may give readers some insight into how a Committee works. I should also add that questions to witnesses are prepared for Senators by the staff and technical advisers to the Committee, although obviously members sometimes made up their own.

I have chosen not to quote from the in camera evidence, primarily because I find most of the content unremarkable, not very secret and not very reassuring on safety issues. The exceptions to this are two points of evidence where a Department of Defence expert appears to be evasive - although confusion and a poor memory is a possible alternative explanation. One of these instances relates to Tomahawk cruise missiles, the other to the terms of a United States assurance to Australia that is still classified. This assurance was the subject of a question without notice that I asked Senator Robert Ray (representing the Minister for Defence) on the 29th of September 1988. Senator Ray's answer stated that Australia did not have a confidential U.S. assurance on nuclear weapons accident liability. Senator Ray corrected his answer on the 12th of October by stating that Australia did have such an assurance, dating from 1976.

During the in camera evidence taken on the 16th of December 1986 some of the text of this assurance was read into the transcript by the Department of Defence witness (pp.1-2), but when the same man was asked a direct question relating to "agreements" on nuclear weapons safety on the 17th of June 1988 the answer was "No" (we have no agreements) (p.29). This was later qualified when the witness "remembered" the only assurance Australia has on nuclear weapons, but he then referred to it in very general and dismissive terms without reading any of the text of the assurance (pp.37-38). I suspect that the sensitive material in the assurance is contained in the first sentence of the second quotation on page one of the 1986 transcript. I include this reference and the page numbers for the convenience of Senators with access to the documents. I should also point out that only Senators belonging to the major parties were present at the 1988 hearing.

If the Department of Defence witness was evasive then this evidence supports my argument in the Introduction on secrecy in the context of the alliance with the United States.

1. Introduction

The Report of the Senate Standing Committee has implications that extend beyond the accident hazards presented by nuclear-powered and nuclear-armed warships visiting Australian ports; it reflects badly upon the ability of our parliamentary institutions to protect the best interests of the Australian people. Even Australian citizens who are not immediately affected by warship visits, or those who willingly accept them whatever risks they present, should be concerned about the nature of this report.

I believe that the basic problem is not the competence of the Senate Committee, but rather its lack of the political will to properly address a contentious issue upon which the major parties have considerable agreement.

The first symptom of this deficiency in the Committee was its determinedly narrow interpretation of the terms of reference to exclude any substantial treatment of the cost-benefit argument that underlies warship visits, despite the fact that the majority of the submissions clearly assumed a cost-benefit value quite at variance with the assessment of the Government and the Opposition.[1] This gives parts of the debate presented in the Report a shadow-boxing character, where differing technical propositions compete in place of the fundamental disagreements.

The second symptom is an unwillingness to come to terms with the apparently paradoxical Australian position on nuclear arms. Australia is a nation that is not nuclear armed and has a strong - if mostly rhetorical - posture on nuclear disarmament. At the same time, it has a close military

1 See Ch.3 para.15, where the Report states that the Committee is "prepared to accept some degree of risk"; how much and why is not made entirely clear.

alliance with a nuclear-armed superpower which deploys its nuclear war-fighting machines in Australian harbours.

I believe the Committee is concerned about safety because it would be absurd for a country basically opposed to nuclear arms - and the machines that deliver them - to suffer damage and casualties from a nuclear-powered warship or nuclear weapons accident. But Australia also has a traditional commitment to the U.S that verges on bondage. Even Australians who doubt the usefulness of our alliance with the U.S fear the consequences of any retreat from this commitment and so the Committee was strongly motivated to find a safety formula that did not compromise the access of the U.S. Navy to our ports.

(a) Nuclear-powered warships

It is important to note at the beginning that all the nuclear-powered ships that have visited Australian ports have been warships of the U.S. Navy and they were all almost certainly nuclear-armed.[2] Both the power systems and the armament are the subjects of military secrecy.[3]

The Committee has inherited the contingency planning policy that currently applies to nuclear-powered warship visits and the Report shows no serious consideration of the option to abandon all safety planning. Yet this is the official advice that Australia receives from its trusted and close ally, the United States. The former Ambassador, Mr L.W. Lane (jr.), at the U.S. Embassy in Canberra, answered the first letter from the Committee (13 October 1986) by directing them to the Australian Government for information,

2 But see below (Introduction (d)) on the nuclear weapons that will be retired.

3 Although submarines of the Royal Navy use similar power plants - under licence from the U.S. - they have not visited Australia and there is no reason to expect them in the future.

did not answer another letter seeking information on U.S. port safety plans (17 February 1987), and did not answer another letter (18 February 1988) repeating the request and reminding him that no answer had been received.[4]

Eventually (20 October 1988), the U.S. Navy attache at the Embassy informed the Department of Defence that the U.S. Navy policy was that no special safety plans were necessary.[5] Furthermore, the U.S. Navy will not assist in the preparation of safety plans, nor even comment on such plans.[6] This is a remarkably hostile policy position for an ally in an "equal" alliance.

The Committee has been denied information by the U.S. authorities and by Australian institutions such as the Department of Defence and ANSTO that have access to privileged information from the U.S. and the U.K. The enquiry has been conducted without the co-operation of the U.S., the nation which operates the reactor systems that enter Australian ports, and without the wholehearted assistance of the Australian bodies that are best informed - if only partially - on the technical facts about naval nuclear reactors. For instance, if through possession of classified documents, ANSTO and/or the Department of Defence were aware of some military feature that could seriously compromise reactor safety, they could not tell the Committee about it unless the U.S. authorities agreed. Long-serving parliamentarians may have become blase about this state of affairs, but to me it represents a serious affront to parliamentary democracy and Australian sovereignty.

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4 Ch.6 para.23; see also Ch.6 n.23 and n.24.

5 Ch.6 para.24; a similar advice is apparently offered by the U.K. to the Australian Department of Defence (Ch.6 para.4).

6 ibid.

Most of the information that the Committee has used in its naval reactor assessment is of three types:[7] firstly, information about civil reactors with similar principles of operation but many practical differences; secondly, information about the reactor systems used on nuclear-powered civil vessels - an almost defunct breed;[8] thirdly, and most importantly, information about military reactors discovered largely by civil overview of the U.S. military, including information inadvertently released or reluctantly released to allay public alarm.

In its effort to discover and collate this information, there is a sense in which the Committee is allied with civil institutions within the United States and opposed both by the U.S. Navy and by Australia's own defence establishment - which has a closer alliance with the military forces of the U.S. than does the rest of Australia. Military institutions of most nations seem to have in common a contempt for the civilians they are charged to protect, especially civilians who question military priorities.[9] And while I commend the Committee's effort at civil overview, in practical terms any attempt by an Australian Senate Committee to penetrate the military secrecy of a foreign superpower is hopeless.

(b) Civil reactors and the Committee

I find that the Committee's reference to civil nuclear reactors does little to convince me of the safety of naval reactors, but it does highlight the extraordinary rigour

7 Ch.3 para.39; the text mentions 5 categories, but all the useful material in the last two (safety plans and assurances) comes from military sources.

8 Note that nuclear-powered merchant ships, like the NS Savannah, were powered by reactors using low-enriched uranium fuel (4.4%), not highly enriched fuel like the U.S. warships.

9 George Bernard Shaw's adage that "all professions are conspiracies against the laity" is just as true for the profession of arms.

required to conduct even the imperfect probabilistic risk assessments used for civil reactors.[10]

A necessary part of this rigour is possession of every structural and operating detail of the relevant reactor; fragments of information and inferences are not an adequate substitute.[11] Readers of the Report will notice that many discussions peter out with a statement to the effect that there is insufficient evidence to determine a particular point. This is also true of arguments central to the case that the Committee presents and I shall deal with some of these in section 2 of this dissent.

Another aspect of the rigour required for a thorough reactor analysis is an informed scientific objectivity. This is essential for the control of dangerous technology like nuclear power systems. The British National Radiological Protection Board is currently proposing that the existing safety standard of one significant civil nuclear accident every 10,000 reactor years should be tightened to a "tolerable" one accident every 100,000 reactor years.[12] Discriminations of this order are not made with knockabout common sense or intuition.

Whether one considers this quality of certainty achievable is another matter, but if the members of the Committee had possessed this rigorous informed objectivity it would have led them quite rapidly to the conclusion that any attempt at

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10 Note the statement in Ch.4 para.31, where the Report refers to "...the possibility that [civil reactor information] may be used to fill gaps caused by military secrecy".

11 Ch.1 para.23; "much relevant information...in fragmentary form".

12 New Scientist, 19 Feb 1989, p.26; in this case these figures are the targets that a civil reactor design analysis and component testing should conform to.

an independent Australian review of the accident risks presented by U.S. naval reactors was impossible.[13]

This insight leaves two clear choices; either to accept the assurances of the U.S. Navy, abandon the safety plans and leave the safety of the Australian public in the hands of the visiting military force, or find some way of excluding these dangerous machines from our ports. But instead the Committee has conducted an extended parody of an investigation, which has produced this weighty tome with its apparently well-meaning but politically harmless recommendations.

During the collection of evidence, Senator Sir John Carrick said: "In the end this document of ours has to stand the test right round the world".[14] As an Australian and a parliamentarian, I rather hope this is not the case. Quite a large number of people in "the world" are very well informed on the technical details of naval nuclear reactors. I don't anticipate with any pleasure the sniggers at the Report's tortuous efforts to establish some simple fact, or worse, to arrive at a totally erroneous conclusion.

This observation reminds me of one of the more risible comments made in the Report. In chapter 7, on submissions to the Committee, it is stated that "none of the authors of these submissions claimed any expertise in naval reactor design".[15] Unfortunately there was also an absence of experts in naval reactor design on the Committee and I suspect that any naval nuclear reactor designer who declared

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13 The Report does appear to reach this conclusion in Ch.3 under the heading "Inability to Quantify the Accident Risks", but continues to make frequent use of the apparatus of quantitative analysis to support a case for the adequacy of current planning concepts.
14 Evidence, 27 March 1987, p.597; see also Evidence, 14 May 1987, p.691, where a similar sentiment is expressed during the cross-examination of Dr T. Speed.
15 Ch.7 para.29.

a willingness to tell all and attempted to present evidence to the Committee would have been run over by a bus on the way to the committee room - probably a navy-blue bus.

However, having said this, I should also observe that the Report is in some respects an excellent summary of the publicly available material on U.S. naval reactors and it will serve as a useful source for parties interested in this subject. Of course, there are some qualifications to this statement. One is that the Report has a politically determined conclusion to justify; its arguments and selection of evidence should be treated with caution. Another is that as the Report is essentially an "alternative" document - dealing with military secrets but without the co-operation of the relevant authorities - it is impossible to know what important facts are missing, or to what extent deliberate mis-information has found its way into the Report.

(c) Nuclear weapons

This Report is the first parliamentary study to consider the possibility of contingency planning for nuclear weapon accidents. As the Report itself states, military secrecy is even more of an obstacle to an objective assessment of nuclear weapon accident risks than it is to the reactor enquiry.[16]

The contradictions in Australian nuclear weapons policy are particularly relevant to this discussion. Australia's acceptance of naval nuclear war-fighting weapons in our harbours is at variance with our declared policy on deterrence. This has become even clearer since the INF treaty was signed, since naval nuclear weapons have a similar de-stabilising potential as well as a lower level of

16 Ch.11 para.13-14.

control safeguards. U.S. and U.K. warships that enter Australian ports do so without declaring their weapon loading under a policy called "neither confirm nor deny", which pretends to be a security measure aimed at potential enemies. In fact this policy is aimed primarily at the citizens of "friendly" countries.[17]

The Committee's basic approach has been to minimise the risks and assert that the "disarmed" nature of the weapons and their safe storage during port visits ensures that accidents will not happen, or are so unlikely that they are not worth planning for.[18] The Report then proceeds - rather unnecessarily - to assert that even if an accident were to occur it would probably not be serious.[19] At the beginning of chapter 11 the Committee promises to use the same methodolology and terminology as the reactor accident assessment.[20] However, although the "risk x consequences" formula is implicit through the nuclear weapons discussion, the Committee has heavily stressed the unlikelihood of a nuclear weapons accident occurring.[21] By reducing the probability of accident occurrence to a vanishingly small number the Committee avoids an extended discussion of accident consequences because even quite a large consequence multiplied by a very tiny probability still results in a small risk.

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17 The Soviet Union claims to have the ability to detect nuclear weapons remotely, Sweden developed the capability within days - if it did not have it already - and in 1966 a U.S. aircraft carrying "advanced nuclear detection" equipment detected plutonium contamination areas while overflying the Palomares accident site at an altitude of 100 and 200 feet. Obviously Australia could develop this capability if it does not have it already (see Ch.2 para.2). See also G. Brown, "NCND Nevermore", Bulletin of Concerned Asian Scholars, Dec. 1988.

18 Ch.11 para.114.

19 Ch.12 para.69.

20 Ch.11 para.4-8.

21 The Report does refer to the Department of Defence as having assessed "likelihood and consequences" without finding an accident that "requires specific contingency planning"; Ch.11 para.8.

A major emphasis was placed upon the need for a "credible" accident scenario before the risk could be considered serious.[22] This, too, is an emulation of the reactor methodology, where one particular type of accident is the basis for safety planning. Considering the attitude of the Committee and the shortage of hard information, this process was unlikely to produce a finding in favour of nuclear weapon accident contingency plans. However, in the last stages of the preparation of the Report, the Committee experienced a partial change of attitude towards the possibility of Australian planning for nuclear weapons accidents; I deal with this specifically at the beginning of section 3 of this dissent.

What should have been stressed are the real possible consequences of a contaminating nuclear weapons accident, which could certainly be more serious than the Committee's reactor "reference accident" and perhaps more serious than even an "uncontained" reactor accident. This is because the likely contaminant - plutonium-239 - has a very long half-life and, in a particulate form, tiny quantities of this substance are capable of producing human cancer fatalities.[23]

With such serious possible consequences we must demand extraordinary benefits or extraordinarily certain safeguards, especially since military secrecy restricts access to the information necessary for even a rudimentary examination of accident probability.

22 See Ch.12 para.45 and Ch.12 para.53 for examples of accidents that the Committee finds not "credible".

23 There are 15 different isotopes of plutonium, but Pu^{239} is the variety used for nuclear weapons. Small amounts of other isotopes have no effect on its contamination potential. I shall refer to this isotope as "plutonium" in the remainder of this dissent.

(d) A late development on U.S. naval nuclear weapons

On 1 May 1989, "The Age" newspaper reprinted an article from "The New York Times" that reported the imminent retirement of several of the older short-range tactical nuclear weapons on U.S. warships. These include SUBROC and ASROC anti-submarine missiles and Terrier anti-aircraft missiles. It was suggested that the decommissioning of all these weapons would be completed by 1991 and that their replacement by new nuclear systems would not occur before the late 1990s; it is possible that the U.S. Navy will not deploy new nuclear systems but continue to rely largely on conventional anti-submarine and anti-aircraft missiles.[24]

There are several reasons why these weapons are being discarded; firstly, all of them are geriatric and probably less safe and less reliable than modern weapons like the Tomahawk cruise missile; secondly, improvements in the accuracy and effectiveness of conventional missiles offset the greater power of the nuclear warheads; thirdly, budgetary constraints have postponed the development of replacement systems and there are probably also considerable savings in the maintenance, training and security areas.[25]

However, there is a less sanguine aspect of this development. The U.S. Navy enjoys several advantages over the navy of the U.S.S.R. that are similar to the Warsaw Pact's conventional weapons advantage over NATO forces - an

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24 The impending retirement of the older weapons is not news, but the U.S. Navy's tacit admission that they do not need them is. However, a request for US$66.3 million for 1990 to develop a long-range, dual-capable version of the Standard anti-aircraft missile is currently awaiting Congressional approval. The U.S. Navy still has the 28 year old B57 nuclear depth bomb which is aircraft-delivered.

25 See the Report Ch.11 para.33 (fn.50) for reference to the U.S. Congress refusal to fund the nuclear Sea Lance replacement for the ASROC missile.

edge that could compel NATO into a first-use of tactical nuclear weapons in any sustained major conflict.

At sea the position is reversed. Among other advantages, the U.S. aircraft carrier fleets are major conventional assets, but are also potentially vulnerable to the nuclear weapons that the Soviet Navy relies upon. The U.S. Navy plan (Sea Plan 2000) is to attempt to restrict a war at sea to conventional weapons, with the accurate long-range Tomahawks initially reserved for land installation strikes if the war escalates.

Professor Desmond Ball has pointed out that this doctrine lowers the threshold for an armed clash between the superpowers and that a U.S. attempt to win by conventional means would probably lead to nuclear war anyway because of the Soviet dependence upon tactical nuclear weapons.[26]

The financial reasons for decommissioning and the fact that this development is in line with U.S. Navy war planning may explain why the announcement of this development has just leaked out, rather than being dressed-up as a peace and disarmament initiative. In practical terms it does mean that the number of nuclear weapons on some types of visiting warships will decline until the deployment of new nuclear weapons - if the U.S. decides that new nuclear weapons are necessary.

(e) This dissent

In the following sections of this dissent, I have chosen to concentrate on only some of the issues that I see as central to the argument of the Report. I am very conscious of how incomplete this treatment is and others will want to take

26 Professor Desmond Ball, "Nuclear War at Sea"; International Security, Winter 1985/86, p.28, p.25.

issue with propositions and arguments in the Report that here are skimmed over or not mentioned at all. However, the Report itself, despite its length, is only a partial - and I would say partisan - treatment of the evidence available. This is not only a product of the genuine scientific uncertainties that exist in the areas under discussion, but much more a result of the military secrecy that applies to both naval reactors and nuclear weapons.

Scientific uncertainties can be resolved by research and experiment, but military secrecy _is_ active opposition to the collection of accurate information. Military secrecy is thus a crippling disability for the whole endeavour of the Committee's enquiry.

2. Nuclear-Powered Ships in Australian Ports and Coastal Waters

Non-specialists find statistics and the jargon of the sciences difficult but in this case some discussion of the statistical and numerical propositions in the Report is a necessity.

(a) Clarifying terms used in the Report

The first item is the use of special terms and redefinitions of common words found in the Report. One of the important special terms that may puzzle readers of the Report is "reference accident". They will assume this term carries some special authority. In fact, the "reference accident" is just a guess based on a sketchy knowledge of naval reactors and their safety features together with the hopeful assumption that a relatively minor accident is more likely than a catastrophic one. The "reference accident" looks like the "maximum design accident" used in probabilistic risk assessment of nuclear reactors but has no proper analysis to back it up.

Redefinitions include the crucial terms "credible" and "incredible". In the Report these terms are used to define a boundary between accidents that could happen and accidents that are effectively impossible. I doubt that Aristotle would be very happy with this dichotomy, since accidents are by definition unanticipated and, before the event, always have an "incredible" character. After the event even the most bizarre and unlikely accidents become necessarily "credible". These terms too are used in formal risk analysis but they are only meaningful when they are the end-products of some defined process of assessment; they are not labels that can be just stuck on.

"Conservative" is a term used in the Report to indicate a safety-oriented approach, for instance, in the assumption of the "worst-case" consequences in a hypothetical accident. In practice this has meant rejecting the possibility of a really serious accident, choosing a lesser accident as the "reference" and throwing the odd factor of 10 into calculations where it will do no harm to the desired conclusion.

A similar approach is evident in the treatment of "probability" and "consequences". These terms are in no way equivalent. We can often be much more certain about the consequences of accidents than their probability. For instance, the limits of the consequences of a contaminating reactor accident are defined by the dangerous elements in the reactor core that could be dispersed. There can be genuine disagreement about the exact dimensions of accident consequences under different circumstances but these difficulties are minor compared to estimation of accident probabilities.

When dealing with a novel technology having a brief history like naval nuclear reactor technology, the most useful skill for estimating the probability of an accident is a gift for prophecy. Yet this is the area where the Committee has concentrated its investigation. The psychological advantage of this choice is that a discussion of probability comes before an accident happens (it is futile afterwards), while discussing the possible consequences of an accident requires imagining that it has already occurred.

(b) Probabilistic risk assessment of nuclear reactors

The Committee has attempted to support its arguments on reactor safety by selective references to the probabilistic risk assessment (PRA) techniques that are applied to civil nuclear reactors. These techniques are valuable design tools for engineers who want to eliminate weaknesses from complicated systems without waiting for them to fail and building a better one next time. This approach requires an intimate knowledge of literally every nut and bolt in a system and is very expensive. The first comprehensive nuclear reactor analysis, called the Rassmussen Report (or WASH 1400) and costing US$4 million in 1975, has been heavily criticised for its methodology. Subsequent studies like the Sizewell B assessment have attempted to correct these deficiencies - but not to everyone's satisfaction. I recommend to readers interested in pursuing this subject Dr T. Speed's very accessible paper incorporated in the Hansard evidence.[1]

Ignore the claims in the Report that it is not attempting a quantitative analysis. It does attempt some quantitative rankings to justify the choice of the reference accident and alludes to other numbers of uncertain provenance. The usual scientific motive behind quantitative analysis is to escape from vague phrases like "perfectly safe", "an infinitesimal risk" and "she'll be right mate" into objective precision. The numbers that come out of this effort are not yet very reliable but they are an attempt to replace vague assurances with a sort of calculus of risk; this is important for modern societies which depend upon dangerous substances and dangerous concentrations of energy but also demand a high standard of health and safety. Unfortunately this Report has taken the vague assurances and appended various numbers to add authority to its predetermined conclusions.

There are several points on formal risk analysis and especially probabilistic risk assessment (PRA) that need to be made very clearly:

1 Evidence, 14 May 1987, p.622-657

(i) This sort of assessment is concerned with achieving a maximum level of safety in the design and construction of nuclear power plants. The result is usually expressed in failures per so many years. Ten thousand years (10^4 years) has become the standard and has achieved the status of a magic number. It seems that any nuclear accident has been assigned a maximum probability of one in 10,000 years.[2] Engineers who understand the construction and operation of these plants do not prostitute these theoretical figures into unequivocal assurances of public safety.[3] Richard Feynman's comments on the NASA risk estimates he discovered while a member of the Challenger Inquiry illustrate this point rather well. Feynman was surprised to discover that the NASA estimate for failure of the main engines of the Space Shuttle was 1 in 100,000 missions. Although the main engines did not fail in the accident, during previous missions there had been many problems with cracked pump turbine blades, split casings, and faults in many other components. Feynman was discussing engine failure with a manager and three engineers and as an experiment handed out pieces of paper and asked each of them to write down his estimate of main engine failure. Two of the engineers estimated 1 failure in 200 missions, the other estimated 1 in 300; the manager estimated 1 in 100,000 missions.[4]

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2 Once in 10,000 years was used by the Minister for Power and Electrification in the Ukraine three months before the accident at Chernobyl; according to the film "Above and Beyond", the scientists of the Manhattan project were required to guarantee the detonation of the Hiroshima bomb to a standard of one failure in 10,000.

3 ibid., p.671

4 Richard P. Feynman; "What do you care what other people think", 1988, W.W. Norton & Co. NY, p.179-82. Also note Feynman's comments on p.183:

"As far as I can tell, engineering judgment means they're just going to make up numbers" (this comment refers to a pipe-rupture probability assessed as 1 in 10^7 per mission), and:

"It was clear that the numbers for each part of the engine were chosen so that when you add everything together you get 1 in 100,000".

(ii) It is not necessary to be a technical expert to have grave doubts about the quality of the insurance provided by PRA. None of the major reactor accidents (Brown's Ferry, Three Mile Island, Chernobyl) have followed the sort of accident paths predicted by PRA. This could mean that PRA is protecting us from certain classes of accidents but it seems just as likely that it is still basically irrelevant to many accidents that happen in the real world.

(iii) The most dangerous elements in nuclear reactor systems walk in through the front door. Human error has been the major factor in serious reactor accidents - and in many other advanced technology accidents. Not just as the initiator of accidents, it also appears in errors of reaction and other compounding mistakes that can turn a minor problem into a catastrophe. This latter mode of human error was critical in both the Chernobyl and Three Mile Island accidents and it is interesting to note that five of the eight operators on duty at Three Mile Island were graduates of the U.S. Naval Reactor school.[5] I believe that it is impossible to contain human error by attempting to write it into a risk assessment system. As Dr Speed pointed out in his evidence to the Committee, it is impossible to anticipate "new, inspired pieces of human stupidity...".[6]

(iv) Civilian reactor PRAs cannot be transferred and applied to naval reactors. The greatest similarity between the two systems is that they share the same acronym (PWR - standing for "pressurised water reactor"). The fuel is different (very highly enriched), the size of the reactors is different, performance demands and cycles are different, the safety systems are different and the locations and operating environments are different.[7] This does not mean

5 Evidence, 27 March 1987, p.611

6 Evidence, 14 May 1987, p.682

7 Note a U.S. Department of State telegram from the Canberra U.S. Embassy of 25 March 1987, containing a draft press release on the visit of Professor Jackson Davis: "...Professor Davis has made

that naval reactors are more dangerous than civil reactors - they may in some respects be safer - but it is would be absurd to make trade-off adjustments and apply the civil safety assessments to these military machines.

If specific and comprehensive PRA assessments have been done on naval reactors - and there is no strong evidence that they have - they carry little assurance if their methodology and conclusions are not open to independent review and criticism.[8] Nuclear reactor-powered warships are machines designed for war, so some aspects of reactor safety are probably compromised for this reason. We know about the "battle-short" switch that overrides the automatic reactor shut-down (SCRAM), we know that the Committee could not determine under what conditions the containment would be vented through a pressure-relief valve. Other safety compromises may still be completely concealed military secrets.[9]

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hypothetical comparisons of commercial reactor and U.S. naval nuclear reactors. These are entirely misleading since there are vast differences between U.S. nuclear powered warships and commercial nuclear power plants with respect to the reactor size, plant design, fuel integrity, manner of plant operation and operator supervision. Consequently, commercial concepts regarding accident potential or accident consequences do not apply".

8 Note the reference in Ch.3 para.28 to the U.K. estimates of 1 in 10^4 reactor years for a contained accident and 1 in 10^6 reactor years for an uncontained accident. I believe that ANSTO holds a copy of a document titled BR 3019 which is usually available to "friendly" institutions - but not to the Committee. Apparently this document includes these estimates but we have no indication of how these figures were derived. Note also the discussion in Ch.4 para.35-46, where it becomes apparent that there is little, if any, real civil overview of naval reactor design and operation.

9 Ch.4 para.109-14 for reference to the "battle-short switch" and Ch.4 para.75-7 for a discussion of the venting of containment. This could be very important, the venting might need to be automatic, with rupture discs, or the captain may have a choice of irradiating the vessel or venting the steam and volatiles to the environment.

(c) The U.S. Navy safety record

The Committee is justified in saying that since the fatal accident at the SR-1 research reactor in Idaho in 1961 the U.S. Navy has had no major acknowledged accident to a nuclear reactor and therefore there probably has been no major accident. Two reactors have been lost (on the USS Scorpion and the USS Thresher) but it is claimed that reactor failures were not the cause of either of these accidents.[10]

If this is correct, the U.S. Navy can claim over 3000 operating years without a major accident. This compares very well with the apparent record of the U.S.S.R., which is the only nation with comparable aggregate years of naval reactor service. The Soviets probably made some unwise early choices in reactor technology, have arguably been more casual about safety generally and have adopted a more experimental approach to reactor design - resulting in more powerful reactors.

By contrast, the U.S. approach - largely under the guidance of Admiral H.G. Rickover - has been very conservative, tending to forgo performance for the sake of safety. This caution may be partly explained by considering the probable adverse public reaction to a serious reactor accident.[11]

However, military secrecy prevents the Committee from finding out the vital details of naval reactor construction and operation and, even more important, from examining operating logs and safety reports where incidents and mistakes with accident potential may be recorded. Near

10 See Ch.5 para.16-17 and note 20 for just some of the different versions of the accidents to USS Scorpion and USS Thresher.
11 Ch.4 para.133 and n.187.

disasters that could have placed civilian populations at risk are the incidents most likely to be kept secret.

(d) Mean annual severity calculations

An important quantitative element that has the potential to confuse readers of the Report is the use of the concept of "mean annual severity". This is a theoretical construct that is used merely in an attempt to rank potential accidents in order of their seriousness. It is not a direct measure of the actual impact of an accident. Many small, relatively harmless accidents might produce the same MAS figure as one catastrophic accident. This technique should have been left on the back of the original envelope. Its utility in discriminating between different hypothetical accidents is very doubtful and yet these calculations are at the core of the Committee's argument rejecting the need to plan for an uncontained accident.

A contained pipe-rupture melt-down

Only a few worked examples of mean annual severity are presented in the evidence (see Appendix 1). One of these is a contained melt-down caused by pipe failure, where the failure rate per foot of pipe is taken from extensive industrial experience. The pipe failure probability comes to 10^{-4}. (Who says there is no order in the universe?) Some plausible estimates of reactor core inventory and emission rates are proposed and these figures are multiplied together to produce a mean annual severity of 0.1 Curies of Iodine-131 per reactor year.

A contained melt-down with open door

A variant on this accident involves the entirely coincidental opening of the interlocked and alarmed doors to the containment compartment at the moment that a pipe-work rupture takes place. Much more Iodine-131 is released - 100 times the amount in the previous example - but the ungenerous assumption that the containment is violated for one hour per year pulls the multiple down to a trivial MAS of 0.001.

There is an air of unreality about this sort of accident scenario; it is more plausible to imagine the alarm disconnected and the doors chocked open with pieces of wood for some practical purpose, or that after some initial mistake or emergency, the doors might be opened as part of an attempt to avert a serious breakdown or perhaps to rescue a misplaced crew member. The Australian Navy has had recent experience of how hard it is to keep track of every crew member, even on a submarine.

A pressure-vessel rupture accident

The third MAS calculation involves a single-stage catastrophic failure of the reactor pressure vessel which ruptures the containment. The core inventory and release is the same as the open-door example (100,000 Curies) and the rupture probability, like the pipe failure, is taken from industrial experience. We have a century of experience with high pressure boilers and there are many of these devices in service. The submission mentions embrittlement by neutron irradiation and the high standard of reactor vessel testing. I presume that these vessels are very carefully assembled and tested but whether the dimensions of embrittlement are yet fully understood is less certain.

The product of the catastrophic failure probability and the 100,000 Curies of Iodine-131 produces a MAS of 0.01. The ANSTO submission then concludes that the contained ("reference") accident is obviously the proper accident upon which to base safety planning since it has a MAS that is 10 times the uncontained rupture model.

The conservative contained footnote accident

Alert readers will notice another contained accident MAS calculation in footnote 15 of Chapter 7 of the Report, where 3750 curies of Iodine-131 are assumed released over a 24 hour period. This calculation uses even more conservative assumptions than the reference accident example and results in a MAS figure of 0.375 curies per reactor year. This is nearly four times more serious than the standard reference accident and one wonders why it is not given more prominence in the Report. It is hard not to suspect that these figures are somewhat rubbery.

It seems obvious that there must be many more ways for a reactor to fail than just simple rupture failures of the pipe-work and the pressure vessel. Although a serious contamination accident might almost necessarily involve a mechanical break in the reactor's primary coolant system, there must be many possible sequences that terminate with this serious condition. Some other scenarios were evaluated qualitatively by ANSTO - for which read "guessed at" - but not calculated.

It is worth noting again that some scientists from ANSTO probably possess information about naval reactors not available to the Committee either because ANSTO holds confidential documents that it is not allowed to release to the Committee, or because individuals have worked in related areas overseas under security classifications that still constrain them. The Committee has been given only a vague indication of some such special competence,[12] but the superficial nature of the MAS survey gives nothing away and does little to inspire confidence.

12 Ch.3 para.26-7 and n.19.

I, for one, have no confidence that the MAS survey has any relationship to likely accidents and it is impossible to know whether even the few figures given are accurate within a factor of 10 or even 100.

(e) MAS calculations you can do at home - collision risks

One of the accidents mentioned in the submission but not quantified to produce a MAS estimate rather intrigued me. It related to ship collisions capable of damaging a warship's nuclear reactor. Some of the elements are quantified and it might be instructive to fill in the rest and produce a MAS figure for such an accident.

[A] According to Lloyd's Register of Shipping (1986) there are about 14,000 merchant ships in the world fleet over 7000 tons (a large destroyer is about 7000 tons). Jane's Fighting Ships only lists about 320 naval vessels over 7000 tons. Let us add 500 to make the total 14,500.

[B] ANSTO estimates that there are an average of two collisions per annum capable of damaging a reactor. Think of collisions as having one striker and one struck ship; we are considering the possibility of a nuclear-powered vessel being the struck ship.

[C] ANSTO estimates the consequences - core inventory available for release - for an uncontained accident as 100,000 curies of Iodine-131.

[D] ANSTO refers to the probability of a collision taking place in a river or harbour as 0.3 (coastal waters - 0.5).

[E] I nominate a special naval safety factor of 10. This assumes that a reactor powered navy vessel is ten times less likely to be involved in a collision than a merchant ship. I think that this is reasonably generous; no amount of regulation could stop a drunken container-ship helmsman striking an anchored or docked warship.

[F] I disagree with ANSTO on the probability of a nuclear-powered ship sinking immediately after a collision. Naval ships are designed to stay afloat even when severely damaged. Furthermore, the Liverpool Safety Plan - one of our best sources - characterises an uncontained accident as being a fairly sudden event.[13]

The basic formula is Probability x Consequences = Mean Annual Severity. In this case it is:

[1/A x B x D x 1/E] x C = mean annual severity

1/14,500 x 2 x 0.3 x 1/10 x 100,000 = 0.414

This is four times the mean annual severity of the reference accident. It is even slightly larger than the 0.375 estimate lurking in the footnote. The difference is that I don't expect my calculation to be taken seriously. Once we move into the more complicated real world there are many factors that can only be guessed at and are therefore subject to conscious - or even unconscious - adjustment to produce an appropriate final figure. However, on p.200 of the Report mention is made of an estimate of collision risks for nuclear-powered merchant vessels where the risk of release of fission products from collision is estimated as 10 times as likely as an accident like the reference accident - if there is no special collision protection. The quotation goes on to say "similar probabilities arise from grounding...".[14] It seems plausible to me that accidents like collision, grounding, fire or conventional explosion would be as likely to lead to a reactor accident as a spontaneous failure of reactor components.

13 Ch.7 para.109; see note 135 for a differing opinion from ANSTO.
14 Ch.7 para.64, n.78 and see also Ch.7 para.71.

(f) The "realistic" revised accident and MAS

It is not necessary to place too much weight on criticism of the MAS technique. The Report has conspired to undermine its utility by fiddling about with the "reference accident" in another attempt to enhance the apparent safety of nuclear-powered ships.

The Australian Ionizing Radiation Advisory Committee (AIRAC) suggested that ANSTO revise the reference accident to take account of recent evidence - largely from the Three Mile Island accident - suggesting that the release of volatiles (like Iodine-131) from the reactor and from containment might be much lower than previously supposed. Other factors are also adjusted down to "realistic" levels but the reduction in Iodine-131 alone has a major influence on the MAS discrimination.

The revised "realistic" model has a probability of the usual one in 10,000 and an emission of only 100 curies of Iodine-131, which calculates to a MAS of only 0.01, which is the same as the uncontained accident.[15] Thus the whole discriminatory function of the MAS technique comes to nothing. If the "real" risk of the contained accident is no greater than the uncontained accident (as measured by MAS), then accident planning should be based on both accidents - as it is in the Liverpool Safety Plan, where the better-informed authorities consider an uncontained accident unlikely but not absurd.

15 I would reject a claim that the uncontained accident could be similarly revised down. The process apparently responsible for the reduction of the amount of free Iodine-131 available for release during the contained accident at Three Mile Island (i.e. combination of caesium and iodine in a high pressure steam atmosphere) probably would not apply to a low-pressure uncontained accident.

The MAS technique seems to have a very limited utility to me, and it might do better as a board game than as a serious technique for the ranking of reactor hazards. I don't blame ANSTO for attempting to quantify these sample accidents but I do blame the Committee for presenting this incomplete and undigested mess of figures as an argument for the safety of nuclear-powered warships.

(q) The revised accident

The revised "realistic" accident model is another example of either the Committee's inability to process information and make decisions, or its desire to present a long and confusing document.

ANSTO and the Committee inherited the "reference accident" from the 1974 study that led to the conditional resumption of nuclear-powered ship visits in 1976, and there is an obvious reluctance to abandon it and start again. There is frequent mention in the Report of how "conservative" (safety-oriented) the reference accident assumptions are, but if the reference accident is the properly assessed basis for planning, what function does the "realistic" accident serve? Indeed, why does it even appear in the text of the report?[16]

Its function is an extension of the psychological process of the Report, which is rather like a fairy-tale (a very dull one) that is attempting to wean us from our unreasonable fear of nuclear reactors. The uncontained accident is a huge fire-breathing monster of an accident that could make a really big mess. This is placed beside the stolid, middle-of-the-road "reference accident" - more inconvenient than dangerous - and suddenly the big monster seems insubstantial, "incredible", to use the language of the

16 See Ch.7 para.16 and para.23-4 for the reasons offered in the Report.

Report. Then the curtain is twitched aside and we see the "realistic" accident, which is tiny and really quite cuddly and not at all dangerous. How childish our fears were!

The problem is, to extend the metaphor, that the big messy monster is always lurking in the core of the reactor. Fallible human engineering and the much more fallible human operators must cooperate to keep it in. Sooner or later it will escape.

(h) Other reactor risks

Outside the recognised accident models there are other risks associated with nuclear-powered ships that, while perhaps less likely, are not successfully discounted by the Report.

Core melt-through

There is the possibility, after a loss of coolant accident, that the molten core could melt through the bottom of the reactor vessel and then perhaps through the hull. It appears that the fission-decay energy available in the 40 MW(t) reactors makes this unlikely, but there might - under adverse circumstances - be enough energy in the larger reactors (85 -100 MW(t) and larger) to melt through both metal containments.[17] During the Three Mile Island accident the average peak temperature of the debris on the reactor floor was about 1900°C and in some areas 2800°C.[18] The melting point of most steels is only about 1500°C. No one has ever dumped a molten reactor core onto the bottom of a harbour; the physical reactions, the nature of the fission product emissions and the effect on the environment are a matter for speculation.

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17 Ch.7 para.52-9. This passage should be read carefully. The fact is, although it may indeed be unlikely, that soon after shut-down, the fuel in a larger reactor may contain enough fission-decay energy to melt through the vessel.

18 Evidence, 27 March 1987, responses by ANSTO to Questions on Notice.

Nuclear "fizzle"

There is also the danger posed by a low-grade critical mass explosion. A U.S. reactor core contains - on average - about 200kg of highly enriched uranium (over 90% U235). This is effectively weapons-grade material and if a large enough mass is present in the right configuration - as little as 25kg in roughly spherical form might be enough - there could be a partial nuclear explosion or "fizzle".[19] This could be equivalent to a few hundred kg of TNT. This is not much by nuclear weapons standards, but it is enough to render discussions on levels of containment and the percentage release of fission products irrelevant; it would be all over the place like the proverbial dog's breakfast.

It is only elementary caution to structure the base of the reactor vessel (perhaps by partition) so that a critical mass cannot accumulate, but is this true for every position of the reactor; for instance, after grounding or capsize? There may be technical reasons why the risk of either melt-through or fizzle are very low, but neither I nor the rest of the Committee are aware of them. It would be truly unfortunate if Australia's first encounter with a nuclear accident was with one of these events rather than the manageable reference accident.[20]

Ageing Reactors

One of the factors that is glossed over by estimates like once in 10,000 reactor years is the fact that like any other machines naval reactors wear out; corrosion, thermal fatigue and neutron embrittlement are some of the still only partially understood mechanisms involved. Many U.S. naval reactors are approaching the limits of their original

19 See the discussion in Ch.4 para.50-2 and n.69.

20 Either one of these accidents could release the whole core inventory to the environment. In Ch.4 note 35, a British figure is cited; 10,100,000 curies for an uncontained accident.

design-life and some may have already have exceeded it. The Report quotes the director of the Naval Nuclear Propulsion Program giving evidence before a Congressional Committee in 1986: "... these ships were originally designed for a 20-year lifetime. Now I am asked to make them go for 30 years, but they were designed for 20 years. We have a large fleet approaching its original design limit".[21] Each model of reactor has a land-based counterpart that is kept ahead - in operating time - of its sea-going fellows in an attempt to predict problems before they emerge on ships in service.[22] However, even this commendable caution cannot guarantee that individual reactors are not degrading more rapidly in some respect. We have seen recently how the ageing of civil aircraft, combined perhaps with a casual approach to maintenance, has introduced a new mode of fatigue failure accident. The first sign of this syndrome in nuclear reactors could be a major system failure in an Australian port.

(i) Reactor accident conclusion

If we had a documented history of perhaps a hundred naval nuclear reactor accidents we would be able to begin calculating and predicting accident probability. Even if we had access to comprehensive operating records we would have some idea of what accidents were probable and whether improvements in equipment and training could avert them.

Since we have none of these, all we can say with confidence is that there are very dangerous substances in a reactor core, with the potential to cause serious health problems for anyone exposed to them. This is the major proposition of the many submissions that have argued against allowing nuclear-powered ships into Australian harbours. The Report

21 Ch.4 para.121.
22 Ch.4 para.138 and n.196.

has dismissed and criticised these submissions for minor mistakes and misinterpretations or for claims that are unsubstantiated by the official records, although the Committee has accepted that the planners - and I include the Committee - should bear the burden of proof of the adequacy of safety planning.[23]

I believe that a concentration on the consequences of possible accidents is the only reasonable approach and that the Committee's ill-informed attempt to quantify the probability of various defined accidents is futile and misleading.

23 Ch.3 para.44-5.

3. Nuclear-Armed Ships in Australian Ports and Coastal Waters

(a) Special problems with the secrecy of nuclear weapons

Military secrecy is an even greater obstacle to evaluation of nuclear weapon accident risks than it is to a reactor accident assessment; as a signatory nation to the Non-Proliferation Treaty, Australia is obliged to avoid seeking out technical information on nuclear weapon construction. Despite severe limitations on its access to information on nuclear weapons, naval storage practices and comprehensive accident records, the Committee initially decided to recommend no accident planning for a nuclear weapon accident. However, at the last minute - on the 7 April 1989 - some additional paragraphs (Ch.11 para.115-17) were inserted with a recommendation that work on the "draft" nuclear weapon accident plan be continued. This is rather odd since this plan was dismissed in Chapter 2, paragraph 8, and the argument proceeded as if it did not exist. Readers of the Report will notice the stilted emphasis on the document's lack of "formal status" or "official approval" that accompanies its eleventh hour resurrection.[1] I have a personal interest in this document.

(b) The "unauthorised" VSP(N) nuclear weapons accident plan

I discovered that this plan existed during a visit to Brisbane on 20 September 1988; it came up during a conversation with the Head of the Queensland State Emergency Services, who actually had a copy of the document on his desk at the time. It may well have been a draft document as it appeared to be only a few pages in length. However, it was developed enough - and official enough - to have been distributed to at least one Head of State Emergency Services

1 Ch.11 para.115.

for comment. I resisted the temptation to seize it and run out the door and in a way this was unfortunate since neither I nor the rest of the Committee - as far as I know - have seen it since.

When the Committee asked about this plan it received only assurances about its informal and unofficial nature, which rather begs the question of why this orphan document was not shown to the Committee - a group unlikely to become hysterical over a hypothetical nuclear weapons accident. The Visiting Ships Panel (Nuclear), which is chaired by the Department of Defence, was the body "unofficially" preparing the plan and it was the Minister for Defence who wrote a letter on 22 December 1988 to the effect that since the document "...was still in the development stage and had no official status, he did not believe that its release to the Committee would serve a useful purpose".[2] We must thus add the Minister for Defence to the list of those who have treated this Senate Committee with disdain. Of course, at the time this plan came to light, the Minister for Defence was making his famous "there will be no accidents" statement in the media. Fortunately, on this occasion, he was right, but having to admit the existence of a "real" nuclear weapons accident plan might have been embarrassing.

(c) The Committee's argument on weapons accidents

The Committee has made an attempt to extend to a weapons accident the "probability x consequence = risk" formula and has backed this up with assertions about naval discipline, magazine safety and the "disarmed" nature of nuclear weapons during port visits. In order to present a "worst-case" argument, the Committee decided to ignore the unfriendly U.S. policy of "neither confirm nor deny" and to assume that

2 Ch.2 note 11; I quote the text of the note, not the letter.

nuclear certified ships are carrying nuclear weapons.[3] However, the indeterminate presence of the weapons acts - as it is meant to do - as a subliminal safety factor.

The argument that leads the Committee to its desired conclusion is contrived. The public record shows two U.S. nuclear weapons accidents on foreign soil that led to widespread plutonium contamination - fortunately in thinly populated areas. Neither of these accidents realized their full potential and both were aircraft accidents but they demonstrate the possible distribution of plutonium by explosion alone (Palomares, Spain) and by explosion and fire (Thule, Greenland).

Despite this evidence - and other lesser examples - the Committee has decided that the manifest accident potential of nuclear weapons can be contained by assurances and safety systems. They found it impossible to imagine a sequence of events that could lead to a "credible" accident and therefore decided that accident planning was unnecessary.

Although AIRAC stated that it believed that control and emergency procedures should be in place for ports visited by nuclear-armed warships, the Report ignores this recommendation and makes a point of stating that AIRAC stressed that it had performed no calculation of the probability of a nuclear weapons accident nor had AIRAC "developed a reference accident".[4] Even the Committee cannot produce "calculations" of any substance on nuclear weapons accident probability and the only overseas figures appear to be a few vague U.S. estimates. One is of the probability of accidental nuclear detonation; less than one in a billion for normal environmental conditions and less

3 Ch.11 para.24.

4 Ch.11 para.3; but notice ch.11 para.13 where the lack of the information necessary to conduct a "rigorous theoretical assessment" is clearly stated.

than one in a million for extreme cases like a fire.[5] There is no indication that these are calculations rather than guesses and the plump roundness of the figures rather suggests the latter.

Although the Report states, in reference to these figures, "Assuming that formal risk assessments have been made...", this proposition is rather contradicted by the footnote to this paragraph (19) which quotes a U.S. Department of Defense expert declaring that the estimate for the accidental detonation of the conventional explosive in an older nuclear weapon was somewhere between 10^{-3} and 10^{-6} (a factor of a thousand); "...we cannot quantify it" he said. As this note states, a nuclear explosion requires the prior explosion of the conventional explosive so we can in fact assume that formal risk assessments have not been made or, if they have, that the results are not available.[6]

Part of the rationale for the different treatment of reactor and weapons accidents is the observation that a reactor is a "dynamic" system and a nuclear weapon is not.[7] This is not entirely fair to nuclear weapons. Mr Beazley told the Committee that the implosion explosive was always assembled with the fissile material in weapons likely to be brought into Australian ports; it is the energy latent in this explosive that provides the most likely immediate cause of widespread radiological contamination.[8] Despite some understatement, even the Report - in the sections dealing

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5 Ch.12 para.13; see also Ch.11 para.51.

6 Ch.12 para.14 and note 19; the claim is made that the probability for the "modern devices...is at least as good as one in a million and maybe better" (my emphasis).

7 Ch.12 para.32.

8 Ch.11 para.64; "...the nuclear material in modern nuclear weapons is kept together with the other nuclear components of the weapon at all times". The Minister for Defence in this passage is confirming, but avoids stating directly, that the explosive and the fissile material are in there together all the time.

with fire and explosion - gives an indication of how serious an accident of this sort could be.[9]

(d) The evidence of Professor W. Jackson Davis

The most comprehensive treatment of the possible consequences of a nuclear weapons accident that was presented to the Committee is contained in a submission by Professor Jackson Davis on behalf of Greenpeace.[10] Prof. Davis models the release of 5kg of plutonium - assumed to be the fissile content of one nuclear weapon - in various Australian ports, under a range of possible enviromental conditions. The Report makes several criticisms of Prof. Davis' submission, some of which are not without substance, but I do not believe that they invalidate his basic proposition.

For instance, Prof. Davis proposes that the total plutonium content of one warhead could be released as a respirable aerosol by a fuel fire with a duration of three hours. Evidence from various experiments - including tests at Maralinga - suggests that distribution from this energy source might be much lower than 100%. A variety of release percentages are cited; 0.1%, 1%, 3% from fire alone, and another set, 1-10% or up to 20% by explosion.[11] I am inclined to accept the percentages for fuel fires, although I believe that release percentages could be higher for other types of fires, especially missile propellant fires. However, the quoted release percentages from detonation of the conventional explosive are contradicted by the evidence from at least one of the accident reports.[12]

9 Ch.12 para.23-28 (explosion) and Ch.12 para.46-53 (fire).

10 Evidence, 27 March 1987, pp.462-500.

11 Ch.12 para.19; Ch.12 para.21 (n.26) for dispersion percentages by fire. Ch.12 para.26-7 (n.34) for dispersion by explosion. See also Evidence, 14 March 1988, pp.723-4 (AIRAC) for a reference to the Maralinga experiments with dispersion by explosive.

12 See section 3(g) below.

The Report also states that "one of the accident scenarios put to the Committee by Professor Jackson Davis rests on the assumption that there would be 100 nuclear weapons on a visiting nuclear weapons capable warship".[13] This is not correct; while he mentions "up to 100 warheads", his scenario rests on the assumption that only one weapon is incinerated.[14] The Committee calculates "an average of less than 4" for ASROC - the most common tactical nuclear missile.[15] And while this is probably correct for many vessels, both nuclear and conventionally powered U.S. aircraft carriers routinely carry up to 100 nuclear weapons. The U.S. Navy has nine such conventionally powered ships that have unrestricted access to Australian ports.[16] The Committee was also unhappy with the sketchy scenario offered by Prof. Davis in which a three-hour fire of unspecified origin releases the plutonium.

It is clear that all these alleged deficiencies are the result of Prof. Davis' concentration upon the consequences of an accident rather than the many possible sequences of events that might lead to an accident. In assuming the dispersal of the contents of one warhead rather than the destruction by fire and explosion of an entire aircraft-carrier load of up to 100 bombs, he is being conservative. And if only one warhead were to be destroyed and a lesser percentage of plutonium released, we could still face severe consequences.

I believe that this focus on results is the correct starting point for an assessment; the U.S. documents certainly

13 Ch.11 para.26.

14 Evidence, 27 March 1987, p.593.

15 Ch.11 para.27; but see note 38 for a discussion of the deployment of Terrier anti-aircraft missiles.

16 J. Handler and W.M. Arkin: Neptune Papers No.2(May 1988), "Nuclear Warships and Naval Nuclear Weapons: A Complete Inventory", p.13, p.43.

emphasise the risk of airborne contamination by plutonium as the most likely serious result of a weapons accident.[17] (U.S. forces have also held regular NUWAX exercises to train personnel in reactions to a nuclear weapon accident; an Australian observer attended the 1981 exercise and the Department of Defence has been briefed on others.) In demanding a rattling good yarn as a prerequisite for a serious examination of weapons accident consequences the Committee is failing in its duty.

Prof. Davis concluded that the range of long-term casualties - as victims of alpha-particle induced cancers - from his hypothetical accidental release of 5 kg of plutonium in Sydney Harbour range from 33 to about 11,000, depending on ambient weather conditions, with possible massive economic and environmental costs.[18] This represents an accident potential that far exceeds any other humanly mediated peacetime disaster. If a fully laden jumbo jet were to crash in a heavily populated part of Sydney - or any other Australian city - we might expect about 1000 deaths, but the major effects would persist for no more than a generation. A large-scale plutonium contamination could turn a large part of an Australian port city into a ghost town and, apart from the more immediate casualties, would present an insidious and worrying health threat for centuries.

(e) Plutonium contamination

The Report does, somewhat obliquely, address the dangers of aerosol forms of plutonium, tending to minimise the possibility of the aerosol form being produced by an accident as well as the dangers to human health.[19] Given

17 Ch.12 para.23 and note 29; Ch.12 para.26 and note 33.

18 Evidence, 27 March 1987, p.489, p.494; note that two different dose factors are also applied.

19 Ch.11 para.35-42; note also the "balancing" statements of note 58.

the Committee's view on the "incredibility" of any accident, this seems an unnecessary excursion.

Fortunately, no large population has yet been exposed to high levels of plutonium contamination - and I hope that an Australian city does not become the laboratory for this experiment - so exact exposure risks remain debatable. But the U.S. authorities - both civil and military - do not regard plutonium contamination lightly; acceptable limits are very low and major efforts have been made to clean up after plutonium releases.[20] Radon gas in both industrial and domestic situations can induce cancers through its "daughter" isotopes in the same way as plutonium; this problem is the focus of continuing concern and study. And the British National Radiological Protection Board is currently trying to establish a study of the distribution of plutonium and americum around British nuclear power plants, suspecting that these elements might provide an explanation for the puzzling clusters of childhood leukemia cases around some of these plants.[21] It is just not accurate to imply that plutonium is a relatively benign substance. It is also widely accepted that the recent data on Hiroshima and Nagasaki will result in a lowering of the radiological exposure reference levels by a factor of about four. These are just some indications of the fact that the malign effects of many radioactive substances are not disappearing as we learn more about them.[22]

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20 For instance, P.R. Ehrlich cites a maximum permissible concentration of plutonium in air of 6×10^{-14} Ci/m^3 and in water 5×10^{-6} Ci/m^3. Since there are 16 grams per curie for plutonium, the figures by mass are 9.6×10^{-13} g/m^3 for air and 8×10^{-5} g/m^3 for water. P.R. Ehrlich, A.H. Ehrlich & J.P. Holdren, "Ecoscience", 1977, W.H. Freeman & Co., San Francisco, p.454.

21 New Scientist, 19 Feb. 1989, p.26.

22 Ch.7 para.112.

(f) The accident at Thule in Greenland

In referring to the accident at Thule in Greenland, where four nuclear devices exploded when a B52 bomber crashed and burned, the Report implies that the accident was relatively harmless in any radiological sense. In chapter 11 the Report says, "A small amount of plutonium became airborne but the total amount of the plutonium dispersed in this way outside the immediate crash site was considered of no biological significance".[23] But it is worth taking a closer look at this accident which is quite thoroughly reported in USAF Nuclear Safety, Jan/Feb/Mar 1970.[24]

A small fire which started in the cabin heating system of the aircraft could not be controlled with the available fire extinguishers. It spread and all electrical power was lost as the aircraft made its approach to the Thule base for an emergency landing. The crew bailed out and the B52 crashed on the sea ice over deep water about 8km from the base. All four unarmed bombs exploded, reducing the airframe to small fragments, and plutonium was blown into the burning fuel. The fuel burnt fiercely and a 7-9kt wind (groundspeed) blew the smoke away from the base and populated areas, mostly out to sea.

Before the clean-up started there were two periods of high winds (one of 12 hours and one of 24 hours duration), with wind speeds of 25kts gusting up to 45kts, further diluting the plutonium spread over the snow and ice.[25] Where the aircraft struck the ice - which was about 1m thick - it was cracked but most of the debris remained on the ice surface or in the layer of snow and ice melted by the fire. This

23 Ch.11 para.104; see also the reference in Ch.11 para.39.
24 USAF Nuclear Safety, Jan/Feb/Mar 1970, Vol.65 (part 2) Special Edition.
25 ibid., p.14.

refroze within minutes of the cessation of the fire and thus immobilized the plutonium oxide particles blown downward by the explosion and caught in water and unburnt fuel.

A major clean-up exercise was instituted, at vast expense. The main phase lasted for two months and 700 people were involved. More than 5.5 million litres of the most heavily contaminated snow and ice (containing about 3kg of plutonium) was removed and shipped back to the United States.[26] Attempts were made to speed up the melting of the rest of the most contaminated ice (containing an estimated 350g of plutonium). No attempt was made to clean up the plutonium contaminated pieces of wreckage that had sunk to the sea floor.

Various surveys were conducted by U.S. and Danish scientists during and after the clean-up. Radio-ecological surveys showed the greatest concentrations of plutonium in bottom-living sea animals (up to 1000 times background levels in bivalves). Levels were significantly raised in many species, including particulate contamination of eider ducks. An examination of dietary and working practices of the native Greenlanders concluded that ingestion and respiratory doses were unlikely to reach the threshold limit.[27] Urine tests on humans were largely negative; early positive tests may have resulted from contamination of the samples. However, plutonium levels were significantly raised up to 20km from the crash site.[28] In this context we should remember that the widespread background plutonium levels are not "natural" - the early atmospheric tests injected about 5 tons of plutonium into the global enviroment. Such testing is now considered A Bad Thing by all parties.

26 ibid., p.38; note also that two trains, one of 66 railroad cars and one of 81 cars was necessary to transport the waste when it arrived in the United States (p.90).
27 ibid., p.74-9.
28 ibid., p.78.

(q) Issues raised by the Thule accident

I mention this accident in some detail partly because it receives little attention in the Report, but also because, as an "achieved" accident it is a valuable precedent.

Firstly, the accident was precipitated by an apparently minor event in a peripheral system. The safety equipment proved to be inadequate and a major system failure followed. I doubt that the Committee would find this scenario "credible".

Secondly, the aircraft carried four nuclear weapons. Although these were fusion weapons, as far as we know the fission components and the quantity of plutonium would be approximately equivalent to four naval nuclear weapons.[29] The fission components - including the explosive - probably belonged to the same design generation as many of the naval weapons aboard visiting warships. Although some safety systems may have been retro-fitted to currently deployed naval weapons, it is believed - as the Report states - that some naval weapons cannot easily be converted to use Insensitive High Explosive.[30]

Thirdly, the aircraft crashed at high speed (estimated at about 500kts) but at a shallow angle, and the explosive in all four bombs detonated - with considerable force. Interestingly, the entire plutonium content appears to have been atomised and oxidised to small particles of plutonium oxide, either by the force of the explosion alone or the combination of the explosion and fire. The plutonium oxide particles had a count median diameter of 2 microns (with a

29 See below n.30.
30 Ch.11 para.55-6 and n.88.

standard deviation of 1.7) and the calculated mass median diameter was reported as 4 microns. Ten microns is considered the upper limit for dangerous respirable particles.[31] There is no mention in the report of large lumps of plutonium. A very high percentage of the plutonium was clearly present at the accident site in the form of a respirable aerosol. I calculate that about 70% of the plutonium was dispersed beyond the clean-up area, most of it as a respirable aerosol.[32]

This accident casts a new light on the section of the Report that stresses the difficulty of producing a plutonium aerosol; it appears that explosion and fire and perhaps explosion itself is capable of reducing a high percentage of a weapon's fissile content into a respirable aerosol. This real-life accident has many of the characteristics of the scenario offered by the AIRAC submission, but with the addition of a fuel fire.[33] The Committee refers in passing to this scenario but avoids an examination of its consequences by failing to find a "credible" context.

The Greenland accident is scarcely the worst that could happen, and several features tended to minimise its effects. The area around the accident site was very thinly populated and at the time of the accident the wind was blowing away

31 USAF Nuclear Safety, vol.65, p.38; see Ch.12 n.32 for a U.S. source for the 10 micron respirable particle limit.

32 ibid.; from a statement on p.40 giving the volume of water required to dilute 350g of plutonium to the maximum permissible level ($5x10^4$ m^3) - which represents a very high level - and a comment on p.20 by the SAC On-Scene Commander, Maj. Gen. R.O. Hunziker, that 1/500th of a cubic kilometre of water would dilute all of the plutonium oxide from all of the weapons to "drinking water standards" (probably the same level), we can calculate that roughly 14kg of fissile material was involved in the accident and that about 10kg must have been dispersed beyond the clean-up area. This estimate is supported by a casual reference to the need to evaluate a possible critical mass accident in storage tanks (p.20). This question would not have arisen if there had been less than about 8kg of plutonium metal present in the four bombs.

33 Ch.12 para.24-5.

from inhabited areas. The fire was brief and fierce, producing a high thermal loft which tended to dilute the plutonium. The environment was seasonally self-cleansing, and the high winds also diluted the contamination. Nevertheless, the decontamination was difficult and clearly very expensive.

(h) Additional information from the Palomares accident

The Palomares accident took place in Spain in 1966. A B52 carrying four fusion bombs collided with a KC-135 tanker during re-fueling. The bombs fell from the aircraft as it disintegrated; three of the bombs deployed their 64ft parachutes as designed, the other may not have. One of the bombs fell into the sea, one fell on land without detonating, one parachute-retarded weapon suffered a partial detonation and the last a much more complete explosion which excavated a crater six feet deep and twenty feet wide. Fragments of the exploded bombs were found some hundreds of yards away and plutonium contamination was obviously widespread, although the records are somewhat sketchy because the equipment used by the clean-up force was inadequate and prone to breakdowns. Vegetable matter and soil from the badly affected areas were shipped to the United States for burial.[34]

Reports of this accident are less comprehensive in many respects than those of the Greenland accident. For instance, I have not found mention of a survey of the particle size of the plutonium contamination, although some indications lead me to believe that it was quite small since some areas were contaminated by the wind resuspending the particles.[35] Reading the report of the clean-up one gathers

34 U.S. Defense Nuclear Agency, Technology and Analysis Directorate, Palomares Summary Report, (DNA, 1975).
35 ibid., p.50.

that although it was extensive - and also clearly a very expensive exercise - some corners were cut. Lightly contaminated land was merely ploughed but the most vivid example concerns some buildings that could not be de-contaminated to an acceptable level with water; they were whitewashed.[36]

(i) Other weapons risks

Accidental nuclear explosion

Some of the submissions by individuals or groups strongly opposed to the visits of nuclear-armed warships have explicitly or implicitly accepted the assurances - reiterated in the Report - that the risk of an accidental nuclear explosion is extremely remote.[37] I have been inclined to accept this myself, with the reservation that naval weapons especially may not be proof against the ingenuity of a mentally disturbed naval officer.

However, the tones of surprised relief in official accident reports make me wonder if we have not been too gullible on this matter. Consider this official comment from the 1975 Palomares Summary Report:

"Small as it is, the probability of a nuclear yield in an accident makes weapon safety the first concern at all levels of military command...It is reassuring that the safety engineering that was employed in the weapons was successful in preventing a nuclear explosion at Palomares and it is important to note that there has never been an accidental nuclear explosion involving United States weapons".[38]

36 ibid., p.60.

37 Ch.12 n.1 for submissions discounting nuclear detonation and Ch.12 para.2-17 for a discussion of nuclear detonation risks.

38 Palomares Summary Report, p.24.

This is scarcely the confident tone of one who knows that an accident to a nuclear weapon cannot produce a nuclear yield - a full or partial nuclear explosion; and I wonder if the development of Insensitive High Explosive was motivated not only by a desire to reduce the probability of an accidental contamination but also to reduce the risk of an accident that could result in at least a partial nuclear yield. This is one obvious area where the military might lie about the real risks. One could speculate about an explosive wavefront impinging simultaneously on two sides of a nuclear warhead, but I don't know whether this could produce a nuclear explosion. Nor does the Committee and we are unlikely to find out.

Explosives on ships

The Committee has alluded to the good magazine safety record of the western navies and even the Falklands War where some damaged ships were saved from total destruction by their fire-fighting systems; of course, some were not.[39] It seems obvious from the Thule and Palomares accidents that full detonation of the explosive in a nuclear weapon would rupture both the magazine and the hull in lightly constructed modern warships.

I notice that the NATO Safety Principles for the Storage of Ammunition and Explosives states that "it is likely that an initial explosion of any significant size will cause the complete loss of the vessel".[40] If a nuclear-capable ship were to suffer a large conventional munitions explosion it seems very likely that the nuclear weapons would also explode. Although this risk may be small, it must be added to the intrinsic risk of the nuclear weapons themselves. Even the best fire-fighting system will not stop an

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39 Ch.11 para.75.

40 NATO Safety Principles for the Storage of Ammunition and Explosives, 1982, part iv, ch.6, para.604.

explosion once it has begun and I have grave doubts about its ability to control propellant fires. There is good reason to believe that nuclear warheads are kept assembled with their missile propellent in the more modern types of magazine. The recent accident on the USS Iowa serves as a reminder that nuclear weapons and nuclear-capable warships are festooned with safety systems not because they are safe, but because they are dangerous.

(j)Weapons accident conclusion

Unlike the Committee, I have little difficulty in imagining a nuclear weapons accident. If a release like that in Greenland were to take place in an Australian port I would not much care what unlikely sequence of events had led to the accident; the results could be terrible. If, for instance, there was a major plutonium contamination in Sydney Harbour not only could many people be exposed to a dangerous and very long-lived radiotoxin, but the commercial life of the city would be brought to a stand-still and harbour-side properties would be going for a song.

The Committee is demonstrably wrong in its assertions about plutonium aerosols, and it is impossible to know what else it is wrong about. I confess to a state of ignorance mixed with foreboding about the probability of a nuclear weapons accident, and I believe that the Committee shares with me at least the ignorance. I do not believe that our allies would provide us with the information necessary to make a realistic assessment, nor would I wish them to. As I observed at the beginning of this section, our Non-Proliferation Treaty commitments oblige us not to seek to acquire this information. To be consistent, however, we should determine not to have anything to do with nuclear weapons, in our harbours or anywhere else.

Finally, in view of the consequences of a full-scale contamination accident, I cannot imagine that the hypothetical VSP(N) Nuclear Weapons Accident Safety Plan could offer a worthwhile defence; nothing short of total exclusion will do.

4. Access, Targets and Dry-docking

(a) The strategic importance of access

The U.S. Navy particularly wishes to keep Australian ports open to its warships, not, I believe, primarily for their rest and recreation facilities, although the well-being of its personnel is an important part of a navy's effectiveness. It is the strategic potential of Australian ports as sources of supply and maintenance that is more important. In a time of crisis many of the rules and "assurances" about U.S. naval practice in Australian ports would be lightly discarded. Not only may we have to suffer the increased risks associated with practices that are currently proscribed during peacetime "goodwill" visits, but, because of our undiscriminating acceptance of nuclear-powered and nuclear-armed warships, we may also suffer war damage associated with these vessels even if the U.S. is engaged in a war of which our Government disapproves.

(b) Conventional targeting of nuclear warships

One risk is that of nuclear-powered and nuclear-armed warships being struck by conventional missiles. If the U.S. Navy's plan to fight a conventional war at sea is realised (see below), then Australian ports may be exposed to the risk of nuclear accidents resulting from conventional missile strikes. The Australian ports most likely to suffer from a conventional missile striking a nuclear vessel would be Western Australian ports already receiving large flotillas of U.S. warships that would present particularly attractive targets for an enemy.

The possibility of collateral damage from conventional missiles was raised in an article in "The Australian", where the plan to locate a petrochemical plant next to HMAS

Stirling was mentioned.[1] During a recent visit to Australia, Professor K. Subramanyan, former director of India's Institute for Defence Studies and Analysis, referred to the danger to coastal installations from missiles that have ranges of up to several hundred kilometres.

It is not only a war with the U.S.S.R. that could expose nuclear warships to attack. India is expanding its navy, leases one nuclear-powered cruise-missile submarine from the U.S.S.R. and probably plans to deploy more of them, and sees itself as an emerging great power.[2] U.S. support for Pakistan led the U.S. Navy to threaten India in 1971 by sailing the USS Enterprise into the Bay of Bengal during the conflict that led to the creation of Bangladesh. This made a deep impression upon Indian strategic theorists and they plan to be ready if the U.S. tries this again. India has dual-capable long-range missiles for its nuclear-powered cruise-missile submarine, and U.S. fleet concentrations on Australia's west coast would be a natural target. A conventional missile strike on a nuclear-powered vessel could clearly cause an uncontained reactor accident. Similarly, a strike on a nuclear-armed vessel could produce a major plutonium contamination.

(c) Nuclear targeting of U.S. warships

Only very odd people like to think about nuclear war. Most of them are nuclear strategic theorists, the people who invented concepts like "mutual assured destruction". Members of the Committee are not odd in this way, although it could be argued that some unpleasant exercise of the

1 The Australian, 22-3 April 1989, p.24.

2 See Dr M. McKinley,"At Anarchy's Rim: Australia and the Indian Ocean", a paper delivered at the Bicentennial Conference ANU, December 1988, p.25 for a forecast that India will aquire six nuclear-powered submarines. See pp.22-26 for a discussion of Indian military expansion, especially naval expansion.

imagination is part of their job. Nuclear targeting did come up during the presentation of evidence by Professor Jackson Davis, when there was a rather heated exchange that wandered over whether nuclear-capable U.S. warships would be targets for nuclear weapons, as well as "theatre" nuclear wars and the "nuclear winter" theory (see Appendix 2b). Senators Hamer and Sir John Carrick entered freely into this discussion and offered some pungent opinions, despite the terms of reference, so I feel I have a special licence to mention nuclear targeting.

On this occasion, Senators Hamer and Sir John Carrick refused to take seriously the possibility of nuclear targeting of visiting warships in a "theatre" or "limited war" - which makes me wonder if they were vocationally suited to a committee considering the accident risks presented by vessels largely designed for that very purpose.[3] However, the latest U.S. Navy plan (Sea Plan 2000) to fight a nuclear-armed enemy with nuclear-armed warships but using only conventional weapons is only another variant of a "limited war" theory that could - if it is ever put into effect - run out of control and bring nuclear missiles down into Australian ports. Again, the target ports are most likely to be the recipients of large numbers of U.S. warship visits. Although analysis shows that the U.S.S.R. has a large surplus of missiles available it is impossible to prove that our ports are targeted, just as it is also impossible to prove that the "Joint Facilities" are targets. Yet our Government has conceded that the latter are likely targets by preparing contingency plans for a nuclear attack.

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3 Evidence, 27 March 1987; Senator Hamer stated that targeting of allied nuclear-capable vessels in Australian ports was "very improbable speculation" (p.586), and Senator Sir John Carrick refused to consider the concept of theatre or limited war valid in a Pacific context (pp.584-9). Note a reference in the Report to "theatre nuclear weapons" on warships visiting Australia, Ch.11 para.22.

(d) Dry-docking nuclear-armed ships

Australia's official position on the repair and dry-docking of nuclear-armed ships is ambiguous. The incumbent Minister for Defence appears to be ready to compromise the Government's policy and at least the spirit of its treaty obligations (under the South Pacific Nuclear Free Zone Treaty) for the convenience of our allies.[4] In a recent letter to the Committee (11 April 1989) the Minister claims that dry-docking of nuclear-armed warships does not constitute the stationing of a nuclear device and therefore does not violate the provisions of the Treaty.[5] If Mr Beazley is right it is because Australia conspired to dilute this Treaty to the point where Mr Spender - if he ever becomes Minister for Defence - could effect his projected deployment of "allied" nuclear weapons without withdrawing from the Treaty by christening his missile sites "HMAS Dry-dock".

The dry-docking issue has arisen with warships of the Royal Navy, but the apparent refusal to dry-dock the HMS Invincible attracted the unconcealed wrath of the United States. As a subordinate ally of the U.S. the Royal Navy is obliged to play the "neither confirm nor deny" game with its NATO-integrated nuclear weapons and it is unclear exactly why the Australian Government was reluctant to offer dry-docking facilities. I had hoped that the Government was motivated by a reluctance to involve Australia any more intimately with nuclear weapons.[6] However, the abandonment of principle and the emphasis upon pragmatism that is

4 See HR Hansard, 8 December 1983, p.3515: Mr Gordon Scholes; "We are totally opposed to nuclear weapons being on Australian soil, and that is a policy we will not depart from".

5 Letter from the Minister for Defence, 11 April 1989.

6 See Senator David Hamer's "Additional Statement", Report p.219 for another explanation.

evident in current Government policy decisions suggests that nuclear-capable vessels will be dry-docked in Australia in the future.

In 1983 Senator Gareth Evans - as Attorney-General - made a lengthy statement in Parliament and said that there was no established policy in place to cover dry-docking situations for "non-conventional weapons", guidelines ought to be established, discussions had taken place at a ministerial level and further discussions would take place at an official level. Senator Evans said that guidelines would be available in months rather than days or weeks.[7] Years later, there is still no declared and justified policy, but the current Minister for Defence is clearly willing to dry-dock nuclear weapons capable vessels, without de-ammunitioning, for "external repairs". He speaks of possible "de-ammunitioning ...(perhaps at sea to a sister ship)" as a way of saving our allies from having to declare the nature of the armaments aboard a more seriously damaged ship.[8]

What will happen in a real emergency will be another matter altogether.

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7 The Senate, 15 December 1983.
8 Ch.11 para.84-5.

5. Conclusion and Recommendations

The United States has assured us that special safety plans are not necessary for visits by either nuclear-powered or nuclear-armed warships; as a matter of policy it refuses to comment upon plans produced in defiance of this advice. This Senate Committee has implicitly rejected this advice from our ally but has conducted this enquiry without the will or the political freedom to do more than apply a rubber-stamp to the existing arrangements.

Military secrecy has proved to be an insuperable obstacle for this enquiry. Many important facts and details have been withheld from the Committee and although an absence of information on a certain point might be noticeable we cannot know what this means. However, it is the military features of naval reactors which compromise safety that are most likely to be secret.

The Committee's naval reactor argument is replete with technical terms, large figures and ingenious calculations. A close examination reveals these to be mostly guesses and unverifiable assertions.

The Committee correctly confesses to ignorance about many aspects of nuclear weapons. Despite this, the Committee concludes that all the nuclear weapon accident hypotheses presented in submissions are "incredible" and that no accident contingency planning is necessary. Nevertheless, it also suggests that an embryonic Department of Defence nuclear weapon accident contingency plan should be completed. If a nuclear weapon accident in an Australian port really is incredible then completion of this plan would be a waste of public resources.

Throughout the Report accident consequences are minimised. Not only does the Committee avoid examining the worst-case consequences of nuclear weapon accidents, it also avoids assessing the possible long-term effects of contaminating accidents involving either nuclear weapons or nuclear reactors.

This Report has failed to establish the necessary technical base for the formulation of safety plans and has revealed the inadequacy of the existing plans. Despite its length and complexity the Report is only a thin shadow of the report that would be commissioned by a Parliament truly concerned about the exposure of the country's citizens to nuclear risks. Such a report could not be begun without the wholehearted cooperation of the nations designing and deploying the nuclear reactors and nuclear weapons.

I therefore RECOMMEND that all nuclear-powered warships be excluded from Australian ports until a thorough safety analysis confirms a level of safety acceptable to the Australian people.

I further RECOMMEND that all nuclear weapons be excluded from Australian ports and that only warships recognised by independent international authorities as not nuclear capable should be invited to enter Australian ports.

DISSENT BY SENATOR DUNN

APPENDICES

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(Evidence, p. 247)

AAEC SUBMISSION TO THE SENATE STANDING COMMITTEE ON FOREIGN AFFAIRS AND DEFENCE *ATTACHMENT 1*

CONSIDERATION OF ACCIDENTS TO NUCLEAR POWERED WARSHIPS

Background

Despite the excellent safety record and the high degree of protection inherent in the design and quality of nuclear propulsion plant, the remote possibility of an accident causing the release of radioactive material cannot be ignored. In the interests of public safety it is prudent to consider the consequences of hypothetical accidents and to make emergency arrangements to protect the public.

2. It is physically impossible for any reactor accident to result in an atomic bomb type explosion. However, it is nevertheless conceivable that serious accidents could result from component failures, material faults, design weaknesses, human errors or deliberate human acts.

3. The AAEC approach to this problem has been to review the various possible accident mechanisms, discarding those which it is considered could result only in trivial activity releases and those with probabilities so low as to be considered incredible (ie, of no practical significance). This procedure identifies a range of credible and significant accidents, and in the particular case of warship reactor systems, leads to a single Reference Accident (contained loss of coolant - see paragraph 11) which is considered to represent an upper limit of risk in terms of its probability and consequence. This Reference Accident, is used as the basis for judging the acceptability of berths and also for planning emergency procedures. The emergency planning does not take account of accidents judged to be incredible (e.g. uncontained loss of coolant accidents).

4. Quantitatively, this procedure is tantamount to evaluating for each hypothetical accident a Mean Annual Severity (defined as the product of the estimated release of iodine-131 to the atmosphere and the estimated annual frequency of this release) as a measure of risk which is based upon probabilistic grounds.

Contained Reactor Accidents

Reactivity Accidents and Start-Up Faults

5. Naval PWRs are heavily undermoderated with close thermal coupling between fuel and moderator, and therefore possess strongly negative and rapid reactivity feedback characteristics. Hence, perturbations in both coolant temperatures and power level are strongly self-correcting. This has been substantiated by published results of the SPERT (Special Power Excursion Reactor Test) experiments in which severe reactivity transients were induced in highly enriched, water moderated cores.

6. Accidents involving the uncontrolled addition of reactivity at any credible rate (for example, as a result of a fault during the withdrawal of the control rods) would therefore be terminated

by this self-regulating characteristic of the reactor before the energy release was sufficient to cause primary circuit rupture. The maximum rate of reactivity addition is limited by design to comply with well known international standards such as the IEEE (Institute of Electrical and Electronic Engineers) Standards endorsed by both the USNRC and US Navy. In addition, the protective system is designed to monitor for such faults and shut the reactor down. However, in the unlikely event of a failure in the protective system coincidental with the fault in the control system the power transient could be sufficient to cause some minor damage to the fuel in the form of local hot spots. From estimates made for similar reactor systems by the Safety and Reliability Directorate of the United Kingdom Atomic Energy Authority (UKAEA), based on analysis of component failure statistics, it has been concluded that the frequency of this combined failure would be less than 10^{-4} per reactor-year. Trivial quantities of volatile fission products would be released into the primary coolant. However, these fission products would normally be contained within the primary circuit and could only be released if a direct path existed from the primary circuit to the environment. This would require, for example, a simultaneous leakage in a heat exchanger and the condenser, the probability of which in a naval installation would be extremely small and would in any case have to be coupled with the unlikelihood of the initial fault, i.e. four unrelated faults each of low probability would be necessary to incur a release to the sea.

7. The possibility of a reactivity excursion of a similar type to that which caused the destruction of the small experimental SL-1 boiling water reactor in 1961 at the then USAEC's Idaho National Reactor Testing Station can be discounted since:

(a) For all conditions relevant to operation in Australian ports the rates or reactivity addition would be limited by the maximum control rod withdrawal rate and by the design of the plant to rates which are orders of magnitude slower than that necessary for an SL-1 type accident.

(b) The Naval reactors are operated by disciplined crews complying with detailed operating manuals. In addition, assurances have been given that no maintenance will be carried out in Australian ports. These considerations preclude the possibility of the situation which led to the SL-1 accident, which occurred during manual reassembly of the central control rod following an extensive maintenance and plant modification program. The reactor, including its protective system, was not fully commissioned during this operation and there was disregard of essential maintenance instructions. Similar maintenance operations to those carried out on the SL-1 reactor at the time of the accident could in any case only be undertaken in special home bases possessing the necessary staff and facilities.

8. It is also relevant to note that in the SL-1 accident the relatively flimsy reactor building was not breached and there is therefore no reason to suppose that the stronger containment of a warship reactor would be damaged in any reactivity accident.

Loss of Power Supplies

9. Naval PWRs, like all other reactor systems, are designed to fail safe in the event of a complete loss of supporting electrical power supplies in accordance with standard practice such as the IEEE Standards. Decay heat would be rejected to a sea-water cooler by means of natural circulation.

Fuel Handling Accidents

10. The conditions of entry into an Australian port will not permit fuel handling. Furthermore, such operations are impossible in Australian port since they would require facilities which are available only at specially equipped dockyards.

Contained Loss of Coolant Accidents

11. Failure of the primary circuit piping causing a range of leak rates of reactor coolant in excess of the make-up capacity is considered credible. This might cause overheating and possibly melting of the reactor core. Fission products would be released into the containment and under the driving force of the high pressure, escaped coolant would slowly leak into the atmosphere until the pressure in the containment was again reduced to atmospheric.

12. The most likely cause of serious reactor coolant leakage would be a failure of pipework. In approximately 2 x 10^3 reactor-years of nuclear operating experience there has never been an accident of this type in a light water power reactor system. Nevertheless, experience of pressure plant in non-nuclear industry has shown that pipework failures can occur in plant designed to Class 1 standards[(1)]. Most recorded failures are minor leaks, incipient defects detected by inspection and failures under test. Also on record are some major in-service failures of conventional plant which in a nuclear reactor might conceivably have led to fuel damage.

13. Conventional plant standards are lower than are acceptable for light water nuclear plant for which the former USAEC published special requirements[(2)]. Therefore, in applying conventional plant failure statistics to nuclear plant, consideration must be given to these differences and there is no doubt that many of the recorded failures would not have occurred in nuclear plant because of higher standards of design, fabrication, inspection and operational control. From a survey

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(1) Gibbons, W.S. and Hackney, B.D. - Survey of Piping Failures for the Reactor Coolant Pipe Rupture Study - GEAP-4574(1964).

(2) USAEC Division of Reactor Development and Technology. Requirements for Nuclear Components. (Supplement to ASME Boiler & Pressure Vessel Code, Section III). - RDT E 15-2T (1971).

of the most relevant experience in conventional plant it has been deduced that the frequency of serious in-service pipework failure, including marine boiler failures, has been in the range 10^{-6} - 10^{-7} failures per ft. per year[1]. In a naval PWR there would be of the order of 100ft. of relevant pipework. Hence the estimated frequency of a serious pipe failure is less than 10^{-4} per reactor per year which is consistent with the figure used in the British assessments relating to their own nuclear warships.

14. For the worst case of a full core meltdown which might be associated with a pipe failure of the type discussed above, the AAEC has assumed that a release of the order of 50% of the iodine-131 in the core is credible and has estimated that approximately a thousand curies of this iodine-131 could leak from the containment to the atmosphere over the period of 12 hours or so. This is also comparable with British estimates. Hence, this accident is estimated to lead to a Mean Annual Severity less than $10^{-4} \times 10^{3} = 10^{-1}$ curies of iodine-131 per reactor per year. This must be regarded as an upper limit of risk in view of the higher standards of design and construction of nuclear plant.

The Possibility of Uncontained Accidents

15. The loss of coolant accident described above represents the maximum credible release of fission products from the core. Any release into the atmosphere beyond that associated with this accident must involve either coincidental failure or sub-standard performance of the containment.

16. In accordance with the general conditions of entry, there will be no intentional breach of the reactor containment in Australian ports. Therefore, the only possible cause of an uncontained airborne release of fission products would be from accidents with simultaneous rupture of both the primary circuit and containment. Such an accident could be caused by a high speed ship collision considered in paragraphs 20 to 22 or by certain conceivable reactor accidents which are discussed below.

17. It could be postulated that a gross failure of the pressure vessel might cause fragmentation of sufficient energy to rupture the containment, thus leading to an uncontained release of fission products. This suggestion has been examined by the AAEC, which has concluded (in common with most overseas reactor safety opinion) that its probability is so low that it can be considered incredible. Therefore no account has been taken of this accident for purposes of port assessment or planning emergency procedures. The basic arguments in support of this conclusion are given in paragraphs 23 to 30.

18. A nuclear reactivity excursion generating shock waves or a high release of energy sufficient to damage the containment is not possible under any circumstances, because of the inherent safety characteristics and design features of the pressurised water reactors used for naval propulsion. However, there are various conceivable mechanisms for failure or partial failure of the containment coincidental with a reactor accident as follows:

(Evidence, p. 251)

(a) deterioration of leak-tightness of containment in service;

(b) generation of shock waves other than by nuclear excursions;

(c) formation of missiles other than fragments of the reactor pressure vessel;

(d) uncontrolled overheating of the reactor fuel·

19. In assessing the risk from these accidents, it is necessary to consider both the probability of the events and their consequences.

High Speed Collisions

20. Nuclear powered ships are subjected to marine hazards such as collision, grounding and sinking which might damage the reactor plant. In particular, it is conceivable that the reactor, its protective systems and its containment could all be damaged in a major ship collision in the approaches to a harbour. Ports in densely populated regions and their approaches are the areas where marine accidents are most likely. For example, an analysis of ship collisions from Lloyds' Register, involving ships over 7,000 tons, shows that about 30% occur in rivers and harbours and more than 50% in coastal waters. Only about 10% occur on the high seas over 25 miles from the coast. In spite of improvement in navigational aids, the annual rates of marine accidents of all types remain about the same. In an average of at least 2 collisions per annum there would have been a significant risk of damage to a reactor installation if the struck ship had been nuclear powered. However, collisions of this severity are highly unlikely in a port because ship speeds are low. They are more likely in the port approaches where ships converge and speeds are higher. The probability of such collisions would be lower in Australian port approaches than in crowded European ports because of the smaller volume of sea traffic.

21. A collision of sufficient severity to breach the reactor of a submarine would almost certainly sink the vessel since the hull and reactor compartment would also have to be breached. Fission products would then be released to the sea rather than to the air, with a correspondingly much lower risk to the population. A surface warship on the other hand would be less certain to sink if involved in a high speed collision. A substantial release of fission products to the atmosphere over a short period of time is therefore a possibility posing a serious hazard to any nearby centre of population.

22. Despite the very low probability of high speed collisions, controls must be exercised (even in the case of submarines) to prevent this type of accident in view of the potential severity of the consequences. The movement of nuclear warships into

ports and harbours should only be permitted during daylight hours with good visibility and other favourable weather conditions, and controls on the speed and movement of shipping to prevent high speed collisions in the vicinity of the coastal towns. It is considered that these precautions, which are subject to Australian control, will reduce to an acceptably low level the risk to the population from marine accidents in the harbour and port approaches.

Failure of the Reactor Pressure Vessel

23. The AAEC is not aware of any case of a pressurised water reactor vessel having failed in service in any mode. From published world sources, including both military and civilian reactors, it is estimated that there are about 2×10^3 reactor pressure vessel-years of experience with no record of a loss of coolant accident from failure of either a pressure vessel or pipework. However, at this stage, the available statistics are inadequate to demonstrate unequivocally whether or not the extremely exacting reliability requirements for reactor pressure vessels have been met, although the evidence to date is clearly encouraging.

24. An upper limit to the failure rate for reactor pressure vessels can be inferred from a study of the failure rate of conventional pressure vessels designed and built to Class 1 Standards[3]. There are a few recorded instances of gross failure of conventional Class 1 pressure vessels undergoing pre-acceptance tests.

25. According to British and German experience[4][5] the frequency of gross in-service failures in conventional Class 1 vessels necessitating major repairs has been of the order of 10^{-5} per pressure vessel-year. This figure is representative of the reliability currently being achieved in conventional pressure vessel practice. Because nuclear pressure vessels are subject to more exacting standards of design, fabrication and inspection (for example, the pre-service testing cost for a nuclear vessel is 10%-20% of the total fabrication cost compared with 0.5% for conventional boiler steam drums[6]) their reliability is certainly higher than conventional pressure vessels. On this basis, it is concluded that the failure frequency for reactor pressure vessels is certainly much less than 10^{-5} per pressure vessel-year.

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(3) & (4) Philips, C.A. and Warwick, R.G. A Survey of Defects in Pressure Vessels Built in High Standards of Construction and its Relevance to Nuclear Primary Circuit Envelopes. AHSD(S) R162 (1968).

(5) Kellerman, O. and Seipel, H.G. Analysis of the Improvement in Safety Obtained by a Containment and by Other Safety Devices for Water Cooled Reactors. IAEA SM-89/8 (Vienna 1967).

(6) I. Mech. E. Periodic Inspections of Pressure Vessels. London (1972), pp 24 and 140.

26. The embrittlement of steel by neutron irradiation introduces a factor which is not encountered in conventional practice, but this effect is now well understood as a result of comprehensive research and development work. The precautions against embrittlement incorporated in both the design and operating procedures of reactor pressure vessels are considered adequate to protect against this type of failure. The main safeguard against irradiation effects is the operational requirement defined in all the USNRC's published Standards and Regulations on pressure vessels, viz. that metal temperatures must be maintained at a safe margin (60°F) above the highest nil-dictility transition temperature when the vessel is under stress. The USNRC further states that this margin must be maintained under all possible conditions of stress, such as normal operation, maintenance, testing and postulated accident conditions.

27. The foregoing assessment of the reliability of reactor pressure vessels is supported by analyses based on the techniques commonly used in relability engineering for synthesizing the overall failure rate of a system by consideration of the component parts which contribute to this overall failure rate. These analyses use direct statistical evidence or, where this is not available, informed judgements. The technique has been used with marked success by the aerospace industries, and has recently been applied by O'Neil and Jordan of the UKAEA's Safety and Reliability Directorate to estimate the reliability of nuclear pressure vessels(7). The probability of failure occurring between service inspections was determined from a series of nine factors, each of which had ascribed to it a failure probability. These factors included failure of the pressure test to reveal faults, failure of the non-destructive testing programme to reveal faults, failure of visual examination, failure to "leak before break", failure in design, material and construction. It was concluded from this study that with only modest assumptions on the reliability of the various validation processes a failure rate of less than 8×10^{-7} per vessel-year could be demonstrated. This conclusion is in agreement with an earlier German estimate(8) and with the findings of the US Advisory Committee on Reactor Safeguards and the US Reactor Safety Study(9) that the frequency of failure of nuclear vessels was at least one order of magnitude less than that of conventional vessels, i.e. the frequency of failure of nuclear vessels was of the order of 10^{-6} per vessel-year or less.

28. These estimates of failure frequencies do not apply to the extreme case of catastrophic fragmentation capable of causing a simultaneous breach of the containment and an uncontained release

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(7) I. Mech. E. - Periodic Inspections of Pressure Vessels. London (1972), pp 24 and 140.

(8) Kellerman, O. and Seipel, H.G. - Analysis of the Improvement in Safety Obtained by a Containment and by Other Safety Devices for Water Cooled Reactors. IAEA SM-89/8 (Vienna 1967).

(9) Reactor Safety Study - An Assessment of Accident Risks in US Commercial Nuclear Power Plants. US Nuclear Regulatory Commission - WASH - 1400 (Oct 1975), page V-45.

of fission products. Such failure simply have not occurred either in conventional or in nuclear plant. Taking the failure frequency of reactor pressure vessels as being of the order of 10^{-6} and making the conservative assumption that 10% of all gross failures of vessels will be of this type then the frequency of such accidents would be of the order of 10^{-7} per vessel-year. Such probabilities are so low as to be of no practical significance, and the application of appropriate controls in the design, fabrication, operation and inspection of plant gives acceptable assurance against this type of failure.

29. The AAEC is satisfied that this judgement is applicable to naval reactors. In fact, there is little doubt that the degree of reliability in naval reactor pressure vessels is higher than in civilian reactors, e.g.:

(a) The quality assurance programmes for naval reactor machinery, including pressure vessels, are extremely demanding and of a higher standard than civil power reactors (confirmed by the UKAEA and USNRC).

(b) The design bases for the pressure vessels of the US nuclear warships reveal a design standard more rigorous than the ASME[10]. Code for nuclear pressure vessels (the civilian code).

(c) The United States Naval Materials Research Laboratories in Washington is considered to be the leading research laboratory on nuclear pressure vessel technology. Leading world authorities in the field of fracture mechanics and the effects of neutron irradiation work in this laboratory (e.g. Pellini).

30. Published estimates of the proportion of the total iodine inventory which might be released into the atmosphere as a result of an uncontained accident of the type described are generally of the order of 10% (about 10^5 curies). With an estimated frequency of the event of the order of 10^{-7} per year the associated Mean Annual Severity is of the order of 10^{-2} curies per year, i.e. less than that from the contained loss of coolant accident. This is considered to be an upper level figure for nuclear warships because the iodine inventory is unlikely to be as high as the full power equilibrium level. Uncontained accidental releases are accordingly discounted and no account is taken of them in planning emergency procedures.

Deterioration of Containment in Service

31. The main guarantee of containment integrity is provided by periodic leak tests given to all compartments within the hulls of all submarines (conventional and nuclear). These tests normally consist in the application of positive and negative pressure differentials, to detect changes in leakage characteristics, accompanied by a vessel inspection for damage, corrosion, deterioration of seals, etc.

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(10) American Society of Mechanical Engineers.

32. A full pressure leak test and strength test is made on the containment during construction. After refuelling, which involves opening and resealing the containment, a further pressure and leak test is carried out.

33. Leakage of radioactivity from the containment bulkheads would be further contained by other compartments within the ship's structure. Any loss of integrity of the hull in normal operation would result in the leakage of sea water and would therefore be noticed and repaired. Furthermore, nuclear submarine hulls are inspected periodically for any indications of physical deterioration.

34. The assumptions made in the analysis of the Reference Accident include an allowance for a 50% deterioration in leak rate over the design specification, although experience has shown that measured leak rates are actually much less than that specified. There is further conservatism introduced into the Reference Accident analysis by the assumption of a constant leak rate over the course of the accident whereas the leak rate will fall by a factor of approximately 10 during the period of the first 24 hours due to the reduction in pressure inside the containment. Since the leakage will be associated with penetrations it will be into the secondary compartments surrounding the containment. As already mentioned, no allowance has been made for the leak tightness of these compartments in the analysis. Hence, overall the conservative assumptions made in the Reference Accident compounded together overestimate the likely leak rate to the atmosphere by a considerable margin.

35. Containment integrity could also be compromised by the unauthorised opening of airlocks through major administrative violation of interlocks and operational controls. During operation of a nuclear warships at sea or in port, violation of containment by action or omission would be contrary to regulations and a breach of discipline. Violation of operational procedures is therefore regarded as improvable in the context of naval operations. Even assuming pessimistically the occurrence of a major violation of containment once a year for a period of an hour, the probability of being in this condition at the time of an unrelated loss of coolant accident is approximately 10^{-4}. It has previously been shown that the frequency of a serious loss of coolant accident can be estimated as less than 10^{-4} per year, and the frequency of this accident with coincidental violation of containment integrity is therefore less than $10^{-4} \times 10^{-4} = 10^{-8}$ per reactor per year. The upper limit of possible release of iodine-131 would be of the order of 10^5 curies. Hence the Mean Annual Severity of the accident is less than $10^{-8} \times 10^5 = 10^{-3}$ curies per reactor per year. This compares with 10^{-1} curies per reactor per year for a contained loss of coolant accident and supports the decision to use the latter accident as the Reference Accident representing the greater risk to the community.

Shock Waves

36. The containment of nuclear warships is designed for the pressure generated by the full release of all energy and contents from the primary circuit, with the addition of heat energy from

chemical reactions involving the fuel and structural materials of the reactor core which would reach high temperatures as a result of the accident.

37. If the forces were applied suddenly the structure would be exposed to a shock loading which might exceed its yield strength. Potential sources of shock wave generations must therefore be considered in order to ensure adequate factors of safety in the design of the structure.

38. The only conceivable mechanism of a significant shock wave due to the release of primary circuit coolant would be the gross bittle failure of the reactor pressure vessel or a heat exchanger. Even this could not cause the complete, instantaneous release of all primary coolant. In view of the quality assurance provisions against brittle failure, and other factors discussed elsewhere, this mode of shock wave generation is considered incredible. Failure of pipework would cause only an insignificant shock wave followed by the blow-down of the primary circuit over a period of at least 5 seconds.

39. In the most serious loss of coolant accident the reaction of the metallic cladding of the most highly rated fuel elements with steam would commence within a minute, due to over-heating of the fuel, but would then continue progressively over a period of uncertain duration. The metal-water reaction produces hydrogen which might subsequently react with air already present in the containment. This problem has been examined for civil power reactors by Moore and Gilby of the UKAEA(11). The actual volumes and quantities relevant to a naval reactor installation are not known for certain. However, from Moore and Gilby's study it appears most unlikely that the composition of the mixture could be within the flammability limit immediately following the accident, and detonation of gases in the free space of the containment is inconceivable. A locally high concentration of hydrogen could only occur in the immediate vicinity of the metal-water reaction, i.e. within the pressure vessel. Engineering tests within the UK naval reactor development programme have shown that shock waves generated by an explosion within the pressure vessel would become attenuated so as not to endanger the containment.

Missiles

40. The primary circuit provides a source of compressible fluid at 2000 p.s.i. If the extreme view were taken that this pressure could be applied to any fragment of the primary circuit or piece of machinery within the containment so as to accelerate it through the distance between its normal location and the containment boundary, then the formation of missiles capable of damaging the containment is conceivable. However, it would not be possible to identify actual physical sequences which could have this effect in a practical reactor installation.

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(11) Moore, J.G. and Gilby, E.V. A review of the Problems due to the Combustion of Hydrogen in a Water Reactor Containment. (AHSB(S) R101 (1966)).

41. The possibility of missile formation is recognised in reactor technology and is prevented by design, layout and quality assurance. Quality assurance provisions have been discussed above, and the techniques of prevention by design and layout can be studied in the documentation of any licensed nuclear power station, e.g. potential missiles associated with the primary circuit are firmly anchored, unrestrained pipe runs are too stiff to move more than a few inchea even in the event of a guillotine failure.

42. It should be noted that primary circuit pumps in a naval reactor are of the canned rotor type with low inertia and would not therefore constitute a significant source of missiles due to rotational energy.

43. It should also be noted that most modes and locations of primary circuit failure would not have the extreme consequence of full core melt down. The Mean Annual Severity of these accidents would therefore be reduced by the low release of radioactivity as well as the remote probability of missile formation.

Breach of Containment by Molten Fuel

44. In a nuclear submarine the containment boundary is formed by the ship's hull. Molten fuel could only reach the inner surface of the hull after melting through the reactor pressure vessel. However, release of gaseous and volatile fission products from the molten fuel would reduce the decay heat power to a level where melt-through appears to be impossible. Even if it is assumed that there is no such reduction in decay heat power in the molten fuel (which is physically impossible) it would require some 3 to 4 hours before the molten fuel would melt through the pressure vessel. At this time the fission product heating is about one-third of a megawatt and it would be readily dissipated through the hull to the sea water. It is therefore concluded that melt-through of the hull will not occur. In a nuclear surface ship the containment may be inside the hull and not in contact with the sea water. However, the hull could be fully sealed in the time available, before any possible melt-through of the containment and would then form an additional barrier to the release of fission products.

The Reference Accident

45. The AAEC's assessments of the suitability of berths and anchorages take into account the detriment to public health that might be incurred, and the feasibility of appropriate emergency procedures to protect the public, in the event of a Reference Accident in a nuclear powered warship during its visit. A Reference Accident is defined as failure of the reactor primary coolant circuit resulting in a full meltdown of the core and the release of gaseous and volatile fission products to the reactor containment. A slow leakage of the fission products to the environment would follow. It is believed that the Reference Accident represents a realistic upper limit of radiological risk to the public.

APPENDIX 2A TO SENATOR DUNN'S DISSENT

(Evidence, p. 658)

SENATE STANDING CTEE ON FOREIGN AFFAIRS & DEFENCE 14 May 1987

ACTING CHAIRMAN - I now invite you to speak on the document circulated to the Committee and at the conclusion of your remarks I shall invite members of the Committee to submit questions to you.

Mr Speed - I wonder whether it would be appropriate for me to give some background to my involvement in this area, because it may be useful to relate some of my answers to it later. I first got involved in this area about 11 years ago, in 1976, when the Fox commission was taking evidence, there was a lot of discussion about the risk of nuclear reactors around the world, and that was being considered in relation to Australia's possible decision to mine and export uranium. Around that time, representatives of the Australian Atomic Energy Commission were publicly citing results from this document, the 'Reactor Safety Study', which I have referred to as reference 1 in my paper. As a statistician, when I heard some of these statements I became sceptical and suspicious. I became interested enough to see what lay behind them. I sought a copy of the 'Reactor Safety Study' and obtained one with the co-operation of the AAEC. Over a period of some months I read it fairly carefully and wrote a critical review of it. I discussed this widely with professional colleagues in Australia and eventually wrote a paper on this, which I will mention later.

In 1978, a couple of years later, I had sabbatical leave and went to Scandinavia, to the United Kingdom and to the United States. During that time I gave a lot of talks and had a lot of discussions about the issue of reactor safety with statisticians or people from the nuclear industry. At around that time the review group of the Rasmussen committee - which I also refer to in my document - was sitting. I submitted my paper to them and I understood that it was considered a worthwhile contribution. I was pleased to find the broad recommendations of the Rasmussen report - which is also the 'Reactor Safety Study' - broadly agreed with my analysis; that is to say that, roughly speaking, the figures themselves were of very limited value for assessing the risks, or as I have stated in my document that they are unable to say whether they were too high or too low but they were sure that any accuracy that was attributed to them was understated.

As I said, I spoke widely on this and visited places like the Nuclear Regulatory Commission in the United States, spoke with statisticians there, got a reasonable background and got what I felt was a lot of support for my views. That, roughly, is where it sat until about three or four years ago and the events leading up to this other document that I have referred to, written by myself, the one relating to the Sizewell inquiry. I was asked to comment on the proposed Sizewell reactor probabilistic safety study. I did that, and the main conclusions there are in a published paper which I have referred to. Since then I have had a bit of experience as an expert witness and as a consultant in the general area of risk analysis. More recently, I was asked to put my views on this topic, and that resulted in my submission.

In summary, I would like to reiterate the opening paragraph of my document. I believe the task of this Committee is to address the following: What could go wrong with a nuclear powered vessel in a port or in a sea around Australia; how likely are any of the things that could go wrong to go wrong; and, finally, if these things go wrong, what are the likely consequences? As I have said in my document, I do not find the advice, the background to the Atomic Energy Commission's recommendations, satisfactory for a number of reasons, which I am sure we will be going into in discussion. In particular I am not impressed by the way in which it has focused on the so-called reference accident. In 1976, in its earlier document, it was called a maximum credible accident, and the same accident in 1986 or 1987 is called the upper limit to the risk. The risk, at this stage, was probability by consequences. It is the same accident, and I feel, that it is unwise to base the entire considerations of this Committee on that accident. I have commented that I feel that the subject of probabilistic risk assessment has come a long way since the 1976 document of the Atomic Energy Commission and I do not believe it has revised its approach to this issue significantly since that time.

Finally, at the end of my document I summarise my conclusions, which I will just repeat. The best way to answer the questions 1, 2 and 3 that I have put in my document and to lay contingency plans accordingly would be to seek the full co-operation of the navies whose vessels we are considering and to get access to the maximum amount of information about the reactors in question and about the data on their past histories, and endeavour to do a comprehensive risk analysis of the kind that I have outlined and with the improvements that I have outlined, and on that basis consider the contingency plans. Without that, I would not have a great deal of confidence in the conclusions of the planning accurately reflecting the risks that might arise.

ACTING CHAIRMAN - You have directed yourself predominantly to nuclear-powered vessels. We have, of course, another reference, nuclear-armed vessels. Is it within your competence to comment in that regard?

Mr Speed - I am sorry, it is not. I know nothing about that issue other than what I have read in the papers associated with this hearing. I have no independent knowledge.

ACTING CHAIRMAN - You have mentioned Three Mile Island and the report of the Nuclear Regulation Commission and so on. Did you attempt to bring your knowledge up to date as a result of further modifications done by NRCs and others and also as a result of world interest in Chernobyl? Are you aware of any reassessments in terms of probabilities as the result, shall we say, of Chernobyl?

Mr Speed - No. I am afraid my review of the literature prior to writing this document was necessarily rather cursory because I have a lot of commitments at the moment and I was unable to do exactly what you said, which is something I would have liked very much to do. I have an idea about what went on at Chernobyl and how that relates to the issue today, but I have not been able to spend the time to find out what impact that has had, for example, in the safety activities of the United States.

ACTING CHAIRMAN - Should we all not so much look over our shoulders - indeed you ask us not to, about the Atomic Energy Commission in 1976 - but start by looking at, shall we say, what the International Atomic Energy Agency may be analysing in terms of probabilities at this moment, 1987?

Mr Speed - That would be the ideal, and if my contribution has brought us closer to focusing on that issue, it will have been of some use. I regret that I have not had the time to do that myself.

ACTING CHAIRMAN - You have not sought to get that information?

Mr Speed - I did not because of a couple of logistical factors. I am shortly to leave the country and not to return for some time and even to get this submission done and to appear here was quite an effort.

ACTING CHAIRMAN - That was not a criticism, it was meant to put it in perspective.

Senator HAMER - I would like to start with your suggestion of how we tackle the basic inquiry, that we look at what could go wrong, then how likely it is and what would be the consequences. That is, of course, a somewhat different approach from the one that has been put to us by the Atomic Energy Commission. But something could go wrong and the consequences might be trivial. Is it worth pursuing them if they are lesser consequences than those which might happen? In other words, is the probability of minor incidents happening important to us if we are providing for a more serious accident which would subsume the consequences of a minor one? Do you see the point? We do not want to pursue each minor accident to a probability conclusion if we are satisfied that its consequences would be less than the major ones for which we are prepared.

Mr Speed - I concede that the issue should be about severe accidents.

Senator HAMER - I find a lot of your remarks about the difficulty of risk assessment very persuasive. Is it true that the likelihood of an uncontained meltdown is less probable than that of a contained one?

Mr Speed - Generally speaking, that would be true. To answer that question fully competently, I think you would have to speak to someone who knows the reactor design. But in a simplistic way, to have a meltdown and a breach of containment, you have to have the meltdown first, so the compound is a sub-set of the----

Senator HAMER - As you understand, what we are looking at is the meltdown, or the loss of cooling and a slow leak, not a total disruption. How likely that is, is knowledge we are having very great difficulty in getting. It is: What is the structural strength of the containment in naval warships? Have you any information in that field?

Mr Speed - Certainly that would be part of it.

Senator HAMER - But do you have any information in that field?

Mr Speed - I am afraid I have no independent information about nuclear reactors in warships. None of the literature I have read has related to warships.

Senator HAMER - You were, I think, critical of the AAEC's quantification of accident probabilities. You are critical of them. What are your views of the accident probabilities and the AAEC's quantification of them? Do you think they are out of date?

Mr Speed - Without trying to sound too disrespectful, I did not see a lot of quantification. The only numbers that I saw, unless I have read the document inadequately, related to 100 feet of piping, and a probability that a rupture might occur over this length. There was not any quantification of a comprehensive kind that I normally associate with a thorough risk analysis. There were just figures like the one that I mentioned. There was a lot of discussion with words like 'incredible' and 'highly improbable' and so on, which I do not regard as quantification. In a sense I see those as professional judgments by the people making them, but not in any sense checkable, scientific analyses. So if I am not wrong, the only actual quantifications were relating to these pipe ruptures.

Senator HAMER - Do you know of any studies that have been made of naval reactors? I presume you have to have two stages: One is the type of accident, the meltdown or the loss of coolant or whatever the possibility is of that. The other is the possibility of that occurring in a form that might seriously rupture the containment vessel. Do you know of any studies that have looked at that?

Mr Speed - No.

Senator HAMER - You see what we want it for, do you not? That is fundamental to our inquiry. We are assured up until now that that is, to use your word, incredible.

Mr Speed - My impression is that the Atomic Energy Commission did not have access to that information either and was extrapolating from civilian nuclear reactors. I guess the thrust of my argument is that it did not do that very well either, without worrying about the issue of whether the AAEC had the more relevant information that we would all like.

Senator HAMER - You appear to have rejected this so-called reference accident as being a suitable basis for our contingency plan, or you are not happy with it as a suitable basis.

Mr Speed - 'Not happy with it' would be better.

Senator HAMER - Before you answer that part, could I ask: Is your worry the probability of this reference accident or the consequence of the reference accident?

Mr Speed - It would be both. What I would have liked to see - and if it exists somewhere I think it should be of interest to the Committee - is the basis on which this reference accident was selected. It is said in one place that it was the accident which had the highest combination of probability by consequences. So there would be some that would have worse consequences but lower probability and, in forming this combination, they were regarded as less important. There would be others with higher probability but lower consequences, and they are less important. And it is suggested - it is almost stated categorically - that this reference accident came in at the maximum of this combination. I would have felt that the Committee would want to look at all combinations of probability and consequences rather than take this numerical combination which purports to single out one accident and base everything on that. That would be my view.

Senator HAMER - But if we have picked one case as our reference - assuming we do stick to a reference accident - and its probabilities are of a certain scale, is there any point in pursuing accidents that have less consequences in trying to establish their probability? What is the point of doing that?

Mr Speed - This is just a personal view, but what I would like to see when I am having my safety taken into account, as it were, is consideration of a wide range of possible accidents. Obviously it is going to have cost issues and, if you like, logistical issues. There would be very bad accidents which have enormous consequences and it might be inconceivable that we could seriously plan for them. At the other end of the scale you might have quite trivial accidents which require next to no planning or contingency. My view is that I would like to be reassured that all of these, in the whole spectrum of consequences and probabilities, have been duly considered. I think that is the task of doing a comprehensive risk analysis, not focusing immediately or fairly quickly on to one thing. This does not necessarily help you if that is not the thing that actually happens.

Senator HAMER - Maybe I did not make my question clear. I am using the reference accident - and I do not like the expression but let us keep this so that we know what we are talking about - but if the consequences of the reference accident are an area of contamination which depends on winds and all sorts of other factors, then we accept that if the reference accident happens these would be the consequences. What is the point of pursuing other accidents where the consequences would be less than that? If we are prepared for the greater one are not the lesser ones subsumed by that?

Mr Speed - That is assuming that we can get a nice, simple quantification of this concept of consequences, but I think different accidents will have different consequences. To answer your question a little more pointedly, I am much more interested in more severe consequences but with apparently lower probabilities that have been disregarded because the combination in general----

Senator HAMER - Do you think we should look more closely at the obvious one, which is the probability of the breach of containment? In an accident we have to look more seriously at that. That, of course, is our fundamental problem; getting the information on which any assessment can be based. When we are looking at these risks, even if you dispute the absolute probability value of assessments that have been made, is there any merit in a sort of mean annual severity, allowing them to rank the things in relative probability?

Mr Speed - In my view, no. If I do not believe the figures in absolute terms, I find myself unable to believe them in relative terms either.

Senator HAMER - It could be the same error in both.

Mr Speed - It is a nice thought, but often if you look in more detail at the objections that I have to the figures, it is not a matter of possible common error. It is things that might be left out entirely. If we talk about modes of accidents that are left out entirely, then the figure is wrong in absolute and relative terms - it is just left out. Quite a common reaction to figures that are a bit rubbery is that maybe they are useful in relative terms, but I am afraid that, as a practising statistician, this does not appeal to me.

Senator HAMER - If, as appears possible, we are unable on security grounds to get really accurate information on the strength of the containment in submarines and surface ships, is there anywhere we can go in your field? Would your approach enable more useful extrapolation from shore-based reactors without special knowledge of what the strength of containment is around a naval reactor?

Mr Speed - I would think so.

Senator HAMER - Maybe you could help me.

Mr Speed - I would think that the sort of thinking that has gone into the Atomic Energy Commission's case, which does not really build on any knowledge of naval reactors, could still be incorporated in a much more comprehensive analysis of the kind that I have described. Of course, it still would not be focusing on naval reactors.

Senator HAMER - They have that problem at the moment in that they just do not know what the strength of that is.

Mr Speed - As I think I alluded to earlier, I am still not happy with the way in which they marshall the material relating to civilian power generating reactors.

ACTING CHAIRMAN - If I may intrude, in considering the law of probabilities you need large samples, do you not? Small samples give you a much greater distortion. Do you regard as a large sample an extent of 30 years, being the history of civil reactors, and a gradual buildup over 30 years to what - some 300 or 400 operative reactors today? I put it to you that that must be a relatively small sample altogether, and therefore, looking at probabilities - even though you may have some thousands of reactor years - is that sample not too small to deal with probabilities?

Mr Speed - In its own right, certainly. I agree that it is a small sample. The 4,000 years sounds like a lot, but when you look at the statistical errors on estimates based on that, they are very broad.

ACTING CHAIRMAN - Probabilities deal with hundreds of thousands, not four thousands, do they not?

Mr Speed - For such small probability events, that is certainly true.

ACTING CHAIRMAN - Without too much whimsy, would we not be better to state the law of probabilities for this Committee, that the probability is that the improbable will happen. I do not say that with too much whimsy. Bear in mind that you are dealing with warships that in ordinary times have to look at every kind of contingency and plan for them. Whilst in port or coming into port and so on, things can happen. Is there too much whimsy in the idea that we should in fact disregard probabilities and just look at each circumstance as it might happen?

Mr Speed - Depending on what you mean by that statement, I would be inclined to agree. In general terms, I am very much against setting a lot of store on these probabilities because I do not believe them. The accident record of nuclear reactors, which is not very extensive, shows that generally the things that happen are things that have been ignored by the calculations and probabilities. Three Mile Island, Chernobyl, Browns Ferry are all things that were left out of the analyses. In that sense you are quite right. Regardless of the size of the sample even, we would be better off thinking what might happen and not letting our thinking be guided by probabilities which may or may not have any value and which I would argue do not have any value. But, of course, what you do next is still a very serious issue, is it not?

ACTING CHAIRMAN - In human life, does not the improbable tend to happen?

Mr Speed - Very much so. In fact everything that happens tends to be improbable.

Senator AULICH - Can we go back to an assumption that you may or may not make, so that I can just clarify where you stand on that. Let us assume that we go into that area of past reactor experience and, as the Chairman said, it is a fact that we do not have a base which we can use for any reasonable probability analysis because of the small experience that we have in that area. Do you assume from that, for example, that there have been improvements to reactor design - both naval and civilian - over the years which lessen the chance of an accident occurring? Or have the parameters of design that have had to be built in through compromise, speed of a naval vessel or even costs and the need to compete in the nuclear industry with other people on a tender basis and so on, maintained the same level of probability of an accident occurring? Or is there in human history always an improvement which, in this particular case, would lessen the probability of the occurrence of an accident of some seriousness?

Mr Speed - The short answer is that I would like to think so. The longer answer is that it is very difficult to see what sort of evidence one can point to to argue that this is in fact happening. If I find that most of the probability figures I see presented are not, in my view, well based, that is not a very good basis for deciding whether there is, in fact, a learning curve or not. On the other hand, if you look at it from the point of view of design or operation, every time something serious happens, such as at Three Mile Island, Brown's Ferry or any number of accidents or incidents that you might mention, one would like to think - I am sure it is happening to some extent - that the experience gained from these incidents or accidents, is fed back into design, into regulatory codes and does make things safer. The problem is whether this is being manifested in probability and that is a much more difficult question, I think. I hope the industry is behaving sensibly; learning as much as it can about accidents; not covering up; not getting cheaper and shoddier and so on, but actually doing what you are suggesting. I am not sure that I could point to much to prove this.

Senator AULICH - So you say there is a hope, but mathematically or in terms of probability the other parameters may well affect the net improvement in terms of safety standards and so on.

Mr Speed - That is the way it works in engineering, generally, and I do not have any reason to believe that things are any different in the nuclear engineering area: You build on experience; design faults become revealed; accidents occur; experience expands, and things get better. I am not trying to sound totally naive but that, roughly speaking, is the way I think things go in building bridges, tall buildings, et cetera. People do not calculate the probability of a very tall building falling over, or a bridge dropping - they build on past experience. Occasionally a new design comes along; they build it and it falls down and they decide that that was not such a good idea. But that was not done on the basis of any probabilistic calculation; this is all just part of what I think is the engineering approach to creating the world we live in.

Senator AULICH - I think that engineering approach dominates the nuclear industry in much the same way as it would dominate other civil engineering approaches.

Mr Speed - Yes. Maybe I could give you a little anecdote which will put that point very clearly. One of the things that has concerned me most about these probability risk analyses that I do not believe, is that somebody else might believe them. If you have a risk analysis which tells you that things are terrifically safe, my concern would be that that might lead you to be rather more lax than you might otherwise be; you might cut corners or decide that you have something that tells you you can use a cheaper component. It was very reassuring to me when I visited the Nuclear Regulatory Commission to talk to the statisticians there. They told me, quite frankly, that they did not think the people in the Commission believed these figures, which were for public relations purposes, but they reassured me that the people actually building reactors and, monitoring and, licensing them, do not give a lot of credence to these figures. That to me is the main worry, that you somehow alter the engineering tradition of improvement and, of learning from experience, by focusing on these figures that I regard, by and large, as anything from misleading to quite bogus, depending on who has done them and how they have been done. If I had any message at the end of the day, it would be that the general principles that are embodied in engineering design remain at the basis of the way in which we view the safety issues associated with the reactors, both civilian and military.

Senator AULICH - So we have three main themes: The mathematical probability theme, the engineering experience approach, and the public relations theme, which you say, are all combined, to some extent, in the one syndrome somewhere along the line. Say you were in this Committee's position of having to, first of all, tease out the main issues and then look at probabilities and at what we can do about them. Where would you start if you were going to cut your way through the enormous amount of technical jargon put in front of us, the occasional public relations statements made by people who probably ought to stick to science rather than public relations, and so on down the line? If you were in our position, where would you be going?

Mr Speed - There is the rather unfortunate problem that you want to tie both my hands behind my back and tell me that I am not allowed to have any information relating to the object of our discussion, namely, a nuclear reactor on a ship. It is a rather unfortunate matter which I hope you do not put aside lightly, because it seems to me that someone, somewhere, must have some information that they are prepared to share with this Committee about the design of reactors in ships and submarines. Putting that aside, I would seek the analyses associated with the risks of civilian reactors that are believed to be most similar to the ones about which we have no information - the military reactors. You have to start looking at the accidents that might occur. I have no real quarrel with the general approach of these probabilistic risk analyses, except that I do not believe the bottom line figures.

The main value of these analyses, and the reason why they are being pursued so vociferously around the United States, is that they ask you to take your reactor apart, do the very best you can to think of ways in which it might go wrong, look at all possible things that could initiate accidents, all possible sequences of accidents. Honest people do not believe that is going to exhaust everything, but that is the way a thorough engineer would go about trying to improve the safety of a complex system - essentially, taking it apart, thinking of what could go wrong, and at the end having to look at the relative importance of these accident sequences.

I do not mind a bit of seat-of-the-pants probabilistic calculation to try to rank these because you obviously have to ask 'Is it more likely that this is going to happen than that one?', if you want to start talking about what you are going to do to protect yourself from it. Again, you do not believe the figures; you just do the best you can and preferably use all the data available. To date I am not convinced that that sort of thinking has been adopted by the Atomic Energy Commission. There is a lot of data available. It is not what I call end event data. If you add up the data on actual major accidents and ask 'How many meltdowns are there? How many years are there?', there are, depending on how you like to count, zero or one or two meltdowns in a lot of years, but there is an awful lot of relevant data that refers to events along the sequence leading to a meltdown, giving you an idea of the relative importances of the difference sequences and hence the relative likelihood, as far as you can get it, of these end events.

Look at all that, do some sort of ranking, and then, of course, you have to look at the consequences. As I have said, there is a lot of uncertainty there, but again you just do the best you can. My view would be that after you have done all this you have an awful lot of information in front of you and then you have to start talking about contingency plans, and what sorts of precautions can be taken. What I dislike intensely is somehow quantifying the consequences in a way that is bound to be plagued with uncertainty, quantifying the probabilities in a way that most statisticians and a lot of other people would not believe, multiplying the two together and saying: 'This is the risk'. I would much rather have the floor of my room covered with all sorts of possible accident scenarios and think of the sort of precautions that one could take and try to come up with something which is a compromise with what is feasible financially in terms of where people are. I suppose if it is necessary to have nuclear vessels visiting and they can only stay in a port at a given spot, then you are inevitably going to say that we have to accept that a particular accident, say, of a significant magnitude, might put some civilians within a certain distance at risk. They are part of the political decisions that are made in building the environment around your reactor or around your port. Rather than trying to quantify it in a way that is potentially quite misleading, just mix in the information, which is the best you have, with these political, safety and other considerations. I cannot see any other way than that. If it sounds a bit vague, forgive me, but I have not really tried to do one of these things in practice.

Senator AULICH - Why is the AAEC going in that particular direction? Is that the bent of scientists or is it a general tendency amongst certain types of institutions and organisations to try to want to quantify everything, even if total quantification and policies based upon that total quantification may in fact not be the whole story or the right way to go, as you have already indicated?

Mr Speed - I am not sure. I could speculate on a whole range of reasons. One, which is not all that insulting but is certainly likely to be part of it, is that they probably set a lot more credence in these figures than I do. One of the ironic things is that statisticians, people who work with figures like this all the time, believe them far less than the people who use them only occasionally, and we know just how ropey they can be.

You get people walking around with figures that are hardly better than something that was made up and then telling somebody else a little bit later that this is a hard figure. I have lots of documentation that suggests that. People do not look into where the figures came from and how well based they are. They are happy to have a figure because it makes life so much simpler. That is certainly an error that people like the Atomic Energy Commission scientists fall into, I think.

ACTING CHAIRMAN - It seems to me to ignore the fact that the AAEC has been closely associated with the studies of both Three Mile Island and Chernobyl and has in fact had representatives at international discussions. If indeed it is obsessed with figures, you are suggesting that it has not allowed its mind to be flexible enough to take in all the new consequences that have flowed from those two accidents. That seems to me to be a long bow. Basically a lot of your document is prior to or at the time of Three Mile Island and, as you yourself have indicated this, it has not the knowledge that has flowed from the re-opening of the minds of scientists as a result of those two accidents. I would have thought one should have given tribute to the AAEC that it might learn from the international discussiohs that are still going on and that the International Atomic Energy Commission would be doing its sums, too, and not be so rigid. How would you react to that?

Mr Speed - Firstly, my comments in the paper were based on the material that the AAEC submitted to this Committee. There is nothing that is post-1976 in those documents, much less Three Mile Island. So if it is a matter of timeliness, I am way ahead of them.

ACTING CHAIRMAN - I know, but you must have known that the AAEC would have been associated with international discussions and information post-1976.

Mr Speed - Of course. I assume----

ACTING CHAIRMAN - Therefore, the AAEC would have applied that to the conclusions it reached. I am not saying anything in defence of the AAEC, I am trying to get the environment in which you reached your conclusion.

Mr Speed - Let me go on to the second point then. What would undoubtedly be true is that the AAEC would have learnt a lot scientifically such as possible accident sequences, and ways in which things might happen that people had not otherwise thought of. That is part of the general knowledge that I was alluding to earlier, that one hopes engineers, and nuclear engineers in particular, are constantly soaking up and implementing in their day to day work. What I do not believe has occurred is any fundamental reappraisal post-Three Mile Island or post-Chernobyl in the AAEC's thinking about risk analysis. I do not believe that a single event like that has had any impact on the thinking that goes on.

ACTING CHAIRMAN - Help me here. The whole of the rest of the world would have been looking at revising its theory of risk analysis as a result of those two accidents, surely. That would be the key to it. We have some new experience - Three Mile Island and Chernobyl. How does that affect our earlier risk analysis? Are you suggesting that the whole world has not caught up to date, or that the AAEC is out of step?

Mr Speed - I would like to emphasise that I have read the risk analysis literature post-Three Mile Island, just not post-Chernobyl. My paper and a lot of the references there are all recent. Three Mile Island did not force a reappraisal of the method of risk analysis, the methodology, the approach, the attitude. All it did, which might sound like not very much, was inject a little more accident experience into it. But this has had surprisingly little effect on the figures that this process produces. It tells them that yet again something occurred which was not in their calculation. I could have told them that was very likely. What happened at Three Mile Island was a pressure-operated relief valve closed when it should have been open and a signal was sent that said it should have done something and they saw the light. That sort of thing is not included in these risk analyses as an initiating event. The difference between a signal indicating that a thing is closed and it closing had not been thought about. So that is an accident which just at the very simplest was left out of previous considerations. Obviously that would be included in subsequent considerations as far as they can, but it does not alter the actual methodology - the approach of risk analysis. This document that I have, dated 1983, certainly uses risk analyses done by Westinghouse in the United States well after Three Mile Island. They have built the technical conclusions of the Three Mile Island accident into their analyses but it has not changed the way they do it. It has not made the figures substantially more believable, in my view.

ACTING CHAIRMAN - Whilst I acknowledge you would not have the technical background of the discussions post-Chernobyl, one could reasonably hope that it having been looked at by something like 40 or 50 nations very closely, that scientists would have modified their risk analysis if the evidence from Chernobyl supported that. Is that not a reasonable assumption?

Mr Speed - One would hope so, but again, I do not think it is the nature of the beast that a single accident revises the whole thinking.

ACTING CHAIRMAN - Chernobyl is not a single accident though, is it? Chernobyl is an international threat and poses an entirely different situation. In itself a great drama, surely it would have forced a reappraisal.

Mr Speed - You think that more goes into these risk analyses than in fact does. There is very little use of the detailed information relating to accidents that have occurred in these analyses. They have a list of initiating events which, of course, gets larger as time goes on because more things happen. They start off with things like 'loss of off-site power' or 'turbine trip' or 'pipe break', but as other things happen this list gets larger. But that does not change the fundamental thinking. Then there are lists of event sequences through the course of the accident and there is the consequence analyses. But the whole way it hangs together and the general approach really does not change - no matter how significant the accident. You just add some possible new events or event sequences that had not been thought of or had been rejected as incredible. Of course, what went on at Chernobyl had previously been rejected because it was people disobeying the rules. There was not a pipe failing, according to something which can be statistically determined, it was a man-made intervention which is impossible to quantify as an initiating event. So in that sense, the main lesson for the probabilistic risk analysis of Chernobyl is: 'Here is another example of something we have left out happening, and causing a very serious accident'.

Senator AULICH - To get back to the question of the AAEC and its presumed reluctance to look at things in the way that you are looking at them, you say that, first of all, there is no evidence in any of the papers that you have seen of late that have taken into account, or could take into account - you will have to make a judgment there for me - the Chernobyl and Three Mile Island accidents. Are you saying that they could not, or they have not?

Mr Speed - I am talking in the context of quantifying probabilities. There are certainly remarks made about Chernobyl. They say: 'An accident like Chernobyl could not happen because that was uncontained and these naval reactors are all supposed to have very strong containments'. There are some remarks, but that is a different thing from changing their fundamental approach to the issue which, as I said, was ultimately assessing the risks by multiplying the probabilities by the consequences. What went into these probabilities and what went into the consequences has not been revealed and there is no evidence that that has been revised. There are just these remarks. Essentially there is very little quantification in that AAEC document. There are remarks that things are incredible, that things will not happen because the designs are different and so on. But that is not what I call a reappraisal of the way you are doing things. It is just a few more caveats, a few qualifications.

Senator AULICH - Let us go on from that to assume, first of all, that there are a lot of factors that cannot be quantified and that you cannot do a type of sum which inevitably gives you almost the total basis on which you make a decision about contingency planning or whatever. What about the question of, say, the movement of naval vessels in a particular harbour? Just for my own information, can you tell me how that can be quantified as increasing the probabilities of certain types of accident occurring - for example, a breach of containment and so on. How do you put those types of factors into a probability exercise? What are the mathematics and the methodology of doing that in the first place? Are all the known methodologies that you know likely to be satisfactory at the end of the day? Are they likely to be able to give us a better picture on which we could base advice, take advice or accept the advice that has been given to us?

Mr Speed - Let us deal with the last question first: I think any analysis that you have, no matter how doubtful or how suspect, is bound to be useful if it is the best possible way of dealing with the problem honestly and competently, admitting that there are inadequacies in data and inadequacies in methodology. Of course, there are a lot of analyses about the movements of ships in contained areas. For example, after the bridge went down in Hobart, statisticians were called in to look at movements of ships and how likely it was that a drifting ship would run into the bridge or something else. There are such calculations for very busy harbours. They are nothing like the hard statistical calculations that one is used to where there is a lot of data, because although you have lots of data on the movement of ships, you do not have a lot of data on things like near misses - how often they come close. This would be much the same as looking at aeroplanes coming in and out of busy airports. The sort of statistical analyses that get done there are not wholly satisfactory but they occasionally give insight into weak points in, say, the management of the operation. You can perhaps simulate and find that if you obey the rules, you might find yourself with half a dozen ships in an area where there should be only three or four. There are ways of getting insight into the situation. I do not think what you will get out of it, though, are the probabilities that tell you that the risk is vanishingly small, negligible, that sort of thing, which is often what people are looking for at the end of these calculations. My view of the value of these calculations is that they give you greater insight into the situation you are dealing with. The bottom line figures are the things that are very, very suspect. It can be done and it is done from time to time. It is obviously very specific to what you are talking about. You do not get bottom line figures, but I think it is worth doing.

Senator AULICH - In other words, from a management viewpoint, the probability of an accident occurring if everyone follows the rules can be worked out. You can say that if everyone is doing the right thing in a particular harbour, the chances are that if these rules are put into operation and people follow them, there is hardly a chance of an accident occurring, particularly one in which there might be a breach of containment. You can put that aside and say that that is a good management tool and it has been very useful; it may give us an idea of probabilities and it will certainly enable us to take management action which could reduce the probability of an accident occurring. I am trained in the humanities, so I have a certain view about science. One of those views is that human stupidity at some time or another will raise its ugly head at times, and has done throughout history, no matter how often we train ourselves to avoid it.

Senator BOSWELL - That is Murphy's law.

Senator AULICH - What do you do about that in your probability calculations? Let us say you just talk in terms of management planning for a particular harbour in Australia which will enable you to reduce firstly, the possibility of an accident and secondly, the possibility of an accident bad enough to have a breach of containment.

Mr Speed - I think you have answered it. What can you do about things you have not thought of - new, inspired pieces of human stupidity that have been left out and have never appeared before? There is obviously nothing you can do. You may get some insight into that by looking at statistical data world-wide and averaging over differences that are going to occur between your harbour, New York harbour, San Francisco harbour or London port. Ignore these for the moment and try to separate the extent of the human stupidity from, say, a loss of power or loss of steering - things that are a little more predictable. Let me say, just as a side comment, that most of the serious accidents in the nuclear business are caused by human stupidity, not by pipes failing and things like that. So you can build up a picture of how frequent those are, as opposed to what you might call the random sort that are occuring because of machine failure, failure of hardware items and so on.

Senator AULICH - You will not get a probability analysis but, from looking at past history of nuclear reactors, for example, you get a picture of when or how often human stupidity raises its head. Of course, you leave aside terrorism, deliberate sabotage, temporary insanity on the part of those who may well be in control of particular important functions in an operation, and so on. You cannot include any of those in the total risk management operation. You may reduce it by having certain rules. Am I correct in thinking that that is part of any calculation you do, that by having certain rules which would tend to push people in the right behavioural direction and you may reduce risks?

Mr Speed - That is all that anybody can do, running. You train people. You hope to have procedures which are safe. Even assuming they are, these odd things still happen, do they not, because things occur for which the procedures have not been laid down in the manual? So the operator does something. He takes a candle, goes and looks behind the switchboard and sets fire to it, and out go the cooling system and the emergency cooling system. That is a genuine accident started by a bloke with a candle. At the time, analyses did not involve fire-initiated accidents; so, from now on they do. You learn from this sort of thing but you cannot rule it out and you cannot quantify the chance that it will happen in the future.

Senator AULICH - It would be very dangerous for us as a committee, for example, to look at the mathematical probability side of things almost totally and assume that that covers all known contingencies which may affect the nature of the accident, the possibility of accidents or the frequency of such accidents. Is that what you are saying?

Mr Speed - Certainly, but I might add that nobody is asking me to do that. That is clearly not the thrust of the Atomic Energy Commission's submission and I hope it is not apparent that it is the thrust of mine. There is a big difference between going through a process of taking your reactor apart, conceptually, and looking at all the sorts of things that might happen, trying to assign some sort of likelihood to them and learning a lot in the process, and doing it all, getting some figures at the end and basing your conclusions on the figures. I think it is the process that is the important thing, not the quantification at the end. That would apply equally to ship movements in ports, possibilities of collisions and so on.

ACTING CHAIRMAN - You are aware that some years ago there was a major explosion of an ammunition ship in Halifax harbour, carrying high explosives, and it took up half the town and so on. You also are aware that in most ports of the world there are, of course, high explosive ammunition warships in port. What conclusions do you draw from the Halifax situation, which was of major consequence? Should all ammunition ships be banned from harbours or is this an extreme case? From then on, of course, I have no doubt magazines were much safer and much more secure. Here is a classic case for you, one that would have been of a magnitude of destructibility that you could conceive in a nuclear reactor type of situation, since you are not going to get a nuclear explosion but you are going to get radiation problems.

Mr Speed - I have views as a private individual about these sorts of things. I do not know that a statistician does have views on those things. Obviously we are in a position to advise, say, planners if there are reasonable bodies of data about the frequency of accidents of different kinds, and we might relate that to the distance between where the accident occurs and where the population is located. As far as transforming that into, say, planning or safety considerations is concerned, that is essentially a political exercise which trades off certain obvious things. All I would urge is that it is not done with some sort of spurious quantification at the beginning but that all the information that is available has been honestly and openly used.

Obviously we have factories, explosives, magazines, and so on situated nearer people than we might like. I think the Army is moving from St Marys now. That has been regarded as a problem and I have actually been asked to help calculate the probability of that doing something - it is almost impossible. Nothing has happened so far, but it is obviously better to have that sort of thing a long way away from people than close to them. Transforming the best and most well-intentioned technical device into planning and safety is essentially a political exercise, I think. It is not something that I have any special expertise on.

ACTING CHAIRMAN - We should look at all the possible accidents that can happen with a nuclear reactor, examine them, and----

Mr Speed - I would think so. Rather than rule out this uncontained one, I would think you ought to ask what might happen if it occurs in the likely spot that the vessels might be berthed. If that is something you can live with once----

ACTING CHAIRMAN - What you are saying is that we should look at the worst possible situation, which would be a major meltdown and fracture of the containment vessel.

Mr Speed - I am reluctant to go down this worst possible route. I think you need to know as many of the possibilities that seem reasonable, because most of the time the worst possible is so awful that you will not do anything. It is not a more sensible basis, I believe, than say, this maximum credible idea, because at some stage there will be tradeoffs. If the worst possible is so disastrous that we are never going to live in buildings more than three feet tall or something then it has not helped us much in planning has it?

ACTING CHAIRMAN - Are you saying then that we take some kind of a mean between the reference accident that we have now and the worst possible and move in that direction?

Mr Speed - I am reluctant to summarise. I think you should have the information available to you and know that if you make such and such contingency plans the worst possible will tax your plans to the utmost. On the other hand just planning for this so-called reference accident, and there is something which might be slightly less probable - bearing in mind that the calculation for its probability is probably very, very rough - but it is considerably worse. It may be that you ought to know about that.

ACTING CHAIRMAN - What is the significance of the observed frequency of reactor accidents when compared to the calculated probabilities from probabilistic risk assessments? That is, what is the degree of difference between the observed and the calculated probabilities? Does the high quality control of material used in naval reactors have any significance, particularly when taking an approach using statistics from land-based reactors to assess the safety of the naval ones? Does the history of reactor operations suggest the main problem with PRAs is that they lead to an unrealistic estimate of probabilities, that the approach used has not anticipated the accidents that have taken place, or that they lead to uncertainties about the consequences of accidents? I am sorry, that is a very long question.

Mr Speed - Fortunately I have a copy of it somewhere here. Otherwise I would have to ask you to repeat it. I think the first matter you mention about relating the calculated risks to observed risks is one of the serious problems. There is not enough data to confirm or deny, if you like, these calculated risks, so that one has to look at the basis of them and say 'Do I believe them or not? Are they credible, well-intentioned, accurate, plausible calculations?' because, it might sound crazy, but you can come up with a small figure like one in 10,000. Then there is Chernobyl; surely that will revise your one in 10,000, but it does not revise it very much. One in 10,000 means you could wait 10,000 years for one; if they are occurring randomly, the horrifying fact is that they are just as likely to occur tomorrow as in 10,000 years. It has happened, so we do not suddenly double everything or multiply by some enormous number. The fact that the Chernobyl accident occurred about three months after the Minister for Power in the Ukraine said that it had a probability of one in 10,000 of melting down, made me suspect their calculations. When it occurs so early in the lifetime, as it were, you do wonder.

ACTING CHAIRMAN - Was he wrong?

Mr Speed - That is one of the imponderables. I would think that that is clear evidence that the Russians are barking up the same wrong tree as we are, that they have fallen for this trick of thinking that they can quantify things. Of course, what actually happened in Chernobyl was left out of their calculation. It is not a question that anybody can answer in any definitive way. I think you have to go back and say that one criticised the calculated risks on internal grounds, not on the grounds that they are incompatible with observed risks because we are talking about such a low probability that it would take eons to get enough data to distinguish. The second part of your question was about the high quality of material in naval reactors. Of course, I see that as part of the general push for safety. By the way, one hopes that high quality materials are used in civilian reactors because I know some people who live close by them.

I just put that in the category of general engineering activity - you hope that people are using the best materials and are not taking short cuts, that they are making decisions consciously or unconsciously about the need for quality in certain areas that they are not cost-cutting, that they are not deliberately falsifying, and so on. Obviously, that is probably more likely to occur in the Navy but I have no real evidence to back that up. One would like to think, I suppose, that somehow military expenditure, apart from the one per cent cut which has just occurred, is somewhat less constrained than, say, the private enterprise expenditure. I would like to think that the military has more stringent requirements for safety, but that is still only saying that they are operating in the mode that one would like to think all engineers operate.

ACTING CHAIRMAN - Except that you are dealing with something slightly different from a land reactor, are you not? In the Navy the primary aim is to keep that vessel intact under virtually any kind of circumstance you can think about, so surely one would predicate from that that safety rules are continuously infinitely greater in their minds than would be the case for a land reactor.

Mr Speed - One would hope so.

ACTING CHAIRMAN - That would be the essence of planning, would it not?

Mr Speed - Am I being unreasonably reluctant in just saying that I would hope so? I do not have any evidence to the contrary.

ACTING CHAIRMAN - We know, for example, that a Leopard tank is built with tracks on it and we know why that is so. Similarly, we know that a naval vessel is built to survive particular categories. It is not just a hope - one knows that steps are obviously taken. Could we say that it would be a reasonable assumption?

Mr Speed - Yes. Certainly reactors are sitting on fault lines in America so one hopes that they are built to withstand seven or eight on the Richter Scale. We are told they have been designed to do that but, again, it is just a hope, is it not? Anyway, I agree with that; I do not have any particular reason not to - I am just being a little sceptical. The final part of that question was: Does the history of reactor operations suggest that the main problem with these risk assessments is that they lead to unrealistic estimates of probabilities? Certainly. I would probably replace 'unrealistic' by 'unbelievable'. If you take the statement I referred to by the Minister from the Ukraine about Chernobyl, saying this in February when in May the accident happened, do you call that unrealistic or unbelievable? I do not believe the bottom line figures, and that certainly makes my point on that question clear. As to the question that the approach has not anticipated the accidents that have taken place, that is one of the major reasons - most of the accidents that have occurred are manifestly outside the domain of the analysis. Finally, as to whether they lead to uncertainties in the consequences, again it is not something we have discussed at any length this morning, but there are many more uncertainties in the consequences, I think, than we are led to believe by some of the papers that have been presented to you. Obviously to do analyses, people fix on consequences, but then you face this problem of giving the impression that it is all cut and dried and that we know what is going to happen, whereas in other circles you can read enormous discussion about how little anybody knows. For example, they still do not know if there was a hydrogen explosion in the Three Mile Island accident - that is a debated question.

ACTING CHAIRMAN - At one stage in my career I did a bit of industrial advocacy and my memory of industrial accidents of all kinds - accidents that happen - is that the main factor is human error.

Mr Speed - Yes.

ACTING CHAIRMAN - It does not matter what the accident is - leave reactors out of it - like walking along the street, motor cars, factories or anything. Do we not have the human error in the situation and is that not impossible in terms of calculating probability?

Mr Speed - Yes, very much. That would be the single most important reason why I think these analyses do not lead to figures that can be believed. Of course, that does not mean that we should not think about the sorts of human responses that might occur in a given situation to try to prevent disastrous consequences, and that is what one hopes the people in the reactor business are doing. I guess it would be nice if we had enough information about naval reactors to do exactly that in the present context.

ACTING CHAIRMAN - I refer you now to page 3 so that you can follow the consequence of actions. The arguments in the submission relate largely to the probability of an accident occurring. The consequences of an accident are presumably independent of its probability. Can you explain the relevance of your arguments to describing the consequences of an accident? Can you explain the significance of your statement, in paragraph 17, that there is an enormous variety of uncertainties associated with release phenomena from the reactor vessel? What evidence is there for this statement? It gets longer as it goes.

Mr Speed - In paragraph 17, I refer to paragraph 16, which in turn refers to the study, so basically my information about these uncertainties is from that study. If you like, that is the evidence which summarises 16 probabilistic risk assessments of different reactors.

I will just mention a few: The magnitude of release of the large number of radionuclides, how much of iodine, radium, thorium and all, which is certainly an area where there is enormous uncertainty; the physical and chemical nature of the released species, whether they are in aerosol form or whether they are in liquid form; the release timing, at what stage of the action they come out; their duration, over what period are they released; the thermal properties, what is their temperature and how fast they are shooting out. All of these things are associated with the course of an accident, about which we have very little knowledge. So to make assumptions like 'X per cent of the iodine in the core will be released and that is it', is reflecting the genuine lack of knowledge as to what will actually happen when the core is melting. These are documented very fully in that reference I have given. That responds to that part.

The second question was: Given the uncertainties that exist, is it possible to take a worse case? I think I have already said that I do not find that appealing because there is a whole spectrum of accidents and somewhere you are going to be trading off an accident which might occur but which you feel is rather unlikely to, against contingency plans which you could but would rather not set into place. I will go for the worst case. Unless you feel you can thoroughly protect against the worst case, there is still the problem: Is it really the worst case? That assumes that you really understand what is going on. I think the thrust of my argument is that there is so much uncertainty that we cannot even be sure what the worst case is. I guess, in general, if you think you can protect against the worst case, that is obviously the one to go for.

ACTING CHAIRMAN - We will have to conclude. I would like to thank you on behalf of the Committee. If you have felt that some of our devil's advocate probing was rather sharp, forgive us, because in the end when we present our report it will be probed, not only in Australia but throughout the world. What you have helped us to do and what we need to do all the time is to open our minds as widely as we can. Your paper has helped us in that regard. I do not want you to think that we are, ourselves, in any containment vessel. We are not. In fact you have helped us in breach of containment. I would like to thank you very much indeed.

Committee adjourned at 9.46 a.m.

APPENDIX 2B TO SENATOR DUNN'S DISSENT

(Evidence, p. 577)

SENATE STANDING CTEE ON FOREIGN AFFAIRS & DEFENCE 27 Mar 1987

CHAIRMAN - Professor Davis, I now invite you to speak on the document circulated to the Committee and at the conclusion of your remarks I shall invite members of the Committee to submit questions to you.

Prof. Davis - Thank you very much. The nuclear policy program with which I am affiliated has as its goal the clarification of scientific and technical issues insofar as they relate to nuclear policy decision. We do consulting work for State and local governments, for the Federal Government in the United States, for foreign governments and for environmental organisations.

The report which I have submitted to the Committee here was done under commission to an environmental organisation, Greenpeace International. This report analyses quantitatively what I consider to be the most credible risks of having warship visits to Australian ports. The major risks are, firstly, the increased probability of nuclear targeting in the event of a thermonuclear exchange. Secondly, the risk of accidental dispersion of the plutonium contained in a nuclear warhead in the event of a ship fire. Thirdly, the risk of a nuclear propulsion reactor melt-down which would distribute some of the radionuclides in the core into the surrounding metropolitan regions.

The consequences of the first accident, namely targeting in the event of a nuclear war, are difficult to imagine and so also are the probabilities. Consequently I have omitted a detailed analysis of that possibility. I was interested to note that the Department of Defence in this country has recently acknowledged that the presence of spy bases is conferring upon Australia the risk of thermonuclear targeting. I was surprised to note the absence of warships from that assessment because, in my view, the presence of warships in Australian ports has the same impact. But inasmuch as the probabilities and consequences are difficult to estimate, I have omitted a detailed analysis of that possibility.

With respect to a nuclear weapon accident and also a naval propulsion reactor accident, the consequences of either accident would be very much the same, namely a cloud of radioactive materials would be produced at the accident site. This cloud would then be transported by prevailing winds in a downwind direction in the form of a radioactive plume. People in the path of the plume would be exposed to the radioactivity via a number of biological pathways. In addition, radionuclides would fall out of the cloud and deposit on to the ground, in what is commonly known as fallout.

I have utilised conventional methodology of the Nuclear Regulatory Commission in the United States to assess these accidents and to determine their quantitative impacts. I would stress that my methodology is nothing new, nothing revolutionary, nothing innovative; it is exactly the same methodology that is used to regulate the commercial nuclear industry in the United States. As such, the methodology is accepted even by people within the industry. According to the results of this methodology, the consequences of the accidents that I have analysed, even under relatively conservative assumptions - that is to say, assumptions that understate the potential impact - would be up to 10,000 casualties in the city of Sydney. My analysis suggests that from a nuclear weapons accident there would be no immediate casualties, no prompt casualties, rather, the casualties would take the form of latent cancers induced in the population in the two to 10 years after the accident itself. These casualties also assume evacuation of the city within 24 hours. Should the city continue to be inhabited then the number of casualties would increase significantly.

Perhaps the most astonishing consequence of such an accident, at least to me, was not the number of casualties but rather the economic impact of such an accident. The accident would contaminate more than 100 square kilometres of urban area at levels that would exceed federal limits in the United States by up to one million times. Consequently, the affected areas would have to be evacuated unless truly astronomical casualties were to be incurred, and decontaminated prior to rehabitation of the city.

These findings suggest the need for effective emergency response plans. I would note that the policy of accepting visits from United States warships has never been evaluated in terms of these prospective costs, at least as far as I can tell. Therefore, they suggest the need for a re-evaluation of costs and benefits of this policy. If the policy were to be continued then more than effective evacuation plans are required. The

Government Accounting Office of the United States Congress recently produced a report stating that emergency preparedness plans cannot operate effectively unless they are periodically rehearsed. So, if in fact warship visits continue, these findings suggest the need for a periodic rehearsal of emergency evacuation plans.

Finally, in 1986 the Government Accounting Office released a study entitled 'Financial Consequences of a Nuclear Power Plant Accident'. This document is cited in my submission to the Committee. According to this document the cost of cleaning up after a major nuclear incident would range from $US0.3 billion up to $US150 billion. This economic consequence is probably beyond the capacity of even a Commonwealth government to absorb and it emphasises to me the need for detailed liability and indemnity arrangements in advance. I have, since I have been in Australia, looked into some of these issues, namely, the emergency response evacuation preparations and also the issue of indemnity and liability. I think that my findings with respect to the former emergency evacuation plans are reasonably confirmed in the recent Lucas Heights incident. There a relatively minor accident was met with substantial confusion in terms of emergency response plans.

It is my understanding that residents were not notified and that fire-fighters, when they arrived at the scene, could not gain access to the building that was on fire. I think this represents a relatively benign probe of the emergency response plans and the problems involved in such plans, especially if they are not rehearsed periodically.

With respect to liability and indemnity, since I have been in Australia I have worked very hard to learn all I can about what arrangements actually exist. As far as I can tell, these arrangements are summarised in the United States General Statement of Assurances under which these visits are apparently conducted. I have obtained a copy of this document. It is a restricted document but we have nonetheless obtained a copy. I would first of all say that this document does not mention nuclear weapons accidents even though these are described as credible accidents by the US military and US military authorities do plan for such accidents.

The second point to be made with respect to the US General Statement of Assurances is that it says that all claims for liability will be settled through diplomatic channels in accord with customary international procedure in these matters. The notion of diplomatic channels means that such claims would be subject to negotiation rather than being a traditional legal claim. With respect to customary international procedure, a legal scholar at the University of Hawaii advises me that, in relation to radioactive contamination that would result following a warship incident, there is no customary procedure. Therefore, all of the information which I have been able to gather suggests that indeed the original recommendation of clarification of liability and indemnity issues could be made even stronger now. Thank you for the opportunity to summarise my report.

CHAIRMAN - Thank you. As I said this morning, the Committee will be looking at emergency services, but it is the reference accident that interests me most at the moment. The emergency services would have to be geared to what the reference accident is. In your calculations on the effect of a nuclear reactor accident, your accidental model assumes a breach of the reactor containment. Australian safety plans are based on a less severe accident in which there is no breach of containment. The more severe accident has been rejected because it is recorded as too improbable. Could you tell me the probabilities of your accident or your scenario and how you came to them?

Prof. Davis - Yes. I would be happy to. It is true that at the time the reference accident was developed, in 1976, that could have been considered the most credible accident that might have occurred. However, in the intervening decade, nuclear scientists have given a lot of consideration to the theoretical aspects of accidents and, in addition, we have now an empirical accident history that we can lean upon. With respect to the theoretical aspects, nuclear scientists now believe that an uncontained accident is substantially more probable than it was given credit for in the past decade. For reference to this point I would refer you to what is probably the most recent authoritative publication on the matter. A large panel of physicists and engineers, members of the American Physical Society, produced a very detailed re-evaluation of nuclear accidents in 1985. It is listed on page 91 of my report, under Wilson et al, 'Report to the American Physical Society of the Study Group on Radionuclide Release from Severe Accidents at Nuclear Power Plants'. In this document there is a lengthy discussion on the possibility of uncontained versus contained accidents. As may be judged from the document itself, the people who wrote it are of the opinion that uncontained accidents have been given far less attention than they deserve. I would emphasise that this report was written before the Chernobyl accident in the Soviet Union, which was, of course, by far the worst nuclear accident that has been experienced by human society and which was an uncontained nuclear accident - that is to say, the core inventory was released from the containment structure directly into the environment.

Senator Sir JOHN CARRICK - In the course of your opening remarks you said that a nuclear power-plant reactor on a vessel in Sydney Harbour would cause 10,000 casualties. Are you aware that all nuclear-powered ships are prohibited from entering Sydney Harbour, so it cannot happen? There are no berths and in fact, by government edict, no nuclear-powered ships come to Sydney Harbour.

Prof. Davis - That is at odds with my information, which is that there are three approved berths for nuclear-powered ships.

Senator HAMER - Your information is false.

Senator Sir JOHN CARRICK - Your information is totally wrong.

Prof. Davis - So there is no longer an anchorage at either Taronga Zoo or Hobbs Point?

Senator Sir JOHN CARRICK - It is possible for you to get information from here which will show you the state of the berths.

Prof. Davis - If, indeed, nuclear-powered vessels do not enter that port, then the analysis would----

Senator Sir JOHN CARRICK - Then you would withdraw your comments?

Prof. Davis - No, not at all. Then my comments would simply apply to any other city within which these vessels are berthed.

Senator Sir JOHN CARRICK - You would withdraw your comments about Sydney and you would, I take it, look at the berths to see whether there were any berths close to a city which could have the same impact.

Prof. Davis - I do not see any reason to withdraw comments that are accurate. The analysis of the nuclear power accident that I have done is fully accurate. If in fact nuclear-powered vessels enter that harbour, the harbour is subject to the type of accident that I have given you.

Senator Sir JOHN CARRICK - You would withdraw your comments about Sydney, if indeed you accept----

Prof. Davis - No, sir, I would not withdraw my comments. This is an analysis of a hypothetical accident scenario which is entirely accurate.

Senator Sir JOHN CARRICK - You did not insert the word 'hypothetical'.

Prof. Davis - If vessels did not visit the harbour, then of course the accident could not take place there. The same is true of nuclear weapons accidents. If nuclear capable vessels did not visit there, neither would that kind of accident be possible, but I should think that is self-evident.

Senator HAMER - I was going to get on to this nuclear weapons matter because there have been some rather odd remarks made in your paper. The first one I would like to deal with is a remark you made in the context of increased risks to the population from a global nuclear war, presumably. You made the flat statement: 'Naval vessels are targeted for destruction in the event of nuclear war'. What is your basis for that statement?

Prof. Davis - Nobody can know for sure----

Senator HAMER - It is a flat statement; I wonder what your basis for it was.

Prof. Davis - No one can know for sure what the targeting strategy of the Soviet Union is. It is all a matter of speculation, even within US----

Senator HAMER - That is not what you say; you say they 'are' targeted.

Prof. Davis - Even within US military circles. However, the assumption is made in the United States that all nuclear capable vessels are indeed targeted by submarines which are alleged to trail them. It is also assumed in the United States by the defence planning agencies that every----

Senator HAMER - Have you any evidence for that statement?

Prof. Davis - I would be happy to try to provide it for you.

Senator HAMER - I would be very happy to see it because I do not believe it.

Prof. Davis - You do not believe that nuclear capable vessels are targeted?

Senator HAMER - It is remotely possible. I want to pursue this because there are deductions drawn which I find rather bizarre. You go on to say that 'hence' their presence in Australian ports renders the corresponding port city vulnerable to nuclear attack. It is your contention, presumably, that in the event of a surprise nuclear attack, a nuclear Pearl Harbor, all ports in which American ships, whether capable of strategic retaliation or not, would themselves be targeted. Is that your assumption?

Prof. Davis - No.

Senator HAMER - That is what you say.

Prof. Davis - No, it is not what I say and it is not what I mean.

Senator HAMER - Whatever you mean, what you say is that 'hence' their presence in Australian ports renders the corresponding port city vulnerable to nuclear attack. What does that mean?

Prof. Davis - That means that if a nuclear capable ship were stationed at Garden Island approximately one and a half kilometres from Government House, that Government House and down-town Sydney would be destroyed by a nuclear blast at Garden Island.

Senator Sir JOHN CARRICK - Why use that hypothesis when we have just told you that that is impossible? Why use a hypothesis that is based upon an absolute impossibility? There will not be any station there.

Senator HAMER - I think he said 'nuclear capable'. I think we can dispose of this fairly quickly----

CHAIRMAN - There is one point I would like to bring up. I draw Professor Davis's and your attention to it. When representatives of the Defence Department came before us I made it quite clear to them that our term of reference was dealing with the emergency facilities and that the question of whether the ships are here or not here is entirely a political question. We accept the fact that they here just now, otherwise we would argue on forever about whether they should be here or not. We are sticking to the term of reference, that is, the probabilities of a nuclear accident aboard a nuclear-powered vessel or a nuclear-armed vessel.

Prof. Davis - That is precisely why I did not belabour that example in my text. There was only----

Senator HAMER - I was only worrying about the flat statements made on what is a matter of speculation - I think very improbable speculation, personally, though there may be different views on this.

Senator Sir JOHN CARRICK - What are your views on the theory of the nuclear winter? Do you support the general theory that, if there were a major nuclear exchange in the world, world-wide there would be some form of nuclear winter?

Prof. Davis - Inasmuch as we have just been advised by your good colleague that speculation is not desirable, I think I would desist from discussing that.

Senator Sir JOHN CARRICK - Unless I have that, I cannot ask you my next question nor can I relate to your paper. Let me----

Prof. Davis - What is your next question?

Senator Sir JOHN CARRICK - Why cannot you answer me? I ask you, as a biologist, whether you believe----

Prof. Davis - Is a nuclear winter within the terms of reference of this inquiry?

CHAIRMAN - If a nuclear winter could come from a reactor accident or a weapons accident, yes, you could include it. You would be drawing a very long bow indeed, and I think the probabilities there are on your side.

Senator Sir JOHN CARRICK - Do you conceive at all that it is possible that there would be an attack on an allied nuclear vessel in any harbour or any sea-way around Australia unless there were at the same time concurrently a world-wide nuclear conflict? Do you see Australia being an isolated nuclear target at all?

Prof. Davis - An isolated nuclear target, all by itself without other thermonuclear exchange?

Senator Sir JOHN CARRICK - Yes, that is right, and without the world going up. Can you see an attack on an American ship or an allied ship anywhere not being part of a total nuclear exchange?

Prof. Davis - Our President, Ronald Reagan, has discussed the possibility of theatre nuclear wars.

Senator Sir JOHN CARRICK - That is not what I asked you. I am asking what you think.

Prof. Davis - Inasmuch as our President and our Defence agencies are planning for theatre nuclear wars in Europe and potentially elsewhere in the world, I would bow to their wisdom and say yes.

Senator Sir JOHN CARRICK - There is no theatre nuclear war in an Australian harbour. I am asking you if there is an allied vessel anywhere in association with Australia which in your context becomes a nuclear target as such. Can it become a nuclear target in terms of a theatre nuclear war or will there not be a world war?

Prof. Davis - I do not know the answer to that.

Senator Sir JOHN CARRICK - Do you not need to know the answer to that? You have made an assertion. I put it to you that the fact of the matter is that what your assertion really underlies is that if you do not have them there, you will not have targets and you will not get into this messy nuclear war.

Prof. Davis - I do believe that the presence of installations on Australian soil that are part of the American strategic war fighting capability renders Australia subject to nuclear attack and your own Defence Department apparently believes the same thing.

Senator Sir JOHN CARRICK - Then would you please answer me on the question that I asked you about a nuclear winter, because it is very important to know whether in fact the attack on Australia's soil aggravates or not what could be a cosmic holocaust anyhow. If you got a nuclear winter and everybody was engaged, and Australia was engaged in ANZUS anyhow, in this situation, however horrible an attack on a ship in our port, the world would be in an enormous holocaust anyhow. So I asked you about the nuclear winter. Do you believe in the theory of the nuclear winter? Please - you must have a view.

Prof. Davis - To tell you the truth, scientists try to avoid belief in theories. What they prefer to do is to examine them and then, ideally, test them. This is a theory which we all----

Senator Sir JOHN CARRICK - Scientists like Sagan?

Prof. Davis - The nuclear winter theory is the subject of substantial debate right now. There is insufficient empirical observation to assess its probability. There are experiments going on right now in the United States involving the observation of large smoke plumes and these will hopefully clarify this possibility. Right now we do not really know what the impact of a massive global thermonuclear exchange would be.

Senator Sir JOHN CARRICK - I take it that you can conceive, because your paper says so, that there could be an isolated attack on an allied warship in Sydney harbour.

Prof. Davis - I repeat what I said before, that that is not my conception, that is United States defence planning policy - theatre nuclear wars.

Senator Sir JOHN CARRICK - Theatre nuclear war is in a theatre of war. Do you see any port in Australia being a theatre?

Prof. Davis - The Pacific is considered a theatre, yes.

Senator Sir JOHN CARRICK - I put it to you, Professor, that the discussion has been about the European theatre of war; that theatre nuclear weapons have been a discussion about Western Europe.

Prof. Davis - Are you saying that there is no planning for Pacific nuclear theatre war?

Senator Sir JOHN CARRICK - A nuclear theatre?

Prof. Davis - Yes, sir.

Senator Sir JOHN CARRICK - I know of none of a limited theatre of war at all. I know of none, and if you have some I would be grateful if you would let us have the papers.

CHAIRMAN - We are getting away from the terms of reference here.

Senator HAMER - The second postulated accident was the accidental incineration of a nuclear weapon. Before we discuss the consequences, we have to assess the probability. Would you run through the assumptions you made when you thought it was a probable accident firstly, on the state the nuclear weapon is in in the magazine and the circumstances under which this fire arises?

Prof. Davis - I would be glad to. As you are very well aware, the disposition of nuclear weapons aboard ships is classified information and indeed the United States Navy will not deny or confirm their presence. So neither the Australian Government nor I can be specific with respect to the disposition of weapons on board ships. We do not know what the situation is.

Senator HAMER - You must have made some assumptions when you were assessing the accident. What were they?

Prof. Davis - The assumptions that I have made and spelled out clearly in my report is that five kilograms of plutonium is dispersed by an accident.

Senator HAMER - No, I am not talking about that. I am talking about the state the nuclear weapon is in. How is this five kilograms dispersed?

Prof. Davis - By an accidental fire, the dispersal of energy for which is fossil fuel.

Senator HAMER - And how does this accident arise?

Prof. Davis - By an accidental fire aboard the ship which----

Senator HAMER - External to the magazine or inside the magazine?

Prof. Davis - I do not know where weapons are on ships. I do not even know if they are on ships, but presumably they are in some place on the ship and my assumption is that a fire reaches them.

Senator HAMER - This fire burns for three hours in a magazine?

Prof. Davis - I did not make any assumptions about where in a ship. My assumption is simply that five kilograms, one warhead, is dispersed by a fire and distributed across the metropolitan area.

Senator HAMER - Yes, I understand that, but I want to get some credible impression of how this came about.

Prof. Davis - Inasmuch as we do not have any information about that, because it is all classified, anything that I now say is bound to be speculative and I thought we wanted to avoid speculation.

Senator HAMER - Yes, except that you are postulating. We have seen newspaper reports of the horrendous consequences of this; it seems to me, quite frankly, absolutely inconceivable, but you have postulated that type of accident. I wonder on what assumptions you postulate this accident.

Prof. Davis - You might be interested to know that the United States military also postulates these accidents and has preparedness plans for them. If you like, I would be happy to read sections of reports from the United States military that document this and to enter them as evidence.

Senator HAMER - You mean shipboard fires burning five kilograms of plutonium?

Prof. Davis - No - dispersion of plutonium from fire involving nuclear weapons.

Senator HAMER - No, that is absolute nonsense. Weapons when they are in magazine storage are in a safe state. What you have to suggest is how the fire starts, what goes off in this magazine and why no one floods or sprays the magazine during this three-hour fire. It has to be some sort of credible accident otherwise it is not worth considering.

Prof. Davis - The fact that the United States military plans for such an accident would suggest to me and, presumably, to your Government that it is a credible accident.

Senator HAMER - All right. In what circumstance does it plan a shipboard fire?

Prof. Davis - It does not say.

Senator HAMER - No, I know it does not - it does not think it is going to happen.

Prof. Davis - Then why does it say that it plans for it?

Senator HAMER - Read the thing and I will tell you. I do not think I should be answering the questions, but I will tell you.

Prof. Davis - There are two documents that I think will be relevant: One is called 'CINPACFLT Instruction 6470.2C', and I have a copy which I would be pleased to enter into the evidence. The subject is: 'Medical Department Responsibility and Procedures in the Event of a Nuclear Weapons Incident/Accident'. One of the three references given to which this is relevant is the 'Naval Ships' Technical Manual', chapter 070. The purpose of this document is 'to promulgate policies and procedures for

Medical Department Personnel in the management of personnel casualties resulting from a nuclear weapons incident/accident'. I would submit that that, in itself, justifies the credibility of this accident - namely, the fact that the United States military is preparing for such accidents.

Senator HAMER - Just because it is preparing for some accident, you now cite specific consequences of a shipboard fire in a magazine in the stowed condition, resulting in the incineration over three hours of five kilograms of plutonium, as I understood your reference----

Prof. Davis - Do you have evidence that nuclear weapons are stowed in magazines aboard----

Senator HAMER - That is what I am asking for.

Prof. Davis - I think you should ask the United States Navy.

Senator HAMER - We have.

Prof. Davis - What did it say?

Senator HAMER - It has not answered yet. You have put forward a proposition which I frankly think is absolute rubbish, nevertheless I have tried to get you to justify on what basis you are making these assumptions. Certainly we will get the answer out of the United States Navy in due course, but what we want to know is on what basis you are making these assertions. I cannot find any basis at all.

Prof. Davis - In order to do a site-specific quantitative analysis of any accident scenario, you must start with a source term. On a typical nuclear weapons vessel there may be up to 100 warheads. I have taken one per cent of that inventory - one per cent of 100 warheads - imagined that it is dispersed accidentally in a shipboard fire, and evaluated the consequences of this.

Senator HAMER - I want to know how you think this may happen?

Prof. Davis - You mean how such a fire could result?

Senator HAMER - Yes, how such a fire could result in such consequences.

Prof. Davis - The answer to that would require access to the following information: Firstly, the frequency and duration of shipboard fires in the United States Navy; secondly, the proportion of these that occur in port; thirdly, the capacity of nuclear weapons to withstand thermal stress in the event of this kind of accident; et cetera.

Senator HAMER - Fourthly, you might like to ask when a fire last occurred in a magazine in a United States warship.

Prof. Davis - Are nuclear weapons stored in magazines aboard ships in harbour in Sydney?

Senator HAMER - They are when they are here - quite so. I happen to know that, but I do not think I should be telling you your evidence. I found the whole thing quite incredible and I do not think it is worth discussing any further.

Senator Sir JOHN CARRICK - Let us see if we can take it step by step. As I understand it, what you are predicating is a fire, not that there will be any nuclear explosion. In long term, after three hours, the ordinary conventional explosive that surrounds the plutonium would cause a conventional explosion and would put a particular plutonium in the air - plutonium oxide, and so on. Am I right in that? So in fact what you are saying is that there is the same risk, except for the distribution of the plutonium, as for every high-explosive weapon lying in every non-nuclear armed vessel in the world, because fire plus high explosives give you explosion. Surely, the very first thing that we need to know is the incidence of that. To understand Senator Hamer, and supposing that there is a risk, we have to make recommendations about protection from the risk. What evidence have we that fire on any vessel has caused the high explosives to blow up?

Prof. Davis - I would answer that question in two stages, if I may. The first would be to read again briefly from the document that I have just entered into evidence from the United States military which says: 'In the handling, storage and transportation of nuclear weapons there is a potential risk of an explosion which is similar to that involved while handling conventional munitions'. So there is the statement of potential risk.

Senator Sir JOHN CARRICK - That is what I have just said, and now we have to measure the risk. It says that it is the same risk of explosion, except that it will disperse plutonium. So will you tell us what that risk of explosion is?

Prof. Davis - I would refer you to recommendation No. 5 on page 85 of my report, which says:

> If port visits by nuclear warships are contemplated for the future, Australian authorities should seek information from the governments of visiting ships that would enable independent calculation of the probability of the type of accidents modelled here.

As it also says clearly in the text, I have not assessed, and cannot assess, this probability because I lack the types of information which I just described to you. Consequently, the acceptance of visits by United States warships is tantamount to accepting an incalculable risk.

Senator Sir JOHN CARRICK - You can, in fact, calculate one thing - because we are both in agreement, as is that document - and that is that there is the same risk of fire, except for the plutonium, as in an ordinary vessel with high-explosive weapons on board. It must be available to you and to the rest of the world what that risk was and has been over the decades. When have fires set off high explosives on vessels?

Prof. Davis - Yes. The United States Navy would have that information.

Senator Sir JOHN CARRICK - Can you lead us to it?

Prof. Davis - Actually Australian ports that are visited by warships are subject to this risk and I would think that the most likely way of obtaining it would be for the Australian Government to ask the Navy for it. When I have asked the Navy for it it has not provided it.

Senator Sir JOHN CARRICK - Supposing that we say to you that the evidence before us so far is that there is almost no evidence of fires being caused on orthodox warships carrying orthodox HE explosives.

Senator HAMER - There have been fires but there have never been magazine explosions.

Senator Sir JOHN CARRICK - There have been fires but there have never been explosions from it. It is very important for us to know whether that is right or wrong.

Prof. Davis - I would say that you have access to information that is classified and that I do not have access to.

Senator Sir JOHN CARRICK - Supposing we are right, then it must minimise the risk.

Prof. Davis - Yes. One of the two ways of computing a risk of a nuclear accident - and I think the best way - is from empirical accident history. I have with me from the General Accounting Office a report which was released in February of this year and which states that the United States military acknowledges 630 incidents involving nuclear weapons and 32 accidents, 12 of which caused significant release of radionuclides and endangered the public.

Senator Sir JOHN CARRICK - Of 600-odd accidents how many were because the nut fell off the bolt and how many of them were related to nuclear matters?

Prof. Davis - Of the 630 incidents the occurrences involved relatively minor unanticipated events such as bent tail fins on a missile, flat tyres on a convoy, et cetera. The 32 accidents involving nuclear materials involved events that could potentially risk lives in the public. The 12 of those 32 that caused the release of radioactive materials did indeed present a risk to the public.

Senator HAMER - Did any of those occur on board ship?

Prof. Davis - Only two such accidents are alleged to have occurred on warships.

Senator HAMER - What were they?

Prof. Davis - One was the loss of an A4 aircraft with weapons aboard in the Pacific; it sank to the bottom. The other was a classified accident aboard a submarine. The submarine is not identified nor is the nature of the accident.

Senator Sir JOHN CARRICK - In probing I want to say to you that we are as interested not to get a distortion this way in the evidence as that way. In other words, we are looking for the objective truth - please accept that from us - and we are interested in not creating public melodrama or underestimating the threat. If we are pressing you, and it looks as though we are trying to minimise the incidents, do not think that that is just a course of action that we are pursuing for that reason. Please accept that.

Prof. Davis - I do. I understand.

Senator Sir JOHN CARRICK - In the end this document of ours has to stand the test right around the world.

Prof. Davis - Let me respond in kind, that I wish that I could answer your question with respect to the probability of a nuclear weapons accident but, as I state in my report, I cannot. All I can do is calculate the consequences of what I regard as a fairly minor accident or a moderate accident and I can do that very precisely. The risk is the equivalent of the consequences times the probability and in view of the large consequences the recommendation that I would make is that you, as members of the Australian Government elected to protect the public from such risks, assess the probability so that you can determine the risk.

Senator Sir JOHN CARRICK - We would be grateful for your help on that. We would like to see if you can get the dimension of your weapons risk. You would agree, I think, that there is no physical possibility, using physics as the word physical possibility, of a nuclear explosion occurring. In other words, what we are not talking about is a nuclear explosion. You would agree, too, that what we are talking about is a fire or some method of dispersal of particulate plutonium. Is that right?

Prof. Davis - Yes.

Senator Sir JOHN CARRICK - That defines the size of the problem. Those who believe that a nuclear weapon anywhere is capable of explosion, unless armed and triggered and so on, would be misled. Is that right?

Prof. Davis - I would not say misled so much as uninformed because, in fact, the details of nuclear weaponry, as you well know, as well as their safety features, which I would presume are, and accept as being, extensive, are unknown. These are classified forms of information. The only kinds of reports that I have on these issues are the types that appear in newspapers and may not be what this Committee needs to know.

Senator Sir JOHN CARRICK - We understand your difficulty. We have difficulties also.

CHAIRMAN - I would like to pose the same question in a different way. You argue in your paper that the most likely accident scenario for a ship weapon is incineration. This is consistent with the submission of the Australian Department of Defence to the Committee that said:

> The worst credible weapons accident that could occur during a port call by a visiting warship is considered to be one that might follow a major fire in the vessel's magazine.

The Department went on to say, however, that it believed that the size of the zone affected would only be a few hundred metres radius and that this would probably be the only area that was unsafe. You can get that in the 'Hansard' at page 10, reporting the Committee inquiry which took place in December 1986. Your model weapon accident suggests much greater problems. Why does your accident have greater problems than the one that our Defence Department had envisaged?

(Evidence, p. 599)

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Prof. Davis - Inasmuch as I do not know what the assumptions and quantitative basis for its analysis were - and I would have to know that in order to compare them - I cannot answer the question. We would have to know how much plutonium it presumed was released, what the dispersal energies were, the kinds of dispersal models it used, the dosimeter reading, et cetera. If I could see that then I could answer your question.

Senator HAMER - I think we might move on to the more serious one which is the reactor accident which has a definite chance of occurring. I think you must be aware of the Australian conditions of entry for nuclear-powered warships. You are aware, are you, that they are assessed against the standard accident model, that is, the reference accident? Are you aware of the difference between the model used and your model?

Prof. Davis - Yes.

Senator HAMER - There are quite serious differences. I am sure you would know of that. Do you think the differences reflect on the validity of the Australian assessments?

Prof. Davis - Yes.

Senator HAMER - Do you disagree with the reference accident as being the most serious?

Prof. Davis - Yes.

Senator HAMER - Is it because you would assess much greater leakage or much greater degradation of the containment vessel?

Prof. Davis - That is one of two primary differences. The other is that that Australian AEC analysis appears only to have concerned a single radionuclide, namely iodine - iodine 131 with a half-life of 8.05 days. In the Rasmussen report which is the alleged basis of Australian regulatory guides, some 52 radionuclides are recognised as contributing potentially significant health defects. I have determined quantitatively the relative impacts of those 52 and will tell you that iodine is relatively minor compared to some of the volatile oxides and other radionuclides which could and have been released in nuclear accidents.

Senator HAMER - You understand that we have to logically go through the likelihood of the occurrence and the scale of it and then its consequences. Therefore, could I concentrate first on the scale of the disaster. What is the cause in your model of the much greater breach of the containment system for the reactor? On what basis do you assume that is going to happen?

Prof. Davis - I make no specific assumption as to the cause of lack of containment. I simply assume lack of containment and calculate source terms on that basis.

Senator HAMER - Why do you assume lack of containment? There is containment there and I presume it has to be breached if there is going to be a serious leak. I think the model assumes a one and a half per cent leakage a day or something like that which is relatively slow. You assume a much faster leak. I wonder why?

Prof. Davis - The model used by the AEC as I have understood it from this morning's additional submissions actually imagines a greater release from a core into the reactor compartment than I do. It is a substantially greater release, a greater fractional release. Then they assume that that material remains trapped inside the hull of the vessel and leaks out only slowly through controlled pressure relief valves that are built into the ship. That is one possible scenario without question. But as I mentioned earlier, the American Physical Society, a collection of a large number of nuclear scientists with broad expertise, believes that the major problem with the Rasmussen report and, by implication, with the Australian analysis is that it underestimates the possibility of uncontained accidents. Indeed, the accident at Chernobyl was just such an accident. Therefore, I believe in line with this more current thinking on the issue that uncontained accidents deserve more attention than they have previously received both on theoretical grounds and also on empirical grounds. That was my reason for using a different reference----

Senator HAMER - You understand that we have had evidence that suggested that the idea of a serious breach of containment is not a credible accident. That is why I am interested in how this could occur. If it does occur it makes a big difference to the whole problem.

Prof. Davis - Any such evidence that you have had must involve classified information about submarine construction that I am not aware of. But certainly even the containment at Three Mile Island must have been substantially stronger than is possible on a submarine simply because you do not have that much room for additional weight on a submarine.

Senator HAMER - One of the differences put to us was the cooling effect and the fact that the ship is floating or possibly submerged in sea-water. That was cited as a big difference to the likelihood of penetrating the hull.

Prof. Davis - Is that the cooling effect of water outside the vessel affecting the reactor core on the inside?

Senator HAMER - It is on the probability of a penetration of the hull by a melt-down.

Prof. Davis - How would cooling the hull change the----

Senator HAMER - I am really asking the question, not answering it. That point was put to us.

Senator Sir JOHN CARRICK - It was put to us that if you had a partial melt-down you could stop it very easily by flooding because you have access to unlimited water.

Prof. Davis - By flooding the reactor chamber?

Senator Sir JOHN CARRICK - Yes.

Prof. Davis - As a general rule you do not want to put water on zirconium in the presence of heat because you evolve hydrogen which blows up.

Senator Sir JOHN CARRICK - But pressurised water reactors have a sump, as we were advised and as it has been demonstrated to us, from which you can draw and replace the fluid over the rods so that the rods are not bare.

Prof. Davis - Is that the primary coolant do you mean?

Senator Sir JOHN CARRICK - Yes.

Prof. Davis - So you are saying that in the event of a loss of coolant you can substitute sea-water for the coolant.

Senator Sir JOHN CARRICK - You can substitute water anyhow.

(Evidence, p. 603)

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Prof. Davis - That is fine so long as the reactor core is not melted and exposed but if it is melted and exposed the last thing you want to do is put water on it because, as I mentioned, water and zirconium at high temperatures evolve hydrogen.

Senator Sir JOHN CARRICK - I understand that. But one anticipates that all this does not happen just like that.

Prof. Davis - On the contrary, a melt-down could happen in minutes in the absence of coolant. It could happen in minutes and a breach of containment could likewise happen in minutes.

Senator HAMER - Your assumption is that the containment in the submarine or on a surface ship is less strong than in a shore-based reactor?

Prof. Davis - Once again I have not made any such assumptions because they would be based upon speculation, inasmuch as the details of construction of a naval propulsion reactor and its hull are classified. In the absence of such information I have simply assumed an uncontained accident and then modelled the consequences of that using the NRC methodology.

Senator HAMER - You can help us as you seem to have considerable detail on the consequences of an uncontained accident, but you cannot help us on the probability of such an accident?

Prof. Davis - The only way I can help you is by analogy with the commercial industry, which I fully acknowledge is an inadequate basis. In order to accurately assess the probability of naval propulsion reactor accidents you need access to the empirical accident history of naval propulsion reactors.

Senator HAMER - That has got us on the same wave length then. We can turn perhaps to the consequence of the accident.

CHAIRMAN - The accident described involved a release of fissionable products to the atmosphere over four hours. How might such an accident occur and, in particular, does it assume that the containment is breached and, if so, how is it breached? I am still not clear. Do you envisage a steam explosion, or what? I cannot see how you envisage the chamber being breached.

Prof. Davis - Once again I have not been explicit in my report as to the specific accident scenario that could lead to an uncontained accident; there are dozens of them that could. Different ones have occurred in different reactors at different times in the history of the industry. So rather than speculate on the details of classified reactors, I have simply assumed an uncontained accident of relatively moderate proportions and then analysed its consequences.

Senator Sir JOHN CARRICK - You have mentioned some 630 accidents and you have reduced it to a small number that had some radioactive consequences. Did any of these accidents occur in a port?

Prof. Davis - To my knowledge, no accidents that have been reported by the military have been reported to have happened in port.

Senator Sir JOHN CARRICK - You have mentioned that there was some release of radioactive material. At any stage was it a significant release, and did it have any measured effects on people, on the community?

Prof. Davis - Are you referring now to the 32 acknowledged nuclear accidents, including those 12 which caused releases?

Senator Sir JOHN CARRICK - I am asking about any accidents that have caused releases but I am not talking about Chernobyl.

Prof. Davis - Yes, there are a number of accidents which have been fully reported in the Press including the loss of nuclear weapons in Spain; the crashing of the B52 on to the ice in Greenland; a crash of a bomb ladened airforce plane at Edwards Airforce Base in California, et cetera.

Senator Sir JOHN CARRICK - Could you take them one by one. The first one, the Spanish one, I think was a dropping of a bomb, was it?

Prof. Davis - Yes, that is right.

Senator Sir JOHN CARRICK - The important thing about that, I suppose, was for both of us to identify that when they are dropped they do not go off. That is the first thing that we note on it. Secondly, what accurate evidence is there of damage to people?

Prof. Davis - There was a substantial dispersion of plutonium that required a costly gathering of soil and the shipping of it back to the United States. It is my understanding, although I am not fully versed in these details, that there is a continuing effort to extract compensation and continuing evidence of biological impacts in Spain.

Senator Sir JOHN CARRICK - I understand those things, but there is no hard proof. I am not trying to minimise it, I am trying to get facts for ourselves as to what did happen. Where have we got firm evidence of the release of radioactivity? We have Chernobyl, of course; we have got very clear evidence at Three Mile Island because that is very largely negative, is it not?

Prof. Davis - That was what?

Senator Sir JOHN CARRICK - Very largely negative in its external effect. It had no particular impact upon the community around.

Prof. Davis - It depends on how you define impact and whose reports you wish to believe.

Senator Sir JOHN CARRICK - Can you help us?

Prof. Davis - With respect to the impact of Three Mile Island?

Senator Sir JOHN CARRICK - Yes.

Prof. Davis - Yes, I can. Firstly I would emphasise that the containment structure in the Three Mile Island case weighs more than a military submarine. So we are talking about a structure that is much stronger than anything that could possibly be on a submarine.

For that reason I question the relevance of TMI as an analogy or a metaphor for a naval propulsion reactor, but in fact that accident was relatively well-contained compared to what might be possible. There was a relatively small release of iodine compared to the total core inventory. I am not certain what the release of other radionuclides was. In fact, I have never seen anything published on it, and I do not know why. Either they were not measured or they have simply not been accounted for.

Senator HAMER - One thing that has worried me a bit is that the Atomic Energy Commission's submission puts weight on iodine. You mentioned this a little earlier. You, I think, in your analysis ignore the other fissionable materials. You put in ruthenium 103 and tellurium 132 which, I think, you said gave a much greater contribution to the health problem than iodine. Could you explain that a little more? Is that generally accepted or is it a theory of yours? It is perhaps unfair to ask you why you differ from the Atomic Energy Commission.

Prof. Davis - No, I do not think it is unfair at all; it is a good question. I approached this problem freshly, without leaning terribly on what has been done in the past, or what has been stated in the past and I know that iodine is generally, even in the United States, considered to be the most troublesome radionuclide. That is the conventional wisdom. My approach to the problem was to take the 52 radionuclides listed in the Rasmussen report and to determine the percentage of health impact of each one of them for several different biological pathways - specifically, cloudshine, inhalation and groundshine. The way that I did this was to take the accepted dose conversion factor for each of these radionuclides and multiply it by the source term; that is to say, the total quantity of available radionuclides. In this way I could determine the contribution to health impact of each of the radionuclides and then express it as a percentage of the total impact. That is done on page 61 of my report for the three pathways that I considered.

You will notice that I ignored ingestion of radionuclides and I ignored resuspension. These are two pathways that are normally considered which I have ignored on the assumption that the city would be evacuated rapidly. As you will see on page 61, the percentage of contribution in each of the three pathways, as expressed in percentages, is relatively small for iodine. It is the third largest contributor to the cloudshine pathway, but with respect to the inhalation pathway it is about eighth or tenth and with respect to groundshine, it is fourth or fifth, in that neighbourhood. The significant feature of iodine is that it is taken up by a single gland, the thyroid, and it has a half-life of 8.05 days. The other radionuclides - caesium 137, for example - not only have a larger contribution for at least some of the pathways, namely inhalation, but in addition they persist for much longer. So if you integrate the consequences of an accident like this over time - I have not done this, but if you do this - then iodine becomes a relatively minor contributor to the overall health impact and to the overall economic impact.

Senator HAMER - In your assessment of health impact were you assuming that iodine tablets would be given out, or that no counter action would be taken? Presumably, if iodine tablets are given out, iodine becomes even less significant, relatively.

Prof. Davis - That is if you are considering thyroid doses, but all of my analyses are whole body doses. In fact, potassium iodate, the non-radioactive iodine, will compete with the radioactive iodine and minimise uptake by the thyroid for that single radionuclide. But inasmuch as it is a minor contributor to the overall health impact, the distribution of potassium iodate tablets would not have a significant mitigating effect on a nuclear accident.

Senator HAMER - Are there any other pills, such as the iodine pills, that can be taken to counter the whole body effects?

Prof. Davis - None that I know of.

(Evidence, p. 609)

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Senator HAMER - All our premises are, as you know, based on distributing iodine tablets particularly to children. From what you are arguing, we are doing nothing about the more serious risks. Is there nothing that can be done, other than evacuation?

Prof. Davis - That is, in general, correct.

Senator HAMER - I did not want to question too much the assumption you made about the nature of the exercise; I am more interested, from what you have been saying, in your estimate of the consequences of the given accident rather than what caused it and how likely that is. I think in your assessment of the consequences you made no allowance for the possibility of the vessel being towed away and removed to a remote anchorage. Would that be correct? You assumed it stayed there for the full period.

Prof. Davis - Yes. I assumed that the vessel would stay there for the full four-hour duration of the release. That is correct.

Senator HAMER - The full four hours. It would be a job getting away in less than four hours anyway, I should think.

CHAIRMAN - The Navy gives us 24 hours.

Prof. Davis - An accident could last longer than that too. The problem there is that if you take a stricken vessel which is emitting radioactivity and begin to tow it, you are in essence distributing the radionuclides over a broader metropolitan area and, in certain senses, compounding the problem.

Senator HAMER - The value of the towing away was based on a much slower rate of emission than you are suggesting and certainly I do not think any vessel would be towed away in under four hours; it would be extremely slick work if it were.

Prof. Davis - The notification procedures could take that long.

Senator HAMER - You are suggesting contingency plans, including evacuation. Do you know of anywhere where anyone has exercised evacuation?

Prof. Davis - No, I do not.

Senator HAMER - But are you suggesting that we should?

Prof. Davis - I do not think that it would be socially realistic to practise evacuating a city like Sydney over the whole area that needs to be evacuated. I think that is unrealistic. What would be socially realistic is to exercise the communication lines that would be activated in the event of an accident, and also to inform the public explicitly what to do in the event of an accident, and that has been done elsewhere. There is a Government Accounting Office report in the United States that was published in 1979, in which the off-site consequences of nuclear reactor accidents and emergency planning were examined. In three of the 15 sites that were examined there were emergency evacuation plans in place, although in none of those places in the United States had they been exercised either. The recommendation of that GAO report was that rehearsal and exercise of those plans be undertaken because, in the absence of rehearsal, the plans could not be effective. This is not my conclusion; this is the conclusion of the General Accounting Office of the United States Government.

CHAIRMAN - The submissions from the Department of Defence and the Atomic Energy Commission state that United States naval operators are trained to the highest standard in the world. You cast doubts on this on page 14 of your submission, where you also state that independent assessment of naval reactors does not occur. What evidence do you have for these statements?

Prof. Davis - With respect to the competence or non-competence of naval propulsion reactor operators, I refer to an article in the 'Enlisted Times' by a man named Lipman, who was a former instructor at the naval propulsion reactor school, who quit the school and, in doing so, made charges of incompetence in teaching and cheating in exams, and so on and so forth. His complaints were later confirmed by other people at the school. I am not saying that that means that the training there is any worse or better than one can get any place else, but it would seem that there are problems in the naval propulsion program educational scheme. I also note in my report that in the Three Mile Island accident, which is acknowledged to have resulted from human error, five of the eight operators on duty at the time had been trained in the naval propulsion reactor school. Perhaps the technical training that one can obtain in that school is as good as one can get anywhere, but what can never be eliminated, as shown by virtually every nuclear accident that has taken place, is the human factor, the possibility of human error.

CHAIRMAN - How are arrangements concerning liability and indemnity in respect to nuclear accidents affected by the Price-Anderson Act, and does this apply to both reactor and weapons accidents?

Prof. Davis - To my knowledge, in the United States there are no arrangements whatever with respect to liability and indemnity in the event of a military accident in a port. I have tried to find out information, both from the United States Navy and from other places in the States, and, as best as I can determine, there are no such arrangements.

(Evidence, p. 612)

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CHAIRMAN - What decontamination actions would be necessary, following an accident of the kind described, and what effect would they have in reducing the casualty figures?

Prof. Davis - The measures that would be required have never been developed. There is no history of radioactive contamination of a large urban area and one simply does not know how one would go about decontamination. I could speculate by describing the kinds of problems that would have to be faced in such an incident. For example, the air conditioning systems in skyscrapers would draw in contaminated air and distribute it within the insides of all buildings in which air conditioning systems had not been turned off. So one is talking about the removal of radioactive contamination from both the inside and outside of all structures within perhaps 100 square kilometres of a metropolitan area. There was a report published in 1986, again by the General Accounting Office of the United States Government, which estimated the cost of cleaning up after such an accident and, although the techniques for decontamination were not spelled out, the estimates of cost range from $US0.3 billion to $US150 billion. Those really have to be considered speculative figures, I think, because we do not know exactly how one would go about that decontamination, how long it would take, what we would do with waste materials, and so on.

The second part of your question was how decontamination would reduce casualties. Unless the city were evacuated shortly after such an accident, as soon as possible - I assume 24 hours is a realistic figure - the casualties would be much higher than those I have mentioned. I have, in my study, computed the casualties, assuming one week of additional habitation and also one year of additional habitation and those figures are presented in my report. They are substantially higher than those which I have orally described here. So I presume decontamination would be necessary. Unless that decontamination were carried out, people could not move back into the affected area without experiencing significant additional casualties, mainly from the resuspension and the ingestion pathways.

Senator HAMER - One of the difficulties we had - because this is a highly technical area and we cannot pretend to be experts - is the difficulty of comparing your work with what the Atomic Energy Commission has given us because you are assuming different accidents. If you accepted our reference accident, except for the issue of iodine and other particles, would you have any other serious disputes about the consequences of the reference accident, not your one? Are you and the Atomic Energy Commission in disagreement on that or substantially in agreement?

Prof. Davis - In order to answer your question properly, I would have to talk with AAEC officials and also see more details of the nature of their calculations. But I did see this morning the supplementary handout that they had given in which they described source term, that is to say, the fraction released from the core to the reactor compartment and that seems realistic to me. I did see some of the meteorological conditions that they have assumed, including the Pasquill F category, which is the most consequential, and that seems prudent to me. Certainly it seems that many of their assumptions are similar to mine. The two basic differences are, first of all, that they assume a contained accident and I have assumed a moderate uncontained one. Secondly, they examine only iodine and I examined the full range of radionuclides.

Senator HAMER - The first one, I think we agreed earlier, is not even going to help us very much, that is the probability of the accident. What we are interested in is the accident having occurred, we have got to decide whether the reference accident is right or the more serious one is prudent planning. Would I be right in saying that you are broadly in agreement on the consequences of the reference accident?

Prof. Davis - No, I would say that the reference accident, by the omission of other radionuclides, itself significantly underestimates the impact. The inclusion of those other radionuclides would, just as an off the hand estimate, increase the consequences by perhaps an order of magnitude or two - a factor of 10 or 100.

Senator HAMER - I see. I am not meaning to be offensive, but are you on your own in your emphasis on these other radionuclides or is that a fairly general emerging scientific opinion?

Prof. Davis - I have never seen regulatory plans based on anything except iodine by itself, although any nuclear scientist is fully aware that the other radionuclides have impacts. The dose conversion factors are published. In fact, they are reported in my appendix and as you can see, they are quite a bit higher for radionuclides other than iodine. The half-lives are well known and it is known that iodine is a relatively short-lived isotope. So why regulatory authorities have put so much emphasis on iodine all by itself I can only speculate. I think probably the accident at Windscale, now named Sellafield, in which much more iodine escaped than anybody had predicted, may have sensitised the nuclear community to the possibility that iodine would have more impact than previously discussed.

Senator HAMER - I want to get this quite clear because this is an obvious area we will have to probe, and I want to see what scale of emphasis it should be given. You would suggest that even accepting the reference accident, that is leakage rather than rupture of the containment was the one we should deal with, assuming that is the conclusion reached, do you still think that the consequences are underestimated by a factor of something like 2? Is that a correct summary of what you just said?

Prof. Davis - A factor of 100 - two orders of magnitude.

Senator HAMER - Two orders of magnitude? One hundred times as serious?

Prof. Davis - Yes. The quantitative basis for that is on page 61 of my report, in which the contribution of iodine to cloudshine is 14.93 per cent. The contribution of iodine to the inhalation dose is 1.87 per cent and the contribution of iodine 131 to groundshine is 8.05 per cent - this assumes no decay. The inhalation dose and the groundshine dose are generally considered to be the biggest and iodine has the smallest contribution to those. Furthermore, the long-lived nature of the other radionuclides would exaggerate the difference between them and iodine even further. So the overall consequences could be at least 100 times greater, even of the reference accident.

Senator HAMER - I am trying to concentrate on the reference because it is the only thing we can really compare with at the moment. If you are right in this - I frankly have no way of knowing - this is a very marked change in the damage assessment. Is this being taken up in America by the nuclear regulatory agencies or are you a lone voice in the wilderness?

Prof. Davis - The impacts of other radionuclides are frequently examined. Caesium 137, for example, is known to be an especially difficult one because of its volatility.

Senator HAMER - The magnitude of difference in consequences is pretty major.

Prof. Davis - Yes, it would be.

Senator HAMER - Do you know if it is being taken up by any of the nuclear regulatory agencies? I am asking that because if we investigate this we would want such information as we can get on whether this is generally accepted because when scientists disagree it is very difficult for a committee of politicians to adjudicate.

Prof. Davis - I understand. I am afraid that I cannot answer you very specifically about to what degree the other radionuclides are taken into account in emergency planning documents in the United States. I could try to find that out; I am interested myself.

Senator HAMER - That would be of great interest to us, because, obviously, we have to pursue this allegation. Whether we accept your accident or not, the consequences are of such a different order of magnitude from what we have been told that they have to be investigated and any lead that you can give us as to where this has been assessed and both pro and contrary views would be helpful.

Prof. Davis - I will, both for my own interest and in the hope of furthering the work of this Committee, look into the question and communicate it to you.

CHAIRMAN - You estimate that strontium nuclides would contribute 19 per cent of the inhalation hazard. What physical mechanism did you assume for the leakage and dispersion of strontium into the atmosphere? Did you allow for greater hold-up in the containment of solid compared with the volatile materials and volatile compared with the gaseous materials?

Prof. Davis - Yes, I did. I assumed that fractional releases were 100 per cent for the noble gases, Xenon and krypton, 10 per cent for the volatile oxides and one per cent for all other radionuclides including strontium 90. The actual release at Chernobyl for strontium was 3 per cent.

CHAIRMAN - Regarding the reference to hydrogen on page 14 have you made any attempt to calculate the quantity which could be generated in a core-melt accident in order to check the feasibility of explosive mixtures of hydrogen and air occurring?

Prof. Davis - No, I have not. I do not feel the need to make such calculations myself to demonstrate the feasibility, inasmuch as precisely that occurred at Three Mile Island. Hydrogen was generated by the interaction of zirconium and steam. The formation of a hydrogen bubble forced the coolant down off the core which is what led to its disruption. The question of whether that hydrogen exploded or not is a controversial one. Some people say that it ignited but did not explode and it may well have been that the relative restriction of air supply limited the rapidity of the ignition so that it could not, in fact, be called an explosion. In any event these events did occur and that is by no means hypothetical.

CHAIRMAN - Could you explain why you have compared your estimated releases of radioactive material with the United States limits for routine discharges rather than that with the limits recommended for use in consideration of discharges following accidents - that is, the emergency reference levels of protective action guides?

Prof. Davis - That question is based upon a misinterpretation of the limits that I actually used. There are no routine limits of plutonium release, for example. The ground contamination limits that I used are limits for the unrestricted use by the public.

CHAIRMAN - Thank you very much for your appearance here and the trouble you have gone to with your submission.

Committee adjourned at 3.26 p.m.