

Board of Inquiry and Health Studies

- 3.1 The initial concerns relating to the health of many workers in the formal DSRS programs, led to the commission of a Board of Inquiry (BOI) in 2001. In response to recommendations from the BOI, a comprehensive system of health care and monitoring along with studies into the health of former DSRS workers was instituted. This Chapter deals with the BOI and the various health studies.

The Board of Inquiry

- 3.2 In July 2000, in response to an investigation by Officer Commanding No. 501 Wing (OC501WG), the Chief of Air Force commissioned a BOI to examine aspects of the four formal DSRS programs in relation to the health, chemical exposure and work practices of employees. The BOI researched over 1.5 million documents, covering a period of 27 years and took statements from over 650 individuals. The BOI report, released on 8 September 2001, included some 53 recommendations, all of which were accepted by the RAAF and were later transitioned as much as possible for wider use by Defence.

Events leading to the commissioning of the BOI

- 3.3 In late 1999 senior staff within the Fuel Tank Repair Section (FTRS) at 501WG at Amberley became concerned at the health effects being experienced by members of the FTRS. Inspections of the Material Safety Data Sheets (MSDS) concerning the chemicals being used in the DSRS process prompted further questions in relation to Personal Protective Equipment (PPE), especially respirator equipment. Concerns were also

raised by the Sergeant in charge of the FTRS with the medical section about the possibility of a chemical-related health issue within the wider F-111 program over a prolonged period. Separate reports from both the Commanding Officer of the FTRS and a doctor at the medical section, raised sufficient concern for the OC501WG to suspend any further fuel tank repairs.¹

- 3.4 On 4 February 2000, a formal investigation was launched by OC501WG to determine the level of exposure to chemicals, the numbers of affected individuals and the re-establishment of safe fuel tank repair processes. This was limited to the spray seal process that was introduced in 1996.
- 3.5 On 19 July 2000, the CAF commissioned a BOI to investigate the four formal DSRS programs in relation to the personnel involved and their health complaints, the chemicals used, the use and adequacy of PPE, work practices and OH&S, Commonwealth compensation legislation, medical and scientific knowledge concerning the chemicals and systematic issues arising that have ramifications for the RAAF or ADF.²

Findings of the BOI

- 3.6 The BOI made a range of findings including:
- The failure of the Air Force medical service, firstly to respond to the seriousness of the symptoms presented and secondly, by employing medical staff on contracts which prevented them from thoroughly examining the occupational environment in which their patients worked.
 - The lack of power felt by aircraft maintenance workers, especially where their health complaints were ignored and they were forced to accept this and 'get on with the job'.
 - The RAAFs reliance on PPE to protect its workers rather than on a commitment to the development of new solutions to prevent fuel leaks.
 - The problems with PPE in that they lacked protection from chemicals and on some occasions were not used at all because of the confined spaces in which the work was conducted.
 - A failure in the chain of command, especially at the lower levels where personnel felt pressured to meet operational requirements. This led to the development of a 'can-do' attitude and failure to insist on following

1 *F-111 Deseal/Reseal Board of Inquiry* Volume 2, Chapter 1.

2 *F-111 Deseal/Reseal Board of Inquiry* Volume 1, Appendix 2.

the full range of PPE and safety procedures. The BOI also identified a communication breakdown between SNCOs and junior engineering officers due to the intense workload placed upon these staff.³

3.7 Defence advised:

The Board of Inquiry report contained 53 recommendations. The Chief of Air Force subsequently added 2 supplementary recommendations (S1 and S2) and modified a number of other recommendations to reflect the broader Defence-wide approach required to resolve the issues identified.... recommendations can be divided into 3 broad categories: those that are Air Force specific, those that deal with systematic issues associated with the corporate management of occupational health and safety (OHS) in Defence and those that require less complex Defence-wide action.⁴

3.8 It should be noted however that the BOI made two key recommendations pertinent to the Committee's inquiry. The first was Recommendation 2.8:

The Air Force should ensure that all personnel who may have been exposed to toxic chemicals, in any of the programs, are provided with medical checkups and sympathetic advice and treatment. This should be at regular intervals, and careful records should be kept. This approach should be refined as the results of the DVA study become known.⁵

3.9 The second was Recommendation 9.2:

The Air Force should appoint someone to act as advocate for fuel tank repair workers whose health has been affected. This advocate should assist these workers in dealing with the authorities and, in particular, assist in preparing compensation claims.⁶

3 *F-111 Board of Inquiry, Volume 1, Chapter 1.*

4 *Department of Defence, Submission No. 122, p. 11.*

5 *F-111 Board of Inquiry, Volume 1, Appendix 3.*

6 *F-111 Board of Inquiry, Volume 1, Appendix 3.*

Health studies

SHOAMP Study

- 3.10 The Study of Health Outcomes in Aircraft Maintenance Personnel (SHOAMP) was commissioned on 8 September 2001 in response to a BOI finding that 'since 1977, some 400 ADF personnel and civilians had experienced adverse health effects while working on the F-111 DSRS maintenance program's.⁷
- 3.11 SHOAMP was conducted by the University of Newcastle Research Associates Limited (TUNRA). It aimed to:
- to assess whether there was an association between adverse health status and involvement in DSRS activities; and
 - to compare the health of the DSRS personnel with appropriate comparison groups.⁸
- 3.12 The SHOAMP was conducted over several phases. SHOAMP states:
- The first phase involved a literature review of the evidence of possible associations between chemical exposure and health outcomes, a qualitative study of a sample of those involved in DSRS, and the development of a protocol for conducting a General Health and Medical Study. The second phase involved mortality and cancer incidence studies... The third phase is a General Health and Medical Study...⁹

Methodology

- 3.13 The study's methodology involved the identification of workers involved in F-111 DSRS activities through lists provided to the BOI, media articles, via contact to a telephone hotline and reviews of other documentation such as photos and Defence records. The 'level of potential exposure was based on a self-completed questionnaire assessing the duration and types of DSRS activities they had been involved in'.¹⁰ This group was known as the 'DSRS Group' or the 'exposed group'. Two comparison groups were then chosen. The first of these were:

7 Department of Veterans' Affairs. *Submission* No. 89, p. 9.

8 Department of Veterans' Affairs. *Submission* No. 89, p. 9.

9 SHOAMP Report, Volume 5, p. xvi.

10 SHOAMP Report, Volume 5, p. xvi.

Technical personnel at RAAF Base Richmond (New South Wales) serving between 1975 and 1999. The purpose of this comparison group was to assess the effect of DSRS-specific exposures over and above other exposures involved in the technical musterings.¹¹

3.14 The second group comprised:

Other personnel, not involved in technical duties, posted at RAAF Base Amberley (Queensland) serving between 1975 and 1999. The purpose of this comparison group was to assess the effect of DSRS-specific exposures, over and above any other local exposures at Amberley, experienced by personnel not involved in aircraft maintenance.¹²

3.15 DVA advised the Committee that:

The SHOAMP was a formal epidemiological study that examined the health of 659 personnel involved in the four formal DSRS programs against two comparison groups comprised of 600 technical personnel at RAAF Base Richmond serving between 1975 and 1999; and another 495 personnel, not involved in technical duties, posted at RAAF Base Amberley serving between 1975 and 1999.¹³

3.16 Consenting participants from all groups were asked to complete a mailed written questionnaire and undergo physical examinations and interviews. Data was collected on several dimensions:

- general health and well-being (including quality of life)
- cardiovascular health (symptoms and postural hypotension)
- respiratory health (symptoms and spirometry testing)
- skin and breast (including dermatitis and gynaecomastia)
- neurological outcomes (including vibration sensation, colour vision, and olfaction)
- male sexual function and female reproductive health
- mental health (including depression and anxiety as measured by the Composite International Diagnostic Interview and neurasthenia)
- cognition and memory (as measured by a battery of neuropsychological tests).

11 SHOAMP Report, Volume 5, p. xvi.

12 SHOAMP Report, Volume 5, p. xvi.

13 Department of Veterans' Affairs. *Submission* No. 89, p. 10.

Findings

3.17 The second and third phases were of most interest to the Committee. The second phase involved two cancer and mortality studies. The first of these showed:

no statistically significantly increased mortality or cancer in the group exposed to F-111 DSRS activities, relative to either nontechnical personnel on the same Base, or technical personnel at another Base.¹⁴

3.18 The second of these however found that:

The analysis indicates a higher than expected incidence of cancer in the F-111 DSRS group, with an increase of around 40-50% in the incidence of cancer relative to both the Amberley and Richmond comparison groups.... The elevation in risk appears to be specific to DSRS activities and not general aircraft maintenance, in that the DSRS exposed had a higher incidence than both comparison groups. Also, the elevation was apparent for both Program 1 and Program 2, although not statistically significant in these sub-group comparisons.¹⁵

3.19 This finding caused the Committee some concern, especially in relation to the 'statistically non-significant' finding. This will be discussed further in Chapter 5.

3.20 The Committee also received submissions from some former DSRS workers that the major threat to their health came from SR51.

3.21 Accordingly, the Committee sought advice as to whether SR51 is a factor in the health outcomes of the SHOAMP study. The researchers told the Committee that:

The increased risk of cancer applies to SR51, but not just SR51. There are people in program 2 who did not work with SR51 who have showed the increased rates. The increased rate applies to both program 1 and program 2.¹⁶

3.22 Furthermore, they added:

We have not seen that program 1, which included SR51, was any different from the other programs.¹⁷

14 SHOAMP Report, Volume 5, p. xvi.

15 SHOAMP Report, Volume 5, p. xiii.

16 Professor J Attia, *Transcript*, 19 September 2008, p. 30.

17 Dr A Brown, *Transcript*, 19 September 2008, p. 30.

3.23 The third phase of SHOAMP was a General Health and Medical study. The findings of this final phase also caused some concern to the Committee. This study found that:

On average, the F-111 DSRS group reported nearly twice the number of poor health symptoms than the comparison groups. The DSRS group recorded significantly poorer quality of life than both comparison groups on both the physical and mental component scores of the SF-36 survey [a 36-item quality of life survey].¹⁸

3.24 This third phase examined a range of health issues including:

- cardiovascular health,
- respiratory health,
- dermatological and breast abnormalities,
- neurological outcomes,
- male sexual function and female reproductive health,
- mental health, and
- neuropsychological outcomes.

3.25 While not attributing causality, the study suggested that:

...the results point to an association between F-111 DSRS involvement and a lower quality of life and more common erectile dysfunction, depression, anxiety, and subjective memory impairment. There is also evidence, albeit less compelling, of an association between DSRS and dermatitis, obstructive lung disease (i.e. bronchitis and emphysema), and neuropsychological deficits.¹⁹

3.26 On the findings, the Committee notes that although the study was primarily to assess the adverse health outcomes of those in the formal DSRS programs, many of the health outcomes reported correlate well with the health outcomes self-reported by those in the squadrons.

18 SHOAMP Report, Volume 5, p. xvii.

19 SHOAMP Report, Volume 5, p. xx.

Third Study of Mortality and Cancer Incidence in Aircraft Maintenance Personnel

3.27 In early 2009, the Australian Institute of Health and Welfare (AIHW) released the third in a series of mortality and cancer incidence studies on former F-111 DSRS personnel within the formal programs. The first and second studies were made as part of the SHOAMP study. Comparisons were made with the general Australian male population, as well as groups from RAAF Base Amberley and RAAF Base Richmond.

3.28 The study made several findings. Among them:

- Overall cancer incidence in male personnel who were involved in DSRS programs was elevated by 44% when compared with the Australian male population; however the very small number of people involved means that this result was **not** statistically significant.
- Lip cancer incidence in DSRS personnel was four times as high as in the general Australian male population. This result was statistically significant, but based on only four cases.
- Overall mortality for the two comparison groups was lower than that found in the overall Australian male population; these results were statistically significant. Cancer incidence in personnel in the two comparison groups (RAAF Base Richmond in New South Wales and RAAF Base Amberley in Queensland) was similar to that of the Australian male population.
- Comparing the exposed groups (the DSRS personnel) with Amberley personnel showed no significant differences in mortality or cancer incidence.
- Comparing the exposed groups (the DSRS personnel) with Richmond personnel showed increased cancer incidence which was statistically significant. The results for mortality were less clear, with analysis of deaths in the period 1980-2004 showing a statistically significant lower rate, whereas analysis for the period 1999-2004 showed a statistically non-significant higher rate.²⁰

3.29 The Committee sought clarification on aspects of these findings. Mrs Roediger, from the Australian Institute of Health and Welfare advised:

... the overall cancer incidence in the male personnel involved in the deseal-reseal programs was up by 44 per cent compared with the Australian male population. However, due to the very small

20 Australian Institute of Health and Welfare (2009) *Third Study of Mortality and Cancer Incidence in Aircraft Maintenance Personnel: A Continuing Study of F-111 Deseal/Reseal Personnel*, Canberra, p. vi.

numbers, this is not a statistically significant result. It is possible that it is a clustering. The lip cancer incidence for the deseal-reseal personnel was four times as high as the general Australian male population. This result is statistically significant, but it is based on only four cases. The cancer incidence in personnel in the two comparison groups, which was a group of personnel at Richmond that was not involved in technical tasks and a technical group at Amberley, was similar to that of the Australian male population. So the differences do not seem to be due to being part of the RAAF or working in a technical capacity.

The overall mortality rate was lower for the personnel involved in deseal-reseal when compared with the Australian male population. That is expected. That is the healthy soldier effect coming into play. However, there were two cases of non-Hodgkin's lymphoma, which was higher than expected. Again, it is two cases. The mortality for the two comparison groups was lower than the Australian male population, and these results were statistically significant. As I say, that is just the healthy soldier effect. When comparing within those three RAAF cohorts, the exposed group, when compared with the Amberley personnel, showed no significant differences in mortality or cancer incidence. But when the exposed group was compared with the Richmond personnel, they showed an increased cancer incidence, which was statistically significant. The results for mortality were less clear, but that is what I have just read out to you. If you take the longer period, it was lower for the deseal-reseal. That is probably a selection or possibly a selection effect. If you take just that shorter period where we are more confident of the selection of the cohort, it was higher but not statistically significant. Overall, these results are very much like the results from the first two studies.²¹

- 3.30 In considering these and other health studies, it is important to recognise that all RAAF personnel were required to pass health tests and therefore have a better standard of health than the general population – producing the 'healthy soldier' effect mentioned above.

21 Mrs J Roediger, *Transcript*, 17 April 2009, p. 3.

CHALUS studies

3.31 The Chemical Hazard Assessment Laboratory at University of Sydney (CHALUS) was commissioned by DVA on behalf of Defence to undertake research work into the desealant, SR51, and to determine whether it was likely to be mutagenic or carcinogenic. That is, whether as a result of animal and cellular testing, would the desealant be likely to cause permanent genetic damage to DNA and likely to be a cause of cancer in humans. Three studies were conducted. The lead researcher provided an overview of their work on SR51:

... It was highlighted in the Board of Inquiry as one of the high risk chemicals of concern. As background, our research group uses laboratory experiments to focus on investigations assessing the toxicity of chemicals. Our main emphasis is really to focus on how chemicals exert their toxic effects, so it is focussing on the mechanism. We use a range of techniques – experiments that are done in a test tube, which we refer to as the *in vitro* experiments, and whole animal systems, which we refer to as the *in vivo* experiments. It was in response to a concern that exposure to SR-51 may be the cause of cancer in some of the deseal-reseal personnel that we undertook a series of studies in which we investigated whether exposure to SR-51 could damage DNA. We did this because damage to DNA is a common and known mechanism of how chemicals can cause cancer. So from these results and a series of *in vivo* and *in vitro* experiments, we found no evidence that SR-51 damages DNA.²²

3.32 The first study:

was designed to investigate the relative toxicities of the four components of SR-51® (Aromatic 150 solvent (Aro150), dimethylacetamide (DMA), thiophenol (TP) and triethylphosphate (TEP)).²³

3.33 This study confirmed that SR51 and its major solvent components produce toxic effects on the mitochondrial particles used in this test. These tests were *in vitro*. It is not known whether similar results of toxicity would result in living mammals.

22 Dr DJ Oakes, *Transcript*, 17 April 2009, p. 12.

23 Effects of a desealant formulation, SR-51 and its individual components on the oxidative functions of mitochondria. Moscova M; Oakes DJ; Pollak JK; Webster WS. *Environmental Toxicology and Pharmacology* 18 (2004) 181 – 184.

- 3.34 In the second study, cells were tested with the chemical up to toxic levels that destroyed the cells -- but there was no evidence that the chemical was mutagenic i.e. there was no DNA damage. The authors concluded that therefore it was unlikely to be a cause of cancer in exposed workers.²⁴
- 3.35 In the final study, due to concerns about memory loss in the F-111 cohort, a study of mice to examine working memory after exposure to SR51 was conducted. Due to methodological and paradigmatic deficiencies, the results neither proved nor disproved SR51 exposure in mice affects memory.²⁵
- 3.36 DVA commented:
- The study found that the toxicity profile of SR-51 is affected by increasing temperatures and also resulted in enlarged spleens in those mice exposed to a high dose of SR-51. Nevertheless, the results neither proved nor disproved that SR- 51 exposure in mice affects memory, and showed no evidence that exposure to SR-51 damages DNA.²⁶
- 3.37 The Committee asked the researchers to elaborate on their finding that SR51 was affected by temperature variation. The researchers responded:
- I think the point we were making is that it is a volatile chemical. The vapour phase is going to contain some of the volatile components of SR-51. When we analysed SR-51 – we were just wanting to know what was in this formulation – we found that the thiophenol in the vapour phase was oxidised. That was not unexpected. It was highlighted in the Board of Inquiry report. We were just making the point that volatile chemicals will be in different combinations in the vapour as opposed to the liquid phase.²⁷
- 3.38 Asked by the Committee whether SR51 could cause cancer:
- This was the main function of our work – to look at that. I am sure you have heard all this before. Because SR-51 has such a very, very strong odour, you can detect it at extraordinarily low levels and

24 Oakes, DJ, Ritchie, HE, Woodman, PDC, NArup, E, Moscova, M, Picker, K and Webster, WS (2009) Genotoxicity studies of a desalant solvent mixture, SR-51, *Toxicology and Industrial Health*, 25:5.

25 Oakes DJ; Ritchie HE; Woodman P, and Webster WS (2005) *Final Report on research into the toxicological effects of chemicals used in the F-111 Desal/Reseal Programs*. DVA Commissioned Report undertaken by CHALUS.

26 Department of Veterans' Affairs, *Submission* No. 89, p. 10.

27 Dr DJ Oakes, *Transcript*, 17 April 2009, p. 13.

way, way below – probably 1,000 times – the occupational health and safety levels that people think it is safe for people to inhale this at. So people are constantly aware that they have been exposed to SR-51. With the slightest amount on their clothes, they are going to keep smelling it. It is very clear that when people are exposed to chemicals that they can smell, they have an automatic emotional response to it. They either like it or they dislike it. Because this is a sulphur compound, they dislike it. So if you can imagine in working with a chemical that you are constantly aware that you are being exposed to, it creates anxiety in people. If you look at all the press reports that came out from the men that worked on this deseal-reseal, they commented on this exposure to SR-51 and the fact that they could smell it. They went home. They were barred from this. People did not want to sit near them. So they were constantly aware that they were exposed to this chemical. It is not in the least surprising that they became fearful of it. Certainly in the anecdotal reports that I have seen and the newspapers et cetera and at the SHOAMP meetings, the men have expressed concern that it was this exposure that was causing them damage.

It was our aim to examine whether SR-51 had properties that could cause cancer. There are very, very standard techniques for looking at these chemicals. The ones that are done by drug companies before chemicals can be registered and the ones that are done by pesticide manufacturers, they are all very standard tests. They are the ones that we performed. **They showed quite clearly that SR-51 did not have any properties that would lead to DNA damage as far as we could tell from those studies. In the absence of it causing DNA damage, it becomes highly unlikely that it is going to cause cancer.** So that was the main part of our work. You focused on some other parts of it that were not so fundamental. But this was the main part of our study.²⁸

Professor Frank Bowling

- 3.39 The Committee also considered the work being conducted by Professor Frank Bowling on Mitochondria in Fuel and Solvent Exposed Ex-Air Force Personnel. Professor Bowling informed the Committee:

28 Professor WS Webster, *Transcript*, 17 April 2009, p. 15.

In 2004, I was commissioned by the Chief of Air Force to study the possible effects on the mitochondria of personnel who were exposed to the F1-11 Deseal / Reseal programs. The purpose of these studies was to identify abnormalities of mitochondria in exposed individuals, both to understand the nature of cell injury following exposure and to identify a possible marker of cell injury.²⁹

3.40 The Committee was told that Professor Bowling's work comprised several pilot studies. As a result of his work, Professor Bowling concluded:

1. The results of these studies implicate changes in mitochondrial proteins in peripheral blood samples in individuals exposed to fuel solvents.
2. The data suggest involvement of immature blood cells (stem cells) in the protein changes seen following fuel exposure. It is my opinion that the mitochondrial changes seen in these pilot studies are an indication of disruption of stem cells in the bone marrow (and possibly in other tissues).
3. One individual who demonstrated a similar pattern had not been exposed to F111 DS / RS solvents but only to Aviation Turbine Fuel (significant accidental ingestion). This indicates that the damaging agent is a constituent of the fuel and not the solvents (used for Re-Seal/De-Seal).
4. The finding of changes persisting in peripheral blood several years after the exposure suggests that the cells responsible for generation of peripheral blood cells (stem cells) in the bone marrow have been affected.
5. The mitochondria in peripheral blood are generated from the mitochondria in the stem cells. Because mitochondria (proteins) are constantly regenerated using mostly nuclear genes and to much lesser extent mitochondrial genes, the most likely explanation is that the changes seen in mitochondrial proteins are a reaction to some disruption in the stem cells.
6. The cohort of individuals involved in fuel exposure are likely to vary considerably in their reponse to the cellular injury. The variation would be due to :-
 - (i) differences in exposure,
 - (ii) individual genetically determined susceptibilities,

29 Professor F Bowling, *Submission* No. 126.

- (iii) individual genetically determined repair abilities, and
- (iv) other lifestyle factors.³⁰

3.41 Professor Bowling informed the Committee:

The studies that we undertook were very small pilot studies. They were investigation studies to test this idea that mitochondria were involved. Three studies were undertaken. In each of them we chose to look at the elements from mitochondria that we call proteins. Each mitochondrion has about 600 proteins. We looked at mitochondrial proteins from airmen who had been exposed and from a matched group of controlled airmen or other individuals who had not been exposed. In each of the three experiments we saw small changes in the exposed airmen's samples. They were independent experiments and each experiment measured something slightly different. But each experiment showed the proteins in the samples from the exposed airmen were different from those in the airmen in the control group who had not been exposed. ... **Statistically it is still possible that in 600 proteins in a mitochondrion you might randomly get five that are increased. But because we got the same five in each of the airmen we tested I think that random chance becomes much, much less likely. I believe that there is a change that we are seeing...**[emphasis added] we need to further understand these proteins. There is another value in understanding them. I would make no guarantee at all of any treatment. But at least if we understand it there is always a possibility of treatment. If you do not know what you are dealing with it is very hard to do anything about it.³¹

3.42 Professor Bowling was asked whether, in relation to DNA damage that had been detected in his studies, there was significant evidence that mitochondrial DNA no longer worked. Professor Bowling responded:

There was no difference in the DNA. We cannot test that they worked, because to test that they work you have to do those biopsies I mentioned. So we looked at the building blocks that mitochondria are made out of – what we call the proteins. Those building blocks are where we found the differences. We did not look at what the building blocks were doing; we just looked at the building blocks themselves... **I believe that the mitochondria in the exposed individuals are reacting to changes or damage in the**

30 Professor F Bowling, *Submission* No. 126, p. 6

31 Professor F Bowling, *Transcript*, 16 April 2009, p. 6

stem cells.[emphasis added] The mitochondria constantly monitor the health of a cell. If they determine that the cell is too unwell, they will deliberately kill it.

Coxon study on psychological effects on spouses

- 3.43 The study was commissioned by CAF in February 2005 and completed in October 2006.³²
- 3.44 This small study³³ of 162 Air Force spouses used three standardised psychological questionnaires to measure psychological impacts on 91 spouses of DSRS participants, from an experimental group of 110 predominantly middle aged female spouses who had been invited to participate. A small control group of 25 Air Force spouses (from an initial group of 52 spouses who were not necessarily caregivers) and whose partners had not been involved in the DSRS processes, also completed the questionnaires.
- 3.45 Statistically significant differences were shown between the two groups on several scales of a self-administered index known as the Personality Assessment Inventory (PAI). The differences were found in levels of somatic complaints, anxiety, depression and antisocial features. The first three of these elements were higher in the experimental group.³⁴ The experimental group also reported higher levels of stress on this scale.³⁵
- 3.46 The researchers noted that:
- The results of the study indicate that there are significant deleterious effects on the psychological functioning of spouses of individuals involved in the F-111 Deseal/Reseal programs as a result of the program itself.³⁶
- 3.47 The researchers concluded that:

32 Coxon LW and Hartley, LR (2006) *Psychological Functioning in Partners and Spouses of Deseal/Reseal Personnel*, Study Commissioned by Chief of the Royal Australian Air Force.

33 Despite the concerns expressed by the F-111 Support Group concerning the effects of involvement in the Deseal/Reseal Programs on partners and families, this study failed to attract the involvement of many of those affected, thereby weakening the results.

34 Coxon LW and Hartley, LR (2006) *Psychological Functioning in Partners and Spouses of Deseal/Reseal Personnel*, Study Commissioned by Chief of the Royal Australian Air Force, p. 8.

35 Coxon LW and Hartley, LR (2006) *Psychological Functioning in Partners and Spouses of Deseal/Reseal Personnel*, Study Commissioned by Chief of the Royal Australian Air Force, p. 10.

36 Coxon LW and Hartley, LR (2006) *Psychological Functioning in Partners and Spouses of Deseal/Reseal Personnel*, Study Commissioned by Chief of the Royal Australian Air Force, p. 10.

...results have demonstrated a willingness for treatment and the likelihood of positive treatment outcomes for members of the Experimental Group, any future resources allocated for this purpose would be likely to be well utilised by these individuals.³⁷

- 3.48 It should be noted that through the course of this Inquiry, the Committee discovered that this particular report had not been made available to the study's participants. The Committee has rectified this.

Danek Report

- 3.49 The Committee also took evidence from Mr Stefan Danek, whose research also formed part of the BOI report. Mr Danek outlined his work to the Committee:

Since the RAAF's acquisition of the F-111 aircraft in the mid-1970s, the Defence Science and Technology Organisation has provided scientific and technical assistance and support to the Air Force on F-111 sealant related issues. The poor hydrolytic and thermal stability of the OEM polyester sealant used to seal the F-111 fuel tanks and its early degradation in service leading to fuel leaks has been well-documented. When the problem of the fuel leaks first arose, DSTO mobilised a team of scientists headed by Dr Brent Paul, now retired, to undertake scientific and technical research to understand why the sealant was in fact failing and to investigate ways in which the integrity of the F-111 fuel tank sealant system could be restored. A substantial corporate scientific and technical knowledge base on the F-111 fuel tank sealants was subsequently built within the DSTO over many years. When the fourth reseal program was halted in January 2000, DSTO was asked to provide technical assistance to the investigating officer appointed by the Air Force to examine existing spray seal procedures and hazards. DSTO continued to provide technical assistance to the Board of Inquiry when it was appointed in July 2000. Enormous reports from various subject matter experts were commissioned by the Board of Inquiry, including a toxicological assessment of deseal-reseal chemicals, the resistance of personal protective equipment, such as gloves and overalls, to various selected chemicals, the monitoring of airborne contaminants

37 Coxon LW and Hartley, LR (2006) *Psychological Functioning in Partners and Spouses of Deseal/Reseal Personnel*, Study Commissioned by Chief of the Royal Australian Air Force, p. 11.

during specific processes associated with the deseal-reseal programs and the modelling of potential exposure or potential airborne contaminants of these same chemicals.

DSTO was then approached by counsel assisting the Board to summarise these often lengthy reports and to provide a concise document to the board. I accepted this task and produced what is referred to as the Danek report, which is included in volume 2, part 1, chapter 7, annex D of the board of inquiry final report.³⁸

3.50 The Danek report includes a risk rating from 1 (lowest) to 9 (highest) for chemicals used in the F-111 repair work. The risk ratings from the report has been reproduced below:

Formulation	Risk Rating	Risk Ranking	Usage in program			
			1 st	2 nd	Wing	Spray
			DS-RS	DS-RS	DS-RS	Seal
SR51/A Desealant	9	HIGH	yes	no	no	no
MMS-425 Super Anzopon	9	HIGH	no	no	no	yes
PR-2911 spray Sealant	9	HIGH	no	no	no	yes
Methyl Ethyl Ketone (MEK)	6	MEDIUM	yes	yes	yes	yes
MIL-C-38736	5	MEDIUM	yes	yes	yes	no
PR-148	5	MEDIUM	yes	yes	yes	no
PR-1750	5	MEDIUM	yes	yes	yes	yes
EC-2216 ("Barrier")	4	MEDIUM	no	yes	yes	no
Q4-2817	4	MEDIUM	no	no	yes	no

Source F-111 Board of Inquiry, Volume 2, Chapter 7, Annexe D.

3.51 On these risk ratings, Mr Danek confirmed:

Initially, ... the aim was to identify the toxic materials that we use – all the products that we used in the deseal-reseal program and from the material safety datasheets and the composition of the products indicated therein to identify the most hazardous materials employed in the various deseal-reseal programs....the toxicologists identified the 12 most key risk materials... Based on those key risk chemicals, we went back to look at and identify what were the highest risk formulations. I tabulated in my report

nine formulations that we used in the various programs in order of their risk factors.

3.52 The report also made comments on a range of chemicals that were used in the formal DSRS programs.

3.53 In relation to MEK, the Danek Report found:

Workplace Scenarios. Connell and Miller estimated the possible exposure to personnel when using MEK in a variety of scenarios. These scenarios concentrated on 'worst case', involving no forced ventilation, with varying levels of natural ventilation and with varying usage rates of MEK. The results...show that under these scenarios the concentration of MEK, inside the desal hangar, would be below the recommended Exposure Standard. **However, the levels inside the tank would be from approximately 25 to 100 times the Exposure Standard** [emphasis added].³⁹

3.54 On this point, Mr Danek told the Committee:

To interpret that, I would suggest, firstly, we look at the assumptions that were made. As I said to you, we have to start somewhere. Whilst I do not have the details immediately to hand, I think the comment was made that it could be up to 100 times in certain scenarios. I believe that is zero ventilation of a fuel tank and then assumptions of a certain large usage rate of the methyl ethyl ketone. Nevertheless, whether it is 100 times or 10 times or five times, it is still a very high risk activity to undertake chemical or solvent cleaning inside a fuel tank in the absence of any ventilation and wearing appropriate breathing apparatus.⁴⁰

3.55 Another study:

...assessed the concentrations of MEK during typical equipment cleaning activity. **The levels of MEK were found to be extremely high, with an average concentration exceeding the TWA by a factor of 15** [emphasis added]. SIMTARS recommended that this practice be carried out in a fume cupboard.⁴¹

3.56 On this point, Mr Danek told the Committee:

One has to be aware that MEK is a very, very volatile solvent. It has a very low boiling point so it evaporates very, very quickly. If

39 *F-111 Board of Inquiry*, Volume 2, Chapter 7, Annexe D, c.55.

40 Mr S Danek, *Transcript*, 17 April 2008, p. 34

41 *F-111 Board of Inquiry*, Volume 2, Chapter 7, Annexe D, c.62.

you are using copious amounts of methyl ethyl ketone in any cleaning processes, and particularly if you have a large surface area of the solvent exposed, evaporation rates are going to be quite high. In the immediate vicinity above the pan or wherever you are working, the concentrations will be very high. SIMTARS recommended, rightly so, that any cleaning activity should be undertaken in a fume hood.⁴²

3.57 The Danek Report also states:

RAAF personnel working in fuel tanks used primarily Ansell Nitrile rubber gloves and also, when available, Butyl rubber gloves.⁴³... Nitrile type surgical gloves were evaluated for use with MEK by the Australian Government Analytical Laboratories, whereupon **“the gloves failed catastrophically during testing”** [emphasis added]. Within 10 seconds of exposure to liquid MEK, the glove material was weakened to such an extent that it could not hold the pressure required for the test process. It was concluded that the nitrile gloves were not considered suitable for usage with MEK due to the rapid degradation they exhibited.⁴⁴

3.58 In another study on these gloves:

Bromwich investigated the protection offered against MEK by Ansell Sol-Vex 37-185 Nitrile rubber gloves. It was found that Ansell Sol-Vex gloves are unsuitable for use with MEK, with an average breakthrough time of four (4) minutes with continuous exposure⁵⁵. They will give limited protection against occasional splashes for up to half an hour. If these nitrile rubber gloves are used in any formulation which has a significant (total > 10%) fraction of chemicals that permeates or degrades the gloves, then the action of those chemicals on the gloves may permit other chemicals that the glove is designed for, to permeate. This includes all ketones and many aromatic hydrocarbons like benzene, toluene and xylene. During cleaning operations inside fuel tanks, MEK is either directly sprayed onto tank structure and wiped off with a rag or applied via a rag dampened with MEK. Under these circumstances, it is reasonable to expect significant contact time of the glove with liquid MEK.⁴⁵

42 Mr S Danek, *Transcript*, 17 April 2008, p. 34.

43 *F-111 Board of Inquiry*, Volume 2, Chapter 7, Annexe D, c.67.

44 *F-111 Board of Inquiry*, Volume 2, Chapter 7, Annexe D, c.68.

45 *F-111 Board of Inquiry*, Volume 2, Chapter 7, Annexe D, c. 69.

Samples of Butyl gloves were also tested by Bromwich with MEK to determine their permeation resistance. Under the 'worst case' scenario of continuous exposure to liquid MEK, the chemical permeated in six hours rather than the published eight hours at 22°C. The permeation rate for an eight-hour shift was considered relatively low, however, the permeation rate would increase substantially for the second consecutive shift. Caution was expressed in re-using the gloves, in addition the breakthrough time was found to decrease markedly at higher temperatures⁴⁶

3.59 In respect of the gloves, Mr Danek told the Committee:

With respect to the gloves, the nitrile rubber gloves that we used in that program showed that they had a breakthrough time of methyl ethyl ketone of the order of four minutes. If you are using those gloves to undertake cleaning processes or cleaning activities in the fuel tanks and you are holding wet rags or rags wet and dripping with MEK, clearly that is not acceptable. If you were undertaking programs of perhaps even spraying, it may have been okay, depending on the residence time of the material on the gloves. But, in any event, the butyl rubber gloves should have been used in the first place. You indicated that there is some consideration given as to whether they should be used a second time. Bromwich's investigation into that looked at continuous immersion of those gloves in methyl ethyl ketone solvent, which is something that you are not going to have occur in any of the programs. At worst, it would be holding damp rags for some period of time and then cleaning inside. But, beyond that, in any of the spraying processes, you would not come across that.⁴⁷

3.60 The Committee also notes the views of Professor Andrew Hopkins on this matter. Professor Hopkins was an expert member of the F-111 Board of Inquiry. Although he did not appear before the Committee, Mr Fraser referred the Committee to his book, *Safety, Culture and Risk: The Organisational Causes of Disasters*, in which Professor Hopkins states:

The gloves sometimes disintegrated within five minutes of contact with the chemicals, and rather than constantly stopping to put on new gloves, workers at times chose to continue work without them. Moreover, some of the work required considerable manual dexterity. The gloves reduced dexterity and so workers

46 F-111 Board of Inquiry, Volume 2, Chapter 7, Annexe D, c. 70.

47 Mr S Danek, *Transcript*, 17 April 2008, p. 35.

sometimes had to remove them or cut the fingers off the gloves to get the job done.⁴⁸

3.61 In relation to workers exposed through coveralls, the Danek Report noted:

Both the Dupont Tyvek Barrier Man and Tychem SL (Saranex) coveralls were tested for breakthrough times and permeation rates against MEK.⁴⁹

Tyvek Testing. Testing of material from the Dupont Tyvek Barrier Man coverall showed that the suit offered no protection against MEK, with an almost instantaneous breakthrough time for the solvent. Similar results could be expected during exposure to other chemicals other chemicals. Examination of the surface of the suit under a microscope revealed a grid of non-penetrating pores, which facilitates 'breathing' but also minimises fluid resistance. Very limited splash protection would be provided against MEK or other solvents, including toluene.⁵⁰

3.62 In respect to the overalls, Mr Danek told the Committee:

The Tyvek Barrier Man coveralls, which were employed in that program, yes, they had very poor resistance to methyl ethyl ketone and to toluene, both of which were in the formulation of the primer MMS-425, which was employed in that program. In fact, the test undertaken by David Bromwich showed that **there was an almost instantaneous breakthrough of the solvent through those coveralls** [emphasis added]. That is not surprising when one looks under a microscope or even with the naked eye. You could see what appeared to be almost like air pores to allow the coveralls to breathe somewhat. It was a very, very thin protective layer of plastic over whatever the substrate was underneath.⁵¹

3.63 Professor Hopkins also makes observations in respect of the coveralls, stating:

The protective suits they were given were also inadequate in many ways. During the last of the programs, which involved spray sealing, and for which protective suits were particularly

48 Professor A Hopkins (2005) *Safety, Culture and Risk: The Organisational Causes*, p. 82.

49 *F-111 Board of Inquiry*, Volume 2, Chapter 7, Annexe D, c. 71.

50 *F-111 Board of Inquiry*, Volume 2, Chapter 7, Annexe D, c. 72.

51 Mr S Danek, *Transcript*, 17 April 2008, p. 35.

important, it turned out the material of which the suits were made was semi-permeable to two of the chemicals in use.⁵²

3.64 On the topic of SR51, Mr Danek told the Committee:

... the thiophenol has a highly objectionable odour which is indicative of its class of compounds of being a thiol. Everyone who has worked with it will vigorously attest to that. As also reported earlier today, the odour threshold for thiophenol is 0.3 parts per billion. As correctly indicated, that is over 1,000 times lower than the workplace exposure limit that is current now as well as what was current back in 1978.

3.65 This research presents a picture of potentially dangerous chemicals and inadequate protective clothing and work practices. It also identifies a range of illnesses and symptoms widely reported amongst F-111 workers. The inconclusive nature of some health studies was the subject of consideration by the Committee and will be addressed in subsequent Chapters.

52 Professor A Hopkins (2005) *Safety, Culture and Risk: The Organisational Causes*, p. 82.