2

F-111 Fuel Tank Maintenance

The need for F-111 fuel tank repairs

2.1 In October 1963, the Australian Government placed an order for 24 F-111C aircraft from the United States Air Force (USAF). While delivery was scheduled for October 1968, technical issues and the loss of some USAF F-111 aircraft in Vietnam meant that the Australian order was not delivered until June 1973. This delay resulted in the Australian aircraft being in storage in the US for a period of some five years.

2.2 The F-111 possesses a number of special and even unique capabilities. One of these is its long range capability, enabling the aircraft to operate without refuelling over very long distances. To accomplish this, the F-111 maximises the storage of fuel in a way not adopted with any other aircraft in the RAAF. It is in one sense a 'flying fuel tank' with armaments attached and a cockpit for the pilot. Unlike many other aircraft, there is no fuel bladder in the F-111.

2.3 The Chief of Air Force (CAF) described the structure of the aircraft's fuel carrying capacity:

> Because of the F111's role as a long-range strike aeroplane—which, again, it was very good at—and the shape of the aeroplane. A classic one is the A2—the aft tank between the two engines. In most normal aeroplanes you would not try to

> fit fuel in there. To maximise the amount of fuel that it carried, pretty much every nook and cranny in the aeroplane where fuel could be put was looked at, and that is where they put the fuel.[1]

2.4 Approximately three months after delivery, the RAAF discovered deteriorating sealant while investigating fuel leaks. Shortly after this, the RAAF became aware of serious fuel leak issues being experienced by the United States Air Force (USAF) in their F-111 aircraft. The discovery of the deteriorating sealant, coupled with the fact that the aircraft had spent such a long time in storage meant that the RAAF was required to rectify major fuel leak issues on the aircraft.[2]

The Formal Deseal/Reseal Programs

2.5 Notwithstanding that 'pick and patch' work commenced almost immediately that aircraft were in service, it was in October 1977, following a similar program put in place by the USAF at the Sacramento Air Logistics Centre (SM-ALC), that the RAAF instituted a formal Deseal/Reseal (DSRS) program at No. 3 Aircraft Depot (3AD) to 'deseal' and then 'reseal' the fuel tanks with new sealant. Some eleven aircraft were maintained at RAAF Base Amberley while the remainder, were sent to the USAF in Sacramento between May 1981 and December 1982. This first Australian program ceased in February 1982. Additional DSRS programs were conducted from 1985 – 1992, 1991 – 1993 and 1996 – 2000.

2.6 The Department of Defence provided a timeline of the various DSRS programs:

> 1977-1982: The first Deseal/Reseal program ran from 1977 to 1982 and used the chemical SR51 (SR= sealant remover) and SR51A, which are now considered to be toxic. This involved RAAF personnel from No 3 Aircraft Depot.'
>
> 1985 – 1993: The separate, but linked, 'wings' program ran from 1985 to 1993. This program did not involve fuel tank entry.

1 Air Vice-Marshal Brown, *Transcript, 21 July* 2008, p. 9.

2 *F-111 Board of Inquiry*, Volume 2, Chapter 2, p. 2-2.

> 1991 -1993: The second Deseal/Reseal program ran from 1991 to 1993 and used more benign chemicals, but still demanded exacting (mechanical) cleaning standards.
>
> 1996 – 1999: The less rigorous spray seal program ran from 1996 to 1999.This process involved a basic clean and then a spray of sealant in the tanks…While the chemicals were also relatively benign, the exposure to airborne particles of sealant exposed maintenance staff to a hazard.[3]

2.7 It should be noted that the Board of Inquiry (BOI) report states that the 'wings' program ran from, 1985 – 1992. The Committee has been advised that the date of 1993 as stated in the above submission was in error.

2.8 Defence informed the Committee that the most accurate estimate of the number of people involved in the formal programs is 872, based on work done for the SHOAMP. This comprised 785 RAAF personnel, 48 civilian contractors and 39 individuals who did not identify their rank at the time of the BOI.[4] The Committee is also aware that some school students undertaking job experience may also have been exposed to this work, albeit for comparatively short periods of time.

The first program

2.9 The first formal DSRS program ran from October 1977 to December 1982. This program was modelled on a similar program being run by the USAF at the SM-ALC in Sacramento. One of the key elements of the USAF program and the first DSRS program at Amberley, was the use of the chemical desealant, SR51, supplied by the Eldorado Chemical Company in the USA. SR51 was not used in subsequent programs.

2.10 It was noted that the DSRS process produced highly noxious odours and potentially flammable fumes and therefore a specific facility was established at Amberley.[5] This facility was building 661 at Amberley and was commonly known as the 'rag hangar'. The building was a canvas-covered, air-transportable hangar, situated some distance from the other maintenance facilities at Amberley. Access to the 'rag hangar' was restricted due to the use of SR51. The BOI noted that

---

3 Department of Defence, *Submission* No. 83, p. 10.

4 Department of Defence, *Submission* No. 122, p. 2.

5 *F-111 Board of Inquiry*, Volume 2, Chapter 3, p. 3-3.

warning signs relating to hazardous chemicals were prominently placed in the hangar during the desealing process.[6]

2.11 The recommended DSRS process itself is well documented in the BOI, However, much evidence has been taken demonstrating that on many occasions, the recommended safety procedures were not followed.

2.12 For example, Personal Protective Equipment (PPE) guidelines were seldom followed due to failures in the PPE, the restrictive confines of the internal tanks, availability of PPE and often very high temperatures in the work environment. Evidence regarding work procedures and PPE are covered later in this report.

The 'wings' program

2.13 Inspection of the wing tanks in Australia confirmed the USAF experience that the sealant in the wing tanks had also begun to deteriorate. The RAAF began a DSRS program on the wing tanks of the F-111 aircraft from 1985 until 1992. The work was conducted in Hangar 277, a general purpose aircraft maintenance hangar staffed with a combination of RAAF personnel and civilian contractors.

2.14 The 'wings' program differed from the first and subsequent programs in that tank entry was not required. Work in very restricted areas common in the other F-111 fuel tank work, was therefore not an issue with wing tank work. It is neither reasonable nor accurate to regard the wing repair work as similar to or as difficult as the F-111 fuselage tank repair work.

The second program

2.15 The USAF experience showed that major deterioration of the sealant could be expected after about seven years. It had also been found that the techniques in the first program and subsequent formal and informal 'pick and patch' activities did not remove all of the degrading sealant.[7] Further fuel leaks had begun to appear and a second DSRS program was instituted at 3AD in 1991 and continued until 1993.

---

6 *F-111 Board of Inquiry*, Volume 2, Chapter 3, p. 3-7.

7 It should be noted that there were two types of 'pick and patch' activities – those conducted as part of the formal DSRS programs, and those conducted as part of the squadron maintenance programs.

2.16 The BOI points out several differences between this program and its predecessor, most notably the decision to send the program to tender to Australian industry due to staff shortages at Amberley. The 'wings' program was not included in the tender documentation. Five aircraft were also sent to SM-ALC in the USA for DSRS.

2.17 Other notable differences could be seen in the methods and sealants employed in comparison to the first program. The Materiels Research Laboratory (now known as the Defence Science and Technology Organisation or DSTO) conducted some research on the reasons behind the failures of the sealants and discovered that the existing sealant could be peeled from the tank surface, even when prepared under the manufacturer's instructions.

2.18 Two options were thus put forward. The first was to remove old sealant with the help of a chemical softening agent (such as the SR51 in the first program) or the use of hydrolasers. The latter option was chosen due to concerns about the health effects caused by the softening agent from the first program. A decision was also taken that the cleaning solvents to be used would not differ from those already in use in the 'wings' program.

2.19 The eventual tender was won by Hawker de Havilland, a subsidiary of Boeing. Several changes were made as part of the contractual arrangements between Hawker de Havilland and Defence including that warnings of the toxicity of chemicals and the need for PPE were included with 'DSRS Work Sheets' (officially known as Australian Aircraft Publications and issued internally by the RAAF).[8]

2.20 The facilities to be used were hangars 278 and 280 belonging to 3AD and later, 501WG.[9] Contractual arrangements also left Hawker de Havilland responsible for some physical aspects of the work area including drainage, ventilation, power, light, water, first aid, the provision of a fresh air supply and adherence to all Commonwealth and State environmental laws. Importantly, as part of the contract, several training modules were also put into place – a five-day DSRS training course run by 3AD (which included aircraft safety, the DSRS process, OH&S and use of the hydrolaser), a DSRS operator's course

8 *F-111 Board of Inquiry*, Volume 2, Chapter 4, p. 4-3.

9 501WG was formed in 1992 and was the successor to 3AD which was disbanded. The functions from 3AD were transferred to 501WG along with those from 482 Sqn. 501WG consisted of other aircraft maintenance sections which dealt with a variety of maintenance issues. Most importantly for the purposes of this inquiry, it carried out DSRS and Spray Seal programs on the F-111 along with major maintenance.

conducted by Hawker de Havilland, hazardous substance training (for the safe use and handling of chemicals) and confined space entry training.

The spray seal program

2.21 The final program, the 'spray seal' program ran from 1996 to 1999. The RAAF became aware of a new process developed by Lockheed which used polythioether sealants. The process involved spraying the new sealant over the old sealant, without the need to remove the old sealant. Trials by Lockheed on F-117 aircraft showed minimal leaks over the course of four years.

2.22 The USAF at SM-ALC had not adopted the method developed by Lockheed due to its prohibitive cost; however RAAF began trials with similar chemicals on the F-111. At the same time, an industrial hygiene survey was conducted by Armstrong Laboratory in the USA which found that this process could be safely conducted using recommended PPE and safety procedures.

2.23 An Australian trial on an F-111 aircraft was approved in 1992 on the proviso that the Armstrong Laboratory instructions were fully complied with. The trial was conducted at 501WG and involved two technicians from SM-ALC providing instruction and also providing some additional PPE as used by the USAF. A report on the trial described it as successful. The SM-ALC technicians stressed the need for a specific minimum level of PPE due to the hazardous nature of the spray seal process.

2.24 The spray seal process was approved in January 1997 and was to be conducted at the 501WG Paint Shop. The BOI found that while the RAAF had appropriate approval and documentation of the processes involved, there were no specified time limits that personnel could be inside the fuel tanks. This was in contrast to the USAF which specified a maximum two-hour shift, with no more than four hours in any eight-hour shift to be performed inside the tanks. Like the second program, training was specified and included a confined spaced entry course, spray seal process training, hazardous substance training and a refresher course for the confined spaces entry course for previous participants.[10]

10 *F-111 Board of Inquiry*, Volume 2, Chapter 4, p. 5-4.

2.25 The Department of Defence informed the Committee:

> In 2000, following growing concern from Unit management at the number of F-111 fuel tank maintenance personnel reporting health problems, the spray seal program was halted on 28 January and a unit investigation began.[11]

2.26 Following the suspension of the program, a BOI was commissioned to investigate areas of concern.

Flight Line maintenance

2.27 Several types of maintenance programs existed – the longer term major fuel leak repairs, conducted in the formal DSRS programs described above, and operational flight-line repairs, conducted in the maintenance squadrons, detailed below.

2.28 Within the formal DSRS programs, there was a full-scale maintenance program to 'deseal' and then 'reseal' fuel tanks. The formal programs also conducted a program of ad-hoc repairs which did not require a complete DSRS overhaul. This was known as 'fuel tank leak repair' or colloquially as 'pick and patch'. Importantly, these 'pick and patch' repairs were also conducted as part of the maintenance work on the F-111s within the maintenance Squadrons 1, 6 and 482 outside of the formal DSRS programs. This form of ad-hoc repair was also conducted prior to the formal DSRS programs. 'Pick and patch' was also conducted at 3AD and 501WG even when no formal DSRS activities took place. The 'pick and patch' work began in 1973 and continued concurrently with all of the formal DSRS programs.

2.29 It should be noted that the 'pick and patch' repair processes within the formal DSRS programs were exactly the same as those used in the squadrons. This ad-hoc maintenance was conducted during times when the formal DSRS programs operated and also during periods when no formal DSRS operations were performed.

Occupations involved

2.30 Defence advised that the main occupation of those engaged in squadron-level 'pick and patch' was that of Airframe Fitter (AFFITT) (later renamed Aircraft Technician or ATECH). Some of these personnel also participated in the formal DSRS program. The Department estimates:

11 Department of Defence, *Submission* No. 83, p. 1.

> …the figure of 2300 covers all AFFITT/ATECH personnel involved in the four formal deseal/reseal programs and at F-111 Squadrons and aircraft depots. Consequently, it is clear that a number of these personnel, approximately 600, have already received an ex gratia lump sum payment from their involvement in the deseal/reseal programs.[12]

2.31 The Committee has taken evidence from many of those who worked in areas associated with DSRS and 'pick and patch' operations. It should be recognised that these individuals, worked in occupations that from time to time included work on F-111 fuel tank repair, or in related activities. Evidence to the Committee has been taken from those who worked in other occupations such as:

- Electrical fitters
- Surface finishers
- Incinerator operators
- Equipment Officers
- Non-Destructive Inspection Technicians
- Instrument Fitters
- Photographers
- Fire-fighters.

2.32 Of these various trades, evidence to the Committee indicates that the occupations of electrical fitters and surface finishers in particular were more likely than others to spend time in fuel tanks.[13] One contributor to the Inquiry notes:

> As an Electrical Fitter I was responsible, among other aircraft systems, for the Fuel Management Systems on the Fl 11 aircraft. This included Fuel Contents, Fuel Quantity, Fuel Distribution, Fuel Transfer and Fuel Dump Systems. As a result, I and other Aircraft Electrical Fitters worked with and in conjunction with the Aircraft Airframe Fitters/ATECHs on many of the fuel system problems experienced on the F111 aircraft.[14]

---

12 Department of Defence, *Submission* No. 123, p. 3.

13 Mr A Aburn, *Submission* No. 22, and Mr G Steinhardt, *Submission* No. 63.

14 Mr A Aburn, *Submission* No. 22, p. 2.

2.33 Other evidence has suggested that checking and repair of electrical wiring within the airframe was not uncommon when the 'pick and patch' activities were being undertaken and whilst the aircraft was defueled. One witness notes that, while these trades were not specifically involved in the actual 'deseal' and 'reseal' of the aircraft:

> …some other trades may have entered the tanks for such things as crack or damage recognition and/or repair, or for wiring or fuel probe removal and/or installation or repair.[15]

2.34 There was some evidence to suggest that while individuals had specific tasks to complete:

> …quite often all aircraft maintenance workers working in the F111C Hangar would pitch in to ensure that aircraft were available for flying duties. This meant that all aircraft trades would be exposed to the types of chemicals used to conduct the pick and patch fuel tank repairs… This practice was quite widespread and, I believe, was condoned by the management.[16]

2.35 Mr Barry Gray, as a former warrant officer engineer in 482 Squadron told the Committee:

> …the reverted sealant, it was everywhere. It was all over the aircraft, running down the sides. To get that cleaned for a flight was very difficult. We used all sorts of chemicals to get rid of it, similar to the tanks. The leaks were that bad we used to joke that you had a put a raincoat on when you walked around the aircraft to do a pre-flight.…When we did the pick and patch, we would be in that tank up to eight or nine hours a day and that could be for a week until you found the leak. In this time, we would defuel the aircraft, get in there and find the leak, if we could, patch it and let the sealant go off. [17]

2.36 In reply to the Committee's observation that it was evident that there was 'a wide range of people who were involved in one way or another'[18] Mr Doug Steley, a leading aircraftman (LAC) photographer at Amberley between 1976 and 1979, said:

---

15 Mr P Johnson, *Transcript*, 29 July 2008, p. 60.

16 Mr W. Knilands, *Submission* No. 13, p. 8.

17 Mr B Gray, *Transcript*, 28 July 2008, p. 38.

18 Chair, Hon A R Bevis MP, *Transcript*, 29 July 2008, p.2.

> The reason for the photographs at that stage was that there were 24 squadrons operating F111s [worldwide] and any defect in any aircraft had to be shown to every other squadron so that they could check that area of the aircraft to make sure that there were no similar problems…you would climb up onto the aircraft and go down into the tanks with one of the workers. They would point out the areas that were to be photographed…Everything that happened inside that fuel tank from the time it had the fuel drained from it to the time it was ready to fly had to be documented.[19]

2.37 While it is accepted that AFFITT and ATECH classifications spent most time in the fuel tanks, it is apparent that there were other staff in occupational categories who entered fuel tanks.[20] For most, but not necessarily all in this category the time spent working in the difficult conditions of fuel tanks was substantially less than others who worked in either the formal DSRS programs or as Airframe Fitters in the squadrons.

Civilian contractors

2.38 In addition to those RAAF personnel who worked in the formal DSRS programs, contract personnel were also used to conduct repairs. These contracted staff worked only in the four formal DSRS programs and therefore would be entitled to the ex-gratia payment and the SHOAMP Health Care Scheme (SHCS) where they met the criteria.

2.39 With respect to compensation, whilst RAAF- employed personnel are covered by the *Safety, Compensation and Rehabilitation Act 1988* (SRCA) or the *Veterans' Entitlements Act 1986* (VEA) or both, civilian contractors have recourse only to the *Workers Compensation and Rehabilitation Act 2003 (Qld)*.

19 Mr D Steley, *Transcript*, 29 July 2008, pp. 2-3.

20 Department of Defence, *Submission* No. 123, p. 4.

Tasks involved

2.40 Defence outlined the differences in tasks between those involved in a 'pick and patch' type activity, and those involved in formal DSRS.[21]

2.41 Defence advised that the range of activities and time in fuel tank repair work undertaken in DSRS was greater than in 'pick and patch';

> …workers re-entered the fuel tanks to 'hand pick' and physically remove any remaining sealants. This was achieved by using an assortment of dental picks, wire brushes, scrapers and rags…. This process used a general purpose solvent and took approximately 28 days for 24 hours per day utilising three shifts a day to complete. Similar tasks using general purpose solvents were undertaken during squadron pick and patch activities, but were generally of much shorter duration than the hand pick and cleaning phase of the Deseal/Reseal programs and significantly less intensive in terms of the amount of sealant needing to be removed…[22]

2.42 The Committee has taken a great deal of evidence from individuals who were not officially employed in a specified DSRS section at Amberley, but were nonetheless exposed to the same or similar working conditions as those in the formal DSRS programs. The SHOAMP recognised that:

> Some repair work similar to DSRS was conducted on the F-111 fuel tanks prior to, during, and after the formal Deseal/Reseal programs. The operation known as "Pick and Patch" was used to repair F-111 fuel tanks that were leaking. As with the formal DSRS programs, the Pick and Patch process involved entering the F-111 fuel tanks, carefully locating suspect areas of sealant, and removing the sealant from the area of concern plus a margin around it using solvents and tools such as dental picks. A patch of new sealant would then be applied. The aircraft subject to this process were in operational squadrons. As such, the Pick and Patch process involved running (*ad hoc*) repairs by the best means available whenever needed – and with a sense of

21 Department of Defence, *Submission* No. 83, p. 14.

22 Department of Defence, *Submission* No. 83, p. 14.

> urgency given the requirements for a certain number of aircraft to meet flying commitments at any one time. [23]

2.43 In addition, some depuddling of fuel tanks was required prior to 'pick and patch' work. For example, Mr Lawler noted that fuel needed to be removed from tanks or 'depuddled' before technicians could get to the sealant to be removed and the area patched:

> 'The other issue is that there was fuel left in the tanks. Those vapours continued to build up and cause us problems.' Although those involved in 'pick and patch', 'did not pull all of the sealant out of the tanks…Sometimes we spent weeks at the squadrons, without exaggeration, digging up different parts trying to patch it. A lot of the time we sent the aircraft back out, it leaked again, and we brought the same aircraft back in.[24]

2.44 Air Vice-Marshal Brown noted in evidence that the 'pick and patch' activities in both the formal DSRS programs and squadrons were essentially the same:

> In reality there was no real difference between the pick and patch work done at Squadrons 1, 6 and 482 and what was done in the reseal-deseal section.[25]

2.45 Whilst the 'pick and patch' work undertaken in the formal DSRS program was virtually the same as that undertaken in the informal program, those in the formal DSRS programs were engaged in more extensive and prolonged work inside the F-111s. Those who undertook informal 'pick and patch' work had other duties unrelated to F-111 fuel tank repair. Defence notes:

> There were guys in squadrons 482, 1 and 6 who spent considerable time in the tanks doing pick and patch work… At the squadrons there would have been people who worked inside the tanks, but they would have also done other work. They might have rigged flaps, done ramp servicing, and

---

23 University of Newcastle Research Associates 2004, Study of Health Outcomes in Aircraft Maintenance Personnel (SHOAMP) - Phase III - Report on the General Health and Medical Study, Dept. of Defence, viewed 18/03/09 <http://www.defence.gov.au/health/research/shoamp/docs/Vol_5_complete.pdf>, p. 8.

24 Mr S. Lawler, *Transcript*, 29 July 2008, p. 7.

25 Air Vice-Marshal Brown, *Transcript*, 19 September 2008, p. 61.

> things like that. The whole time they were in the squadron was not spent inside the tanks. [26]

2.46 There can be no dispute that F-111 fuel tank repair work was not limited to the formal DSRS programs run at 3AD and 501WG. While these areas were responsible for larger and more complex maintenance on the fuel tanks, the personnel in 1, 6 and 482 Squadron were responsible for the day to day operational requirements to keep the fleet flying. In fact, fuel tank leak repair (or 'pick and patch' as it is more commonly known) was conducted solely by 482 Squadron from 1973 until the commencement of the first DSRS program in 1977.

2.47 It is noted that the RAAF provided an allowance to some F-111 fuel tank workers during the period 1981 – 1990.[27] In 1990, this DSRS allowance was revoked and replaced by Arduous Conditions allowance.[28] The details are as follows:

> **RAAF Deseal-Reseal Allowance**
>
> 3. An allowance called "RAAF Deseal - Reseal Allowance" is payable to a member who, during the day, performs –
>
> (a) deseal or reseal duties, other than supervision duties, in the fuel tanks on F111 aircraft, under adverse working conditions; or;
>
> (b) supervision, under adverse working conditions, of a member refereed to in paragraph (a).
>
> **Rate of Allowance**
>
> 4. Subject to clause 5, RAAF Deseal – Reseal Allowance is payable –
>
> (a) in respect of a member to who paragraph 3(a) applies – at the rate of $6.00 for each day on which he performs duties under adverse working conditions; and
>
> (b) in respect of a member to whom paragraph 3(b) applies – at the rate of $3.00 for each day on which he performs supervisory duties under adverse working conditions. [29]

---

26 Air Vice-Marshal-Brown, *Transcript*, 19 September 2008, p. 54.

27 The 1981 Determination can be found at: http://www.defence.gov.au/dpe/pac/58B_1981_57.pdf

28 The 1990 Determination can be found at: http://www.defence.gov.au/dpe/pac/58H_1990_3.pdf

29 The 1981 Determination can be found at: http://www.defence.gov.au/dpe/pac/58B_1981_57.pdf

2.48 The Committee took evidence that the payment of this allowance was at times haphazard and inconsistent.