

# **REVIEW OF DEFENCE POLICY AND PROCEDURES FOR THE MANAGEMENT OF EQUIPMENT CONTAINING TRITIUM-BASED LIGHT SOURCES**

## **CONSOLIDATED SUMMARY OF FINDINGS**

### **1. Use of Gaseous Tritium Light Sources (GTLS) and Gaseous Tritium Light Devices (GTLD)**

The review found that:

- a) Tritium light sources were introduced into military equipment in the 1970s as a safer alternative to the more toxic substances such as radium-226 and promethium-147 that had been used previously to provide radio-luminescent sources;
- b) GTLS are useful light sources for use in small, portable pieces of equipment such as compasses and weapon sights which need to be operated in poor light without battery or electrical power;
- c) GTLS are used widely by our counterparts in the United States, United Kingdom and Canadian armed forces, and in many other militaries;
- d) While some GTLS contain quite significant levels of activity that would translate into exposure to a large dose of radioactivity in extreme circumstances, the literature does not contain evidence to suggest that tritium light sources pose a significant health risk. Moreover, the risks can be ameliorated through the observation of simple occupational health and safety procedures for the operation, maintenance and disposal of GTLS;
- e) Assembling a consolidated summary of the current inventory of GTLD was not a straightforward exercise, and report formats were not consistent across the equipment fleets;
- f) It was not able to form a clear judgment on the quality of the databases that covered GTLD, either in terms of the accuracy of the records or the robustness of the information capture processes. ARPANSA has concerns about Defence's ability to comply with its regulatory obligations as the inventory of radioactive sources is not complete and up to date;
- g) OHS&C Branch, with assistance from JLG and the DMO, has undertaken substantial work to establish the Defence Radiation Source and Facility Inventory (DRSFI), which will be an on-line database; and
- h) A consolidated summary of the characteristics of GTLD that addresses levels of radioactivity and exposure risks for particular types of equipment is not available.

### **2. Health Effects**

The review found that:

- a) All individuals are exposed to ionising radiation from a variety of natural and anthropogenic sources;

- b) Exposure to any form of ionising radiation, be it medical or dental x-rays, cosmic radiation during a commercial airline flight, or gamma rays from a smoke detector, will elevate an individual's risk of contracting cancer or suffering from genetic effects;
- c) The principle of keeping doses 'As Low As Reasonably Achievable' (ALARA) is central to the control of individuals' exposure to radiation;
- d) There is debate in the scientific and medical literature as to the health effects of exposure to doses of radiation below 100 mSv, with no clear-cut evidence that exposure to doses at these lower levels has a harmful effect on a person;
- e) Queensland Health Scientific Services found that the radiation dose to which workers in the Electrical Instrument Repair workshop at Bulimba were exposed fell within the range of 0.34 mSv to 2.4 mSv (with the low figure being assessed as the more likely dose), with these levels falling well within internationally and nationally accepted radiation dose limits;
- f) In commenting on the tritium contamination incident at Bulimba Barracks in 2003, the Chief Executive Officer of ARPANSA, Dr John Loy, advised as follows:  

'Estimates of doses to workers in the work area arising from the contamination are well within national and international dose limits. Doses to workers immediately outside the work area were within the range of doses expected due to background radiation. Assessment of off-site contamination of workers' private cars and homes found radiation doses to be very small, in fact trivial.';
- g) A number of former and current employees involved in either the repair or the receipt and dispatch of GTLD at Bulimba Barracks expressed a lack of confidence in the medical and scientific advice on the health effects of chronic exposure to tritium and zinc sulphide;
- h) Advice to the review from subject matter experts indicated that there is no statistically significant evidence in the medical or scientific literature to suggest a link between exposure to tritium contamination and cancer at the low doses to which the Defence employees at Bulimba were exposed;
- i) Advice to the review from subject matter experts indicated that there is no credible evidence to suggest a link between exposure to tritium contamination and renal cell carcinoma; and
- j) The medical or scientific literature does not contain statistically significant evidence to suggest that chronic exposure to low levels of tritium contamination (say over a period of a decade or longer) leads to adverse health effects.

### 3. Tritium Contamination Associated with Bulimba

The review found that:

- a) GTLS were initially procured for the ADF in the early 1980s, primarily for use in compasses and weapon sights;
- b) While it was not able to identify documentary evidence, the potential for contamination from tritiated water and tritium labelled phosphor would have been present in workshops and storage facilities from the time the GTLS/GTLD were introduced into service;
- c) Prior to the late 1990s the hazard from GTLS was identified as the risk of inhaling tritium gas from a broken GTLS. The procedures in the event of a breakage were set out in the relevant safety management instructions – evacuate the area for 30 minutes and vent the room to allow the gas to dissipate;
- d) Prior to the acquisition of equipment in 2000, Defence did not have a practical or effective means of detecting tritium contamination in gaseous, liquid or solid form. Tritium gas contamination is difficult to measure because the level of energy released with an emission is very low;
- e) While there are isolated accounts in the records of individuals being exposed to tritium contamination as a result of handling broken GTLS (for example compasses), the first incident that is the subject of any substantial written records occurred in early 1998;
- f) It was not able to reconcile the conflicting evidence in relation to the contamination of the first batch of C2 sights that was sent to the United Kingdom for repair in late 1997;
- g) On the basis of the examination of the records and interviews with key personnel, it will be difficult to establish a definitive and uncontested account of the circumstances surrounding the contamination of this first consignment of C2 sights;
- h) The lack of a more concerted response in the aftermath of the 1998 contamination reflects the following factors:
  - i. A judgment on the relatively low risks of tritium contamination associated with work on GTLS/GTLD;
  - ii. A lack of knowledge of the presence of tritium contamination at Bulimba due to the absence of effective detection equipment;
  - iii. The view that the drilling work undertaken by Hall and Watts had caused the contamination of the C2 sights in the UK; and
  - iv. Insufficient attention to the implementation of the ALARA principle in the overall monitoring regime for work being undertaken on GTLS/GTLD;

- i) More extensive investigations will be required to ascertain the circumstances surrounding the shipment of the second batch of contaminated C2 sights to the UK in 1999 (Given the passage of time and the turnover of personnel the review is not confident that further work will result in a definitive account of this incident.);
- j) Whatever lessons were learned in the aftermath of the detection of tritium contamination with the first batch of C2 sights sent to the UK were lost in the intervening period leading to the preparation of the second batch, both at corporate 'headquarters' level and at the unit;
- k) The failure to properly identify GTLS in the sights and to label them accordingly reflects a clear breakdown in oversight and control;
- l) The following factors were at play leading up to the 2003 incident:
  - i. The technicians, managers, the RPO and the regional OH&S officer were conducting their activities on the basis of the known risk of exposure to tritium contamination via the inhalation of tritium gas that may escape from broken GTLS;
  - ii. While there was a general awareness of the risks of exposure to tritium contamination via the ingestion of or contact with tritiated water there was no equipment to test effectively for this form of tritium contamination;
  - iii. There was a general perception that tritium contamination was not a problem at Bulimba Barracks;
  - iv. There was no knowledge of the potential for tritium to absorb onto the phosphor lining inside a GTLS (eg, zinc sulphide) and produce surface contamination;
  - v. While the Berthold monitor was delivered to JLU SQ in June 2000, the suspension of the C2 sight modification program, difficulties in commissioning the monitor, the lack of adequate training, the lack of knowledge of the phenomenon of surface tritium contamination, and the absence of effective oversight at the appropriate levels in the chain of command resulted in the equipment being non-operational for almost two and half years;
  - vi. Little effort was made to respond to the efforts of the C2 sight Fleet Manager to institute more rigorous procedures for the management of GTLS at Bulimba;
- m) There are conflicting views on the standard of house keeping in the Optical Clean Room in the period from 1999 to 2003;
- n) The Queensland Health Scientific Services preliminary survey report indicated that the particular nature of the surface tritium contamination found in the workshop at Bulimba was not well understood in the broader scientific community.

- o) At the time of the incident, neither Dr Ian Gardner (Functional Head, Senior Consultant in Occupational and Environmental Medicine, Defence Centre for Occupational Health) or Defence Health Services recommended blood tests for the affected workers as they were not required in these circumstances - blood tests are not able to detect the very low doses of radiation associated with exposure to low energy tritium light sources;
- p) The Queensland Health Scientific Service Phase Two Report found that '...the radiation doses to critical worker groups and other related off-site groups are well within international and national accepted limits', and '...the radiation dose associated with the transfer of tritiated particulate contamination to off-site locations such as workers private cars and homes has been reported by Queensland Radiation Health as trivial';
- q) In a media release dated 27 April 2007 in which he addressed the contamination incident at Bulimba in 2003, the CEO of ARPANSA said that 'While I can indicate that the incident did not pose a health risk to members of the public, the incident reflects the poor radiation safety practices that existed at the Barracks at the time.';
- r) Comcare was satisfied with Defence's response to the contamination incident and judged that a separate Comcare investigation was not required;
- s) Personnel affected by the contamination incident were provided with comprehensive briefings in the aftermath of the incident, although a number of employees interviewed by the review expressed reservations about the briefing process;
- t) Advice to the Minister for Defence in the aftermath of the 2003 contamination incident was inadequate as it did not provide advice on the earlier instances of C2 sight contamination that occurred in 1998 and 1999;
- u) The site survey and decontamination process undertaken at Bulimba by Queensland Health Scientific Service was comprehensive and effective;
- v) In spite of clear guidance, a cleaning contractor provided insufficient training to sub-contracted employees on the protocols for cleaning contaminated work spaces at Bulimba. Unit management intervened promptly to address the issue at the time;
- w) The Queensland Health Scientific Service provided EIR personnel with several on the job training sessions with respect to testing and contamination monitoring procedures;
- x) In the aftermath of the contamination incident in 2003, specific work instructions were drafted to provide warehouse personnel with procedures for receiving and handling depot stock;
- y) On 28 November 2005, ARPANSA conducted an inspection of JLU (SQ) and identified three minor issues to be resolved.

#### **4. Other Known Incidents of Tritium Contamination**

The review found that:

- a) In the aftermath of the detection of tritium contamination at Bulimba in early 2003, Defence took steps to test for contamination at other sites at which GTLS/GTLD were either repaired or handled in large quantities; and
- b) Since records of instances of exposure of Defence personnel to possible tritium contamination are found in a variety of forms (AC563s, RODUMs) that are not necessarily held centrally it is difficult to assess the thoroughness of incident reporting, particularly for the period from the early 1980s to the late 1990s.

#### **5. Policy and Procedures**

The review found that:

- a) ARPANSA has significant concerns about a wide range of matters associated with Defence's management of its regulatory requirements under the ARPANS Act and Regulations, and advises that there is scope for significant improvement;
- b) ARPANSA is currently considering a Defence request to amend its existing source licence that covers controlled material and controlled apparatus. ARPANSA has permitted Defence to continue to use GTLS while the application is being considered to enable the equipment to be used for training and operations;
- c) While Defence has worked closely with ARPANSA to address regulatory issues since the commencement of the ARPANS Act and Regulations, ARPANSA assesses that progress has frequently been limited by a lack of resources within Defence to respond to ARPANSA requests in a timely way;
- d) The prolonged gestation period of more than four years for the DI(G) on the management of GTLS is symptomatic of the lack of urgency that seems to have characterised Defence's approach to the management of the (albeit low) risks associated with GTLS since the first recorded detection of contaminated C2 sights in early 1998. It is an indictment on Defence that the formal higher level policy document for the management of tritium has been in abeyance since 2003, and will not be formalised until the revised version of the SAFETYMAN is published in mid-2007;
- e) Defence, like other organisations, faces considerable challenges in recruiting officers with the requisite skills in radiation safety;
- f) Given Defence's extensive and diverse inventory of radiological substances and facilities, the current position which sees the organisation's corporate knowledge vested effectively in two individuals is fragile;

- g) Notwithstanding the significant efforts of OHSC Branch to finalise the database of radioactive sources, the review is not confident that Defence has as firm a grasp of its inventory as it should have. There is scope to introduce greater consistency in processes across the different GTLS/GTLD equipment fleets;
- h) There is scope to improve the existing governance arrangements for the network of radiation safety committees in Defence and the current arrangements for Defence's engagement with ARPANSA;
- i) There appears to have been little or no formal auditing and enforcement regime at Bulimba for compliance with the relevant policy and procedural documents. Had the guidelines been followed, the extent of contamination would likely have been reduced;
- j) Under the current federated arrangements there is no single point of accountability or responsibility for the oversight of 'radioactive sources and facilities' in Defence. The review believes that a single point of accountability is required to exercise this assurance role. The key considerations that underpin this proposal are the highly specialised nature of radiation management; the potential severity of the consequences in the event of a major incident, notwithstanding the low probability of such an incident; and the economies of scale associated with managing radiation safety in a centralised manner through the pooling of scarce expertise and resources;
- k) ARPANSA's concerns regarding the lack of clarity in the responsibility and accountability mechanisms for the oversight of radiation safety in Defence reflect the complexity of the current arrangements; and
- l) Further work may be required to complete the disposal of compasses containing radium-226 and promethium-147.

## **6. Current Practices**

The review found that:

- a) Robust arrangements for the management of GTLS are in place at JLU(SQ) at Bulimba, and at JLU(V) at Bandiana;
- b) There is scope to better align the arrangements at DNSDC in Moorebank with the procedures in place at Bulimba and Bandiana;
- c) The workplace procedures in the Instrument Repair facility at JLU(W) are robust, although the unit works only on compasses and is not configured to undertake work on GTLS;
- d) JLU(W) does not have surface contamination detection equipment; and
- e) Work is underway in the United States to identify alternatives to tritium-based light sources.

## **CONSOLIDATED SUMMARY OF RECOMMENDATIONS**

### **1. Use of GTLS and GTLD in Defence**

- a) The Defence Radiation Source and Facility Inventory (DRSFI) be completed as a matter of priority to enable Defence to comply with its regulatory obligations;
- b) Common reporting standards be established for the management of GTLS/GTLD across the various equipment fleets; and
- c) A consolidated summary of radioactivity levels and potential exposure risks associated with each of the 50 or so different types of GTLD in the ADF's inventory be prepared to assist in risk management and safety awareness and training.

### **2. Health Effects**

- a) The advisory material related to the use of GTLS in Defence be revised as necessary to include advice on the health effects of exposure to tritium contamination.

### **3. Tritium Contamination Associated with Bulimba**

- a) Briefings be offered to former and current employees who believe that they may have been affected by tritium contamination at Bulimba to address residual concerns in the areas of:
  - i. The contamination incidents in 1998 and 1999; and
  - ii. Defence's response to the 2003 contamination incident at Bulimba, including the site survey and clean up program, and the health effects of exposure to tritium contamination.
- b) The contaminated soil in the vicinity of the EIR be re-surveyed and removed if necessary; and
- c) Arrangements be put in place to manage the disposal of waste water from Bulimba associated with work on the repair of equipment containing GTLS.

### **4. Other Known Incidents of Tritium Contamination**

- a) DGOHS&C undertake further work to establish whether the advice provided to the review on instances of exposure to tritium contamination at sites other than Bulimba is comprehensive; and
- b) DGOHS&C establish a regime for reconciling radiation incident reports that may appear in different documents (eg, AC563s and RODUMs).

## 5. Policy and Procedures

- a) A single point of accountability (logically JLG) be established for the 'radioactive sources and facilities domain' in Defence to provide assurance that the organisation is meeting its obligations under the ARPANS Act by ensuring that effective internal controls are in place for each element of the domain - corporate policy and procedures; acquisition; inventory management; repair and maintenance; operation of the equipment; safety training and awareness, incident reporting; and disposal. Additional resources will be needed to establish and support this new function;
- b) A project team consisting of representatives from JLG (lead agency) and OHS&C Branch, and supported as required by resources from other Defence elements, is established to develop a business model for the governance of the radioactive sources and facilities domain in Defence, consistent with the guiding principle of a single point of accountability;
- c) In developing the business model, the project team should address:
  - i. ARPANSA's concerns regarding Defence's lack of responsiveness to recommendations arising from ARPANSA inspections;
  - ii. ARPANSA's concerns about the need for clearer lines of responsibility for radiation safety and radiation protection in Defence;
  - iii. The adequacy of current governance arrangements, staffing and resource levels in Defence radiation safety management;
  - iv. The adequacy of radiation safety training and awareness programs in Defence;
  - v. The Terms of Reference for the network of radiation safety committees to ensure that there is an appropriate focus on strategic as well as tactical issues; that there is appropriate representation and engagement from the Services and Groups; and that the Secretary and the Chief of the Defence Force are being provided with the advice they need to discharge their responsibilities for radiation safety in Defence;
  - vi. The arrangements that govern Defence's relationship with ARPANSA to ensure that the Defence ARPANSA Liaison Forum (DALF) is efficient and effective; this includes consideration of the most appropriate mechanisms to facilitate ARPANSA's interactions with the Services and Groups;
  - vii. The current framework for the management and reporting of incidents involving radioactive material and equipment; and
  - viii. The additional resources that will be required, by Service and Group, to establish strengthened governance arrangements for the management of the radioactive sources and facilities domain, consistent with the review's recommendations;

- d) CJLOG, supported by HPE, oversee the work of the project team, and provide progress reports to the Defence Occupational Health and Safety Committee (DOHSC) and the Defence Logistics Committee (DLC) by 31 Dec 07, and 30 Jun 08;
- e) Additional resources be allocated to OHS&C Branch to enable it to develop a more effective regime for internal monitoring of radiation safety in support of JLG's assurance role;
- f) JLG, with support from DMO and DSG, undertake a comprehensive stock-take of Defence holdings of radioactive sources and facilities to validate the accuracy of the data that is being provided to populate the Defence Radiation Source and Facility Inventory.
- g) DMO provide a status report to the DOHSC and the DLC on the disposal program for compasses with radioluminescent paints containing radium-226 and promethium-147 light sources; and
- h) An extract on tritium management written in plain English be developed to enable current fact sheets to be updated.

## **6. Current Practices**

- a) CJLOG review the current arrangements for the management of GTLS to assess the scope to streamline repair, maintenance, storage and distribution processes, and to apply consistent work practices for the management of GTLS across the facilities that deal with these materials;
- b) JLG and OHS&C Branch undertake an inspection of current practices for the management of GTLS at DNSDC;
- c) Liquid scintillation testing equipment be provided to JLU(W); and
- d) The Defence Materiel Organisation keeps a watching brief on work that is under way to seek alternatives to tritium-based light sources.