Australian Government
Nuclear Safety Committee

# REPORT ON THE ANSTO APPLICATION FOR A LICENCE TO OPERATE A REPLACEMENT RESEARCH REACTOR

## Addressing

## The Plan for Maintaining Effective Control of the Facility and Conduct of Operations

## Management of Spent Fuel and Radioactive Waste

**September 2005**

**an advisory body to the CEO of ARPANSA established under the ARPANS Act 1998**
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The mission of ARPANSA is to provide the scientific expertise and infrastructure necessary to support the objective of the ARPANS Act — to protect the health and safety of people, and to protect the environment, from the harmful effects of radiation.

Published by the Chief Executive Officer of ARPANSA in September 2005

## Overview

The Report of the Nuclear Safety Committee (NSC) covers specific terms of reference as requested by the CEO of ARPANSA at the NSC meeting of 5 November 2005. These were to review and advise on aspects of the licence application to operate a Replacement Research Reactor (RRR) relating to:

- the plan for maintaining effective control of the facility in Part B of the Application and the conduct of operations in Chapter 13 of the Safety Analysis Report addressing:
  - organisational structure; safety management systems; lines of communication; delegations; accountabilities; resource requirements
  - roles, responsibilities and authorities, and associated competency requirements; and qualifications, training and accreditation processes for personnel.
- the management of spent fuel and radioactive wastes in relation to:
  - the advice and recommendations provided by the Committee in its report of February 2002; and
  - the adequacy of the Radioactive Waste Management Plan and the Ultimate Disposal or Transfer Plan.

The NSC established two Working Groups (WGs) to address issues relating to:

- Conduct of Operations; and
- Management of Spent Fuel and Radioactive Wastes.

The WGs met on a continuing basis from November 2004 to July 2005 with a draft report generated by each group being considered at an extraordinary meeting of the NSC on 22 July 2005. The final report as presented here has been endorsed by the full NSC.

The Report has been compiled in two parts representing the work of each group. The NSC made several recommendations that appear in each section and are summarised in the "conclusions and recommendations" for each part of the document. Due to time limitations, the work of each group remains to some extent in the context of the manner in which they approached the issues, rather than in like format.

### Members of the NSC who participated in development of this report:

**Dr. Barbara Shields – Chair**
Professor Marcela Bilek
Professor Peter Johnston
Dr. Rob Lee
Dr. Neil McDonald
Professor Rob Melchers
Professor Ian Polmear
Dr. Alan Roberts
Professor Garry Smith
Dr Tamie Weaver

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# Table of Contents

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# 1. WORKING GROUP ON THE REVIEW OF THE CONDUCT OF OPERATIONS PERTAINING TO THE LICENCE APPLICATION TO OPERATE THE REPLACEMENT RESEARCH REACTOR (RRR)

## 1.1 Background

The Conduct of Operations Working Group (CoOWG) was asked to provide input to the NSC's advice to the CEO on its view of the adequacy of the:

- plan for maintaining effective control of the facility in Part B of the Application; and
- conduct of operations in Chapter 13 of the Safety Analysis Report.

In providing that advice, the Committee was asked to address:

- organisational structure; safety management systems; lines of communication; delegations; accountabilities; resource requirements
- roles, responsibilities and authorities, and associated competency requirements; and qualifications, training and accreditation processes for personnel.

In bringing forward its advice, the CEO would be glad if the Committee endeavoured to identify international best practice in radiation protection and nuclear safety in relation to the staffing and competencies for operation of pool reactors that are utilized for functions similar to various of those to be undertaken at the RRR and that are operated on a continuous or near continuous basis.

The CoOWG noted that the CEO was not seeking an alternative in-depth technical assessment of the matters but wanted the Committee's:

> "broad view of these issues based principally upon (their) assessment of the application documentation and in the light of Committee members' personal knowledge and experience".

Where additional information from ANSTO was required to make a reasonable assessment, the CoOWG could request additional information via the CEO.

## 1.2 Membership

Members of the CoOWG were:

Dr Neil McDonald (convenor)
Dr Barbara Shields
Dr Rob Lee
Mr Keith Dessent (ARPANSA support)

Professor Rob Melchers – providing ongoing comment and critique
Professor Garry Smith – providing ongoing comment and critique

## 1.3 Documents Considered

The CoOWG members reviewed the information contained in the following documentation to the extent that it could identify how it pertained to the plan for

maintaining effective control of the facility and the conduct of operations of the proposed facility. The CoOWG conducted teleconferences in order to draft a response. The NSC considered the draft at its extraordinary meeting of 22 July 2005 and requested that the report be finalised taking account of Committee Member's submitted comments.

### 1.3.1 Licence Application Documents

- Application for a Facility Licence, Operating Authorisation for the Replacement Research Reactor, Revision: 0, 10 September 2004;
- Plan for Maintaining Effective Control, Revision: 0, 9 September 2004 (in Part B of the Application);
- Safety Analysis Report (SAR): SAR Chapter 13, Conduct of Operations, Revision: 0, 1 November 2004;

In addressing the content of the documents, the CoOWG found it necessary to also refer to:

- Safety Management Plan, Revision: 0, 9 September 2004 (Part B of the Application);
- Radiation Protection Plan, Revision: 0, 9 September 2004 (Part B of the Application);
- SAR Chapter 12, Operational Radiation Safety, Revision: 0, 9 May 2005, Section 12.1;
- SAR Chapter 17, Operational Limits and Conditions, Revision: 0, 6 May 2005, Section 17.6;
- Operational Limits and Conditions for the OPAL Reactor – Summary for Public Release, Revision: 0, 15 March 2005, Section 5.1;
- SAR Chapter 18, Quality Assurance, Revision: 0, 6 May 2005;
- ANSTO Business Management System:
  - Health Safety and Environment
    - Policies: Health Safety and Environment APOL 2.1, 2 July 2003
      Radioactive Waste Management APOL 2.2, 2 July 2003
    - Delegations: Safety Management APOL 2.1 DOI, 26 May 2000
    - Senior Management Documents: Safety Management Regime (undated)
- ANSTO Safety and Radiation Sources – Safety Directives (update 9 June 2005) (www.ansto.gov.au)
  - SD 1.1 Safety Management System Overview
  - SD 2.1 The Safety System Review and Approvals System, 7 June 2002
  - SD 4.1 The ANSTO Event Response System, 26 November 2001

### 1.3.2 ARPANSA documents

- *Australian Radiation Protection and Nuclear Safety Act* 1998
- *Australian Radiation Protection and Nuclear Safety Regulations* 1999

- Regulatory Guideline on Review of Plans and Arrangements, RB-STD-15-03 Rev 0, August 2003. Parts 1 and 2
- Regulatory Assessment Principles for Controlled Facilities, RB-STD-42-00 Rev 1, October 2001. Paragraph 3.3
- Licence Conditions Handbook – Part 2 Organisational Licence Conditions, ANSTO Handbook, RB-STD-24-01 Rev 1, May 2001 Part 4.1.1 Licence Conditions 3 to 15 (Pages 10 to 13)
- Facility Licence F0118-Construction Authorisation (Licence to Construct the Replacement Research Reactor
    - Decision by the CEO of ARPANSA on the Application to Construct the Replacement Research Reactor at Lucas Heights, Reason for Decision, 4 April 2002
    - Section 2.3.2 International best practice in radiation protection and nuclear safety

### 1.3.3 Facility Operation

- The Operating Organisation for Nuclear Power Plant, Safety Standard Series No. NS-G-2.4, IAEA, Vienna, 2002.
- Recruitment, Qualification and Training of Personnel for Nuclear Power Plant, Safety Standard Series No. NS-G-2.8, IAEA, Vienna, 2002.
- Safety Requirements for Research Reactors, Safety Standards Series, DS272 draft, IAEA, Vienna, February 2004. Section 7 (particularly paragraphs 7.1-7.28, 7.38, 7.51-7.55, 7.81-7.109).
- Safety in the Utilisation and Modification of Research Reactors, Safety Series No. 35-G2, IAEA, Vienna, 1994. Paragraphs 207 to 216; paragraphs 811 to 814.
- Safety Assessment of Research Reactors and Preparation of the Safety Analysis Report, Safety Series No. 35-G1, IAEA, Vienna, 1994. Paragraphs 230 to 232; Appendix A13.

### 1.3.4 Other Documents

#### 1.3.4.1 IAEA Peer Review Mission

The convenor of the CoOWG was briefed by the IAEA Peer Review Mission on the Commissioning and Operation of the OPAL Research Reactor for ARPANSA at the completion of the Mission's work in Sydney. The CoOWG subsequently received the Mission's Report. The Mission undertook a broader scope and intensity of assessment than the CoOWG but there was common ground on some aspects of organisational structure and conduct of operations and some similar views were formed. The CoOWG formed its views independently.

#### 1.3.4.2 Safety Management System (SMS) Information

The CoOWG received useful information about SMS documentation in the aviation industry. It ascertained that ANSTO had an up-to-date, on-line integrated safety

management document system including policy, directive, operational and review elements. This was focussed on nuclear industry practice.

#### 1.3.4.3 Operating Procedures for Research Reactors - IAEA

As part of its long standing program to codify internationally recognised nuclear safety practice for research reactors, the IAEA is to issue two guidance documents: *The Organization, Recruitment, Training and Qualification of Personnel for Research Reactor Facilities*, DS325 and *Operating Limits and Conditions and Operating Procedures for Research Reactors*, DS261. These were still to be finally approved and issued at the time of this review and were unavailable to the WG.

The CoOWG was given a detailed list of questions that the ARPANSA Regulatory Branch had posed to ANSTO on SAR Chapter 13, Conduct of Operations. The CoOWG was advised that the questions comprehensively reflect the recommendations in DS325 and DS261. Answers to the questions should provide the detailed information that would be included in the OPAL Research Reactor's Quality Management System Procedures listed in the Plan for Effective Control, Appendix 1. Given this detailed attention by ARPANSA, the CoOWG did not pursue the content of DS325 further but confined its attention to the documents listed in 1.3.

## 1.4 General Response to the CEO's Request

### 1.4.1 International Best Practice

The CEO of ARPANSA defined the scope of the term 'international best practice' in radiation and nuclear safety in Section 2.3.2 and Annex 2 of his Reasons for Decision on a Licence to Construct the RRR (Licence F00118 – Construction, 4 April 2002). He identified an international regime of best practice documented by international agencies (mainly the IAEA) and in several international conventions.

The specific documented practices for research reactors are confined to the IAEA Safety Series. The general nuclear safety and radiation protection elements of the international regime are also applicable. For research reactors with the power of the OPAL Research Reactor (20 MW thermal), some recommended practices for nuclear power reactors in the IAEA Safety Series are also relevant. The CoOWG was satisfied that the material it considered provided an adequate description of the international best practice relevant to the scope of its assessment.

Given the wide range of types, power levels and utilisation objectives of research reactors, the requirements and recommendations of the international regime for research reactors are rather general in many respects. The CoOWG observed that practices for the new, state-of-the-art, multipurpose OPAL Research Reactor, if based on the requirements of the international regime, with proper attention to the advanced features of the facility (such as its high level of automation) and drawing on ANSTO's long and successful safe operation of HIFAR, should be expected to set new benchmarks for best practice. The CoOWG noted that Australia's regulatory and operational practices have been commended in the Review Conferences of the Convention on Nuclear Safety.

The CoOWG formed the view that the proposals for maintaining effective control and conducting of the operation of the OPAL Research Reactor, as outlined in the application, were overall in accord with the IAEA Safety Series requirements and recommendations.

In specific, but summarised, form the proposals describe the issues the CEO of ARPANSA asked the NSC to address. The CoOWG recognised that these "top level" documents do not contain the level of detail that will be in the Reactor Facility Quality Management System Procedures (listed in Appendix 1 of the Plan for Effective Control). Such detail is being sought by ARPANSA in, for example, the questions referred to in Section 1.3.4 of this Report.

To the extent relevant to commissioning activities, the detailed information must be available to ARPANSA in a timely basis before a particular commissioning activity can proceed. The complete QMS Procedures clearly need to be in place before an operating licence can be finalised.

The CoOWG considered that long established and proven procedures for HIFAR should be adaptable to the OPAL Research Reactor in many areas, particularly those that are non-plant specific, subject to any opportunities being taken for improvement in light of international experience in the nuclear industry and elsewhere, including INVAP's experience with pool reactors.

### 1.4.2 Safety Management Systems

The CoOWG had some difficulties in navigating through the documentation in pursuit of specific issues. This was particularly so for members unfamiliar with the structure and content of documentation for reactor management and operation and for the regulatory/licensing interaction between ANSTO and ARPANSA. A full appreciation of matters such as the organisational structure and responsibilities of the SMS, even at the "top level", can require addressing material in the SAR, several plans, ANSTO's on-line SMS and several ANSTO safety directives. The Requirements cross referenced at Appendix B of the Plan for Effective Control is very helpful, as is the on-line SMS, once accessed. The CoOWG recognises that the system provides a practical basis for activities and arrangements which primarily ANSTO and ARPANSA have to understand. Also, the CoOWG recognises that some arrangements important to the management and safe operation of OPAL are addressed (and regulated by ARPANSA) through ANSTO-wide procedures (eg. safety directives) and/or in other licences (eg waste management). ANSTO'S SMSs have clearly evolved, and been built upon and enhanced, over a considerable time period.

The overall arrangements and their presentation in the Application is not however particularly transparent to the external assessor or observer. A single SMS Manual for the operation of the OPAL Research Reactor, which does not go into operational and administrative detail, but provides an integrated, strategic overview, would be useful for all stakeholders. This would tie the SMS together by outlining its fundamental elements – safety policy, senior management commitment, risk management, safety assessment, accident/incident investigation, reporting and recording systems, safety information system, training and education, safety culture, etc.

Some specific improvements in the Application documentation would assist understanding and should be required by ARPANSA. In essence, some integrated editing would provide consistency across all components of the Application. The following are examples:

**Terminology**: A committee to advise the Reactor Manager is variously identified as:

- Reactor Assessment Committee (SAR Chapter 13, Section 13.5.2)
- Reactor Advisory Committee (Safety Management Plan, Section 4.3)
- Safety Committee (SAR Chapter 17, Section 17.6.5)

The titles could suggest different functional emphasis and the functions are not described consistently. An unambiguous description is essential.

**References**: It would be helpful if a consolidated list of references were included in each Plan and, where references are used, in SAR Chapters. The Radiation Protection Plan provides a good model. Also helpful would be specific cross referencing to Plans and to CMS documentation in the SAR now that this documentation has been identified. The SAR is a "living" plant lifetime report and should be properly cross referenced to the quality system documentation.

**Acronyms**: Similarly, the Radiation Protection Plan provides a model for a consolidated list of acronyms (called Abbreviations in the Plan for Effective Control).

ANSTO has a well developed and proven SMS into which the proposals for OPAL outlined in SAR Chapter 13 and the Plans for Safety Management and Radiation Protection are, in principle, integrated. It reflects IAEA best practice recommendations for there to be committees advising the reactor manager as well as committee(s) independent of the reactor manager advising the operating organisation (ANSTO) (IAEA DS272, Section 4 and paragraph 7.25, 7.26). The specific arrangements for OPAL are outlined in:

- SAR Chapters 13 and 17;
- the Safety Management Plan;
- the Radiation Protection Plan;
- the ANSTO formal safety assessment; and
- the approval system as defined in Safety Directive 2.1.

Notwithstanding the ambiguity in committee title and functions noted above, the committee advising the reactor manager (Reactor Advisory Committee (RAC)) would appear to have the essential functions for review of safety related aspects of operations, safety documentation and reports to ARPANSA, subject to verification by ARPANSA of the final terms of reference. Similarly, the Radiation Safety Committee (RSC) advising the reactor manager also has an appropriate range of functions (Radiation Protection Plan Section 4.5).

Therefore, however, issues requiring clarification are:

- The interrelation of RAC and RSC with the Safety Assessment Committee (SAC) and the ANSTO Health Safety and Advisory Committee (how it fits into Figure 2 of SD2.1 on page 2);
- The resources available to the RAC and, in particular, the location within ANSTO of nuclear safety expertise and RAC's access to the expertise (noting the need for the SAC to also have independent access to such expertise).

### 1.4.3 Responsibilities of Nominee and Reactor Manager

In Chapter 13 and the Plan for Effective Control, the Nominee is the Manager Reactor Operations, to whom the Reactor Manager reports. The Nominee in the Application is the Chief of Operations. The CoOWG understands that that was an interim situation, pending appointments to other positions being finalised. Formal confirmation and elaboration of the intended final arrangements is required.

There would appear to be a splitting of responsibilities of the Reactor Manager as defined in IAEA DS272 between the Nominee and the OPAL Research Reactor Manager. This requires further clarification, including whether the Manager Reactor Operations (Nominee) will also be the Nominee for HIFAR. ANSTO should make it clear to ARPANSA whether this position is actually what the IAEA terms as the Reactor Manager.

The CoOWG noted that, if it is confirmed that the Manager Reactor Operations is the Nominee identified in Fig 13.2/1, Organisation Chart, of SAR Chapter 13, then the proposed arrangements are the same as those that have apparently proved successful, and have been accepted by ARPANSA, for HIFAR.

## 1.5 Conclusions and Recommendations

As noted in the report, the WG concluded that the proposals for maintaining effective control and conducting of the operation of the OPAL Research Reactor, as outlined in the application, were overall in accord with the IAEA Safety Series requirements and recommendations.

Long established and proven procedures for HIFAR should be adaptable to the OPAL Research Reactor in many areas, particularly those that are non-plant specific. ***This should be subject to any opportunities for improvement in light of international experience in the nuclear industry and elsewhere.***

The WG makes the following recommendations arising from its terms of reference:

- A safety culture should be actively promoted throughout the ANSTO organisation;
- The detailed information relevant to commissioning activities be made available to ARPANSA in a timely manner before a particular commissioning activity proceeds;
- Complete Quality Management System Procedures be set in place before a decision is made on whether an operating licence should be issued or not.

- The nomenclature in relation to the organisational hierarchy, including the various safety committees, be made consistent with IAEA documentation;
- Integrated editing of the documentation be carried out to ensure consistency of terminology and acronyms;
- The positions, roles and functions of the various operational personnel and safety committees be clarified, confirmed and, where appropriate, elaborated upon.
- ANSTO advise ARPANSA whether the Manager Reactor Operations (Nominee) is what the IAEA terms as the Reactor Manager.
- ANSTO prepare a single SMS manual for the operation of the OPAL Research Reactor. This manual does not need to go into operational and administrative detail but should provide an integrated strategic overview of the SMS for the reactor.

# 2. WORKING GROUP ON THE REVIEW OF THE MANAGEMENT OF RADIOACTIVE WASTE AND SPENT FUEL ASPECTS OF THE LICENCE APPLICATION TO OPERATE THE REPLACEMENT RESEARCH REACTOR (RRR).

## 2.1 Background

The Management of Radioactive Waste and Spent Fuel Working Group (RWMWG) was asked to provide input to the NSC's advice to the CEO further to the advice that the Committee provided in February 2002 on spent fuel and radioactive wastes in relation to the construction licence application.

This advice would need to address the adequacy of the Radioactive Waste Management Plan and the Ultimate Disposal or Transfer Plan.

The RWMWG also noted that the CEO was not seeking alternative in-depth technical advice but wanted the Committee's:

> "broad view of these issues based principally upon (their) assessment of the application documentation and in the light of Committee members' personal knowledge and experience".

Where additional information from the applicant was required to make a reasonable assessment, the RWMWG could request additional information from ANSTO via the CEO.

## 2.2 Membership

The members of the RWMWG were:

Professor Peter Johnston (Convenor)
Emeritus Professor Ian Polmear
Dr Alan Roberts
Dr Tamie Weaver
Mr Keith Dessent (ARPANSA support)

Professor Rob Melchers – providing ongoing comment and critique
Professor Garry Smith – providing ongoing comment and critique

Members held teleconferences and face-to-face meetings between November 2004 and July 2005 in order to draft a response. The NSC considered the draft at its extraordinary meeting of 22 July 2005 and requested that the report be finalised taking account of Committee Member's submitted comments.

## 2.3 Documents Considered

The following material was available to the RWMWG for consideration:

- Application for a Facility Licence, Operating Authorisation for the Replacement Research Reactor, referred to here as the "Application",

including Part B: The plans and arrangements for managing safety for the reactor facility;

- Report on the ANSTO Application for a Licence to Construct a Replacement Research Reactor Addressing Seismic Analysis and Seismic Design, Accident Analysis and Spent Fuel and Radioactive Wastes (February 2002).
- Government media release on the proposed Commonwealth Radioactive Waste Management Facility.
- Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, International Atomic Energy Agency (IAEA), June 2001.

***Correspondence:***

- Letter from Dr Barbara Shields, Chair of NSC, to ARPANSA, RWMWG questions, 27 April 2005.
- Draft Letter from ARPANSA to Secretary of DEST, RWMWG questions.
- Letter from ARPANSA to CEO of ANSTO, RWMWG questions, 27 April 2005.
- Letter from ANSTO to John Loy, 16 May 2005, re Working Group, Nuclear Safety Committee: Response to RWMWG questions;
- Letter from ARPANSA to Dr Barbara Shields, Chair, NSC: Response to RWMWG questions (ARPANSA), 17 May 2005;
- Letter from ARPANSA to Dr Barbara Shields, Chair, NSC: Response to RWMWG questions (DEST), 18 May 2005.

***Other Information:***

- Briefing by ANSTO personnel, 16 June 2005.
- Site visit to HIFAR and the OPAL Research Reactor and waste storage and processing areas at ANSTO, 16 June 2005.

## 2.4 Issues Remaining Open from the Previous WG (February 2002)

The report of the NSC Working Group (February 2002) investigating issues relating to Spent Fuel and Radioactive Wastes in the ANSTO Application for a Licence to Construct a Replacement Research Reactor highlighted several issues which remained open at the time of reporting in 2002. These issues were identified by the RWMWG and formed the basis of the correspondence between the Chair NSC and Dr Loy and correspondence between Dr Loy and ANSTO mentioned in 2.3.

It is clear that ANSTO has made significant progress in relation to:

- plans for conditioning low level and intermediate level wastes;
- identifying waste that is below the exemption limit; and
- reducing environmental releases.

There have also been considerable effort and resources expended on ensuring that waste arising from production can be stored on-site for many years to allow for the contingency that the LLW repository and Commonwealth Store as discussed in the Feb 2002 report are not available in the near future.

The RWMWG summarises its understanding of waste treatment and storage issues below and makes several recommendations regarding plans for waste management at ANSTO. Much of the information below is taken from ANSTO documents mentioned in section 2.3.

In this report, the NSC uses the definitions of radioactive waste and spent fuel in the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management as:

> "radioactive waste" means radioactive material in gaseous, liquid or solid form for which no further use is foreseen by the Contracting Party or by a natural or legal person whose decision is accepted by the Contracting Party, and which is controlled as radioactive waste by a regulatory body under the legislative and regulatory framework of the Contracting Party;

and

> "spent fuel" means nuclear fuel that has been irradiated in and permanently removed from a reactor core;

respectively.

## 2.5 Low level waste – onsite

### 2.5.1 Storage

Low-level radioactive waste is stored in steel drums in drum storage racks in the low level waste store. The steel drums are stored on pallets in a double deep racking system that makes efficient use of the space. The racking system was designed to withstand seismic loads and certified against Australian Standard AS-1170 Part 4 to ensure that the facility could also be used to store materials that are associated with Hazard Category 3 Facilities[1]. This exceeds the requirements for the storage of low-level radioactive waste.

### 2.5.2 Conditioning

ANSTO has constructed and commissioned a licensed waste treatment and packaging facility (WT&PF) to treat and condition solid and liquid radioactive wastes. The WT&PF is capable of processing the majority of current and future low-level radioactive wastes at ANSTO. This new facility was included in the Waste Operations Facility Licence FO0044B in August 2003, and includes:

- A Waste Inspection and Decontamination Chamber (WI&DC). The function of the WI&DC is to limit the spread of any contamination which may arise during opening of waste drums. Drums of historic wastes will be transferred

[1] In ARPANSA Regulatory Assessment Principles (RB-STD-42-00 Rev 1), Hazard Category 3 Facilities are defined as facilities "where there is potential for significant consequences outside the site".

from drum storage racks to the WI&DC. Decisions related to treatment options for each drum will be made within the chamber;

- A mortar mixing plant able to condition current wastes, and future solid radioactive wastes arising from the OPAL Research Reactor. The purpose of the cementation plant is to prepare specialised cement-based mortar to treat homogeneous and heterogeneous waste forms for transport and disposal at a low level radioactive waste repository; and
- A drum drying facility for drying of liquid waste sludges produced from the processing of low level liquid radioactive wastes. The function of the drum drier is to dry free water from drums containing the normal compacted low level wastes, and drying sludge and evaporator concentrates so that the anticipated waste acceptance criteria for the repository (i.e. less than 1% free-moisture) is satisfied.

Testing on simulated waste forms has been carried out using cement/mortar matrix. The solid and liquid radioactive wastes arising from the OPAL Research Reactor will be similar to radioactive wastes currently being processed at ANSTO. This facility has adequate capacity to handle the future arisings of low-level waste from the OPAL Research Reactor and isotope production.

Gaseous wastes are processed through HEPA and charcoal filters to maintain emissions below the required levels. The resulting solid wastes (HEPA/charcoal filters) will be processed through the WT&PF. HEPA filter radioactivity varies, depending on the location of use, the activity on removal from operation and the decay period since removal from service. HEPA filters are treated as routine radioactive waste through the ANSTO system and are packaged and stored.

Since receiving authorisation for operation of this facility, a few waste drums have been conditioned on a test basis. The conditioning of waste is related to the operation of a Commonwealth waste repository or store for which the acceptance criteria are yet to be determined.

The Radiation Health Committee, established under the ARPANS Act, is developing a new code of practice on pre-disposal radioactive waste management and has prepared a draft of the new code. The RWMWG recommends that completion of this work be a matter of high priority.

### 2.5.3 Capacity

The low level waste store is capable of storing approximately 6200 drums in storage racks on pallets and is located in the secure zone surrounding HIFAR. At the time of writing, there was room for 125 more drums of low level waste equating to approximately 12 months capacity using this arrangement. If drums are stacked to store the maximum number irrespective of the stacking system, the capacity can be increased to 6500 drums, increasing capacity to approximately 3 years storage.

An exempt level waste processing/storage facility was commissioned in 2002 to allow exempt level waste segregation, inspection, monitoring and clearance for off-site disposal.

An options review, currently under consideration, will form part of a capital funds submission (3-year plan) to improve the processing of low level radioactive solid wastes as well as an expansion of storage facilities. One of the processing options includes super-compaction of the low-level solid wastes.

ANSTO has approximately 3 years of storage space remaining for low level solid waste in the low level waste store (stored in 200 litre drums). The options review includes, subject to appropriate regulatory approval, the clearance of approximately 450 × 200 litre drums of exempt level waste that has decayed below the clearance levels required for disposal to municipal tips or industrial wastes depots. This option will provide a further 3 years of storage space.

The options review also includes the installation and operation of a super-compaction facility (which will reduce the volume of low level solid waste by a factor of four) and some extension of the current facility. This option, coupled with a rationalisation of the current low level waste store, will provide ANSTO with the capacity to process and store low level solid wastes for a further 40 years.

It is preferable that waste volume be reduced, where possible. The RWMWG considered that super-compaction of low level waste would be a sensible approach to increasing storage capacity, provided it is authorised by ARPANSA.

### 2.5.4 Management of Radioactive Waste

The Waste Operations section of ANSTO has implemented a waste inventory database for the management of radioactive wastes generated at ANSTO. The database provides an accurate representation of the waste processes, including source of generation, processing steps, radiological characterisation (gamma scanning data), and volumes of waste. The system also tracks the radioactive wastes through the various process steps to a final waste form and storage location.

## 2.6 Intermediate level waste – onsite

### 2.6.1 Storage Facility and Capacity

Intermediate level waste is stored in a steel frame structure, clad with steel sheet, with a row of reinforced glass windows set high in the walls, covering a thick concrete base laid on to bedrock.

Various sizes of pits, tubes and shielded “Decay Cells” are used to store the waste. The decay cells are shielded areas used to store Short-Lived Intermediate Level Solid Wastes (ILSW-SL) until the waste has decayed below a contact dose rate of 500 μSv/h. The waste is then transferred to the molybdenum intermediate level liquid waste store for processing and packing in low-level storage drums.

Long-Lived Intermediate Level Solid Waste (ILSW-LL) is placed in specially constructed concrete pits within the intermediate level waste store for long term storage and future retrieval. There are currently two types of storage used for intermediate level waste.

1. The “A” pits, as they are known, are eight pits constructed in the late 1960s with no internal structure other than the walls that separate adjoining pits. Each pit has dimensions 1.5 m × 5.9 m deep and a volume of about 190 $m^3$.

The outer walls of the pit are 225 mm concrete with a 20 mm bituminous waterproof membrane. The "A" pits contain radioactive wastes put into them before 1990. Since 1990, wastes have been stored in a systematic manner in retrievable storage pits.

2. The "B" or retrievable storage pits, commissioned in mid-1990, are a series of eight pits, each holding eight vertical aluminium racks. Each rack has the capacity to hold 17 aluminium storage bins in which waste has been placed at source or after processing by the Waste Management Section. These bins have a nominal capacity of 72 litres each; the total capacity of the "B" pits is approximately 78 $m^3$.

Additionally, a third type of storage is available in the eastern end of the intermediate level waste and dry spent fuel store which comprises several steel tubes of several diameters and lengths that are used for the storage of solid radioactive wastes. This is currently used for spent fuel storage.

At the time of writing, there was 181 $m^3$ of capacity for ILW in the intermediate level waste store. The RWMWG noted that once OPAL went on-line and OPAL spent fuel was kept in the pool, capacity in the building would be freed up as spent fuel from HIFAR was sent overseas for reprocessing or disposal. ANSTO advised that there was currently 30 years capacity in the intermediate level waste store for OPAL operating waste.

### 2.6.2 Conditioning

ANSTO currently has an ongoing capital project for the long-term immobilisation of legacy $^{99}$Mo Liquid Wastes using synroc technology. The Synroc project commenced in mid-2003, and progress has seen the construction of a full scale "mock-up" facility on a hot cell geometry. The testing of the mock-up will be used to confirm ANSTO's ability to implement the integrated process in a hot cell environment.

The legacy molybdenum waste solution is currently being solidified, in hot cells, to a uranyl nitrate product. The solids from this process will be stored in the vessels (five to a bin) on racks within seven metre deep pits in the intermediate level radioactive waste store, until they are finally conditioned for permanent storage or disposal.

These solid wastes would be redissolved, treated in an integrated mixer/drier, calcined and packaged for hot isostatic pressing as Synroc. The mock-up facility will test the integration of the unit operations within the confines of hot cell geometry using inactive simulants for this particular process. The test plan is to verify the operability and maintainability in this configuration. This testing phase is now commencing. These operations are planned for the hot cell in High Activity Handling Hot Cells No. 1 adjacent to the hot cell where current solidification is being undertaken.

ANSTO expects that Synroc technology will effectively process and re-condition the current legacy Long Lived Intermediate Level Liquid Waste into a stable form suitable for either long-term storage or geological disposal.

## 2.7 Reactor Operations and Minimisation of Radioactive Waste

The utilisation of the reactor and its fuel, insofar as is relevant to the production of waste, covers the production of radioisotopes, the irradiation of silicon and the

irradiation of samples for neutron activation analysis. The use of neutron beams has a negligible effect on waste production.

The RWMWG considered that ANSTO should examine possible avenues for minimising not only directly generated radioactive waste but also spent fuel and therefore spent fuel derived radioactive waste for each application.

ANSTO indicated that all of the above reactor-based applications require a constant flux. The operation of the reactor at lower power levels would result in increased waste production for some waste types as a larger number of irradiations would be required to produce a given quantity of radioisotope. This would require a larger number of containers and process material, all of which would end up as radioactive waste. There would be no change for other irradiations except that they would take longer.

The RWMWG considered that ANSTO should determine the optimum operating power for OPAL for each application, taking into account all factors, including waste minimisation.

Operating the reactor at lower enrichment would not reduce the quantity of radioactive waste produced. It would also increase the quantity of spent fuel given that a greater amount of fuel would be needed to produce the same fluence.

OPAL has been designed to minimise radioactive waste production. This has been achieved wherever possible through efficiency in irradiation processes, and the use of materials in its construction which, after being subjected to neutron flux have activation products with relatively short half-lives, wherever this has been possible. Details can be found in the Plans and Arrangements for Management of Radioactive Waste and the Ultimate Transfer or Disposal Plan, which form part of Part B of the licence application for the OPAL Research Reactor.

ANSTO is progressing with a project to use low enriched uranium (LEU) targets that are more highly enriched than current targets and an alternative processing regime. The use of these targets, which are enriched by a factor of nine over the current targets, should allow production of $^{99}$Mo to be increased without increasing the number of irradiations or the amount of waste generated.

The $^{99}$Mo production process has been reviewed by ANSTO, and a new process identified that will enable ANSTO to meet increasing demand for technetium-99m whilst reducing emissions. A contract has been entered into with INVAP for supply of components and processing technology for this well-proven process that has been used successfully overseas for a number of years. The approval of the CEO of ARPANSA is required before this process can be implemented, and ANSTO discussed issues relating to this approval with ARPANSA officers in November 2004. Current planning is for the implementation of this new process during 2006.

Waste streams arising from the proposed new molybdenum production consist of the following four streams.

*Filter cake containing uranium - intermediate level solid wastes (ILSW)*
After a nominal decay period of 1 year within the High Activity Handling Hot Cells No. 2, ANSTO's preferred option is to transport Uranium Filter Cakes to the High

Activity Handling Hot Cells No. 1 using the existing 6.5T Flask. Uranium Filter Cakes may then be packaged and prepared for transport to interim storage within the vacant fuel element holes in the intermediate level waste store. Final processing options for the Uranium Filter Cakes are currently being assessed in parallel with waste handling and interim storage.

*Liquid waste - alkaline intermediate level wastes (ILLW)*
This waste will be stored within tanks at ANSTO until such time that facilities are prepared for processing. The project is planning to provide up to 10 years of storage in tanks following the removal of ILLW from the High Activity Handling Hot Cells No. 2.

ANSTO's preferred option for ILLW is to pursue 10 year storage within shielded stainless steel delay tanks of identical size to those of the proposed INVAP liquid waste tanks within cell 4 (124L). The tanks may be individually shielded using a combination of high density concrete and steel structure, configured to permit transportation using existing equipment. Storage locations for individual tanks (approximately 80 tanks for 10 yrs) are available at ANSTO.

The second option involves the fabrication of 4 new stainless steel tanks (~4200L each) and associated pipe work within the molybdenum intermediate level liquid waste store basement shielded storage bay. The original construction of the facility at the molybdenum intermediate level liquid waste store had made allowance for an additional 4 fibreglass tanks at 1900 GAL each (~8600L) to be suspended from the ceiling, existing lines and fittings route back to the common molybdenum intermediate level liquid waste store waste manifold. New tanks may be configured to attach to existing framework with the addition of reflux condensers, stirring devises, and dedicated lines to prevent evaporation, precipitation, and mixing of caustic and existing acidic legacy waste. Additional shielding may also be required for tank surrounds and the floor of the existing molybdenum intermediate level liquid waste store waste manifold.

Processing options for ILLW are being progressed in parallel by ANSTO Materials and Engineering Science. Various synroc compositions have been considered in addition to geo-polymers and cement. Integration of temporary storage methodologies with final processing will be examined.

*Liquid waste - alkalised lower activity – low level liquid wastes (LLLW)*
The LLLW will be stored within tanks at ANSTO until such time that the activity is suitable for processing (early estimates indicate 2 years following removal from the High Activity Handling Hot Cells No. 2).

ANSTO's preferred option is to pursue immediate treatment of the LLLW using the existing process of drum drying followed by immobilisation using cement. Transfer of LLLW from the High Activity Handling Hot Cells No. 2 to temporary storage may be carried out using a shielded tank. The tank may be configured to adapt to fixtures and fittings on the existing LLLW transfer truck.

*Solid cell waste - intermediate level solid wastes ILSW*
ANSTO's preferred option is to pursue the use of the existing retrievable waste system to remove all columns and miscellaneous waste from within cells 2 and 5

following a nominal decay period of 1 year. The existing retrievable waste bin storage site (Storage type B in the intermediate level waste store) has sufficient capacity to accommodate low level solid waste generated throughout routine operation, currently expected to be 30-years (see section 2.6.1).

## 2.8 Current disposal mechanisms

ANSTO has introduced several process improvements to accommodate the ALARA principle including:

- waste segregation (at source);
- implementation of ISO 9001 and ISO 14001 certification incorporating waste minimisation principles;
- operations of an exempt level waste clearance facility including improved decontamination and monitoring processes;
- waste management awareness programs (website and training programs); and
- review and monitoring of radioactive waste management principles during SAC submissions for new and ongoing projects, and customer feedback on radioactive waste volumes generated from specific facilities.

### 2.8.1 Determining and disposing of exempt material

An exempt level waste processing/storage facility was commissioned in 2002 to allow exempt level waste segregation, inspection, monitoring and clearance for off-site disposal.

After treatment in the WT&PF, charcoal and HEPA filter waste is stored for delay and decay. Following a relevant storage period, the charcoal and HEPA filters are scanned for residual radioactivity and released as exempt level waste to municipal landfills if they meet the clearance criteria.

The waste is scanned at the exempt level waste clearance facility. The drum waste is categorised at the exempt level waste clearance facility for exemption and clearance. The waste clearance centre is not licensed as it does not contain any radioactive waste, where a further check is done to reconfirm the release of waste for disposal.

### 2.8.2 Discharges to the Environment

ANSTO's Holding Tanks have a capacity of approximately 1260 $m^3$, which is four days of storage capacity of trade waste and reactor secondary cooling water during the dual operation of the HIFAR and OPAL Research Reactors. The site sewer system is now capable of bypassing the Holding Tanks (as it is not from radioactive areas and is not classified as Trade Waste). It is unlikely that the Holding Tanks will reach their peak capacity coincident with a sewer surcharge as ANSTO has the option to by-pass site sewage directly to the Sydney Water discharge pipeline. ANSTO maintains a watch on tank levels and potential meteorological surcharge conditions.

New ventilation systems installed in radiopharmaceutical production Buildings 23 and the High Activity Handling Hot Cells No. 2 have resulted in an immediate reduction

in the levels of gaseous emissions from radioisotope production. The RWMWG noted ANSTO's assertion that:

> "releases from LHSTC have satisfied all public health requirements for many years now. As noted in the ANSTO Report *Environmental and Effluent Monitoring at ANSTO Sites 2003-2004 (ANST E-755):*
>
> > The maximum estimated effective dose for the critical group was 0.0038 mSv/year to the East-Northeast, and was therefore less than 20% of the ALARA objective of 0.02 mSv/year and much lower than the public dose limit of 1 mSv/year and the natural background in Australia of – 1.5 mSv/year (not including medical investigations; Webb *et al*. 1999).
> > …
> > The effective dose-rates to the critical group of members of the public potentially exposed to radiation from routine liquid effluent discharges from the LHSTC were recently calculated to be no more than a quarter of the minimum dose estimated for members of the public potentially exposed to airborne emissions from the LHSTC (Hoffmann *et al*. 2003)."

## 2.9 Disposition of spent fuel – foreign arrangements

### 2.9.1 Reprocessors – conditions/dates

The options proposed by ANSTO for conditioning or reprocessing of spent fuel from the OPAL Research Reactor are set out in the Ultimate Disposal or Transfer Plan in the operating licence application. They are also described in ANSTO's letter of 16 May in response to the RWMWG's questions.

There have been significant developments in ANSTO's arrangements to handle spent nuclear fuel arising from OPAL. These have been formally notified to ARPANSA through correspondence with the CEO of ARPANSA on 17 December 2004 and 15 February 2005. (These documents and attachments thereto are available on the ARPANSA operating licence application web page under "Ultimate Disposal or Transfer Plan"). In summary, these developments include the extension to the US Acceptance Program for Foreign Research Reactor Spent Nuclear Fuel (FRR-SNF) until 2019 for fuel irradiated before May 2016, and the formal inclusion of the OPAL Research Reactor into this program. In addition, ANSTO and AREVA have signed a MOU to cover the reprocessing of all the spent nuclear fuel (SNF) arising from OPAL. Finally, Argentina has ratified the bilateral Australia-Argentina Nuclear Co-operation Agreement, which will allow the reprocessing of OPAL SNF in Argentina.

### 2.9.2 Return of waste

Fuel manufactured from US-origin enriched uranium arising from the operation of a research reactor can be returned to the US under the US Department of Energy (DOE) FRR-SNF. This program commenced in 1996 and was to accept spent fuel irradiated up to May 2006 and transported to the US before May 2009. In 2004, the United States Secretary of Energy announced that the timescale for this program is to be extended. To this end, the US DOE is currently preparing a supplemental analysis required by the U.S. National Environmental Policy Act.

The fuel for the initial operations of the reactor facility is of US-origin and is U-Si fuel, a type accepted under the FRR-SNF program. The preferred option for spent fuel from the initial reactor facility operations will be return to the US. In the case of spent fuel accepted by the US, there will be no return of waste to Australia.

The first alternative spent fuel disposition route is reprocessing by COGEMA in France. The current ANSTO contract with COGEMA for spent fuel reprocessing includes U-Mo fuel but normally excludes U-Si fuel. However, ANSTO has made arrangements with COGEMA for the acceptance of U-Si spent fuel. This is additional to ANSTO's intention that, after the FRR-SNF program ends, the long-term disposition route for Reactor Facility spent fuel will be reprocessing by COGEMA. An agreement with France at inter-governmental level has been concluded to support these arrangements.

The solid waste prepared from reprocessing of Australia's research reactor spent fuels will, as guaranteed under the contract with COGEMA, meet the International Atomic Energy Agency's criteria for classification as long-lived intermediate level waste. Further, the quality of the borosilicate glass in which the intermediate level waste will be encapsulated is equivalent to that accepted by Germany, Japan, Belgium and the UK for the storage and disposal of higher categories of radioactive waste.

ANSTO's contract with COGEMA also includes provision of the multi-purpose transport and storage casks for return transport and long-term storage of the wastes. By providing the necessary packaging, shielding and containment of the wastes, these casks greatly simplify the design requirements for a storage facility. No additional shielding or remote-handling equipment, beyond that which would be required for the other long-lived intermediate level waste to be stored in the facility, will be necessary. The proposed Commonwealth Waste Management Facility for long-lived intermediate level wastes will be able to accept these casks as a small addition to the other quantities of waste in this category that will already be stored there.

As noted above, ANSTO's existing contract with COGEMA for the reprocessing of spent fuel from HIFAR includes provision for the reprocessing of spent fuel from the OPAL Research Reactor. The same waste return provision will apply for OPAL fuel as has already been accepted by Government and regulatory authorities for HIFAR spent fuel. There is therefore every confidence that this same strategy will be acceptable for the OPAL fuel.

Also, as a further back-up option, INVAP has given a written guarantee to provide an alternative solution consistent with Australia's requirements, as stipulated in the Request for Tender, using proven technologies. Argentina has already developed and demonstrated a novel technology for treating aluminium-clad research reactor spent fuel, and has plans to use that technology for managing its own research reactor spent fuel. An agreement with Argentina at inter-governmental level to support these arrangements has been signed by both governments, but has not yet been ratified by Argentina. However, INVAP is still contractually obligated to provide a disposal route for spent fuel (excluding the first 2 cores comprising 32 fuel elements).

In summary, ANSTO's preferred option is that the silicide-type spent fuel from the initial reactor facility operations will be returned to the US under the FRR-SNF program. After the initial operations, and probably after the reactor is converted to

operate with U-Mo fuel, the spent fuel will be returned to COGEMA for reprocessing. Should the US FRR-SNF program not be extended, arrangements are in place with COGEMA to process the silicide-type spent fuel. The Argentine route is contractually available as a further fall-back option.

Arrangements for OPAL SNF shipments will be instigated when the SNF pond is about half-full of SNF which has been appropriately cooled (ie. after approximately 8 years of operation). Consequently, it is expected that the shipment of the SNF will be carried out on a regular basis with sufficient time in hand to handle any possible interruptions to shipping.

## 2.10 Offsite Waste Management and Disposal

### 2.10.1 Commonwealth Radioactive Waste Management Facility

On 14 July 2004, the Prime Minister, the Hon John Howard MP, announced that the Government had abandoned the National Radioactive Waste Repository (NRWR) near Woomera in South Australia. The Prime Minister announced that the Government will be establishing a Commonwealth Radioactive Waste Management Facility (the Facility) on Commonwealth land to manage radioactive wastes produced by Australian Government agencies.

In view of the delay in access to offsite radioactive waste management facilities resulting from the NRWR decision, ANSTO has developed options to increase on-site storage capacity for low-level radioactive wastes. Through reducing the volume of waste by super-compaction and rationalising and extending existing storage capacity ANSTO expects to have the capacity to store its solid low level radioactive waste arisings for the next 40 years.

Since the Prime Minister's announcement, DEST has conducted desk level studies of potentially suitable Commonwealth land in order to advise the Government on siting the Facility. Studies have been conducted on the basis of two Facility concepts – a low level radioactive waste repository co-located with an intermediate level radioactive waste store and a store for both low and intermediate level waste. Three sites were still under investigation at the time of writing.

In July 2005, the Commonwealth Government proposed three potential sites for investigation for the establishment of a Commonwealth Radioactive Waste Management Facility. The waste to be managed in the Facility would be low and intermediate level radioactive waste resulting from the medical, industrial and research use of radioactive materials by Commonwealth agencies, including ANSTO. The three locations are Department of Defence properties located near Katherine and Alice Springs in the Northern Territory:

- Fishers Ridge, Department of Defence property, southeast of RAAF Base Tindal;
- Mt Everard, Department of Defence property, northwest of Alice Springs; and
- Harts Range, Department of Defence property, northeast of Alice Springs.

Field assessment at the three locations commenced immediately to determine the most suitable site with which to proceed with the environmental impact assessment and site licensing by ARPANSA.

The approximate timeline for development of the facility were:

| | |
|---|---|
| **2005-06:** | Site investigations |
| **Late 2006:** | Preferred site(s) referred to Minister for the Environment for environmental assessment |
| **Late 2007:** | Decision of Minister for the Environment and Heritage |
| **2008/09:** | Assessment of siting licence by ARPANSA – Public Works Committee Inquiry |
| **2009:** | Siting works commence |
| **2009/10:** | Assessment of construction licence by ARPANSA |
| **2010:** | Construction commences |
| **2011:** | Assessment of operating licence by ARPANSA |
| **Late 2011:** | Operations commence |

It should be noted that these timelines would be subject to Ministerial approval of the preferred site and ARPANSA licensing processes.

### 2.10.2 Ultimate Disposal

Intermediate level waste from the reprocessing of HIFAR spent fuel is expected to be returned in about 2012 but the first OPAL reprocessing waste is not expected until approximately 2025.

ANSTO plans to transport its radioactive waste to the proposed Commonwealth waste facility. The ANSTO Act prohibits ANSTO accepting the radioactive wastes of others. Since the spent fuel will be processed in batches with the spent fuel of others, the wastes returning to Australia will not necessarily be from ANSTO's spent fuel, but will be equivalent in composition and activity. The RWMWG understands that this precludes the return of spent fuel-derived radioactive waste to Lucas Heights Science and Technology Centre.

At present, Australia has no firm plan for the ultimate disposal of radioactive waste generated through the operation of the research reactors at ANSTO.

## 2.11 Conclusion and Recommendations

ANSTO has made significant progress in relation to:

- plans for conditioning low level and intermediate level wastes;
- identifying and disposing of waste that is below the exemption limit; and
- reducing environmental releases.

There has also been considerable effort and resources expended on ensuring that radioactive waste from operations can be stored on-site for many years to allow for

the contingency that the Commonwealth Radioactive Waste Management Facility and Commonwealth Store are not available in the near future.

The RWMWG considered that ANSTO currently manages its waste safely and effectively and, with the measures outlined in sections 2.5.3, 2.6.1 and 2.6.2, can continue to do so into the future.

The WG recommends that:

- The Government makes a decision about the location and design of a radioactive waste store and a waste repository;
- Supercompaction of waste by ANSTO to reduce volume be strongly considered;
- The possibility of a mixed shipment of HIFAR and OPAL Research Reactor spent fuel be considered at the appropriate time;
- The draft Code of Practice on pre-disposal radioactive waste management be completed as a matter of high priority;
- ARPANSA require that ANSTO examine possible avenues for minimising radioactive waste;
- ARPANSA require that ANSTO determine the optimum operating power for OPAL for each application, taking into account all factors, including waste minimisation.

## Glossary of Acronyms

**ALARA**
As low as reasonable achievable, economic and social factors taken into account
**ANSTO**
Australian Nuclear Science and Technology Organisation
**APOL**
ANSTO policy document designation
**AREVA**
Combination of five French companies: Areva T&D, Cogema, Framatome ANP, Technicatome, and FCI.
**ARPANSA**
Australian Radiation Protection and Nuclear Safety Agency
**CEO**
Chief Executive Officer
**COGEMA**
Compagnie Générale des Matières Nucléaires (France); commercial reprocessor of spent fuel.
**CoOWG**
Conduct of Operations Working Group
**DEST**
Department of Education, Science and Training
**DOE**
(United States) Department of Energy
**EIS**
Environmental Impact Statement
**FRR-SNF**
Foreign Research Reactor Spent Nuclear Fuel
**HEPA**
High Efficiency Particulate Air (filter)
**HIFAR**
High Flux Australian Research Reactor
**IAEA**
International Atomic Energy Agency
**ILSW-LL**
Long-lived Intermediate Level Solid Waste
**ILSW-SL**
Short Lived Intermediate Level Solid Waste
**INVAP**
Investigacion Aplicada (Applied Research)
**ISO**
International Organization for Standardization
**LEU**
low enriched uranium
**LHSTC**
Lucas Heights Science and Technology Centre
**LLW**
Low level waste
**MOU**
Memorandum of understanding
**MP**
Member of Parliament
**MW**
megawatt
**NRWR**
National Radioactive Waste Repository
**NSC**
Nuclear Safety Committee
**OPAL Research Reactor**
Open-pool, Australian, light-water reactor
**PDF**
Portable document format
**QA**
Quality Assurance
**QMS**
Quality Management System
**RAAF**
Royal Australian Air Force
**RAC**
(ANSTO) Radiation Assessment Committee
**RSC**
(ANSTO) Radiation Safety Committee
**RWMWG**
Management of Radioactive Wastes and Spent Fuel Working Group
**SAC**
(ANSTO) Safety Advisory Committee
**SAR**
Safety Analyses Report
**SD**
Safety Directive
**SMS**
Safety Management System
**SNF**
Spent nuclear fuel
**US**
United States (of America)
**U-Mo**
Uranium molybdenum (fuel)
**U-Si**
Uranium silicide (fuel)
**WG**
Working Group
**WI&DC**
Waste Inspection and Decontamination Chamber
**WT&PF**
Waste treatment and packaging facility