Australian Government

Australian Radiation Protection and Nuclear Safety Agency

DECISION BY THE CEO OF ARPANSA ON APPLICATION BY ANSTO FOR A LICENCE TO OPERATE THE OPAL REACTOR

STATEMENT OF REASONS

14 JULY 2006

1. THE LICENCE DECISION

On 14 July 2006, I issued a facility licence under section 32 of the *Australian Radiation Protection and Nuclear Safety Act 1998* (the Act) to the Australian Nuclear Science and Technology Organisation (ANSTO) that authorises ANSTO, its employees, any party it contracts with (Commonwealth contractor) and employees of any such Commonwealth contractor, to operate the nuclear installation known as the OPAL (Open Pool Australian Light-water) reactor, subject to the following licence conditions:

1. the licence condition in sub-section 35(3) of the Act
2. the licence conditions referred to in paragraph 35(1)(b) of the Act and prescribed in Part 4, Division 4 of the *Australian Radiation Protection and Nuclear safety Regulations 1999* (the regulations)
3. the practices to be followed in Part 5 of the regulations
4. the licence conditions that I have imposed under paragraph 35(1)(c) of the Act.

In accordance with section 37 of the Act, the licence continues in force until suspended, cancelled or surrendered.

For the sole purpose of assisting the readers of this decision, I have paraphrased the licence conditions found in the Act and regulations, substituting ‘ANSTO’ for ‘the holder of a licence’ and ‘OPAL’ in place of ‘controlled facility’ etc.

Licence Conditions Prescribed in the ARPANS Act and ARPANS Regulations
<u>35(3) of the ARPANS Act 1998</u> ANSTO must allow the CEO, or a person authorised by the CEO, to enter and inspect the OPAL reactor at reasonable times; and must comply with any requirements specified in the regulations in relation to such an inspection. <u>Regulation 44</u> ANSTO must take all reasonably practicable steps to prevent breaches of licence conditions. <u>Regulation 45</u> ANSTO must investigate suspected breaches of licence conditions. If ANSTO identifies a breach, ANSTO must rectify the breach and any consequences of the breach as soon as reasonably practicable. If ANSTO identifies a breach, ANSTO must also tell the CEO as soon as reasonably practicable.

Regulation 46

ANSTO must take all reasonably practicable steps to prevent accidents involving the OPAL reactor. If an accident happens, ANSTO must:

(a) take all reasonably practicable steps to control the accident; and

(b) take all reasonably practicable steps to minimise the consequences of the accident, including injury to any person and damage or harm to the environment; and

(c) tell the CEO about the accident within 24 hours of it happening; and

(d) give the CEO a written report about the accident within 14 days of it happening.

Regulation 47

ANSTO must ensure that conduct and dealings with the OPAL reactor comply with the *National Standard for Limiting Occupational Exposure to Ionizing Radiation.*

Regulation 48

ANSTO must ensure that all conduct and dealings with the OPAL reactor are in accordance with:

(a) the Recommendations for limiting exposure to ionizing radiation; and

(b) the Code of Practice for the Safe Transport of Radioactive Material.

ANSTO must also ensure that dealings with the disposal of radioactive material arising in connection with the operation of the OPAL reactor are in accordance with the following Codes of Practice:

(a) the Code of Practice for the Disposal of Radioactive Waste by the User;

(b) the Code of Practice for the Near-Surface Disposal of Radioactive Waste in Australia;

(c) the Code of Practice for the Safe Transport of Radioactive Material.

Regulation 49

ANSTO must ensure that all activities related to the OPAL reactor comply with the plans and arrangements for managing safety mentioned in the licence application.

Regulation 50

ANSTO must, at least once every 12 months, review and update any plans and arrangements for managing the OPAL reactor to ensure the health and safety of people and protection of the environment. ANSTO must, after conducting a review, give the CEO information about the review.

Regulation 51

ANSTO must seek the CEO's prior approval to make a change to the details in the application for the licence or a modification of the OPAL reactor that will have significant implications for safety.

Regulation 52

ANSTO may make changes to the details in the application for the licence or modifications of the OPAL reactor that are unlikely to have significant implications for safety without the CEO's approval. However, ANSTO must, at least once every 3 months, tell the CEO about any such changes.

Regulation 53

ANSTO must only dispose of controlled apparatus and controlled material with the approval of the CEO. If ANSTO transfers controlled apparatus or controlled materials to the possession of another person or body, ANSTO must within 7 days of the transfer tell the CEO that the transfer has happened, the name of the other person or body; the number of the licence held by the other person or body and the location of the controlled apparatus or controlled materials after that transfer. ANSTO must not dispose of OPAL, or transfer OPAL to the control of another person or body, without the CEO's approval.

Part 5 of the regulations also requires 'practices to be followed' by ANSTO in the operation of OPAL. These are the radiation protection practices described in the national *Recommendations for limiting exposure to ionising radiation (RPS 1)* effectively specifying dose limits, the ALARA principle, optimisation and application of dose constraints.

The licence conditions I have imposed under paragraph 35(1)(c) of the Act are as follows:

1. Periodic Safety Review

1.1 ANSTO must submit to the CEO of ARPANSA a periodic safety review that is a detailed re-examination of the safety of the OPAL reactor taking into account operating experience and international best practice in radiation protection and nuclear safety.

1.2 The first such review must be completed no later than two years after completion of commissioning of the OPAL reactor and must include revision of the Safety Analysis Report to the satisfaction of the CEO of ARPANSA.

1.3 Reviews thereafter are to be conducted at intervals of no more than ten years.

1.4 ANSTO must arrange for the periodic safety reviews to be subject to international peer review.

2. Periodic review of physical protection

2.1 ANSTO must prepare and submit to the CEO of ARPANSA and to the Direactor General of the Australian Safeguards and Non Proliferation Office periodically for assessment a detailed review of the physical protection and security systems, taking into account operating experience and developments in the security environment and international best practice in physical security for nuclear installations.

2.2 The first such review must be completed no later than two years after the completion of the commissioning of the OPAL reactor and thereafter at intervals agreed with the CEO of ARPANSA and the Direactor General of the Australian

Safeguards and Non Proliferation Office taking into account developments in the security environment.

3. Safety culture and safety performance indicators

3.1 ANSTO must prepare and implement a program to support continuous improvement in the safety culture of the OPAL operating organisation, including regular surveys by an independent organisation of the safety climate within the OPAL operating organisation.

3.2 ANSTO must also propose and maintain a set of safety performance indicators to be agreed with the CEO of ARPANSA.

4. Quarterly report

4.1 ANSTO must provide to the CEO within twenty-eight (28) days of the end of each quarter year a report that includes:

- *(i) information required to be reported under ANSTO Event Notification;*
- *(ii) information related to all proposed relevant changes (including modifications) identified during the quarter;*
- *(iii) the categorisation of all relevant changes, including whether or not the prior approval of the CEO of ARPANSA is required prior to implementation;*
- *(iv) information about the relevant changes (including modifications) in progress during the quarter and their status;*
- *(v) a list of all relevant changes (including modifications) completed during the quarter; and*
- *(vi) the activity of any radioactivity released to the environment from the OPAL reactor during the quarter.*

5. Discharge Authorisation

5.1 ANSTO must comply with the discharge authorisation for the ANSTO site, as amended to include the OPAL reactor, as set out in the ANSTO Licence Conditions handbook.

6. Index of Documents

6.1 ANSTO must develop and maintain an index of documents which demonstrates compliance with the licence conditions for the OPAL reactor to the satisfaction of the CEO of ARPANSA.

2. REACHING THE DECISION

2.1. The basis of my decision making

In making my decision to issue a facility licence to ANSTO authorising it to operate the OPAL reactor, I:

- identified all relevant provisions of the Act and the regulations to be taken into account.

- determined the meaning of the statutory matters to be taken into account, having regard to the object of the Act.

- reviewed all the evidence before me including (but not limited to):

  a) the application from ANSTO to operate the OPAL reactor deemed to have been received on 8 October 2004 (the application);
  b) all the material subsequently submitted by ANSTO as part of its application including the documents referred to in Annex A of this decision;
  c) reports from international and locally engaged experts;
  d) reports from the IAEA peer reviews;
  e) reports from the Nuclear Safety Committee;
  f) the advice of ARPANSA staff reviewers; and
  g) the public submissions.

Having considered all this evidence in the light of my own expertise in the field of radiation protection and nuclear safety, derived from seven years as the CEO of ARPANSA and as a member of relevant international committees and working groups, including chairing the working groups that prepared the international Code of Conduct on the Safety of Research Reactors, and being a member of the IAEA Commission on Safety Standards, I formed the view that the application meets all the requirements of the Act and the regulations and, therefore, ANSTO has satisfied me that it has demonstrated it is able to operate the OPAL reactor safely.

2.2. The legislative framework

The object of the Act is (section 3):

> '*to protect the health and safety of people, and to protect the environment, from the harmful effects of radiation*'.

I understand that all other provisions of the Act need to be read in the light of this object.

Section 14 of the Act says that there is to be a CEO of ARPANSA (the Australian Radiation Protection and Nuclear Safety Agency). Section 15 states that the CEO has a number of functions. The function directly relevant to this decision is in paragraph 15 (1) (i):

> *'such other functions as are conferred by this Act, the regulations or any other law'.*

Sections 25 to 27 deal with the establishment, functions and membership of the Nuclear Safety Committee (NSC). The relevant functions of the NSC in this context are those in paragraph 26 (1) (d):

> '*to report to the CEO on matters relating to nuclear safety and the safety of controlled facilities.'*

Subsection 26 (2) says that '*The Committee's functions are to be performed only on the request of the CEO or the Council'*[1].

The membership of the NSC (section 27) is: the CEO; a person to represent the interests of the general public; a representative of the Radiation Health Committee (another Committee established by the Act); a person to represent the local government or local administration of an area affected by the safety of a controlled facility; and up to 8 other members (seven such members have been appointed). During the course of considering the application, I sought and received the Committee's advice on aspects of the application.

Section 30 of the Act requires that:

> '*A controlled person must not do any of the following:*
>
> *(a) prepare a site for a controlled facility;*
> *(b) construct a controlled facility;*
> *(c) have possession or control of a controlled facility;*
> *(d) operate a controlled facility;*
> *(e) de-commission, dispose of or abandon a controlled facility; unless:*
> *(f) the person is authorised to do so by a facility licence; or*
> *(g) the person is exempted in relation to the conduct concerned by regulations made for the purposes of this section.'*

The definition of 'controlled person' in section 13 of the Act includes 'a Commonwealth entity'. The definition of a Commonwealth entity includes a body corporate established for a public purpose by or under an Act. ANSTO is established by the *Australian Nuclear Science and Technology Organisation Act 1987* for the purposes set out in section 5 of that Act and as such falls within the definition of a controlled person.

OPAL is a reactor for research or production of nuclear materials for industrial or medical use and as such falls within the definition of a 'nuclear installation' for the

[1] The Radiation Health and Safety Advisory Council is established under section 19. The Council has not made a request of the Nuclear Safety Committee.

purposes of the Act. Consequently, and in the absence of an exemption, ANSTO is prohibited from operating OPAL unless authorised by a facility licence.

ANSTO does have a facility licence authorising it to 'construct' OPAL which I issued on 4 April 2002.

Subsection 32(1) of the Act provides:

> *'The CEO may issue a licence to a controlled person that authorises persons to do some or all of the things referred to in subsection 30 (1).'*

The Act defines 'persons covered by a licence' to include controlled persons authorised under a licence to undertake an activity in relation to a controlled facility.

Subsection 32 (3) provides;

> *'In deciding whether to issue a licence under subsection (1), the CEO must take into account the matters (if any) specified in the regulations, and must also take into account international best practice in relation to radiation protection and nuclear safety.'*

I understand that I must give proper, genuine and realistic consideration to any relevant international best practice. I also understand that my obligations under sub-section 32(3) must be considered in two steps. First, radiation protection and nuclear safety must be construed in the context of the application before me, i.e. the licence to operate OPAL. Secondly, any international best practice in relation to radiation protection and nuclear safety, relevant to the issue of the licence to operate, must be identified as a matter of fact.

Section 34 requires that:

> '*An application for a licence must:*
>
> *a) be in a form approved by the CEO; and*
> *b) be accompanied by such fee as is prescribed by the regulations.*

The regulations set out the information that may be requested for a licence to operate a nuclear facility (items 1-4 and 15-18 of Part 1 of Schedule 3) and the fee required for the operation of a nuclear reactor for research (Schedule 3A, item 9).

Regulation 40 states:

> *(1) This regulation applies if the CEO receives an application for a facility licence.*
> *(2) As soon as practicable after receiving the application, the CEO must publish a notice in a daily newspaper circulating nationally, and in the Gazette, stating that the CEO intends to make a decision on the application.*
> *(3) If the application relates to a nuclear installation, the CEO must also include in the notice:*

(a) an invitation to people and bodies to make submission about the application; and
(b) a period for making submissions; and
(c) procedures for making submissions.

Regulation 41 of the regulations sets out the obligatory mandated considerations which, together with international best practice in relation to radiation protection and nuclear safety[2], I must take into account, when deciding whether to issue a licence to operate OPAL. That is:

a) *whether the application includes the information asked for by the CEO; and*
b) *whether the information establishes that the proposed conduct can be carried out without undue risk to the health and safety of people, and to the environment; and*
c) *whether the applicant has shown that there is a net benefit from carrying out the conduct relating to the controlled facility; and*
d) *whether the applicant has shown that the magnitude of individual doses, the number of people exposed, and the likelihood that exposure will happen, are as low as reasonably achievable, having regard to economic and social factors; and*
e) *whether the applicant has shown a capacity for complying with these regulations and the licence conditions that would be imposed under section 35 of the Act; and*
f) *whether the application has been signed by an office holder of the applicant, or a person authorised by an office holder of the applicant; and*
g) *if the application is for a facility licence for a nuclear installation - the content of any submissions made by members of the public about the application.*

Sections 35 and 36 of the Act allow for a licence to be subject to conditions and to be amended. The relevant subsections of section 35 are:

'(1) A licence is subject to the following conditions:

a) the conditions set out in this section;
b) the conditions prescribed by the regulations;
c) conditions imposed by the CEO at the time of issuing the licence;
d) any conditions imposed by the CEO under subsection 36(2) after the licence is issued.

(2)…………………………………………………………………….

(3) A facility licence is subject to the condition that any person authorised by the licence to prepare a site for a controlled facility or to construct, have possession or control of, operate, de-commission, dispose of or abandon a controlled facility must:
a) at any time when the person has possession or control of such a site or facility – allow the CEO, or a person authorised by the CEO, to enter and inspect the site or facility at reasonable times; and

[2] Per Beaumont J in *Greenpeace Pacific Ltd v the CEO of ARPANSA and Anor (2002) 125 FCR 186* at 204

b) *comply with any requirements specified in the regulations in relation to such an inspection.'*

Part 4, Division 4 of the regulations prescribes another 12 standard licence conditions. These conditions relevantly require a licence-holder to:

- take all reasonably practicable steps to prevent breaches of conditions.

- investigate and rectify breaches that do occur and to notify the CEO of such breaches.

- take all reasonably practicable steps to prevent accidents and control and minimise the effects of any accidents and to notify the CEO of accidents within a specified period.

- comply with the national standard for limiting occupational radiation exposure and with other (named) recommendations and codes of practice.

- comply with the plans for safety mentioned in the licence application and review such plans every twelve months.

- seek the CEO's prior approval for changes having significant implications for safety.

- notify the CEO of proposals for changes that are unlikely to have significant implications for safety.

- advise the CEO about the movement of sources and apparatus and seek approval for any transfer of a controlled facility.

- seek approval for the construction of an item important for safety identified in a safety analysis report.

- seek approval to load nuclear fuel into a controlled facility.

Subsection 36(1) provides that the CEO may, at any time, by notice in writing given to the licence holder, amend a licence. Subsection 36 (2) provides:

'*Without limiting subsection (1), the CEO may:*

a) *impose additional licence conditions; or*
b) *remove or vary licence conditions that were imposed by the CEO; or*
c) *extend or reduce the authority granted by the licence.'*

Section 83 provides that:

> *If a law of a State or Territory, or one or more provisions of such a law, is prescribed by the regulations, that law or provision does not apply in relation to the following:*
>
> *(a) an activity of a controlled person in relation to a controlled apparatus or a controlled material;*
>
> *(b) an activity of a controlled person in relation to a controlled facility.*

Section 84 of the Act requires that in exercising any power, or discretion, duty or function, I am authorised to do so only to the extent that the exercise or performance is not inconsistent with Australia's obligations under the relevant international agreements, and that I must have regard to Australia's obligations under those agreements. The relevant agreements are sent out in the *Nuclear Non-Proliferation (Safeguards) Act 1987* or its Regulations.

2.3. Prior OPAL Licensing Decisions

On 7 April 1999 I received an application from the Australian Nuclear Science and Technology Organisation (ANSTO) for a facility licence authorising the preparation of a site for the proposed nuclear installation being the 'Replacement Research Reactor', now known as (and subsequently referred to in this document) as the OPAL reactor, under the Act.

This application for a facility licence was subsequent to the proposal having been the subject of an environmental impact assessment under the *Environment Protection (Impact of Proposals) Act 1974*. On 22 September 1999, I issued a facility licence to ANSTO to prepare a site for a research reactor and published my statement of reasons for so doing.

On 21 May 2001, I received an application from ANSTO for a facility licence authorising the construction of the OPAL reactor. My assessment of this application included:

- a comprehensive safety evaluation of the proposal by ARPANSA staff, who were assisted in certain aspects through the engagement of international experts;
- an international peer review of the application facilitated by the International Atomic Energy Agency;
- reports from the Nuclear Safety Committee;
- two rounds pf public submissions, augmented by a public forum that brought together the proponents and the major public submitters before a panel consisting of myself and three independent people; and
- reports from the three panellists who took part in the public forum.

On 4 April 2002, I issued a facility licence authorising ANSTO to construct OPAL and published a statement outlining my reasons for so doing.
My reasons for issuing the facility licence were the subject of an application for judicial review under the *Administrative Decisions (Judicial Review) Act 1977* by Greenpeace Australia Pacific Limited. On 13 September 2002, the application for judicial review was dismissed by the Federal Court of Australia.[3]

2.4. Application for Operating Licence

On 17 December 2003, I wrote to ANSTO setting out my expectations for an application for a facility licence authorising ANSTO to operate OPAL. Relying on section 34 of the Act which sets out the requirements for an application for licence, in particular paragraph 34(a), I confirmed that I would require all of the items of information relevant to the operation of a controlled facility referred to in Part 1 of Schedule 3 of the regulations. In addition, I stated:

> *I expect to see information pertaining to international best practice in relation to radiation protection and nuclear safety for each authorisation applied for.*

I also suggested that in determining the content of their application, ANSTO may wish to have regard to:

- *Regulatory Assessment Principles for Controlled Facilities RB-STD-44-00*;
- *ARPANSA Regulatory Guideline on Review of Plans and Arrangements (RB-STD-15-03;.*
- A Commissioning Guide being prepared by ARPANSA Regulatory Branch (subsequently published as *RB-STD-09-04 Rev 0* in September 2004);
- IAEA documents for Nuclear Power Plants and in particular the Operations series;
- Safety Series No 35 –S *Code of Safety of Nuclear Research Reactors; Design IAEA 1992;*
- *Safety Series No 35-S2 Code of Safety of Nuclear Research Reactors; Operation IAEA1992;*
- Safety No 50 SG-G3 *Conduct of Regulatory Assessment during the Licensing Process for Nuclear Power Plants IAEA 1980;*
- Standards Series DS259 *Draft 5 Draft Safety Guide Commissioning of Research Reactors 2000*
- Safety Series DS 272 Draft Safety Requirements of Research Reactors April 2003 *(subsequently published as Safety of Research Reactors, Safety Requirements NS-R-4, IAEA 2005).*

[3] Greenpeace Pacific Ltd v ECO of ARPANSA & Ors(2002) 125 FCR 186

On 13 September 2004, I received an application, signed by the Executive Direactor of ANSTO, for a facility licence to authorise operation of the OPAL reactor at Lucas Heights in Sydney.

The application contained:

- General information on the purpose and location of OPAL (Part A);
- The plans and arrangements for managing safety for the Reactor (Part B);
- The Safety Analysis Report (SAR) for OPAL together with associated safety and licensing documentation (Part C);
- The plans and arrangements for Hot Commissioning for OPAL (Part E).

The application did not, however, include Operational Limits and Conditions (OLCs) which are required as item 17 of Part 1, Schedule 3 of the regulations. On 20 September 2004, I wrote to ANSTO stating that paragraph 34(a) of the Act provided that the application must be in a form approved by the CEO. I noted that ANSTO had not provided the specific Operational Limits and Conditions proposed for OPAL. I indicated that I had formed the preliminary view, that the applicant had not satisfied paragraph 34(a) of the Act and I could not accept the application as being a valid application for the purposes of the Act at that time.

On 8 October 2004, ANSTO provided me with Part D of the application which consisted of the Operational Limits and Conditions for OPAL and, on the same day, I wrote to ANSTO advising that the application was now in a form approved by me and as I had already received the prescribed application fee (34(b)), it was consequently a valid application for the purposes of s. 34 of the Act.

2.5. ARPANSA Staff Assessment

I referred the application to ARPANSA staff reviewers for detailed assessment. The ARPANSA assessment team has a wide range of expertise in radiation protection and nuclear safety. The officers who lead the team are of international standing and highly experienced in assessing the safety of ANSTO's other nuclear facilities. As part of the assessment process, the ARPANSA staff reviewers sought and obtained from ANSTO a substantial amount of further information, clarification and verification of the information in the application including through a process of questions and answers.

The ARPANSA staff reviewers were also closely involved with the assessment of requests for approval for the construction of various safety category 1 and 2 systems, structures and components. These assessments, which continued during the assessment of the operating licence application, gave them a close familiarity with the OPAL design.

During ARPANSA staff assessment of the application I was informed and advised of their views and took part in discussions with the senior staff involved. I received copies of the working documents summarising the staff assessments as they were being completed.

It is important to note that the major difficulty encountered by ARPANSA staff reviewers during the process of assessing the application was the extent to which the application was augmented with additional information and the manner in which ANSTO managed the provision of additional information.

As ARPANSA staff reviewers' questions were answered, in many cases ANSTO made undertakings to provide additional information in support of the Application in response to issues raised. This was appropriate and to be expected in the course of the necessary exchange between the regulator and applicant in assessing an application of this complexity. However, the delay in providing that additional information for various reasons, including an expectation that many documents would, in any case, be reviewed and amended in the light of commissioning and subsequent operating experience, sometimes led to difficulties during the process of assessment whereby ARPANSA and ANSTO were unclear as to whether all the changes agreed to by ANSTO had been included in the documentation. In this regard I note that many final versions of documents were not received by ARPANSA until quite late in the assessment process.

I am satisfied that the state of documentation of the application is sufficient to allow me to make the decision that I have. However, there will need to be a process for consolidation of final documentation – including amendment in the light of Hot Commissioning and operating experience. In order to ensure that this occurs effectively, I have imposed an additional licence condition that in part requires that an initial periodic safety review (called the first periodic safety review) be completed no later than two years after OPAL commences operation, following successful completion of Hot Commissioning. At that time I will expect that all documentation has been reviewed and revised.

In assessing the application, the ARPANSA staff reviewers drew upon four documents that had been previously published by ARPANSA:

- *Regulatory Assessment Principles for Controlled Facilities (RB-STD-42-00 Rev 1), dated October 2001 – known as 'the RAPS'.*

- *Regulatory Assessment Criteria for the Design of New Controlled Facilities and Modifications to Existing Facilities (RB-STD-43-00 Rev 1), dated October 2001 – known as the Design Criteria.*

- *Regulatory Guideline on Review of Plans and Arrangements RB-STD-15-03 August 2003 Version 0.*

- *Regulatory Principles for Assessment of Commissioning of the Replacement Research Reactor, including Plant Completion and Pre-Commissioning and Testing – under the ARPANS Act 1998 (RB-STD-09-04 Rev 0 September 2004).*

The principles set out in the documents are based upon the international safety nuclear framework (see chapter 3) and the approach adopted by leading nuclear regulators.

2.6. Public submissions

On 17 September 2004, I issued a statement acknowledging receipt of the application from ANSTO. As previously stated I was not satisfied that the application was in a form acceptable to me at this time, therefore I made a general statement outlining a timetable during which I intended to publish a copy of the application and call for public submissions.

Regulation 40(3) of the regulations provides that if a facility licence application relates to a nuclear installation, the CEO of ARPANSA must as soon as practicable invite people and bodies to make submissions about the application; provide a period for making submissions; and provide procedures for making submissions.

On 1 December 2004, once satisfied that the Application was in a form acceptable to me, I advertised the receipt of an application from ANSTO for a facility licence to authorise the operation of the OPAL reactor and my intention to make a decision on that application in the *St George and Sutherland Shire Leader*, *The Australian,* and the *Commonwealth Government Gazette*. I advised that:

- Part A (General Information), Part B (Plans and Arrangements for Managing Safety in the Reactor Facility) and Part C (an edited version of the Safety Analysis Report for the Reactor Facility with information which may affect security removed) of the application would be available on the ARPANSA website.

- I anticipated that a more complete public version of the application (including Part D, Operational Limits and Conditions and Part E, Plans and Arrangements for Hot Commissioning) would be available in early 2005.

- I would accept submissions from the public until 29 April 2005.

I also advised of the process for making submissions about the application.

Between December 2004 and March 2005, ANSTO maintained claims of confidentiality over Parts D and E and the Probabilistic Safety Analysis of the applications for two reasons:

- Public Interest Immunity based on security concerns; and

- Commercial in Confidence on behalf of INVAP SE (the company contracted to construct OPAL).

While mindful of my responsibilities under the Act to call for public submissions on the application, and for those submissions to be based on as complete an application as possible, I accepted ANSTO's submissions for exclusion of information on the basis that it included matters relating to physical security. However, I did not accept the submissions with respect to the claims over documents that were claimed to be commercial in confidence, particularly as many of documents over which this claim was made were already in the public domain.

In March 2005, ANSTO agreed to provide summaries of Parts D and E of the application for release on the ARPANSA website and a more complete version of Part C of the application, which I agreed would be for limited release and not made available on the internet.

On 13 April 2005 I issued a media release advising that I had extended the deadline for public submissions on OPAL by four months. I advised that when it applied for the facility licence authorising operation of OPAL in September 2004, ANSTO submitted that some information should not be publicly released on the grounds that it was either a threat to physical security or commercial-in-confidence. After consideration of these matters, I reached agreement with ANSTO and a final public version of the application was to be made available in the following form:

- A revised version of Part C of the application, with security -in-confidence details removed, would be sent to state libraries nationally and to pre-identified environmental groups and other stakeholders with an interest in the reactor project as soon as it was provided by ANSTO.

- Parts D (Operational Limits and Conditions) and Part E (Hot Commissioning Program) in a summary form would be placed on ARPANSA's website.

- A public version of the Probabilistic Safety Analysis would also be added to the web site.

I extended the deadline for public submissions by four months, to 31 August 2005. Public submissions were accepted until 4 October 2005.

I called for a second round of public submissions on 18 January 2006 through the ARPANSA website with a closing date of 17 March 2006.

The first round resulted in 843 public submissions – 13 from organisations, 9 individuals, one petition and 820 letters. The second round yielded 84 submissions – 9 from organisations, 4 individuals and 71 letters.

A synopsis of the first and second round of public submissions was prepared by ARPANSA officers and placed on the ARPANSA website.

I have read all the public submissions. I have not endeavoured in this statement to discuss each public submission and how I took account of it in the decision. Rather, I have drawn out what to me appear to be the most significant issues raised in the public submissions, including the presentations at the public forum described below, and discussed them at the relevant stages of this statement, showing how I have taken them into account.

2.7. Public forum

I invited further public comment on the application at a public forum that took place on 8 and 9 December 2005 in Sydney.

The format of the forum was that a number of people and interest groups who had made submissions in the first round of public submissions made oral presentations, along with presentations by ANSTO, Australian Safeguards and Non-Proliferation Office, and the Department of Education, Science and Training (the Commonwealth department responsible for the proposed Commonwealth Radioactive Waste Management Facility). Each presenter was questioned by a panel, which I chaired. The members of the panel were: Dr Lars Hogberg, former Direactor General of the Swedish Nuclear Power Inspectorate; and Professor Jim Falk, Direactor of the Australian Centre for Science, Innovation and Society, University of Melbourne.

Following the forum, each of the panellists provided me with a report and these reports were published on the ARPANSA website along with a full transcript of the proceedings. I also sought a response from ANSTO to the reports and this was also published on the website, together with a short rejoinder from Professor Falk. In addition, the full transcript of the forum was also made available on the website.

At the relevant points in this statement of reasons, I have taken up the matters raised by the panellists and shown how I have taken them into account.

2.8. Peer reviews

On 22 October 2004, I wrote to the International Atomic Energy Agency (IAEA), requesting their assistance in assembling an international peer review team to undertake a peer review of the licence application and advise me on international best practice in radiation protection and nuclear safety in relation to the proposed Operational Limits and Conditions and operating organisation.

The report of peer review team (*IAEA Peer-Review Mission on the Commissioning and Operation of the OPAL Research Reactor)* was published and made available on the ARPANSA website in May 2005.

In this report the peer review team considered issues raised by the previous peer review team that had earlier reported on the licence to construct OPAL. It noted that recommendations made at that time had now been satisfied and were now resolved. It also raised 17 new conclusions and recommendations, making specific recommendations areas about the conduct of operations and operational safety limits and conditions. In summary, the recommendations covered that:

- the surveillance requirements for safety systems should be re-analysed to maximise availability, taking account of the frequent reactor cycling and to avoid excessive extension of the surveillance periods.

- the Reactor Manager should have full control of activities that assure safety, including integrating the Analysis and Engineering Groups.

- justification of proposed minimum staffing requirements to assure safety should be based on all operational states, including transitions such as start-up, and refuelling should be undertaken by two qualified staff.

The recommendations made by the peer review team were drawn to ANSTO's attention for comment. As a result, ANSTO:

- significantly revised downwards the surveillance intervals in revision 2 of the Operational Limits and Conditions, better demonstrating the operability of safety systems. In particular, the operating time of the First Shutdown System will be tested before start up at the beginning of each operating cycle.

- clarified that the Manager, Reactor Operations has full control of activities that assure safety, including the Analysis and Engineering Groups. While this differs slightly from the IAEA guidance it, nevertheless, assures the availability and control of the required resources within the reactor operating organisation.

- clarified that the Operational Limits and Conditions specify the minimum staff complement for the various reactor operations, including two accredited Reactor Operators for the Refuelling State. These minimum staffing levels were tested during Cold Commissioning. This is acceptable to ARPANSA

On 2 November 2005, I again wrote to the IAEA requesting an international peer review team to undertake a peer review of with respect to the proposed operating procedures.

The report of peer review team (*IAEA Peer-Review Mission to Review on the Operating Procedures of the OPAL Reactor)* was published and made available on the ARPANSA website in February 2006. In this report the peer review team presented eight conclusions and recommendations, making specific recommendations about the operating procedures including design, maintenance and operating manuals.

The peer review team expressed confidence that the finalised operating procedures would be comprehensive in coverage. They commented that procedures would be largely tested on the simulator which will provide an excellent training tool for normal operations and some deviations from normal operations. This was regarded as international best practice. The peer review team observed that the design manuals contain the necessary information on design bases, design description, safety, and integrated logistics systems. The peer review team recognised a number of good practices and made a number of recommendations. ANSTO agreed to these recommendations and revised the procedures accordingly.

2.9. Nuclear Safety Committee (NSC)

The NSC is an advisory body created by the *Australian Radiation Protection and Nuclear Safety Act 1998*. On 12 November 2004, I wrote to the Chair of the Nuclear Safety Committee as follows:

> *I am writing to request, under sub-section 26(2) of the Australian Radiation Protection and Nuclear Safety Act 1998, the Nuclear Safety Committee to advise me on aspects of this application for a licence to operate the RRR.*
>
> *I would like to receive the Committee's advice on its view of the adequacy of:*

- *the plan for maintaining effective control of the facility in Part B of the Application.*

- *conduct of operations in Chapter 13 of the Safety Analysis Report.*

In providing advice, I would like the Committee 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, I 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. You will be aware that I defined the scope of the term 'international best practice in radiation protection and nuclear safety' in my reasons for decision on the licence to construct the RRR.

In addition, I would be glad to receive advice from the Committee further to the advice that the Committee provided to me in February 2002 on spent fuel and radioactive wastes in relation to the construction licence application. This advice should address the adequacy of the Radioactive Waste Management Plan and the Ultimate Disposal or Transfer Plan.

As I had done when seeking the NSC's advice in relation to the construction licence, I stressed that:

I am seeking the Committee's broad view of these issues based principally upon your assessment of the application documentation and in the light of Committee members' personal knowledge and experience. I am not seeking an alternative in-depth technical assessment of the matters I have mentioned. Should, however, the Committee agree that it needs additional information to make the reasonable assessment I am seeking, I would be glad, of course, to seek this from the applicant.

The NSC established two working groups to deal with:

- conduct of operations' and

- management of spent fuel and radioactive wastes.

The working groups met on a continuing basis from November 2004 to July 2005. A draft report from each working group was considered at a meeting of the full NSC in

July 2005. The final report to me dated 27 September 2005 consists of the completed reports of the two working groups and was endorsed by the whole NSC.

I forwarded the report to ANSTO for comment on 1 November 2005 and received a response on 5 December 2005. The NSC report and the ANSTO response are available on the ARPANSA website.

The NSC considered the ANSTO response at its meeting in February 2006. The members felt that the response from ANSTO had justified the value of the report. They sought one matter to be followed up concerning the relationship shown between the safety committees. This matter was concluded at the NSC's meeting on 16 June 2006. .

At its meeting on 16 June 2006, the NSC was briefed by ANSTO and ARPANSA officers on the outcome of Stage A commissioning. The full commissioning report had been distributed to them prior to the meeting.

At the relevant points in this statement of reasons, I have drawn upon the NSC findings and how they have been taken into account.

3. FRAMEWORK FOR THE CONSIDERATION OF INTERNATIONAL BEST PRACTICE IN RELATION TO RADIATION PROTECTION AND NUCLEAR SAFETY

Subsection 32(3) of the Act states that;

> *In deciding whether to issue a licence under subsection (1)* [ie a facility licence] *the CEO must take into account the matters (if any) specified in the regulations,* ***and must also take into account international best practice in relation to radiation protection and nuclear safety****.*

In this chapter, I discuss international best practice in relation to radiation protection and nuclear safety. In chapters 10 and 11, I deal with how I have taken into account the matters specified in the regulations.

3.1. What is international best practice in radiation protection and nuclear safety?

I discussed this in my statement of reasons for the decision to grant a construction licence for the OPAL facility[4]. I begin here by recalling this discussion:

> ***International best practice in radiation protection and nuclear safety***
> *The Act does not define 'international best practice in relation to radiation protection and nuclear safety'. I have tried to find the plain meaning of the term, having regard to the context of the Act as a whole and especially the object of the Act.*
>
> *The term 'best practice' is, as far as I am aware, not one used in the nuclear industry internationally as a particular term of art. I note, however, that in the foreword to a recent publication by the International Nuclear Safety Advisory Group (INSAG)[5] that the Direactor General of the International Atomic Energy Agency refers to the publication as presenting 'the principles underlying the best current safety policies and practices of the nuclear power industry.'*
>
> *I have, then, thought of international best practice in radiation protection and nuclear safety from first principles, bearing in mind that I am dealing with the proposed construction of a research reactor. The process of designing, constructing and then operating a research reactor has a number of aspects. First, there are the higher-level decisions about the approach to be taken in the design to radiation protection and nuclear safety and then how those approaches are to be*

[4] My Reasons for Decision with respect to the application to construct OPAL and the annexures are available on the ARPANSA website.
[5] Basic Safety Principles for Nuclear Power Plants, 75-INSAG –3 Rev. 1, INSAG –12, Vienna 1999

analysed and reviewed. I describe in Annex 2, a very well established international safety framework for these activities set up through the IAEA and associated bodies and through international conventions. As noted in the above paragraph, in the Direactor General's foreword, this safety framework does strive to be a description of how things ***should*** *be done, rather than merely a summary of how they are done. I accept that they represent international best practice for the conceptual and analytical aspects of a design and construction project. Certainly, there are no competing approaches in respect of design and construction of research reactors even claiming to be international best practice in radiation protection and nuclear safety.*

Second, a specific reactor design will include a number of safety features – systems to detect problems and to shutdown the reactor, to cool the core after shutdown in various circumstances and to contain and control any released radioactivity. There is increasing international agreement about the desirable approach to such safety features – both within the general safety framework in Annex 2 and in discussions of future reactor systems. It is also a matter that can be addressed by comparing proposed safety features with those built into recently designed and constructed reactors in other countries.

Third, in the construction phase itself, there are issues about management of construction, quality assurance approaches and the codes of practice and standards for the construction of items important to safety. At this more detailed level, the international safety framework can only point to international best practice in the broad sense. The codes of practice and standards should be consistent and chosen from those used internationally, though there may not be a single set of such codes and standards that alone constitute international best practice. International best practice in radiation protection and nuclear safety may capture more than one way of doing things at this detailed level.

Finally, there are the radiation protection and nuclear safety outcomes that are actually achieved. Noting that these can only be estimated from the design at this time, it would nonetheless be appropriate to benchmark these outcomes against those achieved in recent, modern research reactors in other countries, where these are available.

Therefore, my view is that taking into account international best practice relating to radiation protection and nuclear safety with regard to the application before me involves the following being considered:

- *the* ***radiation protection and nuclear safety objectives*** *included as a part of the design, compared with those laid out in the international safety framework that I find to be international best practice in radiation protection and nuclear safety*

- *the specific* ***safety features*** *of the design compared with those recommended in the international safety framework and most successfully applied in recent research reactor designs*

- *the* ***management of the design and construction project,*** *the codes and standards applied to the design and construction of systems important to safety, compared with management approaches and the codes and standards used for similar systems in reactors designed in other countries with best practice safety systems*

- *the* ***design outcomes*** *for occupational radiation doses, discharges to the environment and consequent radiation doses to the public, and the likelihood of core damage, compared with those achieved in recent research reactors in advanced countries.*

There have been developments in the international safety framework since 2002 when I issued a licence authorising ANTO to construct the OPAL and I go on to discuss these. While in 2002 I wrote that the term 'international best practice' was not a particular term of art in the nuclear industry, there has certainly been more international discussion in recent years of notions of a global or international safety framework. Further, I need to elaborate the above discussion to specifically address **operation** of nuclear reactors. Having said this, my general view of international best practice in relation to radiation protection and nuclear safety remains as described above, taking into account the development of the international safety framework that I discuss below.

3.2. Developments in international best practice in relation to radiation protection and nuclear safety – the international safety framework

3.2.1. The Code of Conduct on the Safety of Research Reactors

In 2004, the International Atomic Energy Agency (IAEA) approved and published a *Code of Conduct on the Safety of Research Reactors* (the Code).

A Code of Conduct is an international legal instrument of a non-binding character. Unlike an international Convention that binds countries that become parties to it, a Code of Conduct endeavours to establish international norms through political commitments, without there being a legally binding character to such commitments.

The objective of the Code is:

> *The objective of this Code is to achieve and maintain a high level of safety in research reactors worldwide through the enhancement of national measures and international cooperation including, where appropriate, safety related technical cooperation. This objective is achieved by proper operating conditions, the prevention of accidents and, should accidents occur, the mitigation of the radiological consequences, in order to protect workers, members of the public and the environment against radiation hazards.*

After the preamble, scope and definitions, the body of the Code sets out guidance for the role of the State, the regulatory body and the operating organization, as well as for the IAEA. The Code encourages the use of IAEA safety standards, the use of a graded approach related to hazard, and that, if in difficulty, the State may communicate difficulties and required assistance to the Agency. Major roles for the State are setting up the legislative and regulatory framework; establishing and supporting the regulatory body; ensuring a system for financing safe operation, safe extended shutdown and decommissioning; reviewing the safety of existing research reactors; and ensuring safe management of any research reactors in extended shutdown.

The regulatory body and the operating organization have mirroring provisions dealing with : assessment and verification of safety; financial and human resources; quality assurance; human factors; radiation protection; emergency preparedness; siting; design, construction and commissioning; operating, maintenance, modification and utilization; extended shutdown; and decommissioning.

The role of the IAEA is to disseminate the Code and related information widely; to assist States in application of the Code; and to continue to collect and disseminate information relating to the safety of research reactors, provide safety review services, develop and establish relevant technical standards and provide for the application of these standards at the request of any State.

The Code was adopted by the Board of Governors of the IAEA in March 2004. In September 2004, the General Conference of the IAEA adopted a resolution that said, inter alia, that the General Conference:

> *Welcomes the adoption by the Board of Governors in March 2004 of the Code of Conduct on the Safety of Research Reactors and endorses the guidance for the safe management of research reactors set out in the Code;*
> *Encourages Member States to apply the guidance in the Code to the management of research reactors.*
> IAEA GC (48)/RES/10 pars 39 and 40

In the international safety framework that I described in Annex 2 of my construction licence statement of reasons, the Code now can be seen in the place of the *Convention on Nuclear Safety* insofar as defining the high level guidance that should apply to the safety of research reactors (the *Convention on Nuclear Safety* addresses nuclear power plants).

This was recognised at the third review meeting under the *Convention on Nuclear Safety* that took place in May 2005. The Contracting Parties passed a resolution reading as follows:

> *Having taken into consideration the positive impact of the incentive nature and the benefits of the review Process of the Convention on Nuclear Safety on improving nuclear safety, the Contracting Parties to the Convention on Nuclear Safety request the Direactor General of the IAEA to convene meetings to which all member states would be invited. The objective of the meetings should be to discuss how best to assure the effective application of the Code of Conduct on the Safety of Research Reactors.*

This move was welcomed by the IAEA General Conference in 2005, which continued to endorse the principles and objectives of the Code and looked forward to further progress in implementing it.

The Director General of the IAEA has convened one ‘open ended’ meeting in response to the Convention resolution. From the outcomes of that meeting and also a later international conference on effective nuclear regulation, it seems likely that periodic meetings will be held to exchange information on the implementation of the Code and that these will function in a manner akin to the review meetings under the *Convention on Nuclear Safety*.

In order to take into account this high level definition of international best practice in relation to radiation protection and nuclear safety as it applies to research reactors, I have assessed the OPAL application for an operating licence against the full provisions of the Code. A table showing this assessment is at Annex B of this statement.

Having considered the guidance in the Code and the legislative framework of the Act and regulations, I find that, Australia has established legal and regulatory arrangements consistent with the guidance of the Code; the role and actions of ARPANSA with regard to the assessment of OPAL for an operating licence are consistent with the Code’s provisions on the role of the regulatory body; as is the role of ANSTO as the operating organization that has proposed the siting, design, construction and now the operation of OPAL.

3.2.2. The Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management (the Joint Convention)

At the time of making my decision on the construction licence for OPAL, the Joint Convention had been signed but not ratified by Australia. The Joint Convention had only entered into force in June 2001. Australia ratified the Joint Convention in August 2003 and took part in the first review meeting in November of that year.

The second review meeting of the Joint Convention took place in May 2006.

The objectives of the Joint Convention are:

(i) *to achieve and maintain a high level of safety worldwide in spent fuel and radioactive waste management, through the enhancement of national measures and international co-operation, including where appropriate, safety-related technical co-operation;*

(ii) *to ensure that during all stages of spent fuel and radioactive waste management there are effective defenses against potential hazards so that individuals, society and the environment are protected from harmful effects of ionizing radiation, now and in the future, in such a way that the needs and aspirations of the present generation are met without compromising the ability of future generations to meet their needs and aspirations;*

(iii) to prevent accidents with radiological consequences and to mitigate their consequences should they occur during any stage of spent fuel or radioactive waste management.

The Convention imposes general safety requirements upon the Contracting Parties with respect to spent fuel management as follows (similar requirements are imposed on radioactive waste management):

ARTICLE 4. GENERAL SAFETY REQUIREMENTS

Each Contracting Party shall take the appropriate steps to ensure that at all stages of spent fuel management, individuals, society and the environment are adequately protected against radiological hazards.

In so doing, each Contracting Party shall take the appropriate steps to:

(i) ensure that criticality and removal of residual heat generated during spent fuel management are adequately addressed;

(ii) ensure that the generation of radioactive waste associated with spent fuel management is kept to the minimum practicable, consistent with the type of fuel cycle policy adopted;

(iii) take into account interdependencies among the different steps in spent fuel management;

(iv) provide for effective protection of individuals, society and the environment, by applying at the national level suitable protective methods as approved by the regulatory body, in the framework of its national legislation which has due regard to internationally endorsed criteria and standards;

(v) take into account the biological, chemical and other hazards that may be associated with spent fuel management;

(vi) strive to avoid actions that impose reasonably predictable impacts on future generations greater than those permitted for the current generation;

(vii) aim to avoid imposing undue burdens on future generations.

After these general safety requirements, there follows more specific requirements in Chapters 2 and 3 for spent fuel management facilities and radioactive waste management facilities covering review of existing facilities, the siting of proposed facilities, design and construction, safety assessment and operation. Another article deals with institutional measures after the closure of a radioactive waste disposal facility.

Chapter 4 of the Joint Convention is entitled *General Safety Provisions.* It first requires contracting parties to take the legislative, regulatory and administrative measures and steps necessary to implement the obligations of the Joint Convention. It describes the legislative and regulatory framework, the specification of the regulatory body, the responsibility of the licence holder, human and financial resources, quality assurance, operational radiation protection, emergency preparedness, and decommissioning.

Chapter 5 of the Joint Convention deals with transboundary movement of spent fuel and radioactive waste and the specific case of disused sealed sources. Chapter 6 covers the meetings of the contracting parties, especially the review meeting to be held every three years. Chapter 7 contains other legal technical provisions.

Australia submitted national reports on the Joint Convention for the review meetings in 2003 and 2006. These are both available on the ARPANSA website. The reports cover, of course, the whole of Australia's management of radioactive waste. With regard to ANSTO specifically, the reports address the Australian Government's spent fuel management strategy and reports on the ANSTO site as both a spent fuel management facility and radioactive waste management facility in the terms of the Joint Convention. The national report for the 2006 review meeting described the plans for the Commonwealth Radioactive Waste Management Facility and the spent fuel strategy embodied in the OPAL ultimate disposal and transfer plan.

ARPANSA is the responsible Australian agency for the Joint Convention and led the Australian delegation to the review meetings. At the second review meeting, Australian presentation focussed on issues discussed at the first review meeting including regulatory systems, the management of spent fuel (including the proposed policy presented in the current OPAL application) and radioactive waste management. I am advised that Australia's presentation was well received.

I have also undertaken an assessment of the OPAL spent fuel management and radioactive waste management plans against the provisions of the Joint Convention. A summary of this assessment is at Annex C.

I find that the spent fuel and radioactive waste management arrangements associated with operation of the OPAL reactor are consistent with Australia's obligations under the Joint Convention and that in turn represents international best practice in relation to radiation protection and nuclear safety.

3.2.3. IAEA Safety Fundamentals

The hierarchy of IAEA safety standards begins with *Safety Fundamentals,* which are defined as *'presenting the objectives, concepts and principles of protection and safety and providing the basis for safety requirements'*.

In the past several years, the IAEA has been developing a single, unified *Safety Fundamentals* document to replace separate documents dealing with nuclear safety, radiation protection and radioactive waste management. While the document is still in draft form, it has now been approved by the IAEA Commission on Safety Standards for consideration by the Board of Governors. Thus while it is still formally a draft, the advanced stage it has reached gives me confidence that it represents international best practice in relation to radiation protection and nuclear safety.

The *Safety Fundamentals* are made up of a Fundamental Safety Objective and ten simply stated principles. The bulk of the document provides background and support for the principles.

Fundamental Safety Objective
The fundamental safety objective is to protect people and the environment from harmful effects of ionizing radiation.

Principle 1: Responsibility for safety
The prime responsibility for safety must rest with the person or organization responsible for facilities and activities that give rise to radiation risks.

Principle 2: Role of government
An effective legal and governmental framework for safety, including an independent regulatory body must be established and sustained

Principle 3: Leadership and Management for Safety
Effective leadership and management for safety must be established and sustained in organisations concerned with and in facilities and activities that give rise to radiation risks.

Principle 4: Justification of facilities and activities
Facilities and activities that give rise to radiation risks must yield an overall benefit.

Principle 5: Optimization of protection
Protection must be optimized to provide the highest level of safety that can be reasonably achieved.

Principle 6: Limitation of risks to individuals
Measures for controlling radiation risks must ensure that no individual bears an unacceptable risk of harm.

Principle 7: Protection of present and future generations
People and the environment, present and future, must be protected against radiation risks.

Principle 8: Prevention and mitigation of accidents
All practical efforts must be made to prevent and mitigate nuclear or radiation accidents.

Principle 9: Emergency preparedness and response
Arrangements must be made for emergency preparedness and response in the case of nuclear or radiation incidents.

Principle 10: Protective actions to reduce existing or unregulated radiation risks
Protective actions to reduce existing or unregulated radiation risks must be justified and optimized.

One important implication arising from the agreement on a single set of safety fundamentals is that while radiation protection on the one hand and nuclear safety on the other are to some extent separable disciplines each with their own culture and approaches, they do share and can express the same fundamental safety goals.

The Fundamental Safety Objective is virtually identical to the object of the Act.

Principle 1 is accepted in the Australian context. My decision to issue a facility licence authorising OPAL to operate is on the basis of ANSTO’s management of safety as described in its plans and arrangements, operational limits and conditions and safety analysis. The longer-term issues of the management of safety of radioactive waste may involve a transfer of responsibility from ANSTO as the operator of OPAL to the manager of the Commonwealth Radioactive Waste Management facility (CRWMF), but this will take place in the context of ARPANSA regulation.

The Australian Government has met Principle 2 as it applies to OPAL (and the management of its radioactive waste) through the Act that establishes the position and role of the CEO of ARPANSA.

Principle 3 is a most important one in consideration of the operation of a new facility. How ANSTO proposes to manage the safety of OPAL has been a central feature of the assessment of the operating licence application. Ongoing issues will include safety culture, the feedback and analysis of operating experience and periodic safety review that are the subject of licence conditions. ARPANSA inspections will monitor closely the conduct of operation and the effectiveness of the safety management plans in practice.

Principle 4 is addressed in the case of OPAL through my consideration of the issue of net benefit (Chapter 5 of this statement of reasons).

Similarly, I have addressed Principle 5 in taking account of ALARA as required by regulation 41(3)(d) and discussed in Chapter 5.

Principle 6 is reflected in the regulations that require ANSTO to observe the nationally established public and occupational dose limits.

With respect to principle 7, I discuss the issue of protection of the environment with regard to operation of OPAL later in this chapter and in Chapter 4. The protection of present and future generations particularly applies to the long-term management of radioactive waste. It is addressed in ARPANSA’s draft regulatory guidance for radioactive waste management facilities. Environmental matters are addressed in Chapters 3 and 14 of the SAR and in the Environmental Management Plan that was reviewed as part of the application.

Principle 8 regarding prevention and mitigation of accidents is also highly significant for the operation of a new facility. The primary means of preventing and mitigating the consequences of accidents is ‘defence in depth’, which is that there are a number of consecutive and independent levels of protection that would have to fail before harmful effects could be caused to people or the environment. ARPANSA has stressed defence in depth in its own regulatory assessment principles and the INVAP design and ANSTO application have described how they have sought to achieve it. The five levels of defence in depth are specifically identified in Chapter 16 of the SAR in relation to the series of postulated initiating events.

I address Principle 9 about emergency preparedness and response in reviewing the coverage of emergency preparedness in Chapter 20 of the SAR and the Emergency Response Plan in Chapter 4, taking into account the issues raised by this principle.

Finally, I do not believe that Principle 10 about existing or unregulated radiation risks is relevant in the OPAL context.

Having reviewed the draft Fundamental Safety Principles and the OPAL application and other relevant material, I find that the proposed operation of the OPAL reactor is consistent with international best practice in relation to radiation protection and nuclear safety at this level of Safety Fundamentals.

3.2.4. Recommendations of the International Commission on Radiological Protection (ICRP)

The system for radiation protection adopted in nearly all parts of the world is based upon the Recommendations of the International Commission on Radiological Protection (ICRP).[6] The current Recommendations that form the basis of contemporary radiation protection are found in ICRP 60 published in 1990.

In 2005, the ICRP published new draft Recommendations and sought public comment on them. ICRP is continuing to work on the draft in the light of the comments it has received and it is now expected that new Recommendations may be published late in 2006 or during 2007.

ARPANSA's (and Australia's) system for regulation of radiation protection is derived from ICRP 60 – and the IAEA Basic Safety Standards based on that publication. The OPAL plans for radiation protection have been assessed on that basis. Are the new recommendations expected in the short-term likely to mean that this assessment will no longer be soundly based; and is there is a risk of OPAL being licensed on an outdated definition of international best practice in radiation protection?

In terms of assessment of health risk, ICRP's current system derives from knowledge of the health effects of ionizing radiation derived in large part from studies of Japanese atomic bomb survivors. At low doses and low dose rates of exposure, the ICRP relies upon a 'linear, non-threshold' hypothesis that allows the extrapolation of risk from higher doses and dose rates in the A bomb population down to the low doses that might be expected to be encountered through exposures to well-run nuclear facilities. It does not accept that there is a threshold below which there are no effects from ionising radiation, though the effects from very low doses are low.

The ICRP 60 system of radiological protection is then based upon three principles (simply stated):

- Justification – deliberate exposures to radiation need to do more good than harm.

- Optimisation – exposures to radiation should be kept as low as reasonably achievable, economic and social factors being taken into account (ALARA).

[6] The ICRP is a non government organisation established in 1928 by the International Congresses of Radiology to develop recommendations on the protection of people from ionizing radiation. It has produced overall Recommendations for the system of radiation protection in 1958, 1964, 1966, 1977 and 1991 as well as advice on many specialized topics.

- Limitation – the total dose to an individual (member of the public or radiation worker) from regulated activities should not exceed the appropriate dose limit specified by ICRP

In a presentation by the Chairman of ICRP to the 18th meeting of the IAEA Commission on Safety Standards in November 2005, he stressed that the new recommendations under development represented ‘more continuity than change’. The three principles above will continue as will the currently stated dose limits. There is no significant change to the overall health risk assessment (in fact, it is reduced from that assessed in the 1990 publication largely because of reduced estimates of hereditary effects). The major change that can be expected is a greater emphasis on the process of optimisation and the role in that of ‘dose constraints’. These are upper bounds of dose to be set nationally for different circumstances (below dose limits) that will form the upper bound of steps for optimisation or achieving ALARA.

There will be other developments in the system of radiation protection that may affect the coverage of radiation protection, the treatment of natural exposures, and other matters. However, these are of little direct relevance to OPAL’s arrangements for radiation protection.

If, as expected, the new ICRP recommendations continue along the current path and are adopted into radiation protection world-wide, I would expect to see over time some changes in the way OPAL’s managers in the future might need to demonstrate that they are achieving an optimised outcome – but I do not foresee fundamental change to the management of radiation protection in nuclear facilities like OPAL.

It should be said that the current and future ICRP recommendations are attacked from one side as not taking into account arguments that the effects of exposures to low-level radiation, especially alpha emitters taken internally, are much greater that ICRP suggest using the liner non-threshold model; and from another as not taking into account evidence that the effects of low levels of radiation may be zero or indeed may be beneficial because of DNA repair mechanisms. I have followed this scientific debate closely – and while there are views passionately held on all sides, there is no doubt that international best practice in relation to radiation protection is that based upon the linear non-threshold hypothesis with health risk assessment around the levels suggested by ICRP[7].

3.2.5. Protection of the Environment

The discussion in this chapter to date has been about the radiological protection of humans.

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[7] A recent publication by the US National Research Council of the National Academies of Science (BEIR VII) proposed that the factor used by the ICRP to reduce risk estimates from high dose, high dose rate outcome of the atomic bomb survivors to low dose, low dose rate circumstances should be 1.5 rather than 2. This has the effect of increasing risk estimates at low dose, low dose rates by 1/3, but would not suggest a change in contemporary radiation practice based on dose constraints and ALARA.

In my statement of reasons for the construction licence, I discussed international best practice in relation to radiation protection and nuclear safety with respect to protection of the environment as follows:

> *I have also considered the issue of defining international best practice in radiation protection and nuclear safety with regard to protection of the environment from the harmful effects of radiation. I have construed my role, derived from the object of the Act, as being in relation to the protection of environment from the harmful effects of radiation. Other harms to the environment that may arise from the construction and operation of the RRR were assessed in the EIS process.*
>
> *International best practice in relation to radiation protection and nuclear safety and protection of the environment is changing. The International Commission on Radiological Protection (ICRP) in its publication ICRP 60 took the view that measures to protect humans from radiation also protected the environment.*
>
> *'The Commission believes that the standard of environmental control needed to protect man to the degree currently thought desirable will ensure that other species are not put at risk. Occasionally, individual members of non-human species might be harmed, but not to the extent of endangering whole species or creating imbalance between species. At the present time, the Commission concerns itself with mankind's environment only with regard to the transfer of radionuclides through the environment, since this directly affects the radiological protection of man.'*
>
> *This view is certainly coming under challenge – and the ICRP itself has set up a working group to assess its position. The challenge is especially so for environments where non-human species are likely to be those most exposed – as may be the case for a waste repository, for example. There are ongoing discussions as to the ethical basis that might apply in relation to protection of the environment from ionizing radiation[8]. The US Department of Energy has published an 'interim technical standard' setting out an approach to evaluating doses to aquatic and terrestrial biota. I consider that there is not yet an established radiation protection system for non-human species that can be regarded as international best practice and for application in the context of a research reactor, other than utilized on the protection of humans.*

As I stated in the passage above, in 2000, the ICRP set up a task group 'to advise on the development of a policy for the protection of the environment, and to suggest a framework – based on scientific and ethical-philosophical principles – by which it could be achieved'. The work of the task group resulted in ICRP Publication 91 in 2003 *A Framework for Assessing the Impact of Ionising Radiation on Non-human Species.* In an editorial accompanying the *Framework* the ICRP stated:

> *'The Commission's system for the protection of human beings has indirectly provided a fairly good level of protection of the human habitat. The Commission's decision to develop a system to develop a framework for the assessment of radiation effects in non-human species has not been driven by any particular*

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[8] *Ethical considerations in protecting the environment from the effects of ionizing radiation, A report for discussion*, IAEA TECDOC 1270, Vienna, February 2002

concern over environmental radiation hazards. It has rather been developed to fill a conceptual gap in radiological protection, and to clarify how the proposed framework can contribute to the attainment of society's goals of environmental protection by developing a protection policy based on scientific and ethical-philosophical principles.'

The framework proposes an approach for the development of 'reference' plants and animals. The aim would be to gather a reasonably complete set of related information (dose models, data sets to estimate exposures, data on dose-effect relationships) for a few types of organisms that are typical of the major environments. The reference organisms and their associated data sets would then be used to give information about the possible effects of certain exposures on organisms with similar life cycles, so providing a firmer basis for purely environmental decision-making with respect to an activity leading to radiation exposures.

Following on the work of the task group, the ICRP has established a standing committee to deal with developing the framework outlined. The new Recommendations document is likely to describe the current state of this work, but it is unlikely that there will be a definitive approach laid out for some time to come.

The application of the framework in the case of OPAL would be to try to assess the impact of the air and water discharges from the reactor facility on the flora and fauna in the vicinity. The discussion above makes it clear that there is not yet a method to do this that can be regarded as international best practice in relation to radiation protection. I have considered whether there was value in requiring ANSTO to carry out an assessment of non-human environmental impacts using the somewhat rough and ready screening tools that are available. I do not believe, however, that this is warranted – it would require a commitment of resources that I very much doubt would be justified by the results given the very low levels of discharge planned from the facility and the regulatory limits in the ARPANSA discharge authorisation and the Sydney Water trade waste agreement.

I have proposed in draft regulatory guidelines that such a screening approach be used for the proposed Commonwealth Radioactive Waste Management facility.

Environmental matters are covered in general in Chapters 3 and 14 of the SAR and in the Environmental Management Plan that was reviewed as part of the OPAL application.

3.3. Is there a global nuclear safety framework?

The most systematic approach to considering an international nuclear safety framework of which I am aware has been the work undertaken by the Western European Nuclear Regulators' Association (WENRA). WENRA comprises the chief regulators of 17 European nuclear regulatory authorities. It was set up in 1999 as a means of examining nuclear safety in countries who were then candidates for membership of the European Union (EU), nuclear safety having been included in the EU enlargement criteria. Having done that immediate task, it has extended its membership to cover all EU and EU candidate countries with power reactors. A major role that it has taken up is to develop a harmonised approach to nuclear safety within Europe.

To achieve this harmonised approach, WENRA established a working group on reactor harmonisation and it has now published its report *Harmonization of Reactor Safety in WENRA Countries* (WENRA, January 2006). The working group used a definition of harmonisation:

> *No substantial differences between countries from the safety point of view in generic, formally issued, national safety requirements and in their resulting implementation on nuclear power plants.*

The methodology for the study was:

- A set of Reference Levels identifying the main relevant requirements on reactor safety was developed for 18 safety issues. These Reference Levels were primarily based upon IAEA safety standards.

- Countries assessed themselves against the Reference Levels both with regard to legal requirements and actual implementation.

- The national positions were scrutinised in peer review panel sessions to validate the self assessments. Where judged necessary, changes were made to national assessments and, in some cases, Reference Levels were modified.

- Areas where harmonisation was considered necessary on the implementation and/or legal side in each country were identified.

The safety issues were selected so as to cover the most important aspects where differences in substance between WENRA countries might be expected.
The safety issues were structured into five safety areas as follows:

Safety area	**Safety issue**
SAFETY MANAGEMENT	A. Safety policy
	B. Operating organisation
	C. Quality management
	D. Training and authorisation of staff
DESIGN	E. Verification and improvement of the design
	F. Design basis envelope for existing reactors
	G. Safety classification of structures, systems and components
OPERATION	H. Operational limits and conditions
	I. Ageing management
	J. System for investigation of events and operational experience feedback
	K. Maintenance, in-service inspection and functional testing

	LM. Emergency operating procedures and severe accident management guidelines
SAFETY VERIFICATION	N. Contents and updating of safety analysis report (SAR)
	O. Probabilistic safety analysis
	P Periodic safety review (PSR)
	Q. Plant modifications
EMERGENCY PREPAREDNESS	R. On-site emergency preparedness
	S. Fire protection against internal fires

For each safety issue, Reference Levels were established – the starting point for defining Reference Levels was the IAEA safety standards. Countries were able to propose additional Reference Levels, not based upon the IAEA safety standards, but upon their national regulations. The report of the study states that ‘in practice, there have been few such additions, because the international safety standards in IAEA documents are rising and many WENRA countries have participated in the work of IAEA committee, which has contributed to convergence’.

It is not my purpose here to go into detail about the Reference Levels determined by WENRA for nuclear power plant. But, as an illustration, the Reference Levels for Operational Limits and Conditions are set out in Box 1.

BOX 1 – WENRA REFERENCE LEVELS – OLCs

1. Purpose

1.1 OLCs shall be developed to ensure that plants are operated in accordance with design assumptions and intentions as documented in the SAR.

1.2 The OLCs shall define the conditions that must be met to prevent situations that might lead to accidents or to mitigate the consequences of accidents should they occur.

2. Establishment and review of OLCs

2.1 Each established OLC shall have detailed justification based on plant design, safety analysis and commissioning tests.

2.2 OLCs shall be kept updated and reviewed in the light of experience, developments in science and technology, and every time modifications in the plant or in the safety analysis warrant it, and changed if necessary.

2.3 The process for making modifications or temporary modifications of OLCs shall be defined. Such modifications shall be adequately justified by safety analysis and independent safety review.

3. Use of OLCs

3.1 The OLCs shall be readily accessible to control room personnel.

3.2 Control room operators shall be highly knowledgeable of the OLCs and their technical basis and relevant operational decision makers shall be aware of their significance for the safety of the plant.

4. Scope of OLCs

4.1 OLCs shall cover all operational plant states including power operation, shutdown and utilization, transitions between these states and temporary situations arising due to maintenance & testing.

4.2 OLCs shall include: - Safety limits; Safety systems settings; Equipment required; and Action to be taken in the case of deviations from OLCs.

5. Safety limits, safety systems settings, and operational limits

5.1 Adequate margins shall be provided between safety limits, safety systems settings, alarms, and operational limits to avoid activating safety systems too frequently.

5.2 Safety limits shall be established using a conservative approach to take uncertainties in the safety analyses into account.

6. Unavailability limits

6.1 Limits and conditions for normal operation shall include limits on operating parameters, stipulation for minimum amount of operable equipment, actions to be taken by the operating staff in the event of deviations from the OLCs and time allowed to complete these actions.

6.2 Where operability requirements cannot be met, the actions to bring the plant to a safer state, such as power reduction or reactor shutdown, shall be specified, and the time allowed to complete the action shall be stated.

6.3 Operability requirements shall state for the various modes of normal operation the number of systems or components important to safety that should be in operating condition or standby condition.

7. Unconditional requirements

7.1 If operating personnel cannot ascertain that the power plant is operating within operating limits, or the plant behaves in an unpredicted way, measures shall be taken without delay to bring the plant to a safer state.

7.2 Plant shall not be returned to service following unplanned shutdown until it has been shown to be safe to do so.

8. Staffing levels

8.1 Minimum staffing levels for shift staff shall be stated in the OLCs.

9. Surveillance

9.1 The licensee shall ensure that an appropriate surveillance program is established and implemented to ensure compliance with OLCs and shall ensure that results are evaluated and retained.

10. Non-compliance

10.1 In cases of non-compliance, remedial actions shall be taken immediately to re-establish OLC requirements.

10.2 Reports of non-compliance shall be investigated and corrective action shall be implemented in order to help prevent such non-compliance in future.

The relevant lesson that I draw here is that, at least for nuclear power plant, the group of European nuclear regulators have found that the suite of IAEA safety standards creates a framework for regulatory harmonization in those countries. It is hardly an extrapolation to accept that the IAEA safety standards establish a framework for international best practice in relation to radiation protection and nuclear safety.

I find, therefore, that international best practice in relation to radiation protection and nuclear safety at the detailed level of operation of research reactors is framed by the IAEA safety standards. This is not to say that every single statement in every safety standard is necessarily 'best' practice, but they will be 'good' practice. With the relevant safety standards taken together, a reactor facility that meets all the necessary standards at the level of the safety requirements and that 'scores' highly against the range of guidance in the safety guides can be said to meet international best practice in radiation protection and nuclear safety.

3.4. The application of international best practice in relation to radiation protection and nuclear safety to operation of a research reactor

In 2005, the IAEA published a Safety Requirements document *Safety of Research Reactors (NS-R-4).* The *Safety Requirements* (as it is referred to from now on in this document) covers siting, design, operation and decommissioning of research reactors and replaced earlier documents dealing with design and operation.

A suite of supporting safety guide documents directed toward operation of research reactors is nearing completion:

- *Commissioning of Research Reactors,* DS 259, now approved for publication ARPANSA drew extensively upon a draft of this safety guide in the preparation of its regulatory guidance on commissioning.

- *Maintenance, Periodic Testing and Inspection of Research Reactors,* now approved for publication.

- *Operational Limits and Conditions and Operating Procedures for Research Reactors,* DS 261, Committee approved draft circulated for Member State comment.

- *The Operating Organization and the Recruitment, Training and Qualification of Personnel for Research Reactors,* DS 325, Committee approved draft circulated for Member State comment.

- *Radiation Protection and Radioactive Waste Management in the Design and Operation of Research Reactors,* DS 340, Committee approved draft circulated for Member State comment.

- *Core Management and Fuel Handling for Research Reactors,* DS 350, Committee approved draft circulated for Member State comment

Each of these safety guides applies to the operation of research reactors. ARPANSA staff reviewers were aware of the documents as they developed and drew upon them to support assessments. I refer to them specifically in my discussion in Chapters 4 and 5 relating to the assessment of the operating plans and arrangements and other information contained in the ANSTO application. While the documents are still under development through the IAEA processes, they are at an advanced stage and changes to them are now likely to be at the margin.

The composition of the peer review teams arranged through the IAEA, was weighted towards experts from organisations that actually operated research reactors with major utilisation programs, rather than regulators. This meant that they were comparing their own real-life operational experience with the plans and arrangements proposed by ANSTO for the OPAL reactor.

4. PLANS AND ARRANGEMENTS FOR OPERATION OF OPAL REACTOR

In this chapter I assess ANSTO's plans for the safe operation of the OPAL reactor (Part B of the application). Regulation 39(2) allows me to request that an application for a facility licence include the information in Part 1 of Schedule 3 of the regulations. As stated in chapter 2 above, I requested all of the information in Part 1 of Schedule 3 to be included in the application. Item 4 of Schedule 3 requires that plans and arrangements be submitted with respect to the following matters:

a) The applicant's arrangements for maintaining ***effective control*** of the facility;
b) The ***safety management*** plan for the controlled facility;
c) The ***radiation protection*** plan for the controlled facility;
d) The ***radioactive waste management*** plan for the controlled facility;
e) The ***security*** plan for the controlled facility; and
f) The ***emergency*** plan for the controlled facility

In addition, ANSTO provided me with an environmental management plan for the controlled facility.

For the purpose of comparing the ANSTO plans and arrangements to international best practice in relation to radiation protection and nuclear safety I have assessed them against the IAEA Safety Requirements *The Safety of Research Reactors* NS-R-4 (*the Safety Requirements).* I have also drawn upon, where relevant, the IAEA draft safety guides for research reactors listed in section 3.4.

4.1. Plan for maintaining effective control

4.1.1. Structure of the plan for effective control

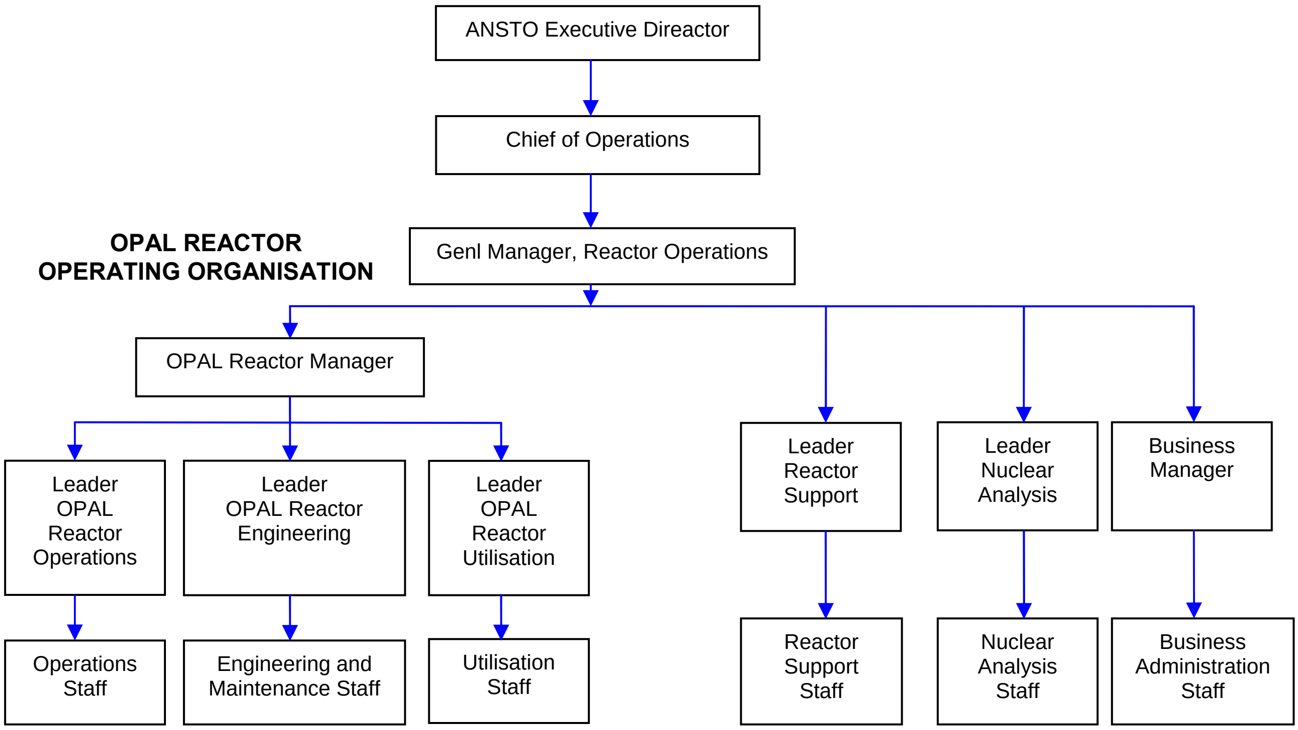
The Plan for Maintaining Effective Control (RRRP-7200-EDEAN-003-REV1) first describes in general terms the accountability of ANSTO as the proposed operator of the reactor. It says that the arrangements to control effectively the technical, administrative and human factors associated with OPAL reactor operations comply with the general policies, safety management systems and quality requirements of ANSTO. The lines of communication, responsibilities and authorities, functions, duties and competencies associated with these activities for the OPAL reactor are documented and are proposed to be administered through the OPAL reactor Operations Business Management System (BMS).

There is a commitment to ensuring that adequate and appropriate human, financial and material resources are provided to implement the plans and arrangements effectively.

4.1.2. Roles and Responsibilities

These are briefly defined in the Plan for Maintaining Effective Control, the SAR Chapter 13 (Conduct of Operations), and BMS Operating Procedure (OP) 05.

The OPAL reactor operating organisation is as set out in the following figure taken from OP05.



The position of General Manager, Reactor Operations is described as being responsible for developing local arrangements for safety management and for operating the systems to implement these arrangements. The General Manager, Reactor Operations, delegates day-to-day responsibility for the safe operation of the OPAL reactor to the OPAL Reactor Manager (and to HIFAR Reactor Manager for the safe operation of HIFAR during the full power overlap period and during HIFAR Decommissioning).

The OPAL Reactor Manager is responsible for the safe operation and maintenance of the OPAL reactor. The OPAL Reactor Manager ensures that the necessary elements for achieving safety are present and that the need for safety governs operations. These responsibilities cover the reactor operations, engineering and maintenance, utilisation and radiation protection.

The IAEA *Safety Requirements* deal with the structure and responsibilities of ‘the operating organisation’ for the research reactor – being ANSTO in the case of OPAL. Under the *Safety Requirements*, the operating organisation must establish an appropriate management structure for the research reactor.

In particular, the *Safety Requirements (para 7.11)* identify a central role for a 'reactor manager' to be established by the operating organisation:

> *'The operating organization shall assign direct responsibility and authority for the safe operation of the reactor to the reactor manager. The primary duties of the reactor manager shall comprise the discharge of this responsibility. The reactor manager shall have overall responsibility for all aspects of operation, inspection, periodic testing and maintenance, and utilization and modification of the reactor.'*

The OPAL reactor operating organisation proposed by ANSTO and shown above divides the responsibilities of 'the Reactor Manager' identified in the *Safety Requirements* between the positions of Manager, OPAL Reactor Operations and OPAL Reactor Manager. ANSTO has acknowledged that there is a difference (ANSTO's response to the report of the Nuclear Safety Committee, letter Smith to Loy, 5/12/05). ANSTO points to the fact that a similar arrangement applies and has long done so to the operation of HIFAR and has been accepted by ARPANSA in this context.

I accept that in the context of the longstanding ANSTO arrangements, the organisational structure proposed by ANSTO is likely to achieve outcomes consistent with international best practice in relation to radiation protection and nuclear safety.

ARPANSA staff reviewers found that the BMS describes a clear management structure. It was judged to provide an effective framework for the organisation and administrative arrangements for the OPAL reactor. There was found to be adequate accountability of the applicant within the BMS. I accept these conclusions.

4.1.3. Documentation

The figure below, drawn from the plan for effective control illustrates how the documents that will form the basis for the operation of OPAL reactor are said to be derived from and relate to the safety case for the reactor and external and internal drivers.

In determining the adequacy of these documents, I needed to be satisfied that the documents to be used for operation – Hot Commissioning and routine operation – were generally satisfactory and adequately covered the scope of operations, taking into account international best practice in relation to radiation protection and nuclear safety. Then, I needed to be satisfied that there was a thorough process for amending the documents – over the life of the OPAL reactor – but especially as matters arise during Hot Commissioning and the first period of operation. Experience in the operation of any complex system is that matters will arise that require amendment of the operational arrangements – that is entirely to be expected, whether the new system is a nuclear reactor, an aircraft, a car, or a software program. The question is whether the initial basis from which those documents will be drawn is sufficiently firm and there is a strong process for assessing effectiveness and changing in response to experience.

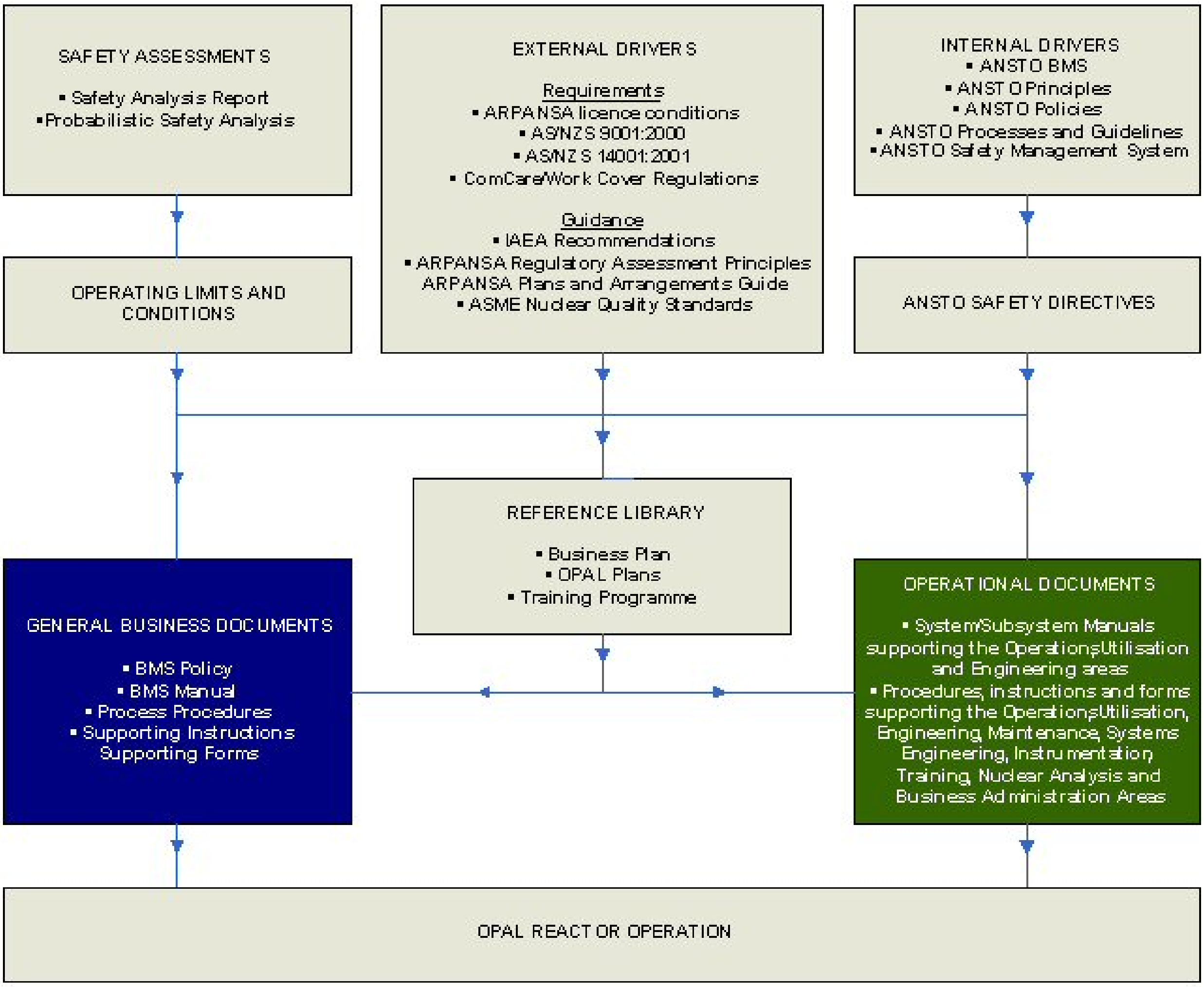
General business documents and operational documents are the main working level documents which will be used during operation of the OPAL reactor. The general business documents have usually been produced by ANSTO and fall under ANSTO control. These documents, collectively referred to as the BMS, form a multi-layered structure. The head document of the BMS is the *OPAL Reactor Operations Business Management System Manual* which has been assessed by ARPANSA staff reviewers as providing a good overview of the system structure and objectives. The important layers cascading below the BMS Manual that are of interest from a regulatory standpoint comprise of the following categories:

- BMS Manual (OM 01)
- OPAL Procedures (OP's)
- OPAL Instructions (OI's)
- OPAL Forms (OF's)
- OPAL Operational Instructions (OOI's)
- OPAL Operational Forms (OOF's)
- OPAL Utilisation Procedures (OUP's)
- OPAL Utilisation Instructions (OUI's)
- OPAL Utilisation Forms (OUF's)
- OPAL Maintenance Procedures (OMP's)
- OPAL Maintenance Instructions (OMI's)
- OPAL Maintenance Forms (OMF's)
- OPAL Engineering Procedures (OEP's)
- OPAL Engineering Instructions (OEI's)
- OPAL Engineering Forms (OEF's)

Within the OPAL Operational Instructions, ANSTO have provided a number of Emergency Operating Instructions (EOIs) covering actions to be taken in the event of a number of potential emergencies.

The BMS documents are held in electronic form on a computerised BMS intranet system which provides read only access to all OPAL reactor personnel. ANSTO have stated that it will be possible to print these to hard copy but that the prints will be date stamped and with a "use-by" date after which use of the copy is not permitted. ANSTO have further demonstrated that hyperlinks to referenced documents will be used widely within the BMS computer system to make navigation between documents easy. Paper copies of these documents will be required to be used by the Reactor Operator (RO) as there is no BMS terminal at the control panels.

The operational documents have been produced under contract by INVAP and will remain formally under INVAP control until commissioning is complete. A homely analogy that I found useful to illustrate the difference between the two sets of documents is a comparison to the use of a car. The operational documents would provide instruction on how to start the car, accelerate, brake and steer; instruction on how to drive safety, keep to speed limits, and stop at traffic signals; instruction on how to maintain the vehicle. General Business documents would provide the purpose of the journey; controls on who can drive; procedures for planning; and when and where to refuel.



Once the operational documents are finally formally delivered to ANSTO, they will become incorporated into the BMS.

The categories of operational documents are:

- Plant Operation manual
- Plant Procedures
- System User Manual
- System Maintenance Manuals
- Vendor Manuals and Associated Procedures
- System Design Manuals
- Engineering Procedures
- Training Documents

Overall, ARPANSA staff reviewers found that the scope of the documents was satisfactory. The BMS currently comprises of approximately 430 OPAL reactor specific documents ranging from top-level policies, manuals and procedures down to individual forms. No significant gaps have been identified in coverage of operational matters. It should however be recognised that improvements will be identified during operation of the facility that may result in changes to the BMS documentation. This is to be expected and ANSTO has incorporated measures within the management systems to identify these and introduce changes in an appropriately structured manner.

Assessment of the adequacy of the operating documents is taken up in specific sections of this statement.

4.1.4. Resources

The issue of overall resources and roles is raised by the IAEA *Safety Requirements* stating that:

> *The reactor manager shall specify the minimum staffing requirements for the various disciplines required to ensure safe operation for all operational states of the research reactor. These requirements include both the number of personnel and the duties for which they are required to be authorized. The person with responsibility for the direct supervision of the operation of the reactor shall be clearly identified at all times. The availability of the staff who would be required to deal with accident conditions shall also be specified.*

ANSTO's proposals for minimum staffing requirements for different circumstances are described in the Operational Limits and Conditions and operating procedures, depending on the operations being undertaken. ANSTO has proposed that the minimum staffing for an operating shift shall be: a Shift Manager, an accredited Reactor Operator, and a Plant Operator. This may be increased for certain activities and each operating manual or instruction specifies the minimum staffing required in conducting the process that it describes.

In a letter dated 4 July, ANSTO has described the specifics of its staffing arrangements for the immediate future dividing the OPAL reactor operations staff into those appointed to the OPAL reactor operations (28 staff), project or commissioning staff (24 staff) and HIFAR dual operation shared staff (12 staff). ANSTO has also supplied numbers of the accredited Shift Managers and Reactor Operators and set out the shift arrangements to apply. I accept that the staffing resources needed to commence the operation of the OPAL reactor are available.

ARPANSA staff reviewers have expressed reservations about the ongoing likelihood of the OPAL reactor operating staff resources being maintained in the light of many new operating staff being professionals (with the likelihood that they may seek other opportunities in due course) and also being exposed to shift work to which many people are unsuited. I accept that this is matter of concern – to ANSTO as well as to ARPANSA – and will need to be kept under close review. Nevertheless, the minimum staffing arrangements are expressed in the documentation, including the Operational Limits and Conditions, and it will not be possible to operate the OPAL reactor below these staffing levels.

The shift rota provided by ANSTO for the commencement of operations is satisfactory, including that the shift length is 8 hours. Any changes to shift arrangements will be monitored by ARPANSA to ensure that they do not bring about possible deterioration in critical staff performance.

4.2. ANSTO's Plans for operation of OPAL – safety management plan

4.2.1. Elements of the Safety Management System

The Safety Management Plan (RRRP-7200-EDEAN-004-REV1) describes the safety management system to apply to OPAL reactor operations, being a part of the overall ANSTO safety management system.

Important elements of the system are:

- The ANSTO Health, Safety and Environment Policy (APOL 2.1) which commits ANSTO to safe operation of its facilities.

- A series of Safety Directives that establish health and safety requirements for ANSTO operations and are issued by the Executive Direactor.

- A safety assessment and approval system (established by Safety Directive 2.1) that sets up a process of review and monitoring. It includes the safety committees further discussed below.

- An incident reporting system that requires that incidents be investigated and corrective actions implemented with lessons learned to be drawn and addressed.

I take up some specific issues in the later subsections below, but overall ARPANSA staff reviewers found that the Safety Management System is satisfactory and sufficiently well developed to allow commencement of operation. The ARPANSA staff reviewers have suggested a number of recommendations that might be considered by ANSTO in review of the documentation. I will recommend to ANSTO that these recommendations be considered, including as a part of the first periodic safety review required by Additional Licence Condition 1.

4.2.2. Safety Committees

The S*afety Requirements* state:

> *One or more reactor advisory groups or safety committees that are independent of the reactor manager shall be established to advise the operating organization on:*
>
> *(a) relevant aspects of the safety of the reactor and the safety of its utilization and*
>
> *(b) on the safety assessment of design, commissioning and operational issues. One of the committees shall also advise the reactor manager (see also paras 7.25 and 7.26). Members of such a group or groups shall be experts in*

different fields associated with the operation and design of the research reactor. It may be advisable to include external experts (i.e. from outside the operating organization) in such committees. Depending on the complexity of the operations carried out at the research reactor, one of the advisory groups could be external to the operating organization. The functions, authority, composition and terms of reference of such committees shall be documented and, if required, submitted to the regulatory body.

The application refers to four committees in relation to OPAL reactor safety:

- The OPAL Safety Review Meeting. This is part of the OPAL reactor line management. It functions as the facility radiation safety committee and provides feedback to and involvement of OPAL reactor line management on nuclear safety, radiation protection and general OH&S.

- The Reactor Assessment Committee. This is independent of line management (it reports to the General Manager, Reactor Operations and not to the Reactor Manager) and addresses OPAL reactor specific nuclear safety issues. It reviews proposed changes and abnormal operating occurrences.

- The Safety Assessment Committee (SAC) is an ANSTO wide committee dealing with radiation protection, OH&S and environment. It endorses proposed operations and changes.

- The ANSTO Health, Safety and Environment Committee (AHSEC) takes an overview of safety at ANSTO and advises the Executive Direactor. It has no approvals function or direct interaction with line management.

The array of ANSTO safety committees and their roles meets what is laid down in the *Safety Requirements.* ANSTO states that the SAC and the AHSEC include external members. The external membership needs to be maintained and extended, where possible.

4.2.3. Safety Culture

The Safety Management Plan under the heading of safety culture refers to the environment of safety created through the safety management system itself and the documented procedures of the BMS. It suggests that open communication and use of the Safety Review Meetings will enable staff to report safety concerns and contribute to effective solutions. It also refers to human factors analysis and task analyses and suggests that periodic safety culture surveys 'are used to identify opportunities for improvement and any emerging issues.'

The emphasis in these statements on the structured safety management system represented by the BMS is very appropriate. The safety management system is obviously a very important foundation for safety in the operation of the OPAL reactor and ARPANSA staff reviewers comment that the 'safety cultural' aspects of the BMS are adequate. The ARPANSA staff reviewers comment that management expectations of staff are adequately expressed through the BMS which is available to all staff on the ANSTO intranet. ANSTO has also agreed to post its safety policy using wall charts in strategic locations as a means of strengthening their message. The intranet is a primary method of communicating to staff. When considered with other measures, including a good event reporting system, the level of staff consultation is considered to be acceptable.

However, ARPANSA staff reviewers have been concerned that there may be a prevailing attitude across OPAL management and operational staff that the reactor has been demonstrated to be virtually invulnerable. This may be in part due to pride in the facility and the need to provide a positive public image – and indeed the OPAL reactor has been demonstrated to be very safe in its design. However, from a regulatory viewpoint, the attitude is considered to have the potential to weaken the safety culture.

The matter of safety culture is a difficult and subtle one for a regulator to deal with in regard to the operation of a facility. The regulator if its approach to safety comes across as being only ‘rules based’ can, in fact, contribute to an adverse safety culture and I am conscious of this. Nonetheless, I want to emphasise that supporting a positive safety culture and measuring progress towards this end is an important function of the operating organisation and I have imposed an additional licence condition to this end.

ARPANSA staff reviewers were also critical of consideration of human factors as reflected in the safety management system. However, I note that ANSTO has responded in some detail to the licence condition on the construction licence requiring further consideration of human factors. This is a matter that needs to be kept under review in the light of operational experience and it will be addressed as part of the periodic safety reviews required under the additional licence condition.

A specific issue related to safety culture that has been identified by ARPANSA staff reviewers is the development of safety performance indicators. The development of such indicators is a part of international best practice in relation to radiation protection and nuclear safety. I am aware that ANSTO is developing these for the OPAL reactor. They need careful consideration to be assured that they invoke a positive safety culture, not merely a reporting culture. I have included the development of these indicators in the additional licence condition dealing with safety culture.

4.2.4. Training, Re-training and Qualification

The IAEA *Safety Requirements* require as follows:

> *7.27. Training and retraining programmes shall be established for the operating personnel, including the reactor manager, the shift supervisors, the reactor operators, the radiation protection staff, the maintenance personnel, the quality assurance personnel and others working at the research reactor facility. Regular training and retraining shall be provided to enhance the knowledge and abilities of personnel continually.*
>
> *7.28. Procedures shall be put in place for the validation of the training to verify its effectiveness and the qualification of the staff.*

ANSTO has addressed these matters in the Safety Management Plan, Chapter 13 of the SAR and under the BMS OP 7.

The SAR Chapter 13 lays down ANSTO's requirements for the roles, qualifications and experience of the Reactor Manager, Reactor Operations Leader, Reactor Maintenance Leader, Reactor Utilisation Leader, Systems Engineering Leader, Nuclear Analysis Leader, other support staff including the Radiation Protection Adviser and Shift Personnel.

In assessing ANSTO's approach to the roles, qualifications and experience of the OPAL reactor personnel, I have drawn on the IAEA draft Safety Guide: *The Operating Organization and the recruitment, Training and Qualification of Personnel for Research Reactors* (DS 325, Draft 17, currently circulated to member States for final comment). In general the roles and qualifications proposed by ANSTO are consistent with those suggested in DS 325, noting however that DS 325 describes both a reactor operator and a senior reactor operator, though not much seems to turn on this. An area of some debate has been the experience needed for the position that ANSTO calls 'shift manager' and DS 325 refers to as 'shift supervisor'. DS 325 says that '*a shift supervisor should have several years of experience as an authorized senior reactor operator.*' ANSTO's proposed selection criteria for shift managers do not set criteria for experience.

In Chapter 13 of the SAR, ANSTO states that reactor operators have a minimum of one year of relevant experience in nuclear reactor operation and posses appropriate tertiary qualifications equivalent to a 'technical certificate' or higher. ANSTO states that for the commissioning and initial operating period, reactor operators having specific experience in design, construction and development of the OPAL operations systems, together with demonstrated competence in operation on the reactor control system simulator will be considered to have the one year of relevant experience in nuclear reactor operation. In practice, ANSTO has recruited graduate engineers to fill the accredited operating roles at OPAL.

For a number of reasons, ANSTO generally has chosen not to transfer experienced HIFAR shift operations personnel to OPAL reactor shift operations and not to use the OPAL reactor personnel to operate HIFAR pending the operation of the OPAL reactor. Thus in the first instance, ANSTO will be relying upon shift managers the majority of whom are likely to lack 'several' years of experience and on operators whose experience has been gained in the construction of the OPAL reactor and via operation of the simulator. However, leaders the OPAL reactor engineering and maintenance, utilisation, and operations sections have considerable experience on HIFAR.

ARPANSA staff reviewers put the view to me that the experience of the construction and commissioning program and the elevated academic qualifications held by the initial operating personnel do not make up for the shortfall of experience in working shiftwork, managing shift crews and making and implementing operating decisions, when considered against the IAEA safety guidance.

To some degree this is inevitable in the early stages of the operation of a new research reactor. It throws an emphasis on the quality of the training and aptitude of the early cohorts of shift personnel. The ARPANSA staff reviewers accepted that the training of the OPAL reactor operators was very good. The IAEA peer review pointed to the value of the OPAL reactor simulator in this regard.

An ARPANSA inspector witnessed the accreditation process for the first cohort of Shift Managers and Operators. He was satisfied with the rigour of the process and the qualities of the accredited people.

My own assessment, taking into account all the matters discussed above, is that the quality of operating staff derived from their qualifications, their training and their experience of construction and commissioning will make them acceptably competent for operation of the OPAL reactor. The training they have received appears to be at the cutting edge of international best practice in relation to radiation protection and nuclear safety in this area and the accreditation process is consistent with international best practice in relation to radiation protection and nuclear safety. The degree of experience would appear to fall somewhat behind international best practice in relation to radiation protection and nuclear safety. Nonetheless, I reach the conclusion that the staffing is appropriate on balance in the context of the overall the OPAL reactor safety case. The operating staffing is certainly a matter that will be kept under close scrutiny by ARPANSA through its monitoring and inspection of the licence, especially in the first few years of operation.

4.2.5. Records and Reports

The IAEA S*afety Requirements* state:

> *For the safe operation of the reactor, the operating organization shall retain all essential information concerning the design, construction, commissioning, current configuration and operation of the reactor. This information shall be maintained up to date throughout the operational stage of the reactor and shall be kept available during decommissioning. Such information includes site data and environmental data, design specifications, details of the equipment and material supplied, as-built drawings, information on the cumulative effects of modifications, logbooks, operating and maintenance manuals and quality assurance documents.*

I discuss elsewhere in this statement, the need for the Safety Analysis Report to be upgraded and maintained for the life of the OPAL reactor.

Records management is described in BMS document OP 04 which refers further to ANSTO BMS documentation. ARPANSA staff reviewers have assessed OP 04 as indicating that a comprehensive records management system is in place for the OPAL reactor which is in line with quality system requirements. The responsibility for records management usually rests with the manager of the section generating the record and OP 04 lists the record keeping requirements for various types of documents. A mixture of hard copy and electronic record keeping measures are employed with records being maintained usually for a ten year period after which they are transferred to National Archives.

Records are maintained of all aspects of reactor operations. This is indicated in Appendix 1 of OP 04. Subject Areas include; Reactor Operations, Systems Engineering, Maintenance and Instrumentation, Nuclear Analysis and Training. Personnel records associated with dose, medical, injury etc. are kept outside of the OPAL reactor business area under pre-existing ANSTO arrangements. ARPANSA staff reviewers were satisfied by these arrangements.

I have reviewed their assessments and I am satisfied that ANSTO meets the standards set by the *Safety Requirements* on record and report management.

4.2.6. Nuclear Safety Committee report on Conduct of Operations

In accordance with my request that the NSC provide advice on Operating procedures (refer Chapter 2 above) they provided me with an assessment of ANSTO's Operating procedures. The overall conclusion of the NSC working group was:

> *The proposals for maintaining effective control and conducting of the operation of the OPAL 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 reactor in many areas, particularly those that are not plant-specific.* ***This should be subject to any opportunities for improvement in light of international experience in the nuclear industry or elsewhere.*** (Committee emphasis)

The working group made the following recommendations, each of which is followed by my comment:

- *A safety culture should be actively promoted throughout the ANSTO organisation.*

ANSTO responded to the effect that a safety culture is already promoted and that it is acknowledged 'internationally as a leader in safety culture'. ANSTO referred to an emphasis on safety culture in its operator training program, but acknowledged the need 'for constant attention to maintain high levels of safety awareness and respect for the technology.'

One might be excused for seeing a slight touch of complacency in the first part of ANSTO's response, but the last part is perfectly appropriate.

I have given a lot of thought as to what the regulator can do to help promote safety culture in the operator. It is important that the more structural components of safety culture are seen to be there in terms of the high-level commitment to safety and the structural arrangements to deal with safety issues. As discussed above, the OPAL reactor plans and arrangements, within the overarching ANSTO safety management system, scores reasonably on this account. The more 'cultural' aspects of safety culture can be influenced to some degree by the regulator's own safety culture and the focus on safety as opposed to mere process. Also, awareness of the dimensions of safety culture need to be a part of the regulator's monitoring and inspection. If problems start to be identified that might have safety culture as a root cause, the regulator needs to raise this issue clearly.

I have discussed safety culture above. It is the subject of an additional licence condition.

- *The detailed information relevant to commissioning activities be made available to ARPANSA in a timely manner before a particular commissioning activity proceeds.*

In general, ANSTO achieved this as described in the ARPANSA construction report discussed in the next chapter.

- *Complete Quality Management System Procedures be set in place before a decision is made on whether an operating licence should be issued or not.*

In current language, the wording ‘complete QM System procedures’ translates to the OPAL Business Management System which has been certified to ISO 9001:2000. There can be little quarrel with the general proposition that the BMS needs to be in place prior to the decision on the operating licence. The area of some exception may be detailed procedures relating to the maintenance of some items that will likely not be maintained until some period into the future. ARPANSA needed to and has satisfied itself that the BMS structure is adequate and that it meets the requirements laid down in the plans and arrangements.

- *The nomenclature in relation to the organisational hierarchy, including the various safety committees, be made consistent with the IAEA documentation.*

ANSTO’s responded by acknowledging that some of its documents used differing titles for safety committees. It provided a chart that set out the role, functions and titles of the different committees and I believe that this is now clear and consistent with the IAEA *Safety Requirements*. The other issue is the dichotomy of the position of Reactor Manager and the Manager, Reactor Operations. ANSTO acknowledged that this differed from IAEA terminology and structure, but argued (as had been noted by the working group) that this was an approach familiar in ANSTO that had applied to the operation of HIFAR for many years. The same issue is discussed in Chapter 7 where I note that I accept the ANSTO position.

- *Integrated editing of the documentation be carried out to ensure consistency of terminology and acronyms.*

ANSTO acknowledged the point and argued that it would be addressed in the further development of the OPAL reactor BMS. A part of the OPAL reactor BMS is a definitive glossary. ARPANSA assessors accept that the current state of the editing of the BMS is satisfactory.

- *The positions, roles and functions of the various operational personnel and safety committees be clarified, confirmed and, where appropriate, elaborated upon.*

As noted above, ANSTO did clarify the roles of the committees in its response. The matter of the roles and functions of the operating personnel is discussed in Chapter 7.

- *ANSTO advise ARPANSA whether the Manager Reactor Operation is what the IAEA terms the Reactor Manager.*

This issue is dealt with above.

- *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.*

In its response ANSTO referred to the BMS including a high-level document 'that addresses safety management and integrates safety into the overall management of the OPAL facility, as well as providing overall linkage to the overall ANSTO safety management system as detailed in Safety Directive 1.1.'

The *OPAL Reactor Operations Business Management System Manual* has been assessed by ARPANSA staff reviewers as providing a good overview of the system structure and objectives.

4.3. ANSTO plans and arrangement for the operation of OPAL - radiation protection plan

The IAEA *Safety Requirements* require the operator to have a radiation protection program approved by the regulatory body. The aim of the program must be to keep radiation exposures within agreed dose constraints to ensure that dose limits are not exceeded. In all operational states, the aim is to keep doses as low as reasonably achievable, social and economic factors being taken into account.

I have drawn more detailed international guidance from the draft IAEA Safety Guide *Radiation Protection and Radioactive Waste Management in the Design and Operation of Research Reactors* (DS 340).

The radiation protection program for the OPAL reactor is included in Part B of the application (Radiation Protection Plan, RRRP-7265-EDEAN-001-REV 1). The OPAL reactor radiation protection plan must be considered in the context of the relevant ANSTO site-wide plans and arrangements. In addition, chapter 12 of the Safety Analysis Report deals with operational radiological safety.

The OPAL reactor Radiation Protection Plan has been reviewed by ARPANSA staff. It defines the roles and responsibilities of the Manager, Reactor Operations, the Reactor Manager, and OPAL reactor staff in achieving the objectives of the plan. The Plan requires that the OPAL reactor Safety Review Meeting reviews and advises on the effectiveness of the operational radiation safety program. It also sets up a position of Radiation Protection Adviser (RPA) who is a person trained in radiation protection who advises management and staff on radiation protection issues, safe working practices, standards, including operational radiation protection measures and on their optimisation. The RPA is the leader of the group of radiation protection personnel, including the health physics surveyors working in the OPAL reactor, provided as part of a service level agreement between the OPAL reactor and ANSTO Safety and Radiation Services.

The dose constraints applying to the OPAL reactor are those defined by ANSTO policy, agreed to by ARPANSA, for the overall site. The effective dose from normal operation of the OPAL reactor to any occupationally exposed person is constrained to be less than 15 mSv per year. The effective dose to a member of the public at the buffer zone boundary is constrained to be less than 0.1 mSv annually. These constraints are below the dose limits that are mandated through the licence condition Regulation 47 and the 'practice to be followed' required by Regulation 59. These dose limits are for effective dose of occupationally exposed persons of 20 mSv annually averaged over 5 years with any year not being greater than 50 mSv; and an effective dose limit for public exposure of 1 mSv per annum.

The OPAL reactor Radiation Protection Plan commits to achieving ALARA following the overall approach of ANSTO expressed in its Safety Directive 5.2. Chapter 12 of the SAR describes the radiological evaluation of the OPAL facility, including the identification of the sources of routine and potential exposure and an estimate of worker doses based upon expected dose rates and frequency and times of exposure. The SAR goes on to identify the radiological protection measures in terms of engineering features, administrative controls and procedures, and protective equipment.

The documents together address:

- the layout and engineering features designed to optimise radiation exposure (eg the hot water layer designed to reduce dose rates above the open pools);
- the radiological classification of areas and the personnel and item circulation within the OPAL facility;
- local rules and procedures, including health physics procedures (that prevent entry into certain areas and rooms during the power stage);
- work planning;
- abnormal occurrence, accident, incident, event reporting;
- monitoring programs;

- reviewing and auditing the effectiveness of the Radiation Protection Plan;
- transport and movement of radioactive materials; and
- training.

The SAR reports dose estimates for normal operations that have been derived from the modelling of detailed dose maps using the available data combined with knowledge of the tasks to be performed by the different workers in the plant. For example, with regard to doses from reactor operations, the modelled dose for a daily plant walk-through with the reactor at power is less than 15 μSv; for doses from production activities, the collective annual dose is estimated at 17.6 man-mSv; for routine maintenance at full power, the annual dose from tightening fittings is estimated at 1.6 mSv. Overall, the estimated average individual dose to reactor operators and utilisation staff is 1.97 mSv and for maintenance staff is 0.31 mSv per year.

The radiation protection measures described in Chapter 12 of the SAR are best international practice in terms of control and monitoring of gaseous and liquid waste arisings. The design provisions plus the radiation protection plan and waste management plan should ensure that ALARA is achieved for operating staff within the containment. Also the location of the control room outside the containment greatly reduces the operator routine doses in comparison to HIFAR operators.

These calculations do indicate an appropriate level of commitment to ALARA, noting that ANSTO's 'ALARA objective' for worker dose is 2 mSv per annum. It will be necessary for these dose rate parameters to be checked as a part of Hot Commissioning and in routine operation. There are detailed procedures for doing this in the ANSTO commissioning documents.

I find that the OPAL reactor Radiation Protection Plan is consistent with international best practice in relation to radiation protection as it is based upon optimisation to achieve ALARA below a dose constraint and the Radiation Protection Plan covers all the essential elements set out in the IAEA *Basic Safety Standards* and the IAEA draft Safety Guide *Radiation Protection and Radioactive Waste Management in the Design and Operation of Research Reactors* (DS 340).

4.4. ANSTO Plans and arrangements for operation of OPAL - radioactive waste management and spent fuel disposal and transfer

4.4.1. Radioactive Waste Management

Operation of the OPAL reactor will produce solid, liquid and gaseous radioactive waste. The waste management system proposed for the OPAL reactor is described in section 12.4 of the *Safety Analysis Report.* Part B of the Application includes a plan entitled Management of Radioactive Waste (RRRP-7272-EDEAN-001) and the OPAL reactor Business Management System includes OP15 Waste Management.

Under these arrangements the management of solid and liquid radioactive waste from the OPAL reactor is proposed to be transferred to ANSTO's Waste Operations and Technology Development (WOTD) section that is authorised under an existing ARPANSA facility licence relating to the facilities operated by that part of the organisation.

ANSTO Policy 2.2 states ANSTO's overall radioactive waste management policy. ANSTO Safety Directive 5.7 covers the safe management of radioactive wastes.

The estimates of the quantities of waste produced have been slightly refined since I considered them in the context of the construction licence application, but have not changed significantly. The following extract from the *Safety Analysis Report* describes the waste arisings:

> *The estimated generation of solid and liquid waste and airborne emissions for routine operation has been provided below. The values are based the anticipated utilization of the facility. Generation estimated per year of operation:*
>
> *Solid waste*
>
> I. *Low-level compactable solid waste: Approximately 5 m^3 prior to compaction (papers towels, tissue paper, rags, mops, plastic gloves, clothing, vials, pipettes, plastic tubing, etc).*
> II. *Low-level non-compactable solid waste: Approximately 1 m^3 (activated aluminium components and cans, activated solid samples, contaminated items from laboratories and reactor).*
> III. *Intermediate level non-compactable solid waste: Approximately one 72 litre aluminium bin (activated metal components).*
> IV. *Filters: Approximately 88 HEPA filters, 3 charcoal filters, and 4 molecular sieve beds per year, equivalent to about 10 m^3 of low-level waste*
> V. *Ion exchange resins from heavy water reflector cooling and purification system: 8 litres.*
> VI. *The ion exchange resin bed from the Reactor Water Purification and the Hot Water Layer Purification: approx 1100 kg. No spent resins will be produced during the first two years, resins being provisionally stored at the Process Room (Level –5.00).*
>
> *Liquid waste*
>
> I. *Trade (C-line): Approximately 52800 m^3 (from trade drainage in controlled areas, beam hall building, auxiliary building and cooling tower blowdown, 50000 m^3 of waste water corresponding to this point).*
> II. *Low-level liquid waste (B-line): Approximately 150 m^3 (from active liquid waste drainage).*
> III. *Others: 400 litres of waste oil, tritiated samples below 1 litre.*
>
> *Airborne waste*
>
> I. *Argon-41: approx 4 TBq per year*

II. *Xenon and krypton: 0.6 TBq per year*
III. *Tritium: 37 GBq per year*

The IAEA *Safety Requirements* state (para 7.104) that

> *The reactor and its experimental devices shall be operated to minimize the production of radioactive waste of all kinds, to ensure that releases of radioactive material to the environment are kept as low as reasonably achievable and to facilitate the handling and disposal of waste. Arrangements shall be put in place for the management of solid, liquid and gaseous radioactive waste in the research reactor facility and its ultimate removal from the facility. All activities concerning radioactive effluents and waste shall be conducted in accordance with the quality assurance programme.*

The OPAL reactor radioactive waste management plans (the Part B plan and OP 15) explicitly address waste minimization, which is also a part of the ANSTO Policy 2.2. With regard to design, the plans refer to various processes that minimise waste generation, including:

- recycling of water;
- delay and decay of radioactive waste;
- condensation of water produced by the Hot Water Layer and re-use within the reactor; and
- appropriate material selection.

The OPAL reactor radioactive waste management plans establish procedures for monitoring and the segregation and classification of the different waste types and streams. Records are to be kept of all relevant aspects of the generation, control and storage of radioactive waste.

With respect to solid waste, segregation at source produces three streams of solid wastes as described above: inactive or exempt-level, low level solid waste, and intermediate level solid waste. Inactive wastes are disposed of directly through the municipal waste management system. Exempt level wastes are processed through the existing ANSTO exempt level waste clearance system. The low level solid wastes are classified in accordance with the ANSTO classification system. Radioactive solid waste packages are managed in accordance with existing procedures.

Intermediate-level solid waste is stored in the service pool where a shearing facility is available to cut large items into smaller sizes for more efficient storage. Long lived intermediate level solids are to be transferred to storage in a shielded container.

The liquid waste will be managed under the arrangements licensed by ARPANSA for ANSTO's Waste Operations and Technology Division (WOTD). It is to be discharged to the sewer after meeting the discharge criteria arising under the trade waste agreement with Sydney Water[9].

The airborne discharges from the OPAL reactor will be significantly less than those from HIFAR. The design of the OPAL reactor to limit the amount of tritium in the primary cooling system, the use of nitrogen cooling for irradiation rigs, and the operation of a hot water layer system all reduce the potential source term for discharges up the stack during normal operation. This achieves the ALARA objective for the OPAL reactor discharges.

Currently, under the ANSTO 'discharge authorisation' from ARPANSA, the calculated radiation dose level at the edge of the restricted zone around the site that form the basis of the 'notification' levels for the stacks on the site is 20 microsieverts, half of which is contributed to by HIFAR and half by radiopharmaceutical production. The predicted dose calculated on the same basis for the OPAL reactor is 0.09 microsieverts. I have decided that the notification level for the OPAL reactor stack should be set on the basis of a restricted area boundary dose of 1 microsieverts. This is a completely trivial level of radiation dose, even if it were to be the actual dose arising from the OPAL reactor discharges[10].

As I discuss further below, the on-site management of solid radioactive waste was reviewed closely by the NSC.

The NSC described the storage of low level solid waste in drums in the low level waste store. It observed that there was space for approximately 3 years of arisings at the time of its report. It pointed to strategies under development by ANSTO including the clearance of waste that has decayed below exemption levels and proposals for super-compaction of wastes to reduce the volume stored. In its response, ANSTO stated that it is committed to the super-compaction of waste and is planning a facility for super-compaction that is hoped to be commissioned in 2007. I note that this will require licensing action by ARPANSA. Existing facilities at ANSTO also allow for the conditioning of low level waste for ultimate disposal.

ARPANSA through the Radiation Health Committee (RHC) is working to establish a nationally agreed Code of Practice and a Safety Guide on the pre-disposal management of radioactive waste. Once completed – and this is expected to take place during 2006 – then I would intend to propose the Code of Practice apply as a licence condition imposed by amendments to the regulations that would require ARPANSA licensees, including ANSTO, to proceed with further steps of pre-disposal management.

While it is not a particularly attractive option, I observe that there is ample space on the ANSTO site for construction of additional low level waste storage facilities but it is not anticipated that this will be necessary.

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[9] In its public submission, the Sutherland Shire Council raised the idea of mining the sewer water use to for local irrigation needs and advocated a nil radioactive waste discharge to the sewer. The Nuclear Safety Committee has looked at possible doses from re-use of sewer water and found them to be trivial even using very conservative assumptions. The matter should be kept under review as proposals for re-use of sewerage water are considered.

[10] In this context, a dose of 10 microsieverts per annum is used in international guidance as the level that effectively defines what constitutes radioactive material.

The NSC also described the storage of intermediate level waste on the ANSTO site. There is a substantial capacity to store further waste in this store – and additional space will be freed up as the OPAL reactor spent fuel will be stored in the reactor service pool until moved off-site. The Committee quotes ANSTO as estimating that there was some 30 years capacity in the intermediate waste store for the OPAL reactor operating waste.

I find that ANSTO's plans and arrangements for the management of radioactive waste arising from the operation of the OPAL reactor are consistent with international best practice in relation to radiation protection and nuclear safety.

4.4.2. Disposal and Transfer of Spent Fuel

This subject is addressed in the ANSTO *Ultimate Disposal or Transfer Plan* (RRRP-7200-EDEIN-REV3 supported by letters from ANSTO of 17 December 2004 and 15 February 2005).

The fuel proposed to be used in the OPAL reactor uses low enriched uranium (19.7% enriched) and is a uranium silicide fuel (U-Si). ANSTO estimates that it will use some 37 fuel assemblies per annum. After removal from the OPAL reactor, the fuel elements will be transferred to the service pool where they will be stored and allowed to cool.

Australia's spent fuel management strategy described in the above ANSTO plan is that the OPAL reactor spent fuel will be shipped overseas:

- for storage and disposal in the US; or
- for reprocessing[11] in France (or elsewhere) with the return of an intermediate level waste form to Australia.

The US disposal option for the OPAL reactor spent fuel arises from the continued operation of a program by the US Department of Energy (DOE) called the Foreign Research Reactor Spent Fuel Acceptance Program. This program was established in 1996 as a nuclear non-proliferation measure with the aim of ensuring that high-enriched fuels were returned to the US for safe storage and disposal.

HIFAR fuel of US origin has been returned to the US under this program and the remainder at present being used in HIFAR will also be so returned.

The program was due to accept fuel irradiated in reactors up to May 2006 and returned to the US by May 2009. However, by November 2004, the US had only received some 35% of the total spent fuel elements estimated to be eligible for acceptance at the start of the program. Nonetheless, the non-proliferation focus of the program in reducing

[11] Reprocessing of nuclear fuel is a large scale industrial chemical process in which the fissile uranium 235 and plutonium are removed from the fuel for re-use in other fuels and a waste form is produced suitable for storage and disposal.

the use of HEU in research reactors remains a US priority and in December 2004, the US DOE announced that it would extend the deadline for irradiation of eligible fuels under the program until May 2016 and extend the acceptance date in the US to May 2019. That decision also included extending eligibility to Australia's OPAL reactor for participation in the program.

The basis for the decision to extend eligibility to the OPAL reactor spent fuel was that the OPAL reactor, formerly called the replacement research reactor, directly replaces HIFAR that was a part of the program and that the OPAL reactor fuel remained an issue in terms of reprocessing because of the unavailability of uranium-molybdenum fuel that is more readily reprocessable in non-US facilities. DOE noted that this change would add only a small quantity of fuel to the original 1996 total estimates.

The DOE decision notes that all of the Australian spent nuclear fuel would be managed at the DOE's Savannah River site until disposal is available at a geologic repository.

On 9 June 2006, I was advised by the Executive Direactor of ANSTO that 'a contract covering the repatriation of ANSTO research reactor fuel has now been finalised with the DOE'. This contract provides for the repatriation of spent fuel arising from the operation of the Moata, HIFAR and OPAL reactors'. ANSTO provided me with a copy of the contract and I have verified its provisions.

The reprocessing option adopted for HIFAR fuel of other than US origin has been to ship the fuel to a reprocessing plant (first in the UK and subsequently in France). When reprocessed, the resulting waste form is intended to be suitable for return to Australia for long term management, including disposal.

A complication in these considerations arises when low enriched uranium silicide fuels are considered. There are difficulties in the reprocessing of such fuels – note that the HIFAR fuels for reprocessing were high enriched uranium-aluminium fuels. The international aim for research reactor fuels is to develop low enriched uranium-molybdenum fuels that will be able to be readily reprocessed.

Nonetheless, in the context of overall arrangements between ANSTO and COGEMA of France, COGEMA has agreed to accept silicide fuel for reprocessing. The relevant paragraphs of the letter of 6 December 2004 from COGEMA to ANSTO are:

> *ANSTO has made arrangements with COGEMA for the acceptance of the U_3Si_2 spent fuel and has confirmed that the long term disposition route for spent fuel from the ANSTO new reactor will be reprocessing by COGEMA.*
>
> *In 2004, COGEMA have agreed to accept silicide fuel during the period prior to the availability of a new processable fuel duly qualified in Australia in the framework of a global AREVA services including supply of U_3Si_2 Standard Fuel Elements and sustainable back-end management.*

In summary then, ANSTO's proposed arrangements for OPAL spent fuel are:

- To commence operations using uranium silicide fuel of US origin. This will be returned to the US up to the completion of the extended FRRSNF program – that is, to fuel irradiated no later than May 2016.

- When available, to switch to uranium-molybdenum fuel. That will not be accepted by the US program if it is still in operation at the time the switchover occurs. ANSTO has a contract with COGEMA of France for the reprocessing of this fuel and the return of a vitrified waste form. An inter-governmental agreement with France supports these arrangements.

- COGEMA has also agreed to manage uranium silicide fuel should this be required pending the development of the uranium-molybdenum fuel. That is, should uranium silicide fuel still be in use after 2016, COGEMA would re-process it pending the development of more readily re-processable fuel.

- Should the reprocessing arrangement with COGEMA not proceed for any reason, ANSTO states that it has a further back-up option being that INVAP is contractually bound to provide an alternative solution consistent with Australia's requirements, as stipulated in the Request for Tender, using proven technologies. An intergovernmental agreement between Australia and Argentina, now ratified by both countries, supports these arrangements.

These arrangements rely upon the international transport of spent fuel and vitrified waste. While such transport remains internationally controversial, I am satisfied that it can be conducted safely, noting the experience of ANSTO to date and the general international experience.

4.4.3. Disposal and long-term storage of radioactive waste

In April 2002, when I made the decision to grant the OPAL reactor construction licence to ANSTO, the plan for disposal of Australia's low-level radioactive waste, including that generated by the OPAL reactor, was through the construction and operation of a national low-level waste repository. In addition, it was proposed to establish a national intermediate-level waste store that could, inter alia, store the intermediate-level waste created by operation of the OPAL reactor.

In August 2003, I received an application from the Department of Education, Science and Training (DEST) for a facility licence authorising it to prepare a site, construct and operate the national waste repository at site 40a in South Australia. I commenced assessment of that application.

On 14 July 2004, the Prime Minister announced that:

> *The Government has decided to abandon the establishment of a national low level waste repository at site 40a near Woomera in South Australia.*
>
> *This decision has been taken in light of the recent Federal Court decision and the effective failure of the states and territories to cooperate with the Australian*

Government in finding a national solution for the safe and secure disposal of low level radioactive waste.

The Prime Minister's statement went on to say:

The Australian Government fully accepts responsibility for its own low level waste. The Australian Government will be examining sites on Commonwealth land, both onshore and off shore, for the establishment of a suitable facility.

In examining possible sites, it is the intention of the Australian Government to co-locate the low level waste facility with the national store for intermediate waste.

On 15 July 2005, the then Minister for Education, Science and Training announced:

The Australian Government has finalised a list of possible locations for the siting of a future Commonwealth Radioactive Waste Management Facility.

These are Defence Department properties at Mount Everard, Harts Range and Fishers Ridge in the Northern Territory.

The Minister's statement and supporting material produced by DEST made it clear that the facility was to manage both low and intermediate-level waste produced by Australian Government activities. Intermediate-level waste would be managed in a purpose-built store; the preference being for the low-level waste to be disposed of in a near-surface repository, but if the favoured site does not lend itself to a repository, then low-level waste would also be stored in a purpose-built store.

In October 2005, the Government introduced legislation into the Parliament. In his Second Reading Speech on the Commonwealth Radioactive Waste Management Bill 2005, the Minister for Education, Science and Training stated that:

The purpose of this bill is to put beyond doubt the Commonwealth's power to make arrangements for the safe and secure management of the small quantity of radioactive waste produced by Commonwealth agencies from the use of nuclear materials in medicine, research and industry.

After Parliamentary debate, the *Commonwealth Radioactive Waste Management Act 2005* (CRWM Act) was passed and came into effect on 15 December 2005.

The CRWM Act provides that the Commonwealth may do anything necessary for or incidental to the purposes of selecting a site (being one of areas announced by the Minister or a site nominated by the Chief Minister of the Northern Territory or a Land Council and approved by the Minister) on which to construct and operate a facility for the management of Commonwealth radioactive waste. The CRWM Act refers to some specific activities that are authorised, including the construction of roads, the operation of drilling equipment, collection of samples of flora and fauna, and so on. It overrides State and Territory and certain other Commonwealth laws to the extent that they might regulate, hinder or prevent the activities needed to select a site.

Funding was initiated in the 2005-2006 Budget for the establishment of the CRWMF. DEST has published a timetable for the establishment of the CRWMF that, subject to positive licensing decisions, foresees operations commencing in 2011. A contractor has been appointed after tender to gather data and carry out the assessment of the sites, prior to submission of applications under the *Environment Protection Biodiversity Conservation Act 1999* and the Act.

In December 2005, I issued draft regulatory guidance for a facility for near surface disposal and intermediate level waste storage and sought public comment. The period for public comment closed on 30 April. This guidance will be used by ARPANSA staff reviewers, but will also be of value to the applicant in preparing submissions under the ARPANS Act.

The Australian Nuclear Science and Technology Organisation Amendment Bill 2006 is currently before the Parliament. That Bill will authorise ANSTO to condition, manage and store radioactive materials and radioactive waste:

- generated, possessed or controlled by the Commonwealth or a Commonwealth entity; or

- at the request of a law enforcement agency or emergency management agency (Commonwealth or State); or

- that has been or is to be sent to Australia under contractual arrangements relating to the conditioning or reprocessing of ANSTO spent fuel.

This last provision will give ANSTO the authority to manage the waste products that are returned from reprocessing of the OPAL reactor spent fuel. The Bill would also support the arrangement made with DEST and described above.

4.4.4. Reports from Forum Panellists

The panellist on the public forum Dr Jim Falk concluded in his report that a licence should not be granted unless:

> *the applicant provides convincing evidence that a clear and definite means is available for the ultimate disposal of radioactive waste and spent fuel produced from the reactor (including the outcomes of conditioning, reprocessing and eventual decommissioning), and that there is a settled and approved selection of the site and design for any interim store which is to be utilized as a step in this process.*

Overall, I believe that the path that Australia is following in dealing with its spent fuel and other intermediate-level radioactive waste is consistent with international best practice in relation to radiation protection and nuclear safety. This is so in that the option of longer term storage pending the development in a phased and adaptive approach of geological disposal facilities is the approach being reached by several significant countries in regard to the management of spent fuel arising from nuclear power facilities. Australia will need to start to explore options for disposal, but these can and should take time and be thoroughly considered in the light of world developments.

Professor Falk also raised the issue of the management of decommissioning, referring both to HIFAR and to the OPAL reactor. Subsequent to the public forum, I have received from ANSTO a broad plan for the decommissioning of HIFAR. The plan is for immediate removal of the fuel and heavy water after completion of operations, a period of 'possessing and controlling' the remainder of the HIFAR for a period of a few years, to be followed by full decommissioning when the Commonwealth Radioactive Waste Management Facility is in operation.

In his report to me, Dr Hogberg, panellist for the public forum, after discussing the ANSTO/DEST plans for the management of spent fuel and nuclear waste, made some observations based upon his experience with the Swedish system, which as he points out is accepted as among the most advanced in the world. In particular, he proposes that a total systems approach to the management and final storage of spent fuel and nuclear waste appears to be the most appropriate way to ensure a high degree of physical and chemical compatibility between the waste, as conditioned and packaged, and the natural and engineered barriers of the final repository facility. He agrees that the total waste volumes and activity levels of the Australian program are far smaller than Sweden and would not warrant the comprehensive research and development and implementation program adopted in Sweden. Nonetheless, certain elements of the stepwise, systematic approach that has worked well in Sweden (and also in Finland) might however be worthwhile to consider also in the Australian context. These are matters that I will pursue with DEST.

4.4.5. NSC Management of Radioactive Waste and Spent Fuel

The overall conclusion of the Nuclear Safety Committee was as follows:

> *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*
> - *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 the Commonwealth Store are not available in the near future.*
>
> *The RWMWG considers that currently ANSTO manages its waste safely and effectively and with the measures* [discussed in the report] *can continue to do so into the future.*

The NSC made the following recommendations, each of which is followed by my comment:

- *The Government makes a decision about the location and design of a radioactive waste store and a waste repository.*

Subsequent to the NSC's report, the Parliament passed into law the *Commonwealth Radioactive Waste Management Act 2005* which identifies sites, places the development of the facility on a firm legal footing and indicates the Government's strong political commitment.

- *Supercompaction of waste by ANSTO to reduce volume be strongly considered.*

In its response ANSTO observes that it is committed to supercompaction and the necessary facility is planned for commissioning by mid 2007.

- *The possibility of a mixed shipment of HIFAR and OPAL reactor spent fuel be considered at the appropriate time.*

I accept ANSTO's response that it is preferable to ship the last HIFAR fuel offsite in 2009 to allow for decommissioning of the HIFAR spent fuel storage facilities to begin straight away, rather than awaiting the shipment of the OPAL reactor fuel.

- *The draft Code of Practice on pre-disposal radioactive waste management be completed as a matter of high priority.*

This Code of Practice and accompanying safety guide is being developed through the RHC. Its completion will allow ANSTO and other radioactive waste generators to treat and condition waste in accordance with national guidance. The Code of Practice and Safety Guide will be released for a period of public comment shortly and can be expected to be finalised by the end of the year.

- *ARPANSA require that ANSTO examine possible avenues for minimising radioactive waste.*

This is a requirement of international best practice and ANSTO has addressed it in the OPAL reactor design and through its Radioactive Waste Management Plan.

- *ARPANSA require that ANSTO determine the optimum operating power for OPAL for each application, taking into account all factors, including waste minimization.*

As the NSC itself notes, there is not a simple correspondence between reactor power and waste. I think ANSTO has the better of the argument in its response to the effect that:

> *OPAL is a multi-purpose research reactor, which will be used simultaneously for radioisotope production, neutron beam research, silicon irradiation, and other purposes. It is very difficult, if not impossible, to envisage an operating regime which could simultaneously accommodate all those demands whilst cycling up and down between power levels. Such a regime would also be detrimental to safety, as it would affect safety system settings and require extensive revisions of the safety case.*

4.4.6. Public Submissions - Radioactive waste and spent fuel

The issues of the management of radioactive waste and spent fuel were major concerns raised in very many of the public submissions. The letters forwarded by more than 800 members of the public and the majority of submissions from individuals and organisations addressed these issues. The fundamental submission being put is that there is no established method for safely dealing with radioactive waste and spent fuel; that the proposals put forward in the ANSTO application and in the Government's policy for radioactive waste management are unsatisfactory; and that the production of radioactive waste should not be added to by proceeding with operation of the OPAL reactor.

The submission from Greenpeace Australia Pacific well summarises the concerns expressed in these letters and submissions:

> *The Australian Nuclear Science and Technology Organisation and the Federal Government have failed to deliver a proven long term strategy for the safe storage of radioactive waste that will be created by the RRR. The current proposal for the dumping of low and intermediate level waste in the Northern Territory is being opposed by indigenous land owners and other community members in areas surrounding the proposed locations. The current waste management strategy which requires the transportation of radioactive waste over large distances will also expose en-route communities to undue risk.*
>
> *In effect ANSTO has not made progress in establishing a repository for the low level waste generated through its operations and in abandoning plans to construct a repository in South Australia has gone backwards. In granting the construction licence you clearly stated, and set conditions that ANSTO must make progress on radioactive waste management plans before you would issue an operating licence. We urge you to firmly apply licence conditions relating to radioactive waste management and not approve the operating licence for the RRR.*

In summary, it is my assessment that significant progress has been achieved:

- ANSTO's plans and activities for on-site management of low-level radioactive waste include the disposal of exempt wastes, the development of super-compaction of existing waste allowing continued storage in existing facilities, and the development of a conditioning facility to prepare the waste for disposal or off-site long term storage (noting also that safety guidance on conditioning is under active preparation by the RHC).

- With regard to intermediate-level waste arising from production of radioisotopes, especially molybdenum production, the current stocks are being solidified, the new molybdenum production process planned for OPAL will produce a solid waste stream, and there are plans for isolation of the waste in a form suitable for long-terms storage.

- The Australian Government has committed itself to the construction of a Commonwealth Radioactive Waste Management Facility in the Northern Territory on one of three identified sites or on a site nominated by the Chief Minister or by an aboriginal Land Council. The Parliament has passed the *Commonwealth Radioactive Waste Management Act 2005* that addresses many of the legal and political hurdles that ultimately frustrated the progress of the national radioactive waste repository in South Australia. The plan will remain controversial and politically contested, but the very fact that the Government has invested such political capital through the passage of the legislation shows to me that it is seriously intent on achieving the goals of the project. I also note that the Opposition, while opposing the Government's legislation, indicated that it accepted the need for the development of a national waste facility[12].

- The ultimate disposal of the OPAL reactor spent fuel is addressed in the first instance by the contract between ANSTO and the US Department of Energy that the latter will accept spent fuel from the OPAL reactor within the US Foreign Research Reactor Spent Fuel Acceptance Program extended until 2016 or until uranium-molybdenum fuel that is readily reprocessable becomes available. There is then the agreement with COGEMA for the reprocessing of the spent fuel in France and the return of the vitrified waste form to Australia and finally, the contract with INVAP and the possibility of processing in Argentina.

I would have preferred it if the national low-level repository in South Australia had proceeded and now be planning its first campaign of waste disposal. But that was not to be. In that context, I accept that it was not possible for the Government to proceed with planning an intermediate-level waste store on the same basis as the unsuccessful repository proposal. But, I think the commitment evidenced by the Government through the passage of the CRWM Act, the planning in the Northern Territory, the allocation of funding to DEST and the passage of amendments to the ANSTO Act which will allow that organisation to operate the facility do demonstrate seriousness and intent to establish an intermediate waste store and repository in the short term.

4.4.7. Findings having regard to international best practice in relation to radiation protection and nuclear safety

There have been no significant changes to the design of the OPAL reactor affecting the generation of radioactive waste or its management since the time of my assessment of these matters as part of the application for a construction licence. In fact, the change of material in the control blades (from cadmium to hafnium) results in an increased life and thus reduces the amount of solid waste represented by used blades.

Having considered the application, the findings of the NSC, the ANSTO response to that report, the regulatory assessment by ARPANSA staff reviewers and the public submissions, as well as having taken into account ARPANSA's licensing of WOTD and its operational experience, I am satisfied that ANSTO's plans and arrangements for management on the Lucas Heights site of low and intermediate level radioactive

[12] 'Labor accept the need for a national waste dump, but we will not ride roughshod over the wishes of Territorians or any other local communities that will have radioactive waste transported along their streets and highways. Labor believes that we must bring the community with us on a waste dump – - - - - - ' Included in the speech on the Second Reading of the Commonwealth Radioactive Waste Management Bill 2005, Ms Macklin, Deputy Leader of the Opposition, House of Representatives Hansard, 31 October 2005, page 110.

waste generated by the operation of the OPAL reactor is consistent with international best practice in radiation protection and nuclear safety.

ANSTO states that it has plans for supercompaction of wastes, is taking action with regard to disposal of exempt waste, and has constructed a plant for conditioning of waste. The forthcoming national Code of Practice and Safety Guide for the pre-disposal management of radioactive waste will provide a regulatory basis for future pre-disposal waste management at ANSTO, including for waste generated by operation of the OPAL reactor.

Turning to the management of spent fuel, I have stated in many forums that any licensing decision that I made had to be in the light of the evidence presented and the requirements of the Act and regulations, but that I did have a general opinion or view of the matters as they relate to the operating licence. This was that, at the time of a decision on the operating licence:

- the arrangements for reprocessing of the reactor's spent fuel would need to be entirely firm.

- with regard to the ILW store, there would need to be substantial and evident progress – such as the features of the design settled, siting criteria established and a strategy and timetable in place for a site(s) – that it was moving forward with clear paths to its future establishment and I could be satisfied that a store WILL exist.

I believe that this position remains an appropriate one in the light of international best practice in relation to radiation protection and nuclear safety. In issuing an operating licence, I need to take into account the matters in the Act and regulations in the context of the whole life and operations of the facility. The safe management of the waste generated by its operation over its life needs to be assured as far as it reasonably can be at the time of issuing the operating licence – even though I do have the capacity to amend the licence or to suspend or cancel it in certain circumstances during the operating life of the facility.

Are the two points above now met?

With regard to the arrangements for the reprocessing of the spent fuel, I think it is clear that the arrangements are firm. For the first decade of operation, the US DOE by contract and in accordance with its public program and consistent with US policy will accept the uranium silicide fuel for storage and disposal.

The ANSTO contract with COGEMA that has been tried and tested in the context of HIFAR fuel will apply to uranium-molybdenum fuel if this comes on stream prior to the announced end of the US program in 2016 and thereafter. I am satisfied that this contract is firm and clear. While environmental pressures on reprocessing remain, in the light of increased interest in nuclear energy and the US revisiting its policy of opposition to reprocessing, the future of continued reprocessing by COGEMA seems, if anything, to be more secure than I assessed it to be at the time of the construction licence.

A qualification is that I am satisfied that COGEMA will reprocess uranium silicide spent fuel from the OPAL reactor while it is seen that there is a high prospect that such fuel will be replaced by a more readily reprocessed fuel, likely the uranium-molybdenum fuel. However, is there a prospect that such fuel in fact will not be able to be developed and in such circumstances will COGEMA's commitment hold? My reading of the papers presented at international conference on the development of uranium-molybdenum high density fuels is that the program has been set back by results from testing of fuels in which the fuel meat is dispersed in a matrix. The testing of monolithic fuels is underway. My assessment is that, given the continued high policy significance of finding readily reprocessable LEU fuels for research reactors, there will be sufficient resources directed to the problem to bring about success before the issue becomes problematic for operation of the OPAL reactor . Similarly, if such circumstances seem to be arising, I would think it highly likely that COGEMA and other capable organisations would turn their attention to processes facilitating reprocessing of uranium silicide fuel.

Has there been sufficient progress towards the establishment of a store for ILW including that generated by the reprocessing of spent fuel. Strictly in terms of the OPAL reactor licensing, it could be argued that some of the urgency about this question is lessened by the fact that at least for several years the OPAL reactor fuel will be accepted by the US and no waste be returned to Australia. However, I am again conscious that in effect I am being asked to license the OPAL reactor operation for its lifetime and should take into account whether it can be operated safely, including in relation to radioactive waste management, for that time.

Decisions about the siting of radioactive waste management facilities are notoriously difficult in political terms in all countries, not only in Australia. The fact that the establishment of a long-discussed national low level radioactive waste repository was abandoned after legal and political action taken by a State Government is a demonstration of the difficulties. The process that I have described above for the establishment of the Commonwealth Radioactive Waste Management Facility, together with the political commitment and expenditure of political capital demonstrated by the selection of named sites and the passage of the CRWM Act, gives me assurance that the matter is of strong political and policy concern to the Australian Government and there is a will to achieve a solution. I also note that the Opposition, while opposing the current process and the passage of the CRWM Act, does acknowledge the need to deal with the issue.

In fact, by having a clear strategy for dealing with the waste and spent fuel for research reactors and starting on a path of implementation of it, Australia is ahead of other countries. It is a signal achievement that all of HIFAR's fuel will have been either returned to the US or sent for reprocessing within a couple of years of its shutdown and there is a plan and implementation path for storage of the returned product. Of course, for countries with nuclear power plants (NPPs) as well as research reactors, the primary focus is directed to the storage and disposal of the spent fuel or re-processed spent fuel waste from the NPPs.

With regard to spent fuel and waste management, the report of the second review meeting of the Joint Convention states:

‘*14.* ***All*** *Contracting Parties are committed to address spent fuel and waste management in a comprehensive manner.* ***Many*** *Contracting Parties have already developed, or are currently developing, spent fuel and waste management strategies based on increasingly comprehensive inventories, including spent fuel and waste arising, or to arise, from decommissioning.*

15. ***Some*** *Contracting Parties have made clear progress with the implementation of their strategic plans.’* (My emphasis added).

I have looked at the reports under the Joint Convention from some industrialised countries that have research reactors but no NPPs.

Austria has three research reactors, two in decommissioning and one in operation. It reports that spent nuclear fuel is stored on site in wet or dry storage facilities and that all spent fuel has been and will be returned to the USA. Austria operates one central radioactive waste management and interim storage facility for pre-disposal management including treatment, conditioning and interim storage of low- and intermediate level radioactive waste (LILW). The small quantities of LILW in Austria (originating primarily from medicine, research and industry and decommissioning) are brought to the central facility; short-lived radioactive waste is kept in interim storage at the producers. There is no final repository for disposal of radioactive waste currently in operation. Up to now no decision has been taken about a geological disposal or near-surface long-term storage. Austria favours an international or regional cooperation in radioactive waste management.

Denmark has begun a program of decommissioning three research reactors (one being of the same class as HIFAR). The Danish report states in relation to spent fuel that 233 kg of experimentally produced and irradiated spent fuel is stored under safe and secure conditions at the reactor site awaiting a decision of final management. Since the spent fuel contains a relatively large amount of long-lived isotopes, special requirements will be necessary for the disposal of this material. The policy in Denmark is presently to wait and see if it is possible to find an international solution. Denmark is commencing a technical and legal process to develop a proposal for a disposal facility for low and intermediate level waste.

Norway has two research reactors in operation and two decommissioned. In earlier days, Norway had spent fuel reprocessed in Belgium, but currently the spent fuel from the reactors is stored at the reactor sites. The report states that existing spent fuel will, as far as possible considering its suitability for later direct disposal, be stored until final disposal is possible. The process of establishing a new long-term storage facility for spent fuel and long-lived waste has been underway for several years. There is a combined disposal and storage facility for low and intermediate-level waste in operation (using concrete containers in caverns). The report states that the Norwegian authorities are, at present, considering future spent fuel and waste management policy.

Spent fuel from the operation of the research reactor in Greece is being returned to the US for disposal. LILW is managed on the sites where it is generated.

I am satisfied that, in fact, Australia has a strong plan for the management of waste and spent fuel. It is comparable to the plans of countries with nuclear power plants and ahead of countries with only research reactors. While I accept that it is desirable practice to proceed with community consent and consultation, the Government was faced with a difficult set of political circumstances. It has responded with legislation and a strong political commitment. The plans for the CRWMF are appropriate and the role of ANSTO as technical adviser is a sound decision that should alleviate many of the difficulties with technical issues faced by the Department of Employment, Science and Training in its previous application to for licences to site, construct and operate a national low level radioactive waste repository. On this basis I find that. ANSTO's on-site plans for management of waste are international best practice in radiation protection and nuclear safety.

In public submissions and the public forum, reference was made to some legal difficulties with respect to the regulatory authorisations for the management of Australian (and other foreign) spent fuel in France. I understand that this has been addressed fully by legislation passed by the French Parliament.

4.5. ANSTO's plans and arrangements for operation of OPAL – security plan

The protection of the OPAL reactor against sabotage leading to a release of radioactivity and the emergency response to such a release are issues that are high in the minds of the public. They are matters that I needed to asses and be satisfied about before I could license the operation of the OPAL reactor.

4.5.1. Physical Protection – roles and responsibilities

The regulatory oversight of the physical protection of ANSTO nuclear facilities is one that ARPANSA shares with the Australian Safeguards and Non-Proliferation Office (ASNO). The regulatory role of ASNO is described in its Annual Report 2004-2005 as follows;

> *ASNO is responsible for nuclear safeguards and physical protection. ASNO ensures that* ***nuclear materials*** *– uranium, thorium and plutonium – and* ***nuclear items*** *– facilities, equipment, technology and nuclear-related materials – are used only for authorised purposes, are properly accounted for, and are protected against unauthorised use. An important part of this responsibility is ensuring Australia's treaty commitments are met, particularly that nuclear activities are conducted for exclusively peaceful purposes. ASNO's responsibilities do not cover general radioactive materials as such.*

ASNO administers the *Nuclear Non-Proliferation (Safeguards) Act 1987* (Safeguards Act) that, inter alia, requires ANSTO as a possessor of an 'associated item' and nuclear material to hold a permit granted under section 13 of that Act. Such permits are subject to conditions, including conditions in respect of the measures to be taken to ensure the physical security of nuclear material and associated items. Further, section 16A of the Safeguards Act required ANSTO to apply for a licence to construct a nuclear facility and apply adequate physical security to nuclear material and associate items at the facility.

My concern about physical protection is a part of my overall responsibility under the Act flowing from its object being to protect the health and safety of people and to protect the environment from the harmful effects of radiation. Item 4(e) of Part 1 of Schedule 3 of the regulations requires submission of a security plan for a facility in an application for a facility licence.

The Direactor General Australian Safeguards and Non-Proliferation Office (DG ASNO) and I entered into a Note of Understanding in 2001 'concerning evaluation of physical protection and security arrangements for the Replacement Research Reactor at Lucas Heights and the protection of associated information.' In that Note, we agreed that the two organisations shared the responsibility for evaluation of the physical protection and security arrangements (PP&S) for OPAL and that each had their specific domains of expertise. The Note of Understanding stated:

> *ASNO is responsible for evaluating the PP&S arrangements, with respect to nuclear materials and associated items, and certifying to ARPANSA that they are appropriate and adequate. This includes evaluating the adequacy of the Design Basis Threat for the PP&S and the design of the PP&S to protect against that threat.*
> *ARPANSA is responsible for evaluating the potential for sabotage of the plant in terms of identifying sabotage targets and the associated radiological consequences. It is also responsible for auditing construction and commissioning of the PP&S against the approved design and will provide ASNO with an audit report on the final installation, or when significant shortcomings are identified.*

Subsequently, ASNO and ARPANSA developed jointly agreed acceptance criteria for the security plan for the OPAL facility. The joint acceptance criteria agreed between me and DG ASNO dated 14 December 2001 covered criteria in ten areas:

- Security management
- Site security and threat assessments
- System of physical protection and security
- Access control
- Personnel security
- Security of information management systems
- Performance assessment
- Record keeping
- Reporting
- Review.

With respect to the security of information management systems, the Australian authority for the security of information and communications technology (ICT) is the Defence Signals Direactorate of the Department of Defence.

4.5.2. Physical security – international best practice in radiation protection and nuclear safety

Just as at the highest level, international best practice in relation to radiation protection and nuclear safety can be found in international Conventions or Codes of Conduct, I believe international best practice for physical protection of nuclear material and nuclear facilities can be found in a recently proposed amendment to the International Convention for the Physical Protection of Nuclear Material (CPPNM)[13]. This amendment was adopted at an international conference that took place in 2005 and the amended CPPNM will come into force when two thirds of the States that are party to the Convention have ratified it.

A feature of the amendment to the CPPNM is the inclusion of 12 Fundamental Principles of Physical Protection of Nuclear Material and Nuclear Facilities. The amendment to the CPPNM would commit States to apply the Fundamental Principles "insofar as reasonable and practicable".

The table provides my assessment of the physical protection of OPAL against the Fundamental Principles.

Fundamental Principle	OPAL Physical Protection Arrangements
A: ***Responsibility of the State*** The responsibility for the establishment, implementation and maintenance of a physical protection regime within a State rests entirely with that State.	Australia has assumed this responsibility with regard to OPAL.
B: ***Responsibilities During International Transport*** The responsibility of a State for ensuring that nuclear material is adequately protected extends to the international transport thereof, until that responsibility is properly transferred to another State, as appropriate	Australia has accepted responsibility for the safe transport of OPAL fuel and will continue to apply this principle in relation to OPAL spent fuel, as it has done for HIFAR.
C: ***Legislative and Regulatory Framework*** The State is responsible for establishing and maintaining a legislative and regulatory framework to govern physical protection. This framework should provide for the establishment of applicable physical protection requirements and include a system of evaluation and licensing or other procedures to grant authorization. This framework should include a system of inspection of nuclear facilities and transport to verify compliance with applicable requirements and conditions of the license or other authorizing document, and to establish a means to enforce applicable requirements and conditions, including effective sanctions.	Australia's legal framework for physical protection of nuclear material and technology is established through the *Safeguards Act 1987*. ASNO is the regulatory agency to apply the system through permits, audits and reviews. ASNO has played this role with regard to OPAL, working jointly with ARPANSA as described above.
D: ***Competent Authority*** The State should establish or designate a competent authority which is responsible for the implementation	ASNO is Australia's competent authority. ASNO has played this role with regard to

[13] The existing CPPNM applies to nuclear materials in international transport. The purpose of the amendment is to widen the scope of the Convention for protection of nuclear material through all stages of its use and to protect nuclear facilities.

of the legislative and regulatory framework, and is provided with adequate authority, competence and financial and human resources to fulfill its assigned responsibilities. The State should take steps to ensure an effective independence between the functions of the State's competent authority and those of any other body in charge of the promotion or utilization of nuclear energy.	OPAL, working jointly with ARPANSA as described above. ASNO is totally independent of the OPAL operator, ANSTO.
E: *Responsibility of the License Holders* The responsibilities for implementing the various elements of physical protection within a State should be clearly identified. The State should ensure that the prime responsibility for the implementation of physical protection of nuclear material or of nuclear facilities rests with the holders of the relevant licenses or of other authorizing documents (e.g., operators or shippers).	ASNO's permits do place responsibility on the permit holder, as do ARPANSA licences. ANSTO is clearly charged with the responsibility for the implementation of the physical protection system for OPAL.
F: *Security Culture* All organizations involved in implementing physical protection should give due priority to the security culture, to its development and maintenance necessary to ensure its effective implementation in the entire organization.	The assessment of ANSTO's security culture was a part of the assessment of the OPAL physical security arrangements.
G: *Threat* The State's physical protection should be based on the State's current evaluation of the threat.	The OPAL physical protection system was designed taking into account a design basis threat prepared by ASNO. There is a requirement for ANSTO to obtain regularly threat assessments and the physical protection system has scalable elements.
H: *Graded Approach* Physical protection requirements should be based on a graded approach, taking into account the current evaluation of the threat, the relative attractiveness, the nature of the material and potential consequences associated with the unauthorized removal of nuclear material and with the sabotage against nuclear material or nuclear facilities.	This has been incorporated into the approach for design and assessment of OPAL's physical security system
I: *Defence in Depth* The State's requirements for physical protection should reflect a concept of several layers and methods of protection (structural or other technical, personnel and organizational) that have to be overcome or circumvented by an adversary in order to achieve his objectives.	This approach has been followed in the design and assessment of OPAL's physical protection system.
J: *Quality Assurance* A quality assurance policy and quality assurance programmes should be established and	ARPANSA reviewed the construction and installation of the OPAL physical protection

implemented with a view to providing confidence that specified requirements for all activities important to physical protection are satisfied.	system as part of its oversight of OPAL construction. One important element of this oversight (see licence condition 4.6) was verification that design, manufacturing and installation took place within a quality system. This requirement was satisfied. Ongoing implementation of the OPAL physical protection system will take place within the OPAL and wider ANSTO quality systems.
K: ***Contingency Plans*** Contingency (emergency) plans to respond to unauthorized removal of nuclear material or sabotage of nuclear facilities or nuclear material, or attempts thereof, should be prepared and appropriately exercised by all license holders and authorities concerned.	Contingency and emergency response plans have been developed for OPAL.
L: ***Confidentiality*** The State should establish requirements for protecting the confidentiality of information, the unauthorized disclosure of which could compromise the physical protection of nuclear material and nuclear facilities.	The information security requirements of the Australian Government's *Protective Security Manual* are applied to the OPAL physical security arrangements.

At a practical level, the primary reference for international best practice in physical protection is the IAEA document INFCIRC/225/Rev.4 (Corrected) *The Physical Protection of Nuclear Material and Nuclear Facilities*. This document has been developed over a number of years, the Rev 4 version being completed in 1998. INFCIRC/225/Rev.4 includes general elements of a State's system of physical protection, similar to what is now stated in the Fundamental Principles; it establishes three categories of nuclear material[14], requirements for the physical protection of nuclear material in use and storage, with a graded approach depending on the category of material; requirements for physical protection against sabotage – some general requirements and then specifics for nuclear power reactors, the protection of other nuclear facilities to be assessed using a graded approach; and finally, requirements for physical protection during transport, again with a graded approach depending on the category of material.

As the fuel for the OPAL reactor is of less than 20% enrichment, it falls into the second category for protection.

INFCIRC/225/Rev.4 has been explicitly applied by ANSTO, ASNO and ARPANSA to the development and assessment of the OPAL reactor physical protection system.

4.5.3. The assessment process

[14](INFCIRC/225/Rev.4 s5.1.1. "In determining the level of physical protection to be implemented for nuclear materials in use and storage or during transport account should be taken of the possibility that the unauthorized removal of plutonium, highly enriched uranium or uranium-233 could lead to the construction of a nuclear explosive device by a technically competent group."

Under the arrangements agreed between ARPANSA and ASNO, the following arrangements have been followed in relation to the assessment of the OPAL reactor's physical security system:

- ASNO has evaluated the physical protection and security measures at the design stage and as constructed.

- ARPANSA evaluated the site security and risk assessments prepared by ANSTO, working with the Australian Security Intelligence Organisation Protective Security (ASIO-T4) and the potential for sabotage, sabotage targets and radiological consequences and advised ASNO to support its evaluation of the PP&S measures.

- ARPANSA and ASNO audited the construction and commissioning of the security systems against the approved design.

ANSTO submitted documentation that assessed the design of the OPAL reactor and threat assessments so as to identify potential target points for sabotage and for theft of nuclear material, the physical damage and radiological consequences that could result from successful sabotage of potential targets. The analysis of various scenarios of sabotage and terrorism were carried out drawing on specialist expertise from commercial aviation, in bombs and explosives from the defence community, and from ASIO. The assessments and analyses were used to develop design measures to reduce the likelihood and consequences of successful sabotage, to examine options for the PP&S measures and to develop response capabilities.

After ARPANSA assessment of this work, I wrote to DG ASNO in May 2004 advising that the site security and threat assessments carried out by ANSTO and ASIO were a suitable basis for the design of PP&S arrangements. I assessed that all the OPAL reactor targets the sabotage of which could produce significant radiological consequences had been appropriately identified and assessed.

In January 2005, DG ASNO gave in-principle approval for the security system design.

With regard to regulatory oversight of the construction of the security systems, ARPANSA treated them in the same way as all other Safety Category 1 and 2 systems, the subject of construction licence condition 4.6. The operation of that condition has been described in Chapter 5 of this statement. With respect to security systems design, ASIO-T4 Protective Security reviewed the documentation and provided comments and revised specifications. There was an acceptable process for recording changes that included acceptance of final design by ASIO, noting that system approval was a joint activity between ASIO-T4, ARPANSA and ASNO.

There were three additional licence conditions imposed during this process of assessment of the detailed requests for Approval of security systems. One of these required the change control procedure and ASIO acceptance of final design; a second was specifically directed to requiring ASIO confirmation as to the robustness of the Safety Access System doors; the third required final certification by ASIO and by ASNO that the system complies with their specifications and requirements.

The pre-commissioning and Stage A commissioning tests of modules of the OPAL reactor physical security system were witnessed by ARPANSA, ASIO T4 Protective Security and ASNO officers in March and May 2006. ARPANSA inspectors were satisfied that the relevant pre-commissioning and commissioning tests were undertaken in accordance with the overall commissioning plans, individual specific inspection and test plans and the associated quality systems; that the tests were detailed and thorough; that the tests demonstrated that the physical security systems were installed in accordance with the construction approvals and ASIO specifications; that the tests demonstrated that the systems were able to perform in accordance the design objective and design performance specifications; and that the tests demonstrated the integration of the subsystems comprising the overall physical security system.

On 19 June 2006, I formally wrote to DG ASNO advising him of ARPANSA's conclusions based on the above material and my satisfaction with regard to the completion of the detailed design, manufacturing and installation of the physical security system and the outcomes of the commissioning.

On 23 June 2006, the acting DG ASNO advised me, inter alia, as follows:

> *After careful analysis of all the documents provided by ANSTO, observation of performance tests and consideration of reports provided by ASIO-T4, DSD and from your agency, <u>I have determined that all safeguards and security requirements have been addressed adequately and that the target level of risk has been achieved.</u> Therefore, I have issued a variation of ANSTO's permit to Possess Associated Items (PA001) to allow the OPAL reactor to be operational pursuant to the* Nuclear Non-Proliferation (Safeguards) Act 1987.

His letter was accompanied by a detailed summary of its evaluation of ANSTO's compliance with the joint acceptance criteria and INFCIRC/225/rev.4 together with section 6 of ARPANSA's *Regulatory Guideline on Review of Plans and Arrangements*. I accept and endorse the ASNO evaluation.

ANSTO has made commitments to address certain issues recommended as being necessary in the assessments of the PP&S arrangements. ARPANSA will follow these up through inspections, working in conjunction with ASNO.

The above discussion has focussed on the physical security system. I addressed the security of computerised systems that affect safety and security through the following licence condition:

> *4.15 The Licence Holder must demonstrate to the CEO of ARPANSA that the final design of hardware and software of computerised control, safety and security systems:*
>
> *(a) complies with any relevant security specifications of the Defence Signals Direactorate of the Department of Defence; and*
> *(b) has been reviewed and approved by the Defence Signals Direactorate of the Department of Defence.*

The Defence Signals Direactorate of the Department of Defence (DSD) carried out the security assessment of the network controlling the physical security system and oversaw the review of the OPAL reactor IT network made up of the Reactor Control and Monitoring System and the First Reactor Protection System.

I received a copy of a letter dated 4 May 2006 from DSD stating that:

> *The ICT security assessment has not revealed any significant nonconformity that should give rise to a need to halt licensing of the reactor. However, it is of paramount importance that the organisation continues to show progress against the recommendations identified within the enclosed reports and notifies DSD through ARPANSA of any significant changes to SecNet or OpalNet prior to implementation.*

ANSTO has undertaken to progress the recommendations identified within the DSD reports – these will be the subject of ARPANSA inspections, working as necessary with DSD. ANSTO has also undertaken to notify significant changes – which, in any case, I would regard as being covered by the requirement for my prior approval under regulation 51.

4.5.4. Public submissions on Physical Security

The vulnerability of the reactor to terrorist attack on the one hand and the viability of emergency arrangements in the event of a major release of radioactivity such as might arise as a result of such an attack were the subject of a number of public submissions and of discussion at the public forum.

I have found that the physical protection system for the OPAL reactor is state of the art and consistent with international best practice.

There has been very careful examination of the vulnerabilities of the reactor – including considering the impact of large aircraft crashes, vehicle bombs, and attacks from within the plant. In terms of providing public assurance on these issues, I would like to be able to discuss them in the same detail that I have discussed the organisational and safety issues – but that would be self-defeating. That these analyses must remain confidential is simply a fact of life.

I discuss emergency arrangements in the remainder of this Chapter. A particular issue that was mentioned in public submissions was the absence of a 'radiological consequences analysis' of the extreme case of the explosive disruption of the entire the OPAL reactor core. I did work with ANSTO to carry out such an analysis in 2002, with the hope that some outcomes might be able to be published. However, I stated early in March 2003 that 'in the current security environment and having sought the views of the Government, I have decided not to release publicly an analysis of the radiological consequences of an extreme sabotage scenario based upon the Replacement Research Reactor at Lucas Heights.'

I can say that the analysis of the extreme sabotage accident – one that assumed that the entire core inventory was explosively released to the environment – while it obviously produced estimated radiological consequences in excess of the OPAL reactor siting reference accident, showed that consequences were not dissimilar to the HIFAR reference accident and that therefore the existing emergency arrangements and allowing for a flexible response were a satisfactory planning basis. I emphasise that the severe sabotage scenario is not in any way realistically based and it is not a useful tool for planning emergency response. But its analysis does give a fundamental comfort that the siting of the OPAL reactor, even in an environment of heightened security concern, is not inappropriate.

4.5.5. Public submissions on nuclear non-proliferation and safeguards

The majority of the public submissions put the view that Australia could become a credible voice against nuclear proliferation by becoming nuclear-free. A similar argument was made by the Medical Association for the Prevention of War (MAPW) in its submission. At the forum an MAPW presenter stated:

> *The goal of eliminating nuclear weapons faces enormous obstacles. They could be listed but there is a large number of them. It is an enormous task. Anything that makes this goal less achievable, more difficult, must be opposed. MAPW believes that a new reactor in Australia will impede the task of nuclear weapons elimination by the spread of nuclear technology, even in the form of research reactors.*
>
> and
>
> *If we believe, as history teaches us, that some countries cannot be trusted with research reactors and will use them for secretly making weapons then the only consistent approach is to phase out reactors in all countries. We cannot make one set of rules for the countries we like and another set of rules for the countries that we don't like. If we wait until the nuclear weapons program is either declared or obvious in a particular country then it's too late.*

While I am required to take matters raised in public submissions into account, I find that these issues of safeguards policy are not relevant to the decision-making I must undertake under the Act and regulations. The legislation directs me to take into account issues relating to the protection of the health and safety of people and the protection of the environment against the harmful effects of radiation.

Having said that, I accept completely the commitment to non-proliferation evidenced by these and other public submissions. The proposition advanced is arguable – but on the other hand, the Australian Government is strongly committed to the goals of the international non-proliferation regime; Australia is a signatory to an Additional Protocol that applies the most effective form of safeguards under that international regime to our nuclear facilities and materials. And while it may be true that research reactors have been used to assist countries to obtain or to seek nuclear weapons, completely eschewing the technology when there are valuable applications and in the context of a strong commitment to non proliferation is not the approach agreed under the Non-Proliferation Treaty.

Submissions also drew attention to the work of Silex Systems Ltd (Silex), a publicly listed company that operates on the Lucas Heights site and is researching the enrichment of uranium using laser technology. The criticism is that it is not consistent with Australia's non- proliferation policy for an Australian company to research new ways of enriching uranium. These policy issues are a matter of legitimate debate, but again, this is not a matter that of itself is relevant to my decision-making. It is not even related to the OPAL reactor, other than through the fact that Silex is located on the same site. Silex is regulated for radiation safety by ARPANSA and the safeguards aspects of its technology are overseen by ASNO.

4.5.6. Panellists' Comments

Professor Falk was of the view that a licence to operate the OPAL nuclear research reactors should NOT be granted until:

> *in relation to hostile acts the list of contingencies considered and the calculations and trains of argument assessing the building's vulnerability are at least in broad terms (sufficient to be consistent with international best practice) made public and subject to open review.*

As previously discussed, the design of the physical security system for the OPAL reactor was undertaken against a 'design basis threat'. This envisages a severe armed attack using insider assistance.

The effect of vehicle bombs has also been analysed as has the impact of a large aircraft crash as discussed above.

I am satisfied that an appropriate set of scenarios has been taken into account in considering the design and implementation of the physical protection and security arrangements.

With regard to physical protection and acts of terrorism, the other panellist, Dr Hogberg refers to the review of the OPAL reactor physical protection system and the discussion at the forum of terrorist attacks, especially using large aircraft. While accepting the need to keep secret most information on physical protection, he suggested that:

> *it might be worthwhile exploring whether it would be possible to give some more information in general terms about selected types of terrorist attack scenarios and likely outcomes, assuming the physical protection measures function as planned.*

He referred to a Swedish paper entitled 'The tolerance of Swedish nuclear power plants to stress from external sources' that dealt particularly with analysis of aircraft crashes. I read the Swedish paper and endeavoured to address similar matters in my discussion of physical protection.

4.5.7. Overall Assessment

As it happens, the timing of the design and construction of the OPAL reactor has allowed the design of the physical security to be assessed in the context of the contemporary security environment while detailed design of the reactor was being completed. There has been enormous effort put into security issues and a very strong collaboration occurred between ANSTO, ASIO T4 Protective Security and the regulators being ASNO and ARPANSA.

In December 2005, based upon a cooperative arrangement with ASNO and as part of a routine visit to Lucas Heights to evaluate security applied to US obligated material (currently fuel for the HIFAR reactor), a US delegation - including representatives from the Department of Energy and the Nuclear Regulatory Commission - concluded for the OPAL reactor that the so far installed and planned security should meet or exceed INFCIRC/224/Rev.4 and international norms for physical protection of similar facilities.

It is also the case that much of the contemporary safety design of the OPAL reactor also contributes to its security. The core of the reactor is effectively below ground in a large steel tank of water, in a massive concrete block and within a concrete building.

Robustness of the containment against the impact of a large commercial aircraft was assessed by ANSTO and ANSTO's analyses were independently reviewed by an independent engineering company. ANSTO's analysis concluded that a crash was not capable of perforating the wall of the Reactor Building and that the aircraft fuel load would be dispersed outside the building even if the walls were penetrated by the crash. The independent engineering company considered that the assumptions and methodology used in the ANSTO analysis was appropriate. In summary, they considered that the analysis showed that a heavy commercial aircraft impacting on the Reactor Building would cause only superficial damage and it is unlikely that there would be any significant damage to the structure. I accept this analysis.

Just as I have thought it necessary to require ANSTO to undertake periodic safety reviews, I have also made a similar licence condition requiring periodic reviews of the physical protection and security arrangements. Of course, these need to be kept under review in the light of ongoing threat assessments, but it will also be of benefit to have systematic and thorough reviews from time to time. Similar to the safety review, I have required that the first such 'security' review take place no more than two years after the OPAL reactor enters normal operation.

4.6. ANSTO's plans and arrangements for operation of OPAL - Emergency Plan

4.6.1. Emergency Plans

The IAEA *Safety Requirements* state;

> *Emergency plans shall be prepared for a research reactor facility to cover all activities planned to be carried out in an emergency. Emergency procedures shall be prepared by the operating organization, in accordance with the requirements of the regulatory body, and in co-operation, where necessary, with the appropriate*

governmental and local authorities or other bodies, to ensure the effective co-ordination of all site services and of external aid in an emergency. Emergency procedures shall be based on the accidents analysed in the SAR as well as those additionally postulated for the purposes of emergency planning. Requirements for emergency planning are established in [Preparedness and Response for a Nuclear or Radiological Emergency, IAEA, GS-R-2].

ANSTO submitted an OPAL Reactor Emergency Plan as a part of the Application (RRRP-7268-EDEAN-001-REV1). Emergency response is covered by OP16 of the OPAL Business Management System and the safety aspects are analysed in Chapter 20 of the SAR. The Emergency Plan for OPAL links to the overall ANSTO *Response Plan for Accidents and Incidents ANSTO/LHSTC (ANSTO Response Plan)*.

The OPAL Reactor Emergency Plan (the Plan):

- identifies the responsibilities of ANSTO/LHSTC personnel. It makes clear that the Shift Manager is responsible for activating the OPAL emergency plan and for initiating the first response to any incident or accident in OPAL. The Shift Manager has local control of OPAL at all times and only transfers control when relieved by another Shift Manager. The Shift Manager calls upon other ANSTO resources as required through arrangements set out in the plan.

- describes the facilities and systems to assist in dealing with an incident or accident, including the main control room and emergency control centre of OPAL, the Post Accident Monitoring System, the alarms and communication mechanisms, the site control centre and site emergency operations centre.

- describes the responses by ANSTO/LHSTC personnel, again emphasising the central role of the Shift Manager in assessing the event, activating the plan, and initiating the appropriate response actions – and in advising that the hazard is under control. If responses by emergency services organisations are required, this is undertaken through the ANSTO Response Plan.

- touches on recovery arrangements, including a role for an OPAL Reactor Recovery Team.

The Plan places responsibility for testing and review of the Plan on the OPAL Reactor Manager. The Plan indicates that there would be a major exercise every two years with a review of the Plan following such exercises. Drills of specific aspects of the Plan are proposed more frequently.

The operation of the Plan was observed by ARPANSA staff members during the emergency exercise included in the Stage A commissioning tests.

The ANSTO Response Plan covers similar ground but from the point of view of ANSTO as a whole. It describes the roles and responsibilities of external organisations and, in particular, the interaction with the emergency service organisations. It includes arrangements to keep the public, the Sutherland Shire Council, the media, ARPANSA and other organisations fully informed of significant incidents that require a coordinated response by NSW emergency services organisations. The ANSTO

Response Plan is endorsed by the ANSTO Local Liaison Working Party which is a committee including ANSTO and State emergency agencies such as Fire, Police, SES and Ambulance. ARPANSA officers and Sutherland Shire officers also attend. The working party meets quarterly and its purpose is to share information and developments in emergency plans and arrangements and keep the plan up to date.

In addition to ANSTO's plans and arrangements above, I have also taken into account local emergency plans established under NSW Government emergency planning and health arrangements. The Lucas Heights Emergency Sub Plan approved by the State Emergency Management Committee was issued in November 2005. It states in its background section:

a. *Due to the safety systems employed within the LHSTC the risk of an uncontrolled radiation leak is regarded as low.*
b. *Advice from ANSTO and ARPANSA is that an uncontrolled radiation leak with off site consequences is extremely unlikely.*
c. *While the current arrangements are considered to be appropriate, three additional safety elements are included:*
    i. *Adopting the World Health Organisation's recommended generic intervention level of 10 mGy avertable dose to the thyroid for adolescents (less than 18 year olds) children, infants, neonates, pregnant and lactating women;*
    ii. *Extending the Urgent Protective Action (Planning) Zone (UPZ) from 2.5 km to 3 km; and*
    iii. *Adopting a policy of evacuating out to 3 km from HIFAR.*

d. *Stable iodine will be available at all evacuation centres for protection from radioactive iodine if necessary.*
e. *More detailed background information is provided in the NSW Health Counter Disaster Unit Paper entitled "The ANSTO Research Reactor Lucas Heights – Strategy for off-site iodine distribution", which is available on the NSW Health website www.health.nsw.gov.au/pubs/a/pdf/ansto.pdf*

The State Lucas Heights Emergency Sub-Plan goes on to set out the roles and responsibilities of all the relevant organisations, including ANSTO and ARPANSA. It touches on prevention and mitigation and preparation. It deals with control and coordination arrangements, emergency response arrangements, and emergency recovery operations.

There is also, under the Georges River Emergency Management Committee, a Lucas Heights Emergency Evacuation Sub-Plan that contains detailed arrangements for the evacuation of the 3 km zone around the Lucas Heights facility.

4.6.2. Assessment of Emergency Plans

The full set of escalating plans – being the OPAL Reactor Emergency Plan, the ANSTO Response Plans and the NSW Lucas Heights Emergency and Evacuation Sub-Plans provide an effective overall planning framework. At a high planning level, they meet all the matters set out in paragraph 7.73 of the *Safety Requirements.*

It could be argued (and well may be so by ANSTO) that some of the planning assumptions on which the NSW plans are based are unnecessarily conservative in view of the safer design of the OPAL reactor as compared with HIFAR. While this is so, the NSW plans strike me as being simple and pragmatically based and would provide the basis for responding to an emergency that could include a terrorist attack. I believe that their straightforwardness and workability should give comfort to people who live near the reactor – HIFAR and then the OPAL reactor – and I would recommend that they be retained when the OPAL reactor comes on line.

4.6.3. Emergency Procedures

The *Safety Requirements* state:

> *The emergency plan shall be implemented by means of emergency procedures in the form of documents and instructions detailing the implementation actions and the arrangements required to mitigate the consequences of the emergency.*

and

> *The operating personnel shall take appropriate action in accordance with established emergency procedures in response to an emergency.*

The OPAL reactor emergency procedures flow from OP 16 of the Business Management System and principally comprise 16 Emergency Operating Instructions (EOI). The EOI have been drawn up following analysis of the initiating events analysed in the SAR.

ARPANSA staff reviewers have acknowledged that the EOI do cover the range of emergency circumstances. They have criticised the approach taken suggesting that while the focus on EOI directed at 'symptoms' is reasonable, there is not sufficient guidance directed as to what might be the cause of the symptoms.

While I acknowledge the force of the criticism, I do not think it warrants delaying the operating licence. The EOIs, to my mind, do ensure that the appropriate responses are taken. Improvement will occur in the light of some operating experience accompanied by a program of tests and drill, overseen by ARPANSA inspections. Therefore I find that the emergency procedures are sufficient to ensure the safe operation of OPAL reactor.

5. CONSTRUCTION, SAFETY ANALYSIS REPORT, OPERATIONAL LIMITS AND CONDITIONS, COMMISSIONING AND OPERATING ARRANGEMENTS

This chapter assesses the other information required by the CEO to be provided as part of the Application, in particular items 15 to 19 of Part 1 of Schedule 3 of the regulations.

5.1. Construction and Commissioning

In this section I assess the information required under item 15 being '*a description of the structures, components, systems and equipment of the controlled facility as they have been constructed'*.

In making my findings in this section I have assessed:

- ANSTO's OPAL Construction Report (RRRP-7033-EBEAN-001-B, Revision B; and
- the ARPANSA staff reviews detailed working document describing and assessing the construction, including Cold Commissioning.

5.1.1. Regulatory oversight of construction

As a result of regulation 54 and an additional licence condition I imposed on the facility licence authorising construction of the OPAL reactor, every structure, system, and component important for safety was the subject of a 'Request for Approval' (RFA) submitted by ANSTO seeking my approval for procurement or manufacture and/or installation of systems, structures and components classified by ANSTO in its Preliminary Safety Analysis Report (PSAR) as safety category 1 or 2.

For any major reactor system, there would usually be a number of related RFAs – the timing of the submission of each to me was determined in general by the detailed construction schedule and was affected by such factors as the lead times for acquisition of materials or components and whether items were to be embedded in the structure and so forth.

For each RFA, ANSTO submitted information in a standard format that addressed the relevant parts of the PSAR and identified any variations from it in terms of material used, codes and standards, equipment function or other aspects. Arguments were advanced as to whether any variations identified had significant implications for safety and thus required my prior approval for the change under regulation 51. The RFA also identified relevant recommendations that had been made in the ARPANSA regulatory assessment report associated with my construction licence decision and set out the response to those recommendations.

During the period from April 2002 to the present, over 130 RFAs have been assessed by ARPANSA staff reviewers and approval for construction given.

I imposed a number of additional licence conditions on the facility licence authorising construction that arose from the RFA assessment process. The imposition of additional licence conditions ensured that matters I considered very important in the construction of items, for example that the vital role of the primary coolant boundary warranted a complete inspection regime of the butt welds involved, were reinforced and complied with by ANSTO.

Changes are a normal part of any complex engineering project. As expected, changes emerged as the detailed engineering design was finalised and fabrication and installation methods were considered. These changes were captured under the quality assurance systems of ANSTO and INVAP, and recorded as part of the OPAL reactor as-built design and plant case history. In addition some of these changes (relevant changes) gave rise to regulatory requirements imposed by regulation 51 of the regulations.

After considering assessments of changes prepared by ARPANSA staff reviewers, I approved 14 proposals for relevant changes with significant implications for safety and rejected one. This latter is discussed in the subsection on issues arising in construction.

The most safety significant approvals for change were:

- Redesign of the flap valves and siphon effect breakers;

- The control rod absorber plates to be made of hafnium instead of a mix of silver-indium-cadmium. While there are advantages to the use of hafnium, including a longer life, this change did involve a re-analysis of reactor transients in Chapter 16 of the SAR;

- A different thermal hydraulic computer code for analysis of loss of flow accidents and loss of heat sink accidents; and

- Change of the Final Activation Logics of the Reactor Protection Systems to achieve better physical separation between trains and from Post Accident Monitoring System trains.

Since the commencement of construction of the OPAL reactor facility in mid 2002, ARPANSA inspectors have carried out over 230 inspections for the purpose of monitoring compliance of ANSTO with the construction licence. These included inspections of the site preparation; civil works; manufacture, assembly and installation of Safety Category 1 and 2 structures, systems and components; performance of tests and inspections; quality documentation; and the commissioning of many items.

Inspections were undertaken at witness points and hold points that I identified, other processes and stages of interest to ARPANSA as well as randomly. ARPANSA assigned a full time inspector to the OPAL reactor construction project. Additional inspectors and specialist consultants advised on particular issues.

In addition, the premises of the primary contractor INVAP.SE, the fuel manufacturers (CNEA) in Argentina and CERCA in France, and facilities of the fabricator of the Cold Neutron Source (PNPI) in Russia, were inspected on a number of occasions. The inspectors observed mock-ups of systems and components, fabrication methods, the review of quality documentation for items during construction and before shipment, seismic qualification tests, pressure tests, electronic control system demonstration tests, and fuel manufacture facilities and associated quality documentation. There were inspections of components such as the Reflector Vessel, the Control Rods, Control Rod Guide Box, and Control Rod Drive Assemblies, the Flap Valves, Chimney pipe, fuel manufacture, Reactor Control and Monitoring System and Reactor Protection systems.

The ARPANSA inspection program drew upon and generally worked with the overall ANSTO/INVAP Construction Inspection and Test Plan and individual Specific Inspection and Test Plans.

5.1.2. Issues during construction

5.1.2.1. The Geological Faulting

In June 2002, ANSTO discovered geological faulting in the excavation of the OPAL site. ANSTO suspended construction activities on the site pending the preparation and submission of a report to me on the nature of the faulting and any implications that it may have for the safety of the reactor if constructed on the site.

Seismic issues had been addressed at some length in my consideration of the application for a licence to construct the OPAL reactor.

In October 2002, I issued a statement that described my reasons for accepting that the faulting did not change the basis for my acceptance that constructing the OPAL reactor on the site was safe. I reviewed the evidence that had been provided by ANSTO following the carrying out of detailed studies on the faulting and the regional geology. As part of the ARPANSA assessment of this evidence, aspects were assessed by an international expert and also by Geosciences Australia.

In brief, I found that the evidence indicated that there had not been significant movement of the fault for 9±4 million years and the fault possibly could be much older. I assessed this against accepted definitions of the capability of faults. Further, I found that the existence of the faulting did not indicate anything about the general geology of the region that would not have been taken into account effectively in the careful seismic assessments that had taken place as a part of the construction licence application and decision.

5.1.2.2. ***The Cut Outs***

During January 2003, I commenced an investigation into a possible breach of licence conditions by ANSTO and INVAP. The matter arose from my approval of RFA001 covering the construction of the reactor pool tank and welded parts. My approval explicitly excluded the cut-outs for the heavy water pipes as I had not yet approved the heavy water penetrations that formed part of a separate RFA submission before me. In the absence of my approval, INVAP instructed its subcontractor to proceed with manufacturing the cut outs.

Following the investigation, I found INVAP in breach of regulation 54, a statutory licence condition, in that it had proceeded to manufacture an item important for safety requiring my prior approval but had not obtained it. I also found that ANSTO was not in breach of any conditions of licence as it had identified the suspected breach, taken steps to rectify it and had brought it to my attention.

I did not take enforcement action against INVAP as it was the first occasion when a breach of licence condition had occurred and I was satisfied with commitments INVAP made to me to improve their processes to ensure that that such a breach did not occur again.

I reported this matter to the Parliament in March 2003.

5.1.2.3. ***The Reactor Pool Liner***

In early May 2003 ANSTO advised me that:

> *'due to a misinterpretation of drawings, the Reactor Pool liner as manufactured to date is not fully consistent with the approved detailed design. Specifically, the locations of a number of penetrations are incorrect.'*

I was advised that unauthorised repairs had been carried out by the reactor tank and piping fabricator on some of the misplaced penetrations. A review of the information provided to me also showed that there had been significant delays in the errors being detected and the fabricator notifying JHEDI (the construction contractor) and then JHEDI notifying INVAP (the designer).

I investigated this matter closely drawing on submissions from ANSTO and INVAP, assessments by ARPANSA staff reviewers and several independent expert reports. The Nuclear Safety Committee was briefed on and discussed the issues.

In August 2003, I issued a statement in which I stated:

> '*After undertaking the assessment described in this statement, I make the following findings:*
>
> - *the error made by the fabricator in rolling the plate inside out for the construction of the tank in all probability was the result of the fabricator applying a 'mental model' of how the convention of drawing a circular vessel applied, rather than examining the drawing sufficiently closely or asking for information;*

- *the fabricator then made errors of judgement in carrying out unauthorised repairs and in not immediately raising a non-conformance report to be resolved by the designer;*

- *the deficiencies in implementation of the QA system by the fabricator arose from lack of resources and a lack of an independent QA decision-maker. That these deficiencies existed also reflects on JHEDI as the construction contractor.*

I have made the following regulatory decisions:

- *The unauthorised repairs to three small holes in the lowest plate of the tank and the repairs in strakes 2 and 8 that required only additional plate and longitudinal welds have been undertaken consistent with the Code that formed the basis of my approval for construction of the tank. Therefore, I accept these repairs as being in conformity with my approval for construction of the tank;*

- *The repair criteria set out by INVAP (and accepted by ANSTO) in the document RRRP-0610-3BEDM-801-A together with:*

    - *the revised welding procedure recommended to ANSTO by the Welding Technology Institute of Australia (WTIA)*
    - *the revised fabricator workshop organisation provided by ANSTO in its submission to me.*

will result in the repaired vessel being consistent with my approval for construction of the tank. Therefore, ANSTO may instruct the fabricator to proceed with the repairs to the other misplaced penetrations (whether unrepaired or previously repaired) on the basis of the INVAP criteria, the revised welding procedures and the changed workshop organisation.

- *I wish to be assured that the repairs are carried out successfully and that all manufacture, repair and testing work has been fully documented. Therefore, I am applying two new licence conditions on the construction licence with the effect that:*

    - *the acceptance by ANSTO of the completed Reactor Pool tank shall be a 'hold point' requiring my approval before acceptance of the constructed tank may take place;*
    - *ANSTO will obtain additional information about the welding of the tank as described in the ARPANSA report to be assessed at the time of the above 'hold point'.*

- *There are lessons learned from the incident and its consequences with regard to quality assurance systems across the entire RRR construction project (that is, including ANSTO, INVAP, JHEDI and sub-contractors). Therefore, I am applying a further licence condition requiring that ANSTO report as soon as possible and thereafter quarterly on the following matters as they apply to primary contractors and manufacturing sub-contractors for Safety Category 1 systems:*

- *the resources applied to QA and the evidence of independence of QA decision-making from construction decision-making;*
- *the implementation of procedures for obtaining authorisation from INVAP for any changes to design documentation;*
- *the implementation procedures for dealing with 'non-conformance' reports;*
- *the implementation of inspection programs, including assurance that sub-contractors have personnel with a sound engineering understanding of the relevant requirements of the project.*

- *I will seek submissions from ANSTO on the licence conditions to ensure that they are formulated effectively to meet my intention.*

- *I will review the frequency and conduct of inspections by ARPANSA staff.*

After considering the submissions from ANSTO I imposed an additional licence condition on the facility licence authorising construction of the OPAL reactor (Licence Condition RFA001-4). This licence condition required ANSTO to undertake quarterly reporting of quality assurance matters relating to contractors and sub-contractors manufacturing safety category 1 systems. The licence condition identified the primary contractors associated with safety category 1 items.

ANSTO has complied with this licence condition by means of the quarterly report to me on these matters.

5.1.2.4. ***Hoist C***

In February 2005, an ARPANSA inspector attended pre-commissioning testing of the Reactor Hall Crane and observed that the crane contained three hoists, whereas my approval for the crane set out in RFA028 had been for two hoists. It transpired that ANSTO had made a change to the number of hoists on the crane and had characterised it as a change not having significant implications for safety (regulation 52) and therefore not requiring my prior approval.

The purpose of the additional hoist, Hoist C, was to move silicon ingots between the reactor pools – the PSAR had proposed that this be done by a manually operated hoist working on the operations bridge.

After correspondence with ANSTO, on 23 June 2005, I made the following decision:

> *'Having reviewed the evidence available and considered the submissions from ANSTO dated 15 April 2005 and 27 May 2005, I find that in installing Hoist C, also known as the NTD Hoist, the changes to the function of the Reactor Hall crane were so significant and the lifting capacity of Hoist C so much greater than the method previously proposed for the transport of silicon cans, that this change should have been identified by ANSTO as a change with significant implications for safety, for which my approval should have been sought.*
>
> *Consequently, I find that by adding Hoist C to the Reactor hall crane, ANSTO breached regulations 44 and 51 of the Australian radiation protection and*

Nuclear safety regulations 1999 - - - - and Section 30(2) of the Australian radiation protection and Nuclear Safety Act 1998 ‘

ANSTO made an application in November 2005 seeking retrospective approval of the change to the Reactor Hall Crane. After further exchange, I decided that this was not acceptable to me and in the absence of any approval, I asked that ANSTO remove Hoist C from the Reactor hall Crane. On 20 June 2006, ANSTO confirmed that Hoist C had been removed.

While this matter has been resolved, it illustrates the importance of achieving a clear understanding between the regulator and licence holder as to the interpretation of regulation 51 ‘relevant change having significant implications for safety’ and for there to be an internal ANSTO assessment of this matter in which I can have confidence. This is a matter that is being clarified with ANSTO with respect to all its facility licences.

5.1.2.5. ***Concrete Cracking***

During the construction of the reactor building, it was observed that there was significant cracking in the concrete floor and walls at levels -5 and -7. Groundwater appeared around some cracks showing that it had propagated through the thickness of the floor slab.

I was advised that the cracking was due to a large concrete pour having been carried out on a very hot day in February 2003, resulting in high concrete temperatures from the heat of hydration. As the concrete cooled, concrete shrinkage, coupled with stress concentrations caused by various structural elements such as walls, columns and metal inclusions (junction boxes etc), and restraint by the foundation rock, led to cracking in the concrete.

I formally raised this matter with ANSTO in March 2005. The issue had been discussed with ANSTO and contractors prior to this and ARPANSA staff reviewers also engaged an external civil engineering consultant to advise me. The major issues were the efficacy of repairs to the cracking; and the possible long term effects on the integrity of the structure arising from any potential for corrosion of the reinforcing steel and any metal inclusions. I requested that ANSTO provide me with a report addressing: the extent of cracking and its causes; the method of repairs to the cracking and their efficacy; the long term consequences of ground water penetrating the cracks below the surface repairs on the integrity of the concrete, its reinforcements and inclusions; and a long term monitoring program of the integrity of the concrete structure.

ANSTO responded in September 2005 providing the repair procedures, the Specific Inspection and Test Plans (SITPs) for the repairs and an assessment of the effects of ground water on the concrete and reinforcements. This report satisfied ARPANSA staff reviewers about the approach chosen to repair the concrete cracking and that the degradation of the concrete and corrosion of the reinforcing steel from acid groundwater, due to the repaired cracks, is unlikely in the medium to long term.

I was advised in May 2006 that the reactor building had been accepted as fit for purpose by ANSTO and INVAP and that some 15 SITPs associated with waterproofing repairs had been completed whilst work associated with a number of SITPs was ongoing. Further ANSTO advised that a maintenance item would be raised annually for inspection of the concrete crack repairs to be carried out by an external building inspector who will address the matter of possible degradation of the reactor building structure.

5.1.3. Monitoring other construction licence conditions

The table below shows how the construction licence conditions that are not dealt with elsewhere in this chapter were addressed by ANSTO.

Licence Condition	Action Taken
4.8 The Licence Holder must provide to the CEO of ARPANSA, initially within 6 months of the issue of this licence and thereafter as agreed by the CEO of ARPANSA, an updated Safety case that takes into account to the satisfaction of the CEO of ARPANSA: a) any recommendations of the RAR b) any changes to the design or the safety case since the Application was submitted	The process envisaged in this Licence Condition was overtaken by the RFA process. ANSTO's RFA submissions identified changes required to the PSAR arising from the detailed design as implemented in the various RFAs. ANSTO has committed to ensure that these changes will be incorporated into the SAR.
4.9 The Licence Holder must, within 12 months of the issue of this licence, arrange for an independent review of the PSAR addressing the effect of human factors on the design, and provide a report to the CEO of ARPANSA on the implementation of any recommendations arising from the review.	ANSTO submitted an alternative approach to human factors review in April 2003. The approach taken is stated to have informed ANSTO review of INVAP design deliverables and inspection of installed systems and components. A report *Overview and Status of the ANSTO Human Factors Review Program* was submitted by ANSTO in May 2006. ARPANSA staff reviewers were satisfied that the approach adopted through ANSTO's Human Factors Engineering Review Plan addressed the intentions of Licence Condition 4.9. It involved ongoing ANSTO review of human factors as an integral part of its review, verification and acceptance of detailed design, manufacture, installation and commissioning of Safety Category 1 and 2 items. ARPANSA staff reviewers are now of the view that this achieved better human factors outcomes than a one-off review of the PSAR by a third party not knowledgeable in the reactor systems and their operation. It also has helped build corporate capability and memory about the human factors engineering aspects of the OPAL reactor. I agree with this assessment.

4.10 The Licence Holder must develop and undertake a program of work during construction, validating the computational modelling used to demonstrate the safety of the specific design of the Controlled Facility and to support its safe operation, to the satisfaction of the CEO of ARPANSA.	ANSTO submitted three Activity Reports directed towards this Licence Condition. The first identified the scope of the computer codes to be included in the validation and verification program. The second described the different codes and their application in establishing the safety case for the OPAL reactor. The third (submitted March 2006) describes the extent of verification and validation for the codes that have been assessed. ARPANSA staff reviewers concluded that the verification and validation of the codes was satisfactory. I agree with this assessment.
4.13 Prior to any application for a licence to operate, the Licence Holder must provide to the CEO of ARPANSA emergency planning arrangements that include offsite responses and that have been independently reviewed by a party agreed with the CEO of ARPANSA.	ANSTO's emergency planning arrangements for the OPAL reactor are included as Part B of the Application Emergency plans for accidents at Lucas Heights Science and Technology Centre were developed and are maintained by the NSW Government. ARPANSA was fully consulted during the development of the plans. This is satisfactory to ARPANSA staff reviewers. I agree with this assessment.
4.15 The Licence Holder must demonstrate to the CEO of ARPANSA that the final design of hardware and software of computerized control, safety and security systems; a) complies with any relevant security specifications of the Defence Signals Direactorate of the Department of Defence b) has been reviewed and approved by the Defence Signals Direactorate of the Department of Defence	ANSTO submitted a report on the relevant security provisions that had been reviewed by DSD and their comments incorporated in February 2003. DSD certification for the RCMS, FRPS and SecNet was received by ARPANSA in May 2006. I accept this certification.
4.16 The Licence Holder must provide to the CEO of ARPANSA a plan for the implementation of the physical protection recommendations contained in the reports named in a Schedule provided separately to this licence. The plan must be approved by the CEO of ARPANSA prior to implementation.	Plan submitted in December 2003. with periodic updates provided subsequently. ARPANSA staff reviewed these reports and were satisfied with implementation of the physical protection recommendations contained in the named reports. See assessment in Chapter 4
4.17 The Licence Holder must ensure that its site security assessment and threat assessment are formally reviewed and updated by the Australian Security Intelligence Organisation , annually and when security circumstances change. Details of any such assessments must be provided to the CEO of ARPANSA and to the Direactor General of the Australian Safeguards and Non Proliferation Office.	Protective Security Risk Reviews for the LHSTC and for the OPAL reactor site from ASIO have been supplied to ARPANSA and ASNO. See assessment in Chapter 4.

5.1.4. Assessment and Findings regarding Construction

ARPANSA staff reviewers closely reviewed and assessed the detailed design, manufacturing, and installation of the OPAL reactor systems, structures and components through the RFA process. There were a small number of issues only where I imposed additional licence conditions to ensure achievement of what I regarded as vital design objectives in terms of my assessment of the construction licence application.

The cut-outs and the reactor pool liner problem early in the construction process showed up some problems in the QA for certain manufacturers, but this was addressed through the implementation of the licence condition described above.

Any relevant changes with significant implications for safety that had an impact on the design were also carefully assessed and only approved if I formed the view that each did not adversely affect the safety of the reactor as approved at the construction licence stage.

The geological fault issue was well handled by ANSTO and I was satisfied with its resolution. The concrete cracking was somewhat greater than might have been expected, but the repair process is sound and has been well carried out. The likelihood of degradation of the structure in the medium to longer term appears low, but in any case there will be an annual inspection addressing that issue.

The installation of Hoist C without my prior approval was as previously indicated a breach of licence condition and therefore of concern to me. I formed the view that it occurred because the installation was handled separately from other construction issues and the safety case was not properly taken into account. My further consideration of the implications of this matter for my decision making is set out in Chapter 6.

There were also perceived design problems with the Control Guide Box Fastener. These were resolved by the employment of two independent experts to review the calculations, and the use of a mock up to demonstrate the safety margins that existed for the axial load.

Taking into account the very detailed assessment by ARPANSA staff reviewers of the manufacture, construction and installation of the systems, structures and components important for safety and the satisfactory resolution of the issues that arose during construction:

- I find that all licence conditions attached to the facility licence authorising construction have been complied with;

- I find that the design intentions with regard to safety have been met; and

- I find that the construction of the OPAL reactor has been undertaken consistent with international best practice in relation to radiation protection and nuclear safety.

My overall finding is that the Application contains a description of the structures, systems and components of the OPAL reactor as they have been constructed.

5.1.5. Cold Commissioning

The IAEA *Safety Requirements* defines commissioning as being:

> *The process during which systems and components of facilities and activities, having been constructed, are made operational and verified to be in accordance with the design and to have met the required performance criteria.*

The commissioning of a nuclear reactor requires the organisation undertaking commissioning to prepare and implement plans demonstrating that the commissioning program covers testing of systems and components within the reactor facility, and the commissioning organisation in charge of the process, as well as the interactions and responsibilities of each organisational unit involved in the commissioning.

A staged approach for testing is adopted prior to the full operation of the reactor: commencing with testing individually each system and component; extending to testing the integration of all systems/components without nuclear fuel loaded into the core (Stage A or Cold Commissioning); and, should this integration be successful, testing of the reactor with nuclear fuel loaded into the core (Hot Commissioning). The quality of the commissioning activities is strictly monitored at each stage of the process.

It should be noted for the purposes of this decision that Stage A (or Cold Commissioning) was covered by the facility licence authorising construction of the OPAL reactor and Stage B1, B2 and C is the subject of this application for a facility licence authorising the OPAL reactor to operate (see review of Hot Commissioning later in this Chapter).

The ANSTO organisation for Stage A commissioning spelled out the following roles:

- A ***Management Group*** of senior ANSTO and INVAP personnel who have the authority of the ANSTO Chief Executive and the INVAP CEO, for the conduct of all activities associated with the commissioning program.

- A ***Commissioning Group*** responsible to the Management Group for arranging commissioning of the OPAL reactor. The Group includes ANSTO and INVAP personnel, including an ANSTO officer in the role of Commissioning Reactor Manager.

- ***Commissioning teams*** that are formed to undertake planning, preparatory work and commissioning tests on the various reactor systems.

- The ***Construction Group*** provides support to commissioning tests and to plant equipment operations.

- The ***Operation Group*** operates the facility in accordance with the applicable plant documentation and commissioning procedures and requirements. In the first instance the operating group includes INVAP personnel, but ultimately, of course, it is solely ANSTO.

- The ***Commissioning Quality Assurance Group***, is headed by the Commissioning QA Manager (INVAP) who reports directly to the Management Group. It consists of quality assurance personnel from ANSTO and INVAP.

The roles and relationships between these groups are described in detail in the ANSTO documents.

The responsibility regarding operation and maintenance of plant systems was gradually transferred from the Construction Group to the ANSTO Operation Group. During Cold Commissioning, the operation of the reactor systems and components was under the control and responsibility of personnel of INVAP, with ANSTO Operating Group personnel undertaking the plant operations assisting required by the tests.

Following the issue of a facility licence authorising it to operate, which, inter alia, will authorise ANSTO to load nuclear fuel into the core (Hot Commissioning), ANSTO personnel will take full responsibility for operation of the reactor systems and components, with INVAP personnel present for assistance. During this second phase, the Commissioning Reactor Manager will be responsible for the safety of the reactor.

I accepted that the above arrangements for Cold Commissioning were consistent with the IAEA safety guidance together with ARPANSA's own regulatory guidance.

As part of the construction licence, I had imposed a licence condition on the OPAL reactor construction licence dealing with the Cold Commissioning.

I varied this condition in January 2005[15] to read as follows:

Commissioning of items important for safety

4.7 Without derogating from the obligations and limitations imposed by regulation 54 of the Regulations, the Licence Holder must gain the approval of the CEO of ARPANSA for the commissioning program prior to commencing commissioning of items important for safety, being those items identified as Safety Category 1 and Safety Category 2 in the Application.

4.7.1 In seeking this Approval the Licence Holder shall provide information establishing that the commissioning program:

(a) Has been reviewed and accepted by the Licence Holder;

(b) Will complete the verification that each item will perform in accordance with its safety performance specifications as set out in the Application;

(c) Will ensure that commissioning of each item is under a certified quality assurance program;

[15] The original licence condition set out requirements addressed to each system, structure or component with significant implications for safety. The experience of working with LC 4.6 made clear that this approach would not be workable for commissioning and that the LC 4.7 should focus on the overall commissioning program and the specifics of certain identified systems.

(d) *Establishes a commissioning schedule that may be made available to the CEO of ARPANSA for the purposes of monitoring compliance.*

4.7.2 *The Licence Holder must, prior to commissioning items important for safety, being those items identified as safety category 1 and safety category 2 in the Application, identified by the CEO, provide any information requested by the CEO that relates to the commissioning of those items or a number of items that comprise a system.*

In September 2004, I issued a guidance document *Regulatory Principles for Assessment of Commissioning of the Replacement Research Reactor, including plant completion and pre-commissioning testing – under the Australian Radiation Protection and Nuclear Safety Act 1998*", RB-STD-09-04-Rev 0. This document was based upon the draft IAEA Safety Guide *Commissioning of Research Reactors*.

ANSTO first submitted documentation covering its plans for Cold Commissioning in June 2004 and confirmed the plans in December 2004. The overall Commissioning Plan (directed to Hot Commissioning) formed Part E of ANSTO's operating licence application submitted in September 2004.

ANSTO's Cold Commissioning program partly relied upon a process of the 'pre-commissioning' of items. Pre-commissioning was the testing of individual systems, structures and components carried out under the arrangements for the construction of the reactor, rather than the formal commissioning arrangements. The outcomes of pre-commissioning were reported to me as part of the ANSTO 'OPAL Construction Report' and assessed by ARPANSA staff reviewers (RRRP-7033-EBEAN-001).

By letter of 17 January 2005, I approved the commissioning program for items important for safety as complying with Licence Condition 4.7.1. I also advised ANSTO that the Stage A Commissioning Group and associated quality arrangements ought to be put in place at an early stage of the Pre-Commissioning and plant completion activities. The purpose was to give confidence that the testing of safety category 1 and 2 items that would occur only during Pre-Commissioning were undertaken adequately and in a manner consistent with commissioning program. ARPANSA also expected involvement of the ANSTO Operating Group at an early stage of the Pre-Commissioning phase so that personnel could familiarise themselves with the operation of the numerous components/systems to be tested earlier. This is desirable because this group would be in charge of the reactor during Hot Commissioning and reactor operations.

With respect to licence condition 4.7.2, I identified specific pre-commissioning and commissioning tests of interest to ARPANSA, required ANSTO to provide procedures for these tests to ARPANSA and nominated these as tests to be witnessed by ARPANSA inspectors. The information was required so that ARPANSA inspectors would be informed about the specific tests allowing inspectors to monitor compliance of the commissioning program for appropriateness and completeness of the testing, and recording and reporting of the results.

ANSTO provided the specific procedure (Specific Inspection and Test Plan) for each pre-commissioning test I had nominated. ARPANSA staff reviewers were satisfied that the procedures were comprehensive and sufficiently detailed in covering the necessary information for transparency of the process and results of the test.

The detailed plan for Stage A commissioning was set out by ANSTO as its Stage A Commissioning Specific Plan (RRRP-7320-EDEIN-001-C, dated 21 November 2005).

In relation to compliance with the terms of Licence Condition 4.7.1, ARPANSA staff reviewers were satisfied that the information submitted by ANSTO in the plan demonstrated that a comprehensive program of testing would be implemented by ANSTO in Pre-Commissioning and Stage A Commissioning activities.

In particular the ARPANSA staff reviewers were satisfied that the licence holder provided information establishing that the commissioning program:

- would complete the verification that each item (Safety Category 1 and Safety Category 2) will perform in accordance with its safety specifications.

- would ensure that commissioning of each item would be under a certified quality assurance program.

- had been reviewed and accepted by ANSTO as the licence holder.

In addition a schedule would be available to the CEO of ARPANSA for the purposes of monitoring compliance.

ARPANSA inspectors witnessed all of the Safety Category 1 systems pre-commissioning tests and many Safety Category 2 systems tests. ARPANSA inspection reports were prepared for these tests. Issues that emerged during these tests included problems with the fuel supply to the diesel generators that required some modifications. After these changes, further tests demonstrated that the fuel supply problem was resolved, with the diesels starting reliably on demand from a cold start and running on load (one week) including with a low fuel tank level.

A second issue that arose was the opening time for the flap valves in the primary coolant system in certain circumstances. It would appear that a systems interaction between the primary and secondary cooling water systems (PCS and SCC) through its interface at the plate type heat exchangers caused the flap valves to open early. The effect only occurs under certain conditions of SCS pump operations, which are not envisaged in normal operation or in transitions from one reactor state to another. In any case, INVAP performed calculations showing that the earlier opening time did not cause any safety difficulty.

On 13 February 2006, I was advised by the Executive Direactor of ANSTO that ANSTO and INVAP had jointly agreed that the OPAL reactor was ready for commissioning and that they had established that all pre-requisites were in place.

In Stage A commissioning, the reactor systems were tested in each of the operational modes that it will ultimately utilise[16] – there were dummy fuel assemblies installed and the nucleonic signals were simulated where necessary. The reactor systems were configured and operated consistent with each reactor mode. The tests were aimed to verify that plant systems are able to perform their assigned safety functions and the key operational procedures are tested. Stage A included the testing of key safety features such as the emergency control centre and the containment. A cold run of the entire facility was carried out as a form of 'summary' of all the previous testing and to verify that the reactor can be operated continuously. There were emergency preparedness tests, including the performance of an emergency drill. The culmination of the testing process was the simulation of the loss of power supply to verify systems behaviour during this event.

The testing undertaken as part of Cold Commissioning were:

- Instrumentation and control system tests. These were designed to verify that systems such as the First and Second Reactor Protection systems and the Reactor Control and Monitoring system functioned as designed and interfaced properly with the operators and the reactor power supplies.

- Power state tests that included:

    - testing the procedures for the transition from the shutdown to the power state and the transition from power to shutdown;
    - testing the cooling systems, including the primary cooling system in forced circulation mode;
    - undertaking core and irradiation rigs coolant flow distribution measurements
    - a first shutdown system test to measure the actuation times for this system with the full coolant flow; and similarly for the second shutdown system; and
    - testing the coolant system coast down after the pumps are stopped and the actuation of the flap valves establishing natural convection flow

- An appropriately similar range of tests for the shutdown, physics tests, and refuelling modes of the reactor.

- Containment and containment ventilations systems tests.

- Control rooms tests to verify the arrangements to transfer control from the main control room to the emergency control room.

- An entire facility cold run test for a period of 36 hours, during which the production cycle bulk irradiation facilities were tested, including the loading and unloading of irradiation rigs.

[16] OPAL has four defined operating states known as Power State, Physics Test State, Shutdown State and Refuelling State. Each State defines a particular reactor operating environment with specific rules, interlocks and alarms as well as requirements relating to configuration of plant systems in order to either allow or preclude the performance of certain tasks.

- Health physics walk-through to verify that the provisions for radiological protection of the operators were in place.

- Cold neutron source tests.

- Emergency preparedness tests, including an emergency drill.

- Simulation tests for loss of normal power supply.

Prior to the commencement of Cold Commissioning, ANSTO provided the specific Stage A Commissioning procedures (Commissioning Inspection and Test Plans). ARPANSA staff reviwers were satisfied that the procedures were comprehensive, and sufficiently detailed in covering the necessary information for transparency of the process and results of the test.

The results of individual tests were evaluated by the INVAP responsible officers with no involvement of the OPAL Reactor Operating Group or the OPAL Project Group. However, the results were routinely provided as Commissioning Reports to the Commissioning Group which had representatives of these groups and met daily and reviewed and endorsed the results and accepted the evaluations. ARPANSA Inspectors observed that the format of the Commissioning reports was transparent and the key results were easily verified.

Generally only one configuration of plant redundancies was tested during a Stage A Commissioning Test. The reason given by ANSTO/INVAP was that all configurations of each system had been tested during pre-commissioning and that, due to the number of transitions that were planned during commissioning, all configurations would be checked eventually anyway. ARPANSA staff reviewers were satisfied that this was the case. I am also satisfied of this fact.

5.1.6. Assessment and Findings regarding Stage A Commissioning

I received a commissioning report from ANSTO dated 16 May 2006 (RRRP-7311-EDEIN-004-B). The Nuclear Safety Committee was briefed by ANSTO and ARPANSA officers on the commissioning report on 16 June 2006. Minutes of this meeting have been published on the ARPANSA website.

A brief summary of the commissioning reports is as follows:

- For instrumentation and control systems : *Stage A Commissioning results - - - demonstrated that the systems are fully operative and integrate in a consistent manner with other plant systems.* One non-conformance report was raised during these tests and was resolved.

- For reactor state tests: *For each reactor operating state, the systems were operated and configured accordingly in order to verify that the reactor systems are able to perform their assigned functions and that plant parameter remain within acceptable limits. Trial tests of plant operation manual procedures, including* *those for transitions between the various reactor operating states, were included in this series of tests.*

Reactor state tests included coolant flow distribution measurements which demonstrated that coolant flow rates within the reactor core and irradiation rig positions comply with the specified acceptance criteria. Also, a blocked fuel assembly simulation which demonstrated that its occurrence would be detected by the FRPS instrumentation was performed.

The operation of the PCS flap valves to initiate the transition from forced to natural cooling of the reactor core following a reactor shutdown was also tested and found to comply with the specified acceptance criteria.

- For containment systems tests: *the test for normal mode verified that containment conditions, including pressure, temperature and humidity, remained within acceptable limits, and that system instrumentation and interlocks relevant to the normal mode were functional. The test for containment isolated mode verified the triggering of the various groups of containment isolation closures, the correct operation of containment systems - - - during and following containment isolation, that containment conditions remained within acceptable limits and that system instrumentation and interlocks relevant to the isolated mode were functional.*

- For control room and emergency preparedness tests: the testing included *procedures for evacuation of the Main Control Room to the Emergency Control centre(ECC) and tests of the operation of the ECC ventilation and pressurization system - - - - . An emergency drill was also conducted -------. The results of these tests demonstrated an adequate level of emergency preparedness within the reactor and its operating organisation.*

- For electrical power systems tests: *the tests included verification of the effect of loss of the* normal power supply *on the reactor protection systems, shutdown systems, reactor control and monitoring system, control room consoles and wall panels, heat removal systems, containment and ventilation systems and* cold neutron source *systems. Also verified was the operation of the* secondary power supply *in response to loss of the* normal power supply *and its ability to supply essential loads including the containment systems, emergency lighting and ventilation, reactor cooling systems and instrumentation and control systems.*

- For other Stage A Commissioning Tests: *the entire facility cold run tests - - - demonstrated that the reactor facility is capable of operating with high availability over an extended period and the plant operating documentation is appropriate. Some tests originally planned for the cold run test relating to operation of irradiation facilities could not be completed due to incomplete installation of some items.*

  Cold Neutron Source tests - - - -were similar to those conducted during pre-commissioning but with deuterium loaded.

  The results of the health physics walk- through was that health physics provisions, including radiation shielding, signage, monitoring equipment, personal protection equipment and decontamination facilities are in place and adequate.

Radiological measurements were made to provide a base line prior to the loading of any nuclear fuel.

The Commissioning Report dated 16 May states that at that time, there were 17 issues raised that had still to be resolved. The reasons for them not being resolved were variously that a replacement part is yet to be delivered by a supplier, a component is still being manufactured, or a repair task is ongoing. In general the planned actions were to repair and/or replace the instrument or component and conduct further tests.

ARPANSA inspectors witnessed many of the tests undertaken as part of the Cold Commissioning. A particular focus of the inspections was the verification and validation of the operating procedures. The ANSTO Operating Group involvement commenced in the latter stages of pre-commissioning and continued throughout the entire Stage A. The shift crew used the Operating Procedures on all occasions in preparing the reactor for commissioning tests, conducting and finalising the tests.

ARPANSA inspectors witnessed tests of operation in all reactor states and all allowable transitions between states, since these procedures are the most demanding for achieving safe operations. The inspectors observed that the process of verifying and validation the procedures worked very well and, although rigorous application of the Operating Procedures increased the length of time necessary to complete system tests, the tests were very thorough and detailed. It was evident that the OPAL operators were familiar with the Operating Procedures for the various reactor states and transitions between states. This reflected their heavy involvement in the review of the procedures over the previous two years and the simulator training to prove the procedures over the previous year.

Other matters covered in the ARPANSA inspection reports are:

- *The reactor control and monitoring system*. ARPANSA inspectors observed many commissioning activities that confirmed the functional performance of the RCMS for controlling reactor operations, monitoring operations and logging the status and operational data about reactor systems. An issue about the absence of a reference to the Control Rod Movement Protection Interlock (CRMPI) system in certain procedures was brought to ANSTO's attention. This was subsequently addressed by including a check of the status of the CRMPI as a step in start-up procedures, and providing for periodic in-service tests and inspections.

- *Main control room and consoles.* The tests and walkdowns confirmed the ergonomic and human-machine interface design aims, with two or more people able to monitor plant status simultaneously, good visibility of the above-pool area and good CCTV coverage of the plant.

- *Hydraulic tests of reactor core and rigs.* ARPANSA inspectors were satisfied that the measured pressure drops and flow distributions conform to those predicted in the Safety Analysis Report and the hydraulic assumptions used in the computational codes. The tests also confirmed the ability to detect blocked flow to a fuel assembly from the measured pressure drop across the core. The general handling of dummy fuel assemblies and irradiation rigs successfully tested equipment for handling, transfer and storage of fuel, irradiations and components and verified the handling procedures. These tests also provided good experience for OPAL Operations Group staff.

- *Protection systems and post accident monitoring system.* ARPANSA inspectors were satisfied that the tests confirmed that the First and Second Reactor Protections Systems and the Post Accident Monitoring System performed in accordance with the performance specifications necessary to fulfil their intended safety functions, as described in the Safety Analysis Report.

- *Reactivity control and shutdown systems.* Tests observed by ARPANSA inspectors demonstrated the response and insertion times of the First Shutdown System Control Rods. The times are well within the 900 ms specified in the SAR, both with pneumatic assist (about 450 ms) and without (about 700 ms). The Commissioning tests were in the Power state, with Primary Coolant System forced flow and the rods dropping against the direction of flow. During Pre-Commissioning, tests were also done in the Physics Test state, with no forced flow. Performance tests of the Second Shutdown System (SSS) reflected the complexities of the Reflector Vessel and Reflector Cooling System by conducting the tests with the FRPS, SRPS and FSS in such states as might best expose any latent or potential adverse interactions between the systems. Pre-Commissioning included confirmation of the reflector dump times with the six dump valves open and with five dump valves open (ie with a single failure). An issue about the SSS isolation valve in the heavy water plant room has been raised with ANSTO and ARPANSA inspectors observed that access to the valve was improved by providing a stand for plant operators while operating the valve.

- *Redundancy, independence and diversity in systems important to safety.* Numerous Commissioning walkdown inspections and tests confirmed correct implementation of separation for Safety Category 1 systems in cable trays, rooms and ducts. One issue is the close proximity of core outlet temperature sensors for the FRPS and SRPS. This was accepted by ARPANSA staff reviewers at the RFA design stage because the cables are well protected and routed separately out of the reactor pool. Walkdown inspections and tests confirmed that, to the extent practicable, reactor process control systems have been kept functionally and physically separate from safety systems, from measurement of the process variable (avoiding common sensors) through to shutdown actuation, so that a system is not relied upon to perform both control and safety functions.

- *Marking of safety systems.* ARPANSA inspectors confirmed that safety systems are effectively distinguished by clear markings (for example, colour codes or affixed notices) so that they stand out in identification against systems that are not important to safety. In general, the distinction between Safety Category 1, 2 and 3 systems and components is very clear.

- *Electrical tests.* The tests verified the correct functioning of interlocks, instrumentation and control (both local and on the RCMS), logic and operation of relays, transformers and breakers. A series of battery discharge tests were done during pre-commissioning. During Stage A commissioning, loss of offsite power tests checked the availability and the operation of the emergency power systems; standby power supply, uninterruptible power supply and emergency lighting.

- *Reactor containment functional performance tests.* ARPANSA inspectors were satisfied that the tests conformed to international practice and demonstrated acceptable leakage performance of the containment during commissioning. The tests also provide a sound basis for regular in-service leak tests to look for any degradation of containment leak tightness. ARPANSA staff reviewers are satisfied that the containment system has been demonstrated to provide a reliable, long-term, leak-tight barrier that would be effective in limiting the release of radioactive material to the environment in design basis and beyond design basis accidents.

The NSC received the ANSTO Commissioning report and was briefed by ANSTO and INVAP personnel and ARPANSA staff reviewers at its meeting on 16 June 2006. The draft minutes of the meeting record that:

> *The Committee advised the CEO that the documentation provided and the briefing from ANSTO staff showed that the Stage A Commissioning appeared to have been adequately handled. There was some comment that ANSTO had produced one of its most 'readable' reports.*
>
> *Members indicated that there were some items in the Stage A Commissioning report that required clarification but the ANSTO discussion had generally resolved those issues with the Members.*

Taking into account the ANSTO Commissioning report, the inspections by ARPANSA inspectors covering the commissioning and pre-commissioning of major safety items, the assessments by ARPANSA staff reviewers of the commissioning program and its results, and the view of the Nuclear Safety Committee, I find that the pre-commissioning and Stage A commissioning has been carried out consistent with international best practice in relation to radiation protection and nuclear safety. The outcomes of the pre-commissioning and Stage A commissioning demonstrate that the structures, systems, and components significant to safety, as they have been constructed, have functioned consistently with their design specifications.

5.2. Safety Analysis Report

In this section, I assess the information required by the CEO to be provided as part of the Application, in particular item 16, namely '*A final safety analysis report that demonstrates the adequacy of the design of the controlled facility, and includes the results of commissioning tests.'*

5.2.1. Overview of the Safety Analysis Report

Assessment of the Preliminary Safety Analysis Report (PSAR) as demonstrating the OPAL reactor safety case was an important factor in my decision to issue a licence to construct the OPAL reactor. I was satisfied that it fulfilled its primary purpose of demonstrating that the proposed reactor would be safe.

Because much of the detailed engineering design of the OPAL reactor was not complete at the time, the ARPANSA staff reviewers made about 100 recommendations for ANSTO to take into consideration during development of the detailed design and the ‘final’ Safety Analysis Report (SAR). Matters arose during the development and assessment of RFAs under the construction licence, as described above, that required (or will require) each to be properly recorded in the SAR.

The changes to the SAR presented with the application for a licence to operate the OPAL arise from the completion of the detailed design and construction which took into account the ARPANSA staff reviewers recommendations, safety significant design changes discussed in the assessment of construction above and continued analysis of the performance of systems in the light of the detailed design.

There are further revisions to the SAR that I will require ANSTO to undertake so that the SAR incorporates all matters that arose during the review of requests for approval to construct under the facility licence authorising construction of the OPAL reactor. ANSTO has undertaken to complete this revision.

It is important for me to assess whether the changes to the safety analysis, contained in the SAR and the revised PSA discussed below, made since I considered the application for a facility licence authorising ANSTO to construct the OPAL reactor in 2002, change my overall finding, that I set out in the previous decision authorising construction of the OPAL reactor, that the reactor should be able to be operated safely.

The SAR consists of twenty chapters. It describes the reactor site, the as-built reactor facility and its design, the process and safety systems and experimental facilities, and presents results of safety analyses to demonstrate adequacy of the as-built safety related structures, systems and components. It includes details of the safety principles and criteria applied to the design and how the reactor systems are integrated to protect the reactor, operating personnel, the public and the environment. The SAR assesses the consequences of anticipated operational occurrences, design basis accidents and severe accidents to show that the design safety limits and radiological criteria are met.

The SAR was closely reviewed by ARPANSA staff reviewers and a large number of questions were sent to ANSTO as a consequence of that review and subsequently ANSTO responses were considered by ARPANSA staff. A summary working document assessing the SAR was prepared to inform my decision.

5.2.2. The basis of the safety analysis

The *Safety Requirements* state:

> *A safety analysis shall be conducted of the design of the research reactor.*
> *The safety analysis shall include analyses of the response of the reactor to a range of postulated initiating events (such as malfunctions or failures of equipment, operator errors or external events) that could lead either to anticipated operational occurrences or to accident conditions. These analyses shall be used as the basis for the design of items important to safety and the selection of the OLCs for the reactor. The analyses shall also be used as appropriate in the development*

of operating procedures, periodic testing and inspection programmes, record keeping practices, maintenance schedules, proposals for modifications and emergency planning.(NS-R-4, para 6.72)

This statement draws out a number of features of what I expect a safety analysis to contain, having regard to international best practice in radiation protection and nuclear safety:

- The analysis begins with a range of 'postulated initiating events';
- The events include those leading to accidents;
- The analysis contributes not only to the design of the reactor's systems, structures and components, but to matters affecting operation throughout the life of the reactor.

The primary approach to safety analysis is a deterministic approach – that is, the initiating event is assumed to occur and then the response of the control and safety systems is analysed to assess whether safety limits are exceeded. The aim of the deterministic analysis is to show that for all credible initiating events, the reactor systems will work in a way that avoids safety limits being exceeded; and in case of highly unlikely initiating events any radiological release can be mitigated.

The performance of the reactor systems flowing from the initiating events being assumed to take place is analysed using thermal-hydraulic and neutronic computer codes and on the basis of conservative assumptions. The analysis draws on the idea of 'defence in depth' in the design. This is the idea that a reactor design should address safety at five levels. It can be illustrated by this table adapted from one in the OPAL reactor SAR:

Level	Objective	How achieved
Level 1	Prevention of abnormal operation and failures	Conservative design and high quality in construction and operation
Level 2	Control of abnormal operation and detection of failures	Control, limiting and other surveillance features
Level 3	Control of accidents within the design basis	Engineering safety features and accident procedures
Level 4	Control of severe plant conditions, including prevention of accident progression and mitigation of the consequences of severe accidents	Complementary measures and accident management
Level 5	Mitigation of radiological consequences of significant releases of radioactive materials	Siting Off-site emergency response

The safety analysis then should show that all the initiating events that have a reasonably credible chance of occurring during the life of the reactor will be handled by the levels of defence in depth up to and including level 3. The safety analysis needs also to review some events that are highly unlikely – 'beyond design basis accidents' – and review their impacts in the light of defence in depth levels 4 and 5.

The deterministic safety analysis is made manageable by only fully evaluating those initiating events the consequences of which exceed the results of other initiating events of the same type. That is, only the most severe event of a class is fully analysed.

The fundamental safety limit that the designers have chosen to apply in the safety analysis of the OPAL reactor is that the temperature of the fuel meat in the fuel plates must be kept below 400^0C for all 'design basis' accidents. This temperature is chosen as being well below the temperature at which it is known that the fuel will blister and begin to release fission products. For the purposes of the analysis and the setting of measurable safety limits, this fuel meat temperature limit is in turn translated into limits to the heat flux in the coolant to be at levels below where bulk boiling phenomena take place and the coolant degrades in its effectiveness.

In modern safety analysis, probabilistic safety assessment (PSA) is also carried out. As the name implies, this approach endeavours to estimate the probability of combinations of events occurring that may lead to a severe accident. PSA includes both design basis accidents and beyond design basis accidents and generally a PSA is performed that provides a surrogate for consequences, namely the core damage frequency (CDF). For the OPAL reactor a PSA was performed that calculated the CDF for a range of faults and internal (fire) and external (seismic) events, as well as the performance and reliability of the containment building and its engineered safety features. A revised and extended PSA has been carried out and submitted as part of the application.

5.2.3. Issues in the Accident Analysis

5.2.3.1. Scope of the Accident Analysis

In my statement of reasons in relation to my decision to issue a construction licence for the OPAL reactor, I referred to the fact that ARPANSA staff reviewers and public submissions were of the view that there should have been analysis of some more severe accidents so as to fully demonstrate the robustness of the design. Thus, during the assessment of the PSAR for the construction licence, ARPANSA sought analysis of certain additional 'events of interest' that had not been included in that PSAR. These analyses were supplied and were assessed as a part of the overall assessment process. I also required that there be a further analysis of a single fuel assembly melting in water to test the effect on the habitability of the main control room.

The SAR submitted with the Application did not include these accident analyses. Nor did it include the analysis of the Reference Accident that had been chosen by ARPANSA to test the siting of the reactor and endorsed in this regard by the Minister for Environment and Heritage in the context of the environmental impact assessment (EIS) process.

ANSTO's position was that these events were not credible in the context of the design of the OPAL reactor. I accept that there can be differing judgments about where to stop the process of analysing initiating events, but it was my view and consistent with the *Safety Requirements* that as it had formed the basis for siting licence, the EIS and the emergency response planning on and off site, the Reference Accident needed to be included as part of the SAR for the OPAL reactor. The melting of a single fuel assembly was, at least reasonable to consider as a beyond design basis accident caused by blockage of a fuel assembly by a foreign body.

ANSTO did submit analysis of the release of tritium from the cold neutron source, the melting of a single fuel assembly, the Reference Accident, as addenda to the SAR. These demonstrated that the radiological consequences of these accidents were acceptably low. Additionally, ANSTO provided addenda analysing the impact of a fuel oxide layer, discussed in the next section. I find that these analyses demonstrate that the reactor stayed safe in these circumstances.

5.2.3.2. Fuel Oxide Layer

The fuel assemblies for the OPAL reactor consist each of 21 fuel plates. The fuel plates are made up of fuel meat –uranium silicide powder dispersed in aluminium – and an aluminium cladding that separates the fuel meat from the coolant water. It is to be expected that the aluminium cladding sitting in water for a period of months will develop a layer of oxide on its surface. The significance of such an oxide layer is that it represents an additional layer of material through which heat must flow from the fuel into the cooling water. The oxide layer, further, is of low thermal conductivity – it is much less effective than the aluminium cladding in allowing the flow of heat. In both normal operation and when accidental 'transients' occur, the existence of an oxide layer will result in a higher temperature in the fuel meat than would otherwise occur. There will also be higher temperatures at the boundary of the meat and cladding, at the cladding-oxide boundary and the oxide-coolant boundary.

In the PSAR, it was argued that control of the cooling water chemistry so as to limit the conditions that would support the development of an oxide layer, with the particular type of aluminium employed as cladding, meant that a significant oxide layer should not be formed. It was not, therefore, taken into account in the analyses undertaken in the PSAR.

However, at the time of submission of RFA095 seeking my approval for the manufacture of the fuel in March 2004, INVAP had carried out further detailed analysis to assess whether an oxide layer may be formed and to analyse the effect of the oxide layer on the relevant temperatures involved. Drawing on results obtained from international research reactor fuel testing, INVAP acknowledged that an oxide layer would form. Using an international model for the formation of an oxide layer in the temperature and water conditions designed to be experienced in the OPAL reactor, the maximum thickness of the oxide layer was calculated to be 49 microns. This thickness would arise on the hottest fuel element at the end of its planned time in the reactor, conservatively assumed to be 190 days with more adverse water chemistry than anticipated for the OPAL reactor.

At the assessed maximum thickness of oxide layer, the effect on the fuel elements affected at full reactor power is to increase the maximum cladding inner temperature of the hottest fuel plate from 108.6 degrees reported in the PSAR to 151.8 degrees in the SAR and the maximum fuel meat temperature from 115.2 degrees to 158.8 degrees. While this is a significant change (noting the conservative assumptions applied) it does not have significant implications for safety in normal operation.

The analysis of the reactor transients presented in the SAR does, as mentioned above, use parameters related to heat flux and critical boiling phenomena in the coolant as a marker for the fundamental limit of temperature of the fuel meat. At first, it was not clear to ARPANSA staff reviewers that these analyses (presented in chapter 16 of the SAR) had included the effect of the oxide layer. ANSTO asserted that it was included – pointing out that the relevant thermal-hydraulic computer code included the oxide layer. ANSTO provided additional calculations from INVAP that assessed the most severe reactivity insertion case assuming the maximum thickness oxide layer. These calculations included all the relevant temperatures including the fuel meat and taking into account the oxide layer. Notably, the event where the first shutdown system failed and the reactor was shut down by later operation of the second shutdown system, produced a maximum fuel meat temperature close to, but still with a margin to the 400^0C limit chosen by the designers as the relevant safety limit.

I find that the analysis of the fuel oxide layer has been adequately carried out and demonstrates that the reactor stays within its safety margins during the most demanding transient. It is, however, important that it be clearly recorded that the margins have been reduced as a result of this analysis.

5.2.4. Probabilistic Safety Analysis (PSA)

5.2.4.1. Description of the PSA

A publication by INSAG (*Probabilistic Safety Assessment, INSAG-6, 1992)* some time ago provides a good definition of PSA:

> *In practice, PSA aims at:*
>
> - *identifying and delineating the* ***combinations*** *of events that may lead to a severe accident;*
> - *assessing the expected probability of occurrence for each combination;*
> - *evaluating the consequences.*
>
> *In order to perform these tasks, PSA methodology integrates information about plant design, operating practices, operating history, component reliability, human behaviour, accident phenomena, and (in its widest application) potential environmental and health effects. The approach aims at achieving completeness in identifying possible mishaps, deficiencies and plant vulnerabilities, and providing a balanced picture of the safety significance of a broad spectrum of issues, including the uncertainties of the numerical results.*

Any PSA must necessarily be reviewed and should evolve over the life of the reactor as more is learned about the specifics of that reactor's operations, reliability and the relevant human factors. This is especially the case for research reactors, where there is a more limited database of knowledge about the performance of some systems and components than exists for power reactors.

The PSA for the OPAL reactor is what is known as a level I PSA. It treats sequences of events in detail to the point where it is possible to estimate their contribution to a frequency for damage to the core of the reactor. A Level II PSA would undertake detailed probabilistic modelling of how radionuclides might be released from the fuel and interact with the materials in the reactor facility and the containment leading to an estimation of release to the environment. Finally, a Level III PSA models the pathways in the environment to estimate doses to people as a consequence of a release.

The OPAL reactor PSA has some aspects of Level II and III in order to allow estimates of the frequency-dose targets that are sought in ARPANSA's *Regulatory Assessment Principles.*

ANSTO included a PSA together with the PSAR at the time of its application for a construction licence. As part of its assessment of the construction licence application, ARPANSA made a number of recommendations about improving the PSA. The version submitted with the Application is upgraded with more information drawn from the detailed design and encompassing the previous ARPANSA recommendations that arose from the assessment of the application for a facility licence authorising construction of the OPAL reactor.

The PSA submitted with the application includes a fire PSA, being the probabilistic analysis of fire events and their potential impact on nuclear safety of the plant and directs particular attention to the locations where the occurrence and spread of fire will lead to damage to safety systems and ultimately core damage. I find that it demonstrates that, because core cooling in the OPAL reactor is achieved by natural convection and given the large volume of water in the Reactor Pool, fires do not contribute significantly to core damage frequency.

In preparing this version of the PSA, INVAP SE, the Contractor tasked with constructing the OPAL reactor, had preparatory material in five key areas independently reviewed. The areas were: initiating events; event tree headings; reactor containment system; fire PSA; and human reliability analysis (the proposed method of treatment of human errors). The review was available to ARPANSA staff reviewers and the reviewer supported the approaches taken in carrying out the PSA, notably with regard to the range of initiating events considered.

ANSTO/INVAP advised that the particular methodology adopted to carry out the PSA followed that methodology recommended in a PSA guide produced by the United States Nuclear Regulatory Commission [17] and an IAEA document[18].

An important part of any PSA is the treatment of failures that may have a common cause. This is because the observed failure probability of a set of items is often significantly greater than would be predicted by the product of the individual item failure probabilities. For this reason, common cause failures are modelled in PSA studies and usually make an important contribution to the estimated risk. The approach taken in the PSA for the OPAL reactor to this dependent failure modeling was to adopt the premise that ultimately all such failures are due to human error and to

[17] PRA procedures guide, US Nuclear Regulatory Commission, NUREG CR-2300, 1983.
[18] Application of Probabilistic Safety Assessment to Research Reactors, IAEA-TECDOC-517, IAEA, 1989.

use a human reliability analysis approach. For example, there may be design errors that result in a hidden design flaw in a set of identical components that fulfil a redundant function. It is postulated that the flaw exists with some probability and if present could cause all such items to fail simultaneously on demand. The process of reviewing and checking the design is modelled, with probabilities assigned to the design flaw not being found at each stage of the review and checking.

5.2.4.2. PSA Outcomes and Assessment

In brief summary, the results from the PSA are that the mean core damage frequency from internal events is 1.43×10^{-7} per year; for external (seismic) events, it is 3.75×10^{-7} per year. The Fire PSA estimates that the frequency of core damage for fire events is 1.28×10^{-8} per year, less than 10% of the contribution from the internal events.

In addressing consequence analysis (the Level III PSA considerations), ANSTO has chosen not to assess the consequences of core damage on the grounds that any given core damage scenario is of such low probability that they are not considered credible (below 10^{-6} per year). Instead the consequences of several other forms of accident that could lead to radioactive release are examined: fuel channel local blockage events; irradiated fuel handling events; and reactor utilisation events, being the loss of cooling flow (local or global) to the bulk production irradiation facility targets. The probabilities and release inventories of the credible scenarios are estimated. The performance of the containment is then considered. Using reasonably conservative assumptions about the performance of the containment systems and conservative modelling assumptions, the doses to people at the edge of the buffer zone at 1.6 km is calculated for each of the scenarios. The results demonstrate doses well below levels of regulatory concern, at worst in the region of tens of microsieverts.

ARPANSA staff reviewers took the view that the lack of consequence analysis for core damage because of low values estimated for core damage frequency was not in accordance with ARPANSA Regulatory Assessment Principle 37, which suggests that an investigation of individual accidents having frequencies down to about 10^{-7} per year should be undertaken to establish that there is no sudden unacceptable increase in consequences in the vicinity of 10^{-6} per year. The seismic induced loss of coolant and loss of flow accidents are cases in point since they have core damage frequencies of 1.25×10^{-7} per year and 2.5×10^{-7} per year respectively, and the seismic event could degrade the containment.

The ARPANSA staff reviewers examined the effect of this omission and were satisfied that neither case would result in a ‘cliff edge’ increase in unacceptable consequences (Principle 37).

Overall, I am satisfied that the PSA compares favourably with international best practice in relation to radiation protection and nuclear safety and it reflects the completed design of the reactor. I find that it is improved in methodology over that submitted with the construction licence application. It includes a fire PSA, and addresses human reliability systematically. I find that it demonstrates that:

- the core damage frequency is well below the objective of 10^{-5} per year, by at least one order of magnitude
- no single accident dominates overall risk and safety systems adequately protect against design basis accidents
- the protection systems are highly reliable.

5.2.4.3.Continuing Development of the SAR and PSA

As noted from the *Safety Requirements* the SAR continues to play an important role in the operation of the reactor over its lifetime and indeed for its decommissioning as the fundamental statement of the how the design of the reactor achieves safety. The Operational Limits and Conditions are derived from the SAR (including the PSA). It is used in the development and change to operating procedures, testing and inspection programs, record keeping and emergency planning. It would form the basis for consideration of any proposed modification of the reactor or its utilization. Experience with operation of the reactor in turn needs to be fed back into the SAR. Thus, it is also important to assess the standard of the document in being robust and well supported – able to be used for its purposes long after the people directly involved in and closely familiar with the design and construction are no longer available.

I find that the SAR ANSTSO has submitted for the OPAL reactor has established the safety case for the reactor that allows me to license its operation. It is comparable to the SARs for other research reactors. I find that it could be distinctly improved as the ongoing repository of design information and intelligence. ARPANSA staff reviewers during the assessment have raised questions about the wording of the SAR and especially the completeness of the referencing to supporting documents containing, for example, the detailed calculations of events. For this reason, I have placed a licence condition on the licence to operate the OPAL reactor that ANSTO update the SAR particularly with more thorough referencing of supporting documentation. ANSTO has agreed to make the changes as the SAR is reviewed and completed following commissioning. I am satisfied that ANSTO now understands the changes that need to be made to the SAR.

Taking into account the views of the ARPANSA staff reviewers and comparing the SAR and PSA with international best practice, I find that they constitute a sound basis for demonstrating the safety of the OPAL reactor and will be a valuable tool over the operating life of the reactor as they are developed in the light of operating experience.

5.2.5. Panellist Report

I note that in his report to me as a panellist on the public forum, Professor Falk recommended that *a licence to operate the OPAL nuclear research reactors should NOT be granted until:*

(i) it has been clearly demonstrated (including through disclosure of contingencies considered) that the chances of a serious accident are remote. Any information withheld in this process for security reasons should be demonstrated by an appropriate process of independent external review to be consistent with

international best practice and predicated on maximising the capacity for an open and informed assessment to be made of risk to the environment and human health from serious reactor accidents.

This recommendation flows from Professor Falk's critique principally of the PSA carried out by ANSTO and INVAP to analyse the safety of the reactor. He observes that there may be initiating events of accidents that have not been taken into account properly (suggesting that the list of initiating events was not available to the public). More especially, he argues that the impact of common cause failures whereby some event such as an earthquake or some human error results in damage to or failure of several safety systems.

I observe that both the SAR and the summary PSA published on the ARPANSA website did set out the initiating events that were considered in the analyses, though not in great detail.

In its response to Professor Falk's report, ANSTO pointed out that the safety analysis for the OPAL reactor is based both upon PSA and deterministic safety analysis. The latter does not rely upon probabilities, but assumes that certain events simply occur and then evaluates the consequences.

I have discussed my findings in relation to the SAR and the probabilistic safety analysis at some length – and, of course, considered earlier versions in considering the application for the OPAL reactor construction licence. The views if Dr Falk do not change the findings I have made in relation to the safety analysis for the OPAL reactor.

I do accept that some level of detail in the application and safety analysis is no longer available to the public because of the current security environment. This is a reality that must be accepted in the contemporary security environment. The information has, however, been fully available to ARPANSA staff reviewers and to the external peer reviewers.

5.3. Operational Limits and Conditions

In this section, I assess the information required by the CEO to be provided as part of the application, in particular operational limits and conditions required by item 17 of Part 1 of Schedule 3 of the regulations.

Operational Limits and Conditions (OLC) for a nuclear reactor are the 'rules' by which the reactor must be operated to provide assurance that it is operating within the parameters of safety that are established by its design and are demonstrated by its safety analysis report.

The OLC establish an envelope or boundary of reactor parameter values and system conditions within which the operation of the reactor facility has been demonstrated by the safety analysis report to be safe, and that the site personnel, the public and the environment are adequately protected from radiological hazards. Thus the OLC contribute to the prevention of accidents and the mitigation of the consequences of accidents should they occur.

OLC are fundamental to safe operation and all the relevant IAEA requirements dictate that they must be established by the operating organisation and approved by the regulatory body. In the event that the operation of the reactor deviates from one or more OLC, remedial actions must be taken and the regulatory body must be notified.

OLC are thus an important basis on which the operating organisation is authorised to operate the facility by the regulatory body.

The framework for OLC is laid out in IAEA *Safety Requirements,* including:

- ***Safety limits*** – set to protect the integrity of the physical barriers that protect against the uncontrolled release of radioactive material.

- ***Safety system settings*** – for safety parameters, there is a system that monitors the parameter and these are the settings at which some automatic action is taken to ensure that the parameter does not exceed the limit. The setting provides a safety margin from the safety limit that takes into account system transients, equipment response times and measurement uncertainty.

- ***Limiting conditions*** – are the conditions established to ensure that there are acceptable margins between normal operating values and the safety system settings consistent with the analyses in the SAR.. This is aimed at avoiding undesirably frequent actuation of safety systems. Limiting conditions include requirements relating to minimum operable equipment and minimum staffing levels and prescribed actions to be taken by operating personnel.

- ***Requirements for inspection, periodic testing and maintenance*** – these are the rules for the frequency and scope of inspection, periodic testing and maintenance, operability checks and calibrations of items important to safety.

- ***Administrative requirements –*** these are the controls addressing organisational structure and the responsibilities for key positions in the safe operation of the reactor, staffing, training of personnel, modifications etc. They also cover the required actions following a violation of an OLC.

OLCs may be established for a research reactor in its different operational states. For the OPAL reactor, these are defined as being: POWER, PHYSICS TEST (low power operation to test core physics parameters); SHUTDOWN and REFUELLING.

The OLC that ANSTO has submitted as Part D of the Application establish ***safety limits*** for the reactor power and reactor core flow of water when the reactor is in the POWER state and reactor power for the PHYSICS TEST state. There are safety limits for the reactor pool water level for the PHYSICS TEST, SHUTDOWN and REFUELLING states. Violation of a safety limit requires immediate shutdown of the reactor and immediate action to restore compliance, with compliance to be achieved within one hour.

The OPAL reactor OLCs then establish a large number of ***limiting conditions*** applicable to reactivity control systems, power limits, instrumentation, the reactor pool cooling systems, the containment, plant systems, electrical power systems, and re-fuelling operations. Each limiting condition first states the limit eg the First Shutdown System shall be operable. It then states the reactor conditions (POWER, PHYSICS TEST etc) to which the limit applies. There is then a table of actions required if the limit is not met eg the reactor must be taken to a SHUTDOWN state within 1 hour if the FSS is inoperable. Surveillance requirements are then stated which establish a frequency at which checks are undertaken relevant to establishing compliance with the limiting condition eg when control rod insertion times are verified.

The ***administrative requirements*** cover minimum staffing requirements for authorised operators in the different states of the reactor and for the availability of other expertise. They also establish systematic requirements for the carrying out of various programs.

The OLCs are fundamental to the safe operation of the OPAL reactor and have been given close attention during the assessment process by ARPANSA staff reviewers. The ARPANSA staff reviewers drew additional international guidance for assessment of the OLCs from the IAEA draft Safety Guide *Operational Limits and Conditions and Operating Procedures for Research Reactors* (DS 261, circulated for comment to member States by July 2006). The draft Safety Guide emphasises the need for clarity, the importance of operating personnel finding the OLCs to be meaningful and clear. The Safety Guide recommends as good practice that the format consist of a brief description of the objective, applicability, specification and basis for each of the safety limits, safety system settings and limiting conditions for safe operation. The presentation could also include a statement describing actions to be taken with the allowed completion time in the event of deviations from the OLC.

ANSTO's proposed OLCs for the OPAL reactor, which were based upon a US format designed for nuclear power plants[19]. They are simply and clearly expressed in line with these recommendations. There is a difference in that ANSTO has chosen to include the bases for the OLCs – the justification of the OLC in terms of the safety case for the reactor – in a separate document. ANSTO argues that this allows the OLC document to be more user-friendly, presenting the necessary information in just one or two pages per limit. I accept that argument because the coverage and approach of the ANSTO OLC is consistent with that suggested in DS 261

The IAEA peer review of March-April 2005 reviewed an early draft of the OLCs. The peer review team particularly pointed to the surveillance requirements. It noted that they had been based on PSA and manufacturers' recommendations resulting in longer surveillance intervals compared to the practice in research reactors. The team asked that the surveillance requirements be re-analysed 'paying special attention to the nature of a research reactor cycling through all four operational states at roughly monthly intervals, with more frequent changes taking place in the irradiation and experimental facilities.' Subsequently, I wrote to ANSTO commending this recommendation from the peer review team.

[19] Standard Technical Specifications for Light Water Power Reactors, NUREGs 1430 through 1434, Revision 2, US Nuclear Regulatory Commission, April 2001,

ANSTO considered the peer review team recommendations and matters raised in questions by ARPANSA staff reviewers in preparing the second revision of the OLCs.

ARPANSA staff reviewers agreed that the second revision OLCs, together with the bases document, do form an appropriate safe operating envelope for normal operation of the OPAL reactor. They also agreed that the limiting safety system settings had been established with appropriate account taken of measurement uncertainties. I concurred with this initial assessment. Three issues remained:

- That the limiting conditions for PCS flow, reactor power and RCPS rigs cooling flow were set at levels that had been used as input parameters to the safety analysis. It could be argued that when measurement uncertainty was taken into account the reactor may be operated with parameters that had not been **demonstrated** to be safe in the safety analysis against certain initiating events.

- That there was not an OLC set for core inlet temperature. This parameter also defined the input state for many of the accident analyses in the SAR and therefore needs mandatory control through an OLC.

- The procedures for verification of the power peaking factor need to allow for errors in fuel loading and other errors.

I put these matters to ANSTO on 23 June and they responded on 4 July. ANSTO:

- Agreed to undertake further transient calculations, after commissioning to be included in the review of the SAR. Information from commissioning and through the licensing process will be used to define a consistent, credible and conservative set of input parameters including uncertainties based upon commissioning measurements.

- Agreed to include an OLC to provide mandatory control of the core inlet temperature. An OLC and basis was provided.

- Responded to the issues about verification of the PPF, accounting for refuelling errors.

ARPANSA staff reviewers have assessed these responses as being appropriate and I find that the OPAL reactor has an acceptable set of OLCs for the operation of the OPAL reactor.

5.4. The Arrangements for Commissioning the Controlled Facility

Cold Commissioning has been carried out under the authorisation of the construction licence. This section deals with ‘hot’ commissioning, that is commissioning with nuclear fuel loaded, as the first part of the proposed operation of the OPAL reactor.

The relevant Hot Commissioning stages as defined in IAEA documentation and proposed to be followed by ANSTO are:

- Stage B1 – fuel loading; approach to criticality;
- Stage B2 – low power tests
- Stage C – power ascension tests and power tests.

That is, fuel is introduced into the OPAL reactor in stages to approach the state in which the core becomes critical. Tests of the performance of the core are then carried out at low power; and finally, the OPAL reactor is brought to full power in steps.

The commissioning arrangements in terms of the management system discussed above apply also to Hot Commissioning. In organisational terms, there is the addition of a Commissioning Safety Review Committee to the structure which was in place for Cold Commissioning. That committee is responsible for reviewing the nuclear safety and radiation protection implications of commissioning tests and reviewing these issues in any quality audit reports during the Hot Commissioning phase.

During Cold Commissioning, operation of the reactor systems and components was under the control and responsibility of personnel of INVAP, with the OPAL reactor operating personnel undertaking the plant operations as required by the tests. The responsibility for operation and maintenance of plant systems was gradually transferred from the ANSTO construction project team to the OPAL reactor operating group.

Under ANSTO's proposals set out in the application, during Hot Commissioning, OPAL operating personnel will take full responsibility for operation of the OPAL reactor systems and components, with INVAP personnel present to manage the tests and to provide assistance. The facility will be operated in accordance with the Operating Procedures and documentation and specific Commissioning Procedures for each test. For individual tests, the OPAL reactor will be controlled by normal shift crews of a Reactor Operator, Shift Manager and Plant Operator, supplemented as required. The Reactor Operators and Reactor Shift Managers will be accredited to their positions by the Reactor Commissioning Manager prior to Hot Commissioning. The Plant Operators will be fully trained for their positions.

The OPAL Reactor Operation Group will also be responsible for maintenance of systems during the Hot Commissioning stages and this will be undertaken by officers trained in mechanical, instrumentation and control and electrical systems.

The full physical security arrangements are to be in operation for Hot Commissioning, as well as the emergency plan.

The tests to be carried out in Stage B commissioning are to confirm that the reactor can be started up in a safe manner and that the reactor physics parameters are satisfactory. During Stage B1 commissioning, fuel assemblies are loaded into the core for the first time. The first loaded core is a sub-critical configuration and is set up according to calculations (it will not be all 16 fuel assemblies and it is anticipated that core will be critical after 12 or 13 fissile fuel assemblies. It should also be noted that the original core is different from the equilibrium core which will not be reached until

5 or 6 full operating cycles are completed). An external neutron source is used to supply a known neutron flux to the core and neutron measurements are carried to measure the sub-critical multiplication occurring and to determine subsequent safe increments in the reactivity of the core from loading further fuel assemblies. The measured core sub-criticality conditions are compared with the predictions of calculations, taking into account the uncertainties in both measurement and calculation. When a core configuration is predicted as capable of sustaining a critical condition, then the approach to criticality is managed by control rod extraction. Once the first critical core configuration has been reached, the shutdown margin of the First Shutdown System is measured.

The First and Second Shutdown Systems are to be operational during this Stage B1 commissioning.

In Stage B2, the aim is to proceed to the loading of the core of 16 fuel assemblies and to conduct performance tests at low power (< 400 kw). As before the two shutdown systems are operational and the core is cooled by natural convection. The tests to be carried out include reactivity measurements, reactivity control and shutdown systems tests, thermal neutron flux mapping measurements and neutron and gamma field measurements. Important parameters that will be measured include those that obtain the feedback in reactivity that arise from variations in the reactor power at this low level. The calibration of neutron and gamma radiation detectors is tested. The changes in reactivity brought about by the use of the irradiation facilities will be tested. The effectiveness of the reactor shielding will be measured.

The purpose of Stage C is to safely increase reactor power in steps up to the nominal power level, carrying out tests during power ascension and at full nominal power to demonstrate that the reactor can be operated safely. Safety related thermal-hydraulic and neutronic parameters will be measured and compared with predicted values and recorded to establish a baseline for parameters routinely measured during operation. A series of tests will be carried out at each step to confirm design and safety.

Tests of the Reactor Protection Systems, Reactor Control and Monitoring System and the Post Accident Monitoring System will be assessed. Surveys will be carried out to confirm adequacy of radiation shielding. Health Physics Surveyors will be available during tests, as required by the individual test procedures. Tests at intermediate power levels of 1, 3 and 5 MW will check the thermal-hydraulic parameters for the Primary Cooling System, Reactor and Service Pool Cooling System, Reflector Cooling and Purification System and Secondary Cooling System. These tests, and calibration of nucleonic instrumentation, will also be done at high power levels of 10, 15 and 20 MW.

The tests undertaken during Stage C will give an indication of the following specific reactor performance characteristics:

- The thermal hydraulic performance at each power level so that predictions of full power performance can be made.
- Reactivity power coefficient measurements.
- Operation of the automatic power control system performance.

- Xenon effect assessment.
- Loss of normal power supply.
- Long term pool cooling system performance.
- Deuterium recombination system performance.
- Containment ventilation system performance.
- Calibration of the N_{16} power detector.
- Final layout adjustment of nucleonic instrumentation position.
- Evaluation of Secondary Cooling System performance.

The Stage B2 and C Commissioning procedures identify the tests associated with irradiation rigs and experiments, from both a reactivity and thermal hydraulic perspective. Dummy targets will be used for the irradiation experiments initially and the reactivity worth’s of both fixed and unfixed irradiation rigs is measured. General tests associated health physics and experimental devices include:

- Assessment of main reactor shielding (measurements)
- Assessment of neutron guide shielding (measurements)
- Activity measurements in liquid and gaseous streams
- Radiation surveys in facility rooms and areas
- Cold Neutron Source tests at below 20 MW
- Cold Neutron Source tests at 20 MW
- Test of the production cycle for bulk irradiation facilities
- Pneumatic transport tests and associated hot cell tests.

The Cold Neutron source (CNS) tests will be done in the Standby Operation (SO) mode, and Normal Operation (NO) mode at a range of reactor operating powers.

5.4.1. Assessment and findings

To assist in assessment of the Hot Commissioning program, I engaged Professor Klaus Schreckenbach, Technical University of Munich. Professor Schreckenbach is an experienced reactor physicist and was the Commissioning Reactor Manager for the modern, pool-type, 20 MW FRM-II research reactor during its successful commissioning in 2003-04.

Professor Schreckenbach reviewed the Specific Commissioning Test Plans for Hot Commissioning and the supporting Commissioning Test Procedures for Stages B1 and B2. He visited Sydney in February-March 2006, inspected the reactor and had discussions with ARPANSA, ANSTO the OPAL Reactor Operations Group and INVAP physicists. Professor Schreckenbach will also witness some tests, on behalf of ARPANSA, during Stage B2 low power physics tests.

Professor Schreckenbach provided a report making observations and a number of recommendations about the Hot Commissioning Plans and Procedures. In general, he found that the organisation and arrangements proposed for the Hot Commissioning, together with the structure of the commissioning procedures were adequate with no missing items identified in the template for procedures.

He commented, however, that some "pre-requisites" were not complete in terms of some important safety issues and that there was a need for a 'tick off' when pre-requisites were satisfied. He also made some other specific suggestions to improve the various test procedures.

I forwarded this report to ANSTO on 24 March 2006, requesting ANSTO to give consideration to its recommendations and comments. ANSTO responded by letter dated 9 May 2006 and this was provided to Professor Schreckenbach on 12 May 2006. ANSTO developed a number of new procedures and modified existing procedures, taking account of the recommendations and comments by Professor Schreckenbach. These were provided to ARPANSA in April and May 2006.

Following review of ANSTO's responses to these recommendations, Professor Schreckenbach provided additional advice to me about the adequacy of the Hot Commissioning Procedures on 18 June 2006. He made a number of recommendations for further change. He advised that, following resolution of these recommendations, the Commissioning Test Procedures are appropriate for Stages B1 and B2 and are complete for safe start up of the reactor and measuring the required reactor parameters and radiation data. The report was provided by letter on 22 May 2006 requesting ANSTO to address the recommendations.

ANSTO responded on 6 July with each test procedure commented upon, providing a revised test procedure or a clarification. The response was satisfactory to ARPANSA staff reviewers. I also find that it was satisfactory.

In addition to the plans and procedures for Hot Commissioning, ANSTO supplied a Commissioning Safety Case (RRRP-7300-3BEIN-002-D) and Commissioning OLCs (RRRP-7315-EDEIN-001-D). The Commissioning Safety Case is required because the operating parameters of the reactor during commissioning including some different safety system settings and especially the initial cores of fuel in the reactor are necessarily different from the equilibrium core that is used in the overall operating safety case.

ARPANSA staff reviewers examined the Commissioning Safety Case. ANSTO argued in the Commissioning Safety Case that the only initiating event that may not be bounded by the events analysed in the SAR are reactivity insertion accidents. ARPANSA Officers accepted this argument. They found, however, some differences between the analysis of reactivity insertion accidents in the Commissioning Safety Case and that undertaken in the SAR and requested that the analysis be re-done in a manner consistent with the SAR.

ANSTO submitted a revised safety case on 6 July 2006 meeting that addressed these issues to my satisfaction.

In general the OLCs for Hot Commissioning are identical to those for normal operation, but there are some exemptions and relaxations for Stages B1 and B2 related to the hazard level from the fission product inventory in the fuel. In general all the OLC omissions and exemptions for Stages B1 and B2 are acceptable to the ARPANSA staff reviewers since the fission product inventory up to the end of Stage B2 is so small

ARPANSA staff reviewers are satisfied that the organizational, management and quality arrangements will be comparable to those in the IAEA safety guide and the ARPANSA commissioning guideline. The successful use of these organizational and management structures, arrangements and processes during Cold Commissioning gives confidence in their application to Hot Commissioning.

The Specific Plans covering the various stages of Hot Commissioning are assessed by ARPANSA staff reviewers as adequately describing the purposes of the stages, the arrangements for undertaking the tests, and the test methods. The Specific Plans detail the organisational arrangements, pre-requisites, tests, scheduling, and applicable Limits and Conditions. They are concise, clear and identify responsibilities, relevant warnings and guidance information relevant to the planning and conduct of Hot Commissioning.

ARPANSA staff reviewers assess the scope of Hot Commissioning tests as being generally comprehensive. The testing planned covers normal operation and anticipated operational occurrences. The anticipated operational occurrences include loss of power and First and Second Shutdown System trips. In addition, the Reactor Control and Monitoring System for automatic power and manual power movements of control rod plates will be tested in all reactor states to ensure the interlocks and inhibitions function correctly.

ARPANSA staff reviewers assess that the individual Commissioning Test Procedures are thorough, concise, easy to follow and include the necessary information, warnings and advice for the safe conduct of the tests. They are satisfied that suitable written procedures following a standard quality format have been prepared and are consistent with IAEA and ARPANSA guidance documents. The individual procedures generally contain the information necessary for the individual tests. ARPANSA's consultant suggested the inclusion of some additional information.

5.4.2. Finding

Having reviewed ANSTO's proposed Hot Commissioning Plan and the assessments and recommendations of ARPANSA staff reviewers in the working documents, I find that the Commissioning Plan compares favourably with international best practice.

A particularly critical part of the commissioning program is the decision to allow the program to proceed from one stage to the next and how any non-conformances that arise are dealt with. The organisational structure above gives the role to the OPAL reactor Commissioning Group to make the decisions on non-conformances. This is appropriate. In terms of the decision to proceed from Stage B1 to B2 to Stage C, ANSTO has agreed that my approval will be sought as part of its Hot Commissioning plan. I will assess the ANSTO report provided to the Commissioning Group and the reports of ARPANSA inspectors arising from inspections during the process. My focus will be to assess whether any non conformances that my have arisen during each stage have been (or will be) appropriately dealt with in accordance with the approved commissioning arrangements. I will brief the NSC at each stage.

Taking into account the views of ARPANSA staff reviewers and ARPANSA's international consultants, together with ANSTO's responses to the matters raised, I find that the arrangements for Hot Commissioning of the OPAL reactor are satisfactory.

5.5. The Arrangements for Operating the Controlled Facility

5.5.1. Operating Procedures

The IAEA *Safety Requirements* states that operating procedures be developed for all safety related operations that may be conducted over the entire lifetime of the reactor facility. It proposes that the procedures should include:

(a) Commissioning;
(b) Operation in all operational states and, where appropriate, the loading, unloading and movement within the reactor of fuel elements and assemblies or other core and reflector components, including experimental devices;
(c) The maintenance of major components or systems that could affect reactor safety;
(d) Periodic inspections, calibrations and tests of SSCs that are essential for the safe operation of the reactor;
(e) Radiation protection activities;
(f) The review and approval process for operation and maintenance and the conduct of irradiations and experiments that could affect reactor safety or the reactivity of the core;
(g) The reactor operator's response to anticipated operational occurrences and DBAs and, to the extent feasible, to BDBAs;
(h) Emergencies;
(i) Physical protection;
(j) Handling of radioactive waste and monitoring and control of radioactive releases;
(k) Inspection, periodic testing and maintenance, as required, of the reactor and its auxiliary systems during extended periods of shutdown of the reactor;
(l) Utilization;
(m) Modifications;
(n) Activities of an administrative nature with a possible effect on safety (e.g. the control of visitors);
(o) Quality assurance.

The *Safety Requirements* make clear that operating procedures are to be developed by the reactor operating organisation and be consistent with and useful for observance of OLCs. The *Safety Requirements* state that they shall be reviewed independently (eg by the safety committee) and be subject to the approval of the reactor manager. The

IAEA draft Safety Guide *Operational Limits and Conditions and Operating Procedures for Research Reactors* (DS 261, circulated for comment to members States by July 2006) provided further detail on the scope and coverage of operating procedures.

ANSTO has developed operational documents and general business documents regarding all aspects of the OPAL reactor operation. This is outlined in section 4.1.3 and forms an effectively quality system covering all aspects of the OPAL reactor operation.

It is not the role of the regulatory body to review and approve individual operating procedures but to satisfy itself that the operating organisation has established an appropriate suite of such procedures and has an effective process for establishing and reviewing them. ARPANSA staff reviewers has assessed ANSTO's process as described at Chapter 13 of the SAR, has reviewed several operating procedures in detail and compared the overall suite of operating procedures with the structure described in the IAEA documents.

ARPANSA staff reviewers, although identifying a number of specific areas for improvement, have assessed the overall scope and coverage of these documents to be comprehensive. ANSTO has acknowledged that further development of the documentation will be undertaken as experience of operation is gained.

The second IAEA peer review team concentrated on reviewing proposed the OPAL reactor operating procedures. The team reported that it was 'confident that, in finalizing the procedural documents, the operator will have a comprehensive set op Operating Procedures'. The review team particularly drew attention to the role of the OPAL reactor's almost full-scale training simulator which allows the behaviour of all the safety related system to be tested and the adequacy of the operating procedures to be verified. The team noted that the simulator serves as an excellent tool in training operators in the standard operating procedures and can be used to train in a number of pre-defined deviations from normal operation. The team regarded this as international best practice. The team made some specific recommendations that were considered by ANSTO.

ARPANSA staff reviewers raised issues about the state of development of the operating procedures documentation in that many important documents appeared not to have been fully reviewed and accepted by ANSTO. I put these matters to ANSTO in a letter dated 23 June 2006.

In its response dated 4 July 2006, ANSTO replied stating that it had authorised for use 241 manuals, procedures and instructions out of a total of 244 such documents. Surveillance Instructions have been drafted by INVAP and are technically complete and are being currently incorporated into the OPAL Reactor BMS. ANSTO noted that all manuals are subject to verification and subsequent modification during the course of commissioning and are marked up during the commissioning process. On this basis ANSTO asserted that it considered that the manuals, procedures and instructions necessary for operation of the OPAL reactor are sufficiently complete and appropriate for use to allow for operation of the OPAL reactor. ARPANSA staff reviewers are of the view that these matters should be re-evaluated at the time of the first periodic safety review, when Hot Commissioning has been completed and some operating experience of implementing the system has been accumulated. I agree with this position.

5.5.2. Inspection, Periodic testing and maintenance

The IAEA *Safety Requirements* state:

> *Inspection, periodic testing and maintenance shall be conducted to ensure that SSCs are able to function in accordance with the design intent and with requirements, in compliance with the OLCs and in accordance with the long term safety of the reactor. In this context, the term 'maintenance' includes both preventive and corrective actions.*
>
> *There shall be documented programmes based on the SAR for the inspection, periodic testing and maintenance of the reactor equipment, especially all items important to safety. It shall be ensured by means of these programmes that the level of safety is not reduced during their execution. The inspection, periodic testing and maintenance programmes shall be reviewed at regular intervals to incorporate lessons learned from experience. All inspection, periodic testing and maintenance of systems or items important to safety shall be performed by following approved, written procedures. The procedures shall specify the measures to be taken for any changes from the normal reactor configuration and shall include provisions for the restoration of the normal configuration on the completion of the activity. A system of work permits in accordance with the quality assurance requirements shall be used for inspection, periodic testing and maintenance, including appropriate procedures for checking off before and after the conduct of the work. These procedures shall include acceptance criteria. There shall be a clearly defined structure of review and approval for the performance of the work.*

Further international guidance was drawn from the IAEA draft Safety Guide *Maintenance, Periodic Testing and Inspection of Research Reactors* (DS 260, recently approved for publication). This document emphasises that arrangements for maintenance, periodic testing and inspection are to be a part of the overall management system for the reactor facility.

The *Safety Guide* draws out the idea of maintenance being:

- preventative maintenance consisting of regularly scheduled inspections, testing, servicing, overhauls and replacement activities. Its aim is to enhance the reliability of equipment, to detect and prevent incipient failures and to ensure the continued capability of the SSCs to perform their intended function.

- corrective maintenance, being repair and replacement activities not occurring on a regular schedule.

Periodic testing should be carried out, generally at fixed time intervals, to maintain and improve equipment availability, to ensure compliance with the OLCs (also fulfilling the surveillance requirements) and to detect and correct abnormal conditions.

On a pre-determined schedule, the operating organisation should examine the SSCs for deterioration and to evaluate the effect of ageing on them so as to determine whether they are acceptable for continued safe operation or whether remedial measures should be undertaken. The *Safety Guide* emphasises the importance of evaluation of SSCs important to safety, particularly embedded piping, tanks and other areas normally restricted from view.

ANSTO refers to the OPAL reactor maintenance activities as being managed within its overall organisational arrangements and safety management system. Within the operating organisation, the engineering and maintenance staff report to the Manager, OPAL Engineering and then to the Reactor Manager. There is a brief discussion of maintenance, testing and inspection in Chapter 13.7 of the SAR. The OPAL reactor BMS at OP 11 and supporting documentation provide the detail on ANSTO's plans for maintenance, testing and inspection.

ARPANSA staff reviewers have found that ANSTO has developed a good maintenance management system. Maintenance activities will be scheduled and managed using a computerised Maintenance Management System. A presentation of this system was provided to ARPANSA officers in February 2006. The system is based closely on the existing maintenance system used by ANSTO site wide. It appears to offer a good level of management control if operated appropriately based upon understanding of the plant, safety systems, OLCs and safety case.

The frequency of surveillance and maintenance activities is defined for safety systems in the OLCs and generally in the maintenance manuals. Maintenance schedules and requirements are programmed into a computerised maintenance management system (SAP) within the BMS.

ARPANSA staff reviewers were briefed by ANSTO on the maintenance management system and witnessed demonstration of its application. The surveillance frequencies set out in the OLC for structures, systems and components important for safety are satisfactory to ARPANSA staff reviewers. They are satisfied and I agree that this system is a systematic and effective process for addressing the in-service inspection, testing and maintenance of items important for safety. ARPANSA staff reviewers are of the view that these matters should be re-evaluated at the time of the first periodic safety review, when commissioning has been completed and some operating experience of implementing the system has been accumulated. I will take this into account in assessment of this periodic safety review.

5.5.3. Fire Safety

The IAEA *Safety Requirements* state that:

> *The operating organization shall conduct periodic fire safety analyses. These analyses shall include: assessments of the vulnerability of safety systems to fire;*

modifications to the application of defence in depth; modifications to fire fighting capabilities; the control of inflammables; the control of ignition sources; maintenance; testing; and the readiness of personnel.

ANSTO's overall approach to fire protection for the OPAL reactor is described in Chapter 10 of the SAR. A fire analysis is also included in the PSA.

ARPANSA engaged the services of *CSIRO Fire Science & Technology Laboratories (FSTL)* to review:

- the design manual for the fire detection, emergency warning & intercommunication system, and suppression systems (RRRP-5315-EBEWO-002-A);

- the fire hazard analysis (RRRP-5315-3BECW-002-A).

On the basis of the document review, FSTL was of the opinion that:

- the methods of analysis adopted were reasonable;
- the acceptability criteria were reasonable;
- the design fire scenarios applied to the fire modelling were appropriate for the application and were reasonably conservative;
- the fire resistance analysis would need to be expanded to demonstrate their equivalence to "Deemed to Satisfy" provisions of the Building Code of Australia Performance Requirements;
- the levels of redundancy in the design of the cabling were demonstrated to be reasonable.

ANSTO confirmed that the equivalence to the "Deemed-to-Satisfy Provisions" will be demonstrated in revisions of the fire hazard analysis.

I find that ANSTO's overall approach to fire protection for the OPAL reactor is acceptable.

5.5.4. Core management and fuel handling

The IAEA *Safety Requirements* state:

Core management shall be used to produce safe operational cores consistent with the needs of the experimental programme. The basic activities for core management are:

(a) To determine by calculation, using validated methods and codes, the appropriate locations for fuel, reflectors, safety devices (such as neutron absorbing rods and valves for dumping the moderator and burnable poisons), experimental devices and moderators in the core;
(b) To keep and update baseline information on the parameters for the fuel and core configurations;

(c) *To procure fuel on the basis of specifications in accordance with the design intent and the requirements of the OLCs;*
(d) *To load the fuel following the procedures for fuel handling;*
(e) *To utilize (burn up) the reactor core while ensuring the integrity of the fuel by maintaining the relevant parameters for the core configuration in accordance with the design intent and the assumptions as specified in the OLCs for the reactor, and by detecting, identifying and unloading failed fuel;*
(f) *To unload the irradiated fuel when appropriate.*

and

> *Fuel handling comprises the movement, storage, transfer, packaging and transport of fresh and irradiated fuel. Applicable safety requirements shall be complied with in these processes.*
> *Procedures shall be prepared for the handling of fuel elements and core components to ensure their quality, safety and physical protection and to avoid damage or degradation. In addition, OLCs shall be established and procedures shall be prepared for dealing with failures of fuel elements and control rods so as to minimize the amounts of radioactive products released. The integrity of the reactor core and the fuel shall be continuously monitored by a cladding failure detection system, not necessarily on-line. If a failure of fuel is detected, an investigation shall be conducted to identify the failed fuel element. Authorized limits shall not be exceeded and if necessary the reactor shall be shut down and the failed fuel element shall be unloaded.*

Additional international guidance has been drawn from the IAEA draft Safety Guide *Core Management and Fuel Handling for Research Reactors* (DS 350).

I imposed a licence condition on the construction licence requiring ANSTO to validate the computational modelling used to demonstrate the safety of the reactor and to support its safe operation. On 17 February 2003, I wrote to ANSTO requesting a plan for addressing the licence condition.

ANSTO identified and investigated computer codes planned for routine use during the OPAL reactor operation. CITVAP is used for general core calculations in the SAR and will support reactor operations. It calculates core neutronic parameters including; excess reactivities and shutdown margins; neutron flux and power distributions and Power Peaking Factor (PPF) for fuel and rig changes; temperature and void feedback coefficients; the kinetic parameters prompt neutron lifetime and delayed neutron fraction.

The methodology adopted for code validation and verification covered:

- comparisons of model solutions with relevant experimental and analytical data,
- assuring that the model results are consistent with the physical assumptions made,
- ensuring correctness of coding, verifying the stability of the numerical methods used, and the correctness of solutions generated from the programmed equation set.

ARPANSA staff reviewers are satisfied that ANSTO undertook an extensive and thorough process to address the validation and verification of the suite of neutronic (and thermal-hydraulic) computer codes used in developing the safety case for the OPAL reactor, and upon which operation of the reactor will rely.

I am satisfied that the validation provides confidence in the accuracies of the estimated values of reactor safety parameters, and quantitative estimates of their uncertainties, used in developing the safety case, defining the proven safe envelope for operating the reactor, and setting the OLC's and safety system settings. ARPANSA staff reviewers are satisfied that the suite of computer codes and their accuracy is comparable to those used for application to similar research reactors.

I note that Hot Commissioning will be used for further validation on the computational accuracy of the codes, particularly the estimates of neutronic parameters, when the reactor is critical and generating power.

ARPANSA staff reviewers are satisfied that the fuel management strategy and control plate operating strategy result in sufficient margin to the analytical Power Peaking Factor limit of 3.0 to allow for operational errors in these strategies and manufacturing error with burnable poison [Analysis of the Power Peaking Factor in Abnormal Situations, RRRP-0140-3BEIN-07].

OLC 5.2.1 covers the PPF Verification Program to demonstrate that after any fuel loading into the core, the PPF would remain below the design value of 3.0 assumed in Chapters 5 and 16 of the SAR. The instruction for the PPF Verification Program, OOI 000-003, is incorporated within the OPAL reactor Business Management System. These would allow the reactor to be operated with a calculated PPF value up to 3.0.

However, while computational error is accounted for in calculating the PPF, neither the OLC nor the instruction accounted for error in fuel loading, missing cadmium wire or control rod misalignment strategies. I wrote to ANSTO on 23 June 2006 requesting this matter to be addressed.

ANSTO responded on 4 July 2006 advising that, before each operating cycle, the PPF will be calculated throughout the cycle for normal operating conditions to account for Control Plate movement and build-up of xenon. In the revised instruction, an allowance of 20% will then be made to account for any abnormal circumstances, bounding the 16.4% effect of two independent errors calculated in RRRP-0140-3BEIN-07. Also, ANSTO expects that any significant abnormal fuel loading error or missing burnable poison wire in a Fuel Assembly will be identified as an anomaly in the predicted reactivity balance ant low power.

I find this approach acceptable.

The instruction for the PPF verification in the OLC contemplates only two series of flux measurements (for the first and second cores) to validate the calculational methodology against measurement. ARPANSA staff reviewers were of view that, to gain confidence in the methodology, the measurement of the PPF should be also be undertaken for intermediate cores up to and including the first equilibrium core that consists fully of standard Fuel Assemblies.

In response, ANSTO referred to advice from Prof Schreckenbach, that flux measurements for the first two cores, providing some 300 measurements, will provide an adequate basis for assessing the accuracy of calculated values of PPF, and deciding whether further measurements are needed.

This is satisfactory to me.

The nuclear design described in Section 5.7 of the SAR accounts for a specific fuel management strategy that was used in the various safety analyses (e.g. Power Peaking Factor (PPF) evaluation, Control Rod Plate management strategy). This strategy results in a limitation of the residence time of the fuel assemblies in the core and thus on their burn-up. I was concerned that other fuel management strategies, and therefore burn-up beyond this implied limit, might result in PPF exceeding the analytical limit of 3.0 in some circumstances. ANSTO agreed to follow the strategy analysed in the SAR and to seek my approval under regulation 51 for any future proposed changes.

The procurement of fuel was covered by RFA095 for fuel manufactured by CNEA and RFA115 for fuel manufactured by CERCA. I approved the manufacture following a thorough review of the specification by ARPANSA staff and I imposed licence conditions requiring ANSTO to arrange third party audit of the manufacturer's quality assurance processes, during fabrication. These audits were reported to me and were acceptable.

The refuelling process is controlled by procedures under the BMS. These procedures were tested and verified using dummy fuel assemblies during Cold Commissioning. ARPANSA inspectors reviewed these and were satisfied that the procedures were appropriate. In particular, they provided for independent verification of correct fuel loading configurations and clamping of fuel assemblies into the core.

Because the irradiation positions and neutron beam guides for OPAL all lie outside the core, OPAL core management is a simpler proposition than for some more complex research reactors. ANSTO also has the advantage of having designed for all the fuel handling, including post-irradiation storage, to be able to take place within the reactor facility.

I find that the OPAL fuel management strategy is acceptable.

5.5.5. Utilization and Modification of the Reactor

The IAEA *Safety Requirements* establish clearly that it is for the operating organisation to take responsibility for all safety aspects of the utilization and modification of the reactor. Utilisation and modification projects having major safety significance must be subject to safety analyses and to procedures for design, construction and commissioning that are equivalent to those required for the reactor itself.

The plans for utilisation of the OPAL reactor are described in Chapter 11 of the SAR, together with the arrangements for review and approval of modifications in utilisation and experimental facilities. Chapter 16 of the SAR analyses reactor utilisation initiated events. Utilisation has been reviewed by ARPANSA as part of the review of the SAR as built design.

The primary use of the OPAL reactor is the production of neutron beams for research and the neutron irradiation of materials. The reactor is proposed to be operated on a continuous basis at full power for several weeks followed by short shutdowns for refuelling and maintenance.

Chapter 11 of the SAR describes the various irradiation facilities, the hot cells and conveyors or other methods used for handling or transport of fresh and irradiated targets. The important safety aspects of the irradiation rigs are described. It gives links to the safety design bases and in particular to Chapter 16 SAR. A special case is referenced for the Cold Neutron Source (CNS).

The irradiation facilities are:

- Bulk Production Irradiation Facilities (BIF).
- Long Residence Time General Purpose Irradiation Facilities (LRT).
- Short Residence Time Irradiation Facilities (SRT).
- Large Volume Irradiation Facilities (LVF).
- Specific hot cells with pneumatic equipment for the delivery and retrieval of specimens and targets to and from the Reflector Vessel.
- A series of installations for Irradiated Material Handling and Delivery.

The beam facilities include:

- Neutron Beam Assemblies with shutters to extract neutron beams from the Reflector Vessel.
- Cold Neutron Source (CNS) facility.
- Hot Neutron Source provisions (to allow future installation of a hot neutron source).
- Neutron Guide System.

The BIF, LRT and LVF are loaded and unloaded from the reactor pool bridge using a bridge hoist. Much design consideration has been given to the prevention of dropped loads, and all the in pile components are protected by metal shields that are designed to withstand the heaviest load proposed (which is a silicon ingot). There are also hot cells with pneumatic equipment for delivery and retrieval of (short residence term pneumatic) targets to and from the reflector vessel and installations for irradiated material handling and delivery. In addition there are interlock safety provisions to prevent the “too early” removal of a BIF target (which is a fissile target for isotope production) from the Service Pool Water into the hot cells.

An important feature is that these experiments and irradiation facilities are located within the reflector and there are none in the core of the reactor, so their effects on reactor control and potential reactivity insertion accidents is minimal. The reactor power is automatically controlled by movement of the central control rod and the effect of the irradiation rigs is not significant in view of the rigs being in the Reflector and not the core.

A significant feature that lowers the OPAL reactor radioactive gaseous discharges to the environment is the use of nitrogen for pneumatic transport and cooling of irradiation targets in the LRT and SRT facilities. This prevents the formation of Argon 41 from irradiation of air. Additionally, targets are not processed in the Reactor Building, but are transported by the Inter-building Pneumatic Transfer System (IPTS) or by shielded flasks to other facilities for processing.

I approved the construction of experimental and irradiation facilities as part of the RFA process, following review of the requests by ARPANSA staff reviewers.

An important safety feature of the CNS is the provision of a Vacuum Containment (VC) within the Reflector Vessel. This is a Safety Category 1 component and was subject to a prolonged fabrication and testing programme in St Petersburg (Russia). I contracted a consultant from TUV-Rheinland to advise me on the design and fabrication of the vessel, as well as to undertake factory inspections. The CNS-VC is designed to withstand a severe deuterium-oxygen explosion without failure. I approved the manufacture and installation of the Vacuum Containment.

The safety of utilisation facilities has been reviewed by ARPANSA as part of the review of the SAR for the as built design. Section 16.7 of the SAR assesses reactivity transients resulting from the insertion and withdrawal of irradiation rigs with absorber or fissile material for irradiation facilities in the reflector vessel. Accidents involving a loss of flow in the irradiation facilities are addressed in section 16.15 of the SAR (i.e. Reactor Utilisation Initiating events). They are analysed with respect to the consequences regarding to the rigs. It is note worthy that Chapter 16 identifies failure of BIF irradiation rig as the highest consequence design basis accident.

The Operational Limits and Conditions (OLC) and Chapter 5 of the SAR limit the amount of reactivity controlled by rigs that can be moved at full power to values that would not result in uncontrolled transients. In addition, there is a limit on the maximum heat flux at the surface of any irradiation rig (limited usually by a BIF fissile rig) to ensure a large margin to the onset of an unacceptable thermal hydraulic or boiling crisis. There has been a significant change from the PSAR in terms of allowable heat flux. I accepted this change during the RFA process.

I find the plans for utilisation and modification of the OPAL reactor to be acceptable.

5.6. Environmental management

Chapter 14 of the SAR states ANSTO's commitment to environmental principles and minimisation of the environmental impact from the operation of OPAL reactor. The OPAL Reactor Environmental Management Plan (RRRP-7270-EDEAN-001-REV1) describes the organisational arrangements for the integration of environmental aspects related to the operation of the OPAL reactor within ANSTO's Environmental Management System (EMS).

The construction licence required ANSTO to obtain and maintain certified to the ISO 14001 standard for the Environmental Management System (EMS) and ANSTO obtained accreditation in June 2004.

A series of Environmental Management Plans (EMPs) have been documented for achieving the objectives and targets, with control measures for:

- managing and monitoring of liquid and airborne radioactive wastes and emissions, and managing solid radioactive waste, following appropriate procedures and arrangements.

- procedures to assess off-site doses to the members of the public.

- monitoring and management of groundwater discharge to ensure that no additional dose is received by the public from such discharge.

- control of surface runoff and sediment from the Reactor Facility. Monitoring of surface water quality enables the detection and quantification of any release of radioactive material.

The airborne emissions expected to be produce at the facility are: Ar-41 and other noble gases (Kr & Xe isotopes); H-3 and tritiated water vapour; airborne particles (aerosols); small quantities of iodine isotopes; and noxious gases from vacuum pumps and fume cupboards. The details of the on-line monitoring system for airborne radioactive emissions are given in Chapter 12 of the SAR and discussed above.

The critical group for airborne emissions from Lucas Heights Science and Technology Centre (LHSTC) is a group of hypothetical people continuously present at the boundary of the buffer zone (1.6 km). The ALARA objective for airborne emissions from all ANSTO activities remains at 20 µSv per year. For airborne radioactive discharges this objective is divided further on the basis of conducts and nature of operation of the facilities:

- less than 10 µSv per year due to the operation of the HIFAR reactor;

- less than10 µSv per year due to radiopharmaceuticals production; and

- less than 1 µSv per year due to OPAL and all other conducts and dealings at the LHSTC

Following consultation with ANSTO, I have included notification levels for OPAL with those for each discharge point at the LHSTC in the discharge authorisation on the basis of this ALARA objective of 1 μSv per year. The discharges must be continuously monitored and the results are to be reported to me each quarter and I will publish them in my quarterly report to the Parliament.

The sources of liquid waste from the OPAL reactor are described and these liquids are managed through LHSTC B or C line depending on the waste content. Dedicated Waste monitors utilising gamma detectors will be in place at the inlet to the waste storage tanks at the OPAL reactor. Further details of the radioactive waste management are referred to Chapter 12 of the SAR.

The limits for liquid discharges to the sewer are set by the Trade Waste agreement with Sydney Water, based on the World Health Organisation drinking water standards for radioactivity, and have been retained unaltered.

The surface water management plan monitors the water quality of run-off; ensures that the physical systems in place maintain stormwater flows at or below the current levels; provides for on-site containment and treatment of any small accidental spills or release of contaminated liquids; and addresses compliance with the state regulations.

Stormwater drainage at the LHSTC flows into small capacity concrete bunds on the three main stormwater outlet points. These provide temporary retention of stormwater/groundwater seepage, enabling containment and treatment of small accidental spills or releases of contaminated liquid. The bunds allow environmental monitoring at daily, weekly and monthly intervals, depending on the general radioactivity or specific radionuclides being quantified.

Stormwater drainage associated with the OPAL reactor will be captured, managed and monitored in accordance with routine practice for the broader LHSTC site in two on-site bunds and two off-site sediment dams. The low levels of tritium routinely found in surface runoff from the LHSTC are expected to be significantly reduced when the transition to exclusive operation of the OPAL reactor is achieved.

A program of radiological characterisation of stormwater and soil/sediment associated with stormwater outlets is in place and the results of such radiological characterisation are presented in ANSTO's Environmental and Effluent Monitoring Reports.

Details of groundwater hydrology in relation to the geology and soil structure of the LHSTC are referred to Chapter 3 of the SAR.

The OPAL reactor has a reduced possibility of contamination of groundwater relative to HIFAR because spent fuel is stored in a pool adjacent to the reactor rather than being transported to, and stored at, a separate location on-site. Additionally, irradiation rigs and targets are not in direct contact with heavy water and the core is cooled with light water. An intermediate cooling system is used for heat removal from the Reflector Cooling and Purification System. This minimises the possibility for tritium contamination of ground water.

A groundwater monitoring program measures and reports groundwater level and quality. This information is presented in ANSTO's Environmental and Effluent Monitoring Reports

The objectives of ANSTO's EMP for radioactive waste are stated to be to:

- ensure the total radioactive content and radioactivity concentration in the effluent released to the sewer from LHSTC and the NMC complies with the Trade Waste agreement;
- reduce the generation of low level radioactive solid waste;
- reduce the inventory of intermediate level liquid waste from production of Mo-99;
- reduce the generation of intermediate level solid waste from production of Mo-99; and
- assess the relative contributions of individual effluent discharges within LHSTC to enable understanding of various sources and thereby enable the minimisation of discharges at source.

The types of radioactive wastes considered include low and intermediate level solid waste, low and intermediate level liquid wastes and gaseous wastes from different sources. The liquid discharges will also be monitored through an on-line monitoring system and the suitability of this system was observed during ARPANSA inspection.

I have as assessed the radioactive waste management plan separately and found it to be acceptable.

The design features and operational controls suggest that the emission of Ar-41 will be greatly reduced, which will result in the reduction of exposure to the public. There will also be major reduction in H-3 emission while the emission of I-131 is expected to be similar to that of HIFAR. The airborne emissions will be monitored by an on-line monitoring system and ARPANSA assessor found this system suitable for this purpose during an ARPANSA inspection.

ANSTO committed to update the EMP for Prevention of Contamination of Groundwater to incorporate the issues relating to the OPAL reactor. ANSTO Annual Report on Environmental and Effluent Monitoring should include the monitoring of groundwater from the vicinity of the OPAL reactor. I will monitor the progress.

I consider that the Environmental Management Plan has addressed the relevant environmental aspects and their controls in relation to the operation of the OPAL reactor. The roles and responsibilities in managing the environmental management system are clearly described and the effectiveness of the environmental management system is reviewed by the senior management. The plan describes the provision for both internal and external audit.

These are satisfactory to me. I am persuaded that proper implementation of the operational controls and procedures for the identified significant environmental aspects, consistent with the environmental policy and targets described, will result in an effective environmental management system.

ARPANSA will undertake inspections to monitor implementation and to evaluate their effectiveness during operation of the OPAL reactor.

6. MATTERS TO BE TAKEN INTO ACCOUNT PRESCRIBED IN THE REGULATIONS

6.1. Whether the application includes the information I have requested

As discussed previously the application included all of the information that I had requested consistent with the information set out in Schedule 3, Part 1 of the regulations.

6.2. Whether the information establishes that the proposed conduct can be carried out <u>without undue risk</u> to the health and safety of the people, and to the environment

In considering my decision to issue a licence to construct the OPAL reactor, I stated my view that ‘without undue risk’ could be considered by comparing the risk objectives of the project with a radiation protection objective and a technical safety objective defined by INSAG. I have no reason to change that position. There are very similar objectives now stated in the IAEA Safety Requirements *Safety of Research Reactors*.

> “205. **Radiation Protection Objective:** *To ensure that in all operational states radiation exposure within the installation or due to any planned release of radioactive material from the installation is kept below prescribed limits and as low as reasonably achievable, and to ensure mitigation of the radiological consequences of any accidents.*
>
> “206. **Technical Safety Objective:** *To take all reasonably practicable measures to prevent accidents in nuclear installations and to mitigate their consequences should they occur; to ensure with a high level of confidence that, for all possible accidents taken into account in the design of the installation, including those of very low probability, any radiological consequences would be minor and below prescribed limits; and to ensure that the likelihood of accidents with serious radiological consequences is extremely low.”*

The OPAL reactor Radiation Protection Plan seeks to ensure that in all operational states the exposure within the installation is within limits and ALARA. I have assessed this plan at Chapter 4 and found that it is consistent with international best practice in relation to radiation protection and nuclear safety.

The OPAL reactor Radioactive Waste Management Plans addresses the planned airborne and liquid discharges from the plant. I have assessed this plan in Chapter 4 and found it to be consistent with international best practice in relation to radiation protection and nuclear safety. The levels of discharge involved result in only the most trivial doses to people off-site representing only the most minimal risk. This is even more the case for the non-human environment.

The prevention of accidents and ensuring that the radiological consequences of any design basis accidents is minor and the likelihood of more severe accidents is extremely low is addressed in the OPAL reactor SAR. I have assessed the SAR in Chapter 5. I find that the SAR does demonstrate that for an appropriate range of initiating events, the defence in depth of the design of the OPAL reactor results in there not being any significant radiological consequences. This conclusion is also supported by the probabilistic safety analysis.

In addition to the protection against accidents, I find that the design of the OPAL reactor, the strong considerations that have gone into analysing the possibilities for sabotage and the physical protection measures taken mean that the likelihood of a successful sabotage attack with radiological consequences on the OPAL reactor is very low.

The mitigation of the radiological consequences of accidents is a part of the design through the defence in depth measures. The final level includes the siting and the emergency planning, which I find to be adequate and appropriate.

Taking all these matters into account, I find that the operation of the OPAL reactor can be undertaken without undue risk to the health and safety of people, and to the environment.

6.3. Whether the applicant has shown that there is a net benefit from carrying out the conduct

6.3.1. Assessment of net benefit

Again, consistent with my earlier licensing decisions, I interpret the matter of 'net benefit' as being the radiological principle of ***justification.*** I understand this to be the intention of Regulation 41(3) (c), first, because the object of the Act is protect the health and safety of people and to protect the environment from the harmful effects of radiation. It is thus directed to radiation protection, not to decision-making as to whether a certain project is the best or most cost effective way to achieve social or economic goals. Second, the subregulation immediately precedes a statement of another principle of radiation protection, namely optimization. There is nothing in the drafting history of the sub-regulation to contradict this view.

The ICRP recognises in its 1990 Recommendations that the complete 'justification' of a practice goes far beyond the scope of radiological protection – the radiation detriment may only be a small part of the totality to be considered.

The IAEA in its Basic Safety Standards[20] puts it this way:

> *A practice that entails or that could entail exposure to radiation should only be adopted if it yields sufficient benefit to the exposed individuals or to society to*

[20] International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, IAEA Safety Series No 115, IAEA, 1996.,

outweigh the radiation detriment it causes or could cause (ie the practice must be justified).

In a generic sense, the operation of research reactors for the production of neutron beams and radioisotopes is considered justified by the radiological protection community.[21] Nonetheless, I do, of course, have to consider whether there is justification – net benefit- of the operation of the OPAL reactor.

ANSTO has described the applications of the OPAL reactor at Part A of its application and Chapter 11 of the SAR. Following the public forum, I sought additional information from ANSTO about the future of the use of medical radioisotopes and the scientific application of the neutron beam instrumentation.

In Part A of the Application, ANSTO states the purpose of the OPAL reactor as follows:

The Reactor Facility has been designed and will be operated to meet Australia's current and future needs for a neutron source in a manner that meets all health, environmental and safety standards. Specifically, the Reactor Facility has the following purposes:

- *maintain Australia's nuclear technical expertise, in order to provide sound advice to Government in support of nuclear policy issues of strategic national interest and international obligations in this area;*

- *maintain and enhance health care benefits provided to the community and ensure security of supply, through local production of the quantities and the known likely range of diagnostic and therapeutic radiopharmaceuticals needed to satisfy the requirements of Australia's medical professionals over the next 40 years;*

- *provide a neutron beam research facility which will not only meet Australia's own scientific and industrial needs, but will also be a regional centre of excellence. Research undertaken using this facility will have broad application to investigations in a wide spectrum of scientific and industrial fields, including the life sciences and medicine, environmental science, chemistry, materials science and engineering science;*

- *provide research and research training facilities and programs to enhance the educational opportunities available to Australia's scientists and engineers;*

- *provide industrial radioisotopes and facilities for neutron activation analysis, irradiation of materials, and neutron radiography to service the needs of agriculture and industry, particularly in the electronics, environmental, resource and minerals processing industries.*

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[21] I acknowledge that the number of research reactors in the world considered to be justified is falling. There is a legacy of research reactors from earlier years that do not always have a utilization program in place. Nonetheless, it is generally accepted world-wide that the operation of a research reactor with a viable utilization program is justified.

Chapter 11 of the SAR describes the irradiation facilities and neutron beam facilities.

My discussion of the applications of the OPAL reactor in the context of the construction licence application was set out in Chapter 10 of my statement of reasons in regard to that decision. In my mind, this assessment stands. I found in Chapter 13 of that statement:

> *It is clear that the benefits that would flow from the planned operation of this reactor are very substantial – at least as assessed today in the light of the planned utilization and applications. Given that the doses received by workers and the public would be ALARA, and the reactor is designed to be constructed and operated so as to limit the risks of accidents, then the benefits very much outweigh the detriment. This is so, at least for now while there are extensive applications for nuclear medicine and a lively and developing scientific field for the application of neutrons.*

6.3.2. Public submissions on net benefit

Specific challenges on the issue of net benefit arise from the public submissions. A letter signed by over 500 members of the public challenged the net benefit of the reactor arguing that it is not required for the provision of radioisotopes for nuclear medicine. The letter referred to a 2004 report from the Medical Association for the Prevention of War (MAPW) entitled *A New Clear Direction.* The submission from the MAPW also referred to their report and the issue was discussed when the MAPW appeared at the public forum.

The MAPW report and its public submission argue that:

> *Like most other comparable countries, Australia can have world-leading nuclear medicine care without a reactor by importing reactor-produced isotopes and producing many other isotopes here in cyclotrons.*
>
> *Australia can do even better than other countries by working to develop new methods of producing key isotopes currently produced in nuclear reactors. We should also support the expanding range of alternative diagnostic procedures which will reduce our long term reliance on reactor based procedures. In addition to the important economic and security benefits for Australia in not replacing the Lucas Heights reactor, such an approach would also help to address the growing and serious global problem of radioactive waste.*

The report and submission set out some steps to move towards the goals outlined in the above excerpt.

At the public forum, the MAPW representatives reiterated that Australia's reactor-produced medical isotope needs could be met by importation. Also the use of PET scanning using cyclotron produced isotopes, CT and MRI scanning is likely to reduce the value and utilization of reactor produced diagnostic radioisotopes. There may be increased use of isotopes for therapy, but this requires longer-lived isotopes that can be imported.

I asked ANSTO to comment on the position put by MAPW at the public forum. They responded by pointing to steady increases in demand for and production of certain reactor produced radiopharmaceuticals in the period 2000 to 2005, the growing use of radiopharmaceuticals for therapy, and the complementary nature of diagnosis through PET scans to use of reactor-produced isotopes. ANSTO also pointed to the risks that would be faced with reliance on importing because of denial of shipment by air transport companies and individual pilots, a problem that has been acknowledged by the IAEA.

I accept that it would be feasible for Australia to rely upon imports for reactor-produced radioisotopes. There would be some consequences in terms of the availability of some pharmaceuticals and certainly some risks of disruption from time to time. The Government has chosen not to accept these limitations and risks and this is properly a decision for Government. The production of isotopes for medical application – both diagnosis and treatment – is a benefit to Australia. When weighed against the radiological risks arising from normal operation of the reactor and the management of its radioactive waste, which I believe that ANSTO has established to be small, there is a clear net benefit to Australian society as a whole. The risks arising from other matters, I address below but do not alter this finding.

As I said in the context of the construction licence assessment, this is not necessarily a once and for all conclusion – the practice of nuclear medicine could change greatly over time. But at the time of this decision there is a clear net benefit.

The net benefit of the OPAL reactor was also challenged in the submission from Friends of the Earth. The submission argued that the OPAL reactor was not warranted for production of radioisotopes because of the possibility of relying on importation and increased use of cyclotron materials. It also suggested that the scientific benefits of utilization of the reactor were limited. The submission suggested that reactor-based research was not the main focus of research at ANSTO and that to the extent that research using neutron beams was worthwhile supporting, it could be achieved by manufacture of a spallation source, particle accelerators, a synchrotron and 'suitcase science'.

The submission from Greenpeace Australia referred to a finding by a 2001 report by a Senate Select Committee. The Committee (majority) stated that in its view the Government had failed to establish a 'conclusive or compelling case' for the OPAL reactor and recommended that a public inquiry be held before proceeding any further. I accept that whether there is a 'conclusive or compelling case' is a proper subject for debate, including political debate. I do not believe, however, that the Act requires me to address whether the objectives established for the OPAL reactor project can be achieved by other means or indeed whether there are more worthwhile objectives that the Government could have pursued instead of investing in the OPAL reactor.

Other public submissions addressed net benefit more indirectly through arguing that the risks of operation of the reactor, including the risk of terrorism and the issues arising from radioactive waste management, outweighed the benefits. I address these matters in the following sub-sections.

6.3.3. Finding

I find that there is a net benefit to Australian society arising from the proposed utilization of the OPAL reactor. The detriments that it may cause from increased exposures to radiation to the workers and the public near the site (as discussed under the undue risk matter) are small and are far outweighed by the benefits arising from the production of radioisotopes and other applications and the carrying out of scientific research using neutrons. I accept that there are alternative approaches to meet at least some of Australia's needs in these areas, but the decision to construct and operate a research reactor is properly one for the Government and I find it produces net benefit.

6.4. Whether the applicant has shown that the magnitude of the individual doses, the number of people exposed, and the likelihood that exposure will happen, are as low as reasonably achievable, having regard to economic and social factors (ALARA)

The issue of the ALARA matter goes to whether the radiation protection at the OPAL reactor is optimised. My assessment of the radiation protection program for the OPAL reactor is in Chapter 4. There is a strong emphasis in the design of the reactor on the minimization of radiation doses to workers and I certainly expect there to be no difficulty at all in normal doses being well below the ANSTO occupational dose constraint of 15 mSv per annum and generally at ANSTO's 'ALARA objective' of 2 mSv per annum.

As the ICRP reviews its Recommendations, it is becoming evident that, while there will be no fundamental change in the radiation protection system, there will be increased emphasis on dose constraints as being a driving force for continuous improvement in achieving ALARA. Acceptance of an occupational 'ALARA objective' of 2 mSv as a level below which there is no need for further consideration is probably not fully consistent with this approach. This is an issue that needs to be addressed on an ANSTO-wide basis, after publication of the new ICRP recommendations.

With regard to public doses from normal operations, as should be expected for a modern facility, these are well below any regulatory concern and it would be difficult to argue for any significant expenditure of resources to reduce them further.

The likelihood of people being exposed also covers the issue of the likelihood of accidents and occurrences that lead to increased exposures. These issues are discussed at length in Chapter 5 of this statement dealing with the safety analysis.

I find that the applicant has shown that the magnitude of the individual doses, the number of people exposed, and the likelihood that exposure will happen, are as low as reasonably achievable, having regard to economic and social factors (ALARA). I emphasise that the nature of ALARA, or optimisation of radiation protection, is a matter for continuous improvement and needs to be addressed on an ongoing basis.

6.5. Whether the applicant has shown the capacity for complying with the regulations and licence conditions

In the decision on the construction licence application, I spoke about this 'capacity for complying' matter as being in two parts: whether the organisation has the human and financial resources needed to implement the plans and arrangements it has put forward and the licence conditions; and the matter of safety culture.

I referred to assessing both the application and the organisational track record in taking this matter into account.

With regard to operation, ANSTO will be on its own as INVAP will no longer be involved at the completion of the contract and effectively it will be ANSTO's reactor. The necessity for ANSTO to 'own' the decisions taken during the detailed engineering design of the reactor and the manufacture and installation of systems was a major focus of licence condition 4.6 and is reported on in chapter 4. In general, ARPANSA staff reviewers during their review of the RFAs found that there was a strong involvement of ANSTO in reviewing, verifying and accepting documentation, asking questions of INVAP and ensuring that issues were dealt with to ANSTO's satisfaction within the quality system.

The development of the OPAL reactor Business Management System has been undertaken by ANSTO directly. ARPANSA staff reviewers have been concerned to ensure that ANSTO has formally reviewed, verified and accepted the operational procedures documents that have been supplied under contract by INVAP. This has been something of a slow process, but now appears to have been reasonably achieved.

Within ANSTO itself, there is also the transition from the project being solely developed by the OPAL reactor project team into one where the reactor will be operated by the OPAL operating team described in Chapter 5. The commissioning program is an important transition phase for both these changeovers – form INVAP to ANSTO and from the OPAL reactor project team to the OPAL operating team. ARPANSA inspections during the Stage A commissioning indicated that this is being well managed.

ANSTO can, reasonably, point to a very good track record for the safe operation of a research reactor, HIFAR, for over forty years. The OPAL reactor project, while not without some blemishes (such as the pool lining quality assurance issues, the construction and installation of Hoist C without gaining appropriate regulatory approval) has also been effectively managed.

ANSTO often comes under fire from public groups and the media – and sometimes politically – when certain abnormal occurrences and incidents occur that lead to some discharge to the environment and/or to the exposure of a worker. These matters, which can occur throughout ANSTO's operations, not only the operation of HIFAR, are important as matters to be considered and reviewed to ensure that vigilance is maintained and lessons learned supporting continuous improvement. It is an important part of the relationship between the regulator and the operator that such matters are properly and effectively dealt with but also are kept in the proper perspective.

At the time of this decision, there has been a recent focus on incidents occurring within the radiopharmaceutical production areas of ANSTO. I am treating these on their merits, as is ANSTO management. While they may be indicative of some operational issues in that area – bearing in mind that it does after all handle thousands of unsealed radioactive sources – it is important to say that I do not believe that these or other issues of similar scope over the years show that ANSTO does not have the capacity for complying with its licences and licence conditions.

The most important and obvious demonstration of their capacity to comply is their compliance with the licence authorizing them to construct the OPAL reactor. As I have discussed in this statement, there were a number of matters where ANSTO or INVAP failed to comply with conditions of the construction licence. Given the vast range of activities undertaken to bring about the completion of the design, the manufacture and the installation of an array of systems, structures and components and the completion of a major civil project, together with the large number of sub-contractors involved, the fact that a number of breaches occurred is not unexpected. I do not detect any pattern of systematic non-compliance.

I do believe that the issue of safety culture at ANSTO needs to be continually addressed. I also have some concern that the need to present a positive public face during the OPAL reactor project – combined with a very understandable and commendable pride in the project of producing an advanced research reactor – could result in some diminution of safety culture that may affect the operation of OPAL reactor. It is proper to assert the safety features of the reactor and to promote and be aware of its strong design and safety case. It would not be good if this resulted in a loss of respect for the technology. My reading on safety culture says that organisations with what is analysed as being the best safety culture live in a state of ‘chronic unease’.

I find that ANSTO has the capacity to comply with the licence and its conditions.

In relation to regulation 41(3)(a) of the regulations and as demonstrated throughout the consideration of the information in the application before me, principally in Chapter 4 and 5, I find that the application contained all of the information requested by me.

In relation to regulation 41(3)(g) I have demonstrated through the assessment of the application, principally in Chapter 4 and 5 that I have taken into account the content of submissions made by member of the public[22]

[22] Another issue that was raised in many public submissions, most notably the Sutherland Shire Environment Centre and People Against a Nuclear Reactor, was that it is not possible for people to insure against a nuclear accident and there was no automatic assumption of liability by ANSTO or the Australian Government in the event of an accident. This was seen as not meeting international standards where absolute liability applies to nuclear facilities and was portrayed as ANSTO or the Government somehow not having the confidence to support the facility in this way.

The formal position is that persons would have to undertake civil action and establish negligence on ANSTO's behalf. In its response to the reports of the public forum panelists, ANSTO stated that it thought it likely that in any real case liability would be assumed and that ANSTO insurers had advised that they would not plead lack of negligence in any liability claim.

The matter was also taken up by the public forum panelists. Dr Hogberg suggested that adherence to the extant nuclear liability regimes assigning strict liability to the licensee for any damage to third parties caused by a nuclear accident was now international best practice.

As I said when I considered this matter during the construction licence, I do not consider that it falls within my decision-making under the Act and regulations. Ultimately, it is not a matter of safety.

I offer the opinion, however, that the public submitters have the better of the argument on this issue. There is now a well established international nuclear liability regime. I think it would be a positive step for Australia to adhere to the relevant international instruments and enact the necessary domestic legislation taking up absolute liability.

Annex A - Documents forming the Application to operate OPAL

Application – Part A
RRRP-7200-EBEAN-001-REV0 and the accompanying application form submitted on 13 September 2004.

Application – Part B
The plans and arrangements for managing safety for the OPAL reactor were updated from the original licence application, and the updates were provided under cover of a Document Transmittal dated 23 February 2006. The current plans and arrangements are:

- Management of Radioactive Waste: (RRRP-7272-EDEAN-001-REV1);
- Radiation Protection Plan (RRRP-7265-EDEAN-001-REV1);
- OPAL Reactor Emergency Plan (RRRP-7268-EDEAN-001-REV1);
- Environmental Management Plan (RRRP-7270-EDEAN-001-REV1);
- Plan For Maintaining Effective Control (RRRP-7200-EDEAN-003-REV1);
- Safety Management Plan (RRRP-7200-EDEAN-004-REV1); and
- Ultimate Disposal or Transfer Plan (RRRP-7200-EDEIN-005-REV3). This plan needs to be read together with ANSTO letters of 17 December 2004 (including Attachments 1, 2 and 3 thereto) and 15 February 2005 (including Attachment 1 thereto).

Application – Part C
The Safety Analysis Report (SAR) RRRP-7225-3BEIN-001-revB, as amended by the following Addenda:

- Addendum to Chapter 3 regarding suitability of the site (RRRP-7225-3BEAN-001-Rev0-Chapter03-Addendum);
- Addendum to Chapter 8 regarding Habitability of the MCR and Environmental Qualification of I&C System Following a Release Equivalent to a Single FA Melting (RRRP-7225-3BEAN-001-Rev0-Chapter08-Addendum1);
- Addendum 1 to Chapter 16 regarding Release of Tritium from the Cold Neutron Source (RRRP-7225-3BEAN-001-Rev0-Chapter16-Addendum1);
- Addendum 2 to Chapter 16 regarding Melting of a Single Fuel Assembly (RRRP-7225-3BEAN-001-Rev0-Chapter16-Addendum2);
- Addendum 3 to Chapter 16 regarding the Reference Accident (RRRP-7225-3BEAN-001-Rev0-Chapter16-Addendum3);
- Addendum 4 to Chapter 16 regarding the Oxide Layer issue (RRRP-7225-3BEAN-001-Rev0-Chapter16-Addendum4);
- Addendum to chapter 20 regarding the Reference Accident (RRRP-7225-3BEAN-001-REV0-CHAPTER20-ADDENDUM);
- Other addenda to various chapters of the SAR.

Probabilistic Safety Assessment, RRRP-7225-3BEIN-002-RevA

Application – Part D
The Operational Limits and Conditions for the OPAL Reactor (RRRP-7230-EDEAN-001-REV2).

Application – Part E
The Commissioning Plan (RRRP-7311-EDEAN-001-A).

Construction and Stage A Commissioning
Executive Summary Report on Construction and Stage A Commissioning (RRRP-7320-EBEAN-001-A)
The OPAL Construction Report (RRRP-7033-EBEAN-001)
Stage A Commissioning Report (RRRP-7311-EDEIN-004)

Stages B and C Commissioning
The Commissioning Operational Limits and Conditions (RRRP-7315-EDEIN-001)
The Commissioning Safety Case (RRRP-7300-3BEIN-002)
The Sub-Stage B1 Commissioning Specific Plan (RRRP-7330-EDEIN-001C)
The Sub-Stage B2 Commissioning Specific Plan (RRRP-7340-EDEIN-001C)

SUPPORTING DOCUMENTATION

Public Consultation
The public consultation process raised a number of issues. ANSTO's response to those issues was contained in the ANSTO letter of 16 February 2006.

Nuclear Safety Committee Report
The Nuclear Safety Committee Report of September 2005 also raised a number of issues. ANSTO's response to those issues was contained in ANSTO's letter of 5 December 2005.

IAEA Peer Review Missions
ANSTO's responses to the reports the IAEA Peer Review Missions of March and November 2005 were provided to ARPANSA under cover of letter from Mr Whitbourn on 9 February 2006 and 10 May 2006 respectively.

BMS documentation
The procedures for commissioning, operation and maintenance of OPAL are included in OPAL's Business Management System. A very large amount of documentation in that regard has been provided to ARPANSA, as listed in BMS Implementation Summaries, provided to ARPANSA last updated 26 June 2006.

Human Factors Review
Human Factors Review (RRRP-7231-EBEAN-001).

Annex B: Assessment of OPAL operating licence application against the provisions of the Code of Conduct on the Safety of Research Reactors

Provision of Code of Conduct	Assessment
Articles 1-8 of the Code define its scope, its application and definition of terms	
Role of the State	
9. The State should establish and maintain a legislative and regulatory framework to govern the safety of research reactors. The framework should place the prime responsibility for the safety of research reactors on the operating organization and should provide for: (a) the establishment of applicable national safety requirements and regulations; (b) a system of authorization for research reactors and the prohibition of the operation of a research reactor without an authorization; (c) a system of regulatory inspection and assessment of research reactors to ascertain compliance with applicable regulations and the terms of authorizations; and (d) the enforcement of applicable regulations and the terms of authorizations, including suspension, modification or revocation of the authorization.	The Australian legislative and regulatory framework is established by the *Australian Radiation Protection and Nuclear Safety Act 1998* (the Act) and the Australian Radiation Protection and Nuclear Safety Regulations 1999 (the regulations). The legislation applying to the Australian Nuclear Science and Technology Organisation (ANSTO) makes clear its responsibility for the safety of its nuclear installations. The CEO of the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), a position established by the Act, establishes such requirements and regulations, working with a Radiation Health Committee and a Nuclear Safety Committee established by the Act. The Act prohibits 'controlled persons' from preparing a site, constructing, operating or decommissioning a research reactor without a licence from the CEO of ARPANSA. The Act establishes clear powers for the CEO of ARPANSA to inspect OPAL for compliance with the Act and licence conditions. Powers to suspend, modify or revoke a licence are included in the Act.
10. The State should have a regulatory body charged with regulatory control of research reactors based on the national legal structure. The regulatory body should be able to conduct authorization, regulatory review and assessment, inspection and enforcement, and should establish safety principles, criteria, regulations and guides. The regulatory body should be effectively independent from organizations or bodies charged with promotion of nuclear technologies or with operation of research reactors. Before the State authorizes building or importing a research reactor, a functioning regulatory body should be in place. If necessary, assistance in developing the	ARPANSA, being the CEO of ARPANSA and staff assisting the CEO, is the regulatory body charged with the control of research reactors controlled by the Australian Government. The role of ARPANSA is established by an Act of the Australian Parliament that has the object of protecting people and protecting the environment from the harmful effects of radiation. The CEO is the single regulatory decision-maker. The CEO is accountable to the Parliament through the Minister for Health and Ageing. A different Ministerial portfolio oversees ANSTO. Where appropriate, ARPANSA has obtained additional capabilities through seeking IAEA missions or other international cooperation and contracting expert advice. ARPANSA develops radiation protection and nuclear

necessary human, technical and regulatory capabilities should be obtained through international cooperation.	safety principles, criteria and guidelines, and maintains the legislative framework.
11. The State should provide the regulatory body with the necessary authority and adequate resources to ensure that it can discharge its assigned responsibilities. No other responsibility should be assigned to the regulatory body that may jeopardize or conflict with its responsibility for regulating safety and protecting the environment from radiation hazards.	The Act provides the CEO of ARPANSA with the necessary authority through its licensing, inspection and enforcement powers. ARPANSA's regulatory functions are resourced through the charging of application fees and annual licence on applicants or licence holders. ARPANSA does have other responsibilities – these are the promotion of uniformity in radiation protection and nuclear safety across the jurisdictions in Australia; providing advice and services and undertaking research in relation to radiation protection, nuclear safety and medical exposures to radiation. As these functions are all directed towards radiation protection and nuclear safety under the overall object of the Act to protect people and to protect the environment from the harmful effects of radiation, they do not fundamentally jeopardize or conflict with its responsibility for regulating safety and protecting the environment from radiation hazards. The Act requires the CEO to take all reasonable steps to avoid conflict of interest between the CEO's regulatory functions and the CEO's other functions.
12. The State should, if it deems necessary, define how the public and other bodies are involved in the regulatory process.	The Regulations require that where the CEO receives an application for a licence relating to a nuclear installation (including a research reactor), he must advertise and seek submissions from members of the public about the application. The CEO must take into account the content of submissions from the public when making a decision whether to issue a licence. These steps have been followed at all stages of OPAL licensing.
13. The State should ensure that the operating organization has a system for financing the safe operation of the research reactor, for maintaining the research reactor in a safe shutdown state for extended periods if this becomes necessary, and for its decommissioning.	The Australian operating organization, ANSTO, is a Government agency established by an Act of Parliament. ANSTO receives funding for the safe operation of its research reactor through annual Government budgetary arrangements. The Government will allocate funding for the decommissioning of OPAL as this becomes necessary.
14. The State should establish an effective system of governmental emergency response and intervention capabilities relating to research reactors.	The Government of NSW has established plans for dealing with any off-site consequences of an emergency at ANSTO.
15. The State should make adequate legal and infrastructural arrangements for decommissioning of research reactors.	The decommissioning of its research reactors is a clear responsibility of ANSTO. The Australian Government is proceeding with plans to construct a radioactive waste management facility that will, inter alia, be able to dispose of and store waste arising from the decommissioning of OPAL.
16. The State should take the appropriate steps to ensure that the safety of all operating research reactors and research reactors in extended shutdown is reviewed. When necessary in the context of this Code, the State should ensure that all reasonably practicable improvements are made	Not applicable to OPAL.

to upgrade the safety of the research reactors. If such upgrading cannot be achieved, appropriate provisions should be made to shut down and then decommission the research reactors. The timing of the shut-down of the research reactors, if safety allows it, may take into account the contributions of each research reactor's utilization programme to society and the possible alternatives as well as other social, environmental and economic impacts.	
17. In circumstances where a research reactor is in extended shutdown and there is no longer any effective operating organization, the State should make arrangements for the safe management of the research reactor.	Not applicable to OPAL.
18. The State should take appropriate steps to ensure that arrangements are put in place to inform neighboring States in the vicinity of a planned research reactor, insofar as they are likely to be affected by the research reactor, and upon request, provide sufficient information to such States to enable them to evaluate and make their own assessment of the likely safety impact of the research reactor on their own territory for emergency planning and response.	Not applicable to OPAL.
Role of the Regulatory Body	
19. The regulatory body should: (a) implement a process of issuing authorizations with regard to all stages in the life of a research reactor;	The Act requires a separate licence from the CEO of ARPANSA to prepare a site for, construct, operate and decommission a research reactor. OPAL has been assessed at the stages of prepare a site and construction to date.
(b) undertake regulatory inspections and assessments of research reactors to ascertain compliance with applicable regulations and authorizations;	ARPANSA undertakes a program of regulatory inspections of the current research reactor and it has continued to inspect the construction of OPAL.
(c) enforce the applicable regulations and the authorization, including suspension, modification or revocation of the authorization;	ARPANSA has and will continue to enforce the applicable regulations and licence conditions.
(d) review and assess submissions on safety from the operating organization both prior to authorization and periodically during the life of the research reactor as appropriate, including in relation to modifications, changes in utilization and experimental activities important to safety;	The regulations impose licence conditions on OPAL which require that prior approval of the CEO is required for a 'relevant change', being a modification or a change to the licensing basis, with significant implications for safety. During construction, individual approvals were required for the manufacture and installation of items important for safety. In addition for OPAL, an additional licence condition requires a periodic safety review to be undertaken.

(e) make available, as appropriate, its regulatory requirements and decisions and their basis, particularly with respect to matters under Paragraph 19(c), above; and (f) implement appropriate arrangements for a systematic approach to quality management, which extend throughout the range of responsibilities and functions undertaken.	ARPANSA published its *Regulatory Assessment Principles for Controlled Facilities* (RAPs) in 2001. The reasons for the decisions in relation to OPAL are published on the ARPANSA website. ARPANSA has recently reviewed its regulatory management processes and is bringing them within an overall quality system.
20. The regulations and guidance established by the State or the regulatory body according to national arrangements should: (a) require clear arrangements for the management of safety by the operating organization, reflecting safety as the highest priority and encouraging the development of a strong nuclear safety culture in the operating organization; *Assessment and verification of safety* (b) require the operating organization to prepare and maintain a safety analysis report and to obtain an authorization for siting, construction, commissioning, operation, modifications important to safety, extended shutdown and decommissioning; (c) require the operating organization to undertake periodic safety reviews at intervals determined by the regulatory body and to make proposals for upgrading and refurbishment arising from such reviews as necessary; *Financial and human resources* (d) require the operating organization to demonstrate that it has sufficient financial and human resources to support safe operation of the research reactor; (e) require those personnel who operate the research reactor and for experimenters who use associated experimental facilities to be appropriately trained; *Quality assurance* (f) require the operating organization to put in place effective quality assurance programmes at the different stages of the life of the research reactor; *Human factors* (g) require the operating organization to take human factors into account throughout the life of the research reactor;	The regulations required the submission of plans and arrangements for the management of safety as part of an application for a licence for OPAL. The ARPANSA RAPS look to a demonstration of a strong commitment to safety culture. The regulations required submission of a preliminary and final safety analysis report for the construction and operating licence for OPAL. The SAR submitted with the OPAL operating licence application has been a central feature of the assessment by ARPANSA. Maintenance of the SAR is a part of the licensing basis for OPAL. The mentioned activities require either an application for a licence, or, in the case of modifications, prior approval by the CEO. Periodic safety reviews are required by a licence condition on the operating licence for OPAL. The issue of demonstrating that ANSTO has sufficient resources for safe operation of OPAL has been a major part of the assessment of the OPAL operating licence. The issue of the level of training for operating and utilization staff has been very substantially addressed in the assessment of the OPAL operating licence. The ARPANSA RAPS propose as principles that the operating organisation has a formal QA program in place and applied at each stage of the life of a facility, including recognized quality practices certification. The ARPANSA RAPS address human factors as being an important part of the first level of defence in depth for a facility.

Radiation protection (h) require that radiation doses to workers and the public, including doses from releases to the environment, be within prescribed national dose limits and be as low as reasonably achievable, social and economic factors being taken into account; (i) provide guidance, as international consensus develops, on the protection of the environment from the harmful effects of ionising radiation;	The regulations require the application of the Australian national guidance on radiation protection to OPAL. This guidance includes dose limits and ALARA. ARPANSA has indicated that for OPAL, the current international guidance that if humans are protected then the environment is protected applies.
Emergency preparedness (j) establish criteria for intervention in emergencies, and require that adequate emergency plans be in place;	The regulations require the submission of an emergency plan for a facility as part of a application for a licence. Australia has national criteria for intervention in emergencies (RPS 7).
Siting (k) establish criteria for the siting for research reactors;	ARPANSA published siting criteria for controlled facilities in 1999. For OPAL, these issues were addressed in the assessment of the application for the licence to site the reactor and confirmed at subsequent stages. .
Design, construction and commissioning (l) require that the design provide for defence in depth and diversity and redundancy in safety systems, so that if failures were to occur, they would be detected and compensated for or corrected by appropriate means; (m) require that construction be carried out in accordance with applicable codes, standards, specifications and criteria; (n) require that a commissioning program be carried out by the operating organization to ensure that the reactor meets design requirements;	These requirements are included in the ARPANSA RAPS and were addressed in the assessment undertaken for the construction licence for OPAL. As above. As above.
Operation, maintenance, modification and utilization (o) require the operating organization to establish operational limits and conditions for the research reactor, with the regulatory body to assess and approve the limits and conditions and changes to them;	The regulations allow for OLCs to be required in an application for an operating licence and OLCs were required of the OPAL application. The assessment of the proposed OLCs was a central part of the decision-making on the OPAL operating licence application.
(p) require the operating organization to report the occurrence of events significant to safety in accordance with criteria established by the regulatory body; (q) require the operating organization to classify modifications according to their safety significance, establish suitable internal review procedures, and keep up to date records of modifications and changes to the research reactor, including temporary modifications arising from experiments;	Licence conditions established by regulations 45 and 46 require the reporting of accidents and breaches of licence conditions. Licence conditions on OPAL imposed through regulations 51 and 52 require that the CEO's prior approval is sought for 'relevant changes' that will have significant implications for safety and the CEO be notified of other relevant changes. The procedure for classifying 'relevant changes' is included in the OPAL BMS OP 10 Modification Management

(r) require access for the regulatory body to the research reactor for the purposes of inspection to verify compliance with regulatory requirements, such inspections to be followed with reports provided to the operating organization for assessment and response; (s) establish requirements for management of radioactive waste arising from the research reactor; *Extended shutdown* (t) where necessary in national circumstances, establish criteria for the safety of research reactors in extended shutdown; and *Decommissioning* (u) establish criteria for the release from regulatory control of decommissioned research reactors.	The licence condition established by Section 35 (3) of the Act requires ANSTO to allow the CEO or a person authorised by the CEO to enter and inspect the site or facility at reasonable times. The powers of inspection are detailed in Part 7 of the Act. Under Schedule 3 of the regulations, ANSTO submitted a radioactive waste management plan for OPAL and this forms part of the licensing basis for the facility. The licence condition on OPAL operation imposed by regulation 48 requires that dealings with radioactive waste be in accordance with several national Codes of Practice. Not relevant to OPAL. ARPANSA is preparing regulatory guidance on decommissioning that will address these issues.
Role of the Operating Organisation	
21. The operating organization should establish its own policies in accordance with State requirements that give safety matters the highest priority, that promote a strong nuclear safety culture and are implemented within a management structure having clearly defined divisions of responsibility and lines of communication.	With regard to OPAL, the management system is set out in the plans and arrangements in Part B of the application and the OPAL BMS, which is linked in turn to the overall ANSTO BMS.
Assessment and Verification of Safety 22. The operating organization should: (a) carry out a comprehensive and systematic safety assessment and prepare a safety analysis report before the construction and commissioning of a research reactor, and carry out safety reviews at appropriate intervals throughout its life, including in relation to modifications, changes in utilization and significant experimental activities and the management of ageing. The safety assessments and periodic safety reviews should include all technical, operational, personnel and administrative aspects of safety related operations. The assessments and reviews should be well documented, subsequently updated in light of operating experience and significant new safety information and reviewed under the authority of the regulatory body; and (b) verify by analysis, surveillance, testing and inspection that the physical state and the operation of a research reactor continues to be in accordance with its design, safety analysis, applicable national safety requirements, and operational limits and conditions for the lifetime of the research reactor.	ANSTO submitted a safety analysis report (SAR) with its application. As a result of the assessment process and exchanges between ARPANSA and ANSTO, the SAR has been amended and accepted by ARPANSA as a part of the licensing basis for the operation of OPAL. Future amendments to the SAR will be the subject of the licence conditions imposed by regulations 51 and 52. A special licence condition requires the conduct of periodic safety reviews of OPAL in accordance with international best practice in radiation protection and nuclear safety at the time of each review. Arrangements for surveillance, testing and inspection for OPAL are set out in the OPAL BMS and the OLCs.

Financial and human resources 23. The operating organization should ensure that there is an overall effective system for the financing of the safe operation of the research reactor, including for any extended shutdown state, and for decommissioning. 24. The operating organization should make available sufficient numbers of staff qualified through appropriate education and training (initial and ongoing) for all safety related activities throughout the life of the research reactor. Appropriate training should be provided for experimenters that will use associated experimental facilities.	ANSTO is an Australian Government entity and funding for the operation of OPAL will be obtained largely through Government budget processes. ANSTO's arrangements for the staffing of OPAL in terms of numbers and qualifications are set out in the OPAL BMS. Minimum numbers are defined by the OLCs.
Quality assurance 25. The operating organization should establish and implement effective quality assurance programmes with a view to providing confidence that specified requirements for all activities important to nuclear safety are satisfied throughout the life of the research reactor. Experimenters using associated experimental facilities should be required to work within the relevant quality assurance programme and with safety arrangements established by the operating organization.	The OPAL BMS establishes the quality assurance program applying to OPAL operations. It is prepared in accordance with (certified?) AS/NZS ISO 9001:2000 and AS/NZS 14001:2004.
Human factors 26. The operating organization should take into account the capabilities and limitations of human performance throughout the life of the research reactor for operational states and in accident conditions, also taking into account human factors relating to experiments.	The design of the OPAL facility and operating procedures take account of human factors during normal operation, anticipated operational occurrences and accident conditions.
Radiation protection 27. The operating organization should in all operational states keep the radiation exposure from the research reactor to the workers and members of the public as low as reasonably achievable, social and economic factors being taken into account, and should ensure that no individual incurs a radiation dose which exceeds prescribed national dose limits. 28. The operating organization should also respond to any guidance that is provided by the regulatory body in relation to the protection of the environment from the harmful effects of ionizing radiation.	The OPAL radiation protection plan was submitted as part of the operating licence application. It is included in the OPAL BMS OP 08. The radiation protection plan includes reference to ALARA and dose limitation as required by the LCs imposed by regulation 47. For OPAL, ARPANSA has not provided any guidance additional to the generally accepted international assumption applying to reactor facilities that if humans are protected then the environment is protected.

Emergency preparedness 29. The operating organization should establish, and maintain by training and exercises, appropriate emergency plans in accordance with established criteria of the regulatory body, and in cooperation with other appropriate bodies, to provide an effective response to emergencies.	The OPAL emergency plan was presented in Part B of the application and Chapter 20 of the SAR and is incorporated into OP 16 of the OPAL BMS.
Siting 30. The operating organization should establish, implement and maintain appropriate procedures for: (a) evaluating all relevant site-related factors likely to affect the safety of the research reactor over its projected lifetime; (b) evaluating the potential safety impact of a planned research reactor on the public and the environment; and c) re-evaluating the two preceding issues at appropriate times so as to ensure the continued safety acceptability of the research reactor.	These matters were addressed for OPAL siting in ANSTO's application for a licence to site the facility. The CEO's reasons for decision to issue a licence and the conditions applied are published on the ARPANSA website.
Design, construction and commissioning 31. The operating organization should ensure that: (a) the design and construction of the research reactor provides for several reliable levels and methods of protection (defence in depth) against the release of radioactive materials, with a view to preventing the occurrence of accidents and to mitigating their radiological consequences should they occur; (b) the design of the research reactor allows for reliable, stable and easily manageable operation, with specific consideration of human factors and the man-machine interface; (c) the construction of the research reactor is in accordance with the approved design (and any approved modifications to the design); (d) the technologies incorporated in the design and construction of the research reactor are proven by experience, testing or analysis; and (e) the commissioning programme demonstrates that the design objectives and performance criteria of the research reactor structures, systems and components important to safety have been achieved.	These matters were addressed in ANSTO's application for a licence to construct OPAL. The CEO issued a licence in April 2002. The fulfillment of the conditions of this licence and the assessment of the construction of OPAL are described in the relevant assessment documents for the licence to operate OPAL.
Operation, maintenance, modification and utilization 32. The operating organization should: (a) establish and revise as necessary operational limits and conditions derived from the safety analysis, tests, commissioning programme and operational experience to identify the limiting conditions for safe operation;	OLCs for OPAL have been established by ANSTO and approved by ARPANSA as part of the licence application assessment process. Amendments to the OLCs arising as described would be addressed through the licence conditions established by regulations 51 and 52.

(b) conduct operation, utilization, modification, maintenance, inspection and testing activities important to the safety of the research reactor in accordance with approved procedures and regulations;	The OPAL BMS and regulation 49 commits ANSTO to operate in accordance with approved procedures and regulations.
(c) establish procedures for responding to anticipated operational occurrences and to accidents;	Procedures for OPAL are established in the OPAL BMS OP 02 Monitoring, Measurement and Improvement.
(d) make available the necessary engineering and technical support in all safety-related fields throughout the lifetime of the research reactor, including through international cooperation;	ANSTO's arrangements for engineering and technical support for OPAL operations are set out in the OPAL BMS, principally OP05 Operating Organisation.
(e) report events significant to safety to the regulatory body, analyse the events and act upon the findings to improve safety in a timely manner;	These arrangements are established by the OPAL BMS OP 05 Monitoring, Measurement and Improvement re-inforced by regulations 45 and 46.
(f) subject modifications to the research reactor over its lifetime to the design, construction and commissioning provisions described in this Code;	Established by OP 10 Modification Management.
(g) assess appropriately modifications proposed to perform experiments;	As above.
(h) establish a safety review committee, as part of the operating organization, but reporting independently from the reactor management, to advise it on safety matters;	The functions and reporting lines of the OPAL Safety Review Meeting, the OPAL Reactor Assessment Committee and the ANSTO Safety Assessment Committee are set out in OPAL BMS OP08 Safety Management.
(i) subject each utilization project having safety significance, including any modification of the research reactor, new construction or experimental device, to an appropriate level of safety assessment and approval; and	These arrangements are included in the OP 10 Modification Management.
(j) keep the generation of radioactive waste resulting from the operation and utilization of the research reactor to the minimum practicable for the process concerned, both in activity and in volume, and ensure that there are effective arrangements for the safe management of such waste at the site of the research reactor.	The principle of waste minimization and the arrangements for managing waste are included in the OPAL radioactive waste management plan (Part B of the application, chapter 12 of the SAR, OPAL BMS OP 15 Waste Management).
(k) maintain documentation in a secure and organized manner throughout the life of the research reactor to assist in its safe operation and ultimate decommissioning. The documentation should include updated technical information and drawings of the facility and experimental devices, and records of operation and events.	OPAL BMS OP03 Documentation Management and OP 04 Records Management.
33. Extended Shutdown	Not relevant to OPAL operations at this time.
Decommissioning	
34. The operating organization should ensure that siting, design, construction, operation, maintenance, and utilization of the research reactor are carried out keeping in view the ultimate decommissioning of the installation.	OPAL decommissioning is addressed in Chapter 19 of the SAR.
35. The operating organization should prepare a comprehensive decommissioning plan and assessment of environmental impact for review	A comprehensive decommissioning plan would be required to seek a licence to decommission OPAL.

and approval by the regulatory body prior to commencing decommissioning activities. The elements of the plan should include: (a) the broad decommissioning option to be pursued and the justification for choosing that option; (b) the decontamination and dismantling techniques to be applied so as to minimise waste generation and airborne contamination; (c) arrangements for dealing with the fuel and radioactive waste arising from the research reactor; (d) arrangements for radiation protection during the decommissioning process; and (e) a description of the volumes, activities and types of waste to be generated in the decommissioning and the means proposed to manage these wastes safely.	
36 Role of the IAEA	Not relevant to operation of OPAL

Annex C - Assessment of OPAL operating licence application against the articles of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management

Provision of Joint Convention	Assessment
Chapter 1: Objectives, Definitions and Scope of the Application	
Articles 1-3 of the Joint Convention define its scope, its application and definition of terms	.
Chapter 2: Safety of Spent Fuel	
Article 4 Each Contracting Party shall take the appropriate steps to ensure that at all stages of spent fuel management, individuals, society and the environment are adequately protected against radiological hazards. In so doing, each Contracting Party shall take the appropriate steps to: (i) ensure that criticality and removal of residual heat generated during spent fuel management are adequately addressed; (ii) ensure that the generation of radioactive waste associated with spent fuel management is kept to the minimum practicable, consistent with the type of fuel cycle policy adopted; (iii) take into account interdependencies among the different steps in spent fuel management; (iv) provide for effective protection of individuals, society and the environment, by applying at the national level suitable protective methods as approved by the regulatory body, in the framework of its national legislation which has due regard to internationally endorsed criteria and standards; (v) take into account the biological, chemical and other hazards that may be associated with spent fuel management; (vi) strive to avoid actions that impose reasonably predictable impacts on future generations greater than those permitted for the current generation; (vii) aim to avoid imposing undue burdens on future generations.	For OPAL, the proposed stages of spent fuel management are storage in reactor pool fuel storage rack; transfer to and storage in the service pool spent fuel storage rack, loading into a transport cask and transport in accordance with the ultimate disposal or transfer plan. Criticality and residual heat are addressed in Chapter 10 of the SAR. The simple handling of OPAL spent fuel within the facility does not generate radioactive waste. The waste product arising from reprocessing (defined as intermediate-level waste) is the minimum arising from the spent fuel. The OPAL spent fuel handling on the reactor site is minimal, the fuel assemblies are suitable for transport. The management of spent fuel by ANSTO is subject to regulation by ARPANSA and consistent with international best practice in relation to radiation protection and nuclear safety. The matters covered in (v) and (vi) are taken up in ARPANSA's draft regulatory guidance for radioactive waste management facilities. The plans by ANSTO and the Australian Government manage the spent fuel during the life of the generation concurrent with the life of OPAL, at least to the stage of long-term storage. The matter of final disposal remains to be addressed.

Article 5 Each Contracting Party shall take the appropriate steps to review the safety of any spent fuel management facility existing at the time the Convention enters into force for that Contracting Party and to ensure that, if necessary, all reasonably practicable improvements are made to upgrade the safety of such a facility.	Not relevant to OPAL.
Article 6 1. Each Contracting Party shall take the appropriate steps to ensure that procedures are established and implemented for a proposed spent fuel management facility: (i) to evaluate all relevant site-related factors likely to affect the safety of such a facility during its operating lifetime; (ii) to evaluate the likely safety impact of such a facility on individuals, society and the environment; (iii) to make information on the safety of such a facility available to members of the public; (iv) to consult Contracting Parties in the vicinity of such a facility, insofar as they are likely to be affected by that facility, and provide them, upon their request, with general data relating to the facility to enable them to evaluate the likely safety impact of the facility upon their territory. 2. In so doing, each Contracting Party shall take the appropriate steps to ensure that such facilities shall not have unacceptable effects on other Contracting Parties by being sited in accordance with the general safety requirements of Article 4.	In the case of OPAL, the 'spent fuel management facility' consists of the reactor structures used for storage of spent fuel and the associated operating arrangements. These have been evaluated in Chapter 10 of the SAR and the relevant RFAs (for example, including for seismic safety) and assessed by ARPANSA. OLCs deal with the management of the spent fuel etc. 1(iv) and 2 are not relevant to OPAL.
Article 7 Each Contracting Party shall take the appropriate steps to ensure that: (i) the design and construction of a spent fuel management facility provide for suitable measures to limit possible radiological impacts on individuals, society and the environment, including those from discharges or uncontrolled releases; (ii) at the design stage, conceptual plans and, as necessary, technical provisions for the decommissioning of a spent fuel management facility are taken into account; (iii) the technologies incorporated in the design and construction of a spent fuel management facility are supported by experience, testing or analysis.	The design and radiological impacts of OPAL spent fuel management are addressed in Chapter 10 of the SAR. The straightforward management and on-site storage of OPAL spent fuel have few issues for decommissioning of OPAL. . Consideration of decommissioning in the design of OPAL is addressed in Chapter 19 of the SAR. Covered in Chapter 10 of the SAR.

Article 8 Each Contracting Party shall take the appropriate steps to ensure that: (i) before construction of a spent fuel management facility, a systematic safety assessment and an environmental assessment appropriate to the hazard presented by the facility and covering its operating lifetime shall be carried out; (ii) before the operation of a spent fuel management facility, updated and detailed versions of the safety assessment and of the environmental assessment shall be prepared when deemed necessary to complement the assessments referred to in paragraph (i).	These matters are addressed as a part of the overall safety assessment for OPAL.
Article 9 Each Contracting Party shall take the appropriate steps to ensure that: (i) the licence to operate a spent fuel management facility is based upon appropriate assessments as specified in Article 8 and is conditional on the completion of a commissioning programme demonstrating that the facility, as constructed, is consistent with design and safety requirements; (ii) operational limits and conditions derived from tests, operational experience and the assessments, as specified in Article 8, are defined and revised as necessary; (iii) operation, maintenance, monitoring, inspection and testing of a spent fuel management facility are conducted in accordance with established procedures; (iv) engineering and technical support in all safety-related fields are available throughout the operating lifetime of a spent fuel management facility; (v) incidents significant to safety are reported in a timely manner by the holder of the licence to the regulatory body; (vi) programmes to collect and analyse relevant operating experience are established and that the results are acted upon, where appropriate; (vii) decommissioning plans for a spent fuel management facility are prepared and updated, as necessary, using information obtained during the operating lifetime of that facility, and are reviewed by the regulatory body.	These matters are addressed as a part of the overall safety assessment for OPAL.
Article 10 If, pursuant to its own legislative and regulatory framework, a Contracting Party has designated spent fuel for disposal, the disposal of such spent fuel shall be in accordance with the obligations of Chapter 3 relating to the disposal of radioactive waste.	Australian Government policy is that spent fuel (apart from that returned to the US) is to be reprocessed or conditioned as intermediate-level radioactive waste.

Chapter 3: Safety of Radioactive Waste Management	
Article 11 Each Contracting Party shall take the appropriate steps to ensure that at all stages of radioactive waste management individuals, society and the environment are adequately protected against radiological and other hazards.	Radioactive waste arising from OPAL is managed in the regulatory context established under the ARPANS legislation. The OPAL radioactive waste management plan addresses waste as a direct part of OPAL operations. The overall management of waste on the ANSTO site is regulated through the facility licence granted to ANSTO WOTD.
In so doing, each Contracting Party shall take the appropriate steps to: (i) ensure that criticality and removal of residual heat generated during radioactive waste management are adequately addressed; (ii) ensure that the generation of radioactive waste is kept to the minimum practicable; (iii) take into account interdependencies among the different steps in radioactive waste management; (iv) provide for effective protection of individuals, society and the environment, by applying at the national level suitable protective methods as approved by the regulatory body, in the framework of its national legislation which has due regard to internationally endorsed criteria and standards; (v) take into account the biological, chemical and other hazards that may be associated with radioactive waste management; (vi) strive to avoid actions that impose reasonably predictable impacts on future generations greater than those permitted for the current generation; (vii) aim to avoid imposing undue burdens on future generations.	Matters (i) to (v) are addressed in the OPAL plan and/or in the wider site plans under the Waste Operations and Technology Development (WOTD) licence. This is a part of the draft ARPANSA regulatory guidance for radioactive waste management facilities. For low-level waste, the Australian Government proposes to dispose of it during the life of the generation concurrent with the life of OPAL. The final disposal of some long-lived intermediate level waste needs to be considered.
Article 12 Each Contracting Party shall in due course take the appropriate steps to review: (i) the safety of any radioactive waste management facility existing at the time the Convention enters into force for that Contracting Party and to ensure that, if necessary, all reasonably practicable improvements are made to upgrade the safety of such a facility;	Not relevant to OPAL.

(ii) the results of past practices in order to determine whether any intervention is needed for reasons of radiation protection bearing in mind that the reduction in detriment resulting from the reduction in dose should be sufficient to justify the harm and the costs, including the social costs, of the intervention	
Article 13 Each Contracting Party shall take the appropriate steps to ensure that procedures are established and implemented for a proposed radioactive waste management facility: (i) to evaluate all relevant site-related factors likely to affect the safety of such a facility during its operating lifetime as well as that of a disposal facility after closure; (ii) to evaluate the likely safety impact of such a facility on individuals, society and the environment, taking into account possible evolution of the site conditions of disposal facilities after closure; (iii) to make information on the safety of such a facility available to members of the public; (iv) to consult Contracting Parties in the vicinity of such a facility, insofar as they are likely to be affected by that facility, and provide them, upon their request, with general data relating to the facility to enable them to evaluate the likely safety impact of the facility upon their territory. 2. In so doing, each Contracting Party shall take the appropriate steps to ensure that such facilities shall not have unacceptable effects on other Contracting Parties by being sited in accordance with the general safety requirements of Article 11.	These matters (i) to (iii) will be taken up in the assessment of proposals for the Commonwealth Radioactive Waste Management Facility and are covered in the draft ARPANSA regulatory guidance. Not relevant to the Commonwealth Radioactive Waste Management Facility.
Article 14 Each Contracting Party shall take the appropriate steps to ensure that: (i) the design and construction of a radioactive waste management facility provide for suitable measures to limit possible radiological impacts on individuals, society and the environment, including those from discharges or uncontrolled releases; (ii) at the design stage, conceptual plans and, as necessary, technical provisions for the decommissioning of a radioactive waste management facility other than a disposal facility are taken into account;	The matters covered by this Article will be taken up in the assessment of proposals for the licensing of the CRWMF (and are covered in the draft ARPANSA regulatory guidance).

(iii) at the design stage, technical provisions for the closure of a disposal facility are prepared; (iv) the technologies incorporated in the design and construction of a radioactive waste management facility are supported by experience, testing or analysis.	
Article 15 Each Contracting Party shall take the appropriate steps to ensure that: (i) before construction of a radioactive waste management facility, a systematic safety assessment and an environmental assessment appropriate to the hazard presented by the facility and covering its operating lifetime shall be carried out; (ii) in addition, before construction of a disposal facility, a systematic safety assessment and an environmental assessment for the period following closure shall be carried out and the results evaluated against the criteria established by the regulatory body; (iii) before the operation of a radioactive waste management facility, updated and detailed versions of the safety assessment and of the environmental assessment shall be prepared when deemed necessary to complement the assessments referred to in paragraph (i).	The matters covered by this Article will be taken up in the assessment of proposals for the licensing of the CRWMF (and are covered in the draft ARPANSA regulatory guidance).
Article 16 Each Contracting Party shall take the appropriate steps to ensure that: (i) the licence to operate a radioactive waste management facility is based upon appropriate assessments as specified in Article 15 and is conditional on the completion of a commissioning programme demonstrating that the facility, as constructed, is consistent with design and safety requirements; (ii) operational limits and conditions, derived from tests, operational experience and the assessments as specified in Article 15 are defined and revised as necessary; (iii) operation, maintenance, monitoring, inspection and testing of a radioactive waste management facility are conducted in accordance with established procedures. For a disposal facility the results thus obtained shall be used to verify and to review the validity of assumptions made and to update the assessments as specified in Article 15 for the period after closure; (iv) engineering and technical support in all safety-related fields are available throughout the operating lifetime of a radioactive waste management facility; (v) procedures for characterization and	The matters covered by this Article will be taken up in the assessment of proposals for the licensing of the CRWMF (and are covered in the draft ARPANSA regulatory guidance).

segregation of radioactive waste are applied; (vi) incidents significant to safety are reported in a timely manner by the holder of the licence to the regulatory body; (vii) programmes to collect and analyse relevant operating experience are established and that the results are acted upon, where appropriate; (viii) decommissioning plans for a radioactive waste management facility other than a disposal facility are prepared and updated, as necessary, using information obtained during the operating lifetime of that facility, and are reviewed by the regulatory body; (ix) plans for the closure of a disposal facility are prepared and updated, as necessary, using information obtained during the operating lifetime of that facility and are reviewed by the regulatory body.	
Article 17 Each Contracting Party shall take the appropriate steps to ensure that after closure of a disposal facility: (i) records of the location, design and inventory of that facility required by the regulatory body are preserved; (ii) active or passive institutional controls such as monitoring or access restrictions are carried out, if required; and (iii) if, during any period of active institutional control, an unplanned release of radioactive materials into the environment is detected, intervention measures are implemented, if necessary.	The matters covered by this Article will be taken up in the assessment of proposals for the licensing of the CRWMF (and are covered in the draft ARPANSA regulatory guidance).
Chapter 4: General Safety Provisions	
Article 18 Each Contracting Party shall take, within the framework of its national law, the legislative, regulatory and administrative measures and other steps necessary for implementing its obligations under this Convention.	For radioactive waste arising from operation of OPAL, this provision is met through the ARPANS framework and the licensing of OPAL and WOTD and the future CRWMF.
Article 19 1. Each Contracting Party shall establish and maintain a legislative and regulatory framework to govern the safety of spent fuel and radioactive waste management. 2. This legislative and regulatory framework shall provide for: (i) the establishment of applicable national safety requirements and regulations for radiation safety; (ii) a system of licensing of spent fuel and radioactive waste management activities;	For radioactive waste arising from operation of OPAL, this provision is met through the ARPANS framework and the licensing of OPAL and WOTD and the future CRWMF.

(iii) a system of prohibition of the operation of a spent fuel or radioactive waste management facility without a licence; (iv) a system of appropriate institutional control, regulatory inspection and documentation and reporting; (v) the enforcement of applicable regulations and of the terms of the licences; (vi) a clear allocation of responsibilities of the bodies involved in the different steps of spent fuel and of radioactive waste management. 3. When considering whether to regulate radioactive materials as radioactive waste, Contracting Parties shall take due account of the objectives of this Convention.	
Article 20 1. Each Contracting Party shall establish or designate a regulatory body entrusted with the implementation of the legislative and regulatory framework referred to in Article 19, and provided with adequate authority, competence and financial and human resources to fulfill its assigned responsibilities. 2. Each Contracting Party, in accordance with its legislative and regulatory framework, shall take the appropriate steps to ensure the effective independence of the regulatory functions from other functions where organizations are involved in both spent fuel or radioactive waste management and in their regulation.	ARPANSA. See Australian national reports to the first and second review meetings under the Joint Convention.
Article 21 1. Each Contracting Party shall ensure that prime responsibility for the safety of spent fuel or radioactive waste management rests with the holder of the relevant licence and shall take the appropriate steps to ensure that each such licence holder meets its responsibility. 2. If there is no such licence holder or other responsible party, the responsibility rests with the Contracting Party which has jurisdiction over the spent fuel or over the radioactive waste.	This is achieved through the relevant ARPANSA licences.
Article 22 Each Contracting Party shall take the appropriate steps to ensure that: (i) qualified staff are available as needed for safety-related activities during the operating lifetime of a spent fuel and a radioactive waste management facility; (ii) adequate financial resources are available	See Australian national reports to the first and second review meetings under the Joint Convention.

to support the safety of facilities for spent fuel and radioactive waste management during their operating lifetime and for decommissioning; (iii) financial provision is made which will enable the appropriate institutional controls and monitoring arrangements to be continued for the period deemed necessary following the closure of a disposal facility.	
Article 23 Each Contracting Party shall take the necessary steps to ensure that appropriate quality assurance programmes concerning the safety of spent fuel and radioactive waste management are established and implemented.	ANSTO has QA programs addressing, inter alia, spent fuel and waste management for OPAL and for WOTD. They form a part of the basis for the relevant ARPANSA licenses. QA arrangements will be required for the CRWMF (draft ARPANSA regulatory guidance).
Article 24 1. Each Contracting Party shall take the appropriate steps to ensure that during the operating lifetime of a spent fuel or radioactive waste management facility: (i) the radiation exposure of the workers and the public caused by the facility shall be kept as low as reasonably achievable, economic and social factors being taken into account; (ii) no individual shall be exposed, in normal situations, to radiation doses which exceed national prescriptions for dose limitation which have due regard to internationally endorsed standards on radiation protection; and (iii) measures are taken to prevent unplanned and uncontrolled releases of radioactive materials into the environment. 2. Each Contracting Party shall take appropriate steps to ensure that discharges shall be limited: (i) to keep exposure to radiation as low as reasonably achievable, economic and social factors being taken into account; and (ii) so that no individual shall be exposed, in normal situations, to radiation doses which exceed national prescriptions for dose limitation which have due regard to internationally endorsed standards on radiation protection. 3. Each Contracting Party shall take appropriate steps to ensure that during the operating lifetime of a regulated nuclear facility, in the event that an unplanned or uncontrolled release of radioactive materials into the environment occurs, appropriate corrective measures are implemented to control the release and mitigate its effects.	This is achieved through the relevant ARPANSA licences.

Article 25 1. Each Contracting Party shall ensure that before and during operation of a spent fuel or radioactive waste management facility there are appropriate on-site and, if necessary, off-site emergency plans. Such emergency plans should be tested at an appropriate frequency. 2. Each Contracting Party shall take the appropriate steps for the preparation and testing of emergency plans for its territory insofar as it is likely to be affected in the event of a radiological emergency at a spent fuel or radioactive waste management facility in the vicinity of its territory.	This is achieved through the relevant ARPANSA licences. Included in the regulatory guidance applicable to the CRWMF.
Article 26 Each Contracting Party shall take the appropriate steps to ensure the safety of decommissioning of a nuclear facility. Such steps shall ensure that: (i) qualified staff and adequate financial resources are available; (ii) the provisions of Article 24 with respect to operational radiation protection, discharges and unplanned and uncontrolled releases are applied; (iii) the provisions of Article 25 with respect to emergency preparedness are applied; and (iv) records of information important to decommissioning are kept.	Decommissioning of the OPAL Research Reactor, is considered in the SAR. This includes the choice of materials to minimise activation, space for access and minimisation of the radioactive waste that will be produced during commissioning. A preliminary decommissioning plan was established during the construction of the reactor. ARPANSA was satisfied that the applicant has appropriate plans and arrangements to satisfy decommissioning requirements at the present stage in the facility lifetime.
Chapter 5: Miscellaneous Provisions	
Article 27 1. Each Contracting Party involved in transboundary movement shall take the appropriate steps to ensure that such movement is undertaken in a manner consistent with the provisions of this Convention and relevant binding international instruments. In so doing: (i) a Contracting Party which is a State of origin shall take the appropriate steps to ensure that transboundary movement is authorized and takes place only with the prior notification and consent of the State of destination; (ii) transboundary movement through States of transit shall be subject to those international obligations which are relevant to the particular modes of transport utilized; (iii) a Contracting Party which is a State of destination shall consent to a transboundary movement only if it has the administrative and technical capacity, as well as the regulatory structure, needed to manage the spent fuel or the radioactive waste in a manner consistent with this Convention; (iv) a Contracting Party which is a State of origin shall authorize a transboundary	Any shipment of spent fuel or radioactive wastes returned to Australia will be subject to a specific transport plan developed for each shipment, addressing these matters. The plan must be by the CEO of ARPANSA and other competent transport authorities.

movement only if it can satisfy itself in accordance with the consent of the State of destination that the requirements of subparagraph (iii) are met prior to transboundary movement; (v) a Contracting Party which is a State of origin shall take the appropriate steps to permit re-entry into its territory, if a transboundary movement is not or cannot be completed in conformity with this Article, unless an alternative safe arrangement can be made. 2. A Contracting Party shall not licence the shipment of its spent fuel or radioactive waste to a destination south of latitude 60 degrees South for storage or disposal. 3. Nothing in this Convention prejudices or affects: (i) the exercise, by ships and aircraft of all States, of maritime, river and air navigation rights and freedoms, as provided for in international law; (ii) rights of a Contracting Party to which radioactive waste is exported for processing to return, or provide for the return of, the radioactive waste and other products after treatment to the State of origin; (iii) the right of a Contracting Party to export its spent fuel for reprocessing; (iv) rights of a Contracting Party to which spent fuel is exported for reprocessing to return, or provide for the return of, radioactive waste and other products resulting from reprocessing operations to the State of origin.	
Article 28 1. Each Contracting Party shall, in the framework of its national law, take the appropriate steps to ensure that the possession, remanufacturing or disposal of disused sealed sources takes place in a safe manner. 2. A Contracting Party shall allow for re-entry into its territory of disused sealed sources if, in the framework of its national law, it has accepted that they be returned to a manufacturer qualified to receive and possess the disused sealed sources.	Not applicable to OPAL.

Chapter 6: Meetings of the Contracting Parties	
Articles 29 – 31 and 33 -37 deal with meetings of the contracting parties	Not applicable to OPAL.
Article 32 1. In accordance with the provisions of Article 30, each Contracting Party shall submit a national report to each review meeting of Contracting Parties. This report shall address the measures taken to implement each of the obligations of the Convention. For each Contracting Party the report shall also address its: (i) spent fuel management policy; (ii) spent fuel management practices; (iii) radioactive waste management policy; (iv) radioactive waste management practices; criteria used to define and categorize radioactive waste.	Australia has submitted national reports to the first and second review meeting held under the Joint Convention.
Chapter 7: Final Clauses and other Provisions	
Articles 38-44 deal with the formal mechanisms for entry into force of the Joint Convention.	Not applicable to OPAL.