Australian Government

Australian Radiation Protection and Nuclear Safety Agency

REGULATORY ASSESSMENT REPORT Periodic Safety Review of OPAL Reactor Facility Licence F0157

Licence Holder: ANSTO OPAL Reactor

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Executive Summary

The OPAL research reactor Licence Condition related to the Periodic Safety Review (PSR) was imposed on ANSTO in 2006 when the reactor was licensed to operate. The condition requires that the licence holder submits a detailed safety review that takes into account operational experience and international best practice two years after completion of the commissioning of the OPAL reactor. In addition, the review must be subject to international peer review.

The initial set of documents of the OPAL Periodic Safety Review (PSR) was submitted to ARPANSA in November 2011. The submission contained a review of the OPAL reactor against the IAEA Safety Guide *Periodic Safety Review of Nuclear Power Plants NS-G-2.10*. The ARPANSA review of the documentation identified issues related to the submission content and scope of some analyses presented. These issues were communicated to ANSTO. ANSTO progressively supplied additional analyses and information to demonstrate that the matters raised by ARPANSA have been addressed. Throughout the regulatory review process, ANSTO also gradually submitted all chapters of the revised OPAL Safety Analysis Report.

The regulatory review process included several formal meetings with ANSTO in order to discuss the concerns identified by ARPANSA reviewers. ARPANSA reviewers consider the information provided to ARPANSA under the PSR to be sufficient to assess ANSTO's compliance with Licence Condition 13 of OPAL Licence F0157.

The ARPANSA review of the information provided showed that ANSTO has adequately assessed OPAL safety against all fourteen safety factors described in the IAEA guide NS-G-2.10. The scope of review covered the plant design, actual OPAL reactor conditions of the safety critical systems, level of equipment qualification, ageing, safety analyses, hazard update, OPAL reactor safety performance, organisation and administration, OPAL reactor business management system, human factors, OPAL radiological impact on the environment, and emergency planning.

Since the guide was developed for nuclear power plants, ARPANSA reviewers applied a graded approach during the assessment, taking into account the relative magnitudes of the hazards of the OPAL research reactor by comparison to those of nuclear power reactors. The application of this grading to individual safety factors followed guidance in the IAEA guide on use of graded approach and is described in specific sections of the report. Details on the graded approach are presented in section 1.3.2 below.

ANSTO demonstrated that the OPAL reactor design is adequate with no significant safety issues. Its operation, supported by appropriate administrative arrangements, has been safe within the last PSR period. ANSTO also showed that it has sufficient provisions in place to maintain safety for the next PSR period.

The ANSTO review resulted in a large number of recommendations. ANSTO showed that the programme developed for the implementation of all actions arising from the PSR can be effective.

Based on the review of the PSR, ARPANSA finds that ANSTO has adequately complied with Licence Condition 13 of OPAL Licence F0157. Hence, the requirements of the condition are considered to be

fulfilled. Therefore, it is recommended that the Licence Condition 13 is lifted to reflect these findings.

In order to maintain long term safety in operation of the facility and to provide reassurance of adequacy of the plans and arrangements for managing safety, the ARPANSA reviewers recommend that the next OPAL periodic safety review be completed by 30 November 2021. Therefore, a new licence condition is recommended to be imposed on ANSTO that will specify the new periodic safety review interval for the OPAL reactor.

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1.Introduction

One of the OPAL Licence Conditions imposed on ANSTO in 2006 when the reactor was licensed to operate is Licence Condition 13 (F0157) related to Periodic Safety Review (PSR):

> *"Licence Holder must submit to the CEO of ARPANSA a detailed review that re-examines the safety of the OPAL Reactor taking into account operating experience and international best practice in radiation protection and nuclear safety, and that has been subject to international peer review. The first such review must be completed no later than two years after the date of completion of the commissioning of the OPAL Reactor and thereafter at intervals agreed to by the CEO of ARPANSA."*

The reactor commissioning was officially completed by the ARPANSA letter on 11 November 2009 [1]. Based on adequacy of the Stage C Commissioning Report, and particularly on meeting the last hold point No. 3, the OPAL reactor commissioning phase was declared closed. According to the requirement of Licence Condition 13 (LC 13) above, ANSTO was required to submit a PSR by November 2011. Appendix 2 provides justifications for this and other relevant licence conditions imposed on ANSTO in the original OPAL licence.

1.1. Responsibilities

According to the IAEA PSR Guide [16], the licence holder should be responsible for PSR: *"The primary responsibility for conducting a PSR and reporting its findings lies with the operating organization of the plant"*

ARPANSA, on the other hand, is responsible for setting the principles or expectations that should be met by the licence holder: *"The regulatory body has the responsibility of specifying or approving the requirements for a PSR, reviewing the conduct and conclusions of the review and the consequential corrective actions and/or safety improvements, and taking appropriate licensing actions. It is also responsible for reporting the outcome of the PSR to the national government and the general public"* [16].

1.2. Purpose and format

The purpose of this report is to document the assessment of information contained in the ANSTO PSR submission against the requirements of the Licence Condition 13 of the F0157 Licence and to make recommendations to the CEO of ARPANSA in the matter of the PSR submission.

The reviewers took into consideration the following documents and information in making recommendations to the CEO:

- The information contained in the initial submission [2] and its references

- Information obtained from the applicant following the receipt of the submission [3], [4], [5], [6], [7]
- Meetings and discussions with the applicant [8], [9]
- Periodic Safety Review Supplement [10]
- Fuel Plate Displacement 'What if' Assessment [11]
- Other documents referred to in the body of this report

1.3. Regulatory Review Process

The following documents have been used to assist the assessment of this submission:

- the ARPANS Act & Regulations [12], [13],
- ARPANSA Regulatory Guideline: Plans and Arrangements for Managing Safety [14],
- ARPANSA Regulatory Assessment Principles for Controlled Facilities [15],
- Periodic Safety Review of Nuclear Power Plants NS-G-2.10 (2003) [16]. The latest revision of this IAEA document (SSG-25, 2013) was not used for the review because this document was not issued at the time the PSR was submitted. Instead, the 2003 edition was used. It is noted that guidelines related to the individual safety factors included in SSG-25 remain identical to those in NS-G-2.10, and
- The IAEA guide on Use of Graded Approach in the Application of the Safety Requirements for Research Reactors [17].

The OPAL PSR Submission as submitted in December 2011 was subject of the ARPANSA preliminary review in January and February 2012. Based on this review, ANSTO was informed of the submission shortfall [18] via a letter. Although that review identified very specific issues of the submission, the requirements to ANSTO stated in the letter were deliberately kept at a systemic level rather than a list of specific issues. The reasons for this regulatory approach were to maintain ANSTO's PSR ownership and associated responsibility as well as encourage ANSTO to identify weaknesses in the PSR itself, and to prevent addressing only the highlighted specific issues rather than wider issues arising from it. This intention was also communicated to ANSTO at various meetings and on other occasions throughout the OPAL PSR process. The regulatory assessment of the submission and its findings are provided in the Assessment and Findings section below.

The communication with ANSTO during the review process involved an OPAL PSR workshop in April 2013. The workshop conclusions formed the basis for ANSTO's revision of the original OPAL PSR Submission resulting in the Periodic Safety Review Supplement. The latter document addressed the areas identified in the ARPANSA assessment process. As indicated above, the PSR Supplement forms a part of this regulatory assessment framework.

The outstanding issues were identified during the ANSTO-ARPANSA December 2013 OPAL PSR meeting. ANSTO provided additional information and analyses requested by ARPANSA so the relevant outstanding actions were completed.

The review process is summarised chronologically below.

1.3.1. Chronology

The main submission review progress milestones were as follows:

DATE	MILESTONE
11 November 2009	Official completion of the OPAL reactor commissioning phase
30 June 2011	Agreed cut-off date for the PSR data acquisition
11 November 2011	Formal OPAL PSR submission date stipulated by Licence Condition 13
23 December 2011	Actual date when the OPAL Periodic Safety Review was submitted
9 February 2012	A meeting held on OPAL PSR providing the initial ARPANSA feedback on the submitted documents
28 February 2012	ARPANSA letter to ANSTO [R12/01831] outlining areas of the OPAL Periodic Safety Review report with shortfalls
June 2012	A draft PSR action plan was submitted by ANSTO [19]
23 July 2012	ARPANSA received a letter from ANSTO [20] with response to the ARPANSA's generic issues identified in 28/2/12 letter
November 2012 and December 2013	ANSTO submitted its updated Safety Analysis Report (Chapters 1 – 20) for review by ARPANSA
3 April 2013	OPAL PSR workshop organised to discuss PSR issues in details [8]
26 June 2013	ANSTO submitted Supplement to OPAL PSR to address the matters of 3/4/13 workshop
4 December 2013	ARPANSA wrote to ANSTO regarding its assessment of the PSR supplement, and to request outstanding items [6]

29 January 2014	ANSTO corresponded with ARPANSA on the outstanding items required to complete the PSR
7 March 2014	ARPANSA questions associated with regulatory review of selected chapters of the OPAL updated Safety Analysis Report were sent to ANSTO [21]

1.3.2. Graded Approach

The main document against which the OPAL PSR review document was assessed was IAEA's NS-G-2.10 (the Guide). However, this document has been developed for nuclear power plants. At the moment, there is no international standard developed to define the periodic safety review process for research reactors.

At ARPANSA–ANSTO meetings prior to the original OPAL PSR submission, ARPANSA outlined that ANSTO's PSR would be assessed taking into account the extent, depth and rigour commensurate with the level of hazard associated with the OPAL research reactor. The scope of the Guide was retained. However, the depth and rigour of compliance with some guidelines would not necessarily need to be as high as required for nuclear power plants, in order to achieve an acceptable level of safety. This is based on the fact that the inventory of radioactive material in a research reactor, and consequent hazard levels, is significantly smaller than in a nuclear power plant, for which the Guide was developed.

The application of a graded approach during the ARPANSA assessment was in accordance with the guidance specified in the IAEA guide on Use of Graded Approach in the Application of the Safety Requirements for Research Reactors [17].

1.4. Scope of review

The Periodic Safety Review of the OPAL reactor has been conducted by ANSTO and the PSR report [2] with supporting documentation was submitted to ARPANSA. Any additional information provided by ANSTO forms part of this assessment.

1.4.1. OPAL Safety Analysis Report

The OPAL PSR requirement, as set out in LC 13 of the OPAL reactor licence, implicitly covers a review of the OPAL Safety Analysis Report (the SAR). ANSTO submitted to ARPANSA the first revised SAR chapter in late 2012. Based on the scope and nature of the SAR review, the decision was made to allow ANSTO to submit the revised SAR chapters progressively by chapters as their revision progresses.

ARPANSA reviewers assessed the OPAL reactor updated SAR by selecting the three most important chapters. These were selected based on significance of their content – *Chapter 5: Reactor* describes the design of the reactor and its operation in steady states; *Chapter 11: Reactor Utilisation* describes

design and operation of the reactor utilisation; and *Chapter 16: Safety Analysis* that discusses results of the reactor safety analysis, presents the actual safety analysis of all postulated accidents and defines the safety envelope of the reactor. These chapters were considered to form the crux of the SAR and therefore in this respect, were deemed as a suitable representative sample of ANSTO's compliance with LC 13.

ARPANSA reviewers adopted this risk-informed sampling method as opposed to a full scale review of the SAR for the following reasons:

- Whilst only three the most important chapters were selected for assessing ANSTO's compliance with the LC 13, the remaining chapters will be reviewed gradually later, outside the PSR assessment.
- A preliminary assessment of safety implications of changes to other chapters was carried out. This assessment did not include a detailed review of the affected chapters at this time.

1.4.2. Timeframe of the PSR

ARPANSA chose 30 June 2011 as the cut-off date for the OPAL PSR data acquisition. ARPANSA selected this date on the basis that the defined period would provide ANSTO with sufficient time to gain the operational experience required to undertake a periodic safety review. Although the reactor was officially declared fully operational in November 2009, it had been effectively operating since November 2006 when full power was reached during commissioning. This period included the extended shutdown from July 2007 to May 2008, due to the 'fuel fault' [22]. The data acquisition cut-off date selected effectively extended the original date outlined in LC 13.

Although the OPAL reactor operating past experience was restricted by June 2011, the other aspects necessary to be considered within the OPAL PSR were taken into account, e.g. consideration of the adequacy of arrangements for the OPAL reactor future operation.

2.Assessment and Findings

The main document against which ANSTO carried out the OPAL reactor PSR and against which ARPANSA reviewed the PSR documents was IAEA's Safety Guide NS-G-2.10 Periodic Safety Review of Nuclear Power Plant. Many of the ARPANSA guidelines are derived from this IAEA document.

In addition, the ARPANSA reviewers used ARPANSA' guides (see section 1.3 above) [14], [15] that contained specific requirements against which the provided information was also reviewed. For example, the information provided in the submission was compared to guidelines on managing safety, the reactor design and safety analyses.

According to the IAEA Guide, the overarching objective of the PSR is to

- determine by a comprehensive assessment of the existing plant the extent to which the plant conforms to current standards and international practices,
- determine the extent to which the licensing basis remain valid,
- determine the adequacy of the arrangements in place that will be followed to maintain the plant safety until the next PSR is conducted, and
- implement safety improvements arising from the safety issues identified during the PSR.

2.1. Structure of PSR submission

The OPAL PSR Submission was structured to reflect this approach. ANSTO assessed the OPAL reactor safety against all fourteen safety factors identified in the Guide. The review conclusion was summarised in the section titled "Global Assessment". The review findings of the international peer review team (see section 2.3 below) were also incorporated into the submission.

The initial ANSTO review resulted in 124 recommendations that were summarised in a dedicated section. This also included the recommendations raised by the peer review team members. ARPANSA requested that ANSTO, throughout the review process, further developed this set of recommendations into an action database called the After-action Programme. This document is the plan and schedule for implementation of the recommendations arising from the PSR. It was updated repeatedly throughout the regulatory review process. In its later revision it also included the recommendations arising from additional ANSTO work requested by ARPANSA, as presented in the sections below. ANSTO showed throughout the submission that there are adequate mechanisms in place to achieve full implementation of the actions raised.

The PSR was supplemented by the updated Safety Analysis Report that supported the Safety Factor 5: Deterministic Safety Analysis. All chapters of the SAR were provided separately from the main submissions, and were supplied progressively between December 2011 and November 2013.

The general findings of the regulatory assessment are presented below, followed by findings which are specific to the individual safety factors. The findings in the following paragraphs are based on all information ANSTO provided throughout the whole review process.

2.2. General Findings

The actual submission of the OPAL PSR documents was overdue by approximately six weeks. Instead of 11 November 2011, the submission was provided on 23 December 2011. Considering the scope of the work the PSR preparation involved, ARPANSA did not consider such a delay to have any significant effect on the overall OPAL safety. ARPANSA had been sufficiently informed on the progress of the OPAL PSR preparation prior to its actual submission and the delay was deemed acceptable.

The regulatory review of the submission identified the following general issues that were common to some of PSR chapters assessing safety factors. ARPANSA requested further information from ANSTO to address these issues in a letter dated 28 February 2012 [18]. The ANSTO responses to the issues raised by ARPANSA are discussed below.

1. The initial submission lacked details in analysis of the OPAL reactor operational performance and implementation of lessons learnt.

   The submission provided clear objectives of the review conducted. However, in many areas, the justifications of recommendations arising from the review were insufficient so it was difficult or impossible to establish the bases for the recommendations. This issue was discussed with ANSTO.

   The additional information requested from ANSTO to further support the shortfall constituted the OPAL PSR Supplement [10]. The document provided the necessary clarifications. It also demonstrated that an additional review of system/processes of the OPAL reactor has been undertaken. Based on the supplementary information supplied, additional recommendations arose which have been included in the After-action Programme.

   Similarly, the submission included the information of various safety relevant operational events. However, the assessment did not include analysis (statistical) of the identified event causes. Therefore, it was not demonstrated whether or not common 'thematic' causes, e.g. maintenance, training, were identified. ARPANSA raised this matter with ANSTO during the review process. ANSTO then integrated the additional analysis in the OPAL PSR Supplement [10]. The information provided did not show any indication of adverse trending.

   Conclusion:

   The ARPANSA reviewers were satisfied that additional analysis sufficiently addressed the issues raised. All outstanding issues arising from this assessment have been adequately logged in the After-action programme.

2. Some specific issues related to OPAL operational events were not explicitly discussed in the PSR.

ARPANSA's review of the initial PSR submission indicated the information did not sufficiently cover special consideration of events, e.g. the fuel fault. Although the event was mentioned in the document, the details of information and lessons that could be learned from it were not deemed sufficient. On ARPANSA's request, ANSTO developed a 'What if' analysis of the event that was provided in December 2013 [11] to support the PSR submission. This information supplied in this document sufficiently addressed the relevant matters raised.

Regarding details of the events that have caused the OPAL Safety Case modification, ANSTO referred in their response to the revised safety analysis that was included in the new revision of the OPAL SAR, Chapter 16. The regulatory review of Chapter 16 conducted later confirmed the relevant events had been appropriately incorporated in the OPAL reactor safety analysis.

Conclusion:

The ARPANSA reviewers deemed the extent to which ANSTO has addressed this issue sufficient.

There are currently no outstanding matters, other than those recorded in the After-action Programme, related to this finding.

It is noted that two OPAL Licence Conditions associated with the 'fuel fault' are still in place [22]. *The matter of assessment of ANSTO compliance with these conditions will be dealt with outside of the OPAL PSR assessment.*

3. The cumulative effect of OPAL relevant changes over the period was not appropriately addressed in the initial OPAL PSR Submission.

Although the submission contained a list of changes that were implemented during this period, the information provided indicated that the analysis that had been carried out for cumulative effect of the changes was insufficient. For example, multiple changes were made to the arrangements for safety management of the OPAL reactor which were not individually categorised to be regulation 51 changes. While individual changes were appropriately assessed to be under the threshold for ARPANSA approval, there was the potential that when effects of those changes were judged together, they might have safety significant implications. This expectation was based on the general PSR rationale stated in the IAEA Guide, and later included in the ARPANSA guide on determination when a change has significant implication for safety [23]. This ARPANSA guide issued in January 2013 has been also developed in accordance with the relevant IAEA guides, e.g. Use of a Graded Approach in the Application of the Safety Requirements for Research reactors, SSG-22 [17].

ARPANSA requested that particular changes not approved under regulation 51 be considered for such analysis. Although ANSTO did not provide such specific analysis, they explained their change management system, and modification safety screening and assessment processes are currently in place. It was shown that these systems have the capacity to screen the cumulative effects of changes although in practice ANSTO has never demonstrated this in the submission to ARPANSA.

ARPANSA continuously monitors OPAL's change control system through its regulatory oversight program. Regular inspections of this specific area are also conducted approximately every second year. The change control management is also partially addressed through inspection of other relevant topics, e.g. event management. The pertinent inspections that have been conducted up to date have not indicated any major safety problems in this area.

Conclusion:

Taking into account the additional information provided and the ARPANSA regulatory compliance monitoring programme, the ARPANSA reviewers have accepted the ANSTO response. There are no outstanding issues related with this finding.

4. The regulatory review of the initial submission showed that some of the information contained within the PSR document was incorrect.

Some statements/claims and information were incomplete or not supported by sufficient evidence (e.g. the evidence supporting a claim that the reactor was completely aligned with the IAEA NS-R-4 was not detailed).

ANSTO subsequently conducted an accuracy check of the document to address this issue. As a result, a substantial amount of information previously presented has been corrected and a document update was provided by ANSTO. Moreover, ANSTO conducted the review of systems and processes applied at the OPAL reactor. These updates were summarised in the OPAL PSR Supplement [10]. As requested by ARPANSA, ANSTO also updated all PSR recommendations.

Conclusion:

The additional information provided accurate information and all issues identified have been addressed. There are no outstanding issues related to this finding.

5. Some claims throughout the submission were not substantiated.

The ARPANSA reviewers noted that certain statements made in the PSR submission were unsubstantiated (e.g. in section 13 stating the procedures are comprehensive, validated, formally approved and subject to rigorous change control), thus not sufficiently demonstrating that the assessment objectives had been met.

In addition, the referencing used in the ANSTO document did not provide the necessary information on supporting documents so the reviewers could not easily verify the claims.

Conclusion:

Although ANSTO provided majority of the missing information throughout the review process, some claims remained unsupported. However, the unsubstantiated claims do not represent issues with high safety significance.

Recommendation 1: It is recommended that the next OPAL PSR should provide sufficient supporting documentation to substantiate the

assertions made. Moreover, the referencing system used should be further improved. It should include clear links/information on the support documents so the relevant claims are readily verifiable.

2.3. Peer Review of OPAL PSR

The licence issued in July 2006 contained a condition requiring the Periodic Safety Review be subject to international peer review. In order to comply with the condition, ANSTO organised the OPAL PSR peer review team.

The international team consisted of four reviewers (two from the Netherlands, one from the USA and one from France) who reviewed the document over a week in October 2011. All four specialists had the credentials and suitable professional experience to conduct the safety review. Their review was included in the PSR submission.

The peer review team closely followed the objectives formulated in the IAEA Guide and as outlined in section 2 above. Their approach consisted of two phases; the preparation phase, where the team studied the OPAL reactor documents in detail and the interview phase, where the team visited ANSTO and conducted interviews with the OPAL reactor personnel. The team formulated forty one recommendations and suggestions. No major issues related to the OPAL reactor safety were identified.

ANSTO provided sufficient information in their responses to the peer review team recommendations and suggestions. Many of the recommendations were implemented before the PSR submission was made. Some of the remaining ones overlapped with recommendations arising from the ANSTO review. The recommendations with a long term implementation have been included in the After-action Programme.

Conclusion:

ARPANSA reviewers consider the approach the peer review team undertook to be adequate and the peer review team work scope sufficient. The peer review team did not identify any major safety issue. All recommendations emerging from the peer review have been appropriately managed.

2.4. ANSTO internal approval of PSR

Apart from the international peer review team, the OPAL Periodic Safety Review documents have also been internally reviewed by ANSTO. The PSR set of documents was jointly reviewed by ANSTO Safety Assurance Committee (SAC) and Reactor Assessment Committee (RAC) and endorsed on 1 November 2011.

The PSR was approved with two recommendations. The first is related to development and implementation of a system for safety categorisation of the large number of recommendations generated by the PSR and the second concerns implementation of the recommendations.

The ARPANSA review showed that the After-action Programme meets both requirements.

Conclusion:

ARPANSA reviewers found the internal review process of the OPAL PSR followed the ANSTO established process. No deviation was identified.

2.5. Safety FACTOR 1: Plant Design

Objective (the IAEA Guide): Determine the adequacy of the design and its documentation in an assessment against current international standards and practices.

Specific guidelines (the IAEA Guide):

a) The plant Structures, Systems and Components (SSCs) should have appropriate characteristics, including prevention and mitigation of safety events.

b) The adequate design information and design basis information should be available to provide safe operation and maintenance and to facilitate plant modifications.

c) A comprehensive list of SSCs important to safety should be developed or reviewed for currency.

d) The review should identify differences in plant design in an assessment against current safety standards and determine their safety significance (strengths and weaknesses).

e) The review should ensure that all significant documentation related to the original design basis has been obtained and securely stored and updated to reflect all modifications made to the plant and procedures since its commissioning.

The ANSTO indicated in the review that there have been no changes to the design bases of the OPAL SSCs since the reactor commissioning. Therefore, all design bases were assessed to have ongoing applicability. The ARPANSA reviewers accepted this argument.

The ANSTO review of the plant SSC categorisation system demonstrated that the process currently in place is adequate. The categorisation system was established during the reactor licensing stage and has been used for many OPAL reactor SSC modifications. The process is subject to a regular ANSTO internal review according to the established quality assurance programme. ANSTO reviewed the OPAL reactor safety categorisation of individual structures, systems and components and found it adequate.

Regarding the review against the current safety standards, ANSTO essentially identified all relevant standards, regulations and guidelines associated with safety. These were checked for currency and

their versions compared with their updates. If variations between these versions were identified, the existing plant and the SAR were assessed against the current standard requirements. The issues arising from this assessment were recorded for further actions. This approach was considered acceptable to the ARPANSA reviewers.

The ANSTO review resulted in many recommendations associated with changes to the standards applicable to the OPAL reactor since commissioning. The changes were assessed and the review did not indicate any critical or urgent design safety issues. Some recommendations were made to investigate the design improvements further to maintain compliance with the current standards. All actions arising from the recommendations were logged in the After-action Programme for implementation and tracking.

ANSTO also reviewed their process for control of plant modifications which is imbedded in the existing OPAL reactor Business and Management System (BMS). The present change control process including the internal approval process was assessed to be adequate. There were no indications in the ANSTO review suggesting issues resulting in significant safety implications.

Conclusion:

The ARPANSA reviewers are satisfied that the relevant SSCs designs were assessed to be in alignment with their design bases. ANSTO identified no safety significant issues related to the OPAL reactor design.

ANSTO provided evidence showing that an appropriate review of the safety categorisation of individual systems was conducted. The system safety categorisation was found adequate for the anticipated OPAL reactor future operation.

The ARPANSA review indicates that the OPAL reactor design documentation has been thoroughly reviewed and is sufficiently up to date. The scope and depth of the review was demonstrated to be adequate for the research reactor. All issues that ANSTO identified have been appropriately recorded in the After-action Programme.

2.6. Safety Factor 2: Actual Conditions of Systems, Structures and Components

Objective (the IAEA Guide): Determination of the actual condition of SSCs important to safety and whether they meet their design requirements.

Specific guidelines (the IAEA Guide):

a) Knowledge of the actual condition as well as anticipated obsolescence of SCCs should be the top priority of the PSR.

b) The review should also confirm that the condition of SSCs is properly documented.

c) A check of the existing records should be carried out to ensure they represent the actual condition of the SSCs, including findings from maintenance and inspection.

d) Each SSC should be assessed against its design basis to confirm that ageing has not significantly undermined the design basis assumptions.

ANSTO limited the scope of this part of review to SSCs that had safety significance–Safety Category 1 (SC-1) items as defined in the OPAL SAR. This decision has been previously subject of communication between ANSTO and ARPANSA at various meetings during the OPAL periodic safety review. ARPANSA agreed with this scope and considered this approach to be appropriate bearing in mind the potential accident consequences of OPAL reactor compared to a nuclear power plant.

ANSTO reviewed the maintenance and inspection records, reactor operation event management system (ROEMS), operation logbooks and project registers of individual SSCs in the PSR process. The assessment was broken into systems and logical structures, which allowed specific issues to be identified. In some areas, declared statements were not substantiated with sufficient evidence readily available to ARPANSA in the initial submission. The information for the most important aspects of the assessment was provided in the OPAL PSR Supplement.

By sampling the presented SSCs, ARPANSA checked the statements and claims made in the ANSTO review. The sampling group focused on matters that have risen from reported OPAL ROEMS events and engineering projects approved under regulation 51. This approach gave the ARPANSA reviewers reasonable confidence that all applicable issues that had been identified by June 2011 had been examined in the PSR.

The ANSTO review indicated that all SSCs of significant safety importance met their design bases. The ARPANSA review did not identify any evidence during the regulatory assessment of the information provided that would suggest the design bases of the SSCs were compromised.

Some of SC-1 components were not checked as ANSTO considered that there was no potential for degradation in the short life of the reactor, e.g. the pool liner. Although ARPANSA reviewers agree that this approach is considered acceptable for this PSR, these issues will need to be more comprehensively addressed in subsequent PSRs.

Regarding point c) above, the PSR did not fully address the recommendation related to record accuracy verification against the actual status of SSCs. However, it was evident from certain recommendations raised by ANSTO that such checks have been conducted. This was deemed adequate by the ARPANSA reviewers.

In some places of the PSR, recommendations could not be backtracked to a corresponding issue in the review. The recommendations appear to be reasonably descriptive so that issues that need to be improved or corrected can be identified and their justification can be deduced. However, the link between the specific issue and related recommendation was not always clear.

Many of ANSTO's recommendations arising from their review contained requests for further reviews of the long term maintenance strategies and improvements to procedures and instructions, drawings, tools and equipment. There has been no major issue identified.

Conclusion:

Although the status of the documentation associated with SSCs as expected by the Guide was not entirely addressed in the ANSTO review, the subject of many recommendations arising indicated that such assessment has been conducted. The ARPANSA reviewers consider that the ANSTO assessment against the guidelines was adequate and proportionate to the actual age of the plant respecting the graded approach.

The ARPANSA reviewers consider that ANSTO appropriately assessed the actual conditions of the plant and that the safety functions defined by the respective design bases remain fully meet.

Recommendation 2: **It is recommended that the next PSR establishes links between the issues identified in the review and relevant recommendations proposed so the reasons for the recommendations are made clear.**

2.7. Safety Factor 3: Equipment Qualification

Objective (the IAEA Guide): Determination whether the equipment important to safety is qualified to perform its designated safety function throughout its installed service life.

Specific guidelines (the IAEA Guide):

a) Equipment important to safety should be properly qualified to perform under postulated service conditions.

b) Qualification procedures should be used to confirm the equipment capabilities while subject to the environmental conditions.

c) Evidence of the qualification should be generated, documented and maintained (ongoing process) considering ageing, modifications, repairs, refurbishment and abnormal operating conditions.

d) The review should determine that the qualification was initially provided, its performance has been preserved (testing, inspections, maintenance, calibration), which includes clear documentation.

ANSTO limited the scope of the review under this safety factor to SC 1 items. SC 1 items correspond to SSCs that have the primary importance to safety. ARPANSA reviewers consider ANSTO's justification acceptable for limiting the scope in the review to only SC 1 items.

No plant walkdown was conducted due to the young age of the plant. The ARPANSA reviewers accepted this decision as appropriate.

ANSTO found the OPAL items important to safety appropriately qualified for the seismic design and electrical/instrumentation safety functions. However, the ANSTO assessment indicated shortfalls in

many areas. For example, ANSTO found that the information related to requirements for SSC qualification was incomplete. Existing qualification documentation was scattered throughout many technical documents and was not appropriately consolidated. However, the ANSTO OPAL PSR uncovered no major issues indicating that safety related SSCs were not qualified for the designed function.

The ARPANSA review showed that adequate recommendations and actions have been raised in the After-action Programme to adequately deal with the issues identified.

Conclusion:

The information submitted to ARPANSA showed that their review has addressed all safety factor objectives, namely regarding assessment of adequacy of the SC 1 systems, the status and use of qualification procedures, and the level of qualification documentation.

The ARPANSA reviewers are satisfied that the ANSTO review of the equipment qualification demonstrated acceptability of the relevant equipment qualification, even though some areas need to be improved. For example, the qualification documentation should be consolidated and ANSTO technical capability improved to perform certain equipment qualifications. Some qualification procedures will need to be revised to better define the qualification requirements.

All issues raised have been adequately recorded for resolution in the After-action Programme. ARPANSA reviewers are also satisfied that these matters will be dealt with in a systematic and planned manner.

2.8. Safety Factor 4: Ageing

Objective (the IAEA Guide): Determination whether the plant ageing is being effectively managed so the required safety functions are maintained and whether the ageing management programme is in place for future plant operation. Where safety factor 2 above intends to establish the actual plant conditions, this safety factor is primarily concerned with the plant conditions in the future.

Specific guidelines (the IAEA Guide):

a) Ageing of SSCs that could impair safety functions should be understood and controlled.

b) The age related degradation of the SSCs to be controlled within the defined limits by:

   i. Operation within the guidelines with aim of minimising the rate of degradation.

   ii. Inspection and monitoring to be consistent with the applicable requirements to detect and characterise any degradation.

   iii. Assessment of observed degradation.

   iv. Maintain the plant to prevent or remedy unacceptable degradation.

c) An effective ageing management programme should be in place.

d) Effective arrangements should be made to fulfil required safety functions for future operations, e.g. policies, procedures, performance indicators, staffing, resources and record keeping).

As indicated in the ARPANSA assessments throughout various stages of the OPAL reactor licensing process, ageing was taken into consideration in the design of SC 1 SSCs. However, there was no system established at that time that would consistently monitor and detect gradual degradation of majority of individual SSCs.

It was evident from the information provided in the PSR that ANSTO has made some progress in this area. An Asset Management System for the OPAL reactor that intends to cover ageing management, and proactive and predictive maintenance has been under development. This system is in its initial stages as far as the results and the programme applications in practice are concerned. However, ANSTO presented sufficient information indicating that solid plans for the continuous development of the system are in place and that the safety functions of the SSCs important to safety will be preserved in the future as ageing of the plant progresses.

Based on the information provided on the OPAL Asset Management System, the ARPANSA reviewers consider that the ageing process of the plant is reasonably understood and controlled within the defined limits. As the system improves, further improvement of degradation management is expected.

Whereas ANSTO's assessment against SF 4 addressed the future plans to continuously monitor, control and assess ageing of the reactor's safety important SSCs, it lacked consideration of operational experience and lessons learned that may have future implications for the plant. For instance, there have been some leaks and overfill spills during the period of time covered by the PSR (e.g. pool overfills) that may have had an impact on safety relevant systems (in this case the pool liner). There was little analysis presented in the PSR that would suggest that this aspect has been considered.

Conclusion:

ANSTO has identified many issues in the review associated with ageing and asset management. The ARPANSA reviewers are satisfied that ANSTO has initiated an Asset Management Programme that will adequately cover all aspects of the plant ageing.

Whereas all objectives of the safety factor 4 have been assessed, the ANSTO review has not considered potential effects of the relevant operational events on the plant ageing.

The ARPANSA reviewers are satisfied that the outstanding matters have been recorded in the After-action Programme and will be progressively addressed.

Recommendation 3: ANSTO should consider the potential effect of the historically relevant OPAL reactor events to proposed ageing strategies, include them in the Asset Management System and discuss this in the next PSR.

2.9. Safety Factor 5: Deterministic Safety Analysis

Objective (the IAEA Guide): Determination of extent to what the existing safety analysis remains valid when the actual plant design, actual SSCs' conditions and their predicted state at the end of period covered by the PSR, current deterministic methods, current safety standards and knowledge have all been taken into account.

Specific guidelines (the IAEA Guide):

a) The current state of the analysis should be reviewed for the completeness of the set of postulated initiating events and for its scope, methods and assumptions. The safety analysis should be updated as necessary.

b) The review should ensure that the current safety analysis is based on actual design, reflects current state and predicted state at the end of the period covered by the PSR.

c) The current analytical methods should be used (computer codes).

d) The review should identify or confirm any weaknesses as well as the strengths of the plant design in relation to the application of defence in depth.

This section of the PSR primarily discusses the OPAL reactor safety analysis which is presented in Chapter 16 of the SAR. ANSTO adopted a systematic approach using the OPAL reactor Fault Schedule that forms the basis for the safety analysis. ANSTO reviewed and updated this document based on the OPAL reactor operational experience and modifications (for example, the fuel plate displacement postulated scenario was included), and international experience (e.g. the Fukushima accident). Each initiating event has been revisited and updated when necessary. The document was found to be comprehensive and its scope and content are acceptable to the ARPANSA reviewers.

The update to the schedule identified some new postulated initiating events related to Loss of Power, Loss of Coolant, Loss of Heavy Water, Special Internal Events and Utilisation Events accident scenarios. The review of the Chapter 16 of the revised OPAL SAR showed that some of these postulated initiating events have already been incorporated in the revision of the SAR provided to ARPANSA under the OPAL PSR, e.g. events related to Heavy Water Upgrade System. However, the majority of the new scenarios have been scheduled for future updates of the safety analysis using the After-action Programme.

The regulatory review of Chapter 16 included the scope and depth of the set of initiating events, their currency particularly with respect to the relevant changes to the plant introduced within the period covered by the PSR. The ARPANSA reviewers verified that the scope, assumptions, methods applied and computer codes used for the safety analysis were found to be current and appropriate. Each postulated initiating event was also reviewed for adequacy of defence in depth to protect against the event. Defence in depth as presented for individual postulated events was found to be adequate.

The review resulted in a set of questions that have been delivered to ANSTO for response [21]. However, none of the issues identified were of such safety importance that an immediate remedy was required. It is acceptable to the ARPANSA reviewers that addressing the identified issues will be carried out under the After-action Programme.

Conclusion:

The ARPANSA review showed that considering the actual plant design and conditions, projected state over the next PSR period, current deterministic methods and up to date safety standards and knowledge, the OPAL reactor safety analysis remains valid. It was appropriately demonstrated that the review has taken into account all corresponding objectives outlined by the Guide.

Identified improvements included a number of new initiating events. These changes will be implemented according to the After-action Programme. This arrangement is acceptable to the ARPANSA reviewers.

2.10. Safety Factor 6: Probabilistic Safety Assessment

Objective (the IAEA Guide): Determination of the extent to which the existing probabilistic safety analysis remains valid as a representative model of the plant when the design changes, plant operation, technical information, current methods and new operational data have been considered.

Specific guidelines (the IAEA Guide):

a) The PSA should identify weaknesses in the design and operation on the plant and to evaluate and compare potential operations for remedying any such weaknesses.

b) The results should be compared with probabilistic criteria.

c) The PSA should be kept sufficiently up to date and useful for the decision making process.

d) The accident management programme for beyond design basis accidents should be reviewed.

ANSTO's assessment of the OPAL PSA demonstrated that due to OPAL reactor's relatively short operational history, the data gathered has had insignificant statistical effect on initiating events frequencies or component failure probabilities. Some modifications that nominally impact on the PSA have been implemented since 2006 (e.g. Heavy Water Upgrade System, 12-hr shift roster change). However, due to the low impact on the general public or negligible impact on core damage frequency, changes were found to be minor and bounded by the previously assumed uncertainty margin.

In addition, the IAEA reliability database for research reactors used for the initial OPAL PSA during the licensing process to operate the reactor is yet to be updated with new data.

Moreover, the reliability data that is normally obtained from conventional equipment databases were not updated at the time the PSR was produced. Based on the past experience, ANSTO expects that the next update will expand the database with new data but the existing samples usually do not change.

Conclusion:

ANSTO showed that an adequate review of the OPAL PSA has been conducted. The review has considered changes in the plant design, operational experience and current available technical data. Based on the findings, ANSTO suggested no changes to the OPAL PSR this time. This is acceptable to the ARPANSA reviewers.

The ARPANSA reviewers are satisfied that the OPAL PSA remains current and all probabilistic acceptance criteria of the plant are met.

2.11. Safety Factor 7: Hazard Analysis

Objective (the IAEA Guide): Determination of adequacy of protection of the plant against internal and external hazards with account to the plant actual design, current SSCs conditions, site characteristics and their predicted state at the end of the period covered by the PSR, and current analytical methods and knowledge.

Specific guidelines (the IAEA Guide):

a) A list of relevant internal and external hazards with account taken of the actual plant design, actual SSCs conditions and site characteristics should be developed.

b) Using current analytical methods and data the review should show that the probability or consequences of the hazards are sufficiently low so that no protective measures are necessary or the existing preventative and mitigating measures against the hazard are adequate.

ANSTO has reviewed the set of internal and external hazards as identified during the reactor licensing and as presented in the OPAL SAR, Chapter 16. The ARPANSA reviewers note that ARPANSA assessed the hazards during all OPAL stages and found that adequate protection measures were in place allowing the siting, construction and operating licence for the facility to be issued.

Many of the hazards have been found to be adequately accounted for in the current analyses and, in those cases, no changes in protection were recommended. However, changes were proposed to hazards that could affect safety based on the relevant local and international operating experience. For example, based on the OPAL reactor past operation, the internal missile hazard (PCS Pump coupling failure) and loss of supporting service (OPAL loss of power experience) are to be updated. The Fukushima accident has given impetus for updates related to the internal explosion and loss of external power.

Where appropriate, ANSTO has included individual hazards projections for the next ten years. The review of Chapter 16 Safety Analysis of the updated OPAL SAR confirmed that the relevant recommendations have been incorporated in the safety analysis.

The ANSTO assessment indicated that based on the review conducted, the hazard mitigation measures have been found adequate. This conclusion is acceptable to the ARPANSA reviewers.

> *It is noted that ANSTO included the draft document Review of the Fukushima Dai-ichi NPP Event – Preliminary Assessment of Implications for the OPAL Safety Case and Lessons Learnt in the PSR. The review of this assessment is discussed in a paragraph below. ANSTO is committed to include arising recommendations in the After-action Programme.*

Conclusion:

The PSR documents showed that ANSTO adequately reviewed the existing suite of hazards. The review has considered the actual design and conditions of the plant, and the current site characteristics. The assessment of all hazards has adequately taken into account anticipated operations at the end of the next decade.

The ARPANSA reviewers are satisfied that the existing hazards and their combinations have been appropriately addressed in the PSR. It is acceptable to the ARPANSA reviewers that currently installed and applied measures to mitigate the identified hazards are adequate for the projected OPAL operation in the next PSR period.

All recommendations raised have been logged in the After-action Programme so their appropriate analyses and consequent implications for protection will be conducted in a timely manner. This is acceptable to the ARPANSA reviewers.

2.12. Safety Factor 8: Safety Performance

Objective (the IAEA Guide): The objective is to determine safety performance of the plant and its trends from records of operating experience.

Specific guidelines (the IAEA Guide):

a) Safety performance should be determined from operating experience, including safety related incidents and record of safety system unavailability.

b) Relevant indicators of the radiation related risk resulting from normal operation and anticipated operational occurrences should be established and analysed.

c) Records of radiation doses and radioactive effluents should be reviewed to determine whether these are within prescribed limits, as low as reasonably achievable and adequately managed.

The PSR was based on various sources of information available to the ANSTO reviewers, e.g. ROEMS (events) database, logbooks, internal and external auditing documents, management meeting

records, radiation doses records, off-site radiation data, etc. The scope of the review suggested that all important areas for safety performance assessment have been taken into account.

ANSTO showed that the associated administrative process in place adequately evaluates safety significance of individual events. The system effectively retains the relevant records for further analyses, even though some weaknesses have been identified, e.g. the analytical functionality of the system was found limited.

The events recorded in the OPAL ROEMS were analysed. The PSR included the current status of event investigation management, it contained some statistical analyses demonstrating that examination of the relevant records have been carried out. For example, the analyses covered the reactor operational data, OPAL reactor safety performance indicators, and integrity of physical barriers for radioactive material containment and radiation doses. The most serious events that occurred at the OPAL reactor since commissioning have been discussed and their effect on safety performance has been examined, particularly its effect on the integrity of physical barriers for containment of radioactive materials. In this regard it was demonstrated that the actual events had negligible effect on workers, the public and the environment. ARPANSA reviewers accepted ANSTO's conclusion.

However, the performance analysis did not cover the OPAL reactor event cause analysis in detail. Whilst the relevant information included in the PSR described the system in place, an in-depth analysis of the data collected over the period was not presented. Although ANSTO claimed the analyses have been done manually, the operational data trend analyses were not included. The associated statements about appropriateness of the analyses level were unsupported. ANSTO themselves identified a shortfall in gathering and processing data of OPAL reactor events in the database and raised an appropriate recommendation calling for a better database software. The issue related to unsupported claims has been raised with ANSTO. Sufficient support documentation was provided later in the regulatory review. This finding is basis for the proposed recommendation stated below.

ANSTO examined the records of the OPAL Safety Performance Indicators (SPIs) in detail. The review showed that the individual SPIs have been appropriately examined. Some of the trends indicated an adverse trend. For example, *Unavailability Detected during Operational Limits and Conditions Surveillance Requirements Rolling 12 Months* has been steadily rising since 2009. ANSTO demonstrated that the trend has been under an investigation for some time and possible contributory causes have been identified. However, no obvious strategy to remedy the trend has been adopted yet. An appropriate action arising from this investigation, which includes addressing these contributing causes, has been incorporated into the After-action Programme. This is acceptable to the ARPANSA reviewers.

The recommendations arising from this finding have been logged in the After-action Programme. ARPANSA's review of the analysis showed that the indicators with undesirable trends have been appropriately addressed.

The measured annual effective dose to the operators was within the ANSTO ALARA objective of 2 mSv/year. The doses have been analysed over the period since 2006. A minor increase was registered after year 2008. ANSTO justified the increasing trend was caused by improved availability

of the OPAL reactor and its utilisation in the period that followed the plant extended shutdown in 2007/2008.

ANSTO showed that individual effective doses were slightly increasing across all groups at the time of preparing the PSR. The doses were below the ANSTO ALARA objective of 2 mSv/year. Currently, this increase has not been fully understood. ANSTO's review resulted in a recommendation to examine this minor increase in the effective dose to operators.

Conclusion:

The PSR demonstrated that their system effectively records and enables evaluation of safety significance of events related to operation, utilisation, maintenance and other aspects of the OPAL reactor. The ANSTO review identified some issues that have been appropriately logged in the After-action Programme for implementation.

Safety Performance Indicators analyses presented improvements in many areas of the OPAL reactor safety. On the other hand, those indicators gauging adverse trends were demonstrated to be under appropriate control. The relevant actions have been raised in order to implement associated corrective measures in a timely manner.

The records of the radioactive effluents and radiation doses to personnel were shown to be well managed, as low as reasonably achievable and within the prescribed limits.

The ARPANSA reviewers have been satisfied that the overall safety performance of OPAL reactor, as presented in the PSR, showed no indication of substandard performance.

Recommendation 4:	**It is recommended that data from OPAL operating experience (events) be appropriately analysed and interpreted so that the benefit of lessons learnt is maximised. The assessment should also include statistical analyses of contributing factors to the events and trend analyses.**

2.13. Safety Factor 9: Use of Experience from other Plants and Research Findings

Objective (the IAEA Guide): It is to determine whether there is an adequate feedback of safety performance from other plants and of the findings of research.

Specific guidelines (the IAEA Guide):

a) Operating experience and research findings from other facilities should be considered because:

- It can reveal unknown safety weaknesses and can help with existing problems.

- Operating experience of similar plants can also be helpful to prevent or deal with various safety problems.

PSR should include a review of the adequacy of the established arrangements for receiving and assessing information obtained as feedback from the normal activities at the facility and the timely implementation of assessment findings.

Due to design differences of research reactors compared to power reactors, a graded approach to this safety factor was carefully considered by the ARPANSA reviewers. The PSR review of international operating experience illustrated that ANSTO had a healthy relationship with other world class facilities that promotes the relevant information exchange. The scope of the OPAL PSR covered assessment of shared information important to operational areas, e.g. the periodic safety review process, asset management and safety analysis. Specifically, OPAL is active in a cooperative group of operators producing radioisotopes which involves the Petten reactor in the Netherlands and the SAFARI reactor in South Africa. The PSR also showed that OPAL sources information from the USA, Canada, France, South Korea and Belgium.

The lessons learnt from Fukushima accident have also been considered by ANSTO. The ANSTO report on applicability of these lessons was submitted with the OPAL PSR documents. It is discussed in a section 2.21 below.

Regarding applicability of the relevant international research findings, ANSTO discussed several research directions important to reactor safety. These included thermal-hydraulic research, OPAL reactor fuel fault research, operational and material research.

In their review, ANSTO identified some shortfalls in their arrangements which deal with receiving and assessing the feedback from other facilities. Appropriate recommendations have been made to improve the system effectiveness. This is acceptable to the ARPANSA reviewers.

Conclusion:

Based on the information presented, the ARPANSA reviewers consider that the PSR adequately considers the operating experience of other research reactors overseas. The relevant international research findings applicable to OPAL reactor have also been considered.

The OPAL PSR associated with this safety factor indicated that inter-facility information exchange has been well developed and a system is in place to process the feedback. However, some recommendations to improve the system have been made and logged into the After-action Programme. The ARPANSA reviewers consider this appropriate.

The ARPANSA reviewers are satisfied that the relevant objectives of the guideline have been met.

2.14. Safety Factor 10: Organisation and Administration

Objective (the IAEA Guide): The objective is to determine if the organisation and administration are adequate for the safe operation of the plant.

Specific guidelines (the IAEA Guide):

a) Impact of organisation and administration on safety should be analysed as it forms important role in safety culture.

b) Compliance of organisation and administration with good practices should be examined.

c) Aspects of review should include management, succession planning, configuration control, management of technical and contractual support, training, quality control, records, and compliance with regulatory requirements.

d) The review should determine whether there is an adequate number of qualified personnel to carry out safety related work.

ANSTO's review discussed a wide range of areas related to ANSTO/OPAL management. The main aspects that have been assessed included policy stating, responsibilities of individuals and groups, configuration management, arrangements to employ external staff, staff training, business management programme, compliance with regulatory requirements and change control of organisational structure or resources.

ANSTO evaluated the impact of these areas to safety. The PSR did not identify any areas of organisational and administration that would compromise safety. However, it raised several recommendations to improve the system that have been added to the After-action Programme. The ARPANSA reviewers are satisfied that the organisation and administration generally follow good practice in the industry.

The submission contained a number of unsubstantiated statements and these were highlighted in ARPANSA's letter to ANSTO on 25 February 2012. For example, the statement that the OPAL reactor is completely in compliance with NS-R-4 (on p 256 of the PSR submission) was not supported by sufficient evidence. ANSTO subsequently reviewed their submission and updated the information presented in the OPAL PSR Supplement.

Although none of the IAEA Guide safety factors specifically deals with safety culture in particular, safety culture is an element which underpins all safety aspects of the operation of a facility such as the OPAL reactor. Safety culture is addressed indirectly under Safety Performance (Factor 8); Organisation and Administration (Factor 10); the Human Factor (Factor 12); and also in introductory remarks: *"Quality assurance (QA) and safety culture are not considered to be separate safety factors because they should be an integral part of every activity affecting safety"* [16]. Whilst ARPANSA reviewers accept that quality assurance and safety culture are mutually supportive they do not regard them as being combined. The PSR of the OPAL reactor does not discuss the ANSTO safety culture, and specifically the OPAL reactor safety culture in detail and ANSTO's statement and references to safety culture throughout the PSR report shows a lack of sophistication in its knowledge of safety culture. The assessment of the facility safety culture and how it affects other safety factors has not been presented.

Therefore, the assessment under the PSR should be strengthened by more explicitly examining the effect and influence of leadership and culture for safety on the operation of the reactor. Although

not used for this PSR, the updated IAEA PSR guide published in 2013[1], [24] highlights safety culture as a key safety factor.

Conclusion:

The ARPANSA review of the information did not identify any areas falling under this safety factor that could compromise safety of the OPAL reactor.

The ARPANSA reviewers deem the information provided in relation to specific guidelines under points a) to d) above acceptable. This considers the fact that ARPANSA regulatory guide addressing the expectations in the area of organisational factors was issued after the OPAL PSR was finalised, and a relatively low risk associated with the organisational and administrative matters identified.

However, safety culture that ARPANSA considers part of this section, and the assessment of its effect on other safety factors has not been included in the PSR information presented. Therefore, the following recommendation is proposed.

Recommendation 5: ANSTO should devote attention to discussing the influence and impact of safety culture on the operation, maintenance and management of OPAL; this is important given that the IAEA guidance acknowledges the influence of safety culture, and its importance is recognised across all high hazard industries.

2.15. Safety Factor 11: Procedures

Objective (the IAEA Guide): The objective is to determine whether the procedures are of an adequate standard.

Specific guidelines (the IAEA Guide):

a) Procedures should be comprehensive, validated, formally approved and subject to rigorous change control. Procedures should be unambiguous and relevant to the plant.

b) The system for the development and control of procedures should be reviewed.

c) The review should focus on procedures significant to safety (not a technical review of the procedures).

d) The review should include normal and abnormal operating procedures, management of beyond-design-basis accidents, maintenance, test and inspection procedures, work permit, control procedures for modifications including updating documentation, radiation protection procedures including on-site transfer of radioactive material.

[1]See also http://www-pub.iaea.org/books/IAEABooks/8911/Periodic-Safety-Review-for-Nuclear-Power-Plants

The scope of the ANSTO review of the set of safety significant procedures was found to closely follow the specific guidelines stated above. Although ANSTO's review provided information describing the current system in place, it showed a low level of critical assessment. For instance, ANSTO included a review of the formal system for revision of procedures. It stated that the system is well developed and used at the OPAL reactor. The ANSTO assessment concluded that the procedures remain unambiguous. However, it appeared that little effort had been exerted to present the evaluation of the actual performance of the system and identification of the system's weak points.

ANSTO reviewed the procedures against good practice set out by the relevant Australian and international standards and guides. The review concluded that the system in place is in compliance with the standards. The ARPANSA reviewers accepted this conclusion.

Conclusion:

It is noted that OPAL BMS procedures are part of a system that has been and will continue to be regularly inspected by ARPANSA and the system shortfalls are well monitored by ARPANSA. The report showed that ANSTO has developed a comprehensive system for development and revision of procedures. The information provided a reasonable overview of the relevant administrative systems in place.

However, the ANSTO review did not show a detailed assessment of the system's effectiveness. Although the information presented was not always clear to the ARPANSA reviewers to make conclusions, the level of information provided was considered acceptable.

Taking into account a graded approach in considering differences between the NPP business management programmes for which the Guide was developed and the OPAL BMS, the ARPANSA reviewers consider ANSTO's system acceptable.

Recommendation 6: **It was observed that there appeared to be a lack of in-depth critical assessment of the OPAL procedures. The next PSR should demonstrate an improvement in this area.**

Note: A relevant requirement to demonstrate critical assessment should be clearly stated in the ARPANSA PSR Guide, which will be produced based on the experience arising from this first PSR.

2.16. Safety Factor 12: The Human Factors

Objective (the IAEA Guide): Determination of the status of the various human factors that may affect the safety operation of the reactor plant.

Specific guidelines (the IAEA Guide):

a) Since all aspects of the reactor safety are influenced by human performance, the status of the human factors should be determined whether these comply with accepted good practices and do not present unacceptable contribution to risk.

b) Operator actions in support of safety should be checked to ensure they are feasible and properly supported.

c) Maintenance related human factors should be assessed.

d) Staffing, selection and training, personnel related issues, the style of procedures and human-machine interface should also be assessed.

The ANSTO PSR well described the formal arrangements for selection of suitably qualified personnel for the safety related roles. ANSTO assessed the current staffing levels of the Main Control Room (MCR) and the general personnel on duty at all times against the requirements from 2006. It also took into consideration the change from 8-hr shift roster to 12-hr.

The staff selection methods, training aspects and their effects to the human behaviour, specifically related to OPAL Operation staff were also assessed in the section. The assessment gave a rise to several recommendations for improvement. The ARPANSA reviewers found ANSTO's assessment of both above-mentioned contributors to human factors adequate.

Human factor aspects related to human-machine interface and equipment design was also acceptably analysed in context with the MCR personnel and MCR panel/consoles layout.

The PSR evaluated the maintenance area primarily focusing on training, personnel qualification and staffing. There was no discussion of how human factors affect various maintenance (specific) activities at the OPAL reactor. Furthermore, there was no information on how the engineering or administrative systems in place promote good worker behaviours and prevent adverse human factors, the system's contextual weaknesses and strengths, etc. An example of this is the continued presence of OLC SR 3.0.3 which allows an extension of surveillance maintenance periods and continued reactor operation if an OLC surveillance requirement is inadvertently missed. Whilst, the operational actions associated with SR 3.0.3 are justified, full current requirement negates a need to declare a breach of the OLC and thereby is likely to undermine the good attitudes to OLC surveillance amongst workers at the reactor.

Similar aspects of human factors were found missing for various work tasks allocated to OPAL Utilisation. Safety implications of the utilisation operator activities have been recognised previously so it should receive attention proportional to its safety relevance.

Other aspects of human factors that were not discussed in the submission were process design and operational environment design. It is understood that the majority of OPAL processes are automated but many tasks, particularly within the Utilisation, are manual and would warrant the relevant assessment.

Weaknesses in engineering processes are also generally recognised as important contributors to human performance particularly in two aspects – designing human error tolerant equipment and

tools, and how human error is prevented in the process (e.g. design review, approval). These views of human factors were also not mentioned in the submission.

Conclusion:

The ANSTO review effectively presented a review of the human factors aspects mentioned in the above paragraphs mainly in relation with the OPAL Operation staff e.g. Shift Managers and Operators. This is acceptable to the ARPANSA reviewers.

Considering that a) the ARPANSA regulatory guide addressing the expectations in the area of human factors was issued after the OPAL PSR was finalised and b) the risk associated with the manual operations, the ARPANSA reviewers deem the information provided in this PSR acceptable. However, the following recommendation is proposed.

Recommendation 7: **Human factors should be addressed in all aspects of OPAL operations, and should include reviews of the processes and the design of the operating environment. Relevant utilisation and maintenance tasks should also form part of the assessment.**

2.17. Safety Factor 13: Emergency Planning

Objective (the IAEA Guide): Determination whether the operating organisation has adequate plans, staff, facilities and equipment of dealing with emergencies; and whether the organisation's arrangements have been adequately co-ordinated with local and national systems and regularly exercised.

Specific guidelines (the IAEA Guide):

a) A PSR should include an overall review to check that the emergency planning is satisfactory.

b) Emergency plans are current as per safety analyses, mitigation studies and good practices.

c) Emergency exercises should demonstrate and identify possible shortcomings in the competence of on-site and off-site staff, the required functional capability of equipment.

d) A PSR should check that significant changes at the plant have been taken into account, which should include changes in maintenance and storage of emergency equipment.

The section provided a good description of OPAL and site emergency plan structure, personnel training, emergency exercises and other relevant arrangements including emergency instructions. ANSTO reviewed the existing OPAL Emergency Instructions and found them to be adequate. The site level emergency instructions were discussed but the ANSTO review did not make it clear whether or not they were considered appropriate. For example, the report omitted to discuss whether or not the revision frequency of the emergency plans was satisfactory.

ARPANSA observers were regularly present during the OPAL emergency exercises in the past. The emergency exercises were described in the PSR. Each exercise, as well as real events that ANSTO has responded to, have led to many recommendations for improvements. This indicates the importance of these practical exercises. However, the report did not outline whether the scope and frequency of the exercises in the past was adequate. The information provided very good examples of when the emergency plans/instructions were activated, the lessons learned from them and how changes to documents are implemented.

The emergency equipment available to the personnel involved in emergency response was listed and found adequate. However, the submission did not provide information whether the maintenance and storage of the emergency equipment were found appropriate.

Conclusion:

Although some aspects of the IAEA Guide were not fully addressed in the submission, the overall information provided in regard to the OPAL reactor emergency planning was found satisfactory. Taking into account the graded approach, the ARPANSA reviewers consider that the objectives of this safety factor have been met.

However, to improve how emergency planning is undertaken, the regulatory review proposes the following recommendation.

Recommendation 8: **In context of emergency planning and within this PSR, ANSTO should also assess the level of maintenance and storage of the emergency equipment available, adequacy of the site emergency plans and instructions, and frequency and scope of the exercises.**

2.18. Safety Factor 14: Radiological Impact on the Environment

Objective (the IAEA Guide): To determine whether the operating organisation has an adequate programme for surveillance of the radiological impact of the plant on the environment.

Specific guidelines (the IAEA Guide):

a) An effective surveillance programme that provides radiological data on the surroundings of the plant should be established.

b) A PSR should examine whether this programme is appropriate and sufficiently comprehensive to check all relevant environmental aspects.

The review ANSTO presented in the section describes the environmental monitoring system currently in place. ANSTO's review addressed adequately the radiological impact assessment of all effluents, including on-site and off-site monitoring systems. The presented information

appropriately demonstrated that the radiological impact of the OPAL reactor's operation has been minimal over the period covered by the PSR. This is acceptable to the ARPANSA reviewers.

The ARPANSA reviewers note that ANSTO reports to ARPANSA on airborne discharges quarterly and on liquid discharges monthly. The summary of the discharges are presented in ANSTO Environmental Reports. All discharges from the OPAL reactor have been within the statutory limits since the OPAL reactor was licensed. All spikes in the discharges, which all were well below the notification limits, have been appropriately explained.

ANSTO analysis of the site discharges over the years of the OPAL reactor operation presented in the PSR document showed that there was no trend indicating deterioration. The trends of Iodine and Tritium site discharges were reduced by shutting down the HIFAR reactor.

The review made a statement in the conclusion that all monitoring systems were considered adequate. However, it did not address in detail the individual monitoring systems and provided little prediction of their suitability for next PSR period. For instance, it was stated that no records are taken of the liquid effluent quantities of activities released from the OPAL reactor to Waste Operations. It was evident that this setup was sufficient at the moment. However, no conclusion was attempted to establish whether or not this arrangement would be sufficient for future OPAL reactor operations. Similarly, ground water activity is monitored using a system of bore holes. Whilst it was demonstrated that the system had sufficient number of wells to monitor the site at present, the review did not give an indication whether the number and location of boreholes should be increased in future based on the predicted OPAL reactor operation.

Conclusion:

Based on the presented information associated with evidence of radiological impact of the OPAL reactor operation since 2006, the ARPANSA reviewers are satisfied that ANSTO maintains an effective monitoring system of the radiological impact on the environment.

ANSTO effectively demonstrated that the environmental impact of the OPAL reactor since the reactor commenced operations has been minimal. All discharges were shown to be well below the limits and notification levels. No significant deviation or 'spikes' in discharges have been recorded over the period.

With regard to future operations, the following recommendation is proposed.

Recommendation 9: ANSTO should consider projected future operation of the reactor in the surveillance programme for the radiological impact of OPAL on the environment.

2.19. Global Assessment

Objective (the IAEA Guide): To present an assessment of plant safety that takes into account all unresolved shortcomings, corrective actions and/or safety improvements and the plant strengths identified in the review of all PSR safety factors.

Specific guidelines (the IAEA Guide):

a) Presenting significant PSR results.

b) Present an integrated implementation plan for corrective actions.

c) Global risk on acceptability of continued plant operation with any shortcomings remaining after all corrective actions have been addressed and respective improvements implemented.

d) Interactions between safety factors should be considered. It should include compensatory measures.

e) What extent the safety requirements of the defence in depth are fulfilled.

The Global Assessment of the OPAL PSR identified the facility strengths and weaknesses through the summary of findings identified in the review against all PSR safety factors. ANSTO presented the overall conclusion stating that the licensing basis of the plant has been found valid. Provided the necessary improvements are carried out, appropriate arrangements are in place to maintain safety of the OPAL reactor for next ten years when next PSR is predicted. The ARPANSA reviewers accepted this global conclusion.

The implementation plan of the actions (After-action Programme) was provided in draft in the original submission. The updated revision with status of implementation has been reported to ARPANSA in six month intervals since January 2014. The details of the review of the After-action Programme are presented below in section 2.22 of this report.

However, the section does not specifically address the interactions between the individual safety factors and individual shortcomings. Although some issues identified indicated that interactions with other matters have been considered, it was not demonstrated that a systematic approach was adopted.

Conclusion:

The ARPANSA Reviewers are satisfied with ANSTO identification of the plant strengths and weaknesses based on the overall assessment. They are also satisfied that the OPAL reactor licensing basis remains valid.

However, the assessment of the safety factors, as well as individual shortcomings and corrective actions in combination has not been presented in a systematic manner. In line with the holistic or system safety approach, that ANSTO's PSR should place greater emphasis on examining interrelationships and interdependence between the 14 individual factors assessed. This will help ensure the analysis is comprehensive and addresses all key aspects of safety.

Some of the interactions could be inferred from the assessment under individual safety factors. Taking into account the graded approach and the fact that the ARPANSA Holistic safety Guideline was issued after the PSR was submitted, the reviewers consider the global assessment acceptable. However, the following recommendation is suggested.

Recommendation 10: **In addition to assessment according to the individual safety factors, ANSTO should also include the assessment of interrelationships and interdependence between safety factors and individual shortcomings in the facility overall safety evaluation.**

2.20. Review of OPAL Safety Analysis Report (SAR)

As indicated in section 1.4.1 above, ARPANSA has reviewed samples of the revised OPAL SAR. Some review findings of the OPAL SAR Chapter 16: Safety Analysis were discussed in context with section 2.9 above. However, it is worthwhile summarising the results of the regulatory review of the selected chapters of the OPAL Safety Analysis Report, Revision 1, as presented under the PSR in this section.

2.20.1. Regulatory Approach

The chapters of the SAR Rev 1 selected for the more detailed assessment (Chapters 5, 11 and 16) were reviewed against several documents as follows:

a) Criteria included within the individual chapters of the SAR (as derived from the IAEA guide for safety analysis preparation [25]). This document provided basic template for the SAR content. The document was consulted during this review to verify various aspects of the SAR content.

b) OPAL Safety Analysis Report, Revision 0.

c) ANSTO Document Revision Register (DRR). This ANSTO document was provided together with each revised chapter and contained the list of changes implemented in the OPAL SAR under Revision 1.

d) ARPANSA's questions with ANSTO responses related to the relevant chapters of OPAL SAR Revision 0 at the OPAL reactor licensing stage. The document was heavily referenced in the DRR.

e) ANSTO document OCR-006 Compliance with Licence Conditions 1.2 (of the then Licence) Rev A. Although his document was issued initially in 2006, it was revisited in 2013. The list of SAR updates included in the document was applicable to this SAR revision.

f) Requests for Approvals (RFA) at the time of the reactor licensing process. The individual approvals of RFAs sometimes included approval conditions in the form of the future SAR update commitment. These commitments were also referenced throughout the DRR list.

g) Regulatory Assessment Report of ANSTO OPAL Research Reactor Safety Analysis Report [26] produced at the time of the reactor licensing. In addition to the selected chapters of the OPAL SAR, the ARPANSA reviewers also considered findings of that regulatory assessment report associated with other chapters of the OPAL SAR.

2.20.2. Conclusions of the SAR review

Many of the changes to update the SAR were editorial such as formatting and language improvement. Safety important modifications of the document originated from

- Regulatory review of the previous version of the SAR in 2006. These changes included implementation of ARPANSA recommendations and associated ANSTO commitments.
- Implementation of Requests for Approval during the construction phase of the OPAL reactor.
- Implementation of safety significant projects. These changes have been previously approved by ARPANSA under the regulation 51 process.

A special group was formed by changes that aligned the SAR with the plant 'as-built' design. These changes were reviewed against relevant documentation available to the ARPANSA reviewers previously submitted by ANSTO outside the PSR. None of these changes were found to have significant safety implications.

ARPANSA review of the selected chapters of OPAL SAR resulted in a number of specific questions which were sent to ANSTO for response. Responses to the specific issues identified in the ARPANSA review [21] will be dealt with separately through the ANSTO PSR implementation phase – the After-action Programme. The decision to transfer the implementation of the issues identified in the regulatory review into the After-action Programme was based primarily on a) low safety implications of the issues identified by ARPANSA, b) transparency and regular progress reporting, and c) ARPANSA monitoring the progress of the PSR implementation schedule.

The following paragraphs outline the major findings arising from the regulatory review that formed the set of questions to ANSTO.

1. Changes introduced in the chapters either did not represent significant change to safety or the changes have been previously approved by ARPANSA under the regulation 51 approval process.

2. Changes recorded in the ANSTO relevant Document Revision Registers did not include all changes made to the chapter. ARPANSA reviewers assessed those changes not identified in the register as having no significant implications for safety.

3. The level of referencing, which was identified as an issue in the ARPANSA review of the OPAL SAR in 2005-6, improved. However, there were statements/values/claims in the SAR not appropriately substantiated.

4. Some ANSTO commitments made in response to the issues arising from ARPANSA's review of the previous revision of the OPAL SAR have not been implemented. Proper justification of why the commitments have not been implemented has not been provided.

5. In addition, a number of specific questions arose related to the reactor thermal-hydraulic calculations and analyses of accident scenarios postulated.

At the time when this report was written, ANSTO has not responded to the set of questions produced by ARPANSA. Therefore, it would be acceptable to the ARPANSA reviewers if the unresolved issues are logged in the After-action Programme to ensure they will be appropriately addressed.

Conclusion:

As The OPAL PSR demonstrated that the reactor Safety Analysis Report has been appropriately revised. The documentation showed that the list of updates to the document proposed has sufficiently covered all issues previously identified either by ANSTO or by ARPANSA throughout out the regulatory review during the reactor licensing process. The ARPANSA reviewers accepted that the relevant modifications implemented between years 2006 and 2011, international operating experience, and relevant standards have been appropriately considered during the SAR review.

The matters identified have been incorporated in the After-action Programme through which their implementation status will be monitored. The ARPANSA reviewers are satisfied that the scope of the OPAL reactor SAR has been adequate. The following recommendation is presented to ensure ANSTO will also address the issues raised by the ARPANSA reviewers.

The ARPANSA reviewers are satisfied that the OPAL reactor safety analysis demonstrated that the existing plant meets safety and licensing requirements and the safety design criteria.

Recommendation 11:	**Any unresolved issue that arises from the ARPANSA review of the OPAL SAR Rev 1 should be included in the After-action Programme.**

2.21. Safety assessment of the Fukushima accident implications for the OPAL Safety Case and lessons learned

The initial PSR submission dated 23 December 2011 included The *Preliminary Assessment of Implication for the OPAL Safety Case and Lessons Learnt from the Fukushima Dai-ichi NPP Event* [3]. Although the document considered the information available at the time it was developed, which was the end of March 2011 – shortly after the Fukushima accident, it resulted in a number of recommendations for the OPAL reactor safety case. By the time this Regulatory Assessment Report was written, ANSTO issued revision B of the document (April 2012).

2.21.1. ANSTO Assessment

In the light of the Fukushima accident, ANSTO reviewed the OPAL safety case for plant based and external hazards. The scope of ANSTO's review included the following events:

- Station blackouts (blackout up to 30min, 30min to 10 days and more than 10 days)
- External events (aircraft impact, bushfires, industrial and transportation accidents, military activities, on-site activities, extreme wind, earthquake)
- Combination of external events (external hazards in conjunction, consequential external hazards and coincidental external hazards)
- Hydrogen explosion
- Spent fuel pool cooling
- Venting of reactor containment

As a result of the analysis, ANSTO recommended changes to the existing OPAL safety case. The changes were related to the following areas:

- Loss of power (blackout) safety analysis should be updated so a 15 day blackout is included. The existing analysis covers the plant blackout lasting up to 10 days. The recommendation for blackout extension is based on ANSTO determination to analyse blackout for the OPAL reactor fuel ever-safe time which is 15 days.

- A further assessment of a potential connection of mobile power generators to the OPAL reactor power distribution system is recommended.

- Inclusion of the combination of external hazards into the OPAL Safety Analysis, Chapter 16 of the SAR, is suggested.

- The report recommends that further analysis of a hydrogen release originating from the Cold Neutron Source within the containment is conducted.

- An analysis of cooling of the Spent Fuel Pool during the extended loss of power (15 days) should be carried out. It should also be included in the OPAL SAR.

2.21.2. ARPANSA review

The ANSTO review of the documents was conducted in conjunction with Chapter 16 of the OPAL SAR and lessons learned from Fukushima as published in various reports, e.g. *Recommendation for Enhancing Reactor Safety in the 21st Century by US NRC* [27]. The ARPANSA reviewers consider the scope of the preliminary assessment appropriate.

Whilst ANSTO's assessment addressed the hazard of events to plant and site associated analyses, it did not include a review of on-site emergency response capabilities, emergency plans and other arrangements in light of the Fukushima accident. However, ANSTO recommended a further assessment of the emergency planning under their review against PSR Safety Factor 13 as discussed above. This recommendation has been included in the ANSTO After-action Programme. Other recommendations appearing from ANSTO's review of the OPAL reactor in light of the Fukushima accident have also been included in the After-action Programme Schedule.

At the time of finalisation of this regulatory report, ANSTO provided technical report *Safety Reassessment of OPAL in the light of the Fukushima Dai-ichi Accident* [28]. This document appears to follow the new IAEA Safety Report Series No. 80 Safety Reassessment for Research Reactors in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant [29] and it is built up on the preliminary safety analysis previously submitted to ARPANSA and discussed above. It addresses facility reassessment, site characteristics, and emergency preparedness and response. However, as the review of that ANSTO assessment warrants more focused regulatory attention, it has not been reviewed under the OPAL PSR. ANSTO's scope of the safety reassessment will be reviewed and dealt with independently.

Conclusion:

The ARPANSA reviewers are satisfied with the development of safety reassessment of OPAL in the context of lessons learnt from the Fukushima accident. *Preliminary Assessment of Implication for the OPAL Safety Case and Lessons Learnt from the Fukushima Dai-ichi NPP Event* has been found adequate.

The ARPANSA reviewers are satisfied that the actions arising from ANSTO's preliminary assessment of the OPAL reactor in light of the Fukushima accident have been appropriately placed in the After-action Programme.

The full scope review of the final safety reassessment of OPAL in the light of the Fukushima Daiichi Accident will be carried out independently from this PSR assessment.

2.22. After-action Programme

The implementation of the proposed After-action Programme is the important phase of a PSR. ANSTO developed a time schedule for the issues identified in the periodic review. The OPAL PSR initial submission contained the summary of the issues but no timeline for their implementation was suggested. The first time schedule draft was provided in June 2012 under title After-action Programme [7]. This document contained the summary of all consolidated actions for implementation categorised by importance. An updated version of this document has been provided in the OPAL report for the second quarter.

The document also incorporated all the outstanding issues arising from the international peer review. ANSTO has committed that all relevant matters identified in the ARPANSA regulatory review would also form a part of the After-action Programme. This is ensured by the Recommendation 11: above. The updated After-action Programme will be reported to ARPANSA six monthly.

This is acceptable to the ARPANSA reviewers provided the reporting of the implementation status of individual outstanding actions is carried out and the issues ARPANSA raised are appropriately addressed.

The implementation progress of the After-action Programme will be in the ARPANSA regulatory monitoring focus via the appropriate inspection programme.

Recommendation 12: **The After-action Programme should be updated six monthly, and its status presented in the relevant OPAL quarterly reports until all after-actions are implemented.**

Recommendation 13: **ARPANSA inspection programme should include monitoring of progress of implementation of the agreed After-action Programme.**

3.OPAL operation events over PSR period

Generally, the OPAL reactor events are reported to ARPANSA quarterly. Many for the events logged into the OPAL reactor operation management system are not nuclear or radiation safety related. However, ARPANSA routinely requested and assessed additional information on those reported events that were identified with a potential regulatory interest.

ANSTO internal event reporting system is discussed under the PSR Safety Factor 8 Safety: Performance (see above).

3.1. Event analysis

In total, 796 events were reported to ARPANSA between October 2006 and June 2011. The distribution of events by quarters is presented in the Figure 1 below. While the trend of the events slowly decreased in 2007 due to the extended shutdown related to the 'fuel fault' event, the number of events increase in the later years. This increase was justified by introduction of a better event operation event management system in the second half of 2008. The new system was more user-friendly, which improved the event reporting practice at the OPAL reactor facility and increased the number of reported events.

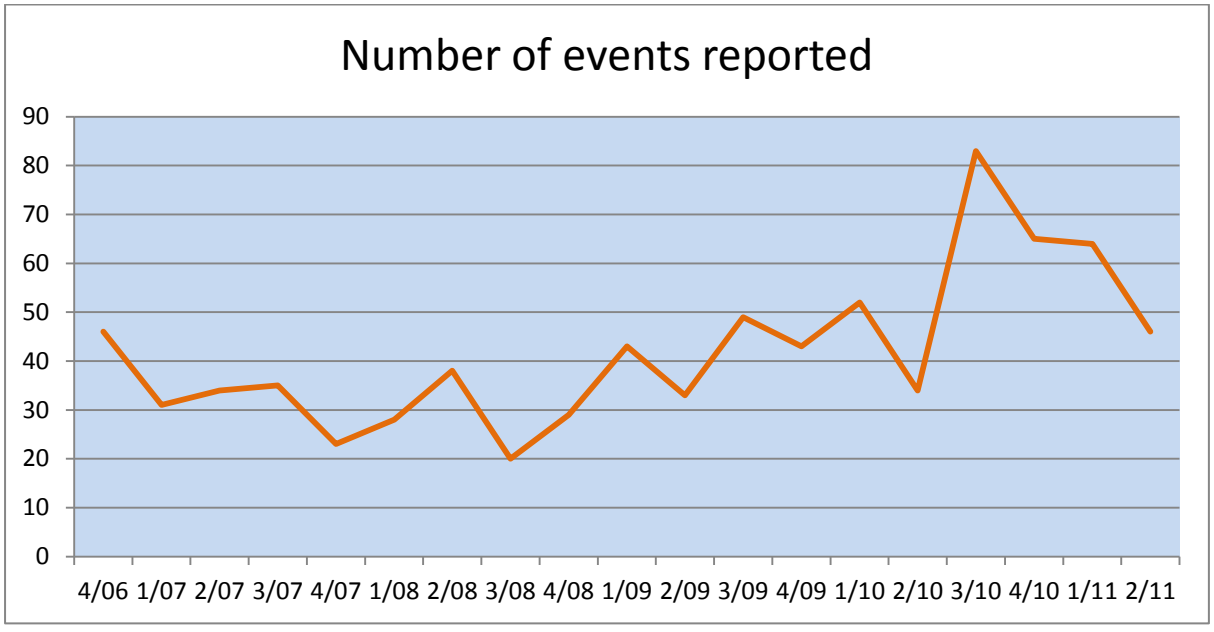

Figure 1: number of reported events between fourth quarter of 2006 and the second quarter of 2011

In addition to twenty six events ANSTO categorised to be nuclear safety related, ARPANSA requested details of numerous other events that occurred until June 2011. Those events fell under different ANSTO's categories, e.g. operations, maintenance and environment. ANSTO event investigations indicated on mainly design deficiencies or procedural deficiencies. Some of the events were assessed

by ANSTO to have included a human factor contribution; however, the general statistical analysis of contributing causes was not presented in the PSR. ARPANSA's analysis of the information available indicates absence of any adverse trends.

The reports to ARPANSA included thirty nine events that were related to health physics. The majority of these events were minor personnel contaminations. None of the health physics events resulted in significant doses to the personnel.

3.1.1. INES rated events

All nuclear and radiological events were assessed according to the IAEA International Nuclear and Radiological Event Scale (INES). This assessment determines a level of safety significance on the scale from 1 to 7, where level 1 is 'anomaly' and level 7 is 'major accident' (Chernobyl or Fukushima accidents). Level 0 or below scale rating means that the event had no safety significance.

Between 2006 and June 2011, ANSTO reported four events out of twenty six nuclear and radiological events were rated INES L1. No events were rated INES L2 and above. The remainder of the nuclear and radiological events were found to be level 0, therefore with no safety significance.

The ARPANSA conducted independent INES assessments of the events with actual and potential nuclear and radiological consequences. The INES rating of all events were confirmed except one– the 'fuel fault'. ARPANSA preliminarily rated that event late in 2007 to be INES L2 and as such reported to the IAEA international database. However, based on changes to the procedures introduced in the INES User Manual, revision 2008, the final rating of the event was down-rated to INES L1.

The four INES L1 events were investigated by ANSTO in considerable detail. ARPANSA was informed about the events according to the relevant regulations and guidelines. In all cases, ANSTO and ARPANSA communicated in the matter continuously and the full investigation reports were supplied. One of these events related to dislodgement of fuel plates from fuel elements during the OPAL reactor operation. This event has been referred to as the 'fuel fault' event. It was considered by both ANSTO and ARPANSA to be very significant and is discussed in a separate section below.

Another event rated INES L1 was also related to fuel element. In this case, a fuel element became detached from the handling tool and dropped on top of the fuel storage rack in the Reactor Pool. There was no release of fission product into the pool water detected. The event resulted in re-designing the handling tool.

Another event of the INES L1 rating was associated with non-compliance with the reactor Operational Limits and Conditions. When a neutron detector's power failed, the OPAL personnel attempted to trip the affected reactor protection channel according to the valid procedure. However, later this channel was not found in trip as expected. It took additional several hours to resolve the difficulties with tripping the channel. The delay caused the task not to be completed within the required time period. The investigation identified the causes and a number of actions were identified to prevent the event from recurring.

The fourth INES L1 event affected a reactor protection system. During a routine set point change, the personnel discovered that one of the neutron detector channel set point was incorrect. Because

it was a recurrence of a similar event from the past, ANSTO correctly elevated the INES rating of the event from L0 to L1.

ARPANSA monitored the rectification processes that resulted from the event investigations. It was confirmed that all actions have been adequately implemented to minimise the risk of re-occurrence.

Conclusion:

The INES L1 events were appropriately rated and acted upon. None of these events led to any actual radiological consequences. The ARPANSA reviewers were satisfied with the process of implementation of actions arising from the investigations.

3.2. 'Fuel fault' event of July 2007

The most significant event that occurred at the OPAL reactor before June 2011 was the fuel plate displacement that occurred in July 2007. During a routine fuel change at the end of an operation cycle, the OPAL personnel noticed that some fuel plates of a few fuel elements were partially displaced outside the designed position. The event initiated a long investigation and testing that caused the reactor to be shut down for almost ten months. ARPANSA officers assessed the event and based on IAEA's INES Users Manual, 2001, rated the event as L2: Incident. This rating was reported to the IAEA via the INES system. However, the INES Users Manual was at that time under review. The new revision issued in 2008 was more prescriptive in using specific methodologies. RE-assessment of the event resulted in down-rating the event. The final INES rating of the event was determined to be L1: Anomaly.

The ANSTO investigation instigated the fuel element design modification. ANSTO submitted the request for the relevant change in December 2007. After a rigorous regulatory review, reviews conducted by external consultants, and reviews carried out by some of the ARPANSA Nuclear Safety Committee members, ARPANSA approved the fuel design modification in May 2008. The reactor was authorised to re-start.

The ARPANSA approval of the change included two additional licence conditions imposed on ANSTO in 2008. They articulated the expectations for the further work to investigate and understand better the OPAL reactor environmental conditions, and a requirement for an additional review of the fuel design.

The submission ANSTO supplied to ARPANSA in order to demonstrate compliance with the licence conditions was reviewed by an external consultant. The review identified some discrepancies that had to be further addressed by ANSTO. The final submission related to the matter was provided to ARPANSA in 2012.

The OPAL reactor fuel has shown good operational fuel performance since the fuel modification. ANSTO has developed a comprehensive OPAL fuel performance monitoring programme. The result of the programme showed that no release of radioactivity to the coolant circuit has been detected, no fuel cladding damage was observed, and no mechanical marks suggesting harmful vibrations in

the core have been observed. However, ANSTO has not clearly addressed an issue of the coolant velocity safety margin to the critical velocity. This matter has also been identified in the OPAL SAR review. It will be followed up via the OPAL PSR After-action Programme.

ANSTO has conducted a review of the current fuel design against other research reactor fuel designs. However, some inconsistencies were identified in the ARPANSA review. Considering the main reason for issuance of the Licence Condition 2 in 2008 was a lack of operational experience with the fuel modification at that time, good operational records of the modified fuel since 2008 provided a reasonable demonstration that the current fuel is fit for purpose with no apparent degradation in safety performance.

Conclusion:

The ANSTO submission to demonstrate compliance with licence conditions associated with 'fuel fault' has been considered complete. The compliance with the above-mentioned licence conditions will be dealt with separately to this RAR.

4.OPAL Regulatory Compliance

The following paragraphs analyse the OPAL reactor compliance with the *Australian Radiation Protection and Nuclear Safety Act, 1998 and Regulations, 1999* in general and specifically with Licence Condition 13.

4.1. OPAL reactor compliance

4.1.1. Compliance Monitoring

Regulatory compliance at the OPAL reactor is monitored regularly using various methods. These methods complement one another in order to provide ARPANSA sufficient information for regulatory decisions. The information is gathered via:

- The ARPANSA inspection programme,
- Review of ANSTO quarterly reports,
- Assessment of applications from the OPAL reactor for regulatory approval to make relevant changes significant to safety, and
- Regular meetings and other interactions with ANSTO.

4.1.1.1. Inspections

Between July 2006 and June 2011, ARPANSA conducted twenty five inspections of the OPAL reactor. The complete list of inspections with the main findings is presented in Appendix 1.

The findings in all of the inspected areas showed a gradual trend to improved safety performance since the reactor was commissioned in 2006, as operational experience expanded. Many areas were inspected regularly to obtain more specific compliance indicators for trending. The inspection programme has covered many aspects of operational activities of the OPAL reactor, such as nuclear safety and radiation protection, safety management, training, emergency arrangements, project and event management etc.

Some underlying issues have been identified by the ARPANSA inspection programme. Inspection of the OPAL maintenance programme showed some shortfalls initially in that the maintenance activities did not align with best practice. These deviations from best practice, although safety related, were not found to have significant implications for safety. These matters were in many cases caused by incomplete maintenance documentation that was under development at the time. As the OPAL Business Management System became more mature, the number of deviations gradually reduced. The main deviations identified were associated with the change control of procedures, control of contractors, and instrument calibration processes. Another important aspect of regulatory compliance monitoring for the OPAL reactor has been the Reactor Operations Event Management System (ROEMS). Over time it has been observed that event investigations, identification of lessons learnt, and implementation of recommendations has been continuously improving with experience.

A similar improving trend has been observed in other areas e.g. OPAL Operations and Utilisation. The main issue highlighted by the inspection programme is project management, particularly some deficiencies in prioritisation of projects. This has resulted in the delay in implementation of some safety related projects raised by event investigations.

Conclusion:

The ARPANSA inspection programme of OPAL compliance matters has identified some common themes over the period covered by the PSR. All the matters identified and discussed above have shown improving tendencies over the period. All the issues have been raised with ANSTO in the appropriate forums. These compliance themes remain in the ARPANSA regulatory focus.

4.1.1.2. Breaches

The OPAL reactor compliance with conditions of the OPAL Licence over the period from licensing in July 2006 until June 2011 has been analysed. During that period ANSTO was found in breach of ARPANS Act and Regulations four times in total, as indicated in the table below.

Table 1: OPAL reactor breaches of ARPANS Act and Regulations between July 2006 and June 2011

Date	Regulatory Requirement	Breach description
July 2007	Regulation 49	Appointment of an OPAL Shift Manager without appropriate accreditation. ANSTO was found to be in non-compliance with their plans and arrangements for managing safety, specifically operation manual OM 02 that specifies the minimum number and qualification of the personnel present at accreditation interviews.
November 2008	Regulation 49	Breach of OPAL Operational Limit and Condition 3.3.3 The OLC 3.3.3 defines operability of the Second Reactor Protection System (SRPS). During a neutron detector fault investigation, one channel of the SRPS was found inoperable for a longer time period than allowed without ANSTO taking required actions. The channel inoperability was identified after a delay, after the channel was repaired and SRPS fully functional. At the time when the breach occurred ANSTO was not aware of the non-compliance and it was ARPANSA that brought this to ANSTO's attention.
February 2009	Regulation 49	Change of the OPAL reactor Shift Roster ARPANSA assessment of the change from an 8 hour to 12 hour

		shift roster identified that ANSTO did not implement its approved change management procedures which stipulate appropriate risk management controls. ANSTO implemented the processes only after ARPANSA intervention.
February 2010	Regulation 49	Non-compliance with OPAL documentation procedure An ARPANSA inspection identified that the hardcopy emergency documentation present in the Main Control Room and Emergency Control Centre, as required by the relevant procedure, was not complete.

All breaches of the OPAL licence conditions identified over the period covered by the OPAL PSR were associated with Regulation 49 which requires that all activities must comply with ANSTO's plans and arrangements for managing safety. ANSTO developed a business management system (BMS) that was subject to licensing assessment prior to the year 2006. Since then, the BMS has been further expanded so that at the end of the PSR period it contained several hundred documents. Considering continuous expansion of the BMS, the number of breaches over time per BMS document does not indicate an adverse trend.

Two of the breaches involve deviations from approved procedures and instructions. These breaches could have easily been prevented by consistent application of the key procedures associated with personnel training, change control and safety screening processes. Due to their importance to safety management, compliance in these areas has remained a focus of ARPANSA regulatory oversight.

One breach was related to OPAL personnel gaps in detailed understanding of the as-built design. Appropriate changes have been implemented since then in order to improve both the design and personnel's in-depth knowledge.

ARPANSA follow-up activities confirmed that all breaches were adequately investigated and lessons relating to the specific breach have been identified and learnt. However ANSTO could do more to address underlying organisational and cultural issues which have led to these breaches to effect performance improvements across a wider range of activities.

Conclusion:

The breaches of the OPAL reactor licence conditions did not indicate any adverse trends. The ARPANSA reviewers are satisfied that all breaches resulted in adequate preventative measures that have been implemented at the facility.

4.1.1.3. Quarterly reporting

The OPAL quarterly report is required to be submitted to ARPANSA at the end of each quarter year pursuant a licence condition.

Following the issue of a quarterly report, a meeting is held between ANSTO OPAL reactor Operations and ARPANSA to discuss compliance for the previous quarter.

Topics which are routinely discussed at these quarterly review meetings include:-

- Compliance with the OPAL facility licence and conditions
- OPAL operational history for the quarter
- Events which are reported to the Reactor Operations Event Management System (ROEMS)
- Performance against an agreed set of Safety Performance Indicators (SPIs)
- Compliance with plant surveillance and maintenance plans
- Status of Regulation 51 and 52 changes
- Discharges of activity and releases to the environment

4.2. Compliance with LC 13

The ARPANSA reviewers assessed the PSR submission and all additional information in context with requirements of OPAL Licence Condition 13.

The ARPANSA review of the OPAL PSR documentation demonstrated that the methodology used complied with the IAEA Guide. All safety factors that are recommended in the Guide have been appropriately addressed through adequately comprehensive assessments, arising issues have been clearly identified and recorded in the After-action Programme. ANSTO showed that appropriate systems are in place to ensure the After-action Programme will be followed up and all actions to rectify the matters will be implemented in a timely manner.

The OPAL PSR specifically demonstrated that

a) The OPAL reactor adequately conforms to current international safety standards and practices,
b) The plant remains within the licensing basis,
c) Arrangements in place are adequate to maintain plant safety until the next PSR, and
d) All safety improvements to resolve the identified safety issues will be implemented.

Taking this into account, the ARPANSA reviewers consider that the objective of the PSR as stated in the IAEA Guide has been met.

Based on the detailed review against various documents as outlined above, the ARPANSA reviewers also found that the OPAL PSR has:

- Been carried out according to the licence condition time requirement,
- Provided sufficient details and depth,
- Taken into account the operating experience at the OPAL reactor and other applicable international operating experience,
- Taken into account international best practice in radiation protection and nuclear safety, and
- Been subject to the international peer review.

These findings showed that all requirements of Licence Condition 13 of the OPAL licence have been fulfilled.

Conclusion:

Taking into consideration the findings above, the ARPANSA reviewers conclude that the ANSTO OPAL PSR submission closely followed the IAEA Guide. All aspects of the guide objective have been appropriately met. The document particularly demonstrated that the plant conforms to the current international safety standards and practices, the licensing basis remains valid, adequate arrangements exist to maintain the OPAL reactor safety until the next PSR is conducted, and safety improvements arising from the review will be implemented.

The ARPANSA reviewers' assessment also concluded that the requirements of Licence Condition 13 of the OPAL reactor Licence F0157 and as cited in the Introduction of this report have been met. Therefore, it is recommended that Licence Condition 13 be lifted.

Regarding the outstanding ARPANSA reviewers' issues arising from this assessment, the following recommendation is suggested.

4.3. Proposal for a new licence condition

The removal of the existing licence condition that set out the requirements for the first periodic safety review should be replaced with another licence condition that will address expectations for the next PSR.

Regarding the time interval to next OPAL PSR, the reviewers have considered the following:

- The time estimate that will be required for implementation of all actions arising from this PSR,
- Preparation of next PSR project,
- PSR review and documentation development and their assessment,
- Allowance for a suitable time separation between two consecutive PSR's,
- The OPAL reactor design configuration, and
- International best practice.

Therefore, to substitute the existing Licence Condition 13, the following OPAL Licence Condition that articulates requirements for the next periodic safety review of the OPAL reactor is recommended:

> **The licence holder must submit to the CEO of ARPANSA a detailed review that examines the safety of the OPAL reactor taking into account operating experience and international best practice in radiation protection and nuclear safety, and that has been subject to independent peer review. The next review must be submitted to the CEO of ARPANSA no later than 30 November 2021. The programme of corrective actions arising from that PSR and forming a part of that submission is to be subject of approval by the CEO of ARPANSA.**

5.Conclusions

The ANSTO submission of the Periodic Safety Review of the OPAL reactor and information provided in support of the submission provided evidence that the ANSTO OPAL PSR submission closely followed the IAEA Guide. The guide objective has been fulfilled considering appropriate graded approach. The documents demonstrated that the plant remains within the licensing basis and the plant safety can be maintained until the next PSR is conducted (assumed to be November 2021).

Specifically, it showed that:

1. The submission and additional information provided sufficient details of the PSR so all aspects of the regulatory review could be addressed.
2. ANSTO internal approval process of the PSR was found adequate.
3. The initial submission showed some shortfalls. However, the follow up interaction with ANSTO resolved the majority of the issues identified through provision of additional information. The outstanding issues were entered into the implementation plan of the actions arising from the PSR – After-action Programme.
4. The plant design was found to be well aligned with the relevant current standards and codes. The documents showed ANSTO has a good understanding of the current plant conditions. There were no indications that the plant ageing and other factors unacceptably affected the items important to safety.
5. ANSTO has been undertaking development of an asset management system that will manage the maintenance optimisation as well as ageing aspects in the upcoming interval between PSRs.
6. The deterministic and probabilistic safety analyses were found to be current. Whereas the deterministic safety analysis was updated to reflect the changes undertaken, the probabilistic safety assessment was found still relevant with no changes proposed.
7. The existing hazards have been reviewed and updated. This has been done particularly in the light of the Fukushima accident. The majority of the hazards remained unchanged.
8. Based on limited data having been available since the reactor licensing, the review of OPAL reactor performance indicated there were no trends that might have significant safety implications. ANSTO demonstrated that the OPAL reactor's safety performance is acceptable.
9. OPAL reactor administration and business management system were shown to be well aligned with the relevant IAEA standards. Although the review showed a weakness due to the occasional lack of critical assessment by ANSTO, no issue associated with the OPAL reactor procedures and instructions would significantly compromise safety.
10. Human factor assessments addressed the majority of human performance aspects of operations. A shortfall found in review of the ANSTO assessment of human factors in maintenance is to be rectified via After-action Programme.

11. The review of emergency planning indicated the existing emergency arrangements and documentation is adequate. Aspects associated with some areas of emergency planning were not completely analysed. For instance, the level of maintenance and storage of the emergency equipment available, adequacy of the site emergency plans and instructions, and frequency and scope of the exercises, were not discussed.

12. ANSTO maintains a very good monitoring system of the OPAL reactor radiological impact on the site as well as on the wider environment. Evidence presented showed that the reactor has a negligible radiological footprint on both the site and environment.

13. The PSR did not address the interrelationships and interdependence of all safety factors and individual shortcomings. Some interrelationships were marginally discussed by their presentation but did not show a systematic approach was adopted. For example, a critical assessment of the facility safety culture that should be examined as an underlying principle to all safety factors was not included.

14. All outstanding issues identified in the ANSTO review under the OPAL PSR, ARPANSA's review of the PSR and relevant peer review team recommendations have formed the implementation plan of actions arising from the review. The plan is called the OPAL PSR After-action Programme and it includes appropriate timelines for individual tasks.

15. ANSTO committed to a transparent monitoring system for the After-action Programme implementation. The status of programme action is now reported six monthly to ARPANSA.

16. The requirements of the Licence Condition 13 of the OPAL Licence F0157 have been fulfilled, specifically, the requirements for international peer review and consideration of best practice.

6.Summary of Recommendations and Licence Condition

Recommendation 1:	It is recommended that the next OPAL PSR should provide sufficient supporting documentation to substantiate the assertions made. Moreover, the referencing system used should be further improved. It should include clear links/information on the support documents so the relevant claims are readily verifiable.
Recommendation 2:	It is recommended that the next PSR establishes links between the issues identified in the review and relevant recommendations proposed so the reasons for the recommendations are made clear.
Recommendation 3:	ANSTO should consider the potential effect of the historically relevant OPAL reactor events to proposed ageing strategies, include them in the Asset Management System and discuss this in the next PSR.
Recommendation 4:	It is recommended that data from OPAL operating experience (events) be appropriately analysed and interpreted so that the benefit of lessons learnt are maximised. The assessment should also include statistical analyses of contributing factors to the events and trend analyses.
Recommendation 5:	ANSTO should devote attention to discussing the influence and impact of safety culture on the operation, maintenance and management of OPAL; this is important given that the IAEA guidance acknowledges the influence of safety culture, and its importance is recognised across all high hazard industries.
Recommendation 6:	It was observed that there appeared to be a lack of in-depth critical assessment of the OPAL procedures. The next PSR should demonstrate an improvement in this area.
Recommendation 7:	Human factors should be addressed in all aspects of OPAL operations, and should include reviews of the processes and the design of the operating environment. Relevant utilisation and maintenance tasks should also form part of the assessment.
Recommendation 8:	In context of emergency planning and within this PSR, ANSTO should also assess the level of maintenance and storage of the emergency equipment available, adequacy of the site emergency plans and instructions, and frequency and scope of the exercises.

Recommendation 9: ANSTO should consider projected future operation of the reactor in the surveillance programme for the radiological impact of OPAL on the environment.

Recommendation 10: In addition to assessment according to the individual safety factors, ANSTO should also include the assessment of interrelationships and interdependence between safety factors and individual shortcomings in the facility overall safety evaluation.

Recommendation 11: Any unresolved issue that arises from the ARPANSA review of the OPAL SAR Rev 1 should be included in the After-action Programme.

Recommendation 12: The After-action Programme should be updated six monthly, and its status presented in the relevant OPAL quarterly reports until all after-actions are implemented.

Recommendation 13: ARPANSA inspection programme should include monitoring of progress of implementation of the agreed After-action Programme.

Recommendation 14: It is recommended that with removal of the existing Licence Condition 13 the following new licence condition is introduced:

Proposed Licence Condition

The licence holder must submit to the CEO of ARPANSA a detailed review that examines the safety of the OPAL reactor taking into account operating experience and international best practice in radiation protection and nuclear safety, and that has been subject to independent peer review. The next review must be submitted to the CEO of ARPANSA no later than 30 November 2021. The programme of corrective actions arising from that PSR and forming a part of that submission is to be subject of approval by the CEO of ARPANSA.

REVIEWING OFFICERS			
NAME: Vaz MOTTL	SIGNATURE:	<original signed>	DATE: 03.10.2014
NAME: John WARD	SIGNATURE:	<original signed>	DATE: 07.10.2014
NAME: Jim SCOTT	SIGNATURE:	<original signed>	DATE: 16.10.2014
BRANCH HEAD A/g			
NAME: Jim SCOTT	SIGNATURE:	<original signed>	DATE: 16.10.14

7.References

1 Letter R Evans to G Storr, 11 November 2009, F0157 OPAL Operation Request for Clearance of ARPANSA Hold Point No. 3 – Completion of Sub-stage C Commissioning
(ARPANSA TRIM Record Number R09/12197)

2 ANSTO. *2011 Periodic Safety Review*, technical report, OPAL-7200-TRP-007
(ARPANSA TRIM Record Number R12/00328, R12/00326)

3 ANSTO (31 March 2011). *Review of the Fukushima Daiichi NPP Event – Preliminary Assessment of Implications for the OPAL Safety Case and Lessons Learnt*
(ARPANSA TRIM Record Number R14/02072)

4 Letter L Dimitrovski to M Dwyer, 19 December 2013, *ANSTO Fuel Fault "What If " Analysis*
(ARPANSA TRIM Record Number R14/01016)

5 Letter L Dimitrovski to M Dwyer, 29 January 2014, *OPAL PSR 2011 and Outstanding Issues*
(ARPANSA TRIM Record Number R14/01295)

6 Letter M Dwyer to L Dimitrovski, 4 December 2013, *OPAL PSR 2011 and Outstanding Issues*
(ARPANSA TRIM Record Number R13/13026)

7 ANSTO. Draft Programme of After-actions
(ARPANSA TRIM Record Number R13/03076)

8 Meeting notes, OPAL PSR Workshop, 3 April 2013
(ARPANSA TRIM Record Number R13/03275)

9 Meeting minutes, 12 December 2013
(ARPANSA TRIM Record Number R14/01687)

10 Letter L Dimitrovski to M Dwyer, 21 June 2013, *OPAL reactor – Periodic Safety Review Supplement*
(ARPANSA TRIM Record Number R13/06812)

11 ANSTO (18 December 2013). *Fuel Plate Displacement – 'What If' Assessment*, technical report, OPAL-0500-TRP-003-A
(ARPANSA TRIM Record Number R13/14053)

12 Australian Radiation Protection and Nuclear Safety Regulations 1999

13 Australian Radiation Protection and Nuclear Safety Act 1998

14 ARPANSA (January 2013). Regulatory Guide: *Plans & Arrangements for Managing Safety v 4*, OS-LA-SUP-240B, Operations Services

15 ARPANSA (October 2001). *Regulatory Assessment Principles for Controlled Facilities*, RB-STD-42-00 Rev 1

16 IAEA (2003). *Periodic Safety Review of Nuclear Power Plants*, Safety standards Series NS-G-2.10, Safety Guide

17 IAEA (2012). *Use of a Graded Approach in the Application of the Safety Requirements for Research Reactors*, IAEA Safety Standards Series No. SSG-22, Safety Specific Guide

18 Letter M Dwyer to G Storr, 28 February 2012, OPAL PSR
(ARPANSA TRIM Record Number R12/01831)

19 OPAL Periodic Safety Review 2011 – Draft Programme of After-actions
(ARPANSA TRIM Record Number R13/03076)

20 Letter G Storr to M Dwyer, 16 July 2012, *OPAL reactor Licence Condition 1*
(ARPANSA TRIM Record Number R12/07222)

21 Questions regarding selected chapters of the updated OPAL Safety Analysis Report (rev 1)
(ARPANSA TRIM Record Number R14/02708 and R14/02709)

22 ARPANSA (May 2008). Decision and Statement of reasons by the CEO of ARPANSA on the submission from the Australian Nuclear Science and Technology Organisation seeking approval under regulation 51 of the ARPANS Regulations to modify the design of the OPAL reactor fuel assemblies to incorporate a stopper and to recommence operation of the reactor with the modified fuel assemblies
(ARPANSA TRIM Record Number R08/04367)

23 ARPANSA (January 2013). Regulation 51 – How to determine when a change has significant implications for safety, Regulatory Guide Rev 1

24 IAEA (2013). Periodic Safety review for Nuclear Power Plants, IAEA Safety Standards Series No. SSG-25, Safety Specific Guide

25 Vienna (1994). *Safety Assessment of Research Reactors and Preparation of the Safety Analysis Report*, Safety Series No. 35-G1

26 ARPANSA (July 2006). Regulatory Assessment report of ANSTO OPAL research Reactor Safety Analysis Report, RB-RAR-46-06
(ARPANSA TRIM Record Number D060019112)

27 US NRC (12 July 2011). *Recommendation for Enhancing Reactor Safety in the 21st Century*, The near-term task force review of Insights from the Fukushima Dai-ichi Accident

28 ANSTO (2014). Safety Reassessment of OPAL in the light of the Fukushima Daiichi Accident, OPAL-7200-TRP-014 Rev 0
(ARPANSA TRIM Record Number R14/10540)

29 IAEA (2014). Safety Reassessment for Research Reactors in the Light of the Accident at the Fukushima Nuclear Power Plant, Safety Report Series No.80

Appendix 1

OPAL Inspections: July 2006 to June 2011

	Scope of inspection	Date	Issues identified
1.	Emergency exercise	20/05/2011	No significant compliance issues identified
2.	OPAL refuelling	13/05/2011	No significant compliance issues identified
3.		3/12/2010	No significant compliance issues identified
4.	Shutdown walkdown	9/05/2011	No significant compliance issues identified
5.	Utilisation and maintenance training	4/04/2011	• Some inconsistencies in radiation training frequency delivery to utilisation staff • Maintenance staff training to improve (generally service providers to OPAL)
6.	Utilisation records keeping	16/08/2011	• Clarity of some forms used in utilisation should be improved • Events sometimes take too long to close
7.	Log keeping	20/01/2011	Minor issues with log entries quality
8.		21/10/2009	No significant compliance issues identified (improvement of logging practice was noticed)
9.		10/09/2008	No significant compliance issues identified
10.		23+25/10/2007	Deviation from instruction on items management at the pool vicinity
11.		20/08/2007	No significant compliance issues identified
12.		4/08/2006	• Shortfalls in control of the MCR logbook (two versions of the form used, missing signatures, no indication of responsibility change during a temporary Reactor Operator relief during the shift)
13.	Project management	22/09/2010	• Deficiency in project safety prioritisation • Actions arising from event investigations were not closed out in a reasonable timeframe • Lessons learnt from event investigations were not always applied to wider organisational and systemic areas
14.	Utilisation safety management	17/03/2010	• Use of superseded training documentation • No systematic check whether the actual work is carried out according to procedures. Instead there was reliance on individuals to conduct the checks at their discretion • Minor deficiencies in communication during operation which arose from some event investigations • Timeframes for some safety related projects that had arisen from OPAL events were considered to be too long (e.g. 20 months) - this is related to safety prioritisation which was also outlined in a

			later inspection (22/9/10)
15.	MCR and ECC documentation	16/02/2010	• Set of instruction manual hard copies not complete. Some of the instructions referenced in the plant procedures were not found in the MCR and ECC • Some documentation references were found to be superseded
16.	Maintenance arrangements	21/11/2008	• Inconsistencies found in the instrument calibration frequency (an issue with instrument calibration was first found in 2007) • Inadequate use of risk assessment (FMEA) was identified in relation to some projects (BIF tool, FA Handling tool)
17.		5/03/2008	• Some instruments out of calibration • OLC surveillance requirement acceptance criterion of a parameter was not established (chemical analysis)
18.		27/06/2007	• Some instruments of all Safety Categories were found out of calibration (first identification of the issue) • Inappropriate control of the plant configuration for maintenance by contractors (part replacement) • Unsatisfactory investigation of foreign particles that cause unavailability of a Diesel Generator (DG)
19.		2/11/2006	• PCS pump maintenance work done using Safe Method Work Statement (SWMS) without developing a work instruction (SWMS process is less robust) • DG battery replacement conducted without appropriate replacement assessment (ANSTO did not understand their responsibility for safety in this case)
20.	Event management	10/10/2008	• Shortfalls in contractor control at OPAL evident from a few event investigations • Minor issue related to long timeframes required for closing out events • Inadequate risk assessment applied to Fuel Assembly (FA) Handling Tool re-design • Little evidence found on how lessons from events are learnt and what adequate measures were taken to prevent their recurrence
21.	Preparation for return to service	2/05/2008	• Minor deficiencies in the log books, e.g. missing signatures and a level of entry details • Instrument calibration issue (related to inspection of 21/11/08 above)

22.	OPAL Support Group	13/09/2007	• Reduction of the Reactor Assessment Committee (RAC) quorum from 5 members to 4 was changed • No formal acknowledgement by staff they have read and understood changes to the BMS
23.	OPAL BMS	5/06/2007	• Minor deficiencies in the log books, e.g. missing signatures, logging practices • Non-compliance with requirements for Shift Manager accreditation
24.	OPAL emergency arrangements documentation	29/01/2007	• Slow implementation of lessons learnt from previous exercises • Slow development of emergency arrangements
25.		31/10/2006	• Shortfalls in MCR and ECC documentation change control (document sets were incomplete, currency not easily verifiable, inconsistency in update implementation) • Absence of emergency equipment (Self Contained Breathing Apparatus (SCBA)) at the -5m stairs. Other SCBA had no inspection labels

Appendix 2

Justification of the relevant original OPAL licence conditions

Justification of the following licence conditions presented below was articulated in the *Decision of the CEO of ARPANSA on Application by ANSTO for a Licence to Operate the OPAL reactor – Statement of Reasons (14 July 2006).*

Licence Condition 1: Periodic Safety Review (PSR)

1.1. *ANSTO must submit to the CEO of APANSA 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 the 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.*

Justification (p17 of the Statement of Reasons, paraphrase): Although acknowledged that the licence application had been sufficient to justify the decision to issue an operating licence for the OPAL reactor, the then CEO of ARPANSA recognised a need for a process to consolidate the final documentation. This consolidation would include amendment in light of the plant hot commissioning and operating experience. In order to ensure that this would occur effectively, the licence condition requiring a PSR was imposed on ANSTO. It was expected that two years of routine operations would be sufficient for all documentation to have been reviewed and revised.

Although not specifically mentioned in the Statement of Reasons, the ten year periodicity of the PSR was established based on the IAEA safety guide Periodic Safety review of Nuclear Power Plants, NS-G-2.10 (2003), where stated: *"The PSR should be conducted typically every ten years and its duration should not exceed three years."*

Licence Condition 2: Periodic Security Review

3.1. *ANSTO must submit to the CEO of AATPANSA and to the Director 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.*

3.2. *The first such review must be completed no later than two years after the date of completion of the commissioning of the OPAL reactor and thereafter at intervals agreed with the CEO of*

ARPANSA and the Director General of the Australian Safeguard and Non Proliferation Office, taking into account developments in the security environment.

Justification (p83 of the Statement of Reasons, paraphrase): There were similar reasons for this licence condition as there were for the licence condition regarding the OPAL PSR. It was expected that there would always be a need to review physical protection and security arrangements with respect to ongoing threat assessments. The benefit of systematic and thorough reviews from time to time was recognised. The reasons for the first such review to be conducted no more than two years after the OPAL reactor commences normal operation were identical to those for the PSR licence condition.

Licence Condition 3: Safety Culture

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 or ARPANSA.

Justification (p50 of the Statement of Reasons, paraphrase): 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. By imposing the licence condition, the then CEO of ARPANSA wanted to emphasise that supporting a positive safety culture and measuring progress towards this end is an important function of the operating organisation.

ARPANSA reviewers were also critical of consideration of the human factors elements as reflected in the safety management system. This reinforced the need for safety culture to be reviewed regularly in the light of operational experience.

An issue related to safety culture which was identified in the OPAL licence assessment, is the development of safety performance indicators. The development of such indicators was acknowledged to be a part of international best practice in relation to radiation protection and nuclear safety. The CEO of ARPANSA was aware that ANSTO was developing a suite of these indicators at that time. He subsequently imposed the licence condition on ANSTO in order to highlight the importance of safety performance indicators, and to invoke a positive safety culture, and not merely a reporting culture.