Licensing of ANSTO's Replacement Research Reactor

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Abstract

This paper presents a general description of the licensing of the 20 MW Pool-type Replacement Research Reactor (RRR) currently being built by the Australian Nuclear Science and Technology Organisation (ANSTO) at their Lucas Heights site. The following aspects will be addressed:

- The influence of ARPANSA's (the Australian regulator) Regulatory Assessment Principles and Design Criteria on the design of the RRR.
- The Site Licence Application, including the EIS and the supporting siting documentation.
- The Construction Licence Application, including the PSAR and associated documentation.
- The review process, including the IAEA Peer Review and the Public Submissions as well as ARPANSA's own review.
- The interface between ANSTO, INVAP and ARPANSA in relation to the ongoing compliance with ARPANS Regulation 51 and 54.
- The future Operating Licence Application, including the draft FSAR and associated documentation.

These aspects are all addressed from the point of view of the licensee ANSTO and the RRR Project. Particular emphasis will be given to the way in which the licensing process is integrated into the overall project program and how the licensing and regulatory regime within Australia influenced the design of the RRR. In particular, the safety design features that have been incorporated as a result of the specific requirements of ANSTO and the Australian regulator will be briefly described.

The paper will close with a description of how the RRR meets, and in many aspects exceeds the requirements of ANSTO and the Australian regulator.

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Introduction

This paper presents a summary description of the licensing of ANSTO Replacement Research Reactor (RRR) with particular emphasis on the way in which the licensing process is integrated into the overall project program and how the licensing and regulatory regime within Australia influenced the design of the RRR. The safety design features that have been incorporated as a result of the specific requirements of ANSTO and the Australian regulator will be briefly described.

The Site Licence

The application for the Facility Licence, Site Authorisation (to give it its proper title) was submitted to the Australian Radiation Protection And Nuclear Safety Agency (ARPANSA) in April 1999. This licence was required in accordance with the ARPANS Act in order to demonstrate the suitability of the proposed site for the construction of the RRR.

One of the principal documents supporting the site licence application was the Environmental Impact Statement (EIS). The EIS had been prepared previously in accordance with the Environmental Protection (Impact of Proposals) Act 1974 by specialist consultants, PPK Environment & Infrastructure Pty Ltd (PPK) as part of the environmental impact assessment during which it was subject both to review by Environment Australia and to public review. Environment Australia prepared an environmental assessment report for the Minister of the Environment that also addressed the public submissions. The Minister for the Environment subsequently made recommendations to the Minister for Industry, Science and Tourism (the Commonwealth Minister responsible for ANSTO). The Commonwealth Government then considered the proposal and made the decision to proceed with the project.

The other principal documents supporting the site licence application were the Siting Safety Assessment - Site Characteristics and Site Related Design Bases and the Reference Accident Submission. These documents were prepared in accordance with ARPANSA Draft Criteria for the Siting of Controlled Facilities.

The assessment of the suitability of a site for a proposed controlled facility involves the determination of the consequences of a hypothetical accident at the facility, called the Reference Accident, and comparing those consequences to the siting criteria. In general terms, the Reference Accident assumes degraded performance of one or more safety systems which leads to a release of radioactive material to the environment together with assumptions about prevailing meteorological conditions. The radiological consequences of the accident would be very unlikely to be exceeded by any actual accident, and are determined using conservative assumptions similar to those that would be used for design-basis accidents. For site approval, these consequences must meet the siting criteria defined in the ARPANSA Draft Criteria.

The Reference Accident proposed by ANSTO and agreed by ARPANSA was based on a generic reference design for a pool-type research reactor. It made a number of conservative assumptions about the actual design of the RRR. For example, the retention of fission products and other radionuclides in the reactor pool water was based on an assumption of a pool water volume of 80 m^3. In practice, the actual reactor pool water volume in the RRR is approximately 200 m^3.

It should be emphasised that the ARPANSA review of the site licence application was a separate but complementary review process that was performed subsequent to the environmental assessment process.

Specification of Safety Objectives and Design Safety Requirements

During the first 6 months of 1999, ANSTO devoted significant resources to the preparation of a Request For Tender (RFT) that specified in detail ANSTO's requirements for the RRR. Integral within the team that prepared this RFT were a number of safety and licensing experts whose functions were to:

1. Prepare a section of the RFT covering the overall safety objectives and the design safety requirements that the Tenderers must meet.
2. Prepare a section of the RFT covering the content and format of a Safety Statement to be submitted by Tenderers
3. Review of other sections of the RFT to ensure that safety issues were adequately and appropriately addressed in a consistent manner throughout all sections of the RFT.

The principal sources used in the identification and development of the safety objectives and the safety design requirements were various International Atomic Energy Agency (IAEA) codes, standards and guidelines and the ARPANSA Regulatory Assessment Principles (RAPs) and their associated Regulatory Guides (RGs). Other sources included the recommendations identified by the Minister for the Environment

as part of the environmental assessment process and Licence Conditions imposed by the CEO of ARPANSA when granting the Facility Licence, Site Authorisation.

The intent of the RFT was to translate all the requirements and guidelines contained in these sources into a single, comprehensive set of requirements that could be readily understood by the Tenderers without their having to try to interpret the IAEA guidance and the ARPANSA RAPs and RGs. This was particularly important since all four of the pre-qualified Tenderers were overseas organisations who although experienced suppliers of research reactors, were unfamiliar with the Australian regulatory regime.

The RFT was released in July 1999 with the call for tenders from the pre-qualified Tenderers. Submissions were received by the end of 1999, including a Safety Statement that would form the basis of the PSAR to be prepared by the successful Tenderer. The purpose of requiring the Safety Statement as part of the tender documentation was as follows:

1. To confirm that there would be no significant problems associated with licensing the Tenderers proposed design within the context of the Australian regulatory regime.
2. To assess the ability of the Tenderer to prepare a suitable safety case in accordance with the standard content and format of a Safety Analysis Report (SAR) as defined by the IAEA.

The same safety and licensing experts who were involved in the preparation of the RFT were also involved in the review of the tenders received as one of the tender evaluation working groups, with particular emphasis on reviewing the Safety Statements with respect to the two aspects above. The safety and licensing working group also reviewed other parts of the tender documentation to confirm consistency with the Safety Statement as well as provided support to other working groups with respect to any safety or licensing issues identified.

As such, the safety and licensing of the RRR was considered as an integral part of the overall RRR project, with the same experts being involved in both the preparation of the RFT and the evaluation of the tenders received from the Tenderers. This also ensured that the evaluation of the various Tenderers' submissions was conducted in a consistent and even manner in accordance with the principles of "due diligence".

The Construction Licence

The application for the Facility Licence, Construction Authorisation (again to give it its proper title) was submitted to ARPANSA in May 2001. This licence was required in accordance with the ARPANS Act in order to commence construction of the RRR.

The principal document in the construction licence application was the Preliminary Safety Analysis Report (PSAR). The purpose of this document is to demonstrate the safety of the Reactor Facility design.

It also serves the following purposes:

1. To aid the designer in confirming that individual systems are integrated correctly, since the reactor design and the development of the PSAR are complementary, interactive processes.
2. To ensure that the safety analysis has properly identified the safety issues relevant to the design and that safety analysis and design are consistent.
3. To aid in the appreciation of the relevant design criteria, their limitations and requirements, and in the evaluation of the hazards posed by the facility.
4. To provide the basis for development of the draft Final Safety Analysis Report (FSAR) which will be submitted to ARPANSA in support of the Application for the Facility Licence, Operations Authorisation.
5. As an aid in operator training and familiarisation with the RRR during the Construction and Commissioning phase of the RRR Project.

The PSAR was prepared in accordance with the guidelines of the IAEA Safety Guide SS 35-G1 "Safety Assessment of Research Reactors and Preparation of the Safety Analysis Report", 1994. It demonstrates that the RRR design complies with the requirements of the ARPANSA RAPs for Controlled Facilities, Draft version, December 2000 and the associated RGs. It was developed from the Safety Statement prepared by INVAP as part of their tender submission as indicated in the previous section. At the time of the submission of the PSAR with the construction licence application, the Preliminary Engineering and Detailed Design stage of the project had been completed and the significant design decisions had been made.

The construction licence application as a whole, and the PSAR in particular, were subjected to extensive review by ARPANSA and 1159 formal reactive review comments were received that required formal responses. There were also a significant number of areas where more detailed discussions were required

and additional analysis and clarification had to be provided. Examples of these include the detailed thermo-hydraulic calculations upon which the safety analysis presented in the PSAR was based as well as additional analysis of some beyond design basis events not considered in the PSAR. At the end of this review, a Regulatory Branch Assessment Report (RAR) was prepared that contained a summary of the ARPANSA review. This identified over 100 recommendations and was presented to the CEO of ARPANSA for his consideration when determining whether to grant a construction licence.

The ARPANSA Nuclear Safety Committee also performed a review of the application in relation to the following three key safety issues:

- Seismicity
- Spent Fuel and Radioactive Waste
- Safety Analysis

This committee is an independent body that advises the CEO of ARPANSA. It is made up of experts and representatives of the community. It not only reviewed the application but also sought additional information from both ARPANSA Regulatory Branch (the part of ARPANSA with the lead responsibility for reviewing and assessing the safety of controlled facilities) and from ANSTO. The committee prepared and presented its own report, containing various comments and recommendations, to the CEO of ARPANSA for his consideration when determining whether to grant a construction licence.

The PSAR was also subjected to an independent peer review by a team of 6 experts nominated by the IAEA. They considered 22 key safety issues and their final report identified 25 recommendations and 18 comments. This report, including its recommendations and comments, was also presented to the CEO of ARPANSA for his consideration when determining whether to grant a construction licence. In addition, the PSAR was reviewed by the Autoridad Regulatoria Nuclear (ARN), the Argentine regulator, who provided a report of their review to ARPANSA.

The PSAR was also subjected to a public review with submissions being made to ARPANSA. To facilitate this, copies of the complete application, including the PSAR, were made available to interested parties such as the Sutherland Shire Council and to various libraries for public viewing, including all the State Libraries and local libraries. In addition, a summary version of the PSAR was prepared and made available on the Internet and in hard copy. The ARPANSA reactive review comments and the ANSTO response to them, together with the final report of the peer review by the group of IAEA nominated experts, were also made available to the public before the end of the public review period. This enabled the public to not only present their own submissions but to also consider the issues raised by the “experts”. Approximately 1150 submissions were made from which 177 issues were identified, virtually all of which had been previously identified in public submissions on the EIS during the environmental assessment process. A Public Consultation Report was prepared summarising the public submissions. This report was also presented to the CEO of ARPANSA for his consideration when determining whether to grant a construction licence.

Finally, in December 2001, the CEO of ARPANSA chaired a public forum in Sydney to hear oral submissions from interested parties. He was assisted in this by three member panel of experts, who each prepared and presented their own report of the public forum to the CEO of ARPANSA.

On the basis of the evidence provided in the various submissions and reports identified above and in accordance with the requirements of the ARPANS Act and associated Regulations, the CEO of ARPANSA granted the Facility Licence, Construction Authorisation in April 2002. This Licence incorporated 18 Licence Conditions and contained a number of specific references to ANSTO demonstrating that recommendations identified in the RAR have been taken into consideration to the satisfaction of the CEO of ARPANSA.

The Ongoing Interface with ARPANSA

The RRR project is currently in the Construction stage. The principal safety and licensing activities during this stage are as follows:

1. The review of Detail Engineering (DE) design deliverables (principally design documentation) to ensure compliance with the safety and licensing requirements and the safety case as presented in the PSAR. Note that all DE design deliverables are subject to an ANSTO review, verification and acceptance process in accordance with an appropriate project procedure and that the safety and licensing review is just part of this.
2. Ensuring compliance with the Licence Conditions imposed by the CEO of ARPANSA when granting the Facility Licence, Construction Authorisation together with the conditions inherent in the ARPANS Act and associated Regulations and demonstrating such compliance to ARPANSA.

3. Obtaining the CEO of ARPANSA approval to construct items important to safety in accordance with ARPANS Regulation 54 and Licence Condition 4.6. Due to the number of items that require such approval and the need to demonstrate compliance with Licence Condition 4.6, a project procedure has been developed and the submission process formalised. In addition, ARPANSA have set up a Reg54 Assessment Committee to which ANSTO reports on a regular basis to facilitate their review of these submissions.
4. Obtaining the CEO of ARPANSA approval for changes that will have a significant effect on safety in accordance with ARPANS Regulation 51 and Licence Condition 4.11. Note that at this time, although there have been numerous changes as a result of the development of the detailed engineering of systems and components, no changes have been identified that constitute a change that will have significant effect on the safety of the RRR.
5. Managing the interface with ARPANSA in relation to the ongoing procurement, manufacture, construction and installation of the RRR with particular emphasis on items important to safety as identified in the PSAR. This principally involves ensuring that ARPANSA are aware of the ongoing status of the project and facilitating their inspections and audits.
6. Updating of the PSAR in accordance with Licence Condition 4.8 and developing it into the draft FSAR. This also includes the revision of various nucleonics, thermo-hydraulic and transient analyses in line with the development of the detailed engineering of the RRR as well as the validation of the computational modelling used for such analyses in accordance with Licence Condition 4.10.

Ensuring compliance with the Conditions imposed by the Minister for the Environment arising from the environmental impact assessment and demonstrating such compliance is also an ongoing licensing activity. However, this is being done as part of ANSTO's site-wide Environment Management Plan.

From the point of view of the project, it is the third of these items that is involving a significant amount of effort, since it has meant that every Safety Category 1 and 2 structure, system and component (as defined in the PSAR) requires regulatory approval prior to procurement or construction. The need to integrate this Reg54 approval process with both the schedule for the review, verification and acceptance of DE design deliverables and with the construction schedule for a whole new facility has resulted in a complex process requiring careful control. In particular, it has become necessary to make multiple submissions for approval for some systems in order to comply with ARPANSA Regulation 54, the availability of accepted DE design deliverables and the construction schedule.

For example, the Primary Cooling System (PCS) was split across three submissions, one covering the decay tank, one covering the other main components with a significant manufacturing lead time (ie the main PCS pumps and heat exchangers), and one covering the remainder of the system. The submissions were done this way because the decay tank needs to be installed very early in the construction schedule prior to the pouring of the heavy concrete for the Reactor Block and the manufacture of the decay tanks involves a significant lead time. As such approval to manufacture the PCS decay tank was required before all the DE design documentation for the remainder of the PCS completed the ANSTO review, verification and acceptance.

The setting up by ARPANSA of the Reg54 Assessment Committee to facilitate the review process and provide a working level forum planning and progressing these submissions has been of considerable benefit.

Future Licence Applications

The application for the Facility Licence, Operating Authorisation will be submitted to ARPANSA in anticipation of the authorisation to operate the RRR. As identified previously, the principal document in the operating licence application will be the Final Safety Analysis Report (FSAR). Prior to this application, a draft FSAR will be submitted to ARPANSA as part of an application to load fuel into the RRR and perform the Stage B Commissioning, which will involve low power operation of the reactor.

The purpose of both versions of the FSAR is to demonstrate the safety of the "as-built" Reactor Facility, with the difference between these versions being the extent of the commissioning results available. The FSAR will also incorporate details of the operating regime for the RRR, including the Operational Limits and Conditions (OLCs). This approach is consistent with the ARPANSA RAPs and internationally accepted practice for nuclear facilities.

Specific Design Features that Resulted from Australian Regulatory Requirements

A number of features were incorporated into the design of the RRR in response to the safety objectives and the safety design requirements specified in the RFT and the specific requirements imposed by the Australian regulatory regime. A few of the more significant examples of these are identified below:

1. Provision of a Diverse and Independent Shutdown System

   The provision of diverse and independent shutdown systems is a common approach adopted for modern nuclear reactors. As a result, and in accordance with ARPANSA RAP 96, a specific requirement was incorporated into the RFT stating that diverse and independent shutdown systems must be provided in the design. The RRR design does incorporate two such diverse and independent shutdown systems, the First Shutdown System (FSS) and the Second Shutdown System (SSS), each actuated by its own diverse and independent protection system, the First Reactor Protection System (FRPS) (digital design) and the Second Reactor Protection System (SRPS) (hardwired design).

   The FSS consists of absorber plates that drop into the reactor core upon generation of a Trip 1 signal by the digital FRPS. The FSS pneumatic system ensures successful insertion of these plates even in the event of mechanical deformation caused, for instance, by an earthquake. The FSS is fail-safe in that the control rods connected to the absorber plates are themselves connected to the control rod drives by means of an electromagnet. Thus, in the event of the loss of power, the electromagnets are de-energised and the control rods, together with the connected absorber plates, are released from the drive mechanism, allowing the absorber plates to drop into the core.

   The SSS consists of the partial draining of heavy water from the Reflector Vessel that surrounds the reactor core upon generation of a Trip 2 signal by the hard-wired SRPS. The SRPS generates a Trip 2 signal on the basis of a diverse set of trip parameters to those used in the FRPS as well as upon detection of failure of the FSS system. The SSS is also fail-safe with respect to the loss of power to the SSS dump valves in that they fail open, dumping the heavy water into from the Reflector Vessel.

2. Provision of a Reactor Containment

   The Reference Accident for the EIS and the site licence application assumed the presence of a reactor containment. As such, a reactor containment approach was adopted for the design of the RRR to be consistent with the site licence and the environmental impact assessment.

   The Reactor Containment is a sealed volume within the Reactor Building that encompasses that reactor and the associated process systems. The purpose of the Reactor Containment is to form the final barrier to the release of radioactivity to the environment in the event of a beyond design basis accident, isolating the reactor from the environment. The two other barriers are the fuel matrix and fuel plate cladding, and the reactor's primary cooling circuit.

   The Reactor Containment System consists of the following:

   - Reactor Containment Boundary: the physical barrier that includes components such as the floors, walls and roof of the Reactor Building and the penetrations through this boundary.
   - Containment Isolation System: the penetrations through the physical barrier (the Containment) and the isolation provisions provided on those penetrations.
   - Containment Energy Removal System (CERS): a two train system that removes heat from the containment during normal operation and following containment isolation, thus preventing the pressurisation of the containment and minimising any leakage.
   - Containment Pressure Relief and Filtered Venting System (CPRFVS): a backup system that consists of pressure relief valves designed to protect the Containment from structural damage under beyond design basis accident conditions that may otherwise over-pressurise the building. Additionally it provides a flexible means to manage accidents by permitting the venting of filtered air from the Containment to the stack where this might be an appropriate accident management measure.
   - Containment Vacuum Relief System (CVRS): a backup system that consists of a set of vacuum relief valves designed to protect the Containment from structural damage under beyond design basis accident conditions that may otherwise cause the pressure in the building to be significantly less than atmospheric pressure.

The Reactor Containment's design pressure is ± 2.5 kPa with a maximum leakage rate of 3% of the total volume per day. These design conditions are consistent with the assumptions of the Reference Accident identified in the site licence application and the EIS.

3. Protection Against Aircraft Crash

   The probability of a light aircraft crash is sufficiently low that it may be considered to be beyond the design basis. However, ANSTO made a commitment that a light aircraft crash would be taken into consideration and that as a result, the RFT incorporated such a requirement.

   As a result, the RRR design incorporates a doubled layer designed to mitigating the effects of a light aircraft crash consisting of an aircraft impact grillage and the inherent strength of the Reactor Building itself. The design intent was that the aircraft grillage would absorb the bulk of the "soft" impact (ie the bulk of the aircraft) whilst the Reactor Building structure would then absorb the "hard" impact (ie the engines and bulk components). In practice, due to the conservatism incorporated into the design of the Reactor Building and the aircraft impact grillage, the RRR has very large margins to failure. These margins are such that the RRR could reasonably be expected to withstand an impact from a significantly larger aircraft that that assumed for the design basis.

Conclusions

This summary description of the licensing of RRR demonstrates the way in which the safety and licensing aspects have been an integrated part of the overall project program.