Australia's Replacement Research Reactor Project

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The initial purpose for HIFAR was for materials testing to support a nuclear power program. Changing community attitude through the 1970's and a Government decision not to proceed with a planned nuclear power reactor resulted in a reduction of materials testing activities and a greater emphasis being placed on neutron beam research and the production of radioisotopes, particularly for medical purposes.

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In 1997 the Australian Government decided that a replacement research reactor should be built by the Australian Nuclear Science and Technology Organisation at Lucas Heights subject to favourable results of an Environmental Impact Study. The EIS identified no reasons on the grounds of safety, health, hazard or risk to prevent construction on the preferred site and it was decided in May 1999 that there were no environmental reasons why construction of the facility should not proceed.

In recent years ANSTO has been reviewing the operation of HIFAR and observing international developments in reactor technology. Limitations in the flexibility and efficiency achievable in operation of a tank type reactor and the higher intrinsic safety sought in fundamental design resulted in an early decision that the replacement reactor must be a pool type having cleaner and higher intensity tangential neutron beams of wider energy range than those available from HIFAR.

ANSTO has chosen to use it's own resources supported by specialised external knowledge and experience to identify the technical and contractual requirements of the project. A project manager with extensive experience in major defence projects has been contracted and a team of technical and contracts specialists has now completed documentation which has been issued as a Request for Tender to four pre-qualified reactor vendors. The four vendors were selected as a result of a worldwide invitation in mid 1998 for expressions of interest.

The tender process is a "two envelope" system whereby the tenderers are required to submit in one envelope the technical and contractual details of their bid whilst submitting the pricing details in the other envelope.
Tenders close on 3 January 2000. A contract is expected to be agreed by mid 2000 with commissioning completed during 2005.

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Introduction

HIFAR, a 10 MW tank type DIDO Class reactor (Fig. 1) has operated at the Lucas Heights Science and Technology Centre for 43 years. The reactor is D_2O moderated and cooled with a graphite reflector. HIFAR and the 10 kW Argonaut reactor "Moata" which is in the Care and Maintenance phase of decommissioning are Australia's only nuclear reactors.

The initial purpose for HIFAR was for materials testing to support a nuclear power program. Changing community attitude through the 1970's and a Government decision not to proceed with a planned nuclear power reactor resulted in a reduction of materials testing activities and a greater emphasis being placed on neutron beam research and the production of radioisotopes, particularly for medical purposes.

HIFAR is not fully capable of satisfying the expected increase in demand for medical radiopharmaceuticals beyond the next 5 years and the radial configuration of the beam tubes (Fig. 2) severely restricts the scope and efficiency of neutron beam research.

Over the last 10 years ANSTO has been considering the ongoing needs for a neutron source and particularly the future of HIFAR. In 1992 the Minister for Science and Technology set up a review of Australia's needs for a new nuclear research reactor to replace HIFAR. The Research Reactor Review[1] was to assess the benefits and costs of HIFAR operations, its remaining useful life and its eventual closure and decommissioning. It was also to consider possible locations for a new reactor, environmental impacts at alternative locations, a recommended preferred location and regulatory and organisational arrangements for reactor based research. The outcome of the review was a series of recommendations as follow:

- "Keep HIFAR going;
- Commission a probabilistic risk assessment to ascertain HIFAR's remaining life and refurbishment possibilities;
- Provide an additional $2 million per year for scientists to gain access to international advanced neutron scattering facilities;
- Commence work immediately to identify and establish a high level waste repository;
- Accept the financial implications of the fact that neither the current nor any new reactor can be completely commercial;
- Accept in consequence that any decision on a new reactor or other neutron source must rest primarily on the assessed benefits to science and Australia's national interest; and
- Make a decision on a new neutron source in about 5 years' time when the relative arguments relating to spallation sources, cyclotrons and reactors might be clearer and when Australia's scientific neutron scattering performance is more evident."

In 1994 as part of an ANSTO strategy review[2] four neutron source options were examined;

- Closing down HIFAR
- Upgrading HIFAR
- Building a replacement reactor
- Building a spallation neutron source

The preferred option was identified as the construction of a replacement multi-purpose research reactor, considered to satisfy the wide range of Australia's nuclear requirements.

As a result of the recommendation of the Research Reactor Review to ascertain HIFAR's remaining life and refurbishment possibilities, a probabilistic safety assessment and remaining life study was commenced in 1996 by Pickard Lowe and Garrick for the Department of Industry, Science and Tourism. The findings of PLG[3] , released in 1998, indicated HIFAR to be in good condition with no obvious evidence of major damage and age-related degradation that could be life limiting.

Consideration by ANSTO of the option to upgrade HIFAR indicated that it would cost at least $150 million, that the work would take 6 years to complete and would involve a shutdown of

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15 months. It was concluded that such an upgrade would not result in a facility meeting Australia's future needs as;

- HIFAR is not expected to be fully capable of satisfying the increase in demand for medical radiopharmaceuticals production beyond the next 5 years.
- neutron beam research would be restricted without the features of tangential beam holes and clean neutron beams of high flux.

It also noted that an upgrade would entail a significant economic risk, as failure of a major component would lead to closure of the reactor.

Project Commencement

In September 1997 the Australian Government decided that a replacement research reactor should be built by the Australian Nuclear Science and Technology Organisation at Lucas Heights subject to favourable results of an Environmental Impact Study. ANSTO immediately organised a project team (Fig. 3), which proceeded to establish a plan to achieve completion of the project. The project team was structured to address three aspects of the program. These were:

1. Environmental Assessment
2. Safety and Licensing
3. Specification

Managers were assigned to these areas of responsibility reporting to a senior management committee of Division Directors. The senior management committee is responsible to the Executive Director. A project manager with extensive experience in major Defence projects has been contracted to specifically manage the project. To assist ANSTO in management of the project specialist experience has been contracted from an Australian Consulting Engineering company Sinclair Knight Mertz in partnership with the UK organisation AEA Technology.

Consideration over the preceding 10-year period by ANSTO of future needs for a neutron source and awareness of available reactor technology meant that there was a conceptual idea of the desired replacement reactor at the time the Government decided that the project should commence. Hence the requirement for a pool type multi-purpose reactor with a peak neutron flux exceeding $3*10^{14}$ $n.cm^2.sec^{-1}$ using low enrichment fuel had already been decided.

Environment Impact Assessment

In December 1997 PPK Environment and Infrastructure Pty. Ltd. (PPK) was appointed by ANSTO to prepare for submission an Environmental Impact Statement on the siting of the proposed reactor at the Lucas Heights Research Laboratories. PPK prepared a draft EIS in accordance with guidelines set by Environment Australia on behalf of the Minister for the Environment.

The draft EIS[4] was released for public comment in August 1998 resulting in receipt of 935 responding submissions. Seven hundred and seventy six submissions were pro-formas and a further 50 were pro-forma based or repeated issues contained in the pro-formas. Substantive submissions included technical submissions from the local Sutherland Shire Council, from Greenpeace Australia, from the three Peer Review Consultants and from the New South Wales Government. The submissions identified 205 distinct issues for which responses were prepared. The issues ranged from simple editorial matters to concern about a Chernobyl type incident; concern about the ozone layer; concern about the effects on health; belief that reactor funding could be better utilised; concern that cyclotron production of isotopes was not sufficiently addressed; and concerns that no solution or site has been identified for disposal of radioactive waste in Australia. A supplement[5] to the Draft EIS that addressed the comments and issues raised in those submissions was prepared and lodged with Environment Australia in January 1999.

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The Minister for the Environment, to assure the public that the process was rigorous and complied with world best practice, commissioned three separate independent reviews of the EIS.

- The company CH2M Hill reviewed the safety and handling of nuclear wastes and emissions.
- The IAEA conducted a hazard and risk analysis of the EIS in respect to facility siting and possible risks to the community.
- Parkman Safety Management provided a further independent review of hazards and risks.

At the end of March 1999 the Minister for the Environment decided that there were no environmental reasons including those of safety, health hazard or risk which were grounds to prevent construction and operation of a replacement reactor at Lucas Heights, but recommended that the proposal be implemented in accordance with 29 specified conditions[6]. The conditions were imposed to ensure that the reactor is built and operated in accordance with best international practice in respect to:

- Construction and operation
- Management of wastes
- Monitoring and containment of emissions
- Management of hazards and risks
- Emergency management plans; and
- Community consultation

In May 1999 the Minister for Industry, Science and Resources accepted the recommendations of the Minister for the Environment.

Safety and Licensing

Whilst ANSTO has been in the process of identifying the design and siting requirements for the replacement reactor the Australian regulator has been involved in a major structural reorganisation. Until recently, the safety of the two Australian reactors was monitored by the Nuclear Safety Bureau, a small group of technical specialists which was originally part of ANSTO but separated from the Organisation in 1992 to become a Branch of the Commonwealth Department of Health. In February 1999 the Nuclear Safety Bureau and the Australian Radiation Laboratories were amalgamated within the Department of Health becoming the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA).

The Parliamentary Act which established ARPANSA provides the regulator with considerably more influence over the activities of the operating organisation than were previously available to the Nuclear Safety Bureau and permits the regulator to license all nuclear facilities on Commonwealth property. Only the reactors HIFAR and Moata were regulated by the Nuclear Safety Bureau under Authorisations to Operate. The new arrangement will involve the regulator issuing separate licenses through the various stages of the life of a facility starting with a Site License followed progressively with a Design License, Construction License, Operating License and finally a Decommissioning License.

Throughout the period of regulation under the NSB there has been a successful working relationship between both parties and there have been some formal bases for design and operation. One such requirement is a prescribed number of containment barriers based on postulated event frequency and consequences. Generally design criteria for plant changes have been agreed on a case by case basis using IAEA Regulatory Guides, USNRC Regulatory Guides or other standards as appropriate. ARPANSA is now developing its own formal requirements, which are being published as Regulatory Guides and when requested ANSTO has provided a users perspective during the preparation of these documents. The consultation process is being extended to the Replacement Reactor Project to ensure that there are no surprises for either of the organisations at any time in the licensing process.

In July 1999 application for a Site License was made to ARPANSA for the replacement reactor and the License was issued in September 1999.

Safety and licensing matters are prominent in the requirements of the specification. Emphasis is placed on ANSTO's safety objectives and safety criteria, regulatory requirements and the primary safety requirements applicable to normal operation and accident conditions. Safety and licensing requirements apply to the siting, design, construction, commissioning, operation, and decommissioning of the reactor facility. The safety objectives of the project are to achieve; (a) Fundamental Safety, (b) Radiation Protection and Technical Safety, (c) Defence in Depth and (d) Safety Culture.

A Defence in Depth principal is required to support the radiation protection and technical safety objectives by ensuring the design and operation of the facility incorporates multiple levels of protection against the release of radioactive material. Five successive levels of defence in depth required are:

1. Prevention of deviations from normal operation and of failures.
2. The detection and interception of such deviations and failures in order to prevent anticipated operational occurrences from escalating into accident conditions.
3. Control of the consequences of the resulting accident conditions in the unlikely event that escalation of certain anticipated operational occurrences is not arrested by a preceding level.
4. Control of severe conditions including prevention of accident progression and mitigation of the consequences of a severe accident.
5. Mitigation of radiological consequences of significant releases of radioactive materials.

Specification

Throughout the period that ANSTO was becoming acquainted with current reactor technology it was clear that any decision to build another reactor would involve reliance on knowledge, skills and manufacturing facilities for some crucial parts, particularly the reactor core, outside Australia. Whilst there will be reliance on overseas technology for parts of the project it was recognised that major contributions could be made by many local companies and that a condition of contract should be local industry involvement.

At the outset of the project it was recognised that a prescriptive specification would be unsuitable as it would be restrictive and could favour one vendor. It was obvious that a performance specification would be more appropriate but it was also recognised that arranging a contract on only a performance specification could result in an unsatisfactory outcome. Further consideration of this matter resulted in a decision that the vendor should produce a prescriptive specification from the Principal's Project Requirements which is essentially a performance specification prepared by ANSTO.

The structure of the PPR is generally aligned with the table of contents of IAEA Safety Series No. 35-G1 Safety Assessment of Research reactors and Preparation of the Safety analysis Report. Staff from ANSTO with relevant experience in matters covered by the PPR were drawn into the project team to manage the preparation of sections of the document. These people were given responsibility for the contents of the particular sections to which they were assigned and have been required to liaise with those responsible for other sections where interfaces occur, to achieve consistency. In some instances user groups were formed to establish requirements. Such groups were formed to identify the requirements for neutron beams and for the irradiation facilities.

The PPR identifies the desired features of the new facility ranging from design and performance objectives through to project management matters and documentation needs. Some of the matters addressed in the PPR are mandatory requirements though most are preferred features that the tenderers should consider in preparing their specifications.

On completion of the draft PPR a review was undertaken by an independent group to identify consistency of requirements and quality of presentation. The draft document was also provided to four pre-qualified vendors to assess and to provide feedback, for example, on the viability of the requirements. The PPR was then revised to correct shortcomings identified by the reviews.

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Whilst preparation of the PPR was in progress work was also proceeding on the terms and conditions of contract which would be included in the package of documents provided to the vendors in the Request for Tender.

Requirements
The successful tenderer will be required to construct on the Lucas Heights site a pool type multi-purpose research reactor of modern design using proven technology.

The reactor is to be used for neutron beam research, radiopharmaceuticals production, industrial radioisotope production, NTD Silicon production and neutron activation analysis using low enrichment fuel. A design life of 40 years is envisaged.

A peak thermal neutron flux of no less than $3*10^{14}$ $n.cm^2.sec^{-1}$ is required whilst reactor operating power shall not exceed 20 MW.

The power coefficient of reactivity and the temperature and void coefficients of reactivity should be negative. At least one automatic fast-acting shutdown system and a second independent system will keep the reactor in a safe shutdown state with a shutdown reactivity margin of at least 1%. A reactor is sought with an operating cycle providing maximum availability, having routine shutdowns no longer than 4 days and at a frequency of no more than once in four weeks. Ability to recover from a spurious reactor trip before experiencing “poison out” is considered important in respect to maximising reactor availability.

Noise and vibration from operating plant, maintenance and operating activities, materials handling and other processes should be addressed in the design to ensure that it does not degrade the working environment and compromise the quality of work undertaken.

In addition to the need for compliance with appropriate building codes, the structures, systems and components should be able to withstand an Operating Basis Earthquake during operation of 0.09g peak horizontal ground acceleration and 0.06g peak vertical ground acceleration. Safety systems and safety related structures, systems and components will be relied upon for mitigating the effects of the Safe Shutdown Earthquake of 0.30g peak horizontal ground acceleration and 0.20g peak vertical ground acceleration.

The probability of flooding at the site is judged as insignificant, taking into consideration its location and topography.

The normal range of ambient conditions for the site is as follows:

PARAMETER	UNIT	NORMAL	
		Minimum	Maximum
Temperature (dry bulb)	ºC	1	45
Humidity	%	5	100
Pressure	kPa	95	105
Wind speed	ms^{-1}	0	50

The maximum normal conditions are not expected to prevail concurrently for temperature and humidity. Whilst cooling towers are likely to withstand the maximum wind speed without damage they would not be expected to operate under such conditions.

The facility will include a neutron beam hall within the reactor building to accommodate beam instruments that need to be located close to the reactor. However a neutron guide hall adjacent to the reactor building which will accommodate most of the beam instruments. The beam halls will be provided with cranes, air conditioning, ventilation and normal building services.

Neutron Beams

Neutron beams of the following energies have been requested by our clients.

- Cold - energies below 10 mev
- Thermal - 10 mev to 100 mev

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- Hot - 100 mev to 1000 mev
- Fast - energies greater than 1 ev

A range of in-pile assemblies to supply neutrons to guides and collimators, have been identified (Fig. 4). They are:

1. An assembly to provide thermal neutrons to three neutron guides that extend into the guide hall.
2. An assembly to provide cold neutrons to three neutron guides that extend into the guide hall.
3. An assembly that supplies cold neutrons to one neutron guide that terminates in the reactor beam hall.
4. An assembly to provide thermal neutrons to one neutron guide that terminates in the reactor beam hall.
5. An optional assembly to supply two independent beams of hot neutrons in evacuated or helium filled guides to the reactor beam hall.

Line of sight access to the reactor core, fuel or any irradiation facility is undesirable for the beam collimators and neutron guides. The desired quality of the neutron beams is likely to be achieved through the provision of tangential collimators and guides.

The following outcomes are sought for each neutron beam:

- Maximised neutron flux within the specified energy or wavelength.
- Minimised neutron flux outside the specified energy or wavelength.
- Minimisation of gamma rays.
- Minimisation of background radiation in the beam hall and guide hall while the reactor is operating.

The facility should be arranged so that a second neutron guide hall can be added, if required, at a later date.

Thermal neutron flux at the reactor face of $2 * 10^{10}$ $n.cm^2.sec^{-1}$ and a beam flux of $3 * 10^9$ $n.cm^2.sec^{-1}$ in the neutron guide hall is expected to satisfy the user requirements.

A cold source will maximise the yield of neutrons of energies less than 5 mev. An operating temperature of the cold source of less than 25 K is expected to provide neutrons at the reactor face having a temperature less than 40 K. A liquid and/or gaseous cold moderator is preferred. The desired cold neutron flux at the reactor face is $1 * 10^{10}$ $n.cm^2.sec^{-1}$ with a flux of $5 * 10^9$ $n.cm^2.sec^{-1}$ within the guide hall. In order to satisfy safety requirements the cold source moderator vessel must comply with a recognised pressure vessel code. Operation of the cold source cooling system should be able to continue if the reactor is shut down and the reactor should be able to operate if the cold source is in the stand-by mode.

The hot source should operate at a temperature of 1800^0 C or greater with the reactor at full power, providing neutrons with wavelengths between 0.3 A and 0.8 A. The neutron flux at the reactor face is required to be about $1 * 10^{10}$ $n.cm^2.sec^{-1}$.

A primary shutter at the reactor face for each neutron guide should attenuate the radiation level at full power to less than 20 μSv per hour.

Neutron guides are to be evacuated to less than 13 Pa except for sections within the reactor biological shielding if filled with helium. The performance requirements for the neutron beams is expected to necessitate the guides to be aligned to an accuracy of $1 * 10^{-4}$ radians and 0.1 mm in both the vertical and horizontal planes. The effects of vibrations or pressure variation within the guides from atmospheric down to operating vacuum should result in misalignments of less than $5 * 10^{-5}$ radians. The thermal neutron guides to the guide hall are to be arranged on a radius of curvature of 4.5 km for the initial distance of 43 metres from the reactor face whilst the cold neutron guides to the beam hall are to be on a radius of curvature of 1.3 km for an initial distance of 22 metres. The neutron guides supermirrors should have a critical angle of at least 3 times that of nickel.

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Irradiation Facilities

The thermal neutron flux is to be maximised within the reflector region both with and without irradiation rigs and targets in place. The irradiation facilities are to be arranged to minimise flux variations to less than 5% in targets due to loading and unloading of other targets. The objective in respect to irradiation facilities is to achieve in comparison to HIFAR:

1. An increase in the flux available in the bulk production facilities.
2. An increase in the number of irradiation tubes available in the bulk production facilities.
3. An increase in the number of target positions available at the higher flux levels in the thermal neutron long residence time general purpose irradiation facilities.

All irradiation rigs will be designed for an effective core height of 600 mm.

The following irradiation facilities will be provided:

- Bulk facilities in locations of medium, high and very high fluxes.
- Long residence time general purpose facilities in thermal and fast neutron fluxes.
- Short residence time general purpose facility in thermal neutron fluxes.
- Large volume facilities in thermal neutron fluxes to accommodate very large, large and medium diameter targets.

The bulk irradiation facilities will accommodate rigs of 50 mm diameter containing targets at 150 mm pitch. A maximum power per rig of 100 kW is envisaged.

In the medium flux positions the thermal flux averaged within any target position is required to be at least $6 * 10^{13}$ $n.cm^2.sec^{-1}$. There will be ten medium flux irradiation tubes.

For the high flux positions the thermal flux averaged over the number of irradiation tubes and axial target positions should be at least $1 * 10^{14}$ $n.cm^2.sec^{-1}$. Three irradiation tubes are to be provided.

Two irradiation tubes are required in positions of very high thermal flux of at least $1.7 * 10^{14}$ $n.cm^2.sec^{-1}$.

Long residence time facilities will accommodate targets having a residence time from 1 minute to a full reactor operating cycle. These facilities are required to be provided complete with rigs, transfer tubes and terminal stations and control and software systems for automated irradiations. A pneumatic target transfer system is preferred though a hydraulic system would be acceptable. Cushioned stops in the transfer system may be necessary due to the fragile nature of some targets. Excessive can velocities may also have to be avoided to prevent damaging the targets. Ability to load and unload targets without moving other targets would be a desirable feature.

The flux levels and number of positions needed for thermal neutron irradiations in the long residence time facilities are:

Nominal Flux ($n.cm^2.sec^{-1}$)	Number of Irradiation Can Positions
$2 * 10^{12}$ to $3 * 10^{12}$	3
$8 * 10^{12}$	6
$1.5 * 10^{12}$	12
$3 * 10^{13}$	6
$5 * 10^{13}$	6
$7 * 10^{13}$	6
$>1 * 10^{14}$	6

The long residence time facility for fast neutron irradiations will accommodate up to 6 cans at any time in a flux of $1 * 10^{13}$ $n.cm^2.sec^{-1}$ or greater.

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The irradiation cans for the thermal and fast neutron long residence time facilities will be about 25 mm diameter by 70 mm long.

Additionally, one large facility for long residence time thermal neutron irradiations will be required with a flux of $1.5 * 10^{13}$ $n.cm^2.sec^{-1}$. The can size for the facility will be about 45 mm diameter by 70 mm long.

A short residence time general purpose irradiation facility with a thermal neutron flux of 2 to 5 $* 10^{13}$ $n.cm^2.sec^{-1}$ will be used for neutron activation analysis applications. This facility will also be provided complete with rigs, transfer tubes, terminal station and a control system. The irradiation times will range from a few seconds to several minutes. The irradiation cans for this facility will be about 35 mm diameter by 90 mm long.

Several large volume irradiation facilities are required for production of NTD Silicon. These facilities will consist of irradiation tubes in the reflector tank complete with flux flattening devices, replaceable self powered neutron detectors and equipment for transferring the targets between irradiation rigs and the service pool. The irradiation rigs will be designed and supplied by ANSTO. The thermal to fast neutron flux ratio is required to exceed 200 for these facilities.

Facilities are needed to meet the bulk handling demands for irradiation targets. This may be achieved by provision of one or more above pool hot cells. Loading and unloading of targets from rigs will be undertaken within the bulk handling facility. An existing 6 tonne bottom loading flask is to be used to transport irradiated targets from the bulk handling facility to existing radioisotope processing facilities elsewhere at the Lucas Heights site.

The terminal stations for the loading and unloading of targets of long residence time irradiation are required to be accommodated in an “individual target handling facility”. Pneumatic conveyors will be used to transfer targets from the “individual target handling facility” to other buildings.

A service pool adjoining the reactor pool will contain racks for storage of large volume irradiation rigs and components, silicon ingots and irradiation cans. The service pool will also contain racks for storage of spent fuel for ten years after removal from the core.

Reactor Cooling

The ultimate heat sink for all cooling systems is to be the atmosphere. The cooling systems are required to handle the maximum power at which the reactor is capable of operating. The cooling systems will be required to maintain the fuel and core temperatures within their operational limits during normal operations and within their safety limits following all design basis fault sequences.

The primary cooling system will have inherent safety features that take advantage of the pool concept including establishment of natural circulation to cool the core following a reactor trip. A secondary cooling system will remove heat from the primary cooling system and discharge it to either a tertiary cooling system or the ultimate heat sink.

Engineered Safety Features

The necessity for the ESFs will be determined from the safety analysis report. The extent to which the ESFs are automated and the conditions for which manual override is required will be assessed by safety analysis. The following systems are likely to be classified as ESFs:

- Reactor Protection System
- Emergency Power Supply System
- Confinement/Containment System
- Active Area Heating, Ventilation and Air Conditioning Systems
- Emergency Core Cooling System
- Emergency Control Centre

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Instrumentation and Control

The reactor systems, auxiliary systems and other plant systems will be controlled and monitored from the reactor control room. Automatic control systems are preferred.

Essential controls and instrumentation for safely shutting down the reactor and maintaining it in a safe state, including post accident monitoring (PAM) instrumentation, and CCTV, will be available in the reactor control room and in the emergency control centre.

Those parts of the instrumentation and control system that are required to operate and maintain essential plant equipment in the event of a mains supply interruption, and for post accident monitoring instrumentation following a plant accident will be connected to uninterruptible power supplies.

The reactor protection system will be fully redundant and will automatically initiate the operation of appropriate systems to ensure that safety limits are not exceeded during any relevant design basis fault sequence. It will initiate all automatic reactor trips and, dependent on design, may include engineered safety features actuations as well. The following characteristics of the reactor protection system are desired to ensure a fail safe design:

a) The protection circuits to function automatically and independently of other systems.

b) Detection and actuation mechanisms to trip the reactor in adequate time to protect the reactor from exceeding specified limits.

c) No manual intervention necessary, following initiation of the trip system.

d) Trip signals must not be generated using auto resetting devices and require deliberate operator action to reset.

e) The system design is required employ diversity to enable all postulated initiating events to be detected in a minimum of two different ways (where physically possible).

f) The system is to comprise redundant channels that are independent and isolated from each other, to prevent a common mode failure.

g) Instrumentation and tripping systems should enable trip levels to be set with adjustable margins, against a trip parameter.

h) The system is required to have the capability to identify the parameter which initiated the first trip signal.

The desired features for the reactor shutdown systems are:

i) Each shutdown system to have redundant channels and to be isolated from each other to prevent common mode failure.

j) No single component failure to be able to prevent reactor a shutdown system from operating.

k) Provision of redundant shutdown systems that are independent to ensure that failure of one system will not inhibit operation of another.

l) Provision of fail-safe systems.

In addition to and independent of the reactor protection and shutdown systems, separate reactor control, instrumentation, monitoring display, alarm and warning systems and support facilities are needed to serve the normal operating requirements of the reactor plant.

Electrical Supplies

Electrical power for the entire reactor facility will be derived from the existing 33/11 kV Energy Australia (EA) on-site zone substation. The supply from the substation will be via two independent 11 kV feeders to a local area substation. Redundancy and separation requirements will apply in accordance with IEEE standards. Diesel generators if required as

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part of the supply system are to be suitable for autostart and unattended operation for the duration of the mission time identified in the Safety Analysis Report.

Pre-qualification of Tenderers

In July 1998 invitations were called for registration of interest from reactor vendors interested in submitting tenders for construction of the replacement reactor. Expressions of interest were received from nine organisations. Eight of the organisations were invited to participate in the prequalification process.

In December 1998, following consideration of the technical capabilities and the commercial history of the organisations participating in the prequalification process four vendors were selected to continue in the tendering process. The vendors selected were:

- ✓ Atomic Energy of Canada Ltd.
- ✓ INVAP
- ✓ Seimens AG
- ✓ Technicatome

Partnerships

The policy of the Australian Government in major projects is to maximise the involvement of Australian industry. Whilst recognising the inability of local industry to lead a specialised project of this type it was realised that Australian companies could make a significant contribution through participation as a partner to the prime contractor. Hence each of the prequalified vendors has been required to arrange with an Australian company to undertake significant involvement in the design and construction of the facility.

Public Works Committee

All large-scale public works in Australia must be referred to a Parliamentary Works Committee, which considers proposals in respect to the government expenditure involved and the benefits derived by the community. The Public Works Committee recommendation was accepted by Parliament in August 1999.

Request for Tenders

Tender documentation packages have now been issued to the pre-qualified vendors and the closing date for tenders has been set at 3 January 2000.

The process of tendering adopted for the project is the “two envelope” system. This will enable ANSTO teams to undertake a technical evaluation and clarification of the offers without knowledge of the submitted prices.

Tender Deliverables

The following documents are required from each tenderer:

- ➢ Statement of Compliance (Technical & Commercial)
- ➢ Qualification of Tenderer
- ➢ Schedule of Sub-Contractors
- ➢ Preliminary Project Management Plan
- ➢ Preliminary Construction and Commissioning Plan
- ➢ Preliminary Technology Transfer Plan
- ➢ Safety Statement
- ➢ Tenderers Risk Register

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- Tenderers List of Applicable Standards, Codes & Practice
- Representations Relied upon for the Purpose of the Tender
- Tender Specification
- Preliminary Design Plan
- Reactor Data & Analysis
- Contact Details
- Statement of Compliance (Financial)
- Price Schedule
- Preliminary Schedule of Contract Payments & Cashflow
- Options Prices
- Schedule of Imported Items
- Preliminary Australian Industry Involvement Plan
- Price Variation Formulae
- Schedule of Rates for Contract Variations
- Financial Information for Annexures

Formalisation of Contract

It is expected that a contract will be formalised in mid 2000. The contract will cover design, construction and commissioning of the works as well as training of ANSTO personnel in operation and support. It will also include provision of comprehensive records of the design, construction and commissioning and the supply of an operations quality management system.

Contract Deliverables

Whilst the prime deliverable of the contract is the replacement reactor and the integrated management system for safe and efficient operation, a considerable amount of documentation is required to be delivered throughout the course of the contract to support applications for licenses to construct and operate and also as part of the process of project management. The documentation includes:

- Project Management Plan
- Risk Management Plan
- Technology Transfer Plan
- Integrated Logistics Support Management Plan
- Project Quality Assurance Program
- Safety Analysis Report
- Construction Environmental Management Plan
- Stormwater Control Plan
- Construction Inspection & Test Plan
- Design Plan
- Commissioning Plan

Contract Completion

The target date for reactor start-up is 2005. Upon completion of commissioning HIFAR and the replacement reactor will be operated in parallel for a period of about 6 months, after which HIFAR will be shut down.

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References

1. McKinnon, Henderson-Sellers and Hundloe, Future Reaction, Report of the Research Reactor Review, August 1993, Commonwealth of Australia, Canberra.
2. Bain International/Battelle Memorial Institute (1994), ANSTO Strategic Review Recommendations - Final Report, Bain International/Battelle Memorial Institute, Sydney.
3. Pickard, Lowe and Garrick, 1998; A Level 1+ Probabilistic Safety Assessment of the High Flux Australian Reactor, for Commonwealth Department of Industry, Science and Tourism, Canberra.
4. PPK Environment & Infrastructure, Replacement Nuclear Research Reactor – Draft Environmental Impact Statement, July 1998, for ANSTO, Lucas Heights NSW.
5. PPK Environment & Infrastructure, Replacement Nuclear Research Reactor – Supplement to Draft Environmental Impact Statement, January 1999, for ANSTO, Lucas Heights NSW.
6. Media Release – Lucas Heights Environmental Clearance, 30 March 1999, Senator the Hon Robert Hill, Leader of the Government in the Senate, Minister for the Environment and Heritage, Canberra.

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