RESEARCH REACTOR DEVELOPMENTS IN AUSTRALIA

Robert Godfrey
Counsellor (Nuclear)
Australian Nuclear Science and Technology Organisation
Embassy of Australia, Washington DC

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ABSTRACT

The Australian Nuclear Science and Technology Organisation (ANSTO) operates the 10 MW research reactor, HIFAR, at the Lucas Heights site approximately 30 kilometres south of Sydney. Although recent reviews and inspections have confirmed that HIFAR operates safely by an adequate margin and has minimal impact, it was concluded that the reactor design and age places limitations on its operation and utilisation, and that HIFAR is approaching the end of its economic life. In September 1997, a decision was made by the Australian Government to fund ANSTO for the construction of a replacement research reactor on the existing Lucas Heights site, subject to the requisite environmental assessment process. A Draft EIS has been prepared and is currently undergoing public review. A design specification is in preparation, and a research reactor vendor pre-qualification process has been initiated. Spent fuel shipments have been made to Dounreay and to the Savannah River Site, and discussions are continuing regarding the disposition of the existing spent fuel and that arising from HIFAR's remaining operation.

HIFAR DESCRIPTION

The High Flux Australian Reactor (HIFAR) is a 10 MW DIDO class reactor. The core consists of 25 concentric-tubed fuel elements with uranium-aluminium alloy fuel sections, is heavy water-cooled and moderated, and is surrounded by a graphite reflector. Control and shutdown of the reactor is achieved with six europium-tipped cadmium control arm blades which move between the rows of fuel elements. Additional shutdown capacity is provided by two cadmium shutdown rods, placed on the periphery of the core. It is a multipurpose reactor, used for neutron scattering, radioisotope production, neutron transmutation doping (NTD) silicon irradiation, materials irradiation, neutron activation analysis and delayed neutron analysis.

HIFAR commenced operations in the late 1950's with fuel elements containing uranium enriched to 93%. From that time, the level of enrichment was gradually reduced: to 80% in 1962, to 75% in 1981 and then to the current level of 60% in 1983. The original Mark II fuel elements were box-type with curved fuel plates, and the Mark III involute plate, "hollow fuel elements", with a central irradiation facility were introduced in 1962. These were replaced in 1970 by the current Mark IV concentric tubed fuel element. The fissile mass, initially 100g, increased to 115g, then to 150g, then to the current mass of 170g. Throughout HIFAR's operation, fuel elements were trialled with up to 0.24% cadmium poison, and of a coextruded design. The current fuel element design consists of three radially welded "picture-frame", uranium-aluminium alloy fuel plates. Throughout its operation, HIFAR has used fuel elements containing uranium from both the United Kingdom and the United States.

HIFAR underwent a refurbishing program throughout the 1980's, which included installation of a fully instrumented emergency core cooling system to mitigate against loss-of-coolant-accidents (LOCA), a space conditioning system for heat removal during an accident, a dual train electrical power supply system with guaranteed supply for critical, safety related equipment, replacement of the reactor protection system equipment, placement of an additional liner in the spent fuel storage pool and replacement of the cooling towers of the secondary coolant system. Significant development of many of the neutron scattering instruments also took place. Through this same period, ANSTO undertook core conversion studies as part of the RERTR program, but increasingly gave more serious consideration to replacement of HIFAR, primarily due to the limitations placed on operation and utilisation due to the age and design.

Oversight of HIFAR operation is provided by the independent Nuclear Safety Bureau (NSB) who are responsible for monitoring and reviewing the safe operation of ANSTO's nuclear plant and have the power to impose restrictions and conditions on operation. The HIFAR reactor is operated in compliance with an Operating Authorisation. The Authorisation identifies the requirements, set by the NSB, which ANSTO must meet to ensure the safe operation of HIFAR. The requirements of this Authorisation are met in a formal documentation system which include the Safety Case, the Technical Specification and the Quality System. HIFAR received formal accreditation to the AS/NZS ISO 9001 standard in May, 1996.

The Nuclear Safety Bureau requires that HIFAR undergoes an extended shutdown every 4 years, which includes inspection of components and testing and maintenance which cannot be undertaken during routine operations. The NSB must agree to the scope of work prior to commencement of the shutdown and must agree to the restart of the reactor following successful completion of the scheduled tasks. The shutdown is typically of several weeks duration. At the most recent shutdown in 1995, inspections concluded that the reactor vessel is in excellent condition and nothing was identified which would preclude HIFAR continuing to operate for the foreseeable future.

RESEARCH REACTOR REVIEWS

During the early 1990's, a number of reviews were undertaken and a number of decisions made which furthered the consideration of the construction of a replacement reactor.

In considering the continued operation of the HIFAR reactor, the NSB in 1992, advised ANSTO that it would subject HIFAR to a safety assessment against contemporary research reactor standards and require upgrading of safety systems by about 2003, unless the reactor was to be permanently shut down within an acceptably short period from that date.

The Australian Science and Technology Council (ASTEC), in its 1990 report "Small Country....Big Science", concluded that the facilities at HIFAR were no longer suitable for all types of neutron beam research; that they are limited by the relatively low neutron flux from HIFAR; and that an increasing number of scientists need to do research overseas. It noted that this need would become acute in the absence of a significant upgrading of HIFAR. Further, the report concluded that an upgrade or replacement of HIFAR was needed before the year 2000. The identification of this need was based on the increasing number of Australian scientists who required access to more intense neutron beams than could be provided at HIFAR. It was also based on the recognition that stronger domestic capability in this area was a necessary and complementary base for access to overseas facilities.

The 1992 ASTEC report "Major National Research Facilities" recommended that a program of continual review and investment in major national research facilities be undertaken immediately by Government. Further, it identified criteria to be used in assigning priorities for the establishment, upgrading or replacement of major national research facilities. These criteria dealt with such topics as: scientific value, relevance to the needs of Australian industry, benefits to the Australian community and promotion of Australia's international standing. The criteria were used to evaluate ninety-six proposals for major facilities. Seven facilities, including replacement for HIFAR, were identified as having the highest priority for development in an overall national program for major research facilities. The report also recommended that a budgetary allocation be provided to fund the development of those seven facilities over a ten-year period.

Taking account of the 1992 ASTEC report, the Government commissioned an independent Research Reactor Review (RRR) in the latter half of 1992. The terms of reference included: whether, on review of the benefits and costs, Australia has a need for a new research reactor, and a review of the present reactor, its benefits and costs, its likely remaining life and its eventual closure and decommissioning. The review was required to schedule public hearings and call for submissions from interested parties.

The RRR's final report, published in August 1993, acknowledged the unique nature and value of research using neutrons: recognised the research limitations imposed by HIFAR's age and its design; concluded that HIFAR operates safely by an adequate margin; determined that its benefits to the Australian medical community are substantial; and argued that, in its national interest, Australia needs to maintain capability to effectively participate in international nuclear affairs.

The report recommended that: HIFAR continue to operate, a Probabilistic Risk Assessment be done to ascertain HIFAR's remaining life and refurbishing possibilities and to provide an additional assessment of safety margins; $2 million per year be provided for scientists to access overseas facilities; the decision on a new reactor be based primarily on the benefits to the national interest and science; recognising that no reactor can be completely commercial, the decision be delayed for five years (until 1998); and work begin immediately on a high level waste repository. This last requirement was recognised by the Government to indicate the requirement to develop a long term strategy for management of HIFAR's spent fuel. Finally, the RRR concluded that a positive decision on a new reactor should be made in about five years: if progress is made on the "waste" issue; if competing technologies for neutron research and isotope production are not more attractive; if the scientific benefits warrant it; and if the national interest remains a high priority.

A review of the ANSTO Mission was undertaken by consultants Bain International Inc. and the Battelle Memorial Institute in 1994 to review ANSTO's strategic direction, capabilities, research programs, facilities and management. Amongst other things, it concluded that operation of a reactor is essential for ANSTO to fulfill its mission and meet the expectations of stakeholders and therefore, that a commitment to replace HIFAR be sought at the earliest possible date, and preferably before the date of 1998, as suggested by the RRR.

In keeping with the RRR recommendations, a PSA was performed by the consultants PLG Inc. The PSA established seven benchmarks: two primary safety objectives and five secondary safety objectives. HIFAR met the first primary safety objective comfortably, leading PLG to conclude that HIFAR is adequately designed to prevent fuel in the reactor and the storage pool from overheating. The second objective was considered not to be met, due to the lack of data on severe earthquakes considered by the study. Of the five secondary safety objectives, three were regarded as met; the remaining two were not met because of the lack of data on both large earthquakes and fuel element transfer flask movements. A number of plant improvements have been made as a result of the insights provided by the PSA, and it is intended that this assessment will be maintained as a "living PSA", by ANSTO. As a part of the iterative process of the PSA, ANSTO will conduct further analysis to reduce the uncertainty in the input data as recommended by the consultants.

Also in keeping with the RRR recommendations, a Remaining Life Study of HIFAR was undertaken by Failure Analysis Associates Inc on the possible life-limiting issues of some of the key, passive components of the plant. The study concluded that, overall, HIFAR is in good condition with no obvious evidence of major damage or age-related degradation. However, one possible life-limiting issue was identified with the reactor tank, which could not be verified by inspection. This aspect has been assessed by independent consultants who concluded after detailed analysis, that the concern could not be substantiated.

REPLACEMENT REACTOR DECISION

Following submission of a case addressing the conditions of the RRR recommendation to replace HIFAR, a decision was made by the Australian Government in September 1997 to fund ANSTO for the construction of a replacement research reactor on the existing Lucas Heights site, subject to the requisite environmental assessment process.

A Draft Environmental Impact Statement (EIS), has been prepared and released for public review and comment over a twelve week period. The Draft EIS concludes that "the scale of environmental impacts that would occur would be acceptable, provided that the management measures and commitments made by ANSTO are adopted." A Final EIS is expected to be released before the end of the year, taking into account issues raised during the public comment period. An independent evaluation of community consultation regarding the replacement reactor project was undertaken, which confirmed that the consultative process implemented by ANSTO with the community was sound and acceptable for stage one of the EIS. Further, a number of independent analyses are being undertaken in parallel with the EIS to assess the level of hazards and risks associated with the replacement reactor, and of the associated waste management practices.

ANSTO has commenced the formal Siting Safety Submission to the NSB, which includes a reference accident assessment for a generic reactor design. The NSB concluded that the reference accident assessment for the generic design met the requirements of their radiological siting criteria. ANSTO will confirm these safety assessments in the Safety Analysis Report once a specific reactor design has been selected.

The replacement reactor would be a state-of-the-art pool-type design, have a maximum power of 20 MW, would use low enriched uranium (LEU) fuel, and is expected to be commissioned during 2005, after which time the existing 10 MW HIFAR research reactor would be shutdown. The replacement reactor will continue and expand upon the range of products and services provided by the existing reactor, and will include tangential neutron beamlines and a cold neutron source. Further, ANSTO has commenced a pre-qualification process with potential reactor vendors.

HIFAR will continue to operate until the replacement reactor is commissioned (about 2005) and then be permanently shutdown. It is anticipated that following shutdown and removal of fuel and other components, the reactor will be kept under surveillance for approximately 30 years. Following this, the options can be reviewed to either encapsulate the remaining core in concrete or to be completely dismantled and removed, returning the site to “greenfield” condition, or to implement a further surveillance and maintenance schedule.

At the time of announcing the replacement reactor decision, the Federal Government also announced it will establish a new agency to regulate and license the Commonwealth's future nuclear and radiation activities and to ensure the standardisation of regulations across the states. The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) will combine the existing resources of the Australian Radiation Laboratory and the Nuclear Safety Bureau, and will be empowered to license, inspect and to enforce standards on radiation and nuclear activities.

SPENT FUEL DISPOSITION

At the time of the decision in support of a replacement reactor project, the Government also announced a decision to fund the overseas shipment of existing spent fuel and that arising from the remaining operation of HIFAR. Shipments of 114 spent fuel elements were made in April 1996 to Dounreay, Scotland and of 240 fuel elements in May 1998 to the Savannah River Site, South Carolina, USA. This latter shipment, and a further two shipments to the SRS were agreed to by the US Department of Energy on the basis of a commitment on the part of the Australian Government to shut down HIFAR within the duration of the foreign research reactor spent fuel take-back program (i.e. by May 12, 2006) and of demonstrated progress with the replacement reactor project. The remainder of the current spent fuel holdings and arisings from the operation of the HIFAR reactor until it closes will be shipped overseas. The proposed strategy for the management of the spent fuel from the replacement reactor is based on the continuation of the strategy put in place and approved by the Australian Government for the management of HIFAR spent fuel. ANSTO owns its own, purpose built flask for spent fuel shipments which can carry 120 spent fuel elements in two baskets. This flask was successfully used in the two spent fuel shipments referred to above.