SPENT FUEL STORAGE AND TRANSPORTATION – ANSTO EXPERIENCE

TONY IRWIN
AUSTRALIAN NUCLEAR SCIENCE AND TECHNOLOGY ORGANISATION

Introduction

The Australian Nuclear Science and Technology Organisation (ANSTO) has operated the 10 MW DIDO class High Flux Materials Test Reactor (HIFAR) since 1958.

Refuelling the reactor produces about 38 spent fuel elements each year. Australia has no power reactors and only one operating research reactor so that a reprocessing plant in Australia is not an economic proposition.

The HEU fuel for HIFAR is manufactured at Dounreay using UK or US origin enriched uranium. Spent fuel was originally sent to Dounreay, UK for reprocessing but this plant was shutdown in 1998. ANSTO participates in the US Foreign Research Reactor Spent Fuel Return program and also has a contract with COGEMA for the reprocessing of non-US origin fuel.

Spent fuel storage on site

The HIFAR core contains 25 fuel assemblies, 100mm diameter and 2 metres long with a fuelled section of 600mm. The fuel plates are aluminium clad with an aluminium uranium HEU core.
HIFAR is currently operating on a 5 week cycle. During each shutdown, three or four fuel elements are removed from the reactor, and stored in a cooling pond for about three years. During this time, the fuel is cropped on a rig with two circular saws to 638mm,ie leaving a margin of 19mm at each end of a fuel tube to the fuel meat.

Cooling ponds

ANSTO operates two stainless steel lined cooling ponds. One pond has a cropping bay and a storage bay with racks to hold 390 fuel elements for interim or long-term storage. The second pond is used for preparation of fuel elements for shipment and loading of fuel shipment casks. This pond has recently been re-racked to hold 244 fuel elements.

The ponds have demineralised water supplies and water quality is maintained by recirculation through skimmer boxes, particulate filters and an ion exchange system.
Target parameters:

Conductivity	µS/cm	
PH		
radioactivity	<100Bq/L	(action level 1000 Bq/L)

Dry store

In 1968, a dry storage facility was constructed to hold 1100 fuel elements. The facility consists of 50 holes, 16 metres deep, drilled into sandstone and lined with 140mm internal diameter stainless steel tubes. HIFAR fuel elements are stored in individual aluminium cans, two cans in each stainless steel canister, and eleven canisters in each lined hole. When loaded with fuel, the tubes are evacuated and filled with nitrogen to inhibit corrosion of the fuel cladding. Checks of relative humidity, temperature, oxygen and krypton–85 are performed Biennially.

Spent fuel disposition

ANSTO had a contract for reprocessing spent fuel with UKAEA Dounreay, but this plant was shutdown in 1998 and will not be restarted.

ANSTO currently has two agreements in place:

US DOE Savannah River

On 13 May 1996, the US Secretary of Energy signed the Record of Decision on return of foreign research reactor aluminium based spent fuel containing uranium enriched in the United States. The final EIS Appendix B included fuel from HIFAR and the shutdown MOATA reactor. To be eligible for inclusion in this policy, fuel must be removed from a reactor by 12 May 2006 and be shipped to the US by 12 May 2009.

In 1997, the Governments of Australia and the United States exchanged diplomatic notes which constituted a Memorandum of Understanding on the issue. The USDOE's acceptance of spent fuel is subject to:

- The shutdown of HIFAR by 12 May 2006
- Any new research reactor to be built in Australia must use LEU fuel.

An initial shipment of 240 fuel elements took place in 1998. Further shipments are planned.

It is useful that unirradiated fuel is also accepted. French law prevents COGEMA accepting unirradiated fuel.

COGEMA

In January 1999, ANSTO signed a contract with COGEMA for the management of all the non-US origin spent fuel - about 1300 fuel elements. The contract includes transport of spent fuel, reprocessing at La Hague, conditioning of the waste into a stable form and return of residues to Australia.

The contract for HIFAR specifies four shipments. Two shipments with a total of 668 fuel elements have been completed to date.

HIFAR started operating in 1958. To date, 1172 fuel elements have been sent abroad in 5 shipments. Up to the end of the planned HIFAR shutdown in 2006, a further1100 fuel elements will be sent for reprocessing. There are a number of factors to be considered in determining the timing, quantity and destination of spent fuel shipments for the remaining life of HIFAR:

Fuel Type

HIFAR has operated with three different types of HEU fuel elements. Mark II fuel elements consist of 10 parallel curved fuel plates fitted into an open ended aluminium box. These were used in HIFAR between 1958 and 1971. Mark III fuel elements consist of 10 curved plates fitted as spiral fins in the annulus between inner and outer aluminium tubes. These were used between 1962 and 1971. Since 1970, the Mark IV design of four concentric fuel tubes has been utilised. The different types require different handling arrangements, both on site and abroad. When the Mark IV fuel is cropped to length, the four tubes are loose and are clipped together for transport. A tag is required for identification.

ANSTO will also have some Mark IV type LEU silicide fuel. This is US origin and is included in the USDOE EIS inventory for Australia.

Fuel condition

Spent aluminium fuel stored in carefully controlled conditions can remain in a good physical condition for many years. There are fuel elements in storage at ANSTO, removed from the reactor more than 30 years ago, that are still in perfect condition.

Fuel in the cooling ponds is visually inspected to identify plate deformities, pitting in the cladding or unusual surface marking. Any fuel that is "suspect" is individually sip tested. The sip test procedure is:

- The individual fuel assembly is transferred to the sip test tank in the hot cells and immersed in demineralised water overnight to remove readily removable surface contamination prior to the commencement of the test
- 10 litres of water is continuously circulated through the covered sip test tank
- Samples are taken at the start and regularly over a 100 hour period
- Samples are analysed for Cs-137, Cs-134, C0-60, C0-58, gross alpha, gross beta

For the purpose of classifying HIFAR spent fuel for shipment, an indicative soundness threshold of 10kBq/hr gross beta has been derived.

Pond gross beta activity is also a useful indication of fuel condition. All HIFAR spent fuel that has been in long term dry storage releases accumulated surface radioactivity when transferred to wet storage. Any increase in pond activity is normally of short duration.

Both SRS and COGEMA set criteria for the acceptance of sound spent fuel. Fuel that meets the sound fuel criteria is generally accepted. Unsound fuel can be accepted provided suitable precautions are agreed. This could include canning.

SRS

- The spent fuel must be structurally sound such that it will not change shape during handling
- The spent nuclear fuel must not be bent or deformed that would cause interference with a cask basket or cask insert surfaces.
- All spent nuclear fuel shall be individually handled during cask loading operations as a final check that each assembly is structurally sound
- Increase in Cs-137 for a twelve hour test of shipping cask water sample less than 20.7μCi/hr/cask
- Cooling time of less than 2 years upon arrival at SRS requires further evaluation prior to acceptance

COGEMA

- The spent fuel must be physically sound, ie there must be no material dissemination during handling or transport
- If the fuel is mechanically sound but there are signs of corrosion, the fuel is accepted subject to a satisfactory radioactivity release rate

- The βγ activity (excluding tritium) of a gas sample from a loaded spent fuel transport cask shall not exceed 0.37MBq/m^3

Fuel origin
The US will only accept fuel that was produced from nuclear material supplied by the United States. Providing formal retransfer arrangements are agreed by the US, COGEMA will accept US origin fuel.

Spent fuel shipments
Spent fuel shipments are expensive so there is an obvious advantage in storing spent fuel on site until there is the optimum quantity, or sharing a shipment with other operators. Due to Australia's remote geographical position, shipments to date have not been shared.
The 1996 US Record of Decision specified a maximum of 8 casks on a ship. In 2000, a revision to the Record of Decision increased this number to 16.

The shipments from ANSTO to COGEMA normally consist of 5 casks with a maximum of 360 fuel elements.

Spent fuel transport casks
ANSTO owns one spent fuel transport cask designated LHRL-120. This was US designed and manufactured in 1988 to comply with US standards and IAEA Transport Regulations.
The cask consists of a containment vessel, lead shielding, outer shell, bottom end closure, and bolted closure lid, all structural parts being of stainless steel. Two semi-cylindrical steel shells filled with polyurethane foam completely surround the cask and act as an impact limiter and provide protection in the event of exposure to fire. The cask is designed for passive cooling for a heat dissipation of 290 W and carries a total of 120 HIFAR fuel elements in two identical baskets. Individual basket cells are 109mm diameter and 660 mm high.
ANSTO have also used COGEMA Logistics TN-MTR (52 fuel elements) and NCS TN7/2 (60 fuel elements) casks. Using the LHRL-120, two TN-MTR's, two TN 7/2's and NAC-LWT casks, shipments of more than 400 fuel elements are feasible. This requires planning well in advance.

It is important to identify limitations in the cask Certificates of Approval, eg for the LHRL-120:
- Minimum post-irradiation cooling time is 8 years
- Damaged fuel is not allowed

Waste
For spent fuel returned to the US, there is no return of waste.

Residues from reprocessing spent fuel sent to COGEMA will be returned to Australia. The waste will meet the IAEA criteria for long-lived low and intermediate level waste. Two types of waste will be returned in COGEMA's Universal Canisters:
- Fission products and actinide solutions immobilised in borosilicate glass
- Compacted technological by-products and wastes.

It is estimated that all the residues of both types from reprocessing all the 1300 fuel elements contracted to COGEMA can be returned in two TN-81 combined transport and storage casks.

Conclusions

Spent fuel from the HIFAR reactor is stored on site under carefully controlled conditions and even fuel over forty years old is still in excellent condition.

ANSTO has agreements for disposition of the spent fuel with the US DOE and COGEMA and all parties work in a very collaborative manner.

By this combination of storage and shipment, ANSTO is able to ensure the safe disposition of the spent fuel from HIFAR.

References

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