# Regulatory Management of Research Reactor Spent Fuel Facilities in Australia- Managing a Cropping Incident

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**Abstract**. The work describes the approach of Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) in the regulatory management of research reactor spent fuel facilities and regulatory response to incident using a cropping incident as an example.

## 1. Introduction

The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) is responsible for the regulation of nuclear installations in Australia under the *Australian Radiation Protection and Nuclear Safety Agency Act 1998* (the Act) [1] and the Australian Radiation Protection and Nuclear Safety Regulations 1999 (the Regulations) [2]. Nuclear Installations covered by the Act include research reactors, radioisotope production facilities, waste management facilities and fuel management facilities. All of Australia's existing nuclear installations are under the control of the Australian Nuclear Science and Technology Organisation (ANSTO).

There are two shut down research reactors that have been principally responsible for Australia's volume of spent fuel. ANSTO operated 10 MW HIFAR for about fifty years. ANSTO also operated an Argonaut type 100 kW reactor (MOATA) for about 34 years with HEU fuel. In the case of the HIFAR reactor the spent fuel arising from operation included both HEU and LEU fuel assemblies. The volume of LEU was much smaller since LEU fuel was only used in HIFAR reactor from 2004 till the time of its final shutdown in early 2007. ANSTO's new 20 MW OPAL research reactor utilises LEU, hence, future volumes of LEU will be greater. The major function of the ANSTO fuel management facility is passive, that is the safe storage of new and spent fuel in engineered purpose-built facilities.

The Fuel Management facilities (known as Fuel Operations) principally comprise: the Spent Fuel Wet Stores; the Active Handling Pond where loading of casks with spent fuel takes place for off-site transport, High Activity Handling Cells used for inspecting spent fuel elements, or the handling of other radioactive items; and, the Nuclear Materials Vault and Store used for storing new HIFAR fuel and other fissile material. All of these facilities are located at the Lucas Heights Science and Technology Centre (near Sydney).

This works describes the regulatory approach in managing incidents that occur during routine operation. The particular example used is a cropping incident.

## 2. ARPANSA regulation of ANSTO fuel management

The fuel management facilities of ANSTO are licensed under ARPANSA legislation taking into account the requirements set out in the Act [1] and in the Regulations [2]. In particular the CEO of ARPANSA must take into account international best practice in radiation protection and nuclear safety when making licence decisions.

Of particular importance in the assessment of an application for a facility licence are the plans and arrangements for managing safety. These plans require the demonstration of appropriate arrangements for maintaining effective control, the implementation of an appropriate quality system, safety management plan, radiation protection plan, radioactive waste management plan, security plan and emergency plan. The plans and arrangements for managing safety are the assessed against regulatory guidelines developed by ARPANSA. These guidelines are based on international best practice in radiation protection and nuclear safety, drawing from national and international publications and experience, especially from the International Atomic Energy Agency (IAEA).

In addition, the assessment of the Safety Analysis Report (SAR) of each facility is also an important component of ARPANSA's regulatory assessment. ARPANSA expects that the SAR will demonstrate the appropriate application of defence in depth principles and that the plant, its processes, controls, activities, and the management of future modifications are in accordance with ARPANSA's regulatory assessment principles, and conform to good engineering practice and to appropriate standards and code of practice. These requirements are to ensure that the operations of the facilities are adequately safe during normal operations and accident conditions as they operate under defined limits and conditions. For spent fuel storage facilities the analysis of Postulated Accidents forms part of the Safety Analysis Report. For operations undertaken within the cropping pond the following accidents were considered in the facility's SAR:

i. Accidents involving the shear/transfer flask- accidental dropping of the shear/transport flask onto spent fuel elements in the cropping pond is unlikely but should be considered as a bounding accident.
ii. Accidents involving the General Purpose Flask – An accident with the GP flask (such as moving the flask before the canister containing the spent fuel elements is withdrawn inside) could potentially expose personnel to a significant radiation dose and is a bounding accident.
iii. Accidents with other flasks.
iv. Cutting a spent fuel elements with the cropping saw-Accidental cutting of a spent fuel element with the consequent exposure of personnel to fission products and radiation is a bounding accident

The 'Analysis of Postulated Accidents' within this SAR concluded that the above postulated bounding accidents have no off-site consequences, since there is no significant fission product release from the spent fuel. For accidents in which there is leakage of pond water, in circumstances where the barrier presented by the pond structure is breached, the low specific activity of the pond water mitigates the effects of the leakage on the groundwater and therefore has no off-site consequences also. It should be noted that it is a requirement under the licence that covers this facility that the radioactivity level in the groundwater must be within the limits specified by the Australian Drinking Water Guidelines. In addition, the operator (ANSTO) is required to provide the regulator (ARPANSA) with results of analysis of water from bore holes, adjacent to the spent fuel facilities on a quarterly basis.

ARPANSA's key methods of regulatory oversight of the fuel management facilities and the shipment of spent fuels is by prior assessment of the safety case, compliance monitoring through regular reporting (quarterly and annually), and planned and reactive inspections of the fuel management facilities. In addition it is a condition of that:

(1) *The holder of a licence must take all reasonably practicable steps to prevent accidents involving controlled materials, controlled apparatus or controlled facilities described in the licence.*

*(2) If an accident mentioned in subregulation (1) happens, the holder of a licence must:*

- *(a) take all reasonably practicable steps to control the accident; and*
- *(b) take all reasonably practicable steps to minimise the consequence of the accident, including injury to any person and damage or harm to the environment; and*
- *(c) tell the CEO about the accident within 24 hours of it happening; and*
- *(d) give the CEO a written report about the accident within 14 days of it happening.*

## 3. Description of cropping operation

Cropping of spent fuel is performed periodically to remove non-fuel portions of the element in order to facilitate storage and shipment. Cutting is performed by a machine at the bottom of the pond- the demineralised water in the pond provides shielding and confinement. The pond, which consists of a cropping pond and an irradiation portion, is about five metres deep. The cropping machine, located on the base of the cropping pond, consists of two parallel rotating saw tooth blades. The fuel element is positioned on the cropping machine relative to the fixed datum (end stop).

The cropping pond is 4.0 m long, 1.6 m wide and 6.2 m deep with a working depth of 5 m. The pond walls and floor are 0.3 m concrete with a stainless steel lining.

Spent fuel storage areas which are accessed routinely for ongoing operations require radiation monitoring and alarms, as well as airborne contamination sampling. This is the case for the wet storage areas and the appropriate monitoring equipment is provided.

Most operations carried out in Fuel Operations are manual or only semi-automated so that human factors are an important component of nuclear safety.

External cooling of the wet fuel store pond water is not required due to the low heat generation of the spent fuel which has been cooled longer than 28 days. Administrative procedures ensure that spent fuel remains in the HIFAR containment building No.1 Storage Block for at least 28 days. After this period, the structural component of the fuel element is sheared off using equipment in the containment building before it is transferred to the cropping pond, for cropping of the outer aluminium cylinder, and then the wet store.

When stored dry, the spent fuel does not have any special cooling requirements provided it has been cooled for more than 21 months. Administrative procedures ensure that spent fuel remains in wet storage for at least 21 months.

## 4 Description of the incident

The cropping machine was removed from the pond for maintenance. The cropping saw was taken apart and reassembled a number of times during that period. Following the maintenance the cropping machine was tested for its functionality but a dimensional check of the cutting blades was not performed. Cropping of irradiated fuel was recommenced on 15 March 2002 after the maintenance. Soon after the cutting of the first element began, workers detected elevated dose rates in the general work area indicated by their personal dosimeters. The work was discontinued immediately and the workers informed their supervisor and health physics surveyor (HPS).

### 4.1 Consequence of the incident and counter measures taken

The health physics results indicated that some fission products had been released to the pond water. The HPS measured that the pond had a dose rate of 400 μSv/hr at 0.25m above the water and the wall mounted water filters indicated a dose rate of 40 mSv/hr at contact. A pond water sample was analysed using a portable gamma spectrometer within an hour that confirmed that a small amount of fission products was released. Subsequent visual inspection confirmed that the fuel cladding in the vicinity of the fuel meat had been cut during the cropping activity. Airborne samples were collected in the area and their results were negative. The incident resulted in the gross beta activity of 140 kBq/L in the pond water. In general, radioactive contamination of the pool water, for occupational safety reasons, is maintained at levels of about 30 kBq/L or less [3].

Airborne activity was not detected during or after the incident. Whole body monitoring was conducted on the active handlers and results were negative for both inhalation and ingestion. The personnel involved were monitored for doses received from this incident and their measured doses were not significant. The effective dose to each worker was less than 40 μSv for the entire activity that day.

Radioactivity in the pond was continuously monitored. Based on the reading of purification filters activity, it is estimated that less than 0.5g of irradiated fuel was released into the pond.

Two weeks after the cropping event the damaged fuel element was transferred to a stainless steel canister for storage on the bottom of the cropping pond.

The radioactivity of the pond water was reduced from 140 KBq/L gross beta immediately after the event to about 30 kBq/L within approximately 5 weeks, whereas normal activity before the event was 1 kBq/L. The water contamination after a month was indicative of suspended radioactivity in the pond which suggested that much of radioactivity was in the form of settled particles. Additional clean up was undertaken to ensure all particulates were removed and the original level of water activity restored.

Daily surveys and samples were taken over the following week. Slight contamination on a worker's clothing triggered the requirement for an additional survey to be undertaken. The personnel lockers, office spaces and other location frequented by those involved or were in the pond vicinity were surveyed. The result indicated the highest contamination was 5,000 cps. No skin contamination occurred.

### 4.2 ANSTO Investigation, Root Cause Analysis and Recovery Actions

ANSTO conducted an internal investigation to find the root cause and contributing factors to this incident. The key question used in the root cause analysis was: "What factor, if prevented, would have prevented the primary effect from occurring?" The identified root cause included:

A spacer, previously bolted against the spent fuel rod end stop, was missing. The spacer, approximately, 32 mm thick, had been removed during the decontamination and maintenance of the cropping saw. After the maintenance, the spacer had not been replaced back onto the end stop.

Human factor was the key contributor to this incident- familiarity with the well established procedure resulted in a high degree of complacency; inappropriate check after recommissioning

The final report resulted in five recommendations involving the following matters:

a) Implementing a formal protocol for the transfer of equipment
b) Review of the cropping procedure
c) Review of training process
d) Implementation of measures to ensure continual Health Physics input into the development of procedures and work instructions

***Recovery actions for normal operation***

The key remedial actions taken to date to return the pond back to normal operation have included:

i. Installation of an in-pond swarf filter for particulates resulting from the cropping operation
ii. Ongoing purification of the pond water through the ion exchange column
iii. Ongoing replacement of the particulate filters as required by pressure drops on the ion exchange filtration system.

iv. Results of surveys, including water samples taken between the pond liner plates and the relevant adjacent bore holes, confirmed the integrity of the liner platers with no release of any radioactivity from the pond
v. Use of a dummy fuel element to ensure the appropriate alignment of the fuel element before any cropping operation
vi. Replacement of the hydraulic control system of the cropping saw

## 5 ARPANSA Regulatory Response to the incident

After receiving the notification of the incident ARPANSA inspectors visited the facility to obtain information on the incident and awaited ANSTO internal investigation report. The cropping operation was suspended until the investigation is complete. ARPANSA inspection covered the following areas:

a) Chronology of the incident
b) Records- operational logs, health physics survey records
c) Facility walkthrough
d) Checking performance of monitoring equipment
e) Operating procedures and work instructions
f) Corrective actions taken

ARPANSA’s initial assessment suggested the contributing factors that led to the incident included:

- Human factors
- Procedural inadequacies
- Safety culture deficiencies

Inadvertent cutting of the fuel cladding during cropping led to loss of barrier to the release of fission products and fuel material. ARPANSA characterised the incident as Level 1 using the INES User’s manual [4] taking into account the loss of defence-in-depth and on-site consequence in terms of operator dose and spread of contamination.

ANSTO provided ARPANSA with a Final Investigation report that identified the root cause of the incident and recommended actions for preventing the recurrence of such incident.

Following the incident ARPANSA conducted a series of follow-up inspections to ensure that the recommended actions arising from ANSTO investigation report were properly implemented.

The findings of ARPANSA inspection were in agreement with those identified in ANSTO investigation report. ARPANSA accepted the proposed recovery actions for normal operation and witnessed the recommencement of the cropping operation. Since this incident was considered in the deterministic safety analysis of this facility ARPANSA advised ANSTO to incorporate the lessons learnt from this incident into the revised SAR for this facility.

## 6 Conclusion

The radiological consequence of this incident was not significant and restricted to the immediate area surrounding the pond. However, the incident is significant in term of operational safety and numerous lessons have been learnt from this incident. The inspection findings underline the importance of human factors in managing safety in a spent fuel facility. The effectiveness of the recovery process of the cropping facility including the cleanup of the pond water has been demonstrated by the current gross beta activity level of about 0.5 kBq/L in the pond water, which is half of the pre-incident level. ARPANSA regulatory approach in managing the spent fuel facilities and regulatory response to this incident have been found effective in achieving the object of the Act, that is, to protect people and to protect environment from the harmful effect of radiation.

## REFERENCES


[1] Australian Radiation Protection and Nuclear Safety Act 1998.

[2] Australian Radiation Protection and Nuclear Safety Regulations 1999

[3] The Safety of Nuclear Fuel Cycle (2005), Nuclear Energy Agency/OECD

[4] The International Nuclear Event Scale (INES) User's Manual (2001), IAEA and OECD/NEA