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The ANSTO Waste Management Action Plan

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SUMMARY ANSTO's Waste Management Action Plan is a five-year program which addresses legacy issues that have arisen from the accumulation of radioactive wastes at Lucas Heights over the last forty years. Following an extensive review of waste management practices, a detailed Action Plan was prepared involving seventeen projects in the areas of solid wastes, liquid wastes, control of effluents and emissions, spent reactor fuel and organisational issues. The first year of the Waste Management Action Plan has resulted in significant achievements, especially in the areas of improved storage of solid wastes, stabilisation of uranium scrap, commissioning and operation of a scanning system for low-level waste drums, treatment of intermediate-level liquid wastes and improvements in the methods for monitoring of spent fuel storage facilities. The main goal of the Waste Management Action Plan is to achieve consistency, by the year 2000, with best practice as identified in the Radioactive Waste Safety Standards and Guidelines currently under development by the IAEA.

1 INTRODUCTION

For over forty years, radioactive wastes have been generated by ANSTO (and its predecessor, the AAEC) from the operation of nuclear facilities, the production of radioisotopes for medical and industrial use, and from various research activities. The quantities and activities of radioactive waste currently at the Lucas Heights Science and Technology Centre are very small compared to many other nuclear facilities overseas, especially those in countries with nuclear power programs. Nevertheless, in the absence of a repository for radioactive wastes in Australia, the waste inventory has been growing steadily.

In July 1995, the ANSTO Board endorsed an ambitious and far reaching policy for the management of ANSTO's wastes. The declared policy is as follows:

ANSTO will manage its radioactive waste in a manner that protects human health and the environment now and in the future. In doing so, ANSTO is committed to:

- *complying with all relevant legislative and regulatory requirements, in particular,*
  - *ensure that all discharges are within authorised limits,*
  - *monitor and report regularly radioactive releases to the environment;*
- *ensuring that radiation exposures will be kept as low as reasonably achievable (ALARA), economic and social factors taken into account;*
- *disposing of wastes when appropriate disposal routes are available;*
- *being in accord with international best practice.*

A full statement of ANSTO's policy, including specific strategies and actions is available (1).

ANSTO's Radioactive Waste Management Policy required that:

i. a review be carried out of current waste management practices, and
ii. an integrated waste management action plan be prepared.

To fulfil the first requirement, a team of staff from across ANSTO was assembled to carry out a detailed technical review. The report of that review (1), published in May 1996, gives details of:

- relevant legislative, regulatory and related requirements,
- sources and types of radioactive waste generated at ANSTO,
- waste quantities and activities (both cumulative and annual arisings),
- existing practices and procedures for waste management and environmental monitoring,
- overall strategies for dealing with ANSTO's radioactive wastes.

The report makes 24 recommendations covering solid and liquid wastes, airborne emissions, liquid effluents, spent reactor fuel and organisational issues.

Following completion of that review, the Waste Management Action Plan (WMAP) was prepared for the period 1996-2000. It deals only with "legacy" issues that have arisen from the accumulation of radioactive wastes at Lucas Heights or with existing facilities that may need refurbishment or replacement. Routine waste management operations are not considered as they are managed within the normal business of ANSTO's Nuclear Technology Division.

The WMAP is a internal document which gives information on projects, milestones, resource requirements and budgets to implement ANSTO's Waste Management Policy. Seventeen projects are currently part of the WMAP which is updated annually to take account of changed circumstances and priorities. Estimated expenditure requirements for the five years of the WMAP are approximately $11 million.

The implementation phase of the WMAP began in July 1996. This paper gives an overview of radioactive waste management at ANSTO and highlights the achievements of the first year of the WMAP.

2 WASTE INVENTORY

Table 1 gives the approximate generation rate and inventory of radioactive waste and spent fuel at ANSTO. Over the past few years, ANSTO has been successful in reducing the quantities of solid waste produced each year.

Table 1: ANSTO's Radioactive Wastes and Spent Fuel (as at mid 1997)

Waste Type	Each Year	Total Inventory
Low-level solid waste	150 drums*	5000 drums*
Intermediate-level solid waste	1.5 cubic metres	200 cubic metres
Intermediate-level liquid waste	300 litres	6500 litres
Spent fuel	37 elements	1630 elements

* 200 litre capacity

3 SOLID WASTES

Low-level solid wastes are generated in ANSTO laboratories where radioisotopes are handled. They include a variety of items such as tissues, disposable gloves and plastic tubing. Such wastes are collected in plastic-lined cardboard containers and then compacted into 200 litre steel drums. Typically, this reduces the waste volume by a factor of six.

Non-compactable solid waste includes contaminated equipment, dried sludge from treatment of the site waste water, mineral processing wastes and uranium and metal scrap.

ANSTO also produces small quantities of intermediate-level solid wastes. Examples include metal cans that have been irradiated in the HIFAR reactor, alumina columns used in chemical processing of radioisotopes, and spent ion exchange resins used to purify the reactor's cooling water. These wastes are stored below ground in specially-designed storage pits.

3.1 Radionuclide Inventory

Before the WMAP began, little was known of the radionuclide content of the ANSTO's solid wastes. Wastes were historically categorised according to the maximum dose rates on the external surface of the drums. Because much of this waste contains short-lived radionuclides, the dose rates have decreased significantly over time.

Knowledge of the radionuclide content of solid wastes is needed before disposal in a repository and will need to be reported under the new *International Convention on the Safety of Radioactive Waste Management*.

In 1996, a scanning system was purchased to measure the activity of gamma-emitting radionuclides in ANSTO's solid wastes. A small facility was constructed adjacent to ANSTO's waste storage building to house a Q^2 scanning system suppled by Canberra Instruments.

Standard 200 L drums are counted inside a cabinet with 100 mm steel walls to minimise background radiation. To minimise errors due to non-homogeneity, three germanium detectors are used and the drums are rotated during counting. The software system controls the analysis time, records drum weight, corrects for dead time and self absorption, locates peaks in the gamma spectra and identifies radionuclides from those peaks.

A second system has also been set up to scan intermediate-level wastes and the 5% of 200 litre drums where the activity is too high (>0.25 mSv/h) to be reliably measured on the Q^2 system. This system consists of a turntable for rotating non-standard packages and a single germanium detector mounted on rails that allow it to be accurately positioned at various distances from the source. It is also suitable for scanning about 300 oversized drums currently in storage.

During December 1996, both detector systems were received from the USA and installed at ANSTO. The Q^2 system, in particular, has performed very well and, at time of writing, over 1,500 drums have been scanned. Gamma rays have been identified from 55 different radionuclides with 13 radionuclides appearing in more than 10% of all drums. The most common nuclides are cobalt-60 (in 94% of drums), caesium-137 (in 89%), potassium-40 (in 41%) and uranium-238 (in 37%).

Most of the drums satisfy the criteria for Category A waste according to the definition in the NHMRC's *Code of Practice for the Near-Surface Disposal of*

Radioactive Waste in Australia (2). Based on the measured gamma emitters, 1.7% of the drums exceed the limits for Category A and need to be classified as Category B waste. This percentage will increase somewhat when the contribution of difficult-to-measure radionuclides (e.g. those that emit only beta particles) are included.

3.2 Stabilisation of Uranium and Thorium Scrap

Approximately four tonnes of uranium and thorium scrap has been generated by ANSTO over the past 35 years from the melting, casting and machining of thermal neutron filters, reflectors, blankets and shielding components. Finely divided uranium and thorium are pyrophoric and, under certain conditions, can spontaneously ignite in air or water. For this reason, ANSTO's uranium and thorium wastes are stored under kerosene or oil.

Stabilisation of this scrap material was given a high priority under the WMAP. A number of options were considered:

1. recovery by melting,
2. alloying with aluminium,
3. chemical dissolution,
4. conversion to oxide by burning,
5. conversion to oxide by controlled calcination.

Following an initial assessment, two options - chemical dissolution and controlled calcination - were selected for detailed evaluation in the laboratory. Both methods were found to be feasible, however, controlled oxidation in a rotary calciner was selected because of its higher throughput and its ability to deal with both uranium and thorium in the same process.

Figure 1 shows the arrangement of equipment for the calcination process. Before calcination, kerosene is drained from the scrap under an inert atmosphere and the scrap is loaded into stainless steel crucibles inside a glove box.

A single batch operation normally involves three crucibles and up to 30 kg of scrap. The rate of oxidation is controlled by varying the temperature and the flow rates of air and nitrogen. A tube with predetermined holes passes through the three crucibles to allow nitrogen and air to be injected directly into the scrap. Individual thermocouples monitor the temperature in each crucible.

The furnace temperature is set at 200°C and nitrogen gas is used to flush the kerosene vapours through the system. After removal of the kerosene, the furnace is reset to 500°C for uranium and 900°C for thorium. Air (up to 250 litres per minute) is admitted to oxidise the swarf. Once oxidation is complete, the furnace is held at temperature for three hours to ensure complete oxidation which has been confirmed by XRD analysis.

The performance of the rotary calcination process has been excellent and over 2.5 tonnes of uranium scrap has been stabilised to date. The entire inventory of scrap is scheduled for treatment by the end of 1997.

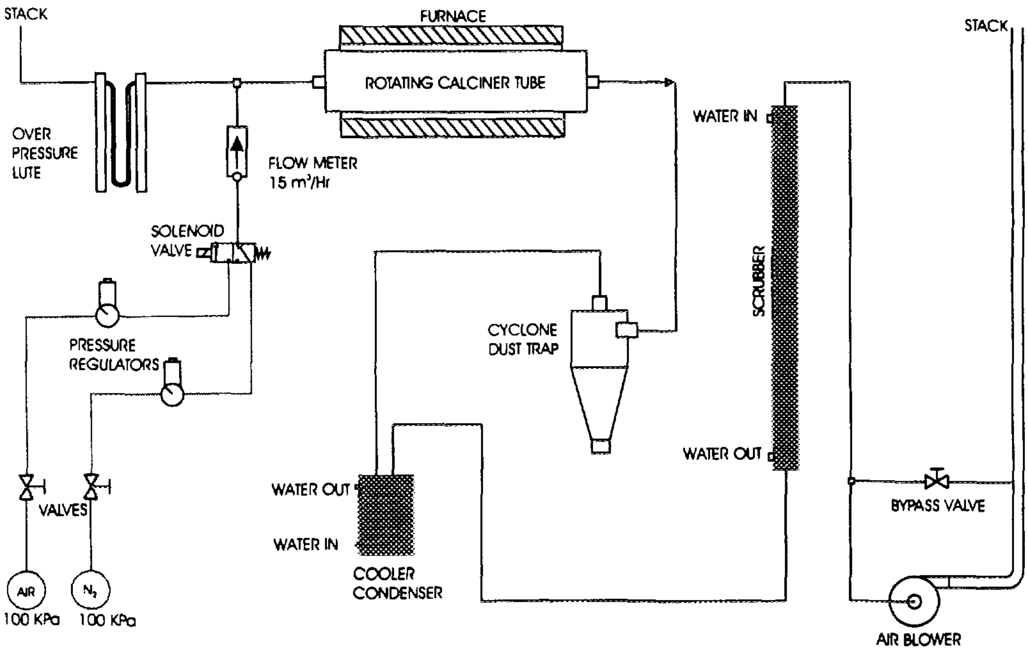

Figure 1: Equipment for controlled calcination of uranium and thorium scrap

3.3 Improved Storage of Solid Waste

Building 59 Bulk Storage Facility is the main store for solid low-level radioactive wastes at Lucas Heights. The building was constructed in 1967 with asbestos cement corrugated cladding over a steel frame. The cladding had become embrittled with age and significant areas were cracked and in danger of breaking away. Although it was structurally sound, it was obviously in need of upgrading.

The building was filled with pallets stacked up to five high in a pyramid fashion. As this method of stacking was potentially unsafe, access to the area was strictly controlled. Installation of a shelving system was given a priority A status under the WMAP. The average pallet loads are 800 kg but the racking system has been designed for 1200 kg. Seismic loads were included in the design and certified against the Australian Standard to ensure that the facility could also be used to store any materials that were associated with category III hazardous facilities.

The new system was installed in early 1997 and is now fully operational. It has capacity for 5700 standard drums and 1000 oversized drums.

3.4 National Waste Repository

Most of ANSTO's 5000 drums of waste solid are suitable for disposal in a repository for low-level wastes. The Australian Government through the Department of Primary Industries and Energy is currently in the process of selecting a repository for low-level and short-lived, intermediate-level wastes. Eight regions have been identified as having potential for a waste repository (3) and the next stage is nomination of one region for more detailed assessment and selection of a specific site.

ANSTO is committed to providing technical assistance, as required, to the national waste repository project.

4 LIQUID WASTES

Technetium-99m is the most widely used radionuclide in modern diagnostic nuclear medicine. Devices known as generators, which produce technetium-99m on demand from molybdenum-99 have been marketed by ANSTO/AAEC for more than 25 years.

At ANSTO, molybdenum-99 is produced by the fission product route. Uranium dioxide pellets, 2% enriched in uranium-235, are irradiated for up to seven days in HIFAR. Following irradiation, the pellets, containing the molybdenum-99 and other fission products, are dissolved and the molybdenum-99 is separated by adsorption onto alumina columns. The molybdenum-99 is removed from the columns by elution using ammonia. Two liquid waste streams are generated from the process; primary liquid waste (PLW) which contains most of the uranium and unwanted fission products, and the less radioactive secondary liquid waste (SLW) from washing of the alumina columns. Both waste streams contain about 0.8 M nitric acid solution and small quantities of ammonium nitrate.

The PLW and SLW streams fall within the category of intermediate-level liquid wastes and their handling, transportation and storage are strictly controlled. On average, 90 litres of PLW and 230 litres of SLW are produced per year. There are approximately 6500 litres of these liquid wastes stored in tanks in a shielded facility at ANSTO.

The solidification of these wastes has been given the highest priority under the WMAP. Special attention has been given to elimination of the safety hazard associated with the presence of ammonium nitrate in the waste. The selected process is depicted in Figure 2. It involves concentration of the waste by evaporation, destruction of ammonium ion, partial denitration of the nitric acid followed by crystallisation of an uranium salt, uranyl nitrate hexahydrate. All the steps in the process have now been tested on a non-radioactive scale. Design and installation of equipment for full scale plant, which will be operated inside a hot cell, are nearing completion.

The waste will be crystallised in stainless steel vessels which are suitable for interim storage for at least 50 years. Immobilisation of these wastes in a non-leachable form is a longer-term goal. Two waste forms have been considered, Synroc and cement. Laboratory-scale quantities of Synroc and cement have been prepared containing simulated waste. The chemical durability of zirconolite-rich Synroc containing up to 44 wt% waste calcine is particularly good (see Table 2) and comparable with standard Synroc.

Table 2: Leach rates of Synroc containing 44 wt% simulated molybdenum-99 waste, measured for seven days at 90°C in deionised water

Element	Leach rate (g m^{-2} day^{-1})
Ba	0.020
Cs	0.13
Sr	0.13
Ti	0.00003
U	0.00009

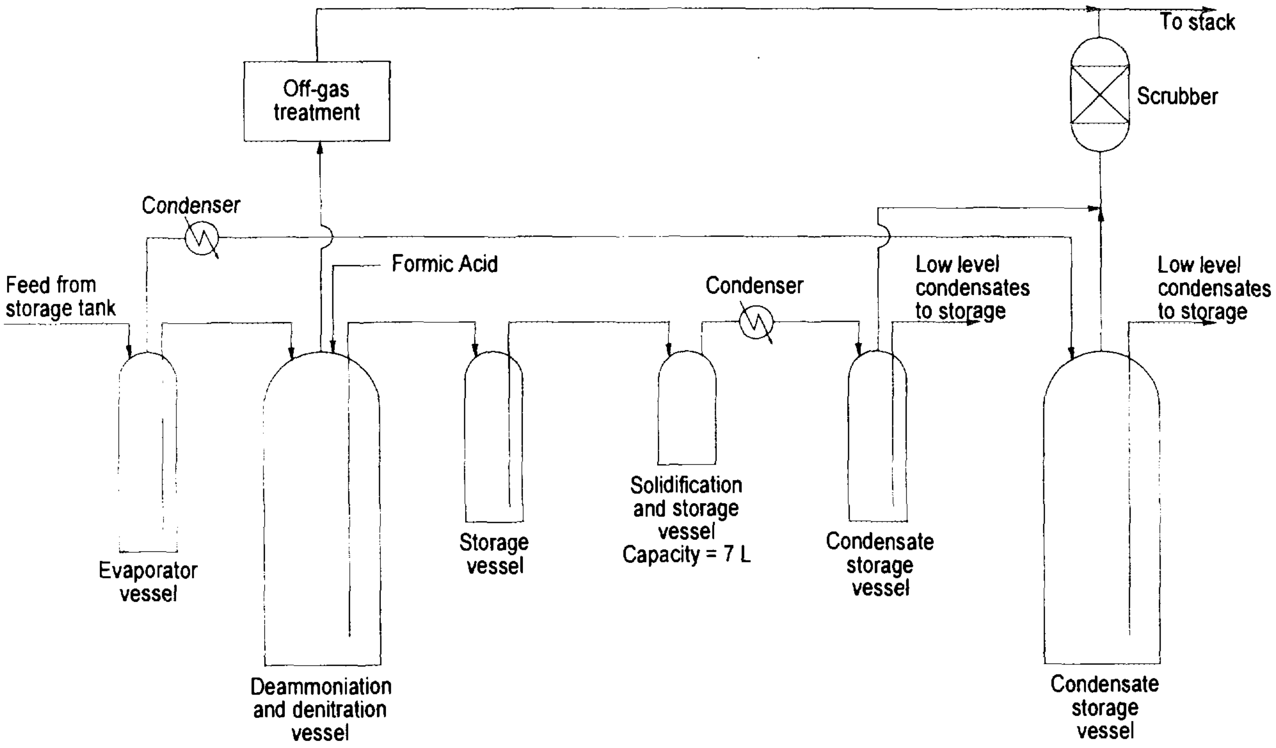

Figure 2: Schematic diagram of in-cell equipment for solidification of molybdenum-99 wastes

5 SPENT FUEL

ANSTO's research reactor, HIFAR, is powered by 25 fuels elements each containing 280 grams of uranium. The fuel remains in the reactor for about nine months after which it is removed and put into a small pond adjacent to the reactor. The heat and radioactivity in the spent fuel decrease rapidly.

After about one year, the fuel is transferred to another pond and the ends of each element, which do not contain any uranium, are cut off. The section that contains the uranium is stored under water until the heat has decreased sufficiently to permit dry storage. As of mid-1997, ANSTO had 1630 spent fuel elements, most of which are kept in dry storage in an engineered facility or in storage flasks.

The Spent Fuel Storage Facility is an engineered in-ground storage facility built in 1968 at Lucas Heights for the interim (medium term) storage of 1100 spent fuel elements pending their ultimate disposition. The facility consists of 50 holes, 15 metres in depth, drilled into sandstone and lined with 140 mm internal diameter sealed stainless steel tubes. HIFAR spent fuel elements are stored, two to a stainless steel canister and eleven canisters in each lined tube. The top of each tube is closed with a steel plug and rubber gasket and sealed with IAEA safeguards seals.

There are also 175 spent fuel elements in seven "Dounreay" storage flasks. These flasks were originally built to transport spent fuel to the UK reprocessing facility at Dounreay, Scotland. The flasks would no longer meet the most modern IAEA standards for transport flasks so there is no intention that they will be used for that purpose.

Aspects of ANSTO's spent fuel management activities were taken up as high priority activities under the WMAP with two main objectives; (a) to facilitate an eventual reduction in the on-site inventories of stored spent fuel, and (b) to ensure that ANSTO continues to manage its spent fuel inventory in accordance with best practice with regular inspection and monitoring of the storage facilities.

The spent fuel management project has three main tasks:

- refurbishment of the Dounreay flasks to ensure their ongoing integrity,
- regular inspections of the fuel storage facilities,
- maintenance of an overview of ANSTO spent fuel facilities, including identification of strategies for the ultimate disposition of spent fuel and timely arrangements for possible overseas shipments.

During the past year, the required lifting and pond frame equipment were built and certified to enable the Dounreay flasks to be refurbished. Refurbishment involves replacement of seals and performance of leak tests to ensure the seals are functioning. The spare Dounreay flask was successfully refurbished, reassembled and leak tested. This flask is now available to accept spent fuel transfers from one of the full flasks to permit that flask to be refurbished. It is proposed to proceed with refurbishment at the rate of one or two flasks per year until such time as spare storage capacity is available to allow the flasks to be unloaded and phased out.

As a sub-task of the WMAP, a review was undertaken of the existing equipment and procedures for purging the storage tubes and monitoring the tube atmospheres in the engineered, in-ground storage facility. The outcome of the review was that the equipment and procedures were found to be generally adequate for the tasks for which they were intended. However, a number of improvements were identified to improve the sensitivity and responsiveness of the measurements.

During the year the gasket seals on the top plug were renewed on each of the 50 storage tubes. As part of an overall review of past monitoring arrangements, it was determined there was a need for additional information on the condition of the atmosphere inside the storage tubes. New equipment was constructed and commissioned for regular sampling and monitoring of the in-tube atmosphere for oxygen, moisture and krypton-85.

The improved system was successfully applied and identified a small number of tubes that could contain moisture. The fuel was completely removed from the hole with the highest humidity. Corrosion was apparent in some elements, mainly in the aluminium cladding. Examination of the stainless steel tube showed it to be in good condition and fully sealed.

The conclusion from these investigations is that the spent fuel continues to be stored in a safe and secure manner. Further and more comprehensive monitoring of the fuel storage facility is planned for the coming months.

As circumstances have permitted, ANSTO has returned spent fuel to its country of origin. Two shipments were made to Dounreay: 150 elements in 1963 and 114 elements in 1996. Under the terms of the most recent contract, the waste from the processing of this fuel will be returned to Australia within 25 years.

During 1996, the United States Government announced it would accept all spent fuel of US origin from research reactors until 2006. As at mid-1997, ANSTO had 689 spent fuel elements of US origin. Preparations are in hand for shipment of some of these fuel elements back to the USA. The USA will take over ownership of the spent fuel and no wastes will be returned to Australia.

6. FUTURE PRIORITIES

The first year of the WMAP has resulted in significant achievements, especially in the areas of improved storage of solid wastes, stabilisation of uranium scrap, commissioning and operation of a scanning system for low-level waste drums, treatment of intermediate-level liquid wastes and improvements in the methods for monitoring the spent fuel storage facilities.

The most important goals for the remaining four years are:

- Solidifying and immobilisation of ANSTO's intermediate-level liquid wastes,
- Compiling a complete inventory of all ANSTO's radioactive wastes,
- Designing and constructing a new facility for treatment of the site waste water,
- Providing technical support for the establishment of a waste repository in Australia,
- Minimising the quantities of radioactive wastes generated and stored at Lucas Heights.

The main objective of the WMAP is to achieve consistency, by the year 2000, with best practice as identified in the Radioactive Waste Safety Standards and Guidelines currently under development by the IAEA.

REFERENCES

(1) Levins, D.M. et al (1996) ANSTO's Radioactive Waste Management Policy - Preliminary Environmental Review, ANSTO Report E/728.

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