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The Management of Wastes Generated in Post Irradiation  
Examination Facilities

Part II - The General UK Position and AEE, Winfrith

by

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### Summary

The general strategy for the disposal of radioactive waste in the United Kingdom is described. Radioactive waste is classified as high, intermediate or low level. High level waste will be immobilised in glass and then placed in surface stores until its heat generation has decayed to a negligible level. Low level waste (LLW) will continue to be disposed in a national shallow trench burial site. A replacement for this national low level disposal site will eventually be required. There is currently no disposal site for intermediate level waste (ILW). United Kingdom NIREX Ltd. is responsible for developing the ILW and the replacement LLW site but neither will be operational until after the year 2000. In the interim ILW will have to be stored.

The arisings of ILW and LLW from a typical annual throughput in the PIE caves at AEE, Winfrith of 110 CAGR and 2 SGHWR fuel elements are given. The present methods of dealing with the upper and ILW, the lower end ILW and LLW are described.



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## 1. The Disposal of Radioactive Waste in the United Kingdom

### 1.1 The Regulatory Framework

The Sixth Report of the Royal Commission on Environmental Pollution (Reference 1) recommended that the responsibility for developing the strategy to deal with radioactive wastes should lie with the Government Department responsible for the protection of the environment. This view was accepted by the Government (Reference 2) which placed the responsibility with the Secretary of State for the Environment together with the Secretaries of State for Scotland and Wales. As Harrop has pointed out (Reference 3), there was logic in placing responsibility in this manner allied to a certain detachment from the promotion of nuclear energy.

The main legislative controls over radioactive waste are provided by the Radioactive Substances Act 1960 (Reference 4).

### 1.2 Categories of Waste

In the United Kingdom solid radioactive waste is classed as low, intermediate or high level. During the Sizewell Inquiry the organisations concerned with radioactive waste in the UK agreed a common set of definitions (Reference 5), which are summarised as follows:-

- (a) low level wastes (LLW). Wastes containing radioactive materials not exceeding 4 GBq/tonne alpha-activity or 12 GBq/tonne beta and gamma-activity, but which do not qualify for disposal as ordinary non-radioactive refuse;   
 *~ 300 mCi* *~ 100 mCi*
- (b) intermediate level wastes (ILW). Wastes with levels of activity exceeding the limits for LLW, but not requiring the heat generated by radioactive decay to be taken into account in the design of storage or disposal facilities;
- (c) high level wastes (HLW). Wastes which require the heat of radioactive decay to be taken into account in the design of storage or disposal facilities.

### 1.3 Current Disposal Routes

The main national site for disposal of Low Level Waste is at Drigg in Cumbria. This is a fenced site occupying about 120 hectares owned by BNFL and located about 6 Km south of Sellafield. It receives solid waste principally from Sellafield but also from operations elsewhere in the United Kingdom.

The wastes are buried in trenches within, but not penetrating, the glacial clay which isolates them from the underlying sandstone formation.

The wastes authorised to be buried at Drigg are subject to Regulations which control both the burial procedure and the activity level. The waste is buried under at least 1 metre of clean soil and this results in a typical radiation dose rate to a person standing on the trench surface of up to 0.2  $\mu$ Sv/hour which is about the background dose rate from natural radiation sources.

Because there is a national disposal site for LLW there is no significant backlog of LLW from current operations. In contrast there is no disposal route for Intermediate or High Level Waste in the UK.

A series of changes is being made to the Drigg site in the light of improved standards being applied to possible new disposal facilities. They include:-

1. Design of a concrete lined engineered burial trench and capping with water-resistant materials to minimise the movement of radionuclides.
2. Containerisation of waste in 220 litre drums or larger metal boxes to enable the trench to be filled in an engineered manner and further reduce the movement of radionuclides.
3. Proposals to reduce the volume of wastes in 220 litre drums by compression in a high force compactor.
4. Implementation of Quality Assurance requirements.

#### 1.4 United Kingdom NIREX Limited

NIREX was set up by British Nuclear Fuels plc, the Central Electricity Generating Board, the South of Scotland Electricity Board and the United Kingdom Atomic Energy Authority in July 1982 with Government approval. The lineage of NIREX can be traced to the recommendations of the Sixth Report of the Royal Commission for Environmental Pollution which reported in 1976. NIREX was transformed into United Kingdom NIREX Limited in 1985 as a company wholly owned by the four partners mentioned above plus the UK Government, represented by the Department of Energy. The Department of Energy holds a single share in UK NIREX Ltd with power of veto, thus ensuring a long-term commitment by the Government. The formation of UK NIREX Ltd as a Limited Company gave it a legal identity, with the ability to place contracts, apply for planning permission and hold a nuclear site licence.

The overall responsibility of NIREX is to develop and implement a comprehensive national plan for the disposal of Low and Intermediate Level Waste. No firm date for the availability of the first NIREX disposal site has been set but it is likely to be after the year 2000.

NIREX has no responsibility for High Level Waste. The Windscale Vitrification Plant (WVP) for incorporation of liquid high level waste into glass is being built at Sellafield. The product from the WVP will be held in a surface store until such time as the heat generation has dropped to a low enough level to be disposed underground in the same manner as low and intermediate level waste. In fact, at that stage, 50-100 years from the present day, it could be reclassified as intermediate level waste.

#### 1.5 General Disposal Strategy and Requirements

The strategy for eventual disposal of any solid radioactive waste is to place a number of barriers between the waste and human beings. This is sometimes termed the multi-barrier approach and there are various ways of defining the total system. A general definition is

given in Figure 1 which treats the system in three parts, the 'near-field', the far-field and the biosphere (Reference 6). Some redundancy in the set of barriers is implied.

The 'near-field' consists of the waste, its packaging and the immediate (engineered) surroundings. The 'far-field' consists of the remainder of the geological pathway between the waste and the human environment. The biosphere is the rest of the environment and includes the atmosphere, the oceans, fresh water and terrestrial ecosystems.

Within the near-field, the first barrier can be defined as the waste form with the second barrier then becoming the container surrounding the waste. The third set of barriers can be classed together as the engineering of the repository. Once the container is breached after, say, 100 years the waste can begin to be leached and therefore potentially able to be transported into potable water.

The engineering of the repository will include the use of large quantities of cement. As a result, the repository groundwater will be highly alkaline and most radionuclides will be insoluble under these conditions. The host rock will have been chosen such that the groundwater movement is extremely slow. The movement of radionuclides beyond the third set of barriers will therefore be dictated by radionuclide diffusion and solubility effects. Thus an essential cornerstone of the UK strategy is the imposition of chemical control.

## 2. The Management of Solid Waste from Post Irradiation Examination at AEE Winfrith

### 2.1 General Policy

The overall policy for solid radioactive waste management at AEE, Winfrith which includes the policy for post irradiation examination wastes may be summarised as follows:-

- (a) the maximum use will be made of continuing off-site disposal options. This includes sending LLW solids to silos at British Nuclear Fuels plc (BNFL), Sellafield and LLW solids to BNFL, Drigg.
- (b) for other wastes, not able to be disposed off-site, an appropriate range of on-site stores is required where wastes can be safely kept and monitored whilst also taking precautions to minimise radiation exposure. The period for which the on-site storage is required is uncertain because the date of availability of the first NIREX site is not yet firm. It must therefore be provided in a flexible manner.
- (c) on-site intermediate level wastes will require immobilisation and packaging prior to disposal at a NIREX site. Such packaging will be undertaken as soon as technically possible, particularly for those wastes whose storage in raw form presents potential environmental risks. For small volume waste streams it may be more economical to build joint facilities with other establishments or organisations.

- (d) a Quality Assurance plan will be implemented to assure the correct identification of radioactive wastes that is allocated to an appropriate treatment and disposal route as well as compliance with the technical requirements of that route. Further aims of Quality Assurance are to minimise the volume of radwaste arisings and to ensure that waste is not over-classified. It will be recognised that minimisation of arisings may not always be compatible with minimisation of radiation dose.

## 2.2 Arisings

About 110 CAGR fuel elements and 2 SGHWR fuel elements are processed each year in the PIE caves at Winfrith. Typical annual arisings including liquid waste are summarised in Table 1.

## 2.3 Irradiated Fuel

As pointed out in Reference 7, the design of the CAGR fuel element is such that a limited number of individual fuel pins can be removed from the assembly with a minimum of machining. The structural integrity of the fuel element bundle is not impaired. Apart from samples which are sent for examination in the hot cells at the CECB's Berkeley Nuclear Laboratories, essentially all the irradiated fuel which enters the caves is eventually shipped for pond storage at Sellafield pending reprocessing. It does not enter the waste stream until reprocessing is undertaken and is therefore outside the scope of this document.

## 2.4 Upper End ILW Solid Wastes

It can be seen from Table 1 that the PIE programme produces a relatively small volume of waste (approximately 1 m<sup>3</sup>/y) containing highly activated materials largely arising from post irradiation examination of CAGR fuel. In former times there were significant arisings of waste from Dragon Reactor and SGHWR fuel element breakdown. Some material has been sent to one of the BNFL silos at Sellafield in heavily shielded containers but certain items have been of such a nature or size, that they could not be conveniently dealt with by the above route. For these reasons, about 10 m<sup>3</sup> of such waste has accumulated in temporary storage facilities at Winfrith.

The upper end intermediate level waste which is currently generated can be classified under the following headings:-

### (a) Irradiated Structural Material

This waste is produced as a consequence of fuel element dismantling and mainly comes from SGHWR fuel element bundles although CAGR post-irradiation produces some swarf from the machining of bent over ends of CAGR pins (termed depeening) and occasionally some graphite from fuel element sleeves. This material consists mainly of stainless steels, as well as zirconium alloys and a small amount of nickel-base material. Examples are stainless steel pin support grids, element top and bottom blocks, retaining screws, Zircaloy sparge tubes, grid springs.

The gamma radiation levels are usually very high ie. 10-100 Gray/hour at 30 cm.

(b) Redundant Cave Equipment

As its name implies, this waste consists of redundant general purpose and specialised cave rigs, tooling and components. It can be heavily contaminated with fuel dust or irradiated swarf. In-situ decontamination is not always successful.

The gamma radiation levels can be between 1 and 10 Gray/hour at 30 cm.

(c) Consumable Cave Items

This waste consists of minor consumable cave items such as saw blades, vacuum cleaner hose, vacuum cleaner filters and it can be contaminated with fuel dust or irradiated swarf.

The gamma radiation levels can be between 1 and 10 Gray/hour at 30 cm.

(d) Cleaning Materials and other 'Soft' Waste

This category includes material contaminated with fuel dust or swarf from activated components. Examples are paper swabs, muslin, plastic sheet, master-slave manipulator gaiters.

The gamma radiation levels can be between 0.1 and 10 Gray/hour at 30 cm.

The fissile material content of the shipments to the Sellafield Silo is below accountable limits.

At the end of the paper presented at 1982 Plenary Meeting of the EEC Working Group on Hot Laboratories and Remote Handling (Reference 7) it was pointed out that improvements are needed in reducing the volume of waste. A programme of work has been undertaken to free space in the storage holes local to the PIE facilities at Winfrith. The waste consists mainly of fuel element structural material coming from the breakdown of Dragon and SGHWR fuel elements prior to 1976. The waste was originally placed in 100 small cans 45 cm long, 20 cm diameter to suit flask handling into the storage holes. The procedure is as follows:-

1. Recover the can from the storage hole and transfer to PIE cave.
2. Open the can.
3. Examine the contents and reduce the size of pieces as necessary to facilitate compaction.
4. Repack in original can.
5. Press in hydraulic press with 15 Te force.

By this technique the final volume of can and contents is being reduced to about 60% of the original volume.

## 2.5 Lower End ILW Solid Wastes

This waste is placed in drums inside concrete shielded drums similar in design to those formerly used for sea disposal. The concrete thickness is tailor-made so that the surface dose rate is less than 2 mSv/hour. Such waste used to be disposed to sea but since 1974 it has been accumulating on site at the rate of about 4 m<sup>3</sup>/year.

Packaging plans for this waste have been affected by changes in national policy viz:-

- (a) loss of sea disposal
- (b) the UK Government's decision in 1986 that short lived ILW could not be consigned to shallow land burial, making it necessary to plan on storing these wastes until a burial site is available, possibly not earlier than 2005.

It is planned to process the lower end ILW in a new central radwaste facility which is being built at AEE, Winfrith. The Radwaste Treatment Building is virtually complete and installation of the plant will commence in September 1987 with the plant coming into operation during the second half of 1989.

The Radwaste Treatment Plant consists of a series of stations connected by a linear waste drum transport system. Drums mounted on robust battery - powered trolleys running on rails are moved by remote control to the various stations. The plant has been designed to be able to immobilise sludges or solids in cement.

Solid waste will be taken into the Radwaste Treatment Plant and sorted in a special module before being placed in a basket within a 500 litre stainless steel drum. The drum and filled basket will then be moved to the cementation station where it will be grouted.

After completion of grouting the waste will be allowed to set before the drum is moved to a multi-role robot operated drum processing station.

The unshielded 500 litre drums of radwaste which are the output from the Radwaste Treatment Plant will be stored on site in a new shielded store until an ILW disposal route is available.

## 2.6 Low Level Waste

The policy on Low Level Waste is to dispose of it as it arises using authorised routes. For AEE, Winfrith this implies disposal in the shallow trench burial site of BNFL at Drigg. Waste leaving the Hot Cell Building is classified as compressible or non-compressible. Compressible waste is compacted using an in-drum compactor and by this process the volume of compressible waste is reduced by a factor of 2.8.

The conditions for acceptance of LLW by BNFL for disposal at Drigg have been regularly tightened in recent years as part of the application of improved standards referred to in Section 1.3.

### 3. Comments

The management of wastes from the PIE facilities at AEE, Winfrith is part of the general management of wastes on the site. The disposal scene in the UK has been changing significantly in recent years. LLW can be disposed in a trench burial site at Drigg. The remainder of the waste ie. the lower end ILW and some 10 m<sup>3</sup> of upper end ILW is temporarily stored on site. The lower end ILW will be grouted with cement in standard NIREX unshielded 500 litre drums in a plant which is due to be operational in the second half of 1989. The cemented waste will be stored in a shielded store until a disposal route is available, probably about 2005.

### References

1. Royal Commission on Environmental Pollution, Sixth Report (London : HMSO) Command 6618, September 1976.
2. Command 6820, (London : HMSO).
3. P Harrop, Opening Statement at Proc. BNES Conference on Radioactive Waste Management 27-29 November 1984 (London : BNES), 1985 p.1.
4. The Radioactive Substances Act, 1960, (London : HMSO).
5. Department of Energy, Sizewell B Public Inquiry Report by Sir Frank Layfield, Volume 3, 1987.
6. G M Smith and M D Hill, National Radiological Protection Board, Lecture Notes 'Management of Low, Intermediate and High Level Solid Radioactive Wastes', NRPB LN61, May 1987.
7. S A Cottrell and T R Jay, 'PIE Radwaste - Handling and Transfer Techniques in the UK', Paper presented at 1982 Plenary Meeting of EEC Working Group on Hot Laboratories and Remote Handling, Mol 10/11 June 1982.

**Table 1 Typical Annual Arisings of Radioactive Waste  
from Post Irradiation Examination at AEE, Winfrith**

Waste Category	Approximate Volume (m <sup>3</sup> )	Approximate Radioactivity Ci            TBq		Details of Waste	Current Method of Storage/Disposal	Comments
Upper End ILW (Solid Waste)	1	Not measured		In cave waste eg. saw blades, electric cables, master slave manipulator 'fingers', polythene sheet, swabs	Packed into 54 litre cans and transported in Modular Flask to Sellafield Silo or stored on site	Based on throughput of 110 CAGR and 2 SGWR fuel elements. Some of backlog being compacted to reduce volume held on site
Lower End ILW (Solid Waste)	4	3	0.11	In cave wastes, monitored in cave to ensure that activity is sufficiently low	Stored on site in concrete lined drums, concrete thickness adjusted so that surface dose rate is less than 2 mSv/h	
LLW (Solid Waste)	120	6	0.22	All waste other than cave waste from active side of change barrier. Swabs, plastic sheet, gloves, shoe covers, scrap metal turnings	Separated into compressible/non-compressible. Compressible subjected to in-drum compaction. All LLW sent to Drigg for disposal.	
LLW (Cave Extract Filters)	2.5	2.5	0.09	Cave Extract Filters	Burial at Drigg	
LLW (Decontamination Liquids)	250	20	0.74	Effluent from decontamination plant	Passed to site central collection tanks of low level liquid waste. Treated as necessary (eg. to adjust pH) and discharged via sea pipeline.	



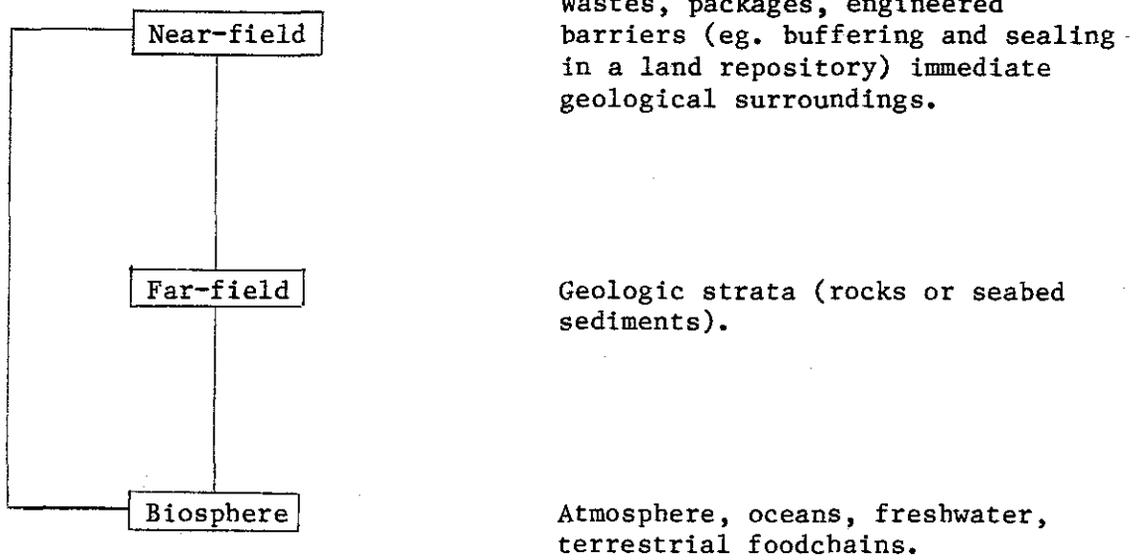


Figure 1. Modelling Framework for Disposal Assessments  
 (from Reference 1)



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