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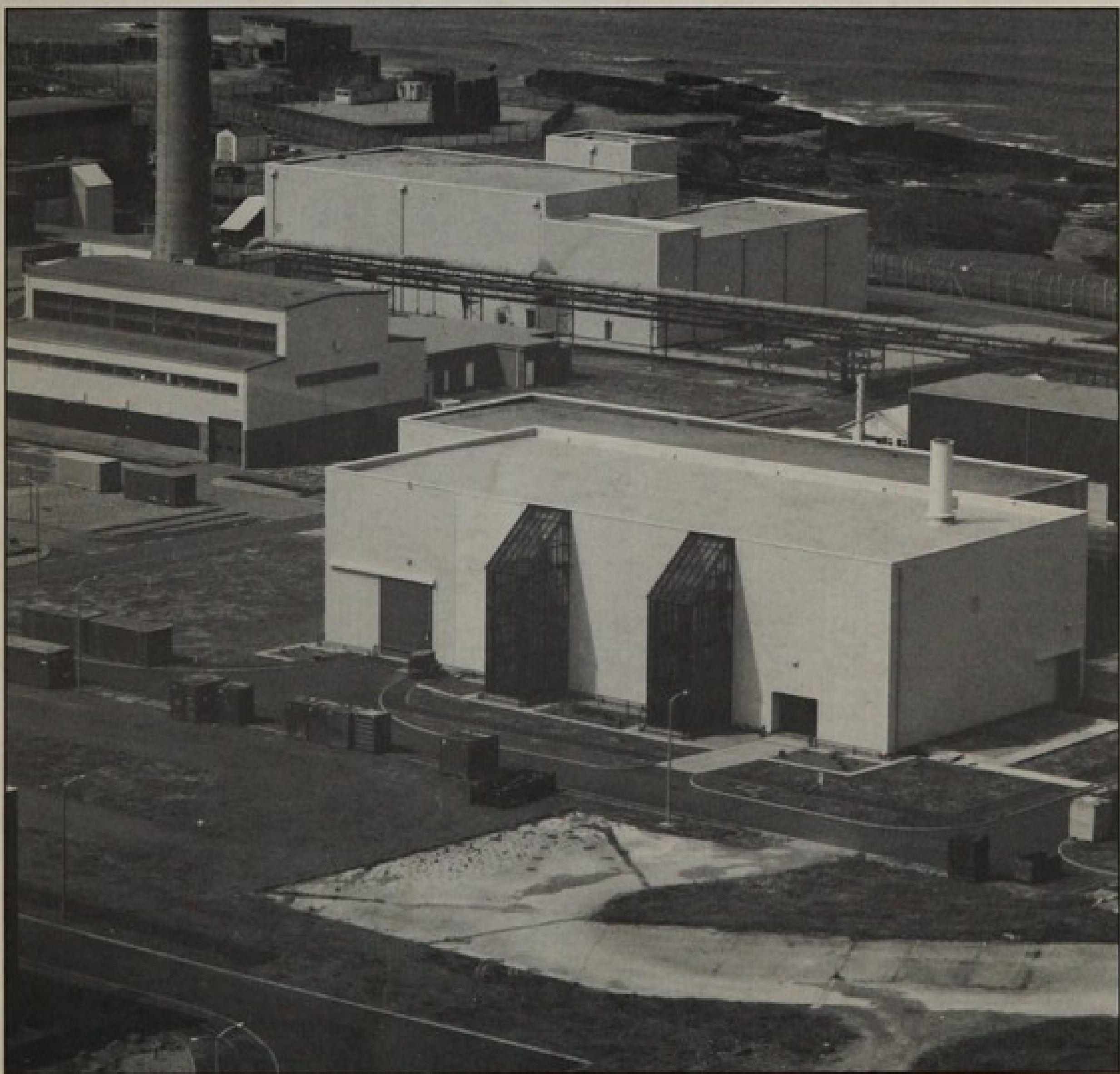
Advisory Committee on the Safety of Nuclear Installations

Study group on the accumulation of radioactive waste

Report on the accumulation of radioactive waste arising from sites operated by AEA Technology and from plant decommissioning

HSC
Health & Safety Commission



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ACSNI STUDY GROUP ON THE ACCUMULATION OF RADIOACTIVE WASTE

Report on the accumulation of radioactive waste arising from sites operated by AEA Technology and from plant decommissioning

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Cover photo: AEA Dounreay showing PCM store and adjacent equipment maintenance and decontamination centre (*courtesy of AEA Technology*)

Contents

Preface

I would like to thank the Chairman of the ACSNI Study Group on the Accumulation of Radioactive Waste for this report on AEA Technology sites. The Committee endorses the report and commends it for publication.

Professor J H Horlock FEng, FRS
Chairman of ACSNI

July 1993

Foreword

At its meeting on 7 December 1987 the Advisory Committee on the Safety of Nuclear Installations (ACSNI) set up a study group to make a written report to the committee on the impact of the accumulation of radioactive waste on nuclear sites including reprocessing plant, power stations and research facilities. This report, the final phase of the Study Group's work, relates to sites operated by AEA Technology and to radioactive waste arising from decommissioning activities.

Mr R H Campbell OBE, FEng
Chairman of the Study Group

March 1993

Preamble and terms of reference

1 The Advisory Committee on the Safety of Nuclear Installations (ACSNI) set up the Study Group on the Accumulation of Radioactive Waste on 7 December 1987.

2 The terms of reference to which the Study Group worked were:

(a) to advise ACSNI on the safety policy and practices for the accumulation and storage of all types of radioactive waste at nuclear installations;

(b) to advise ACSNI as to the most appropriate form (eg encapsulated, liquid etc) and type of storage for these wastes until the wastes are transferred to a repository, recognising that disposal may not be possible for some decades.

The Study Group and its work

1 The membership of the Study Group was as follows:

Mr R H Campbell OBE, FEng	*Chairman* Formerly Managing Director of Babcock Energy Ltd, and ACSNI member
Mr J Bridge	ACSNI member (TUC nominee)
Mr W Cassidy MBE	Member of Radioactive Waste Management Advisory Committee (RWMAC)
Professor J F Richardson OBE	Formerly Professor of Chemical Engineering, University College of Swansea, and ACSNI member
	Observers
Mr I Handyside	HM Inspectorate of Pollution
Dr I Hall	HM Industrial Pollution Inspectorate, Scottish Office
Mr B Spoonley	HM Nuclear Installations Inspectorate, HSE

2 The Study Group appreciates the willing help given by all those who have been approached for information and especially the staff of AEA Technology. The support of the Secretariat has been essential to the work of the Study Group.

3 ACSNI occasionally wishes to study topics in greater detail than is possible in the time available in its full meetings. When this problem arises a small study group is set up, the membership of which generally consists of Committee members, observers and other co-opted persons.

4 A study group is asked to examine, in depth, the subject referred to it and to further its understanding in order to assist ACSNI in advising the Health and Safety Commission (HSC) on the policy issues involved. However, a study group is not a technical committee as such.

5 The decision by UK Nirex Ltd in May 1987 to abandon its search for a shallow disposal site has implications for the accumulation of radioactive wastes on nuclear sites. Until it can be consigned to a repository, radioactive waste accumulates, in general, on nuclear sites. The environmental consequences of decisions about disposal are matters for consideration by the Secretary of State for the Environment in consultation with other Ministers, having taken advice from the Radioactive Waste Management Advisory Committee (RWMAC). ACSNI needs to form a view on the impact of such accumulations on the safety at nuclear sites in order to advise HSC. A Study Group on the Accumulation of Radioactive Waste was therefore set up to assist ACSNI in forming that view.

6 The Study Group made visits to and had discussions with other organisations in order to obtain background information and to provide a context in which to put the information gained from AEA Technology.

7 Stores of radioactive waste are vulnerable to accidents and external hazards which increase the potential risk of radiation exposure of the operators and the public. The form in which waste is stored and the type of packaging can affect both the size of potential releases due to accidents and the normal day-to-day dose to the operators on the sites. Furthermore, the period for which waste has to be stored on the sites, and the period for which the operators and the public are potentially at risk,

is determined largely by the availability of a repository for disposal of the waste. As part of its responsibility for the design and provision of the repository Nirex has to specify the conditioning required for each type of waste.

8 Disposal of waste in the UK is regulated by the Authorising Departments, ie Department of the Environment, Welsh Office, Scottish Office and the Ministry of Agriculture, Fisheries and Food, taking note of advice by RWMAC. Safety on sites is regulated by the Health and Safety Executive (HSE) appointed by HSC who is in turn advised by ACSNI. It is inevitable that there is some overlap between the work of ACSNI and that of RWMAC in this area and it is considered not only desirable but essential that both committees consider these aspects of the problem. A link between the two committees is provided by a Study Group member who is also a member of RWMAC.

9 The report of the first two phases of the Study Group's work on BNFL's Sellafield plant (Part 1) and on the UK nuclear power stations (Part 2) was published in July 1992,* leaving the AEA Technology sites and decommissioning to be reported on later.

10 It has been decided to deal with the third and fourth phases, AEA Technology and decommissioning, together in this report. The background to this decision is outlined below.

11 Under the terms of reference, the Study Group is to advise on the safety policy and practices for the accumulation and storage of radioactive waste including the most appropriate form and type of storage. It is on these aspects of decommissioning that the Study Group is charged to report. The report on Sellafield (Part 1) has already included comment on all the major waste handling and storage problem areas there. The only commercial power reactors which have been shut down - Berkeley and Hunterston A† - are in the first stage of decommissioning (defuelling at Berkeley was completed early in 1992; this continues at Hunterston) and it will be many years before the work on these plants reaches the stage where significant amounts of radioactive waste are being produced. The detailed plans for the later stages have not yet been set down so there is no comment the Study Group can usefully make at this time. Under the decommissioning heading this leaves only the projects in AEA Technology to be reviewed. It is simpler to comment on all the AEA Technology activities together since some of the waste facilities are used both for normal operational and decommissioning activities. This report does that and therefore completes the tasks laid on the Study Group.

12 A glossary of the terms and phrases used, including definitions of the different classes of radioactive waste, can be found in the Appendix.

* ACSNI Study Group on the Accumulation of Radioactive Waste, *Report on the accumulation of radioactive waste at BNFL Sellafield and at UK nuclear power stations*, HSE Books, ISBN 0 11 886342 8

† Note: Trawsfynydd power station was closed by Nuclear Electric in July 1993, after completion of this report

Introduction

1 The Study Group has noted that the waste facilities with the most serious problems are those which have been operating from the earliest years of the nuclear programme. At that time the same degree of consideration was not given either to decommissioning or to the long-term integrity of waste stores as is the practice today. Of the AEA Technology sites Harwell, Windscale and Dounreay are all in the category of very early sites.

2 The other important factor is the total activity of radioactive material on the site and this is greatest where highly irradiated fuel is reprocessed and where power reactors are decommissioned. Dounreay is the only AEA Technology site where significant quantities of fuel have been reprocessed; but the amount of reprocessing there has been much lower than that at Sellafield.

3 In 1986 the United Kingdom Atomic Energy Authority became a trading company and the then Department of Energy took responsibility for expenditure on waste handling and decommissioning of redundant plant and buildings related to all activity before that date. The Department of Trade and Industry (DTI) has inherited this responsibility. For the period subsequent to 1986 AEA Technology commercial contracts included provision for waste management and decommissioning costs.

4 AEA Technology is now organised into business units, the heads of which are ultimately responsible for safety in their own sphere of operations. In addition, there is a Director for Safety who ensures that adequate safety standards are maintained throughout the organisation. The Director is represented by a 'Head of Safety' at each site. Across the whole organisation, decommissioning and management of radioactive waste, including its preparation for final disposal, is the responsibility of the Corporate Decommissioning and Radioactive Waste Management Operations Directorate (DRAWMOPS).

5 Before the setting up of the business units and the Corporate DRAWMOPS Directorate, the Director of each site was responsible for the safety of all operations on the site. The practices and arrangements were audited by the UK AEA's Safety and Reliability Directorate with safety submissions approved by peer review at meetings of the Site Safety Committee.

6 The nuclear sites of AEA Technology have been subject to licensing only since 1990. The operators continue to be fully responsible for the safety of their plants but the regulators (HSE acting through its Nuclear Installations Inspectorate (NII) and the Authorising Departments) have to be satisfied with the characteristics of the plants, the techniques and procedures used to operate them and their environmental impact. There is inevitably a more formalised approach now with distinct organisations - AEA Technology and the regulators - involved. This change has given rise to a very considerable work load in both the production and clearance of safety cases. However, this is being effected without any serious delays.

Funding of waste handling and decommissioning within AEA Technology

7 With the financial liability for waste handling and decommissioning for AEA Technology sites predominantly in the court of DTI, the budgeting process and control of expenditure has to follow the normal procedures of government departments. This involves a ten-year rolling review of the programme and its up-to-date costs together with a four-year programme letter from DTI, but with expenditure approved only for the current year. Government guidelines set down that the plans should be produced on the basis of the lowest discounted cost so long as safety is not impaired.

8 In its management of waste AEA Technology has to comply with UK policy which can be summarised as follows: the basic objective is to ensure that as far as possible, waste management procedures are optimised in respect of the total system, extending from the creation of wastes to their final disposal. If, and for so long as, an appropriate waste disposal facility is not available, the objective will be to avoid foreclosing waste management options without justification. This entails not treating that waste which may remain safely stored in untreated form. In other cases

treatment may be justifiable in order to improve the safety of storage.

9 Further delay in the national repository programme will have adverse effects on cost and on dose to workers through waste having to be handled as waste packaging deteriorates and as old stores have to be replaced. Where Nirex specifications for conditioning particular wastes are not available, a choice has to be made between continuing to store in the raw form, thereby increasing the hazard, or going ahead and applying what is considered to be the most appropriate form of conditioning and thereby risking the possible additional task of having to recover the waste and repackage it when the repository specification is clarified.

10 The AEA Technology decommissioning strategy is to limit work to that needed to bring redundant plant and buildings to a safe state where surveillance and maintenance costs can be minimised unless complete decommissioning can be demonstrated to be the most cost-effective option for specific situations. The levels of surveillance and the tasks required to achieve a safe shut-down state are dictated by the nature of the plant and this sets the expenditure on stage 1 of the decommissioning process. Beyond this first stage there are choices to be made about how far and how quickly to proceed with decommissioning. The approach being followed is to proceed with further decommissioning on the basis of minimum discounted cost using a discount rate of 6%. Account has to be taken of storage costs for the active materials arising from the decommissioning process in the absence of approved disposal arrangements. This approach must inevitably stretch the decommissioning programme over a very long period.

11 An exception to this strategy of limiting decommissioning work to achieve minimum discounted cost is the work on the Windscale AGR. This is programmed to be fully decommissioned to a green field site in order to develop and demonstrate decommissioning techniques and to provide information on costs.

AEA Technology sites

12 The sites of AEA Technology are shown on Figure 1.

13 The greatest accumulations of radioactive waste are associated with power reactors and in particular with the reprocessing of the fuel irradiated in them and with their decommissioning. Dounreay has both power reactors and fuel processing; Windscale and Winfrith have both had power reactors operating, but all are now shut down and in various stages of decommissioning. Winfrith still has two experimental reactors operating. Harwell has had experimental and materials testing reactors and again these are shut down.

14 As preparation for this part of their report the Group visited AEA Technology establishments at Harwell, Winfrith and Dounreay to view the relevant facilities and to discuss any operational problems. They also held discussions at Risley on Windscale, Springfields and the one small plant at Aldermaston which is the liability of AEA Technology.

15 The fuel removed from the Winfrith SGHW reactor, BEPO at Harwell and the reactors at Windscale (AGR and the Windscale Piles) has been sent to Sellafield for storage/reprocessing and that from the Harwell reactors DIDO and PLUTO sent to Dounreay where it has been reprocessed, as has fuel from DMTR, DFR and PFR. The capacity of the reprocessing facilities at Dounreay is about 1% of that at Sellafield.

16 High-level or heat-generating waste (HLW) arises only from the reprocessing of highly irradiated fuel rods; Dounreay is the only AEA Technology site which stores HLW.

17 In general, none of the accumulations of intermediate-level waste (ILW) presents problems of the severity of some of those outlined in the Study Group's report on the Sellafield site, eg the magnox silos. The amounts of activity are orders of magnitude less and there are not the same chemical complications as with magnox waste. There is one exception - Pile 1 at Windscale. The accumulation of activity here which resulted from the accident is commented on in paragraphs 57-61.

18 There is a similar debate, referred to in the report on Sellafield, as to when particular varieties of waste should be packaged for disposal depending on the potential mobility of the waste material and when agreement might be reached on

Figure 1 AEA Technology sites

DOUNREAY

Dounreay materials testing reactor (DMTR)

Dounreay fast reactor (DFR)

Prototype fast reactor (PFR)

Dounreay cementation plant (DCP)

WINDSCALE

Piles 1 and 2

Fuel development laboratories

Post-irradiation examination laboratories

Windscale advanced gas cooled reactor (WAGR)

WINFRITH

Steam generating heavy water reactor (SGHWR)

High temperature reactor DRAGON

Zero energy experimental reactor ZEBRA

Two small experimental reactors (still operating)

HARWELL

British experimental pile (BEPO)

Materials testing reactors (DIDO and PLUTO)

Graphite low energy experimental pile (GLEEP)

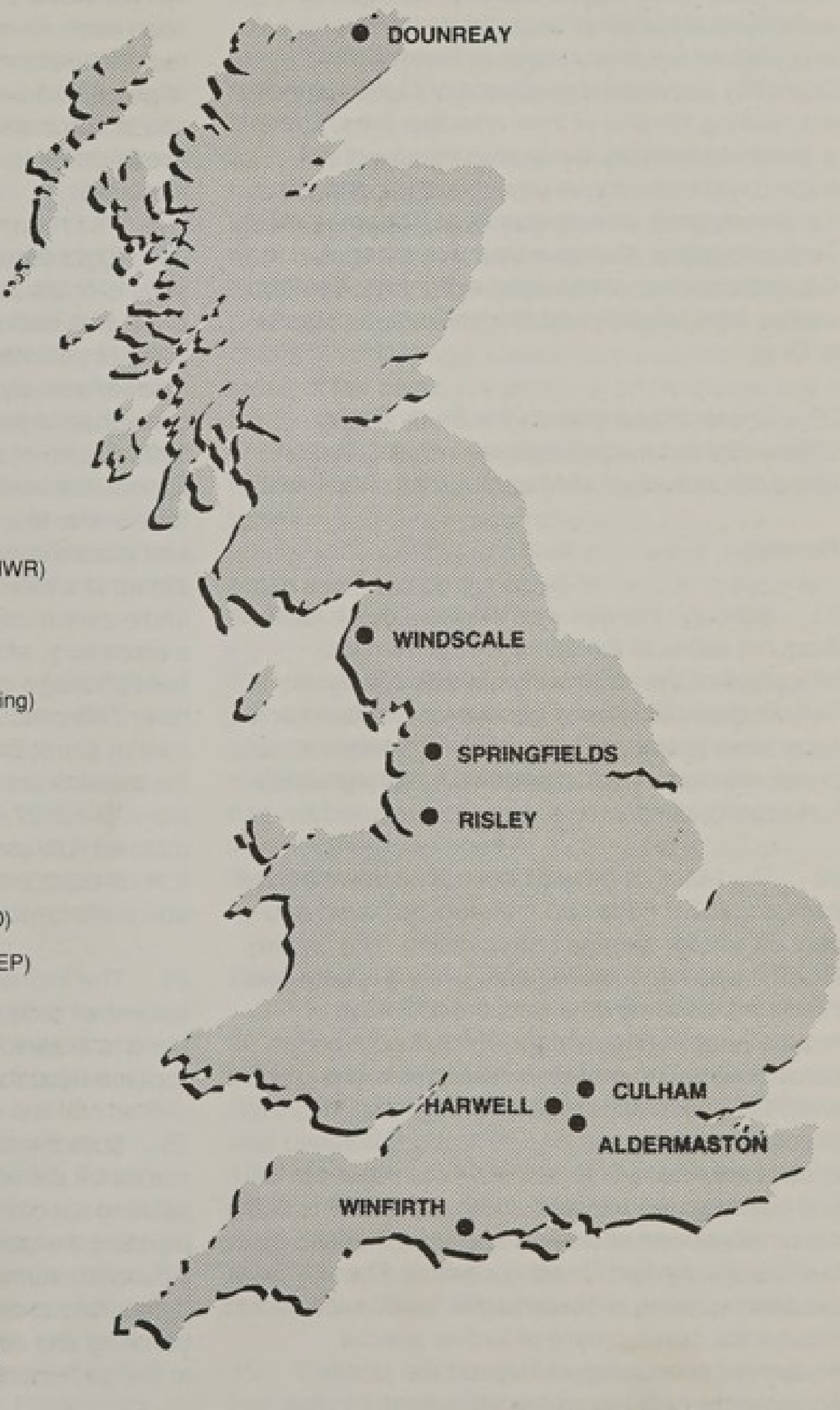
Variable energy cyclotron

SPRINGFIELDS

Laboratories (being decommissioned)

ALDERMASTON

Plant for making prototype fuel for Dounreay prototype fast reactor



how that mobility affects disposal requirements. To that is added the question of when it is most economic (as defined by government guidelines) to carry out the packaging work.

19 All sites except Dounreay send their low-level waste (LLW) to Drigg. Dounreay has its own authorised disposal arrangements on site. Incinerators are in operation at Harwell and Dounreay to reduce the volume of LLW, but these are nearing the end of their effective lives. There is a tendency towards the increasing use of supercompaction for volume reduction and a supercompactor is in operation at Dounreay. AEA Technology has also operated a number of supercompaction campaigns at Winfrith, treating wastes from Winfrith and Harwell before disposal to Drigg.

20 Those aspects which the Study Group considered to be significant are commented on under the individual site headings which follow.

Harwell

21 Although Harwell was the first UK AEA site, it does not suffer to the same extent from the difficulties of the other early sites at Windscale/ Sellafield and Dounreay because it has been an experimental station throughout with only low power reactors operating and with no large-scale fuel reprocessing.

22 The reactors have all been shut down and all except GLEEP have had their fuel removed and sent off site for storage/reprocessing. The fuel in GLEEP was hand loaded and, while it is only lightly irradiated, its removal awaits the provision of remote handling equipment which is now under construction. The materials testing reactors DIDO and PLUTO are still in the first stage of decommissioning and GLEEP and BEPO are under care and maintenance. Of the other plants and buildings the variable energy cyclotron is being decommissioned and there are a number of facilities earmarked for early closure. The decommissioning of these plants is not expected to require the development of further special equipment or techniques beyond the robotic equipment which has proved successful in the decommissioning of gloveboxes and shielded cells.

23 The decision in 1983 to cease sea disposal of waste has left a considerable volume (1900 m^3) of LLW and ILW packed in drums. Harwell, which was the collecting and dispatching centre, has over 90% of this with Winfrith having the remainder. The drums which are of mild steel with a concrete lining were not intended for long-term storage, but are still considered acceptable by the operators for the short term. Overpacking or repackaging will be required before sending to a Nirex repository. Lack of precise knowledge of the contents could give rise to some difficulty, particularly if the Nirex specification is exacting with regard to organic materials.

24 Eight thousand cans of (alpha)beta/gamma solid ILW are stored below floor level in building B462.2/.9, the cans being of various designs and sizes (2 - 45 litres). This store does not meet modern standards and waste has not been consigned to it since licensing began in October 1990. Some of the cans are corroding and a special machine will be required to retrieve them for transfer to a cell line where they will be assayed and placed in 400-litre drums. These drums will be stored in a new vault store, B462.27, which is under construction, awaiting eventual despatch to a repository, after conditioning. There is a short-term shortage of storage capacity for ILW arising now. This difficulty will be removed when an interim store, B462.26, becomes fully available. In the medium term (until about 2005) the new vault store, B462.27, will provide storage for all the planned ILW production. A new store for alpha ILW, B462.23, is now fully operational and will be adequate for the foreseeable future.

25 The incinerator which is used to reduce the volume of solid LLW is approaching the end of its life. It is likely to be replaced by a mobile supercompaction unit.

26 Both the uncertainty in the programme time-scales for the Nirex repository and the clearance of packing specifications make for difficulty in planning the storage facilities. If the delay becomes extended, some of the waste packaging will deteriorate and could lead not only to double handling and additional dose to operators but also to the generation of additional secondary waste.

Winfrith

27 The power reactors at Winfrith have been

shut down - DRAGON in 1974 and the steam generating heavy water reactor (SGHWR) in 1990. The experimental reactor ZEBRA has also been shut down leaving two small experimental reactors operating.

28 Following the shut down of DRAGON, the highly enriched coated-particle fuel was removed from the reactor in 1975. The fuel elements were dismantled and the fuel compacts loaded into mild steel containers. These containers were placed in two stores which are formed by arrays of holes in concrete blocks set in pits in the floor. Water accidentally entered one of the stores and a number of the containers have been affected. Studies have shown that there is no risk of criticality either at present or during the lifting of containers with water present. There is the added difficulty of lifting the containers if they are heavily corroded. The intention is to repackage the fuel from the damaged containers and to store all the fuel in 500-litre drums in a new surface store for 50 to 80 years by which time the activity levels will have fallen to the point where it is anticipated that it should be possible to dispose of the fuel compacts as ILW.

29 Stage 1 decommissioning of the SGHWR is proceeding in a straightforward manner with the fuel being sent to Sellafield for storage/reprocessing. Most of the other waste arising at this stage of the decommissioning will be LLW. The disadvantage of a direct cycle reactor system in the decommissioning phase can be seen from the additional work involved in disposing of the power generating plant.

30 The largest accumulation of ILW in respect of the SGHWR is in the sludge tanks. They contain sludge and decontamination liquors from the SGHWR active drain system. There are four tanks - single skinned with reinforced concrete walls 600 mm thick. Three of the tanks are full. Tests have shown that the contents, of which about 32% is solid material, can be readily homogenised to permit removal from the tanks for conditioning. The construction of the tanks does not permit full inspection and, while no deterioration can be seen, it will be difficult to satisfy the regulators that they have a life beyond five to ten years. Preliminary design and development are in progress on a plant for lifting the contents and conditioning with cement. These sludges are at the lower end of the ILW range and within 20 years will have decayed to LLW; in view of this decay alternative strategies are under consideration which involve continued storage either in the existing tanks or after transfer to new tanks.

31 The fissile materials store is no longer required to the same extent for its original purpose and provides good storage conditions for the alpha active plutonium-contaminated materials (PCM).

32 The inventory of heavy water stored on site has been increased by the emptying of the SGHWR moderator circuit and the transporting from Harwell of the heavy water from DIDO and PLUTO. Some of the heavy water is tritiated and detection equipment is fitted throughout the store to check for leakage. Leaks have occurred as a result of the acidic conditions in a few drums, but the leakage is at a low rate and easily detectable. There is no longer a market for heavy water and it is likely that it will have to be disposed of. Disposal to sea would require an increase in the authorisation limit, but it is now believed that the entire stock will be accepted by the Canadians for treatment and reuse.

33 As part of AEA Technology's diversification of activities there are two stores with 800 000 gaseous tritium luminous devices which were used to illuminate telephone dials. The disposal route has not been established. In addition to these at Winfrith there are another million and a half of these devices in store in the UK.

Dounreay

34 The AEA Technology site at Dounreay has been predominantly devoted to fast reactor development. The Dounreay fast reactor (DFR) was used throughout its operating life (1963 to 1977) to test fuel for the 250 MW prototype fast reactor (PFR). The PFR was intended to prove the main design features on which a commercial reactor would be based. The Government has decided that the PFR will be shut down in 1994.

35 The fuel from both the above reactors and that from the materials testing reactors at Dounreay and Harwell is reprocessed at Dounreay and this activity produces the majority of the waste arising on the site. The capacity of the

reprocessing plant is only 1% that at Sellafield and the total activity of waste correspondingly lower.

36 Prototype fuel for PFR was made in a special line at Aldermaston. Plans for decommissioning this facility are in the preliminary stage.

37 The Dounreay materials testing reactor (DMTR) was decommissioned to stage 1 level in 1969. Some further decommissioning has been carried out subsequently to provide spares for the Harwell reactors DIDO and PLUTO.

38 The Dounreay site is not well provided with waste storage capacity. In a number of cases stores are almost full and it has been left to a late stage to arrange for more capacity to be provided. The more important cases are commented on below.

39 DFR is part way through its stage 1 decommissioning programme. The entire secondary circuit, including the NaK coolant, has been disposed of and all the secondary circuit penetrations through the containment sphere wall have been sealed. The core fuel, except for the remains of one stuck element, has been removed and reprocessed, but the reactor still contains 1025 breeder elements. Most of these are thought to be jammed in the top and bottom plates with some jammed at intermediate positions because of poor cooling during operation. Special equipment will be required for the removal of these elements. There is still NaK in the primary circuit held at a temperature of 60°C to keep it molten. When it is removed, the same process as that developed for the secondary circuit NaK will be used - react with caustic soda and neutralise. The resultant will then be decontaminated. The method of disposal of the breeder fuel has yet to be resolved. The removal of the breeder will start in about five years' time and decommissioning could be completed within 20 years although the timescale may be extended due to financial considerations.

40 PFR decommissioning will follow the same general lines as DFR, starting after reactor shut-down in 1994 with the reprocessing of the driver fuel charge completed by about 1997. As with the DFR breeder fuel, there are no reprocessing or disposal routes identified as yet for the PFR breeder. Nor is there provision at Dounreay for long-term storage of the plutonium which will arise in significant quantity from the reprocessing operations. It is expected that this plutonium will be stored by BNFL at Sellafield after conversion to solid plutonium oxide.

41 The only HLW on site is the DFR and PFR fuel raffinate. It is stored in double-skinned tanks awaiting a decision on which encapsulant should be used - glass, cement or synroc (synthetic rock). The earlier tanks in which the lower activity DMTR, DIDO and PLUTO raffinate is stored are single skinned. There are no in-built provisions for inspecting these tanks and shortage of capacity could limit the extent of further reprocessing. The cementation of DMTR raffinates is being given a high priority.

42 Storage capacity for ILW is tight at Dounreay. The high beta/gamma wet silo is nearly full and the high alpha/beta/gamma store will be full in 1994. The PCM store is nearly full, but a relatively simple modification will extend the life to 2001.

43 The completion of modifications to the Dounreay cementation plant (DCP) will, subject to agreement by the regulatory authorities and Nirex, permit the encapsulation of DMTR raffinate to start in 1994. It is also intended to be used to overpack into 350-litre drums the solid ILW which is presently stored in 200-litre drums.

44 The high (activity) beta/gamma silo has been in operation since 1971 and stores the waste under water. It is of single-skinned reinforced concrete construction and has no leakage detection system other than sampling of ground water. No provisions have been made for emptying the contents; however, these are not expected to have formed a solid mass as has the magnox waste at Sellafield.

45 A shaft close to the shore, excavated originally in 1956 to provide access for the driving of the sea discharge tunnel, was sealed off from the tunnel and until 1977 was authorised for the disposal of various types of waste including some ILW. There is uncertainty regarding the amount and type of waste in the shaft and a continuing effort is required to monitor and control the water level and effluent. A review of the future of this facility is in hand.

46 The Dounreay policy for the disposal of solid LLW is to continue to place it in the site LLW pit

complex which has been authorised as a disposal facility since the early days of the Dounreay site. The pits were excavated to a depth of 7 metres into the bedrock and drained to allow the water movement through the pits to be controlled. There are seven pits for LLW plus one reserved for non-active hazardous material - mainly asbestos. Four of the pits are full and covered over with a metre of earth. The other three are still open and are used separately for drummed waste, bulk waste and the supercompacted drums. The latter are grouted in as the pit is filled. The pits are all nearly full and there are stacks of waste in drums above ground in the area. It had been intended to store these mild steel drums only until they could be super-compacted but delays have resulted in the drums corroding to the point where this is no longer possible for most of them.

47 A planning application to the Highland Region Council was made in 1992 to extend one of the pits in the adjacent area, but no decision has been reached (March 1993). If permission is not granted, the LLW will have to be sent to Drigg. Even if an extension is granted, there will be a need to improve the protection of the present untidy stacks of drums. The Study Group considers that the storage of LLW is unsatisfactory, especially as many of the drums were placed there in the last five years. Plans are now in hand to provide temporary storage of new LLW arisings and to protect the above-ground stack of drums in preparation for their removal and treatment.

48 The incinerator which has been used for volume reduction of combustible LLW is ageing and may be replaced by a unit with better effluent clean-up if planning permission is forthcoming.

49 A supercompactor, operating since October 1990, has a capacity large enough to handle the backlog as well as the current arising. However, a large proportion of the drums stored outside in the LLW pit complex are unlikely to be in a suitable condition for compacting. The assay equipment on the supercompactor is new and efficient and will be complemented by the addition of equipment for alpha measurement.

50 LLW liquids are discharged to sea after sampling in one of the effluent storage tanks. There are only two of these tanks and while one is filling, the other is sampled and then discharged. The throughput of liquor is such that the tanks are utilised full time. There is thus no provision for taking a tank out of service for maintenance and keeping the system operating at full rate; managerial restrictions have to be placed on plant operations to minimise active liquor arising while maintenance is carried out. The tanks were not designed to be inspectable and checks for leakage are restricted to sampling ground water. The sea discharge pipelines have been replaced this year.

Aldermaston

51 The only relevant Aldermaston topic is the decommissioning of the prototype fast reactor fuel plant set up when the Aldermaston plant was part of the UKAEA. This is a collection of 60 glove-boxes and no particular problem is foreseen.

Springfields

52 The UKAEA laboratories at Springfields are being decommissioned. They handled depleted, natural and enriched uranium, but the only significant hazard remaining is from beryllium in ventilation dusts. Plans are being made to deal with the situation and then to hand the site back to BNFL.

Windscale

53 The AEA Technology Windscale site forms an enclave within the BNFL Sellafield site. Any waste generated from the normal day-to-day operations is transferred to the Sellafield site for storage in the case of ILW and disposal to Drigg in the case of LLW. The activities considered by the Study Group are therefore all related to decommissioning.

54 The plants being decommissioned at Windscale are redundant fuel development laboratories, post-irradiation examination laboratories, the Windscale advanced gas cooled reactor (WAGR) and the two Windscale Piles. The laboratories do not present any difficult or unusual problems.

55 The WAGR operated from 1963 to 1981 at high load factor, being shut down when the commercial AGR programme no longer required it as a test facility. It was decided to decommission

the plant to develop methods and techniques for decommissioning, to demonstrate the feasibility of ultimately decommissioning a power reactor back to a green field site and to provide a better basis for costing. The work was started in 1981 and the present state is that the fuel has been discharged, the refuelling machine removed, and the reactor top dome removed. The remaining radioactive material consists mainly of structural materials such as steel, graphite and concrete, which have become activated by neutron irradiation. The next stage is to dismantle the reactor vessel. An encapsulation plant has been constructed for handling the active wastes, but modifications have been called for before the plant can be licensed. The waste will take the form of concrete monoliths which can be disposed of directly to a repository subject to agreement by Nirex and Authorising Departments. Because the repository does not exist, a store is being built to house the monoliths. This exercise is proceeding well and gives rise to no particular concerns; however, financial priorities may require some slowing down of the overall programme.

56 The same cannot be said for the decommissioning of the Windscale Piles. These are on the AEA Technology site, but the chimneys and pond are within the BNFL site boundary.

57 Both Piles were shut down in 1957 following the fire in Pile 1. The undamaged fuel from Pile 1 was discharged, but it is estimated that the core still contains 15 tonnes of damaged fuel with a further 5 tonnes of damaged fuel elements external to the core - mostly in the water ducts through which fuel was transferred to the pond but with some in the air ducts. Pile 2 fuel was discharged, but the core is still believed to contain a few fuel elements. The graphite core of this reactor was not annealed before fuel removal and is estimated to be storing 10^{12} Joules or 300 MWhr of Wigner energy. With both piles vented to the atmosphere through the filters in the chimneys, great care continues to be necessary to avoid any release of material being generated during the course of remedial activities.

58 In 1982 work started on phase 1 of a decommissioning programme to put a barrier between the cores and the chimneys. This was completed in March 1993 for Pile 1 together with a new ventilation system. By 1996 the fuel should be removed from the water and air ducts for both Piles but not from the core. Design work and procurement of equipment for the removal of fuel from the air and water ducts is in hand. It is not yet clear what methods should be used to dismantle the graphite stack. Great care will be required in the removal of the fuel from Pile 1 to avoid further damage and during work on Pile 2 because of the high level of stored Wigner energy. A two-and-a-half year programme of work is planned to answer these questions. Flooding with argon or water are possibilities but the structure not being leaktight makes this more difficult.

59 The structure of the chimneys is deteriorating and they also require a great deal of work to be done. They have to be reduced in height by removing the filter and diffuser/concentrator sections. The chimney lining of asbestos, clad in aluminium, then needs to be removed and the chimneys capped. This will all have to be done in the presence of considerable activity, particularly in the Pile 1 chimney.

60 The fuel handling route to the pond needs to be refurbished and the pond emptied and decontaminated.

61 There is thus a very long programme of work required to get the Piles into an adequately safe condition. At present they fall far below the 'as safe as reasonably achievable' criterion.

Summary and general comments

62 Part 1 of the Study Group's report commented on the position at Sellafield and Part 2 on the commercial nuclear generating stations. Part 3 was to be on the management and storage of waste within AEA Technology and Part 4 on decommissioning throughout the nuclear industry. However, with more than 80% of the AEA plants having been or being decommissioned it was decided to combine both aspects in this final report. The terms of reference of the Study Group are to review the management and storage of waste arising during normal operation and during the decommissioning process. Since the only two commercial nuclear stations to be shut down - Berkeley and Hunterston A - are in the first stages of decommissioning and no significant quantity of waste has yet arisen, there is no comment to be

made here; and the report on Sellafield has already reviewed all the major waste handling and storage activities there. The three parts of the Study Group's work therefore deal with the whole area to be covered.

63 The Study Group's reviews have shown that the problem areas in waste handling and storage are associated with those plants constructed in the early years of the nuclear industry and principally with the products of reprocessing of highly irradiated fuel. The AEA Technology sites have been operating over the same time span as Sellafield, but the problems are very much less serious because firstly, the amounts of radioactivity are so much smaller and secondly, the chemical problems associated with magnox are missing.

64 However, the Windscale Piles are an exception to the above generalisation. There are still serious problems not cleared up since the accident occurred there in 1957. Apart from discharging as much of the fuel as possible, the reactors were left undisturbed until 1982 when work was started to design and construct a barrier between each reactor and the chimney and to fit a new ventilation system. In the case of Pile 1, it is estimated that there is still 15 tonnes of damaged fuel in the core and a further 5 tonnes in the water and air ducts. The new barrier was in position in spring 1993.

65 At Dounreay the situation is not out of control, but there is very much of a hand-to-mouth existence as regards storage of waste, particularly with solid ILW. There is limited storage capacity for active liquors to allow the reprocessing of DMTR fuel to continue beyond the present campaign and the tanks being used for this purpose are single skinned with no provision for inspection. Remedying of this situation awaits the active commissioning of the cementation plant. Solid ILW is having to be transferred from store to store to make use of what capacity is available. The wet silo for ILW is nearly full and there is as yet no plan or provision for the removal of the waste. The store for PCM is nearly full, but a relatively simple modification will extend its life to 2001. A plan is needed to determine what to do regarding the waste which has been disposed of in the waste shaft. The LLW disposal pits are nearly full and planning permission has been sought for an extension. There is an untidy, unprotected stack of drummed waste in the area awaiting supercompaction, but the effect of the sea and weather on the mild steel drums will prevent many of these being supercompacted. The new supercompactor is working well on current waste arising, and has first-class beta and gamma assay equipment to which is to be added alpha assay capability.

66 The positions at Harwell and Winfrith are satisfactory with actions in hand to deal with the problems which have arisen.

67 The change in status to licensed sites in October 1990 has resulted in a high work load in producing and assessing safety cases for all plants. Inevitably the different arrangements call for a more structured and a more highly documented approach and this is taking time to work through. However, there have in general been no hold-ups of an important nature in plant operation.

68 The changed safety responsibilities in the new AEA Technology structure should produce a consistent approach across all sites, but inevitably one feels that something is lost in not having one person on a site with direct responsibility for safety over the whole site. However, the Study Group did not come across any case where this change specifically has resulted in lower safety standards.

69 While HSE's NII and the Authorising Departments are both working to government guidelines, the Study Group detects a difference in emphasis on the timing for the encapsulation of waste. There is an understandable tendency for NII to ask for early encapsulation, particularly if the waste is in liquid or slurry form, to lessen the risk of accidental release; whereas the Authorising Departments lean more to deferring the encapsulation of waste until it is quite certain that the process used will package the waste in a form acceptable to Nirex for final disposal. Considerations of safety to the operators of the present sites lead the members of the Study Group to support the emphasis of NII; but the best solution would be to speed up the issue of Nirex specifications which could have a significant impact on the waste storage capacity required and in some cases prevent double handling of waste with the added operator dosage that can incur.

70 In concluding its report the Study Group

would like to note that all of its findings are well understood by AEA Technology and HSE. It wishes to underline its three principal concerns:

(a) the generally unsatisfactory situation concerning the two *Windscale Piles*;

(b) the problems associated with the inadequacy of the *waste storage capacity at Dounreay*; and

(c) the delay both in the *Nirex repository programme* and in the *agreement on packaging specifications* which is preventing the more secure storage of waste.

Appendix: Glossary

Cell

An enclosure, usually heavily shielded, in which radioactive materials can be safely processed or stored and which is not generally accessible to personnel.

Conditioning

The conditioning of radioactive waste involves treatment to achieve a proper and fit condition for storage and/or disposal.

Containment

The prevention of release, even under the conditions of an accident, of unacceptable quantities of radioactive material. Also, commonly, the containing system itself.

Decay

The change in activity of radioactive material as it transforms spontaneously from one nuclide into another or into a different energy state of the same nuclide. Radioactive decay is usually accompanied by the emission of charged particles and/or gamma-rays.

Decommissioning

The process of recovery and removal of radioactive materials from a disused nuclear plant in order that the plant may be made safe and its site made available for other uses.

Disposal

The disposal of radioactive waste implies its dispersal or emplacement in a medium without the intention of retrieval.

External dose

External dose is that to which the person is exposed from radiation sources outside the body; the average dose rate may be reduced by moving the person from the source of radiation to another job with less exposure.

Fuel storage pond

A large container, usually made of concrete lined with stainless steel, filled with water in which irradiated fuel is stored after its removal from the reactor. Fuel is stored in this way until its activity has decayed to the desired level and it can be processed. The water acts as a coolant and a radiation shield.

High-level or heat-generating waste (HLW)

Waste in which the temperature may rise significantly as a result of its radioactivity, so that this factor has to be taken into account in designing storage or disposal facilities.

Individual dose

Workers exposed to radiation carry personal monitors which measure the amount of radiation to which each individual has been exposed. The units used for individual dose are 'milli-Sieverts per year' (mSv/y).

Intermediate-level waste (ILW)

Waste with radioactivity exceeding the boundaries for low-level waste, but which does not require the generation of heat to be taken into account in the design of storage or disposal facilities.

Internal dose

Internal (or committed) dose arises from radioactive species ingested into the body and consequently moves with the person.

Low-level waste (LLW)

Waste containing radioactive materials other than those acceptable for dustbin disposal, but not exceeding 4 GBq/te alpha or 12 GBq/te beta/gamma.

Radioactive waste

Material which no longer serves a useful purpose and contains radioactive nuclides.

Wigner energy

Displacement of carbon atoms in the crystal lattice of graphite as a result of continued bombardment with neutrons. It leads to changes in overall shape and size of graphite, and the build-up of stored energy which may be released as heat. The effect is serious only in reactors operating at temperatures below those needed for power production.

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