RADIOACTIVE WASTE MANAGEMENT IN THE UNITED KINGDOM

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ABSTRACT

The management of radioactive waste in the UK is described. The role of the waste producers is to prepare it for disposal and the role of UK Nirex Ltd is to provide the necessary transport system and disposal facilities.

The waste with low levels of activity will be put in trench type disposal facilities and four sites have been identified as having suitable potential, but only one will be required. The intermediate level wastes will go deep underground and desk studies are being made of under sea bed locations out at sea, close to the coast and under land locations. There is a variety of rock formations in the UK and again at least three locations will be finally identified for field investigations.

The need for a transport and container system with a fully developed range of standard containers is noted. The importance of informing the public at all stages is stressed.

INTRODUCTION

1. Commercial nuclear power stations, supported by fuel production and irradiated fuel reprocessing plants, have been operating in the UK since 1956. These stations and the associated plants are the principal sources of radioactive waste, although the research and development establishments of the United Kingdom Atomic Energy Authority (UKAEA) also make a contribution, notably from the Dounreay Prototype Fast Reactor which has its own fuel reprocessing plant. Additionally, other sources of waste, generally of low activity, arise from the production and use of radioactive sources for non-nuclear industrial purposes and in universities and hospitals. Coincident with the development of nuclear power in the UK, a regulatory system of licensing, control and authorisation has been built up, administered by various Government departments and their agencies; this system of regulation covers all aspects of power generation including the storage, transport and disposal of radioactive wastes. Hence the UK has much experience in the waste management field and can offer advice in many areas for your consideration.

THE ROLE OF UK NIREX LTD

2. The 1982 White Paper on Radioactive Waste Management (Command (Cmnd) 8607, Her Majesty's Stationery Office (HMSO)), reported that "The Government has agreed that the component parts of the industry should, in co-operation, set up a Nuclear Industry Radioactive Waste Executive (NIREX) in order to provide a mechanism by which they can successfully fulfil their own responsibilities in this field and work within a comprehensive plan for waste management".

3. In November 1985, the Executive was reconstituted as United Kingdom Nirex Limited with shares held by the Central Electricity Generating Board (CEGB), British Nuclear Fuels plc (BNF plc), South of Scotland Electricity Board (SSEB), UKAEA and a special share held by the Department of Energy on the Government's behalf. The Company's task is to ensure that the above Government strategy for the management of low and intermediate level radioactive wastes can be implemented, in particular by the provision of appropriate disposal facilities. Responsibility for the strategy remains with the Government (the Secretaries of State for the Environment, for Scotland, and for Wales). This involves managing the necessary work for planning, developing and eventually operating disposal routes for the wastes arising from the partner organisations and other waste producers such as Amersham International, medical, industrial and educational establishments and the Ministry of Defence if it so wishes. The aim is that Nirex should provide a complete disposal service for solid low and intermediate level radioactive wastes.

THE NATURE OF THE WASTE

4. Radioactive waste arises at all stages of the fuel cycle for the nuclear generation of electricity, which now accounts for about 20% of the electricity generated in Great Britain. These stages include uranium enrichment, fuel fabrication, the fission process itself, spent fuel reprocessing and finally, decommissioning. Radioactive wastes also arise from the beneficial uses of radioactive materials in medicine and industry, and from the nuclear weapons programme.

5. The wastes generated cover a wide range of toxicity and radioactivity. For convenience, the industry talks in terms of high level waste (HLW), intermediate level waste (ILW) and low level waste (LLW).

6. HLW generates significant heat as a result of rapid radioactive decay. The wastes arise from the first stage of reprocessing irradiated fuel. Although the quantities are small (only some 4000

tonnes are expected to arise in total by the end of the century), HLW contains 95% of the total radioactivity from the nuclear fuel cycle.

7. ILW has negligible heat output but its activity is sufficiently high to require shielding to protect workers during its handling and transportation. It comprises, for example, fuel cans, reactor components and sludge and resins from effluent treatment plants. Some of this waste category will remain radioactive for hundreds or thousands of years, and is therefore referred to as long-lived ILW. The activity in short-lived ILW decays to low levels - about 1% within about 300 years.

8. LLW includes some waste whose activity is so low that it could be disposed of with household refuse. Generally, it consists of trash from areas where radioactive materials are handled, for example, protective clothing, air filters, worn-out laboratory equipment, which may have trace contaminants of radioactive material.

9. As a rough guide, the radioactive content of a given volume (say one cubic metre) of Intermediate-level Waste (ILW) is a thousand times less than that of the same volume of High-level waste (HLW), and that of Low-level waste (LLW) is a thousand times less again, but there is a wide range of radioactive content in each category. Nirex does not have a responsibility for HLW management.

10. The quantities of radioactive waste produced are relatively small compared with the quantities of other wastes. For example, about 25 million tons of domestic refuse, 5-10 million tonnes of industrial waste, containing hazardous materials, 15 million tonnes of ash from coal burning and 50 million tonnes of spoil from coal mining are produced annually in the UK. From now to the year 2000 those annual arisings add up to over 1 billion tonnes. The domestic, industrial and coal mining wastes all contain chemically toxic materials which, unlike radioactive materials that gradually lose their radioactivity, retain their toxicity forever. The amount of solid radioactive waste from electricity generation plus all industrial, medical and defence uses, adds up to one thousandth of that, or about 1 million tonnes by the year 2000. Most of that is low level waste, with only about 4,000 tonnes of high level waste and 160,000 tonnes of intermediate waste.

PLANS FOR THE DISPOSAL OF LLW AND ILW

11. Currently, nearly all of the low level waste is disposed of at Drigg in Cumbria, which is operated by British Nuclear Fuels plc. However, the site is limited in capacity, and so Nirex has been charged with finding another land site for LLW disposal, leaving Drigg to deal only with LLW generated at Sellafield. ILW is stored on nuclear sites.

12. A small quantity of waste is deemed suitable for deep ocean disposal and this route has been satisfactorily used for decades up to a level of 3,700 tons/year of disposed material, 10% of which was radioactive waste and the remainder concrete. Sea disposal is particularly suitable for a number of categories of wastes such as those containing tritium, secondly wastes which are bulky and have only limited levels of short-lived contamination or induced activity and thirdly waste containing essentially short-lived beta-gamma isotopes. This disposal operation was always closely monitored and was reassessed in 1985 by many national and international bodies and was found to be technically satisfactory. The nuclear industry remains convinced of the soundness of its basic safety and wishes to continue its use. In particular the cargo prepared for disposal during 1983, which is packaged to the standards currently adopted by the International Atomic Energy Agency (IAEA) and the London Dumping Convention, should be disposed at sea since all other options are less acceptable radiologically.

13. Technical considerations favour the early disposal of low level and intermediate level wastes: unlike the case of HLW, there are no advantages to be gained in storage to reduce the amounts of radioactivity to more readily manageable levels. On the contrary, there may be disadvantages in storing such wastes for prolonged periods since, without knowing the final disposal route, there would be doubt about the best treatment, conditioning and packaging for the waste. Moreover, it would be irresponsible to make future generations maintain stores and take decisions about the final disposal methods when the present generation is perfectly capable of disposal.

14. The objective of disposal was advocated in the Sixth Report of the Royal Commission on Environmental Pollution, chaired by Sir Brian Flowers (Cmnd 6618, HMSO, 1976). That objective was endorsed in the 1977 White Paper (Nuclear Power and the Environment, Cmnd 6820, HMSO), by the Radioactive Waste Management Advisory Committee (Annual Reports), in the 1982 White Paper (Radioactive Waste Management, Cmnd 8607, HMSO), in Radioactive Waste Management, the National Strategy, Department of the Environment (DoE) 1984 and, most recently, in the Report of the Environment Committee and the Assessment of Best Practicable Environmental Options for Management of Low-and Intermediate-Level Solid Radioactive Wastes, both published in March 1986. Disposal involves effective isolation of the waste from man's environment, making monitoring and surveillance strictly unnecessary, although they can be readily carried out for as long as the authorising Departments consider it desirable.

15. In December 1984, the DoE, the Ministry of Agriculture, Fisheries and Food (MAFF) and the Scottish and Welsh Offices, the authorising Departments under the Radioactive Substances Act 1960, published a document describing the principles they would apply in considering whether to authorise a land based repository for low and intermediate level wastes (Disposal Facilities on Land for Low and Intermediate Level Radioactive Wastes: Principles for the Protection of the Human Environment, HMSO, December 1984). The objective is that:

"The appropriate target applicable to a single repository at any time is a risk to an individual in a year equivalent to that associated with a dose of 0.1 m Sv; about 1 chance in a million".

16. Differences in background radiation account for variations in annual average effective doses from one locality to another of more than 1 mSv, and the total annual effective average dose from natural and artificial sources of radiation in the UK in 2.4 mSv. Thus the risk imposed by a radioactive waste repository is much less than that which could arise from moving from one area of the country to another. Moreover, the ALARA (as low as reasonably achievable) principle will also be followed, which may bring the risk down even further.

17. In order to meet these very strict safety standards, a "multiple barrier" approach will be used. Protection is provided by the immobilisation and packaging of the waste, then by the engineering of the repository and finally by the local geology of the site. The methods of achieving the required protection depend on the levels of activity and on whether that activity is long-or short-lived.

Low-Level waste

18. Low-level waste will be placed in containers. These containers will be checked on arrival at the disposal site, and placed in deep trenches, which will be sealed and capped with concrete when full, and then the top soil or clay will be reinstated. This will all be done subject to the agreement of the authorising Departments.

19. For LLW, the level of radioactivity is typically only a thousandth of that in intermediate wastes, and hence little packaging is required. Normally, subject to the authorising Departments' agreement, the wastes would be compacted in steel drums or boxes and placed in lined trenches to be sealed, capped and covered when full.

20. The natural properties of the geology of a well chosen clay disposal site provide a further barrier to the migration of radioactivity from the waste through the alkaline cement environment which provides a chemical as well as physical barrier, by providing low permeability and good sorption of many radionuclides.

21. One repository will suffice for the disposal of all of the LLW likely to arise over the next 50 years or more. LLW will be delivered to the site, in standard containers acceptable to Nirex and the authorising Departments. About 20 lorry loads or one train load per week will be involved. The detailed design and layout will depend upon the site chosen, but typically simple trenches about 15 metres wide, with drums stacked to a height of about 10 metres, would be constructed. In one year, about 300 metres of the trench would be filled, using an area of about 2 acres.

22. Some 200 people would be employed at the site during the construction phase, involving construction of reception facilities, monitoring and support buildings and the first lengths of trenches. In the operational phase, about 100 people would be employed on site, engaged in trench construction, waste reception, loading, sealing and closure of trenches and on and off site monitoring.

23. Enough statistics have been quoted here to indicate that the impact of such a repository, in terms of land use, traffic movements and nuisance would be very low.

24. After several decades, the repository would be closed. However, monitoring and supervision would be continued for as long as the authorities considered it desirable. Full records will be kept of the waste disposed of, enabling retrieval at any time.

Intermediate Level Waste

25. Long-lived ILW has to be isolated from man's environment for very long periods. By disposing of these wastes under the sea bed or at least 100 metres underground at a suitable land site, the possibility of inadvertent human intrusion will be reduced, and the natural geology will provide additional barriers to the return of radioactivity to man. Nirex is currently studying different technical concepts for the development of a repository for ILW: land disposal in a deep purpose built cavity or existing mine, or disposal under the sea-bed gaining access by tunnelling from the shore or by an off-shore platform facility.

IMPLEMENTATION OF THESE PLANS

26. In January 1985, the Secretary of State for the Environment told the House of Commons that he had decided that Nirex should be required to carry out geological investigations of at least three possible sites for each type of repository. Nirex was asked to select at least two further sites, in addition to Elstow in Bedfordshire, which had already been identified as a potential site, for investigation for the facility for short-lived wastes. Nirex was also asked to start the search for alternative sites for intermediate level waste, rather than the Billingham mine which had been identified, while further work reviewing the technical options proceeded. The Secretary of State would ask Parliament to give the necessary planning permission for the site investigations by way of a Special Development Order.

27. Nirex has announced a list of 3 additional sites it wishes to investigate for a repository for short-lived wastes. They are at Bradwell in Essex, Fulbeck in Lincolnshire and Killingholme in Humberside. Several factors have influenced the choice of sites for investigation. These include geology, hydrogeology, population density, transport networks, conservation (with National Parks, Heritage Coastlines and Areas of Outstanding Natural Beauty excluded) and, by no means least significant, Nirex's ability to acquire the land for its purposes.

28. Site investigations are necessary to provide detailed information on the geology, which will be

used for the engineering design of the repository and for the safety assessment of the proposed design. The work will be carried out in two phases: drilling and coring of boreholes which will take at least a year, and secondly monitoring to study water flows and many other parameters related to a technical and environmental assessment. The studies will take one to two years.

29. When Nirex has considered the information acquired during site investigations, it will be in a position to assess which of the candidate sites is the most promising for the development of a repository. It will then apply to the local planning authority covering the site for planning permission, in accordance with the requirements of the Town and Country Planning Acts. The application will be accompanied by a detailed Environmental and Radiological Assessment statement. The Department of the Environment has already indicated the Secretary of State's intention to call in such an application for his own determination and that a public inquiry will be held. At the public inquiry, the authorising Departments and the Nuclear Installations Inspectorate will give their provisional views on whether the proposed facility could be authorised and licensed. Their final, formal, approval or disapproval would not be given until much later when the outcome of the planning application is known. By then, the safety case and detailed design work would have been further refined as a result of the acquisition of more site specific data and further design work. Not until their formal approvals to go ahead have been received could operation of a repository begin.

30. The timescale for the deep repository for long-lived waste is a longer one: geological consultants have been appointed to identify potentially suitable formations on land and under the sea-bed. The next stage will be to search for such formations, while assessing the merits of the various concepts. At least three sites will then be selected for detailed fieldwork to ascertain their geological and hydrogeological characteristics. The planning procedure thereafter is expected to be the same as that outlined above for the less deep repository for the more voluminous LLW and short-lived ILW.

R & D PROGRAMME

31. The continuing aim of the Nirex R&D programme in the land disposal sector is to provide the data and calculational methods which will be needed to prepare safety cases for proposed radioactive waste repositories, on the necessary timescale. Much of the information required is already available, from the generic R&D programmes of the DoE, from other countries' programmes, and from the R&D of the producers related to their own wastes. However, Nirex finds it necessary to supplement this information with specific studies, which constitute the programme described, its progress, and proposals for continuing work. Close interactions with other programmes is an important part of the Nirex work.

Land Disposal

32. The R&D in this sector continues to concentrate on acquiring the models and data with which to calculate individual doses and associated risks from waste repositories resulting from the groundwater pathway, since these doses are considered certain to be incurred. They will be compared with the target set in the Environment Departments' "Disposal Facilities on Land for Low and Intermediate-Level Radioactive Wastes: Principles for the Protection of the Human Environment", and the ALARA principle, in assessing the safety of repositories. The timescale of the work is directly linked to the Nirex repository development programme, for which the information will be needed in support of public inquiries into planning applications and for disposal authorisations. It currently assumes preparation during 1988 for an inquiry into a "trench" repository, and into a "deep" repository at least two years later.

33. The structure of the programme continues, as before, around the three areas into which the repository system can be divided, the near field, the far field and the biosphere. Each area is appropriately modelled, and with the data which the models require, dose calculations can be carried out. The programme therefore includes model development and data acquisition, the progress of which are described as individual items of work each with a defined objective.

Near-field modelling

34. The objective is to provide a theoretical understanding of the expected chemical and physical behaviour of a repository over its lifetime, to enable experimental data to be used to derive a near-field source term.

35. The progress of the work is bringing together information on concrete behaviour, steel corrosion, solubilities, diffusion etc, which together with geometric repository models already developed will provide source terms for those radionuclides for which data are available. The recent work has been in these main areas. First, a database for cement chemistry is being assembled, so that changes with time can be estimated. Second, theoretical estimates have been made of the general corrosion rates of steels in concrete, being extended to cover localised corrosion. Third, chemical changes in clay near a shallow repository due to its construction have been estimated, in particular changes caused by the introduction of oxygen from air.

Repository designs

36. There is the need to provide the supporting R&D for designs for "trench" and "deep" repositories, for use inter alia in safety appraisals. A design has been produced for a "trench" repository based nominally on a site at Elstow in Bedfordshire. A feasibility study for a "deep" repository is being made.

Waste inventory

37. It is necessary to produce an inventory of the data provided by the waste producers on the volumes, radionuclide contents, chemical and physical properties of the conditioned low and intermediate level wastes expected to arise over the operational lifetimes of repositories. Data on waste volumes and radionuclide contents updated to 1985 are being compiled under a joint Nirex-DoE contract. Estimated arisings to the year 2030 are included. As are enhancements of the inventory to include information on the physical and chemical composition of wastes, improved radionuclide data, and information more directly related to disposal requirements.

Source term studies

38. A study is being made to provide the source term for the movement of radionuclides from the repository into the far-field. This area of work covers the measurement of the solubilities of the important radionuclides over a range of repository conditions and the development of calculational methods for radionuclide concentrations in actual repositories over their lifetimes. Since 1983-84 the measurement methods have changed from the use of combinations of real wastes and repository materials to solubility measurements on individual radionuclides under the appropriate conditions of pH and redox potential. This is because the original methods in some cases gave concentrations too low for accurate measurement, and ageing effects, which include ingrowth of radionuclides not originally present, could not be properly simulated.

39. The effects of organic substances which may enhance radionuclide solubilities by complexing with them are now being addressed in a number of programmes.

Corrosion of waste canisters

40. The corrosion rates of carbon steel and stainless steel under repository conditions is being carried out under a joint Nirex-DoE contract. A numerical model for the general corrosion of steel in concrete has been developed. The general corrosion rate of carbon steel is controlled by the rate of oxygen diffusion through the surrounding concrete. If this is very low the water reduction reaction takes over. Both processes are being studied and indicate very low corrosion rates, 1×10^{-6} m/a or less. Whilst oxygen is readily available, more rapid localised corrosion may occur, and this is also being studied, including the influence of chloride and sulphate ions in the water. Information so far indicates that the localised corrosion phase may be relatively short-lived (3-30 years) and therefore will not cause penetration.

Transport properties and durability of concrete

41. The interactions between cement/concrete and the disposal environment are being studied, to enable predictions of the evolution of key properties over the repository lifetime. A review has been carried out of concrete durability and the effects which it will have on radionuclides as they migrate through it. It concludes that appropriately-chosen concrete compositions can retain their physical integrity for 500-1000 years per metre thickness, and under conditions of low groundwater flow rate can maintain the near-field pH above 10.5 for the order of 1 million years. Aspects of these conclusions are being checked by leaching and ageing experiments on cement materials and diffusion and sorption measurements using Cs-137, Sr-85 and I-131. In addition, a laboratory examination is in progress of a large (2 metre cube) block of concrete which has been buried in Elstow clay for over 40 years. This is confirming the expectations of durability.

Microbiological effects

42. To determine the extent of microbiological activity which would be expected in a trench repository. Samples of clay from depths up to 12 metres on the Elstow site have been examined for material microbial activity. No unexpected activity was found. A study has begun to establish the viability and behaviour of micro-organisms in the expected repository environment. In addition a natural chemical analogue of a repository has been identified in Oman consisting of underground springs which are highly alkaline and reducing and any naturally occurring organisms are being identified and studied in this system.

Gas generation in repositories

43. A review is approaching completion of the mechanisms of gas generation in repositories by chemical degradation and corrosion, by radiolysis and by microbiological action. This is to determine sources and quantities of gases which may be generated in repositories.

Far-field modelling

44. Models are required which are efficient and validated to enable rates of radionuclide movement through the far-field to be predicted, and to apply the models to proposed repository sites as required.

45. Geological media may be considered as uniformly permeable, or fissured, and so two main types of model are needed. Two finite element programmes are appropriate for flow and migration in uniformly-permeable media where groundwater flow follows Darcy's law. They have been developed, tested and validated over a number of years. They were used to construct a regional groundwater flow and migration model for the region around the Billingham mine, as part of the preliminary radiological safety appraisal of a repository at that site. (This site is not now being considered as a waste repository). They will be available for assessment of proposed sites, the first of which (trench type) will be on clay, as field data become available.

46. For fissured media there exist at present two codes, which set up statistical representation of fracture networks in two dimensions and calculate flow, migrations and hydrodynamic dispersion through them. There are problems in reconciling the dispersion behaviour with that commonly assumed to hold in permeable media, and this is an area of current investigation. Most significantly, methods have now been developed to extend the fracture network calculations to three dimensions, and the overall framework for the 3-D codes is now complete. In this respect the work is in advance of any other in the UK or elsewhere.

Geology and hydrogeology

47. The objective here is to provide data and materials from candidate repository sites as required by the modellers and experimentalists. Data have been provided from already available information to contribute to the preliminary safety appraisals of a trench site based at Elstow and a deep site based on Billingham. Data and materials from proposed repository sites will be made available to the various sections of the programme as site studies progress.

Far-field properties

48. Techniques are being developed and measurements will be made of the properties of geological media needed to calculate the rates of migration of radionuclides through the far-field. Techniques are available for measuring permeability, diffusivity and sorptivity of rocks such as sandstones and limestones. These measurements are proving more difficult on clays, which now have priority, but techniques are expected to be available when required. Good sorption data are particularly important since sorption is likely to be an important delay mechanism for radionuclide migration both in the far-field and also in the near-field concrete. The validity of the "batch" method of measurement on which much existing data is based has been seriously questioned, since measurements are made on crushed specimens at unrealistic water-rock ratios. The new permeability and diffusion methods make measurements on relatively undisturbed rock specimens under realistic conditions. Present indications are that they give lower sorption coefficients (often by more than one order of magnitude) than the "batch" method.

Natural analogues

49. It is important that use is made of natural analogues of respositories (uranium deposits, naturally-occurring trace quantities of uranium-series minerals) to validate migration calculations. Measureable amounts of uranium-series nuclides exist in samples of Elstow clay, and calculations so far indicate that the clay must have remained stable for the order of 10^5 years. Sorption coefficients for these radionuclides have been estimated. The accuracy of these estimates is limited at present by the small samples available. Further work awaits larger samples from proposed repository sites.

Site safety appraisals

50. Development is in progress of a methodology for calculating repository post-closure doses and risks to individuals, for comparison with the DoE targets with the ALARA principle, and as guidance preliminary appraisals have been carried out on a specimen "deep" repository based on the Billingham mine site and a specimen "trench" repository based on Elstow. The "deep" study indicates that technetium would contribute a large proportion of the dose, although within the DoE target. The study used a simple source term calculation which does not take account of recent near-field data, and a small extension of the study is in progress to incorporate a more realistic source term. The "trench" study shows that the risk is dominated by that from intrusion into the repository, although the present indications are that this would not seriously limit the wastes which could be so disposed.

Ocean disposal

51. Nirex R&D in this sector covers these items. The first is to provide further data on the release of radionuclides from packages disposed of on the ocean bed under the London Convention, to improve the realism of the methods used to calculate doses. The second is to investigate the behaviour of void-containing packages during descent to the ocean bed. The third item covers investigation of the removal of plutonium from buoyant plastics through long immersion in the sea.

CONSULTATION

52. None of the sites to be investigated could be used for the disposal of radioactive waste unless specific approval is given under various sets of legislative requirements: the Radioactive Substances Act 1960, the Town and Country Planning Act 1971, the Health and Safety at Work Act 1974 and legislation yet to be enacted to implement the 1985 European Directive on environmental assessment.

53. Throughout the investigatory stage, Nirex will consult a wide range of bodies whose expertise or interests will contribute to the design and assessment work. Such consultations will take a variety of forms: in some cases they are required by legislation, in others they are a matter of common sense.

54. The Department of Environment's 1984 document provides a useful summary of the information required by the various regulatory authorities, but with particular emphasis on the DOE's own requirements. It also provides, in an Appendix, guidance on the factors to be considered in the environmental assessment and the bodies to be consulted about various aspects of the assessment.

55. Nirex will set great store by the consultative exercise to be carried out during site investigations. Effective consultation will have

several benefits: it will clear much of the ground with the authorising Departments before a formal application is made to develop one of the sites for use as a disposal facility; it will provide input to the environmental assessment of the effects of the proposed development on the environment and quality of life; it will enable the local authorities to influence Nirex thinking before final designs are presented and considered at a public inquiry. It is hoped that open consultation on the issues in a professional, non-combative forum will remove many of them from contention, so that Nirex can present the Public Inquiry with agreed statements on many of the local planning issues. Consultation will also assist Nirex in improving general understanding by those outside the industry of the nature of radioactive waste and the technical ease of its disposal, thereby helping to close the gap between public and technical perceptions of the state of the art.

FOREIGN EXPERIENCE

56. Disposal of radioactive waste is often discussed in terms that suggest that it is technically unproven, with uncertainties so great that other countries have rejected the disposal option in favour of storage. The reality of the situation is less dramatic. Technically, the disposal of non heat generating solid radioactive waste presents no problems, and the multiple barrier concept outlined here enhances further the degree of isolation from man's environment. The problem, in the UK at least, is that lack of scientific understanding coupled with distrust of parts of the nuclear industry has made a significant part of the population extremely hostile to the idea of radioactive waste disposal. This cannot be wholly ascribed to the "not-in-my-backyard" phenomenon known to developers everywhere.

57. No country with a nuclear power programme has rejected the idea of disposal of non heat generating solid waste, although some are considering indefinite storage of spent fuel as an alternative to reprocessing. In France, a shallow repository is operated at Centre de La Manche near Cherbourg; four other sites are being investigated with the intention of developing a further shallow repository for short-lived waste. They (the French) also intend to develop a deep repository for long lived waste before the end of the century. In West Germany, a LLW disposal facility in a former iron ore mine is being considered for commissioning by the end of this decade. The Asse salt mine was used between 1967 and 1978 for "test disposal" of all LLW and ILW generated in that period. Routine disposal at the Asse mine is now being considered, as is the use of the Gorleben salt dome. The Swedes are constructing a repository (described as a final storage facility) under the seabed at Forsmark, and various trench repositories are under construction in the USA, to supplement the established Barnwell site. Geological surveys and research programmes for land disposal are being conducted in Switzerland, Belgium, Italy, Netherlands and Japan.

ACCEPTABILITY

58. When the CEGB applied for consent to build a Pressurised Water Reactor (PWR) at Sizewell in Suffolk, almost half of the objections received gave concern about the management of radioactive wastes as the main cause for objection. Whenever a site is named in connection with radioactive waste disposal, even for geological investigations, protest groups Against Nuclear Dumping are formed. Despite worldwide unanimity of opinion on the scientific justification for it, there is also a popular view that disposal of nuclear waste at the bottom of the deep ocean is "wrong". The London Dumping Convention has called for its indefinite suspension, and British Trade Unions have refused to handle cargoes destined for the sea disposal operation.

59. The response to public concern about the sea disposal operation provides a salutory example of the power of public attitudes. In 1983, the National Union of Seamen refused to handle the planned disposal of 3,500 tonnes of packaged wastes in the North East Atlantic. The Government, with the agreement of the Trade Union Congress, set up an independent inquiry to review the scientific evidence on the safety of the practice. Professor Holliday, the Chairman of the inquiry, published his report in December 1984. The Report advanced no technical arguments against disposal at sea, pronounced the risks to be very low (and indeed probably overestimated), but nevertheless recommended that resumption of sea disposal should await the results of other reviews and that a Best Practicable Environmental Option study should compare sea disposal with disposal on land. This paralysis of decision making, and advocacy of further delay, indicates the extent of political concern about disposal.

60. A valuable contribution to the public debate is the Best Practicable Environmental Option Study by the Department of the Environment in the UK. The study published in March of this year demonstrated there are safe and practical options for the storage and disposal of every type of low and intermediate waste. The arguments in the paper are supported by one of its findings that on economic and radiological grounds an optimum strategy for storage and disposal would involve early use of all disposal options including sea disposal. That this is arrived at by the further very thorough study by independent consultants is a valuable aid to decision making in radioactive waste management.

61. The nuclear industry cannot by itself resolve the general concern: it can provide only scientific facts and scientifically based judgements. The question remains of how opposition to nuclear power might be reduced. Certainly it is important that the industry takes every opportunity for presenting the factual background to its programme and projects, both nationally and in the regions which are to be influenced. Nirex is making every effort to do this and the nuclear industry is in turn devoting more effort to explanations of its role.

62. There has always been a great time lag between the introduction of a new technology and the public

coming to terms with it. During this period the need for the product, its interaction with the public, the visibility of the product etc. all weld together to create the public's perception of the value of the new development. An important ingredient in this process is some understanding of the basic principles of the technology to allow members of the community to make informed judgements. Education especially in the schools about radiation and radioactivity and about risk and probability is essential if the role of the nuclear industry is to be given a balanced assessment. A natural extension of this will be a better based understanding of the best practicable environmental options for the management of radioactive wastes.

CONCLUSION

63. The role of Nirex in the national strategy for waste management has been described. The volumes of waste are relatively low, safe disposal requires not new technology, but a careful application of well understood procedures and these procedures will be controlled by independent regulatory authorities.

64. The considerable concern in the public mind must be addressed not only by the industry presenting full explanations of its developments, but by providing to the public, and the young in particular, sound, simple, basic knowledge about radioactivity and risk so that their judgements of the proposals of the industry are based on some personal knowledge of the basic principles. Hence education especially in schools about the scientific background is essential.

65. The UK has a well established nuclear power programme, and nuclear experience of the use of radioisotopes in industrial and medical applications. It has developed a safe radioactive waste management policy to support the industry and UK Nirex Ltd has the task of developing transport and disposal facilities for the low and intermediate radioactive wastes. The management and technical developments supporting the waste management programme will be of interest to other countries with nuclear or radioactive commitments.