STATUS REPORT ON THE MANAGEMENT AND DISPOSAL OF RADIOACTIVE WASTES IN THE UNITED KINGDOM

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ABSTRACT

UK Nirex plans to develop in Britain a single near-surface repository for the disposal of low-level waste (LLW), to become operational by the middle of the 1990's and to receive waste until 2040. In addition, it is also considering plans to develop a deep, mined repository to receive intermediate-level waste (ILW). The purpose of this paper is to describe how these plans are to be implemented and to highlight any developments that have occurred in the last year.

INSTITUTIONAL ARRANGEMENTS

In 1982 the major bodies constituting the UK nuclear industry set up as a partnership, with Governmental approval, the Nuclear Industry Radioactive Waste Executive, NIREX, in order to provide a mechanism by which they could successfully fulfill their own responsibilities in this field and work within a comprehensive national plan for waste management.

In November 1985 the Executive was reconstituted as a limited company, United Kingdom Nirex Ltd, with all the partner organisations becoming shareholders and with the British Government holding a special share. The aim of the company is to provide a complete disposal service for solid low and intermediate-level wastes for its shareholders and for other producers of such wastes in the UK.

Nirex will have to operate within the safety guidelines set by the Department of the Environment. In particular, it must demonstrate that for any proposed repository, the dose to the most exposed individual in any one year shall not exceed 0.1mSv. This is equivalent to a risk of a one in a million chance of a serious health effect. In addition, the Department requires that exposure to radiation be kept as low as reasonably achievable (ALARA principle) taking into account economic and social factors. This may bring doses down to well below the target level.

It is worth noting here that this target dose is some ten times smaller than the variation in natural background radiation within the United Kingdom; and that the average total annual effective dose from both natural and artificial sources in the UK is 2.4mSv.

LOW-LEVEL WASTE MANAGEMENT

The Nature of the Waste

Nirex does not have responsibility for high-level wastes, its interest being confined to the low-level and the intermediate-level wastes. Low-level wastes are defined as wastes containing radioactive materials other than those acceptable for dustbin disposal (a term used for the authorised local disposal of very low-level arisings) but not exceeding 4 GBq/te alpha or 12 GBq/te beta gamma. Low-level waste generally consists of trash from areas where radioactive materials are handled. It includes, for example, protective clothing, air filters, and worn-out laboratory equipment, all of which may bear trace contaminants of radioactive materials, or may in fact be free from contamination but are merely suspected of having picked up such radioactive traces.

Plans for Disposal of LLW

The UK annual arisings of LLW are around 25,000 cubic metres. Currently, nearly all of this waste goes to a disposal site at Drigg in Cumbria, operated by British Nuclear Fuels plc. This site is only a few miles from their Sellafield reprocessing plant which produces about half of the waste. However, the capacity of the site is limited, hence there is a requirement to identify a new near-surface land site for LLW disposal, leaving Drigg to receive only the LLW generated at Sellafield. A single new repository for the reception of LLW will satisfy UK requirements well into the twenty-first century. Subject to the authorising Department's agreement, the LLW would be compacted in steel drums or boxes and placed in concrete-lined trenches to be sealed, capped and covered when full. A common feature in all candidate sites for LLW is that they lie in a terrain rich in clay; this provides a barrier to the movement of ground water and also has marked sorption properties for radionuclides in solution. Additionally, the alkaline nature of concrete shielding provides a further chemical barrier to the migration of radioactivity.

The LLW will be transported from its various points of origin either by road or rail, converging on the selected site at an arrival rate equivalent to 20 lorry loads or 1 trainload per week. Detailed design layout will of course be site-dependent but typically simple lined trenches are envisaged about 15 metres wide, with drums or boxes stacked to a height of 5-10 metres. Each year it is expected that about 300 metres of trench would be filled, covering an area approaching 1 hectare, and the trenches will usually be capped with concrete, clay and topsoil before grassing. Employment will be offered to about 200 people during construction, reducing to about 100 in the operational phase which would last for several decades before closure. Monitoring and supervision of the site would continue for as long as is deemed appropriate by the authorities, and retrieval of waste would always be possible if considered necessary.

Fig.1. Representation of a near-surface repository for the disposal of LLW.

Implementation of the Plans for LLW Disposal

The first task in site selection procedure was to identify those parts of the UK in which to concentrate the search. Several factors were considered important in determining the suitability of a site, including geology, population, planning and conservation, and transport networks. These factors are discussed more fully below.

Geology - The clay and marl which outcrop across the southern half of Great Britain were identified as having the most suitable geology and hydrogeology by virtue of their low permeability and good sorption characteristics. These would enhance the engineered barriers by preventing the migration of radionuclides.

Population - If the radioactive wastes were safely contained within a designated site, the proximity of a given population should not materially affect site selection. Nevertheless, areas of low population density were preferred on political grounds. In this regard reference was made to the siting criteria of Nuclear Power Stations; districts or boroughs with populations of over 5 persons per hectare were excluded.

Planning and conservation - Many areas of the UK have been designated as being of national importance in terms of conservation and landscape protection. National Parks, Areas of Outstanding Beauty and Heritage Coastline were thus excluded.

Transportation - If a choice of equally suitable sites was available after taking into account the above factors, then preference was given to a site where transport distances were minimised.

When all these factors were combined, an area of search was defined. The next stage was to survey this area for sites, taking into account other factors that could not be mapped, for example, land use, site size and other planning considerations.

Each site with potential was then assessed by a team of geologists, planning consultants and Nirex staff, who rated each site in terms of safety, planning and the technical feasibility of constructing a repository.

In October 1983 Nirex recommended that a site at Elstow, a former storage depot owned by the Central Electricity Generating Board near Bedford, should be examined for suitability as a near-surface repository. In January 1985 there was a Government decision to increase the number of candidate sites. Nirex announced the three additional sites it wished to investigate for such a facility in February 1986. These sites are at Killingholme in Humberside, Fulbeck in Lincolnshire and Bradwell in Essex; the second, like Elstow, being inland, the first and third being coastal.

Site Investigations

Site investigations are necessary to provide more detailed information on the geology and hydrogeology of the areas. This is vital to the evolution of a site-specific engineering design and for the associated safety assessment. Planning law in the UK would normally call for specific permission to be sought in respect of each individual site even for exploratory work, but this procedure was replaced in this context by a single Special Development Order, approved by Parliament in May 1986, which would allow Nirex to proceed with all the site investigations. The work will be carried out in two phases; the drilling/coring of boreholes, to be followed by monitoring to study water flows and other parameters related to a technical and environmental assessment.

Nirex has now entered this last phase of selection of a site for a LLW repository. The drilling commenced on all four sites towards the latter part of last year and these investigations will take up to two years. When Nirex has considered the information acquired during site investigations and the advice of the leading authorities in this technical area, it will first reject any site that proves unsuitable, and then assess which of the remaining candidate sites is the most promising for the development of a repository.

When a site has finally been chosen, Nirex will then have to submit their proposals to a Public Inquiry. Only with formal approval could construction and operation of a repository begin.

The projected date for commencement of construction of a LLW repository is therefore sometime in the middle of the 1990's.

INTERMEDIATE - LEVEL WASTE MANAGEMENT

The Nature of the Waste

As their name implies, intermediate-level wastes fall between the high and low-level categories, and are formally defined as wastes with radioactivity exceeding the boundaries for low-level wastes, but which do not require high temperatures, resulting from radioactive decay, to be taken into account in the design of storage or disposal facilities.

Plans for Disposal of ILW

In the United Kingdom, the waste is currently stored on various nuclear sites awaiting permanent disposal. However, Nirex is now planning to develop a repository that will be designed to take all ILW from the UK nuclear industry for up to 50 years. As the UK annual arisings of this waste are only about 2500m^3, a single repository is all that is deemed necessary.

UK Nirex Ltd is currently assessing three concepts for the design of an intermediate-level waste repository. These are: land disposal in a deep underground repository in a suitable geological environment, the important feature of which is low ground water flow; a repository under the seabed accessed by tunnelling from a land based facility; and a repository under the seabed accessed from a sea based facility.

The aim in disposing of radioactive waste is to remove the radionuclides to a position where they will not pose any threat to the human environment or biosphere. In the UK, intermediate-level waste has traditionally been divided into short-lived waste with a half-life of less than 30 years, and long-lived waste. While it is entirely feasible to construct engineered barriers to contain the radioactivity for 300 years or ten half-lives of short-lived waste, safe containment cannot be guaranteed for the many thousands of years it takes for long-lived waste to decay. Therefore, for safe disposal of long-lived waste, the geology of the environment chosen to host the repository must act to back up the engineering and prevent migration of radionuclides back to the biosphere. It was planned to dispose of suitably packaged short-lived intermediate-level waste in the same near-surface repository as proposed for LLW. Since Nirex last reported to this Conference, however, the position has changed. In May 1986 the Government decided that all ILW should be excluded from the near-surface designs and that both short and long-lived ILW should be disposed of in a deep repository.

The geological requirement is a host formation where movement of groundwater towards drinking-water sources, or the surface, is extremely slow. This can be achieved by constructing the repository in an impermeable geological formation, or where movement of groundwater is in a direction which allows a sufficiently long pathway back to the biosphere. A minimum depth of 100m has been taken as the cover needed; this also allows for erosion during periods of glaciation that will occur while the waste remains radiologically significant.

Feasibility studies are now being carried out on the three concepts of repository and eventually these will be used, together with radiological and geological studies, in assessing site potential and deciding which of the concepts to investigate further.

Underground Repository

The development of underground space is a well established technology. As a concept, therefore, the construction and operation of such a repository would be quite simple. The waste will remain monitorable and retrievable during the operational lifetime of the repository, after which it will probably be backfilled with a suitable grouting material to add physical stability to the near-field and add a further engineered barrier to prevent the migration of radionuclides.

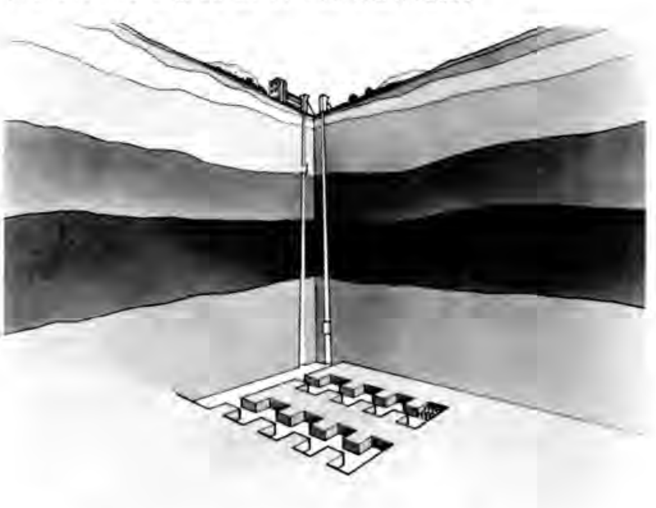

Fig.2. Representation of an underground repository for the disposal of ILW.

Sub-seabed Repository Accessed from the Shore

In concept, this is similar to the underground repository, but it is situated beneath the seabed and accessed by shafts and tunnels from a coastal site.

A particular attraction of this concept is that offshore ground water will be saline or moving towards the sea and therefore separate from freshwater sources. Even so, this benefit does not remove the requirement for a geology having a low hydraulic conductivity.

A drawback of this sub-seabed concept is that there may be a *comparative* lack of geological knowledge and an increase in the cost of investigation. However, technology has advanced rapidly in this area in recent years as a result of the off-shore oil industry, so that now site reconnaissance can be reliably carried out, and it will be possible to investigate areas showing potential.

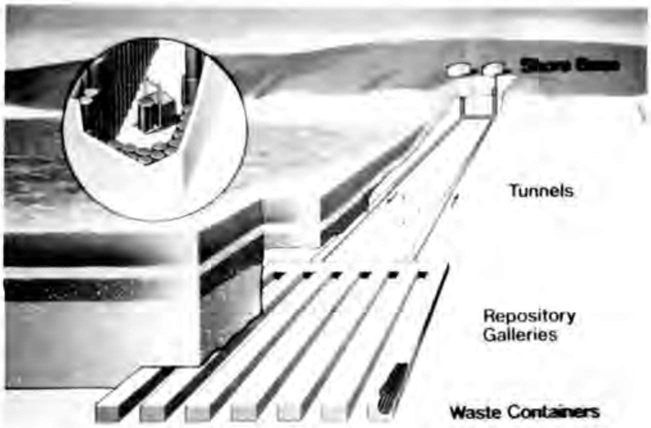

Fig.3. Representation of a sub-seabed repository accessed from the shore.

Fig.4. Representation of a sub-seabed repository accessed from the sea.

Sub-seabed accessed from the sea

The third concept presently under consideration is the construction of a repository under the seabed with access from a mobile or fixed sea platform, or even an artificial island. There are a number of variations on this concept. Boreholes, tunnels, caverns or trenches would be constructed in the seabed to hold the waste. Feasibility studies were carried out on each and concluded that for long-lived intermediate-level waste, trenches were unsound on radiological grounds, and that tunnels would offer less potential than caverns in a suitable geology.

Further work is needed to assess fully the practicability of boreholes and caverns. To drill boreholes into a salt dome, a mobile or artificial island would be needed and the construction of an offshore shaft for cavern excavation would be a complex civil engineering task. The advantage of both, however, would be that the pathway back to the shore through a tunnel would be totally eliminated as long as the shaft or borehole remained in a marine environment.

Once these three options have been assessed and the basic choice between the concepts has been made, Nirex will then have to choose a site. This stage is expected to be reached some time in 1989. The same range of safety, technical and planning factors will have to be applied in the selection of favourable areas and the actual candidate site as were used in the choice of LLW sites.

Packaging

Most intermediate-level waste will be immobilised in a cement matrix within special 500-litre drums and carried in returnable steel transport containers. The drums will probably be placed within concrete boxes for final disposal in order to reduce the radiation levels during further operations. A smaller amount of waste will already be in self-shielded concrete boxes and, as with the drums, the waste will be immobilised in a solid matrix inside the box.

Most of the operations will be carried out by remote handling and this too will have a bearing on the design and maintenance of transport and lifting gear.

R&D PROGRAMME

As mentioned above, a fundamental principle of radioactive waste disposal in the UK is that it should satisfy certain safety standards; therefore, before being allowed to develop a repository, Nirex must provide evidence that its disposal system will meet all such targets. All possible pathways by which radioactivity from the repository could return to man's environment must be considered, and the radiation dose which each could present is included in the safety case which will be required at the repository planning stage.

One pathway which is considered certain to be present in any UK repository - which will inevitably be below the water table - will be that due to moving ground water. Such water will at some time contact the waste, dissolving and mobilising the radionuclides. The behaviour of the radionuclides thereafter will be influenced by a range of chemical and physical parameters and Nirex has developed a large R&D programme to evaluate these parameters and to enable the calculations necessary for the safety case to be made.

This programme divides the repository system into near-field and far-field. The near-field consists of the immobilised waste in its container, surrounded by cementitious grout within a concrete structure. All this is under the control of the repository designer. The far-field is thought of as the natural geological material in which the repository is situated. The approach is to develop a theoretical understanding of both the near and far-fields, and to construct mathematical models which, for a particular repository design and geological situation, can be used to calculate time-related doses to man.

It must be shown that these doses would always be within the regulatory target before an authorisation to dispose of waste can be given.

The R&D is concentrated in the following areas:

The near-field

(i) Properties of concrete - its durability and the effect it will have on radionuclides as they migrate through it.

(ii) Corrosion studies - the corrosion characteristics of various types of steel drum and the resultant effects on the release rate of the short-lived radionuclides and on the local chemistry.

(iii) Source term studies - the measurement of the solubilities of important radionuclides under expected repository conditions.

(iv) Chemical and thermodynamic studies - theoretical calculations of solubilities to complement the above.

(v) Further theoretical solubility studies - extended to cover organic ligands.

(vi) Microbiological studies - the study of the presence, viability and behaviour of micro-organisms in the expected repository environment.

(vii) Near-field modelling - computer models to pull together the results of the studies to provide a simplified source term for use in far-field calculations.

The far-field

(i) Far-field modelling - computer models which describe the behaviour of radionuclides as they migrate with any ground water through rock and soil.

(ii) Mass transfer and sorption - measurements to complement the migration modelling, i.e. permeability and diffusion properties of rock and soils and sorption characteristics of each radionuclide of importance.

(iii) Uranium series measurements - to observe the variations from the equilibrium of the radionuclide concentrations in the uranium and thorium series in the various clay phases to obtain an understanding of diffusion and sorption characteristics.

(iv) Natural analogues - the study of natural analogues of repositories to assist in the development and validation of models.

Another potential pathway for radionuclide transport is by gas movement out of the repository. Studies are being made of the mechanisms by which gases could be generated, such as chemical degradation, radiolysis and microbiological attack, and also of the ability of the gases to move through the repository materials and surrounding geology.

A third pathway which could lead to a radiation exposure is intrusion into the repository, for example from building foundations, water extraction or mineral exploration at some future time when records of the repository might have been lost. The risk is related to the consequences of such intrusion, which are being studied in a realistic way, and to the probability of it happening, which decreases with depth of disposal. Some aspects of this are not amenable to scientific evaluation, and need an approach to be agreed upon with the regulatory authorities.

Other pathways back to man's environment could result from events such as seismic disturbances, meteorite impacts or major geological changes. These are generally of such low probability that their effect on risk is very small. However, they cannot be ignored.

The extensive R&D programme illustrates one aspect of the careful and safe approach taken to radioactive waste management. It indicates the great detail which must be gone into to meet the very high standards of safety required; other areas of radioactive waste management meet equally high standards.

PUBLIC EDUCATION

In addition to its responsibility for the safe management and disposal of Britain's solid low and intermediate-level radioactive wastes, UK Nirex Ltd has a large and important role to play in informing the public about the nature of its work. It seeks to respond to any public concern by providing the fullest possible information of its work and plans, so that people may be better able to reach their own conclusions. The objective of Nirex's information programme is essentially to raise the level of public understanding to such a point where assurances about radiological and environmental impacts are accepted by genuinely concerned members of the community.

Until individual sites were identified, Nirex concentrated on a programme of national education and reassurance. However, it was kept in mind that after announcement of specific sites, opposition to Government policy on radioactive waste disposal would become considerably more ferocious. It was hoped that this could be anticipated and so met appropriately. Studies indicated that national public interest would inevitably centre upon perceived threats to public health and the environment, and that local interest would very probably reflect the same views more intensely. This would be overlain with the understandable human response of "Not in my Back Yard" (NIMBY).

The primary goal at the national level was to help to remove the sinister mystique that surrounds the natural phenomenon of radioactivity. It seemed likely that the most appropriate means of achieving this was by enabling people to place the hazards of radiation in a clear perspective with other, larger, but more socially acceptable hazards. At the local community level the message needed to be essentially the same but with more concentration on specific issues. It would need to explain in detail exactly what any proposals might entail and what might be the effects on the locality.

Nirex employed advertisements, nationally and locally, to identify the issues of concern and also to publicise its existence. Invitations to readers to correspond with Nirex elicited an excellent response for its publications. The company maintained a full and active programme of public meetings, and sought to inform the opinion formers such as politicians, trade unionists and journalists. It also sought to publicise the strength of its case at exhibitions, lectures, international conferences, and briefing meetings with numerous interested bodies and organisations.

With the identification of the four sites believed suitable for closer investigation, Nirex concentrated its efforts substantially on the local communities. At a local level, Nirex was the cause of emotions ranging from interest through concern to anxiety and hostility, and in all the areas named protest groups have sprung up.

Local and regional media interest tended to reinforce public interest. Visits to waste management and disposal facilities in Britain and abroad were arranged for the press, MPs and other groups. Speakers from Nirex attended a great many local public meetings, being joined on platforms by MPs, councillors and local and national protest organisations.

Members of the communities were kept informed through house-to-house distribution of a free newspaper. Nirex invested in a mobile exhibition vehicle to provide a display facility that could visit county shows or village greens. Information offices were opened in the towns near the four candidate sites in order to make Nirex known to as wide a public audience as possible. These also provide a valuable demonstration of Nirex's commitment to a Public Information Service.

A continuing programme of opinion research was commissioned, the value of which rests with its merits as a tool for anticipating the nature of public perception problems and retrospectively assessing Nirex's attempts to solve them.

The research was helpful in identifying the precise nature of public fears. Surveys showed that safety was a strong issue. This resulted in specific advertisements being designed to deal with the relatively innocuous nature of the wastes, the proven track record of concrete, the simple technologies employed, and the stringent care and after-care.

Ironically, retrospective opinion research revealed that people tend to be sceptical of advertisements in general. This led to reduction of expenditure on advertising and to concentration on mass distribution of information to people living near the sites. The research also indicated that the most useful form of advertising was not the discussion of broad issues, but rather it appeared preferable to address the more specific concerns and anxieties.

Given the constraint that any information to the public may serve only to heighten anxiety, Nirex is reasonably satisfied with the progress of its program of public education.

It is recognized that it may be impossible to resolve the understandable although unjustified concern felt by those who do not want nuclear waste buried 'in their Back Yard', but it is also considered that there is a social duty to inform. In some cases this is of positive benefit to the work of Nirex; in others it is not. However, just as the disposal of radioactive waste is an issue in the broad national interest, so is a sustained program of public information and education.