WASTE CHARACTERIZATION AND CONTROL ARRANGEMENTS ASSOCIATED WITH SOLID LOW-LEVEL WASTE CONSIGNMENTS TO THE UK DRIGG DISPOSAL SITE

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ABSTRACT

The Drigg disposal site is the national repository for solid low-level radioactive wastes in the United Kingdom. Wastes arise from a wide range of sources including nuclear power generation, nuclear fuel cycle activities, isotope manufacturer, universities, general industry and clean-up of contaminated sites. This paper reviews the comprehensive series of waste characterization and control arrangements associated with disposals to the Drigg site. These include waste stream characterization, waste monitoring, quality assurance arrangements, consignment document verification and receipt monitoring of wastes prior to acceptance for disposal.

INTRODUCTION

British Nuclear Fuels plc provides nuclear fuel cycle services both within the UK and internationally. It operates a number of sites in the UK associated with uranium enrichment, fuel manufacture, reactor operation, fuel reprocessing and waste management. As such BNFL has a wide experience of the management and control of radioactive wastes. This paper considers solid low level radioactive wastes from the principal perspective as operator of the Drigg disposal site but coupled with the experience of BNFL as a waste consignor.

In the UK, low level radioactive waste (LLW) is defined as that material (other than that which is acceptable for local disposal) whose activity does not exceed 4 GBq/t alpha and 12 GBq/t beta gamma. The wastes are very heterogeneous in composition but include paper, metallic and plastic items, rubble and soil. Wastes arise at a wide range of establishments including the Sellafield nuclear fuel reprocessing complex, other nuclear sites, radioisotope manufacturers and a significant number of industrial, medical and educational establishments. Current levels of arisings of LLW in the UK are of the order of 30 000 m^3 per year.

The Drigg disposal site, owned and operated by BNFL, is the principal national disposal site for LLW in the UK. It has a total area of about 110 hectares, of which 35 hectares have consent for disposals. Historically disposals have consisted of tumble tipping of essentially loose wastes into trenches excavated so that their bases, at a depth of 6 to 8 m, are in clay. These trenches have been up to 750 m long and 30 m wide and to date six trenches have been completed. A final one, Trench 7, is now in use only for Sellafield wastes until a new waste conditioning facility, based on high force compaction, is in operation in 1993. To date, of the order of 750 000 m^3 of LLW have been disposed of to the trenches. Wastes for trench disposal arrive principally in skips containing baggged and wrapped items, spoil, miscellaneous items and some drummed wastes.

In 1987 BNFL announced a program of upgrading the facilities at the Drigg site. In particular the first concrete vault was subsequently commissioned in 1988. This has a total capacity of 180 000 m^3 and represents a major presentational upgrade. All wastes consigned into it are containerized in either 18 or 38 m^3 gross volume ISO containers and emplaced and stacked in the vault. The larger containers typically have drummed wastes, whilst the half-height ones contain high force compacted or non-compactable wastes.

CONSTRAINTS ON WASTE CONSIGNMENTS

Consignments of LLW to Drigg are accepted for disposal under the terms of an authorization issued by the UK Department of the Environment and the Ministry of Agriculture, Fisheries and Food under the Radioactive Substances Act 1960. The principal features of the authorization are summarized in Table I. Some of the conditions within the authorization directly control the nature of wastes, whilst others give rise to controls indirectly by placing certain requirements on the impact of the wastes and hence on site management practices. This latter aspect is also important in that the non-radioactive nature of the impact of the site is controlled under consents issued by the National Rivers Authority under the Control of Pollution Act 1974.

BNFL, as the owner and operator of the Drigg site, has established "Conditions for Acceptance by British Nuclear Fuels plc of Radioactive Wastes for Disposal at Drigg". The objectives of these are principally threefold:

- to provide detailed interpretation of the legal requirements of the Drigg authorization,
- to establish requirements to ensure good standards of disposals,
- to provide guidance to waste consignors.

Part A of the Conditions is a "Specification for Acceptance". This defines the nature and limits of wastes which will be accepted for disposal at Drigg. The main features are listed in Table II. Of particular note is that disposals

TABLE I

Principal Aspects of the Drigg Disposal Authorization

- Only solid, radioactive waste to be disposed of
- Consignment specific activity limits
- Annual activity disposal limits
- Best practicable means to be used to:
  - Compact wastes
  - Limit activity migration
  - Collect and monitor leachate
- Marine discharge plus stream concentration limits
- Monitoring of wastes and the environment
- Keeping of records

TABLE II

Principal Aspects of the Drigg Specification for Acceptance of Wastes

- Definition of solid LLW.
- Requirement to ensure waste compaction.
- Materials to be excluded or made safe.
- Radioactivity limits.
- Fissile content limits.
- Packaging, labelling and documentation requirements.
- Quality assurance requirements.

must only be of "solid radioactive waste which has been treated or packaged in such a way as to render it so far as is reasonably practicable insoluble in water and not readily flammable". Details of the requirements include, for example, the need to exclude or make safe certain items such as pyrophoric materials, combustible metals, pressurized gas cylinders and other identified materials. Some of these requirements are to ensure the safety of persons transporting, handling and disposing of the wastes whilst others relate to the long-term safety and environmental impact of the site.

Part B of the Conditions is the "Procedures for Acceptance" and provide guidance on the administrative requirements to ensure acceptance of wastes. Of particular note in the present context are the requirements to have provided, inter alia, waste stream characterization data to BNFL prior to commencement of disposals. Also, in order to ensure annual disposal limits to the Drigg site are complied with, a system of prior notification, agreement and allocation of disposals is operated.

Any departures from these standard Conditions for Acceptance can only be made by specific written request to, and agreement from, BNFL. Any such requests are considered on a case by case basis but in all instances any variations must ensure both full compliance with the disposal authorization and careful evaluation to ensure good waste management practices and acceptable environmental implications.

To ensure compliance with these constraints on disposals a number of control measures are applied. Some are principally carried out by the waste consignor, others by BNFL as the waste recipient and disposal organization. These various, complementary control measures are described in the following sections.

WASTE STREAM CHARACTERIZATION

Before LLW is accepted for disposal at Drigg, BNFL requires waste stream characterization data to be provided by the consignor. These data comprise radionuclide, chemical and physical descriptions and the method of determining waste activity content. They are required so that quantitative generic waste information is available for use with the quality assurance documentation, and to allow an early assessment of the waste as to its acceptability for disposal at Drigg.

Streaming of the waste can be done in a number of ways. The two systems most commonly used being those based on physical properties (waste compactibility, combustibility etc) or radionuclide composition. The system used for Drigg, and also recently adopted for the UK Radioactive Waste Inventory, is the latter. This has advantages when assessing the activity of the waste to be disposed of, as described later.

For most solid low level radioactive wastes it is possible to describe the waste in terms of its source of arising from a site/plant area that has a discrete "radionuclide fingerprint". All the waste in any one stream will have a similar ratio of radionuclides present, though the total activity level of the waste may vary and the physical and chemical forms of the waste may be heterogeneous.

The number of waste streams necessary to define the LLW from any one site will depend on the range of activities being carried out and the waste generated. Other than sites with a single waste source, consignors typically have two to six operational waste streams, such as "Laundry LLW", "Effluent Treatment Plant LLW", "Incinerator Ash" etc. For each of these waste streams, data on radionuclide composition and information on physical and chemical characteristics will have been measured by the consignor to demonstrate that the proposed arrangements are a valid streaming of the waste arisings. This is usually done by

campaigns of sampling the LLW, though for some plants it may be acceptable to use plant analyses or flowsheet figures.

The waste streams are an integral part of LLW handling operations at each consigning site. All waste has to be segregated by stream until its activity content has been determined, logged and apportioned to individual radionuclides.

WASTE MONITORING

For most LLW it is not possible to directly assay the activity content and radionuclide composition of a consignment. Use therefore has to be made of a known property of the waste which can be directly measured and related to the activity content. This relationship is identified and justified in the waste stream characterization.

The most common forms of relationship are:

a. Where the dose rate measurement from the waste (usually in a bag or a drum) is proportional to its activity content. For this to be valid the waste must contain a gamma emitter so that the radiation can penetrate the container and also reduce self-shielding errors. This information will already be known from the radionuclide fingerprint of the waste. The radiation measurement/activity content relationship can be derived by either mathematical models, practical tests (putting known activity of the same composition in the waste container and measuring the resultant radiation), or destructive analysis of containers of waste whose radiation levels have been measured. Once the total activity is calculated, it is possible to apportion this to individual radionuclides including non-gamma emitters by reference to the fingerprint.

b. Where the specific activity of the waste can be shown to be constant, and so its activity content is proportional to its weight. For this to be valid a series of samples of the waste will have been taken and analyzed. The results of these analyses will form the radionuclide fingerprint. A measurement of the weight of the waste will therefore yield total activity and individual nuclide data.

c. Where the specific activity is not constant and the radiation produced is either alpha or soft beta. This is the most difficult waste to assess activity in, and generally involves an extensive destructive sampling campaign to produce activity concentration and radionuclide composition data. A fixed activity is then assigned per unit volume of waste.

Having established such relationships, routine monitoring of waste in terms of dose rate, weight or volume can be used to assess the activity content and hence to complete the necessary consignment documentation. It is however important to stress the need to maintain discrete waste streams prior to this monitoring stage and to ensure regular review, and update as necessary, of the technical basis of the activity quantification.

QUALITY ASSURANCE

Wastes are only accepted for disposal at Drigg if the consigning organization has in operation a quality assurance (QA) system for the management of LLW and those QA arrangements have been documented and approved by BNFL. The principal objective of the QA system is to ensure that consignments of LLW comply with the BNFL Conditions for Acceptance, and hence also the Drigg authorization, and that the wastes are correctly characterized and the documentation correctly completed. The QA system, including the audit program, is also intended to enhance confidence that the waste management and control arrangements are working correctly.

The QA documentation prepared by consignors must detail the effective management and control of the waste from generation to the point of acceptance by BNFL. The principal aspects to be addressed in the documentation, and to be applied in practice, are listed in Table III. Quality assurance documents will themselves refer to other, more detailed documentation such as Procedures and Working Instructions. The persons (by post) responsible for the various measures necessary will be clearly identified and arrangements made to demonstrate and record compliance.

TABLE III

Principal Aspects of QA Arrangements

- Generation of Waste
- Form Raising
- Waste Characterization
- Record Keeping
- Monitoring of Waste
- Notification of Consignment
- Packaging & Labelling
- Transport
- Training

QA documents by consignors are submitted to BNFL for review and comment. The review process includes both procedural and technical aspects to ensure that all necessary matters are addressed and adequate arrangements are in place. Only once QA documentation is formally accepted by BNFL can consignments of waste be accepted for disposal.

This in itself does not necessarily ensure that the arrangements described are actually followed or that prac-

tices do not change without adequate incorporation into the QA documentation. Consignors as part of their own QA system will generally carry out self-audits and QA arrangements must be formally reviewed at least annually by the consignor. Additionally, BNFL carry out independent compliance audits of consignors. It is the objective of the audit program that major consignors, defined as those with volumes greater than 500 m^3 per year and/or those whose activity exceeds 10% of any of the Drigg authorization annual disposal limits, are audited on an annual basis, that 'one-off' consignors are audited at the time of consignment and that all consignors are audited over a three year period. Third-party consignors (ie those consigning LLW via an agency) are also subject to audit by BNFL.

Some of the findings of reviewing QA documentation and from compliance audits include:

a. Working arrangements and QA documentation needs to be consistent and up-to-date,

b. Working Instructions should describe how tasks are to be carried out and not solely express their objective,

c. Clear measures to ensure materials to be excluded or made safe need to be correctly identified and managed,

d. The methodologies for activity assessment need to be clearly defined and justification for their use provided,

e. Attention needs to be given to ensure both full and correct completion of documentation, full traceability of waste through all management stages and good standards of record keeping.

BNFL is keen to ensure that good communications exist with consignors. This includes that full feedback from audits is available to consignors and that BNFL welcomes the views of consignors on QA and other requirements.

CONSIGNMENT DOCUMENTATION VERIFICATION

All waste consigned to Drigg is accompanied by a "Form D4" in which the consignor states, inter alia, the activity, radionuclide, chemical and physical content of the waste. When this arrives at Drigg, and before the waste is emplaced in its final disposal position, a number of checks are carried out by entry of the documentation contents on to a computer database and control system in order to verify that the waste can be accepted for disposal. The main checks are:

a. The specific activity - to ensure that the waste is correctly categorized as LLW.

b. The total activities - to ensure that the sum of the individual radionuclide activities equals the total given on the form.

c. Confirmation that the activity within the consignment is within the activity allocation given to the consignor for that year.

d. Fissile content - to ensure that criticality clearances for disposals are not breached.

e. Consignment weight - to ensure that proscribed weight limits for the individual container or stack of containers are not exceeded.

Only if all the entries are verified by the computer is the consignment accepted for disposal. If the waste is not accepted by these checks, the consignment is "held" for investigation. The waste is returned to the consignor if it cannot pass these checks after the investigation.

WASTE RECEIPT MONITORING

The aspects described in the preceding sections - namely waste stream characterization, waste monitoring, quality assurance arrangements and consignment documentation verification - provide a comprehensive series of controls over LLW disposal at the Drigg site. Yet, despite these measures, there is often a perception that wastes should be in some way "checked" prior to acceptance for disposal.

BNFL has given careful consideration to this in terms of both policy considerations and technical practicability. The result of this review has been to establish a three tier system of waste receipt monitoring:

Level 1 - Weight, radiation and contamination measurements

Level 2 - Non-destructive, instrumental assessment

Level 3 - Intrusive inspection and analysis

For Levels 2 and 3 not all consignments can practicably be measured but rather a proportionate basis is being established, with the emphasis being directed to wastes from high volume and/or high activity consignors and wastes of more variable compositions or with particular features. Feedback from QA audits will also be taken into account together to some extent with random sampling.

The objective of this receipt monitoring is that the disposal organization is providing an additional tier of control in order to give further assurance that waste consignments are what they are declared to be and therefore acceptable for disposal. This in no way takes away any of the roles of the control arrangements described previously nor the associated responsibilities of consignors. Characterization and control of wastes is most effectively carried out as the waste arises at the consigning establishment. Nevertheless, BNFL sees some merit, particularly in pres-

entational terms, in establishing this receipt monitoring capability.

Presentational merit has two components. First, to waste consignors, the carrying out of confirmatory monitoring will provide a strong message that the disposal organization will carry out an independent system of checks, ie in crude terms it will provide a deterrent to poor practice. Secondly, to members of the public, regulators and others, such monitoring demonstrates that the disposal organization has as comprehensive a system of controls as practicable and hence this is seen as an important role in ensuring public confidence in waste disposal practices.

One of the difficulties in developing a practical approach to this receipt monitoring has been the relatively large size, up to 40 m^3, of containers delivered for disposal. Non-destructive measurements on such sized containers would be very difficult and even if practicable the results would be very dependent on the distribution of waste within the container, hence making quantitative interpretation in many respects meaningless. The strategy on waste receipt monitoring has therefore been developed in association with plans to introduce a waste conditioning facility for LLW based on high force compaction.

During conditioning waste will be available for monitoring on the scale of 200 l drums and nominal 1 m^3 boxes. At this scale, non-destructive assay becomes practicable, noting in particular that the requirement is not to produce a primary quantification but rather to provide confirmation that existing documentation is correct. During the conditioning stages samples of wastes can also be taken for Level 3 intrusive inspection and analysis. Importantly, consignors who wish to carry out their own waste conditioning may do so but are still subject to this monitoring regime in that BNFL has the right under the Conditions for Acceptance to take samples of consignors' wastes. Arrangements for such sampling are currently being established.

Levels 1 and 3 receipt monitoring are currently in operation. Level 2 monitoring will commence with the introduction of the Waste Monitoring and Compaction (WAMAC) Facility in 1993. Some further aspects of each of the three levels of the waste receipt monitoring program are discussed below.

Level 1 Monitoring

Level 1 waste receipt monitoring consists of radiation and surface contamination measurements on the waste container and weighing of the consignment. The radiation and surface contamination measurements show whether the waste is within the limits required to meet Transport Regulations and requirements given in the Conditions of Acceptance in respect of on-site health physics controls. The weight is used to confirm the specific activity, or in some cases the total activity, values given on the "Form D4". If these measurements show that the waste is outside the Conditions for Acceptance limits, the waste is again "held" for investigation before disposal is allowed.

Level 2 Monitoring

Level 2 waste receipt monitoring will involve non-destructive examination and analysis of drummed and boxed LLW. Three sequential measurement systems will be employed - a real-time radiography device, a gamma spectrometer and a neutron counting system.

The objective of the radiography system is to provide a means of visually examining the contents of waste packages. This will provide confirmation as to the nature of the consignment and therefore potentially identify, for example, mis-labelled wastes or, by vibration, the presence of a free liquid phase. For wastes already compacted, it will be able to examine for significant voidage. Also, a density distribution measurement can be carried out for use in interpreting the results from the radio-assay systems.

Trials of various radiography systems are currently in progress using a 1 m^3 box of simulated, miscellaneous waste items. Most of the systems under evaluation have energies in the range of 150 to 500 keV, although higher energy systems are also being considered. Image processing and recording systems are also being evaluated. These trials are programmed to be complete and a system specification produced during 1991.

In terms of the radio-assay systems, BNFL has extensive experience of a wide range of measurement systems. Work is currently in progress to establish the detailed measurement requirements and to develop the necessary instrument specifications and the associated mechanical handling, control and interpretation systems. The gamma measurement system is expected to be a high resolution spectrometer whilst for neutron measurements a differential die-away system is the lead option.

These Level 2 monitoring systems are to be located in the WAMAC facility, at Sellafield. A proportion of incoming consignments will be diverted to receipt monitoring such that the whole of each of the chosen consignments is measured for comparison with the consignment documentation. Consignments will be chosen based on a number of considerations including for example those from high volume and/or high activity consignors and based on the findings of QA audits. Following such monitoring the wastes will be either directed for conditioning as per normal or, if matters requiring further investigation are identified, the consignment will be held to enable discussions to be had with the consignor and the situation resolved satisfactorily.

Level 3 Monitoring

Level 3 waste receipt monitoring is the technique whereby a sample of the consignor's waste is removed from the despatching plant, or from the waste consignment itself, and examined and destructively analyzed. The form of sample at present is a drum or bag of waste with a volume in the range 100 to 200 liters. When the WAMAC facility becomes available, the typical sample volume will increase up to about 1 m^3. The sampled waste is opened in a specially ventilated enclosure and the physical contents of the sample logged and checked against the consignor's description and the requirements of the Conditions for Acceptance. Each waste item is then monitored and selected items submitted for radiochemical and chemical analysis. The results of these analyses are reported back to the consignor and any discrepancies against the Conditions for Acceptance and/or their waste description highlighted. This will be the subject of possible further action and incorporation into a future QA Audit.

CONCLUSIONS

BNFL as the operator of the Drigg disposal site in the United Kingdom has established a series of arrangements for the characterization and control of solid, low-level radioactive wastes consigned for disposal. These represent a comprehensive system of controls, both technically and with the objective of ensuring overall confidence in low-level radioactive waste management practices.