QUALITY ASSURANCE OF RADIOACTIVE WASTE DISPOSAL AT THE WINFRITH TECHNOLOGY CENTER

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ABSTRACT

The Winfrith Technology Center generates a wide range of different radioactive wastes, in liquid, solid and gaseous form across the spectrum of lower and intermediate levels of activity. These wastes are generated by site activities including reactor operations, post-irradiation activities of used fuel and general research and development activities. It is the intention that all such wastes will be sent off-site, either to a disposal repository, or, in the case of low level liquid effluent, by discharge to the sea. There is an increasing need to show that site radioactive waste operations meet the requirements of the regulatory and disposal authorities, which has resulted in the site having to implement effective Quality Assurance Systems across a wide range of activities. This paper describes some of these requirements and the approach to Quality Assurance adopted by the site, for three of the most important waste streams.

INTRODUCTION

The Winfrith Technology Center is one of the business sites of AEA Technology and has over 30 years' experience of research and development in the field of nuclear power and other high technology industries. The site undertakes a wide range of activities, including power reactor design, development and operation (it currently operates the 100 MWe Steam Generating Heavy Water Reactor); metallurgical research and post-irradiation examination of fuel; research and development into waste immobilization and disposal, an intermediate level waste (ILW) cementation plant is currently being commissioned; research and development into radioactive materials transport including design and manufacture of flasks and containers; and research to support the oil and petroleum industry including development of methods for enhanced oil recovery.

The above activities generate a wide range of different radioactive waste streams in liquid, sludge and solid form across the spectrum of lower and intermediate levels of activity.

It is the intention that all such wastes will be sent off-site, either to a disposal repository, or, in the case of low level liquid effluents, by discharge to the sea. Irrespective of the method of disposal, there is an increasing need to satisfy the appropriate regulatory and disposal authorities that the wastes are of an adequate "quality" prior to them leaving the site. In this sense, quality is taken to mean satisfying the authorities as to the chemical and physical forms, radionuclide levels and species, quantities and for packaged wastes other essential properties that the disposal authorities require. Adequate records must also be kept demonstrating that all wastes comply with the requirements. In essence, this requires that all wastes are packed, stored and disposed of in accordance with approved quality assurance (QA) programs.

This paper gives some details of the quality assurance being applied to three of the sites' main radioactive waste streams. These are low level solid wastes which are sent to the Drigg site near Sellafield for burial and intermediate level solids and sludges which will be packaged in cement and temporarily stored on site prior to being sent to a future repository.

Radwaste operations on the site are covered by a QA system arising from a number of requirements. AEA Technology is committed to excellence and the Chairman has laid down that "it is the responsibility of each Establishment or Management Unit to ensure that an appropriate Quality Assurance system, based on an appropriate national standard is set up and operated effectively in the areas under its control." To meet this objective, the Director of the Winfrith Technology Center laid down that "effective Quality Assurance systems are to be established and maintained, based on the requirements of BS 5882 'A Total Quality Assurance Program for Nuclear Installations' as interpreted by the corporate document 'The Application of Quality Assurance with AEA Technology.'"

The Winfrith Quality Assurance manual has been compiled to specify the method of carrying out these instructions. It defines the overall quality assurance policy and is the first tier document in an integrated system. It complies with the relevant British Standards and corporate Quality Assurance policy, insofar as they apply to the work carried out at Winfrith.

The technical content and scope of the QA systems applied to radioactive waste management have to include the relevant requirements imposed by the various regulatory authorities, disposal authorities and statutory requirements. Within the United Kingdom (as is the case for several other countries), no single Authority carries all the responsibility for defining these requirements and as a consequence, the site has to interface with a number of organizations. The main UK regulatory authorities are the Health and Safety Executive (HSE), who regulate all safety related activities on the site, and the Department of Transport (DTp) who are the UK competent authority for transport. British Nuclear Fuels plc (BNFL) operate a disposal site for solid LLW at Drigg in Cumbria and UK Nirex Ltd. will operate the future deep disposal repository for solid ILW.

All of these organizations impose a requirement that operations are conducted in accordance with approved QA systems which in general need to conform to the requirements of BS 5882 if they are to be acceptable to the various authorities.

The site also has to meet a number of other requirements arising from statutory requirements. These include, for example:

- The Ionizing Radiations Regulations, 1985, which regulates the protection of personnel against ionizing radiation.
- The Radioactive Substances Act, 1960, which regulates how the site handles radioactive materials.

All of the above impose a variety of technical requirements and imply good management practices to ensure that they are met.

INTERMEDIATE LEVEL SOLID AND SLUDGE WASTES

Radioactive sludges, which come from operation of the Winfrith Steam Generating Heavy Water Reactor, consist mainly of Powdex ion exchange resins with small quantities of Stella filter aids and decontamination reagents. The sludges are stored in one of three tanks, the total inventory of sludge being about 270 m^3 and the rate of accumulation about 10 $m^3\,y^{-1}$. The main radioactivity in the sludge comes from ^{60}Co and ^{137}Cs, and the material is at the low end of the intermediate level waste category. Smaller amounts of intermediate level solid radioactive waste are generated primarily from post-irradiation examination of fuel elements for the electricity supply industry. These wastes are dominated by the activation product ^{60}Co from cobalt in alloy steels.

It is intended that these wastes will be processed in the new Radwaste Treatment Plant (RTP) currently being commissioned at Winfrith.

The sludges will be immobilized in a homogeneous cement matrix, while the solids will be encapsulated and grouted within cement. The final cemented product will be contained within welded, stainless steel drums of nominal 500 liter capacity. The drums will initially be stored on site in a fully engineered, retrievable store, which will allow for monitoring of their condition.

The key feature of the QA system to be applied will be to show that the physical and chemical properties of the processed drum meet the repository acceptance criteria and to collect an appropriate set of data that define these properties.

The repository acceptance criteria in the UK are still to be finalized, but it is likely that they will address, inter alia, the following product properties:

- Physical and chemical properties of the waste,
- Activities of principle radionuclides,
- Drum material properties,
- Drum identification,
- Matrix strength and homogeneity,
- Drum dose rates and surface contamination level,
- Drum physical properties (e.g., size and mass).

The above list is not comprehensive but is intended to indicate the rate of data required to be collected for each disposal package.

It should be noted that the data requirements fall into four distinct groups, viz:

a. Those that can be identified directly at the time of package dispatch, et mass, dose rate etc.

b. Those that can be identified, but only at the time of processing, et physical and chemical properties of the raw waste.

c. Those that cannot be identified directly but only inferred from other measurements made at the time of processing, e.g., matrix ultimate strength.

d. Those that cannot be measured at all but rely upon other aspects of the Winfrith quality assurance system, e.g., container lifetime assurance.

Considering the actual data requirements, it can be deduced that only a very limited amount of data can be generated at the time of package dispatch, and that the majority of data will have to be collected at (or deduced at) the time of package manufacture. Thus, not only will a considerable quantity of data have to be collected, it will also have to be stored. For this purpose, it has been decided to use a mini-computer under the control of a fourth generation relational database management system to allow for data storage, manipulation and retrieval. The resultant database will be organized to provide a complete record of the quality assurance information for each package.

In order to simplify the data collecting and recording tasks as much a possible, and also to minimize the possibility of errors, it is intended to collect as much data as possible by the computer via the treatment plant control system using a specially-designed interface. Status and event "flags" provided by the control system will trade drum progress through the plant and will indicate the availability of data as and when it is collected by the plant instrumentation. For example, an event flag may represent the completion of transfer of powder to a weighing hopper, the relevant data being the actual weight of powder transferred. Not all data can be obtained automatically and will thus have to be entered manually into the system by the plant operators.

The main parameters being measured include the following:

- Drum weights,
- Drum identity and location,
- Physical/chemical description of wastes,
- Radionuclide content of incoming wastes,
- Weight of raw materials in the storage hoppers,
- Water temperature and flowrate,
- Grout level and flowrate,
- Metering tank levels,
- Sludge holding tank weights,
- Process temperatures,
- Mixing motor torque,
- Drum welding parameters,
- Matrix hardness and
- Drum dose rate and contamination levels.

The following gives examples as to how some of the most important data will be collected.

Drum Identity

The single most important item of data is the identity of the drum as it enters into the plant: All other data collected is then related to the unique drum identification number. This number is scanned by a TV camera prior to the drum entering into the plant, optically processed and offered to the operators alongside the drum number as viewed directly by the camera. The processed number is entered directly into the database although the operator can reject this number if for any reason it has not been processed correctly. The plc controls the movement of each drum through the plant and is thus aware of the drum identification at each processing stage. Nevertheless, the drum identification is remotely read by TV cameras at various stages through the plant, in order to compare the actual drum location with that recorded by the plc. The operator is warned if errors are detected. It will also be noted that the drum design for solid wastes is different internally from that used for the sludges (although as seen from the outside the drums appear identical). From the drum identification numbers, the plant control system is able to differentiate between drum types, and will not allow the "wrong" type of drum to enter the plant in relation to the type of campaign (solids or sludge treatment) being undertaken.

Matrix Constituents

For drums holding sludges, weights for cement and additives will be recorded at the storage silos and also at mixing stations. The actual quantities of cement, liquids and additives used will be calculated by the computer and entered into the database.These values will be compared to the acceptable process envelope values and the operator alerted to any discrepancy. The weight of the drum after filling will also be recorded and checked against the expected weight change computed from the weights of the materials added to the drum. Again,the operator will be alerted to any discrepancies. Similar measurements and records will be made when encapsulating solid ILW.

Activity Levels

For drums containing sludges, the activity contents of the key isotopes identified by Nirex will be determined by direct assay of the raw sludge, and manually entered into the database. This data being identical for a large batch of drums. For drums containing solids, the activity content of each drum will not be known until the drum is loaded. The contents of each drum will be assayed (prior to encapsulation) by a gamma spectrometer situated within the plant. The spectrometer output will be processed by the main computer and the activity levels of the key isotopes computed and passed into the database.

Lid Weld Quality

The Winfrith drum design incorporates an all welded lid. The welding process itself will be carried out by an industrial robot sited within the plant. During the welding process, the appropriate welding parameters (e.g., filler wire feed rate, current, etc.) will be recorded and processed by the computer. The key parameters measured will be compared to the process envelope requirements and a successful weld indicated to the database. The operator will be alerted to deviations.

Some redundancy of measurement is built into the system whereby important parameters are measured twice. For example, weights of powders and additives used in a drum will be measured and compared with the acceptable process values. The weight gain of the drum after filling will also be measured and compared with that expected from the weights and additives. Any nonconformances or errors will be announced to the operators. Data requiring manual entry, such as physical descriptions of the waste, will be undertaken using customized keyboards for ease of data entry.

Data collection alone cannot assure product quality. Other activities such as research and development, plant design, installation, commissioning and operation all potentially affect product quality. Table I gives an indication as to how particular package requirements are dependent upon this aspects.

parameters affecting quality remain within the acceptable operating windows.

f. Storage of the processed packages to ensure that no unacceptable deterioration occurs.

g. A record system to define the record requirements and the measures to be taken to ensure retrievability and legibility for extended periods of time.

TABLE I

Package Requirements

Active Content	Operation	Design
Dose Rate	Operation	Design
Surface Contamination	Operation	Design
Drum Size/Shape	Design, Procurement	---
Drum Weight	Operation	Design, Commissioning
Matrix Properties	R&D, Commissioning	Design, Operation
Indentification	Procurement, Operation	---

From the above table it can be deduced that all of the above activities are important, since at least one requirement is strongly dependent on each of them and most requirements are, to an extent, dependent upon having a correct design of the plant.

The Winfrith QA system covers all of these activities, in that document procedures are, or will be, in place defining responsibilities for activities and how they are to be carried out. As examples, topics covered include:

a. Research and development activities where the work undertaken and the justification for choosing particular materials and processes is formally recorded.

b. The design of the plant, documenting the thought processes that lead to the selection of a particular option and the justification that it meets the specified requirements.

c. Procurement of stainless steel drums and raw materials (e.g., cement powders and additives, etc.) to ensure compliance with specifications.

d. Installation and commissioning of the treatment plant to ensure that all features of the plant that affect package quality operate as designed.

e. Operation of the plant to ensure that all the process

LOW LEVEL SOLID WASTES

These wastes are generated from a wide range of different site activities and are sent to the burial site at Drigg operated by British Nuclear Fuels plc (BNFL). BNFL has established a comprehensive set of acceptance criteria defining the nature of wastes that can be accepted for disposal. Such criteria are necessary to ensure that both the radiological and conventional hazards resulting from site operation comply with the regulatory requirements. This demands that the nature and quantity of the radionuclides sent for disposal are both known and kept within authorized limits, and that certain materials are excluded. These include, for example, combustible materials, pyrophoric and explosive materials, free liquids and putrescent materials.

These wastes are collected, treated and transported to BNFL under a QA system with the objectives of:

a. Ensuring that all material consigned to Drigg for disposal complies with the consignor's authorization or noting letter issued under the Radioactive Substances Act 1960 and with the current Conditions for Acceptance by British Nuclear Fuels plc of Radioactive Waste for Disposal at Drigg,

b. Ensuring that all such material is transported in accordance with appropriate legislation,

c. Ensuring that all necessary records are generated, maintained and available to demonstrate that the appropriate requirements have been complied with.

The most important requirement is that the nature of the waste sent conforms to the definition of low level waste (which is defined as waste whose activity does not exceed 4 GBq/t for alpha emitters and 12 GBq/t for all other isotopes) and that it is allocated to the appropriate waste stream as previously agreed with BNFL.

While it would be inappropriate to go through all of the details of the Winfrith system, it is interesting to highlight three of the most important aspects of the system which help ensure that waste sent for disposal complies with the technical requirements.

Documentation

Management procedures are documented and issued which give a clear definition of responsibilities for activities that have to be carried out. These procedures are:

- Prepared to a common format;
- Issued on a controlled basis;
- Changes are properly reviewed and authorized;
- Subject to periodic review.

Technical aspects covered by these procedures include activities such as:

- How the waste is packaged;
- Whether the waste is compacted;
- The containment method used;
- The labelling and recording methods used;
- Health physics monitoring of the package;
- The forms which are raised;
- How notifications of intended/accepted consignments are given;
- Health physics monitoring of consignment/transport which is carried out;
- Transportation arrangements.

Interfaces

The system gives a definition of the interface requirements and responsibilities of waste procedures on the site. In particular, this gives a clear definition of the nature of LLW that can and cannot be sent to Drigg for disposal.

Other technical aspects covered include:

- How the waste is collected;
- How the waste is segregated (where necessary) from other wastes;
- Any preconditioning and treatment that is carried out;
- How the waste is monitored to determine radioactivity content and categorized with appropriate reference to any prior waste stream characteristics.

Management Review

The system requires that management regularly and consciously review the operation of the system for meeting the quality requirements of the site and for operational efficiency.

CONCLUSIONS

At first sight it may seem strange to equate "quality" with "waste." Waste is normally just thrown away and forgotten about, but in the field of radioactive waste management, it is becoming increasingly clear that radioactive waste has to conform to an ever increasing number of technical and other requirements imposed by regulatory and disposal authorities. In other words, there is an increasing need to show that such wastes are of an adequate quality.

Radioactive waste operations are both extensive and complex, and as is becoming increasingly clear, expensive. There is an obvious incentive for management to ensure that such operations are carried cost effectively and efficiently, as well as safely. Winfrith has responded to these requirements by recognizing that to achieve quality, and to demonstrate quality to customers and regulatory authorities, requires a large team involvement and a commitment from management.

This paper has indicated some of these requirements and shown the structure of the relevant management and control systems introduced into the site to help ensure that the requirements are met in a cost effective way.

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