THE LONG TERM MANAGEMENT OF INTERMEDIATE LEVEL WASTE PACKAGE RECORDS AT THE UNITED KINGDOM WINDSCALE ADVANCED GAS-COOLED REACTOR

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ABSTRACT

The management of radioactive waste packages requires continued access to detailed, comprehensive and reliable information. It is therefore necessary for waste package custodians to establish and implement at an early stage a system for managing information records. This paper will describe the nature of the specific and generic radioactive waste-related information to be recorded for individual package records, the media currently available and a description of a system that has been implemented in the UK for ensuring information remains accessible for an extended period.

A system for the long-term management of waste package records is being implemented at the UK's Windscale Advanced Gas-cooled Reactor (WAGR) decommissioning demonstration project. This project is now nearing completion and all of the intermediate level waste (ILW) has been packaged into concrete WAGR containers for interim storage pending transfer to a national facility for their long-term management. This project has provided a catalyst for the United Kingdom Atomic Energy Authority (UKAEA) and Nirex to work together to develop and implement a records management strategy.

INTRODUCTION

The UKAEA has constructed and operated a wide range of nuclear facilities since the late 1940s supporting the development of all aspects of atomic energy research including reactor systems, fuel and reprocessing technology and fusion. Latterly, UKAEA has been tasked with managing the liabilities from these nuclear facilities.

UKAEA's current mission is to restore the environment of it's sites in a way that is safe and secure, is environmentally responsible, provides value for money and is publicly acceptable. This restoration includes the decommissioning and removal of all redundant facilities and the conditioning of waste generated from this process to produce passively safe waste packages for long-term storage and eventual disposal in accordance with UK Government policy.

United Kingdom Nirex Limited (Nirex) is the organisation within the UK that has been charged with the development of options for the long-term management of radioactive materials. Its mission is "To provide the UK with safe, environmentally sound and publicly acceptable options for the long-term management of radioactive materials". Following the Government's refusal to support a planning application by Nirex for the construction of a Rock Characterisation Facility (RCF) in 1997, it was

recognised that it would be necessary to review the national strategy for the management of radioactive waste. This review is currently on going and is due for completion in 2006.

The UK nuclear industry has undertaken a significant amount of work in order to provide a high degree of assurance that waste package integrity can be maintained for an extended period of interim storage, if handled correctly within a controlled environment. In support of the effective and appropriate management of the waste packages, the records containing information on the package contents and production must be continuously accessible. Nirex, in consultation with UKAEA and other waste producers, have therefore sought to identify the elements of a strategy that identifies not only they key waste package specific information that must be recorded, but also the generic information that will assist future custodians to safely manage the waste package. The strategy recognises that there are many factors that potentially threaten continued access to the package information over the longer term but particular attention has been paid to records media and their storage arrangements.

Nirex has developed guidance on the technical content of the package records and the management of the media on which the waste package information is likely to be stored. This guidance has been issued to UK waste producers to assist in the development of their own waste package information management strategies.

This paper describes how UKAEA and Nirex have worked together to develop and implement a waste package information management strategy for the WAGR decommissioning project.

UKAEA WASTE MANAGEMENT STRATEGY

It is UKAEA policy that radioactive wastes should be treated by transferring them into a chemically and physically stable form such that they can be stored in a safe condition. As far as practicable, the treated wastes should be compatible with future disposal requirements by packaging ILW in accordance with waste packaging specifications developed by Nirex.

The UKAEA and Nirex engage in an iterative process to develop an acceptable waste conditioning and packaging process which culminates in the issue of a "Letter of Comfort" (LoC). This process enables a wide variety of issues to be addressed for each ILW package type, and minimises the risk of producing waste packages that are incompatible with the management options for a national repository. Full details of the Nirex waste package specifications can be found in Nirex report N/007, which can be downloaded from the Nirex website (www.nirex.co.uk).
UKAEA have recognised that, because of uncertainties with the timescale for the availability of a national repository, there will be a requirement to manage these waste packages on UKAEA sites for possibly the next 50 years, potentially extending to 100 years, prior to their transfer. The long-term storage of these packages will also require the long-term management of the information intended to demonstrate that they are compatible with the present criteria for disposal at a national repository.

THE ROLE OF NIREX

The Nirex remit covers all ILW and certain low-level radioactive waste (LLW) that cannot be disposed of in current LLW facilities. In order that waste packages do not preclude long-term waste management options, Nirex encourages waste producers to implement the LoC process. The criteria that have been developed to assess the waste package have been derived from a generic deep geological disposal facility.

The Phased Disposal Concept (PDC) has been developed by Nirex as a technically viable option for the long-term management of ILW and LLW. The PDC represents a stepwise approach to the disposal of radioactive waste within a deep geological repository that also includes retrievability until a decision is

made on closure. Nirex believes that the PDC represents a supportable and technically feasible option for long-term radioactive waste management, but it also recognises that further work would be necessary to fully develop it.

Development and assessment of packaging proposals against the PDC has provided a clear view of the many technical requirements and constraints that transport, handling, storage and disposal of packaged radioactive waste would entail and these have been compiled into a 'Generic Disposal System Specification' (GDSS). In order to assist waste producers when preparing to undertake waste conditioning and packaging campaigns, Nirex have produced a suite of 'Waste Package Specification and Guidance Documents' (WPSGD) that specify the requirements for ILW and LLW packages.

Guidance on the long-term management of waste package information and records has been included in the WPSGD. This guidance is now being used to support the development of waste producer information management strategies and makes reference to issues concerning hard copy records, digital records, alternative media technologies, threats to record integrity, record storage regimes and recommendations on the development of a long-term records management strategy.

NATURE OF INFORMATION TO BE RECORDED

The principle behind recording data on waste packages is:

> Information shall be recorded for each waste package to enable conformance with the necessary performance and acceptance criteria to be demonstrated for future phases of waste management.

Nirex requires that waste producers establish a data recording system for acquiring, recording and subsequently managing information for each waste package such that the package may be assessed against requirements for safe and cost-effective handling, transport, storage and potential disposal. What needs to be recorded, therefore, is information that can be used to establish, infer or predict package properties and performance under all relevant circumstances. Ultimately, this information may be used to demonstrate conformance with future transport, handling, storage and possible disposal (or long-term storage) acceptance criteria.

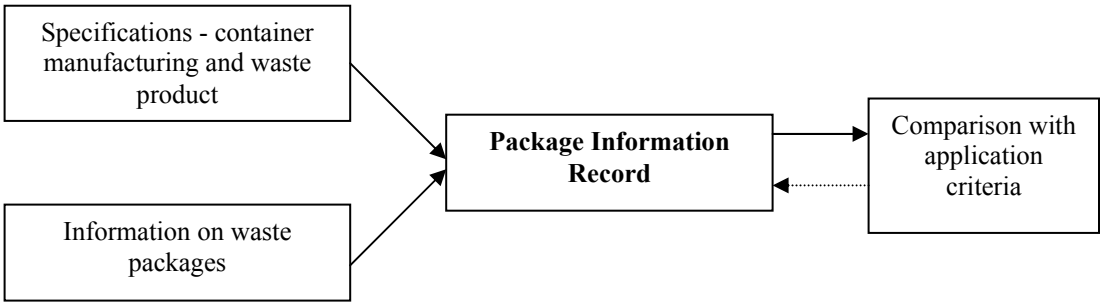

Fig. 1 The use of package information to confirm compliance

The range of information that will need to be recorded for each individual waste package will be unique and whilst a 'standard' approach will be used as far as possible, the development of a tailored system may be required for each waste type or packaging campaign.

Information will be created over the entire lifetime of the waste package, from process conception, through process development, waste package production, storage, transport and ultimately disposal. It may be considered appropriate to split the information sources into four distinct groups, namely: generic

information related to a number of packages, batch specific data, package specific data and administrative information. These different groups of information may be populated by different means and their relationship can be illustrated as follows:

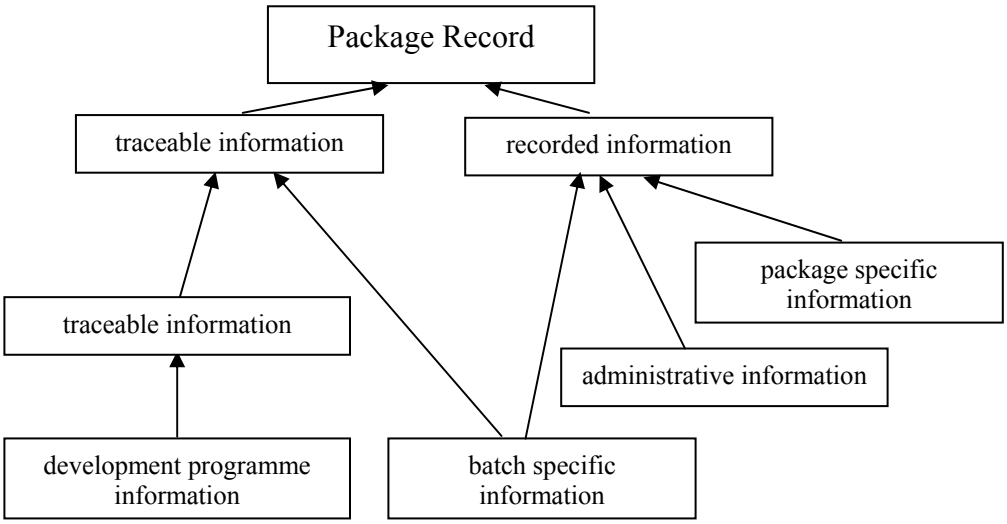

Fig. 2 Information source relationships

Development Programme Information

During the development of a process for packaging the waste, consideration will have to be given to the relevant properties of the final waste package and its evolution over time. Information created during this development programme will contribute to the knowledge on the final waste package. The following information should be recorded:

- waste conditioning and packaging materials and processes.
- encapsulation materials used in the creation of a waste package;
- a record of the proposed waste package properties and performance over time;
- the relationship between these and the nature and quantity of waste;

Parameters likely to influence the quality of the final package are particularly important to identify as these will require close control during manufacture and accurate data recording.

Information recorded on the findings of the development programme will form an important component of the package record. This information is likely to be retained as 'traceable information' which will be referenced from the package record or from other related documents such as the Waste Product Specification.

The Waste Product Specification will define the characteristics of the intended waste package and is the result of research and development programmes. It provides a means for specifying the waste package production envelope.

Batch Specific Information

Some information will be common to a number of packages. For example, relevant information will be created during the manufacture of the containers (where a batch of containers is supplied for a packaging

campaign) or as a result of the purchase of bulk supply materials (such as the encapsulant). Information of this type may be duplicated in numerous of sets of package records, alternatively, it may referenced as traceable information preserved elsewhere. The means of preserving such information will depend on its nature and the media used but it will be at the discretion of the Waste Producer. Nirex will offer support and advice on the optimum management arrangements for preserving such information sources.

Package Specific Information

Package specific information is that which is unique to a single entity. Examples of this information include the package identity, data demonstrating conformance with prescribed limits (conformance data) and a description of the nature of the waste. Information may be derived from measurements or calculations conducted at any stage of the package manufacturing process or subsequent interim storage.

As suggested earlier in this paper, decades may elapse between the package manufacture and its ultimate disposal. Consequently, packages will be monitored during interim storage in order to demonstrate that they continue to comply with handling, transport, storage and disposal requirements. An historical record of the storage location, environmental conditions, duration and any significant events will complement the package specific information. A combination of package specific and storage information will enable a detailed history of the package to be built up thus providing valuable information on the expected long-term evolution of the package.

Administrative Information

In addition to the information described above, there will be a requirement to derive data to demonstrate compliance with administrative and regulatory requirements related to transport and disposal of the waste. Such administrative information will accompany the package throughout. In general, the information would not be required until the time of consignment of the waste for long-term storage or disposal.

Some waste will contain accountable quantities of safeguarded nuclear materials. Where this is the case, information on the precise quantities and locations, will have to be maintained and routinely declared to the Safeguards Authorities.

INFORMATION COLLECTION AND MEDIA

The wealth of information relating to the creation of radioactive waste, its processing, conditioning, packaging and interim storage exists in a variety of forms at disparate locations in the UK. Waste package specific information is commonly found in log-books, process plant log-sheets, container manufacturing and inspection records and package store records. The generic and batch specific information may be found in process research and development reports, process plant drawings, specifications for immobilising materials, results from inactive packaging trials, and quality system assessment reports. Together, these sources provide the means for establishing a comprehensive knowledge base that will enable future custodians to make informed decisions based on accurate and reliable information.

Information currently resides on a range of media including paper, microform, computer diskette, magnetic tape, CD-ROM and, to a lesser degree DVD-ROM. The majority of the information collated to date is stored under secure conditions, but there are currently very few site-based records storage facilities designed and constructed with the specific intention of preserving waste package records media for the long-term. The records management systems generally in place have been implemented to meet the immediate operational or regulatory needs of the nuclear facility licence which extend to between 30 and

50 years. The issues affecting continued long-term accessibility to the information have not been explicitly addressed although, using the WAGR project as a typical case, progress is now being made.

CONTEMPORARY RECORDS MEDIA

Nirex undertook a study of the characteristics associated with the range of records media in use today and their suitability for storing information and ensuring continued accessibility over the long-term. The records media considered were initially categorised as 'hard-copy' and 'electronic'. Hard-copy records were defined as those on which data can be recorded without the need for subsequent processing or conversion. Electronic records were defined as those created and presented electronically (for example, a spreadsheet) or those that undergo some form of secondary digital processing (for example, an electronically scanned hard-copy record).

Most papers display qualities compatible with long-term preservation and their longevity is further enhanced if they are stored in a controlled environment. There are a number of standards that provide recommended conditions for optimum preservation and these can be readily achieved given modest resources. Other measures are recommended to increase longevity including restricted access to originals, the use of lint-free gloves when handling paper records and the elimination of all metals and plastics such as staples, paper clips and PVC covers, all of which have been shown to have a detrimental effect. However, with the ever increasing pressure to implement 'environmentally-friendly' processes, the use of re-cycled paper is now commonplace. These papers should only be used with extreme caution, particularly where their constituents are poorly defined and long-term performance is unpredictable.

Microforms have been a popular medium for many years where large volumes of data, drawings and diagrams require preservation. However, it is noticeable that with the increased use of electronic data storage systems the popularity of microform has declined. Continuing improvements to film construction, the introduction of laser printing techniques, combined with its long-term stability and competitive cost, suggest that this medium has the potential to feature in future waste-related information systems.

Analogue data stored on magnetic disk or tape was the principal storage medium until the mid-1980's. Much important historical information, potentially of interest to future waste custodians, resides on these media and whilst our understanding of the long-term characteristics of them is less well advanced than that of paper, there is a fairly substantial knowledge base. The subsequent development of optical media saw a move away from the relatively error-prone and delicate magnetic media to optical disks. On first inspection their apparent robustness and durable nature suggests an ideal storage medium that will complement any long-term information system architecture.

Digital information storage is dominated today by CD-ROM. They are undoubtedly hard wearing, require little maintenance, have a large storage capacity and are readily available at low cost. However, there is relatively little experience in their use and consequently, there is only limited knowledge, based on accelerated ageing, of their suitability for information preservation over the long-term. The low production and purchase costs of CD-ROM disks can be achieved by employing low-cost materials and mass production. In many applications a small number of failures may be acceptable but the preservation of radioactive waste data does not fall into this category. Care must be taken if CD-ROMS are used and high quality media combined with regular checks is highly recommended.

The past twenty years has seen a significant increase in the use of electronic systems for creating and storing data. The convenience, storage capacity and low cost of the media, makes an electronic-based system a very attractive option to a paper or microform-based system. Most organisations use computer systems for the creation of key records and it is understandable that there will be a strong incentive to

assume that the advantages offered by electronic media in the sort-term can provide a basis of an argument for their use over the long-term. Continued and long-term access to information is placing new and unfamiliar demands on the media and it would be unwise to make critical decisions without first fully understanding the real threats.

RISK MANAGEMENT

Development of a robust information management system requires firstly, the identification of the threats to data accessibility and, secondly, the measures necessary to eliminate or mitigate the risk of these threats. Measures employed could be 'preventative', such as the installation of a fire detection and suppression system, or 'anticipatory'. An anticipatory measure pre-empts the effects of an unplanned event and ensures that a full recovery is possible, for example, copying records and transferring them to a remote storage facility.

One of the greatest and most tangible threats to the loss of information results from organisational change. The UK nuclear industry has undergone significant organisational change in the past and is likely to undergo further changes in the near future. The risk associated with changes to organisational structures lies in three areas: firstly, information is 'lost' or misplaced during the transfer of responsibilities; secondly, it is successfully transferred but its significance not recognised; and, thirdly, the recipient organisation operates a different management system with which the recorded information is incompatible.

Another threat, generally associated with electronic media, is loss of data accessibility as a result of technological advance. 'Low-technology' solutions (for example paper or microform-based records) are less likely to be affected than 'high-technology' solutions (for example, digitally based records). The latter rely heavily on a number of interacting technologies (both hardware and software) so whilst the 'electronic' solution has many short-term advantages, it also has great potential for long-term accessibility problems if migration onto replacement media is not carried out.

ACCESS TO STORED INFORMATION

The relative merits of any of the aforementioned media types is irrelevant if there is no reliable means for the recovery of the stored information in a form that allows common and accurate interpretation. The principal objective of the information management system strategy is to provide future generations with relevant information with which they can make reasoned decisions concerning waste packages manufactured today. Accessibility to the preserved information is the principal driver that will influence how we preserve information for the long-term future. Accessibility comprises three elements:

- Readability - the ability to recover the data from the medium;
- Intelligibility - the ability to convert the data such that it is recognisable to the user;
- Usability - the ability to interpret the data in such a way that it is meaningful.

These three elements apply to any media, but it may be helpful to illustrate the significance of each by using an 'electronic record' as an example. Data are stored on a magnetic disk as a series of binary digits. Firstly there needs to be a 'system' that reads the binary digits and, secondly, converts them into something 'intelligible', for example, a temperature or the identity of a radionuclide. To enable these two processes to be successfully carried out it is necessary to have access to the data context, content and structure - known as the file 'meta-data'. In simple terms the meta-data represents the key with which the raw data can be 'decoded' and turned into a real resource. The meta-data and other supporting

information can then be used to interpret the record. The significance of preserving accurate and appropriate meta-data cannot be over emphasised, as without it the raw data will almost be inaccessible. Preservation of information is driven by the need to access data in the future. Information storage is merely a means for enabling future access. It follows, therefore, that any strategy developed should be driven by data access considerations, rather than a preferred choice of media.

STAGES IN THE DEVELOPMENT OF A LONG-TERM INFORMATION MANAGEMENT STRATEGY

There are a number of steps to be taken in the development of an information management strategy:

- recognition, understanding and widespread agreement of the information to be preserved;
- agreement to support a strategy that ensures the continued accessibility of information;
- consideration of the threat of information loss and the creation of a risk register; and
- support for the strategy and adaptation of local systems, where necessary.

One of the most challenging aspects will be to gain a common understanding of what waste-related information is to be preserved. Agreement should be made at a national level with widespread commitment to support the strategy and to allocate appropriate resources. It is recognised that future information requirements will be somewhat speculative rather than definitive. In view of this, it is inevitable that a range of 'supporting information' will be required. This information may also form the core of the meta-data required to interpret the raw data.

The implementation of a strategy for information management must take into account the existence of the diverse range of historical information. It may be that significant amounts of information have been created and stored over the years without serious consideration about how it should be actively managed. The strategy must therefore consider the need for managing historical information and, if necessary, migrating it onto preferred media whilst ensuring there is no loss of accessibility. Some historical information may require prompt attention and this will require a programme of prioritised migration.

There is no generic solution for the preservation of waste package information but the information management system must be based on a sound and accepted strategy that meets the needs of both present day and future custodians. The full range of stakeholders should be involved in its development in order for it to be accepted and supported. Media choice is clearly important, but it is not critical as a well-developed system will recognise the media characteristics. Accessibility to the data is the single most important factor and this, ultimately, will drive strategy.

PUTTING THE STRATEGY INTO PRACTICE

Reactor History

The Windscale Advanced Gas-cooled Reactor was built to study the advanced gas-cooled power reactor system; to provide a facility for in service testing of fuel destined for commercial reactors; to serve as a test bed for further development of fuel and other components; and to provide operational experience of power production. In total, fourteen commercial-scale reactors were constructed on seven sites based on the knowledge gained at WAGR. The reactor design comprised a carbon dioxide cooled, graphite moderated system fuelled by uranium dioxide fuel clad in stainless steel. The reactor consisted of a

graphite moderator 15ft (4.6m) diameter and 14ft (4.2m) high, housed in a cylindrical reactor vessel with hemi-spherical ends. The reactor, its associated heat exchangers and concrete shielding are enclosed in a steel containment building 134ft (40.8m) high and 135ft (41.1m) maximum diameter.

Constructed between 1957 and 1961, WAGR achieved full design output in 1963 and operated at an electrical output of 33 MW(e) for 18 years with an average load factor of 75%. In 1981 the reactor was shut down after satisfactory completion of all the research and development objectives.

In anticipation of the UK's likely nuclear decommissioning needs the UKAEA initiated preliminary decommissioning studies for WAGR in 1975 and followed these in 1981 with the decision to decommission WAGR to Stage 3 (restoration of the area occupied by the facility to a condition of unrestricted re-usability).

The project objectives at the time were:

- To demonstrate the feasibility of dismantling a nuclear reactor safely and at acceptable cost in terms of both money and dose uptake;
- To establish a route and appropriate authorisation procedures for the disposal of the active waste;
- To highlight engineering problems and to develop the necessary equipment and techniques to overcome them;
- To acquire and record the information, data and expertise that would be of use in the design and subsequent decommissioning of nuclear power plants, especially gas-cooled nuclear reactors.

Planning the decommissioning of the WAGR started before the reactor shut down in 1981, which has resulted to date, in an excess of 20 years accumulation of documents relating to both the methodology of decommissioning and the nature of the wastes arising from decommissioning. In that period four different teams of people have been tasked with the decommissioning work. Initially this started with the operating staff and has culminated at this time with a UKAEA supervisory team who have executive and supervisory responsibilities which ensures that contractors appointed to carry out the decommissioning work do so in a safe and controlled manner.

The decommissioning work itself has progressed steadily over the last 20 to 25 years from a fully fuelled reactor to a stage where basically only the steelwork associated with the lower half of the pressure vessel and concrete shielding remain. Much of this work was done in stages such as the development and design work associated with the concrete boxes used for storing the ILW which was done in the mid 1980s, the construction of a waste handling facility in the 1980s, the removal of the top dome of the reactor in 1991, the erection of a remote dismantling machine in the 1990s and the removal of the heat exchangers in 1995. The Top Dome and Heat Exchangers were classed as LLW and have been disposed of as such.

Development of an Information Management Strategy

All this work has had an effect on the way the associated documentation was created, filed and stored. The three earlier teams who worked on the project were from different companies and each had its own document control system. Fortunately they all worked in the same building as the present team and the documentation associated with the project has remained at the same location. This has assisted the present team to create a database of all the reports and files prepared since decommissioning started. This database was originally developed for identifying and locating early decommissioning studies in order to

help with the preparation of the safety cases necessary for each of decommissioning campaigns associated with the removal of the various parts of the reactor itself. The database is now being used to source many of the original and current generic papers associated with the ILW containers and the nature of the waste itself.

As the ILW from the reactor was being packed into the concrete waste containers it became apparent to the UKAEA Quality Assurance personnel on the WAGR decommissioning project that a completely new approach to the handling of data, records and reports was required. Traditionally the UKAEA, as a non-departmental public body, reviews its documentation after five years and then again after 25 years prior to depositing it the United Kingdom's National Archive in Kew on the outskirts of London. At any of the two reviews, documents can be destroyed or retained according to certain established principles. It was therefore apparent that the ILW documentation had to be labelled in a way that a reviewer would easily recognise its importance. It was also realised that the ILW documentation should be separated from other decommissioning paperwork while the decommissioning personnel were still on site so that any problems arising regarding identification of the correct data to store could be addressed by people familiar with the work. This then established a time scale for the collating of the necessary ILW information with an end date prior to the completion of the current decommissioning work which is expected to be in about 18 months time.

A Project Management Plan (PMP) was prepared by the UKAEA decommissioning team specifically for the Long Term Storage of WAGR Records. This PMP defined the aims and objectives of the project and included such things as the identification of stakeholders and their requirements, the risks to the project, the programme of work and associated costs. The project management duly accepted this PMP.

Nirex's specification for waste package data (part of the WPSGD suite) which identifies the information that should be held for the waste and its packaging was used by the UKAEA to produce a conformance report. This conformance report lists all the reports, correspondence, drawings and data necessary to be collated and archived for the WAGR ILW being produced and subsequently being stored on site. Although this report cannot be finalised until decommissioning work is completed this conformance report has become a working document on the project for those associated with preparing the ILW records.

Records Media

The work done by Nirex investigating suitable media mentioned earlier in this paper influenced the decision on the choice of media to be used for storing all the necessary information on ILW arising from the WAGR decommissioning project. Paper was chosen due to its proven performance over the other possible forms of media for the reasons outlined earlier in this document. As part of the PMP process the risks associated with holding data on paper were examined. The highest risks identified were associated with Organisational Change and Deterioration of Records. To mitigate against these, and other risks such as fire and aircraft impact, procedures are being introduced which will ensure that the records are duplicated and held at two different locations within the United Kingdom and also special "permanent" paper will be used. Permanent paper is acid free paper that will not deteriorate or discolour in the way that recycled paper which has a high lignin acid contact does.

Implementation of the Information Management Strategy

Early inspection of the information recorded on the detailed records associated with each waste package (known as the box package records) revealed a number of problems, which have subsequently been addressed. They were varied and included the simple case of having the reference for the packing plan of each box as a location in the waste route building. This was changed to a reference point on the box itself

as the details of the building and the box position at time of loading are not expected to be known after the passage of time. Another was associated with the assay of the waste itself. As a bespoke method of calculation is used for determining the radionuclide content of the package it was realised that insufficient data was being included in the box records to allow verification or recalculation of the content if necessary at a later date. Problems such as these have instituted a detailed examination of all of the box packages prior to their final acceptance. This work involves both engineering and technical expertise and is expected to be on the critical path with regards to the completion of the project.

The collating of the necessary data on the ILW arising from the decommissioning of the Windscale Advanced Gas-Cooled Reactor for long term archiving is now a well-established part of the decommissioning project. The ILW generic information is now being separated from the normal document control system ready for photocopying onto permanent paper. A programme to examine and modify, where necessary, the individual box package has commenced. Duplicate interim box package records are being prepared as a result of this programme which are now being held separately in different buildings on the Windscale site. Generic information is currently available at a number of locations so duplication in a controlled system in the short term is not deemed necessary. Photocopying of both the individual box records and the generic information onto permanent paper will be carried out at the end of the current phase of the decommissioning work so that it can be controlled as a single task.

CONCLUSIONS

The long term management of radioactive waste packages requires continued access to detailed, comprehensive and reliable information. It is therefore necessary for waste package custodians to establish and implement at an early stage a system for managing information records.

In the absence of national guidelines for the development of an information management strategy UKAEA have developed, with the assistance of Nirex, such a strategy for the WAGR decommissioning demonstration project. This system will be used as the basis for the development of corporate guidelines on the management of information in support of other UKAEA waste packaging projects.