Meeting the Waste Challenge for Sellafield Cleanup

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ABSTRACT

With over 200 nuclear facilities, Sellafield is the largest and most complex nuclear cleanup site in the world. It comprises activities that span the entire nuclear fuel cycle. British Nuclear Group is the primary contractor for the site that is now owned by the Nuclear Decommissioning Authority (NDA).

The Waste Project Group, working in the Cleanup organization for British Nuclear Group at Sellafield, is responsible for providing a Low-level Waste (LLW) and Transuranic waste (TRU) management service.

This paper sets out initiatives that are presently being pursued at Sellafield to meet the waste management challenge associated with the cleanup and how it meets the intent of the NDA national strategy for effective nuclear waste management.

INTRODUCTION

With over 200 nuclear facilities, Sellafield is the largest and most complex nuclear cleanup site in the world. It comprises activities that span the entire nuclear fuel cycle. British Nuclear Group is the primary contractor for the site that is now owned by the NDA.

The Waste Project Group, working in the Cleanup organization for British Nuclear Group at Sellafield is responsible for providing a LLW and TRU management service that supports both commercial operations as well as the expanding cleanup scope of work. Other intermediate and high level waste streams are also of major strategic importance to the site but are not addressed in this paper.

The massive cleanup task represents a major waste management challenge, it is widely recognized that waste management is the rate determining step for cleanup programs. Up until recently, the focus at Sellafield has been on supporting commercial operations with relatively steady state and well characterized waste arisings. Waste management was therefore an important activity but not under the spotlight. As the site progressively moves into a cleanup regime this paradigm completely changes.

The NDA published their draft strategy in September 2005 that captures key issues for UK nuclear cleanup and sets out the proposed approach to tackle them. One of the six priorities is to determine a better approach to interim Intermediate-level Waste (ILW) storage (including TRU waste) and LLW disposal.

This paper sets out initiatives that are presently being pursued at Sellafield to meet these challenges. These initiatives combine the use of best available technology as well as simple low cost methods to deliver cost effective waste management for the Sellafield cleanup mission.

NDA STRATEGY FOR WASTE

The NDA draft strategy for UK nuclear cleanup was published in September 2005 for public consultation. It is due for government approval by 31 March, 2006. It sets out the key issues to be addressed and sets out the proposed approach to tackle them. The strategy also sets out the arrangements for competition. One of the six stated priorities in the strategy is to determine a better approach to interim ILW storage and LLW disposal

With regards to ILW and LLW, the draft strategy outlines the following Table I.

Table I. NDA Key Issues

Key Issue	**NDA Proposed Approach**
ILW Management • Whether and how, to rationalize the interim storage of ILW pending the availability of final management arrangements	**ILW Management** • NDA proposed approach is to encourage the government to reach an early decision on the long term ILW solution • In the meantime, NDA will evaluate the options for national/regional interim storage, taking advantage of potential economies of scale.
LLW Management • How best to dispose of increasing volumes of LLW • How best to reduce the cost of disposal • Costs of disposal of LLW at the Drigg facility are very high by international comparisons. • The future capacity of the LLW facility of Drigg is limited • It will not be able to take all LLW that will arise from decommissioning and cleanup operations.	**LLW Management** • NDA intend to encourage the government as part of its LLW policy review to look at the provision of new, more flexible LLW disposal capacity. • NDA plan to compete the management and operation of the Drigg facility and the proposed LLW facility at Dounreay together in April 2006. • NDA will consider whether there are better, more cost effective solutions for LLW other than the disposal facility at Drigg.

It further describes the requirements to address more detailed issues including:

- How to minimize the volume of LLW that will arise from decommissioning and cleanup activities and reduce the demand on disposal facilities.
- What opportunities exist for reutilizing and recycling materials that arise on NDA sites as part of decommissioning activities?

These issues and proposed approaches are entirely consistent with the initiatives British Nuclear Group is pursuing and that are further described in this paper. These initiatives to support cleanup in the UK are entirely consistent with International Atomic Energy Authority (IAEA) best practice for decommissioning waste management.

LOW-LEVEL WASTE MANAGEMENT

It is widely recognized in the nuclear industry that the first principle of waste management is to minimize the amount of waste generated. At Sellafield this has been addressed in the design of new facilities, assessing both operational and decommissioning wastes. It is also achieved through operational practices that we continually seek to improve. This paper however focuses on the measures on improving waste processing and determining the most appropriate disposal solution following waste generation.

Waste Projects Group provides the LLW management service to the Sellafield Site. Compactable soft waste is routed to a facility that monitors the waste content into boxes that are then high-force compacted with the resultant pucks being placed in 20 m^3 ISO containers. This facility, named the Waste Monitoring and Compaction plant (WAMAC) achieves 3:1 volume reduction and has been successfully operated since 1991. WAMAC also monitors and compacts waste on behalf of other UK LLW waste generators.

A proportion of LLW, such as structural steel and building rubble, is classed as non-compactable. This waste is monitored at source and placed directly into ISO containers and then transported for disposal at the LLW Repository.

These monitored ISO containers meet the regulatory approved Conditions of Acceptance for the LLW Repository at Drigg. This is situated nearly 13 km south of Sellafield and containers are transported via rail. At the repository these containers are grouted to fill the void space and then placed in an engineered concrete vault for long term disposal. This high integrity approach to LLW disposal replaced the simple tumble tipping of waste in1991.

Over recent years, Sellafield sends approximately 3,000 m3/year compacted waste to the repository via WAMAC and 3,800 m3/year non-compacted wastes direct to the repository; to date this has been dominated by commercial operations related to reprocessing.

As stated in the NDA strategy, disposal capacity at the repository is limited, not only by volume but also by radiological content. The large quantity of waste to be generated from cleanup will place a big challenge. It is also clear that there will be large quantities of demolition related waste that will be essentially inactive; it does not make economic sense to dispose of this at the repository. There is also a potential recycling value associated with decommissioning waste, notably for steel.

The current lifetime plan for the Sellafield site shows a massive 1.4 million m^3 of LLW to be generated until the year 2120 with a total cost provision of over $3.4 billion in today's money values. At least 75% of this future arising is anticipated to be classified as exempt waste that will not need to go to the LLW disposal facilities. The challenge is on the Waste Projects Team to establish initiatives at this early stage to deliver huge long term savings over the long term cleanup mission.

The Waste Projects Team is therefore pursuing initiatives that are described in this paper:

- Preparation for free release of LLW
- Minimization of volume and activity on the waste that needs to go to the LLW repository
- Establish recycling for metals
- Characterization of decommissioning waste

Preparations for Free Release of LLW

In conducting commercial operations, Sellafield has applied environmental standards and has minimized waste quantities. Some limited initiatives have operated for a number of years to reroute very LLW to free release routes. (E.g. segregating office waste arising within controlled areas) These are routes that are classified as exempt from the stringent LLW disposal requirements. The radioactivity limit for free release is less than 10.8 pCi/g.

The onset of cleanup and new contracting arrangements with the NDA put a greater focus on reducing the LLW sent to the repository and the Waste Projects Team is pursuing a number of initiatives:

Historically, compactable LLW waste from Sellafield operations is bagged and monitored at origin prior to being consigned to WAMAC for compaction and onward disposal at the repository. In many areas of Sellafield this leads to an over-estimation of radioactivity due to the ambient radiation conditions.

Waste Projects have established a Waste Handling Facility with low ambient radiation conditions. In a simple covered area, waste is received for monitoring using a commercially available bag monitor. In this way a fifty-fold reduction in measured activity has been achieved. Even if this waste is still sentenced to the LLW repository, this is still highly significant as the repository capacity is bounded by total radioactivity content as well as total volume.

Studies have indicated that approximately 25% of compactable LLW is of such low activity that it could be considered for free release. A process is being put in place to achieve this in line with a nationally agreed code of practice with in built assurance to ensure that radioactive waste is not sent inadvertently to a free release route.

After initial measurement in the bag monitor as described above, waste meeting the free release criteria will be removed from the LLW “red route” stream to a clearly delineated “green route” within the Waste Handling Facility. Waste will then be subjected to measurement by a second radiometric instrument. Pass or fail at this stage is based on the UK Nuclear Industry Code of Practice defined limits for exemption. Packages that fail this second assessment are again returned to the red route system.

To ensure a quality assured system in line with the code of practice, selective destructive analysis will also be applied. Waste passing this green route process will be immediately consigned to a secure green route skip awaiting final disposal via an approved waste handling contractor. It is expected to have this free release program in place during 2006 and is projected to deliver a $1.05 million per year saving in disposal costs to the LLW Repository.

Improvements in Disposing of Non-compactable Waste

Non-compactable waste from Sellafield operations is traditionally placed directly into a container with only very rudimentary efforts to reduce voidage. This is typically metal and building rubble that is not compatible with the WAMAC compaction facility. With no dedicated area, this waste processing is performed in the open where the North West of England climate causes a bottleneck. This is especially important in the Legacy Ponds and Silos area where the stripping out of redundant plant and equipment is a critical path activity to allow for the subsequent removal of high hazard material.

By using simple waste sorting in a lay down area, packing efficiencies have increased from 30% to an average of 65% (Fig. 1.). This equates to an annual saving of $1.93 million of disposal costs to the repository.

A further improvement is to provide a covered area and low cost conventional size reduction equipment such as car crushers and pipe splitters. This will further improve the packing efficiency of this non-compactable waste. This will be fully delivered in 2006.

Fig. 1. Waste packing efficiencies —29% on the left and 96% on the right

Establishment of Metal Recycling

The cleanup process at Sellafield will generate a large amount of metal waste including structural steel along with redundant plant and equipment. A large amount of this will be of low surface-only-radioactivity. Waste Projects are presently commissioning a Metals Recycling "Wheelabrator" Facility to process this material (Fig. 2.).

The first feedstock for this facility is 450 redundant and deteriorating LLW ISO containers. A cutting booth is used to break down the containers to strips of metal that can be fed through the Wheelabrator. This is a conventional technology used worldwide for descaling and surface preparation of metals. 16-tons of 1 mm diameter metal shot are propelled at speed by vaned wheels to remove surface contamination from the metal. The shot is then removed through an extract and filtration system where the resultant small volume of LLW is removed. The cleaned metal is extensively monitored and then passed for free release. It is sold into the open scrap metal market and, in this way, metal that otherwise would have been sent to the LLW Repository is recycled for valuable reutilization.

After demonstrating the process on these ISO containers, operations will be expanded to tackle metal waste generated from decommissioning. Discussions are underway with the Calder Hall Power Station decommissioning team to determine the feasibility of breaking down the heat exchangers. To date ten of the ISO containers have been processed and it is scheduled to complete this task by 2008.

A similar Wheelabrator (without the cutting booth) has been used for the Windscale Pile Chimney decommissioning project and has already free released over 1,000-tons of structural steel.

Fig. 2. Wheelabrator at the new Sellafield Metals Recycling Facility

Characterization of Demolition Waste

The above initiatives are aimed at current waste management activities within the radiologically controlled areas at Sellafield for commercial operations and decommissioning activities associated with the removal of plant and equipment. The final decommissioning stage of demolition will generate a much larger volume of LLW; much of this material should be acceptable for free release. Waste Projects are putting in place a dedicated clearance and characterization team to manage this task. In advance of final demolition the team will carry out detailed quantity estimates by conducting building walk-downs as well as investigation of historic building drawings and records. Characterization samples will be taken and from this a detailed waste estimate will be produced along with identifying the most appropriate waste routes. By doing this work upfront of demolition, the appropriate waste sorting arrangements can be put in place. In this way waste that needs to be consigned to the LLW Repository can be greatly minimized.

This is done on a building by building basis. This process has been recently utilized on a redundant controlled area change room facility where over 600 m^3 of waste was cleared and released as exempt waste, whereas historically it would have been consigned to the repository. Over the next 5 years over 40 buildings are planned to be demolished at the Sellafield site. These include first generation reprocessing facilities, fuel fabrication facilities, and research & development buildings as well as the simpler support buildings. With this commitment to characterization it is envisaged that a large majority of the waste generated from this work should be free-releasable.

TRANSURANIC WASTE MANAGEMENT

In the UK this waste is described as Plutonium Contaminated Materials (PCM) and as thus is further described as PCM in this paper. PCM is defined as waste with greater than 0.11 Ci/ton of alpha activity.

PCM has been generated at Sellafield for over forty years. It is stored in a variety of stores ranging from the older stores that do not meet modern storage standards and are under regulatory driven programs to empty; to the modern engineered and seismically qualified stores that are suitable for interim storage pending the availability of a national repository. In line with the NDA draft strategy, the challenge at Sellafield is to ensure that PCM is converted into a storage form as agreed with the Nuclear Industry Radioactive Waste Executive (NIREX) suitable for interim storage pending the availability of a national repository for ILW. There are key regulatory deadlines to be achieved that are related to PCM:

- *90% of the PCM inventory as of 2000 must have been processed into a form suitable for long term interim storage by 2020*
- *All PCM waste must be removed from the old stores by 2008*

This presents a range of challenges:

- There is only one processing plant available that produces a PCM product that meets the expected Conditions for Acceptance for the future repository.
- There are a range of PCM waste streams that are not compatible with this processing plant.
- Meeting the legally enforceable regulatory deadlines

Current Processing Capability

At present the Waste Treatment Complex (WTC) is the only facility presently available for conditioning PCM to a form suitable for ILW disposal. In WTC, 200 L waste drums are monitored to ensure compatibility with acceptance criteria and then super-compacted to give an overall 2:1 volume reduction. Resultant pucks are then grouted into a 500 L stainless steel product drum. Final assaying then ensures that the product conforms to the NIREX Letter of Compliance (LoC) for interim surface storage pending final disposal at a future ILW repository.

This final product from WTC has the following benefits for long term disposal:

- Exclusion of oxygen by compaction
- Exclusion of water by compaction
- 2:1 Volume reduction by compaction
- Radiation shielding by grouting
- Chemical stabilization by grouting
- Enhanced containment by grouting and stainless steel outer container
- Resistance to impact by stainless steel outer container
- Resistance to external corrosion by stainless steel outer container

Since restarting operations in January, 2003, the facility has steadily ramped up throughput; overcoming equipment operability, reliability and obsolescence issues. WTC is on track to achieve the 4,000 feed drums/year throughput capacity by 2008 that is required to meet the 2020 regulatory commitment date.

PCM Storage

PCM is presently stored in a number of buildings on the Sellafield Site. The older storage buildings, originally constructed several decades ago, do not meet the current design safety criteria. In the mid 1990s a new 100 year life store design was approved. Engineered Drum Store (EDS) 1 and 2 are already in use. EDS 3 has just been constructed, coming in below budget, and has been handed over to operational management two months ahead of schedule (Fig. 3.). This brings the total modern storage capacity to 90,000 of 200 L drum equivalents.

Fig. 3. Inside the recently constructed Engineered Drum Store 3

A schedule has been agreed with regulators for the emptying of the older stores. The oldest stores were emptied two years ahead of schedule in 2004. Emptying of the other older design stores is progressing with all interim targets being achieved ahead of schedule with an overall target of 2012 for complete removal of PCM.

Crated Items

A particular challenge facing the Waste Project Team in emptying the older stores is the removal of large crates. There are over 700 of these crates that contain a wide range of large PCM items. The crates include several large items of plant and equipment from historic reprocessing operations (Fig. 4). At present there is no solution to meet the final ILW repository storage requirements for these crates. Several options have been put forward with very large capital investment required and long lead times.

Fig. 4. Crated items at Sellafield

We now propose to use an existing decommissioning facility at Sellafield and convert it into a crate breakdown facility at significantly reduced lifetime costs as outlined below:

To decommission this PCM facility, dating back to the early 1950s, a $14 million investment was needed to put a seismically qualified overbuilding in place along with retrieval equipment. Decommissioning commenced in 2002 and over 250-tons of PCM waste has been processed with a forecast completion date of December 2005, three months in advance of the regulatory deadline. When the project completes and the original facility has been demolished, it is proposed to leave the overbuilding in place and invest a further $3.07 million to convert it into a crate breakdown facility. The breakdown methodology will be based on predominantly simple manual techniques, proven in the decommissioning project that has an excellent track record in conventional safety as well as dose control. Crates from the stores will then be transported to the breakdown facility where they will be processed into 200 L drums for onward treatment and further volume reduction at WTC. Another advantage of this initiative is that segregation of waste can be achieved. It is conservatively assumed that 20% of the crated waste can be disposed of as LLW to reduce the demand on high cost ILW disposal.

This innovative approach will deliver an operating facility by the end of 2006. The alternative capital facility was expected to cost in the order of $70 million and processing would not have commenced until at least 2008/9. Therefore, this represents a major cost saving as well as acceleration of cleanup.

There are still many challenges to deliver PCM in the final acceptable waste form for the ILW repository but real progress is being demonstrated.

CONCLUSION

The waste challenge for the cleanup of the Sellafield Site is huge with over 1 million m^3 of LLW projected to be disposed over a 100 year timeframe. The NDA have raised challenges to determine a better approach for both the LLW disposal and ILW interim storage pending the availability of a final repository.

This paper has outlined the current initiatives pursued at the site to begin meeting these challenges as the mission of the site changes from commercial operation to cleanup. For LLW, these initiatives are focused on reducing the cost associated with the long term cleanup program and ensuring that the LLW repository only receives waste that needs to be routed there. For PCM we are delivering the projects that will ensure that the waste meets the requirements for long term safe storage.