

## **REMEDIATING SELLAFIELD - A NEW FOCUS FOR THE SITE**

N.D.Baldwin

British Nuclear Fuels Plc, B582/3S, Sellafield, Seascale,  
Cumbria CA20 1PG

### **ABSTRACT**

The structure of the ownership and management of nuclear liabilities on civil sites in the United Kingdom is undergoing fundamental change. The UK Government will take responsibility for the liabilities on the UKAEA, BNFL Sellafield and Capenhurst sites and the Magnox Generation sites. When fully implemented the accountability for long term strategy will rest with the new Government Nuclear Decommissioning Authority (NDA), and contracts will be placed on M&O contractors to manage the site and implement the liabilities discharge plans.

At Sellafield whilst the commercial reprocessing and MOX contracts continue, it is clear that the overall focus of the site has changed to remediation. Until the NDA is established the task of undertaking the planning is the responsibility of BNFL. To address this task the Site Remediation Team has been established.

The production of the Sellafield Lifecycle Baseline Plan requires the existing long term decommissioning and waste management plans (primarily produced for provisioning purposes) together with several other specific strategies to be combined and developed into a co-ordinated and optimised plan for the remediation of the Sellafield Site, recognising the ongoing reprocessing, MOX manufacture and long term fuel storage activities. An important principle within the plan is to achieve early hazard reduction whilst demonstrating value for money.

The paper will address the scale of the remediation challenge and the process being followed to develop the necessary strategy. The paper will appeal to those involved in managing remediation of large, complex and interdependent nuclear sites.

### **INTRODUCTION**

Sellafield is the largest and most complex nuclear site in the United Kingdom with over 200 active facilities. Whilst initially part of the military weapons programme the site has evolved to become a fully commercial operation with two full scale reprocessing plants and over 50,000 te of fuel reprocessed in its 50 years of operation. The planning and discharge of the nuclear legacy from the earlier operations has always been part of the activities on the site but the Governments decision to bring civil nuclear liabilities together in the NDA brings a new focus on remediation. Given the scale of nuclear liabilities and the proportion to be funded from national resources there is a clear need to demonstrate that remediation is a co-ordinated and gives value for money. The Site Remediation Team has been set up by BNFL to ensure the development of an integrated and focused strategy for the Sellafield Site.

### **HISTORY**

## **Location**

In the mid 1940s when the United Kingdom decided to develop its own nuclear weapons programme an ex wartime munitions factory in a remote location in the North West of England was chosen as the Plutonium Production facility. The Sellafield site is located at the western side of the English Lake District in an area of outstanding natural beauty. The site is only about 2 square miles but now contains over 1000 buildings with a complex and interconnected product and waste routing system.



**Fig. 1. Aerial View of the Sellafield Site**

## **Military Programme**

The initial requirement was for production reactors and the associated reprocessing facility to extract plutonium. Construction started in 1948 and by 1953 the first reactor was operating with the second a year behind. Both were air cooled, natural uranium, aluminium clad fuelled. The associated cooling and decanning pond, primary separation plant, Plutonium and Uranium finishing and necessary waste management facilities were also constructed and brought into service. Solid intermediate wastes including fuel cladding was stored in a dry above ground silo and highly active liquors were stored unconcentrated and not neutralised.

## **The Civil Programme**

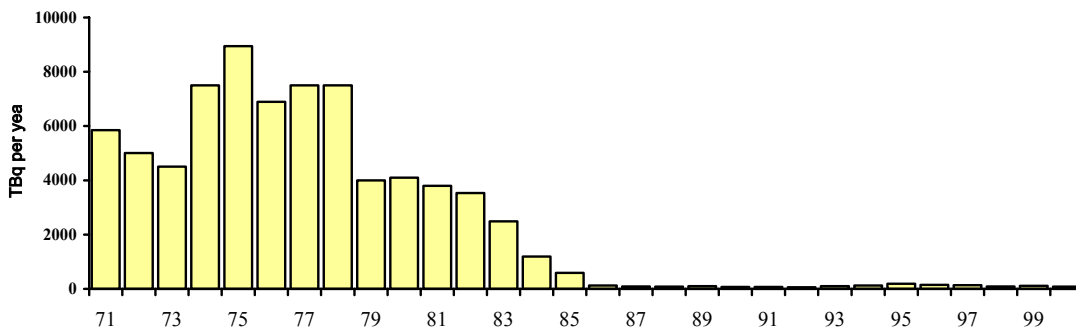
In 1956 the first Magnox civil power station (Calder Hall) came into service at Sellafield closely followed by a sister plant at Chapelcross in South West Scotland. Each had four reactors which were CO<sub>2</sub> cooled with natural uranium, magnesium alloy clad fuel (Magnox). The fuel was reprocessed through the existing route at Sellafield. In the late 50's it was decided there should be a significant increase in nuclear generating capacity within the UK and the Magnox reactor building programme commenced. Increased reprocessing capacity was required and by 1963 a new fuel receipt and decanning pond, a new dedicated Magnox

reprocessing plant and enhanced waste management facilities were brought into service. Key aspects of waste management were the decisions to store fuel cladding and other solid intermediate wastes in water filled silos and to evaporate and concentrate the HA liquors and store the concentrate in double skinned cooled stainless steel tanks.

In the late 1970's with the civil reactor programme developing towards oxide fuels the decision was taken to increase the reprocessing capacity with a new Thermal Oxide plant which could reprocess both the UK AGR oxide fuels but also fuel from overseas customers. New ponds for Magnox and AGR fuel together with new Oxide fuel ponds were constructed in the 1980s and in the early 1990s the THORP plant came on stream.

## Waste Management

As the reprocessing throughput on the site increased there was also recognition of the need to significantly reduce the liquid radioactive discharges and a number of new very effective liquid effluent treatment plants were brought into service. This resulted in the significant reduction of liquid discharges from the site despite increased reprocessing and much higher burn up fuel.



**Fig. 2. Beta discharges to sea from Sellafield 1971-2000**

For solid wastes the UK policy was moving towards deep geological disposal and recognising this BNFL decided to immobilise in cement and the Magnox Encapsulation Plant, Waste Encapsulation plants and Waste Product Encapsulation Plant were brought into operation. For Low level wastes the nearby Drigg disposal site moved from tumble tipping to compaction and grouting in ISO freight containers place in a concrete line vault. For HA liquors vitrification was the selected option and the first two vitrification lines were brought into service in the early 1990s.

The waste management programme on the site has achieved the following:

- 2500 containers of vitrified glass containing some  $7.5E+08$  Ci.
- $488 \text{ m}^3$  of spent solvent has been treated.
- $10,700 \text{ m}^3$  of medium active liquors have been treated.
- 26,000 drums of intermediate level waste encapsulated and place in modern standard stores.

## THE CHALLENGE OF REMEDIATION

### Active Facilities

To support the operations described above a total of 1150 buildings and facilities have been constructed of which 244 were active. Currently 230 active facilities remain on the site. The early active facilities are grouped in a 'separation area' where existing waste treatment facilities were utilised for a number of plants with a complex range of interconnections. For newer plants there has been a move to 'island sites'.

### Waste from operations

To date in excess of 50,000 te of fuel has been reprocessed at Sellafield and whilst the waste from current operations is treated as it arises the legacy from history is significant. It includes:

#### *Highly Active Liquors*

1500m<sup>3</sup> of concentrated Highly Active liquor is stored in 21 double walled, water cooled stainless steel tanks with total activity exceeding 1.03E+09 Ci, individual tanks up to 1.08E+08 Ci and heat generation of up to 330kW. The characteristics of this waste is well known and the backlog of liquors is being working off through the existing three line vitrification facility.

#### *Solid Intermediate Level Wastes*

3500 m<sup>3</sup> of intermediate solid waste consisting of mainly aluminium and magnox fuel cladding, swarf and graphite but also miscellaneous other wastes is stored in dry silos. This is basically a grain silo design and comprises a six compartment above ground structure. Whilst in general the waste has remained in good condition due to the potential fire risk from degradation of some of the waste an argon purging regime has recently been commissioned.



**Fig. 3. Picture of Dry Silo Building**

9700 m<sup>3</sup> of mainly magnox fuel cladding swarf but also other miscellaneous solid intermediate level waste is stored in water filled silos. This facility was initially of six compartments but three extensions increased the number to 22 and also progressively improved the build standard. The condition of the waste varies between the compartments. Corrosion of the Magnox fuel cladding was encouraged in the earlier compartments by the addition of sodium chloride whilst in later compartments cooling and caustic dosing of the water has sought to reduce the rate of corrosion. The potential for hydrogen generation has resulted in the installation of a high capacity emergency nitrogen purge system. Whilst the inventory of the waste is broadly known its condition varies and sampling can only be indicative.

#### *Pond Wastes*

1100 m<sup>3</sup> of sludge, mainly from corroded fuel, and about 320 te of fuel debris remains in the first two operational ponds together with the pond furniture. The pond is subject to a substantial purge to control the activity levels but it is impossible to fully arrest the corrosion process.

#### *Other Wastes*

3100 m<sup>3</sup> of spent solvent and 13400m<sup>3</sup> of medium active liquor concentrates.

15000 m<sup>3</sup> of TRU waste in drums and crates in 16 stores.

A number of minor streams (e.g. Zinc Bromide, lead, waste oil, wood)

## **PROGRESS TO DATE**

### **Clean Up Strategy**

The site had two main strategies for the site addressing decommissioning and waste management. Decommissioning adopted the well known phased approach from post operational clean out through initial decommissioning and dismantling to plant demolition. The programme for implementing decommissioning was influenced by the extended period of reactor safestore and the availability of waste disposal facilities being provided by NIREX. For ILW the strategy aimed to recover and treat the waste with minimum further storage prior to disposal to NIREX.

### **Decommissioning**

Formal decommissioning commenced on the site in the late 1980s since when over 25 facilities have been decommissioned and a further 24 are undergoing decommissioning. Because of the limited size of the site and the number of experimental programmes carried out, many of the older facilities were constructed in existing or decommissioned plants resulting in poor access and the hazards of interfering with ongoing operations. Extensive expertise has been developed in decommissioning and size reduction techniques including extensive use of both remote and hands on technologies.

Facilities decommissioned include:

- Co-precipitation plant for the production of mixed oxide
- Enriched uranium recovery plant
- Tritium production plant
- Two plutonium finishing lines
- Reprocessing pilot plant



- Solvent recovery plant
- Neptunium plant
- Various R&D facilities

Facilities currently undergoing decommissioning include:

- First reprocessing plant
- Caesium extraction plant
- Plutonium finishing plant
- Fast Reactor Mixed oxide fuel plant
- Various R&D facilities



**Fig. 4. Caesium Plant Decommissioning**

Whilst the current decommissioning programme is extensive it will expand significantly when the Magnox and Thorp reprocessing plants reach the end of the planned operations around 2012.

### **Waste Management**

As stated above from the mid 1990s it has been BNFL policy to immobilise current waste arisings and plants are in operation to deal with current arisings. Extensive work has already been undertaken to address the legacy waste issue. Projects undertaken to date include:

#### *Early Settling Pond*

This was a small pond used to allow entrained solids in the pond purge water to be settled out prior to discharge, this pond was completely full with 220m<sup>3</sup> of sludge. A project to install remote sludge remobilization and pumping equipment has been successfully completed with the sludge moved to modern stainless steel storage.

#### *Wet Silo Compartments 19-22*

Because the swarf in these latest silo compartments was in the best condition it was decided to trial recovery from the wet silos by recovering this waste. A project to install bulk swarf recovery equipment and transport the recovered swarf to the Magnox Encapsulation Plant has been successfully completed and important lessons have been learned.

#### *Magnox Pond Sludge Recovery*

Due to a pause in reprocessing in the mid 1970s the rate of corrosion in the Magnox Pond increased significantly. Measures introduced to cope with this problem included the deliberate pumping of sludge from the skip washing machine to one of the pond wet decanning bays. A project to remobilise this sludge and pump to modern storage has been initiated though full recovery of the sludge has not been completed due to downstream capacity problems.

#### *Original Site Pond*

Extensive refurbishment of this first pond has been completed and oxide fuel hulls stored here from the early oxide fuel reprocessing campaigns have been recovered and transferred to more suitable storage.

### **PRESSURES ON THE EXISTING STRATEGY**

A number of factors are now influencing the development of the strategy for the remediation of the site.

#### **National Waste Policy**

The existing national waste policy for intermediate level solid wastes is to place in deep geological repository to be provided by NIREX. Wastes being generated at Sellafield are treated and packaged to meet NIREX acceptance criteria. Following the refusal of planning permission for the Rock Characterisation Laboratory for NIREX in 1997 both the date and the location of a repository remain uncertain. Without a specific location the NIREX acceptance criteria have become more restrictive and it had become clear that it would be extremely difficult and take a significant time to achieve these requirements.

#### **Safety Justifications**

Developing safety case methodologies were primarily focussed on new plant development and rightly require the demonstration of a very high level of confidence for the proposed process for the duration of the impact of that process. The argument must be that there is a net positive benefit to society to allowing the plant to operate. These methodologies were being also applied to work to tackle the legacy wastes where 'do nothing' or 'do not proceed' is not a realistic option. In the case of the B41 and B38 wastes it was becoming increasingly difficult to develop the same level of robustness for the safety case to retrieve and treat the waste.

#### **Condition of the Plants**

The condition of the existing facilities was considered acceptable for the anticipated waste recovery timescales in the existing strategy. As the additional treatment requirements were significantly increasing, the period for which the existing structures would be required was

extending. It therefore became necessary to initiate improvements to the plants both to allow them to remain longer and also to support the waste recovery operations.

### **Focus on Level of Risk**

The previous strategy was focussed on maintaining the plants and their contents in an acceptable condition whilst the project to develop the waste treatment methods continued. With the increasing timescales there is a realisation that there is significant benefit from achieving an early reduction of risk even if the final solution may need to take more than one step.

## **STRATEGY DEVELOPMENTS**

### **Organisation**

In the Autumn of 2001 the UK Government announced its intention to change the way in which the nuclear liabilities resulting from the nuclear power development programme and the Magnox programme would be managed. A new Nuclear Decommissioning Authority (NDA) was to be established which would become the owner of the assets and liabilities associated with the UKAEA sites, the BNFL Sellafield and Capenhurst sites and Magnox Power station sites. M&O contractors would be appointed to manage the sites on behalf of the NDA. The NDA would be responsible for developing national strategies and whilst the NDA would be the owner of the strategies for the sites it was anticipated that they would be developed by the contractors. The draft legislation to implement these changes has been published and should be implemented during the 2003 parliamentary session leading to the formation of NDA in 2004 or 2005. Of all the sites, Sellafield is by far the most complex with ongoing commercial reprocessing and a large waste legacy. In June 2002 BNFL established the Site Remediation Team whose task was to develop a fully integrated strategy for remediating the Sellafield Site.

The Government has also made clear in its proposals that dealing with the nuclear legacy is a national issue, not just a problem for the site licensees. As such it is necessary for all stakeholders including the regulators to be actively engaged in seeking solutions to the problems.

### **Interim Safe Storage (ISS)**

Unlike some countries, the United Kingdom only has a disposal facility for LLW. In the absence of a NIREX repository and with uncertainty over what criteria may apply to a site if selected, it is clear that pragmatic steps need to be taken to achieve early risk and hazard reduction on the Site. BNFL has evolved the principle of treating waste sufficiently to allow it to be placed into safe storage for a period of up to 100 years primarily in a passive form. The ISS waste form should meet NIREX criteria or not preclude further treatment where possible but there must be a sensible balance between the ultimate form and early risk and hazard reduction. The principle of ISS has been discussed with regulators and is now moving forward to specific proposals for particular waste forms.

### **Building End States**



In the absence of waste disposal facilities there is a need to consider pragmatic end states for the existing active buildings. It is anticipated that the concept of an 'Interim Safe State' for buildings will also be developed which will balance the risk and hazard of the remaining structure with the waste routes and resources available. For some plants, such as plutonium facilities, complete decommissioning to demolition will remain the logical approach but for others such as emptied waste silos it may well be more sensible to place the structure in a condition for minimum surveillance for an extended period.

### **Safety Cases**

Recognising the absence of the do nothing option in many of the remediation projects combined with the near impossibility of a full waste characterisation there is a need to change the emphasis in the generation of safety cases. One particularly important aspect is the concept of time at risk acknowledging that the waste retrieval and treatment activities are time bounded after which the hazard and risk are significantly reduced.

### **Evolving Strategy Development**

Adopting the principles above a fundamental review of the ILW strategy is underway to identify options for improvements to the existing plans particularly to achieve earlier hazard reduction. The application of the ISS principle for wastes is expected to yield significant programme reductions and earlier hazard reduction compared with attempting to achieve NIREX criteria. There are over 40 strategies for managing the various aspects of the Sellafield site and it is necessary to fully review all of these to ensure alignment with the site objectives and to achieve optimisation. The full site Lifecycle Baseline Plan reflecting the new focus is being prepared. A structured and fully auditable strategy development process is being applied which must have the confidence and support of the key stakeholders. Independent peer review is a key aspect. Full focus of all available resources both in and outside BNFL will be required to implement the strategies.

The key aspects of the new focus for the site are:

- Priority on legacy and risk reduction
- Packaging of waste for safe extended storage
- Pragmatic approach to safety cases
- Ambitious but realistic programmes
- Balance of BNFL and supply chain skills

### **CONCLUSION**

Remediation of Sellafield is an exciting and massive project. The establishment of the Site Remediation Team demonstrates BNFL's commitment to developing a co-ordinated and integrated strategy that will achieve the earliest practicable reduction of hazard on the site.