

B41 WASTE RETRIEVAL PLANT AT BNFL SELLAFIELD

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ABSTRACT

BNFL is implementing a strategy for the recovery of radioactive material accumulated in storage ponds and silos at Sellafield.

This paper details the project work being undertaken on one of these silos, known as building B41. The objective of the work is to recover 3200 cubic meters of intermediate level waste from the ageing silo, and to despatch it for treatment. The reactive nature and conditioning requirements of the waste together with the location of the silo pose unique technical and safety challenges to the project. The requirement to maintain safety at all times during the construction and operation of the waste retrieval facilities is paramount and has had a large influence on the design. The need to demonstrate that the work is giving value for money has also been a feature.

The paper describes the main safety challenges for this unique project and the preferred option for waste retrieval. The impact of the results of development work on the design decisions is also highlighted. By January 1999 initial design work has been completed, with detailed design well underway and construction of facilities on site started. The paper will be of interest to readers with decommissioning work dominated by safety and technical challenges. It is concluded that for building B41, optioneering processes have enabled solutions to be determined which satisfy a complex set of safety, technical and commercial considerations.

INTRODUCTION AND PLANT HISTORY

The plant known as B41 was built in 1950 to receive solid waste arising from the decanning of fuel irradiated in the first Windscale production piles. Although the original specification is now not available, it is likely that it was designed to hold intermediate level waste from the decanning of modest quantities of low burn-up fuel. Like the rest of the Windscale plants, the design was pioneering and no design standards existed then; the construction reflects what was good commercial and engineering practice at that time. By the end of its operational life, the plant had received wastes significantly different to the design intent, the main reasons being the limited waste disposal routes available at Windscale in the early years, and a substantial expansion of the nuclear programme with the development of the Magnox reactors during the lifetime of B41. The plant operated from 1952 to 1965 and has been under a care and maintenance regime ever since. The safety systems at the plant were upgraded progressively through the 1970s and the 1980s, reflecting the changing regulatory requirements. Since 1996 a substantial programme of investment has been in place for B41, to refurbish the existing structure and to construct waste retrieval and treatment facilities.

PLANT DESCRIPTION

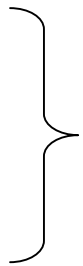
The plant consists of six compartments formed in a reinforced concrete structure, with a nominal capacity of 4,800 cubic metres. On top of the plant roof is a structure known as the transfer tunnel, made from steel and brickwork, and a steel framework hoistwell is at the East end of the building. Flasks of waste arrived at the building by road transporter and were lifted up the hoistwell. A trolley carried the flask into an ante-chamber where its lid was removed. A second trolley then took the flask down the transfer tunnel where it was positioned above a chargehole to one of the six compartments. The flask was then tipped upside down, depositing the contents down the chargehole. A short distance below the chargehole aperture, a deflector plate is positioned, to spread the waste out and prevent excessive mounding.

Although the plant is now dry, a certain amount of water was carried over with the waste, which came primarily from underwater decanning operations. The original design provided each compartment with sumps with sand filter beds, and a drainage system was fitted. There was a water ring main on the plant roof, used either for dust suppression or for fire fighting. Figure 1 gives more detail.

PLANT INVENTORY

The disposal records kept during operation in the 1950's and 60's did not provide the level of detail that is needed now to support a safety case for retrieval, so their absence has not been a hindrance to the project. An inventory has been reconstructed by examining the production records of the Windscale production plants that were known to have consigned waste to B41. These were primarily the underwater decanners that supported the Windscale production piles and the first generation of Magnox reactors at Calder Hall and Chapelcross.

The principal wastes are:

Aluminium Swarf		Each of these materials is believed to be present in quantities in the range 100 - 1 000 te
Magnesium Swarf		
Irradiated Uranium		
Graphite		
Total Mass		1894 te
Total Volume		3127 m ³

The above are all categorised as intermediate level wastes and the intended route for final disposal is to an underground repository. This will follow encapsulation in cementitious grout and a period of above ground storage.

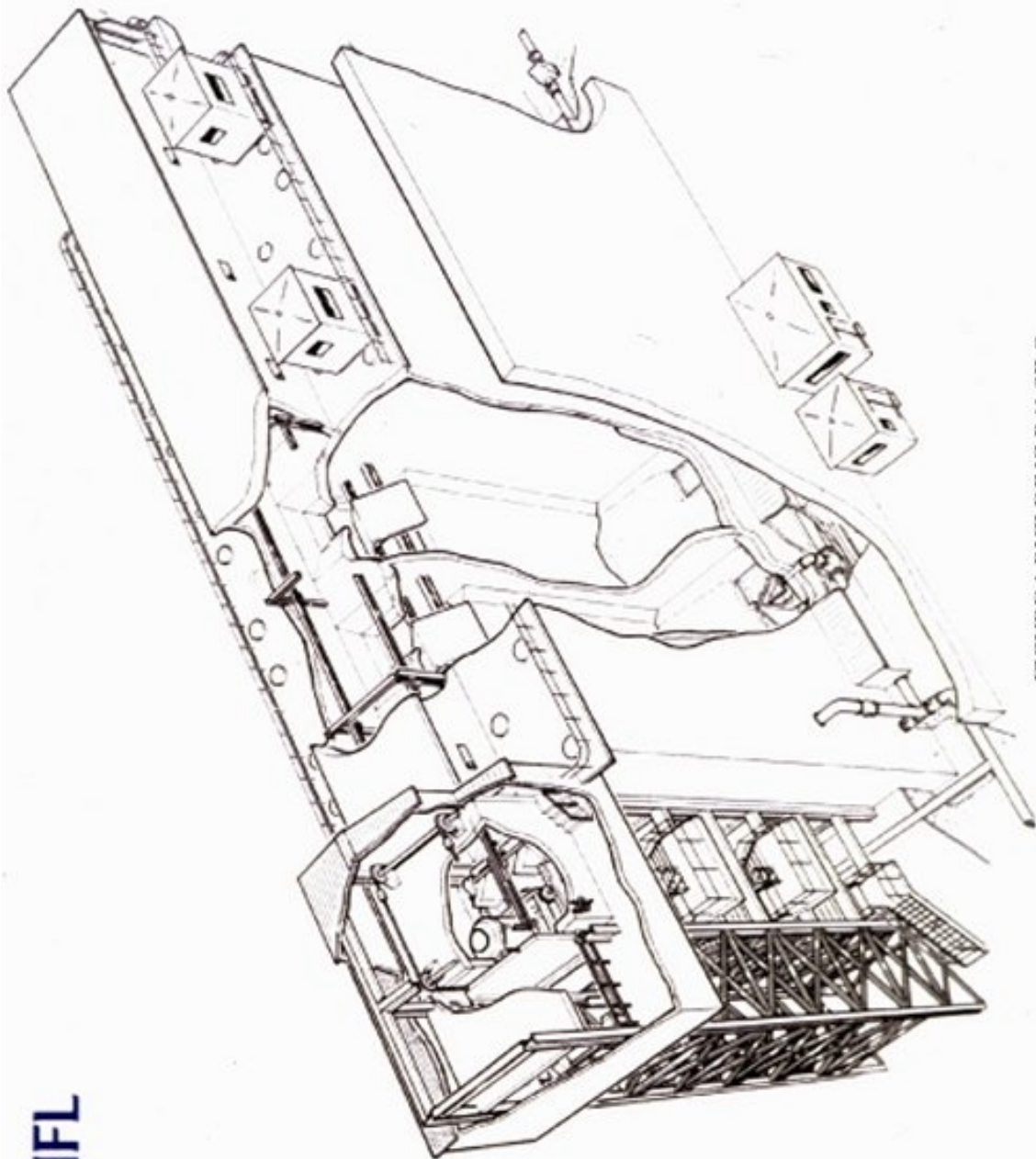


FIGURE 1 BUILDING B41 SILO

Other materials are present, including organics, steel, lead, ashes and sludges; the safety case and Waste Retrieval Plant design recognise that there may be metallic Sodium present in containers. The true inventory will only be known on the completion of retrieval.

While most of the waste rests within the compartments, a significant quantity is on the floor of the transfer tunnel where compartments have been overfilled. This happened because waste lodged on the charge hole deflector plates, leaving a void below it. There is not, on average, a shortage of volumetric capacity in the compartments. The waste in the tunnel will be consolidated down into the compartments for it to be retrieved. A major project driver is the long term safety of this storage regime in a structure which is now nearly 50 years old. The reactive nature of some of the constituents and especially that of uranium hydride, led to the decision in 1986 to empty and ultimately to decommission the building.

CURRENT STATUS OF PLANT

Two significant upgrades have taken place in the plant lifetime. The first was the addition of further shielding. This consisted in part of shielding slabs bolted to the building walls, and in part it consisted of free standing shield walls around the building. This shielding was put in place to allow the construction and operation of nearby plants to take place in a low dose rate environment. Some of this was done during the plant's operational life and some was done later. Radioactive decay has reduced dose rates from the stored wastes and the removal of this shielding has not led to excessive radiation exposure in the nearby buildings. The second was the provision of fire detection and fire fighting systems, done in the 1980s. Fire fighting is with Argon gas being injected at both top and bottom of each compartment.

Detailed inspections have been made of the structure and have revealed that the walls and foundation structure are sound and closely match the available drawings of the building. Significant corrosion was found in the roof structure and some remediation has been necessary.

A programme of building improvements has been completed to support the future retrieval operations. The improvements were undertaken prior to the construction of the new facility when access to the silo was still possible. The walls of the structure have been inspected and corrosion of the structure was found to be limited with no significant repair necessary. The structure was reinforced with Carbon fibre strapping to meet future dynamic loading during retrieval. The walls were then coated with a sealant to aid Argon retention.

SELLAFIELD INTERMEDIATE LEVEL WASTE STRATEGY

In the early 1990s BNFL evolved a site wide strategy that returned the lowest lifetime costs for dealing with the legacy of the complex variety of wastes that have arisen from nearly fifty years of reprocessing operations at the Sellafield site. Figure 2 shows the various waste streams concerned. It can be seen that treatment of ILW wastes hinges round two new plants: The Sellafield Drypac Plant (SDP) will receive corroded sludges, dry, supercompact and encapsulate them. The Box Encapsulation Plant (BEP) will place solid ILW into boxes of three cubic metres capacity, and encapsulate them in a cementitious grout. The waste from B41 comprises over 50% of the feed into BEP.

The cost case for the ILW treatment plants suggests that optimum costs come from them being operated until about 2014. Current contracts for reprocessing at Thorp cease then. All the ILW plants and other downstream plants tied mainly to Thorp operation will then shut down together. Current project progress indicates a likely start up for the ILW retrieval and treatment plants of about 2002, giving a 12 year window in which B41 must be emptied. The operational research model of the plant indicates that this can be achieved with 10 working shifts per week. Plainly, plant output can be increased by raising the working pattern to work 21 shifts per week, and the current design of the Waste Retrieval Plant is confirmed at its present size and capacity.

B41 RETRIEVAL STRATEGY

Waste will be recovered from the existing compartments using remotely operated manipulators under an inert Argon gas atmosphere. It will be transferred to a process cell in the same plant where it will be exposed to a normal atmosphere. Pre-treatment of the waste at B41 will be limited to that sufficient to allow the waste to be safely transported to the BEP and comply with the conditions of acceptance generated by the treatment process. A radiometric camera will identify significant pieces of Uranium. Operator intervention will be required to identify and segregate other wastes requiring pre-treatment. Sheets of plastic will be segregated, placed in disposable containers and subjected to modest compaction. Sealed containers of waste will be opened and the contents identified. Any pieces of Sodium will be set aside into vessels where they will be corroded by ambient humidity in the cell air, the residues will be neutralised and then absorbed onto a solid medium. Wastes will be transported dry in purpose designed containers, in shielded transport flasks; except for segregated Uranium pieces, which will be transported under a cover of water in the same type of containers. Figure 3 gives a pictorial view.

THE FUTURE WASTE RETRIEVAL PLANT (WRP)

Space constraints at the B41 site are such that two buildings will be built. A Retrieval Building around the existing plant will house the remotely operated retrieval manipulators and nearby will be the Process building, housing the process cell, flask export facility, ventilation plant, control room, and maintenance rooms.

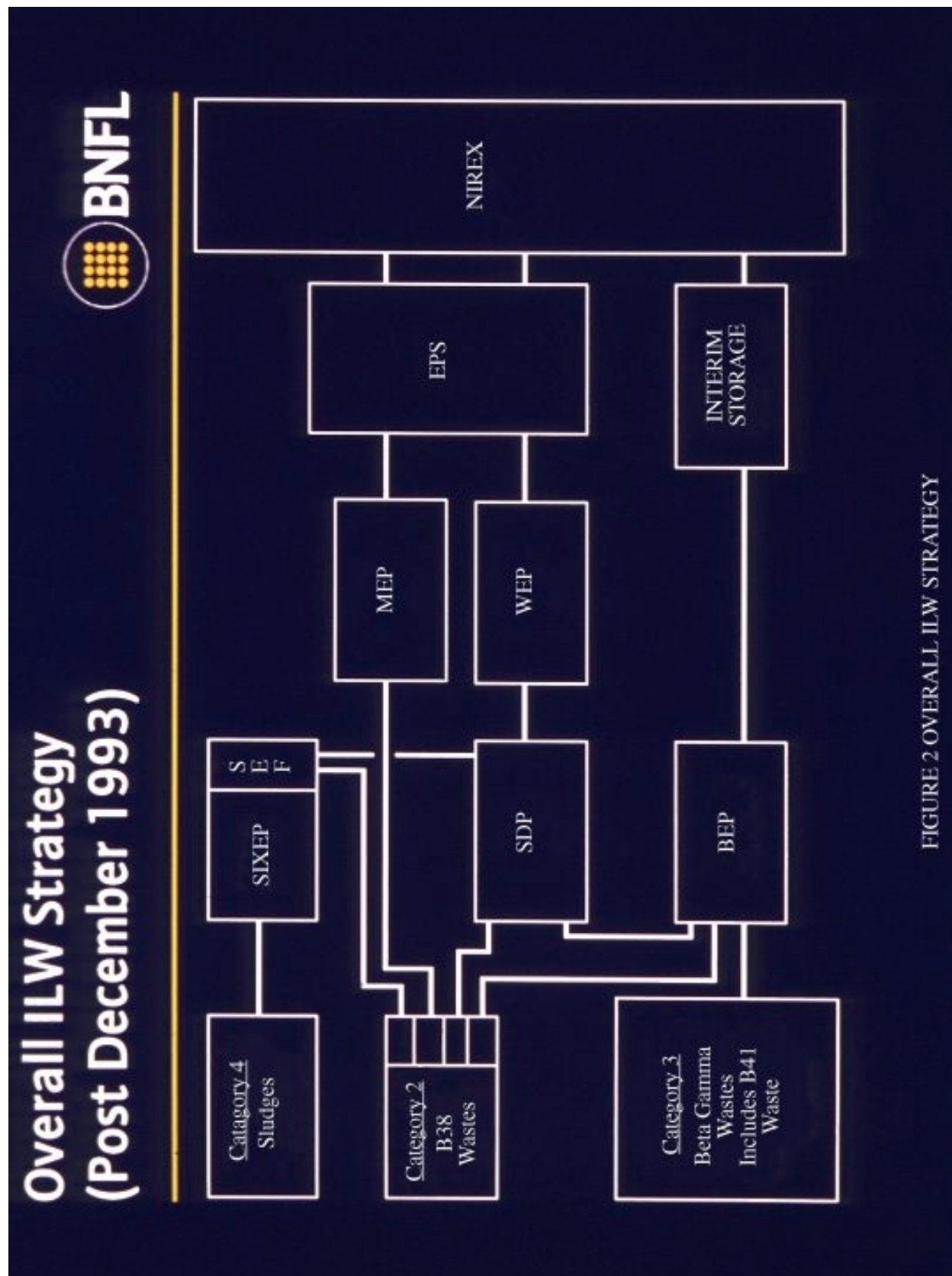


FIGURE 2 OVERALL ILW STRATEGY

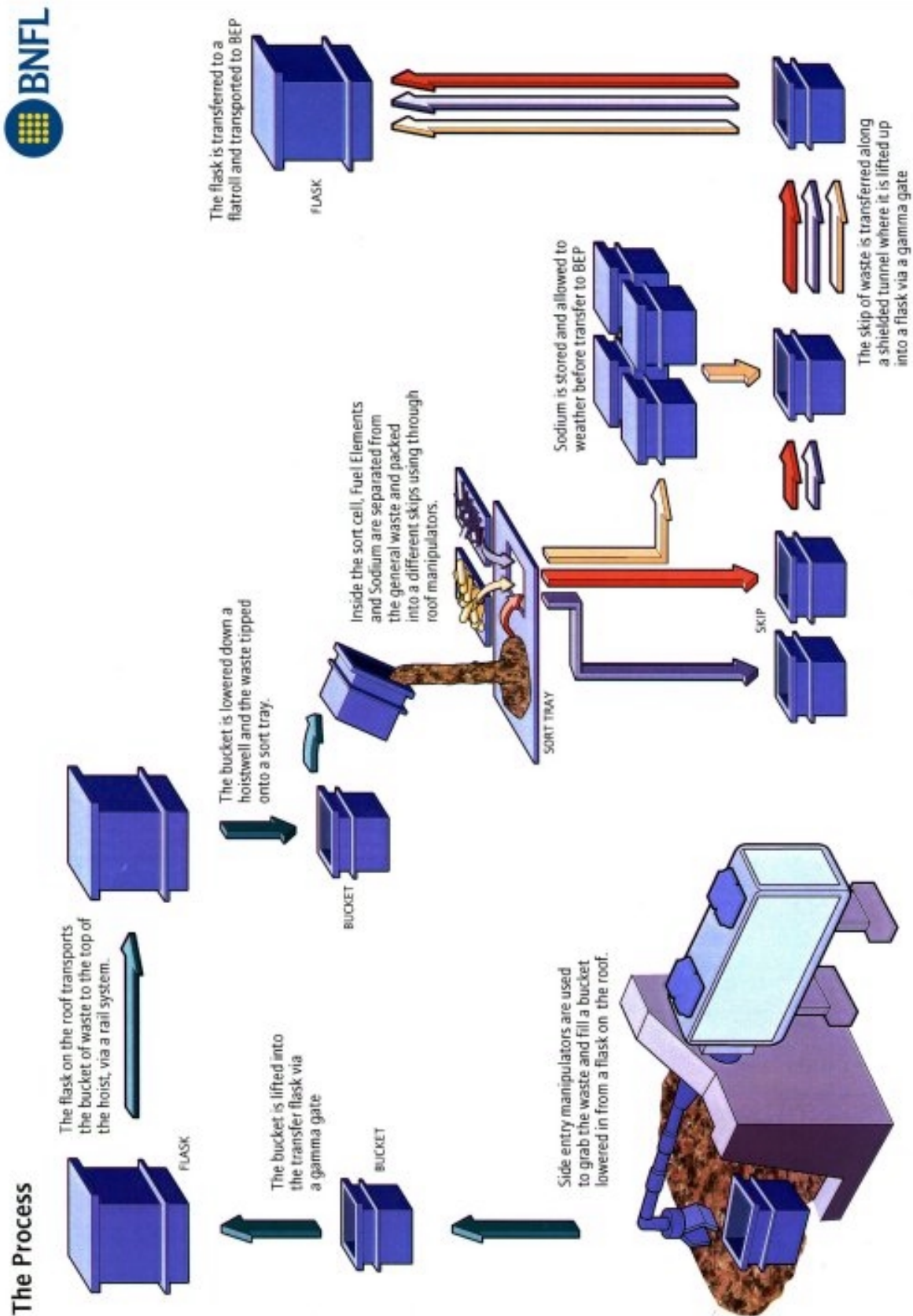


FIGURE 3 THE WASTE RETRIEVAL PLANT PROCESS FLOW DIAGRAM

Retrieval will be by side mounted manipulators, acting through penetrations made through the side walls of the existing plant. They will load the waste into buckets lowered from internal transfer flasks positioned on the roof of the compartments. Full buckets will be raised up into the internal transfer flask, which is fitted with a bottom opening door. The filled flask is transferred along a high level transfer corridor to the process building, where the bucket is lowered into the process cell and emptied. After pre-treatment the waste is placed into a transport skip which is placed into its shielded flask. Transport across the Sellafield site to the BEP is by rail.

The final form of the WRP facilities followed 4 years of detailed optioneering studies. The project posed many unique technical challenges and it was often the case that the best answer for one problem was incompatible with another problem. An example was the problem posed by construction in an area of relatively high background radiation levels; minimisation of radiation dose to the construction workforce demanded the use of rapid and labour efficient construction techniques. The use of tower cranes offered a solution to this problem however the risk from dropped loads on the silo structure prohibited this approach when the full risks were assessed. The optioneering process had to cope with many paradoxes and acceptable compromises found. The process thus relied heavily on the techniques of value engineering and multi-attribute decision analysis (Kepner-Tregoe studies) to achieve the optimum design. The design has two construction features resulting from this approach.

The construction of the Process Building is based on the idea of quickly forming a concrete shell for the building using a continuous slip form or jump form technique. This method provides a 0.75 m thick reinforced concrete structure to the full height of the building in a short period of time (6 to 8 weeks). This then creates a shielded area where labour intensive mechanical/electrical construction work can be undertaken with the benefit of reduced radiation dose. The method also provides a solution to another concern, that of damage to nearby operating plant from construction activities: The reinforced shell of the Process Building provides an effective protection to nearby plant from dropped loads and at the same time allows the Process Building contractor to proceed with the construction work with the minimum of interference from adjacent areas. This in turn gives benefits in terms of productivity by reducing disruption and helps with another project aim of delivering the project at minimum cost.

The second feature is the design of the Retrieval building. A steel frame work structure is to be constructed around the existing silo and over the operating shielded pipebridge. Small piece steel construction techniques are to be employed so that the building can be erected without the use of tower cranes and at the same time keeping the size of any piece lifted small enough to enable the risks from dropped loads to be managed. This solution balances the risks of dropped loads against the risks of radiation dose uptake from a more labour intensive operation.

The design of the WRP facilities have thus been influenced by the construction problems and solutions arrived at have also considered the operation of the facilities for the silo emptying phase. The operating philosophy is based on keeping as much of the work as possible in the process building, where operators will have the benefit of the thick concrete structure to keep radiation dose rates down. Much of the equipment in the Retrieval Building has been designed to be remotely operated from the Process building. Figure 4 gives details.

WASTE TREATMENT

Waste treatment at BEP consists of direct tipping into a 3 m³ container which is then filled with cementitious grout. The only processing consists of monitoring to confirm compliance with criticality limits on fissile material inventory per box. Dust or sludge will be collected into crushable, disposable containers and consigned with the bulk of the waste. The filled box will be cured for 24 hours, after which a grout 'lid' will be poured on to fix any loose materials that may have floated up to the top of the main pour. The box will then have its lid fixed in place, its exterior surfaces will be monitored and if necessary decontaminated. It will then be placed in a store pending disposal in the future.

DEVELOPMENT WORK

As has been described, the proposals for waste retrieval relied upon the use of manipulators and Argon inerting. Key development work was undertaken to underpin these assumptions:

The behaviour of Argon gas inside the silo compartment was assessed using a scale model, filled with pieces of polystyrene to simulate the waste. Oxygen monitoring equipment throughout the simulated waste measured the oxygen depletion as Argon gas was fed in at the bottom of the rig and drawn away at the top. The results obtained from the scenarios modelled provided key information for the design of the Argon delivery and silo ventilation systems. The modelling work gave confidence that the proposals would work.

The second area of development concerned the potential for Argon inerting to create new problems. It was known that uranium hydride, the major concern with the silo inventory, was formed by the corrosion of uranium metal in damp and oxygen deficient atmospheres. On exposure to a normal air environment, the uranium hydride could decompose violently, generating heat and flame. So, could inerting the silo to guard against the risk of uranium hydride catching fire actually lead to the production of even more uranium hydride from the uncorroded metal and give an even bigger risk should the inert atmosphere be lost due to a fault condition?

Key development work was undertaken to determine the formation rates of uranium hydride in Argon-air mixtures. The results fully supported the overall strategy by showing that hydride formation was inhibited by trace quantities of oxygen of the order of 8 ppm. Thus, provided oxygen concentration levels were above 8 ppm and below 2% v/v, the risks posed by uranium hydride could be safely managed.



FIGURE 4 AN ARTIST IMPRESSION OF THE FUTURE WRP

The third key area of development work focused on the use of manipulators for waste retrieval. Full scale development trials were undertaken on a rig representing part of a silo compartment and a commercially available hydraulic manipulator. The waste was modelled using inactive Magnox cladding and debris and based on TV inspections of the silo compartments. The development work demonstrated the principle of waste retrieval and provided useful design parameter information for incorporation into operational research models. This work showed that the silo could be comfortably emptied over the lifetime of the ILW strategy by deploying two manipulators.

PROGRESS TO DATE

At the time of writing, design studies for the WRP are complete, specifications have been produced, detailed design is underway and major construction work will start in mid 1999. At the existing silo, a programme of preparatory work is well advanced. Work finished so far includes:

- External shielding has been removed. This consisted of two separate sets of shielding. The first set was shielding blocks bolted to the plant walls. The second set consisted of free standing shield walls around the plant. Most of the material has been consigned as free release material under the definitions of the Radioactive Substances Act.
- The roof, walls and foundation of the plant have been surveyed. This survey indicated the need to improve the roof to bring it up to the necessary standards of seismic robustness to meet a modern safety case.
- This roof reinforcement has been done. The work involved the installation of a pair of new external roof beams with anchor bolts to transfer load from the roof to the supporting walls.
- The walls have had surface erosion of concrete and reinforcement made good. They have been strengthened with Carbon fibre strapping to meet the dynamic loads that may arise during the retrieval operations in the future. They were then sealed to aid retention of Argon.
- New Argon plants, to provide continuous inerting have been provided, along with a ventilation plant to manage the exhaust gases and to provide aerial effluent management and monitoring.
- New fire detection systems have been fitted to the plant, using detection methods more appropriate to the conditions of retrieval under inert atmosphere. The old fire detection systems were suitable for passive storage of the waste.

- Equipment is being provided to consolidate the waste in the tunnel on the plant roof down into the main storage compartments (where it was intended to be). The intention is to deploy an hydraulically operated manipulator, mounted on a trolley, into the transfer tunnel. This remotely controlled operation then allows the waste to be pushed down into the compartments whilst the whole operation is smothered in an inert gas blanket.

COSTS AND PROGRAMMES

The overall cost of the WRP facilities are of the order of £140 million (\$ 224 million), with construction activities starting in 1999, to enable commissioning by undertaken by 2002. Operation of the facilities will then commence and it will take 10-12 years to empty the silo compartments.

COMMERCIAL CONSIDERATIONS

After safety, the desire to achieve demonstrable value for money has been important. The ultimate funding for the work comes from Government and the demonstration of value for money is important. The construction methodology has enabled an efficient commercial risk sharing approach. Some commercial risks are best managed by BNFL, such as the disruption to construction work due to plant operations; other commercial risks are best be managed by the construction contractor. An Alliance between BNFL and AMEC is in the process of being formed to enable a single project team to be set up which is focused on problem resolution and project delivery. The risks will be shared and a target cost for the project agreed and any benefits from superior performance will be shared by the Alliance and Government.

A further consideration aimed at achieving a good safety and commercial outcome has been to capitalise on the synergies offered by the group of projects within the ILW strategy. The use of standardised equipment has been sought where ever possible and the facilities use standard cranes, crane components, flasks, manipulators and other capital intensive pieces of plant and equipment. This approach is aimed at achieving life cycle cost savings from design, through to operation and into decommissioning.

CONCLUSION

The emptying and decommissioning of the B41 silo at Sellafield has posed a unique set of challenges. BNFL has developed and implemented the Waste Retrieval Plant project to meet these challenges and to provide a safe and cost effective solution.