ENVIRONMENTAL PROTECTION CONSIDERATIONS DURING DECOMMISSIONING

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ABSTRACT

The BNFL Sellafield site has been involved with the UK nuclear program since its inception. Consequently, the company is now faced with a major decommissioning challenge which is being met by a rolling 10-Year Program of decommissioning.

The site has industrial scale plants reflecting the whole nuclear cycle from reactors through reprocessing to fuel manufacture with all associated waste facilities, etc. BNFL is committed to decommissioning of all of these facilities within a fixed period from cessation of operations. The paper reviews this program, outlines project organization and management and discusses the constraints imposed by the UK waste disposal situation.

Decommissioning involves decontamination, dismantling and demolition all of which generate mobile radioactive material with potential to escape to the environment. Liquid and aerial effluents and solid residues all require attention to be paid to containment and environmental protection. BNFL's basic principle in these operations is to contain activity and immobilize it as close to the source as practical. The application of this concept is illustrated by examples from two very different projects, respectively a Mixed Oxide Fuel Fabrication Plant and the 400 ft. high Windscale Pile Chimneys.

INTRODUCTION

BNFL's Sellafield site in Cumbria, northwest England, has been involved in nuclear operations since the start of the nuclear industry in the United Kingdom in the late 1940's. The site has a full range of nuclear plants from reactors to fuel storage and cooling ponds, fuel decanning, fuel dissolution and reprocessing, finishing of uranium and plutonium and all the associated waste handling and effluent treatment plants. Current operations involve the reprocessing of some 1,200 tons of fuel annually. Over the years, several plants have shut down and some have been decommissioned to make room for new facilities. The company is committed to decommissioning through to dismantling of all its plants. As more facilities became redundant and with the prospect of a large number becoming surplus at the end of the Magnox era, early in the next century, a specialist Decommissioning Unit was established in the early 1980's to plan and execute the necessary decommissioning.

PROGRAM

The Decommissioning Unit's planning activities led to the development of a rolling 10-Year Decommissioning Program. This was explained in some detail in Mr. A. Colquhoun's paper, Decommissioning at Sellafield, presented at the Oak Ridge Model Conference in 1988 (1). This program has now been running for four years and there are currently fourteen projects in progress. These cover all types of plants, including the following examples of which two are later considered in more detail.

No. 1 Fuel Storage Pond

A fuel storage and decanning plant was built to support the original Windscale Production Piles. The facility has two cooling ponds and twelve decanning bays. Some fuel is still stored in the plant and there is a requirement to sort skips and remove all unnecessary waste. Also involved is the treatment and removal of pond sludges and decontamination of large areas of concrete.

Pile Chimneys

These were built to filter and discharge cooling air from the Windscale Production Piles. They ceased operation in 1957 following the fire in Windscale Pile No. 1. They are a complex construction, very expensive to maintain, and are therefore being partially dismantled to ensure their long-term stability. There are severe contamination problems involved with the Chimney associated with No. 1 Pile where the fire took place.

Co-Precipitation Plant

This was a plant for the production of mixed oxide for fast reactor fuel. It is a complex glove box line which handled large quantities of plutonium and uranium oxides. The plant was grossly contaminated internally at the end of operations in 1976. The task is to decontaminate and dismantle the plant for packaging for interim storage.

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These plants are for the recovery of highly enriched uranium from various waste streams and also for the production of tritium. The plants has now been shut down for some five and twenty-five years respectively and will shortly be dismantled and the buildings reused.

First Primary Separation Plant

This is the original reprocessing facility at the Sellafield site. It is a major ten-story building with four highly active and two medium active cells. Part of the plant was converted for the treatment of oxide fuels. The plant varies with some facilities still containing highly active liquors through to areas which have been cleared out for man access. The challenge is decontamination and remote dismantling of a very extensive plant.

Cesium Extraction Plant

This was a facility for the extraction of radio-cesium from highly active waste liquors for medical purposes. The plant has now been shut down for about thirty years and is grossly contaminated internally. The task is to remotely decontaminate and dismantle the plant and correctly dispose of the waste.

Plutonium Purification Plant

This was originally a plutonium purification facility associated with the original reprocessing plant, see above. The facility was later converted for the treatment of waste streams and the recovery of plutonium. Unusually, for a plutonium facility, it is a four-story building, with two major brick clad cells containing various pipework vessels and columns. The plant is grossly contaminated and poses a major challenge for dismantling and demolition while containing any alpha activity adequately.

ORGANIZATION AND MANAGEMENT

BNFL operates on the principle of appointing Project Managers to see projects through their whole life from original conception to practical execution. The normal route for a project is for the Project Manager to produce an Initial Scoping Paper laying out the current status of the plant, the objective of the decommissioning planned and an outline of how it may be executed. This paper will also identify major areas of uncertainty. Where areas of uncertainty cannot be resolved in the Initial Scoping Paper, a Feasibility Study will be carried out considering all viable decommissioning options and weighting them for generation of wastes, dose uptake, aerial releases and other factors. A Feasibility Study would normally conclude with a recommendation for a chosen option which may require a further Engineering Study to confirm its full viability. The Feasibility Study would have associated with it some Initial Safety Studies which would consider dose uptake, aerial releases and other safety issues.

Following identification of a feasible option, initial design, planning and cost estimates are prepared. Funding for the project is sought and once obtained the detailed design and planning together with full safety assessments can be undertaken.

Extensive use is made of Hazard and Operability Studies as a framework to support the detailed safety assessments. At this stage, the project team is expanded significantly to allow the practical implementation of the project to take place. At a minimum, the objective of any project would be to place the plant in an initially decommissioned state. This would be a state in which the plant may, if necessary, be left with minimum surveillance and maintenance until full decommissioning is carried out. The initial decommissioned state would, for example, try to ensure that all safety systems are passive, e.g., loose contamination removed or sealed such that, where possible, operational ventilation systems would not be required.

WASTES

In the United Kingdom, only low-level solid waste disposal is available at present. A deep repository for higher levels of waste will be available possibly around the year 2005 with bore hole tests for a suitable location currently on-going. Despite the lack of ultimate disposal, however, it is the policy of the company to continue with decommissioning as far as it is practical. Buildings which housed decommissioned plants will be used for the interim storage of waste which will be in a better and more passive form than leaving plants in their current state. Where possible, the wastes will be packaged in their ultimate disposal form.

Decommissioning generates wastes; in fact, waste is the main product of a decommissioning operation. The handling of any radioactive wastes has the potential for the release of radioactive material, and therefore, anything which can be done to reduce the volume of waste and to ensure effective containment is beneficial. The company's philosophy is to attempt to reduce or contain radioactive material at the source. The first line of defense, therefore, is to undertake decontamination where practical at the work-face. Significant development effort is therefore ongoing to identify better and more effective methods of decontamination. Supporting this is development of monitoring and categorization techniques to ensure that accurate and minimum quantities of waste are generated. BNFL has extensive experience in conditioning and packaging solid wastes for disposal. The main method for the higher levels of waste is to immobilize the radioactive material into a solid matrix normally concrete.

Liquid effluents from decommissioning are normally generated from decontamination operations. In the past, it has not been unusual in the nuclear industry for liquid discharges to be regarded as an easy option. This is no longer acceptable and BNFL is investing extensively in new liquid effluent treatment facilities to remove all types of activity. During decommissioning, therefore, it is necessary to ensure that any liquids generated are compatible with the existing site effluent system. Unfortunately, the site system tends to be targeted towards those effluent liquids normally generated during plant operation. It is likely that effective decontamination of a facility cannot be undertaken using just those liquids which are used in normal operations and will require more aggressive agents. A good example is when stainless steel vessels and pipework in normal operation could perhaps only be targeted with nitric acid. However, during decontamination for decommissioning, more aggressive techniques, which remove the surface layer of material, are acceptable. Development work is therefore on-going to design effluent treatment facilities which can be installed local to the plant to cope with these more aggressive decontaminants. The object is to transfer the activity from the decontaminant liquor on to a solid matrix which can then be encapsulated.

ENVIRONMENTAL INTERFACE

Decontamination and dismantling activities during decommissioning generate mobile forms of activity which have the potential for release into the environment. The basic concept of operations at BNFL is to contain activity and immobilize it as close to the source as is practical. Once activity is allowed to spread, it is much more difficult to contain or deal with. The principle of containment at source has a benefit of reducing secondary wastes. All waste streams generated from decommissioning must be considered against the available treatment facilities. The application of these principles is reviewed below in relation to two current projects.

Co-Precipitation Plant (2)

The history of the dismantling of this plant will demonstrate our principles of decommissioning as applied to a typical alpha facility. The plant had handled large quantities of plutonium and uranium oxide and was in a heavily contaminated state at the end of operations.

Co-precipitation Plant was basically a glove box line which took uranium and plutonium in their nitrate form, mixed them and then precipitated them together, hence, co-precipitation. This was then dried and converted to an oxide. The plant therefore split into wet and dry sections. The first task for the Decommissioning Team was to undertake decontamination as far as was possible. The imminent closure of the Plutonium Residues Handling Plant meant that any liquid decontamination had to be undertaken and completed quickly. Decontamination of the dry section of the plant could be carried out manually through the normal glove ports of the glove boxes. However, the high burn-up of the plutonium and the age of the plant meant there was a growth in gamma emitting daughter products with a knock on penalty of dose uptake for the operatives. This led to a requirement for a decontamination method which could remove gross contamination and thus allow extended periods of hands-on operation for the dismantling. Cleaning with non-hydrogeneous solvents had been tried in the past on other sites but was unable to clean down to release levels. It was felt, however, that the method had potential for the removal of gross activity to allow for extended working periods. A solvent jetting-cleaning system has been designed and is currently undergoing development to enable gross quantities of dry oxide contaminant to be removed, filtered and recovered for storage in a safer form. This system is currently undergoing trace active trials prior to final active trials on the Co-precipitation Plant.

One of the tasks facing the Decommissioning Team was the cutting and removal of a large quantity of pipe and ductwork. In the past, normal methods for removing pipework would be to cut, using either manual or mechanical cutting means. This method invariably led to the release of activity at the point of cutting and therefore normally required tenting or some form of secondary containment which led to secondary wastes. A better method of cutting was required and a crimp/shear technique has been developed for the smaller bores of pipe. This method involves the crimping of the pipe at the point of cutting followed by the shearing through. The crimping is designed to seal the cutting point. The tool used on the Co-precipitation Plant has the capacity to cut up 25mm or 1 inch stainless steel pipework. Several hundred cuts have now been undertaken using this tool. There have only been two occasions when activity has been released and there were extenuating circumstances in these cases. The tool has proven very reliable and hence, cutting of pipework can now be undertaken with minimum secondary containment and without undue requirement for protective clothing by the operatives.

There was also a requirement to cut large diameter pipework and ductwork both in the Co-precipitation and other alpha plants. It is impractical to develop the crimp/shear technique for larger bore stainless steel pipework because of the large forces involved, and therefore, a foam-filling technique has been developed. This involves drilling through the pipe or ductwork near the proposed point of cutting and filling a localized area of the pipe with an expanding foam. This foam seals all activity against the surface of the pipe and cutting can then be undertaken with the activity contained. Trials of this technique have been carried out and it has been used on active pipework within the Co-precipitation Plant very successfully.

Frequently, during volume reduction of glove boxes, secondary containment is required. Historically, this has been provided by the use of PVC sheet tenting. While this is effective, it does lead to the generation of large quantities of secondary waste. PVC tenting is also more vulnerable to damage during operations with the potential for the release of activity. It was felt that a better form of secondary containment could be employed and a Reusable Modular Containment system has been developed for use on active plants. This employs the assembly of secondary containment using preformed reinforced glass fiber panels. The panels are used to construct the secondary containment with the minimum practical volume. Small amounts of PVC may be employed to make up irregular edges at contact with the plant. The joints of the containment are then taped and the whole internal surface of the containment sprayed with a strippable coating. During operations within the containment at periodic intervals, depending on activity levels, the surface of the containment is sprayed with tie-down coating. Several layers of tie-down coating can be applied before there is a need to strip the internal surfaces. At the end of operations or depending on the number of tie-down coatings used at some intermediate point, the internal surface of the containment can be stripped. The use of the strippable coating as the underlayer means that the stripping is achieved quickly and easily. Experience has shown that any contamination remaining after stripping is very low and in all cases to date, the panels of the containment have been released for unrestricted movement within the plant for reuse. The total level of waste generated from this operation is less than 10% of that which would be generated by the use of normal PVC tenting. The RMC is provided with a filtered ventilation extract normally tied in to the existing plant system through a full secondary system can be employed where necessary.

Alpha plants are normally constructed within buildings. Therefore, while the plant provides the primary and secondary containment, further containment is erected as necessary during dismantling operations but the building structure provides a further line of defense. Dismantling through to demolition therefore tends to be a method of working from the inside out. The active plant is decontaminated and dismantled and the operation then slowly moves outward until the building itself is demolished. Provided the dismantling operation is carried out correctly, there should be very little if any contamination of the main building structure. Demolition, therefore, is normally a relatively simple operation. This may not always be the case with plants where the main building structure has become badly contaminated at some stage in its operational life.

Windscale Pile Chimneys (3)

The Windscale Pile Chimneys were built to filter and discharge cooling air from the Windscale Piles. The filters were an afterthought during construction and were therefore situated near the top of the Chimneys leading to their unusual shape. At first sight the Chimneys appear to be concrete, but in fact, the upper sections are a complex structure involving a steel frame and either concrete or brick infill. The whole Chimney is lined internally with aluminum and this backed with insulation to provide a thermal barrier for the main civil construction. This insulation is a glass fiber mat in the Upper and Concentrator Sections and a composite boxed construction of aluminum insulation and steel below this level. The structure of the Chimneys has deteriorated over recent years and it would be extremely expensive to refurbish . It was therefore decided that dismantling of the upper sections should take place as soon as practical and anyway by the end of 1997. For the Chimney associated with Pile 2, dismantling of the Concentrator and Upper Section is a relatively straightforward task because of the very low levels of contamination. Dismantling is largely undertaken manually with local containment as necessary. Air sampling has been undertaken throughout the operation and no release of activity has been identified. During the stripping of the insulation, which was the work which gave rise to the greatest airborne concentrations, a local ventilation system, with filtration, was provided. Sampling of the discharge from this system indicated very low release levels of activity.

The Chimney associated with Pile 1 is substantially different from that associated with Pile 2 because of a fire in Pile 1 in 1957. During the fire, the whole Chimney was badly contaminated and this contamination is now trapped in the cavity between the aluminum lining and the brick outer shield. The brick, the steel, the lining and the insulation are all contaminated but sampling has indicated that the majority of the contamination is trapped in the insulation layer which would appear to have acted as a filler. The levels of contamination are such that the radiation field precludes manual stripping of the insulation, though once this has been removed, the indications are that manual dismantling of the brick and steel structure could be undertaken. It is therefore necessary to remove the insulation remotely.

Experience on the Pile 2 Chimney has shown that the insulation is extremely friable and that any attempt to move it would give rise to airborne activity. Examination has shown that the aluminum lining which is a sheet and riveted construction has a significant number of leak paths. Ideally, the removal of the insulation would be undertaken with a full secondary containment provided over the top of the Chimney. Unfortunately, the construction of such secondary containment is precluded by the wind loadings which would be incurred in the West Cumbrian environment. It is therefore necessary to strip the insulation utilizing the brick and the aluminum lining as the only containment. A special machine has been designed and produced to strip the insulation and force it down into the Concentrator Section where it will then be exported using a special waste packaging and conditioning plant.

The machine will access the cavity via sealing valves which will be installed in the cap plates sections. Twenty-four valves, one for each Chimney segment, will be installed utilizing a method designed to minimize release. In operation, the machine, which is fitted with a similar mating valve, will dock onto the access valve and then both valves will be opened simultaneously to allow access into the cavity. To ensure that activity does not escape via the leak paths, a large extract system is required. An assessment of the potential leak paths led to the design and installation of a 16,000 cfm fully-filtered extract system. This system extracts from sixteen points in the Upper and Concentrator Sections, each of which can be individually valved. Current work on the Chimney is to make the connection of this extract system into the cavity. Again, to ensure there is no release of activity during the installation of these extract points (involving cutting of the brick shield), a specially-manufactured and high-integrity containment system has been designed and installed.

The insulation stripping machine itself is currently undergoing extensive inactive trials on a full-scale inactive test facility. The trials will also be used to better characterize the release of activity using a simulant and to establish the best ventilation balancing regime to ensure that activity is contained without unnecessarily blinding filters. The extract system is of course fully and continuously monitored and connected to suitable alarm panels to indicate any problem with the filtration.

Once the insulation has been removed, it is assessed that the remainder of the structure can be dismantled manually, perhaps using some stand-off techniques. To ensure that there is no airborne release during this operation, a special local containment system which will not place undue load on the Chimney structure has been designed. This system is best described as a caterpillar-like tent which will follow the dismantling operation around the Chimney. The dismantled section of the Chimney will be sealed behind the operation as the tent moves forward. The extract system will remain operational and provide extract both from the tent and from the cavity to ensure that there is no release into the atmosphere. At first sight, the ventilation system may seem oversized for the task, but consideration has to be made for the height and winds which can be experienced. In addition, any release from this height would quickly spread and could not be contained to the controlled area of the site. It is, therefore, necessary to ensure that every possible measure is taken to contain the release of radioactive material.

CONCLUSIONS

Decommissioning Operations by their nature disturb the existing plant condition and therefore have additional potential for release of radioactive material. The objective of decommissioning is, however, to place the radioactive material remaining in a safer state than it would have been if left in the existing plant.

Experience at Sellafield has, however, shown that decommissioning of complex radiochemical facilities can safely be undertaken without endangering the environment.

Environmental protection can be ensured by containing radioactivity at all times as close to its point of origin as practical and by detailed planning and careful execution of every phase of decontamination, dismantling and demolition.

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