DECONTAMINATION & FREE RELEASE OF REACTOR POND FURNITURE

S. P. Burke and M. J. Sanders
AEA Technology

ABSTRACT

As part of the Stage 1 decommissioning project for the Steam Generating Heavy Water Reactor (SGHWR) at AEA Technology's Winfrith site in the UK, the 20 fuel racks in the fuel pond are to be removed. At Winfrith, considerable experience of waste disposal via the free release (below regulatory concern) route has been built up; the potential for disposing of fuel racks in this way was recognized. Using a redundant rack, a trial was carried out to assess the technical and economic feasibility of the decontamination/ free release route. An electrochemical process was employed. The trial successfully demonstrated technical feasibility, and an economic assessment concluded that the route can be justified financially. Therefore a decision was taken to dispose of all the racks by decontamination and free release.

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BACKGROUND

The Steam Generating Heavy Water Reactor (SGHWR) at AEA Technology's Winfrith site in the UK shut down in September 1990 after 22 years successful power generation and use as an experimental reactor. Stage 1 decommissioning is now well under way.

An important part of the Stage 1 work is to consider future management options for the fuel handling pond, and all furniture therein. Major items of furniture include 20 fuel racks, a fuel flask handling station, and a fuel transfer trolley.

One option for managing the pond furniture is to decontaminate lowering its waste category from Low Level Waste (LLW) to a level which is below regulatory concern, thus allowing it to be free released to the scrap metal market.(In the UK, LLW is defined as radioactive waste containing less than 12 GBq/te [1.2×10^4 Bq/g]. Free release waste, known as below regulatory concern in the USA, must contain less than 0.4 Bq/g.)

The free release option is attractive because:

- it reduces the need for disposal of radioactive waste, and hence could have economic advantages
- it reduces the volume of waste for disposal at Drigg,the UK's LLW disposal site
- pond furniture can be disposed of now, thus eliminating the need for storage at SGHWR

PREVIOUS EXPERIENCE

At Winfrith we have successfully developed and used the free release route to dispose of considerable quantities of waste. The process began in 1988 with pilot studies on three redundant fuel flask transport wagons (Flatrols) which led to a contract to decommission the entire fleet of 22. The total weight of the redundant fleet was 525 te from which 483 te of uncontaminated steel were separated and free released for sale to the conventional scrap metal market. This work was the subject of two papers presented at WM91 (1,2).

During 1990 and 1991, HECTOR, an experimental physics reactor at Winfrith, was fully decommissioned. Experience gained from the Flatrol work was applied, and a monitoring and segregation system set up. Out of a total weight in excess of 1,000 te, 0.5 te of contaminated material was isolated and disposed of as LLW. The bulk of the reactor was free released: 200 te of metal (mostly mild steel) was sold as scrap; 900 te of concrete shielding blocks were removed and many have been put to non radioactive uses on the Winfrith site.

During 1991 and 1992, 212 transport containers were decommissioned at Winfrith. These ranged from relatively small packages for carrying sources, typical weight 100kg, to pilot scale fuel flasks weighing 3 te. 86 containers were free released as non active scrap, and 126 were disposed of as LLW. Flatrol and HECTOR experience contributed significantly to this project.

With the above experience behind us,the potential for decontaminating and free releasing pond furniture at SGHWR was quickly recognized.

ELECTROCHEMICAL DECONTAMINATION

This technique has been extensively researched and developed by AEA Technology over a number of years (3,4), primarily for decontaminating stainless steel, but by varying the process parameters it can be applied to carbon steel and many non- ferrous metals. The process operates at ambient temperature generating no gas or heat, and at low current density.

It is often convenient to operate the process in a simple immersion tank arrangement, where wastes for decontamination are handled in a titanium process basket. The equipment can be sized to suit the work in hand. In the work reported here, the equipment comprised: a stainless steel process tank, 1.4 m x 2.1 m x 1.5 m high; a titanium basket, 0.9 m x 1.5 m x 0.5 m high ; a lifting frame to lift the basket into and out of the tank; a mobile 2000 amp low voltage DC power supply; and a rinse tank 1.4 m x 2.8 m x 1.5 m high. The process tank and basket are illustrated in Fig 1.

The operational sequence for the work was as follows. The basket was loaded with stainless steel items and placed in the tank, which was charged with 1500 litres of 6 % nitric acid. The basket is connected electrically to the power supply to form an anode, while the tank, which is electrically isolated from the basket, forms the cathode. The items in the basket are in direct contact with the basket so that they are connected to the anode supply. When a current is passed, the surfaces of the items are dissolved electrochemically. Turning off the current instantly terminates the process. On completing a process run, the basket was retrieved, placed in the rinse tank, and the items thoroughly washed with water.

Fig. 1. Basket containing size reduced items being lowered into electrochemical process tank.

The rates at which metal is removed and acid is consumed, depend on the size of the current and the surface area of the batch of items. Typically, with a current density of 1mA/cm2, a single batch of acid will treat at least 1000 m2 of stainless steel before acid regeneration/replacement needs to be considered. Stainless steel dissolution products can rise to a concentration of 20 g/liter before significant loss in decontamination efficiency is observed.

Another important feature of the process is the good "throwing power" of nitric acid. Many electrolytes require very good electrical contact between the anode and item being processed, to ensure all surfaces of the item are fully available to the electrochemical process. This often means individually connecting items to the anode supply, and processing items in more than one orientation (ie multiple runs). Nitric acid does not have this drawback; only minimal contact is necessary to make all surfaces of even irregularly shaped items available to decontamination. This good "throwing power" eliminates the need for elaborate "jigging" and positioning of items, and facilitates the use of the basket arrangement described above.

Electrochemical decontamination is a simple and effective technique capable of achieving activity levels below the 0.4 Bq/g free release limit. It was therefore selected as the most appropriate technique for decontaminating stainless steel fuel racks for free release.

RACK DECONTAMINATION TRIAL

To demonstrate the feasibility of decontamination and free release, and determine operational requirements, a full scale trial was carried out at SGHWR. In the trial a redundant fuel rack was size reduced and decontaminated using the electrochemical technique described above. The rack was systematically monitored before and after the process to determine the degree of decontamination achieved. The technical and economic feasibility of the entire operation was assessed.

The following paragraphs describe the trial in more detail.

The rack, removed from the fuel pond in the mid 1970s, was a rectangular frame made from stainless steel sheet and square section tubing, and was a welded construction. Each of the two sides was a 5 mm thick sheet 0.33 m wide and 4.35 m long. A rectangular channel (70 mm high and 170 mm wide) was welded along the entire (internal)length of each side.

The top of the rack was a 10 mm thick plate 0.9 m long, with notches and catches for securing fuel elements. The base was a rectangular frame of 50 mm square section tubing.

Attached to the bottom end on one side was an unusual arrangement of tubes, not found on any other racks at SGHWR.

To summarize; the rack had overall dimensions 4.35 m long, 0.9 m wide and 0.33 m deep, and weighed 452 kg. (Fig. 2.)

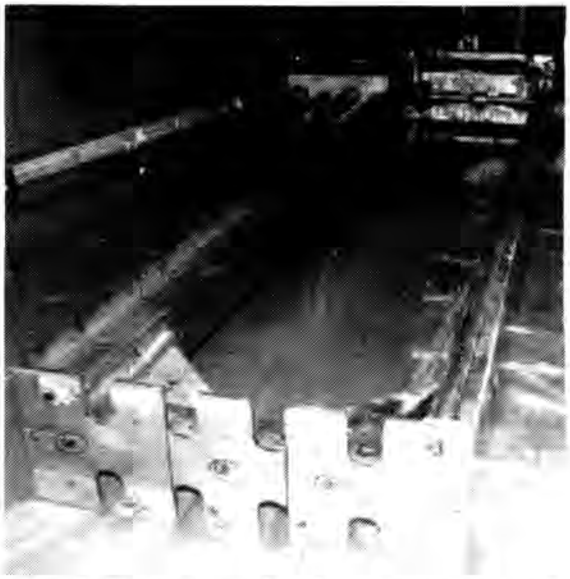

Fig. 2. Fuel rack used in decontamination trial.

In order to fit it into the decontamination process basket, the rack had to be size reduced. This was successfully accomplished using a pneumatic grinder and electric nibbler to produce 50 size reduced items. Total cutting time was 20 hours, and two operators were employed.

Decontamination was carried out in two sets of runs. In the first set (runs 1 to 4), all 50 items were processed in 4 separate batches. Subsequent monitoring revealed that contamination levels had been reduced on most items, but the free release level was only achieved for 20 items. Two reasons were identified for this:

- a number of items contained "hidden" surfaces that were partly shielded from the process, and also difficult or impossible to monitor by hand.
- some items were not fully rinsed after processing, mainly due to inaccessible "hidden" surfaces

To overcome these problems items with "hidden" surfaces were fully opened up and processed a second time. Certain items, mainly connected with the tubular arrangement could not be further opened without significant work. These items were not processed a second time.

The fully opened items were processed in three batches (runs 5 to 10). For each batch, two runs were performed with items in two different orientations. This procedure maximizes exposure of all surfaces to the process and to rinsing.

As the tubular arrangement was atypical, it was decided to discount all items associated with it when considering the fraction of the rack decontaminated. This amounted to 22 items with a total weight of 71 kg. Therefore, when determining percentage decontamination a rack weight of 381 kg was used.

On this basis, 61% (231 kg) was decontaminated to free release levels, and 39% (150 kg) was not. In the latter category, certain heavy items were classed as LLW because they contained "hidden" surfaces inaccessible to monitoring. Only six items with a total weight of 28 kg were actually shown to be LLW by monitoring.

Due to delays between the first and second sets of runs, two batches of acid electrolyte were used. This generated a total volume of 3,000 litres of liquor (ie neutralized acid plus rinse water) containing approximately 30 MBq of activity, which was discharged to the SGHWR active effluent system. (NB: Normally, a single batch of 1400 litres of acid would have been used; theoretical calculations and solution analysis show that a single batch would have been more than adequate. The total waste liquor would then be approximately 1500 litres.)

Decontamination effectiveness was measured by hand monitoring each item before and after processing, using standard Health Physics equipment (Mini Monitor and HP210 probe.) Direct monitoring results in counts per second were converted to Bq/g for comparison with the 0.4 Bq/g criteria for free release.

CONCLUSIONS FROM TRIAL

The trial demonstrated that decontaminating a full size fuel rack to free release levels is technically feasible. The fact that only 61% was decontaminated to the required level was due to the "minimum cutting" policy adopted during size reduction. This policy was adopted because mechanical grinding is such a time consuming and physically demanding cutting method; it was uneconomic to spend excessive time grinding open every single "hidden" surface.

Plasma arc cutting is very rapid, and would enable a fuel rack to be size reduced far more quickly. In addition, all "hidden" surfaces could be readily opened. We are confident that plasma arc cutting would enable at least 80% of a fuel rack to be decontaminated to free release levels.

Based on the trial, the disposal cost of a fuel rack via the free release route is comparable with disposal as LLW. By applying experience gained from the trial, and using plasma arc cutting, we can show that the free release route is economic when compared with LLW disposal.

POND FURNITURE DECOMMISSIONING

An essential task in decommissioning the fuel pond is removing the radioactive sludge on the pond floor. To allow full access to the floor, it is necessary to remove the fuel racks, and certain other items of pond furniture. Once removed, pond furniture will become LLW. The Environmental Protection Act, 1990 requires radioactive waste arisings to be minimized, and for LLW to be disposed of by an authorized route.

The two options for pond furniture are disposal as LLW, or disposal by decontamination and free release. The decontamination and free release option was chosen on the basis of the trial results, and the requirement to minimize LLW.

DISCUSSION AND CONCLUSIONS

Since the mid 1980s, Winfrith, and in particular the Decontamination Operations Department of AEA D&R, has built up considerable experience in using the free release route for waste that would otherwise have been disposed of as LLW. A key element in this success has been gaining and keeping the confidence of the relevant regulatory body (Her Majesty's Inspectorate of Pollution). This has been achieved by closely involving the local inspector at a very early stage in the work, demonstrating sound, practical monitoring and segregation methods (the basis of the Quality Assurance procedures developed for this type of work), and continually updating the inspector as work progresses.

The fuel rack decontamination trial provided an excellent opportunity to successfully demonstrate electrochemical decontamination on a large item of pond furniture. We have shown that it is possible to decontaminate LLW to free release levels on a significant scale.

Interest in decontamination for free release is growing because the technology exists, and the economics support it. Decontamination Operations Department is currently involved in negotiations to decontaminate and free release fuel racks for other European nuclear sites.

In conclusion, we believe that there is considerable scope to extend use of the free release route in general, thus reducing the volume of radioactive waste requiring disposal or storage by the nuclear industry. Pond furniture is a specific area where decontamination can be used to facilitate use of this route.

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