

**"HOT LABS" CONFERENCE**

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**Decontamination as applied to the  
Decommissioning and Refurbishment  
of Hot Cells**

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## 1 Introduction

Hot cells equipped with remote handling apparatus are used for active operations throughout the nuclear industry, especially in fuel reprocessing and post irradiation examination.

Decontamination of these hot cells is occasionally necessary when internal modification or refurbishment is required. Similarly, decontamination would be necessary as the first stage in final decommissioning of the cells.

The aim of any hot cell decontamination is to reduce radiation to a level which will allow man-entry, for reasonable periods of time, for the execution of internal refurbishment or decommissioning operations. This will require the following four general stages, each of which should give a large progressive reduction in radiation levels:

- (i) Remove fuel and any processing liquors and solids.
- (ii) Remove all loose equipment.
- (iii) Decontaminate cell using remote handling apparatus.
- (iv) Decontaminate cell using hands-on methods.

In order that the dose to operating staff be kept to a minimum (following the principal of ALARP) it is vital that stage (iii) be as effective as possible and it is in this area that current and future efforts should be concentrated.

This paper summarises the techniques that have been used for the decontamination of hot cells in the UK and assesses their effectiveness, concentrating on those which may be applied remotely. The options for future such decontamination exercises are also considered.

## 2 Current Experience in Hot Cell Decontamination

Most cave lines have been designed with some thought to easing decontamination operations. Typically the concrete walls are coated internally with epoxy paint and the floor (and sometimes the walls) are clad with stainless steel sheet.

**NB:** This is not necessarily true of early caves and hot cells.

The nature of the contaminants present will depend on what the hot cell has been used for eg irradiated fuel dust in Post Irradiation Examination (PIE) caves and dried on spillages of active liquors in fuel reprocessing lines. The isotopes present will be mostly fission products with some activation products and also alpha emitters including U-235, Pu and Am.

The decontamination of caves and hot cells at some of the major UK nuclear sites is described below.

### 2.1 Winfrith

The Active Handling building (A59) at Winfrith is used for PIE of fuel, mainly from the AGR reactors and the Winfrith Steam Generating Heavy Water Reactor (WSGHWR).

The south cave line in A59 has dimensions of 10.2 m x 3.6 m x 3.3 m high. It has 1.5 m thick concrete walls and is fitted with zinc bromide windows and master slave manipulators (MSMs). A 6 mm thick sheet stainless steel bench supported on a steel framework is installed 1 m above floor level over the full area of the cave. The bench surface is coated with epoxy paint. The walls of the cave are also coated with epoxy paint.

Decontamination was last carried out in 1986 in order to allow substantial refurbishment to take place. The following sequence of activities were carried out to decontaminate the cave:

- (i) Remove fuel and all free standing equipment from cave.
- (ii) Brush bench and dry vacuum using MSMs.
- (iii) Wipe down bench with damp swabs using MSMs.
- (iv) Carry out gamma survey of cave using MSMs.
- (v) Clean bench using phosphoric acid based foam applied using MSMs and collected using wet suction apparatus.
- (vi) Carry out gamma survey of cave.
- (vii) Strip paint from bench using inorganic paint remover (caustic based).
- (viii) Carry out gamma survey of cave.
- (ix) Allow man-entry to carry out further decontamination by foaming and swabbing.
- (x) Carry out gamma survey of cave.

The gamma dose rate was reduced from 2.6 mSv/hr (stage (iv)) to 0.45 mSv/hr (stage (x)).

The decontamination exercise was successful with an overall dose saving during the subsequent refurbishment work.

Virtually all of the activity remaining after stage (iii) (above) was associated with the paint on the bench top. Removal of this paint was required to achieve a satisfactory decontamination.

Though the application and removal of foam did not significantly reduce the overall contamination levels, as the remaining activity was associated with the paint film, it did greatly reduce the airborne contamination levels. On another occasion when foam was used to decontaminate an unpainted stainless steel floor, a good decontamination was achieved.

## **2.2 Dounreay**

A major refurbishment exercise was carried out during the period 1972 to 1976 to convert the Fast Reactor Irradiated Fuel Reprocessing Plant from its original function of servicing the Dounreay Fast Reactor (DFR) fuel cycle, to that of reprocessing fuel from the Prototype Fast Reactor (PFR).

The levels of activity in the plant were very high, with gamma radiation levels of up to 10 Sv/hr and alpha contamination levels (by swab) of over 1000 cps.

The approach adopted in the dissolver and extraction cells was to repeatedly wash out vessels and pipework internals with nitric acid and steam, followed by washing with more aggressive media including sulphuric acid, caustic, and nitric acid/sodium fluoride solutions.

The cells and vessels were then washed down, from the cell access doorway, using high pressure (10000 psi-67 MPa) water jetting apparatus. Radiation levels were thus reduced to below 10 mSv/hr permitting short term entries to locate radiation source areas which were dealt with on an individual basis.

The cave facilities were decontaminated by removing all loose equipment and sweeping and swabbing all accessible surfaces using the MSMs. The remaining equipment and benches were then cut out using electric arc cutting apparatus held by the manipulators.

The empty cave was then decontaminated by water jetting, initially remotely, but later using hand held guns. Removal of the structural concrete shielding by drilling and thermal lancing then followed as required.

In the fully stripped out areas the radiation levels were reduced to below 100  $\mu\text{Sv/hr}$  and contamination levels were below 5 cps (by smear).

### 2.3 Berkeley

The cave line at Berkeley has been undergoing complete refurbishment since 1986 to convert the line from its former function of the post irradiation examination of Magnox fuel to the examination of irradiated AGR fuel.

The working surface was painted carbon steel and aluminium alloy benches, raised to approximately waist height and covering the full area of the caves, but not sealed. Residual contamination (after removal of equipment) was mostly associated with the bench surface, though substantial contamination, including leakages of hydraulic fluid, was found on the floor beneath the benches.

Extensive decontamination was carried out using the remote handling equipment. The techniques used included those mentioned previously (brushing, vacuuming, swabbing, foaming) and some additional techniques described below.

A recirculating Freon rig was built to wash the internal cave surfaces. The Freon was filtered to remove the contaminated material but it was found that some of the active material was apparently soluble in the solvent. The soluble material was successfully removed by passing the solvent through an activated carbon column, but overall it was considered that the technique was too complicated and time consuming for extended use.

Another method developed for cleaning the bench surfaces was a slow moving sander mounted with a scouring pad, drip fed with a solvent and held by a manipulator. This was found to be a fairly effective technique.

A strippable coating was used in difficult to access areas such as the corners of benches. The application technique consisted of upending a container of the coating material using the manipulators such that the liquid flowed into the inaccessible area and also covered an item suitable for gripping by the manipulator. When the coating had dried it could be removed, along with any loose contamination present, by gripping the item (which was covered in the coating) with a manipulator, and pulling. Complete removal was usually achieved as long as the coating was fairly thick.

After decontamination the average dose levels at 1 m above bench were in the range 3 - 5 mSv/hr. Man entries were then started to remove the benches and clean the residual activity on the cave floor. The floor was cleaned, with the cave access doors partially withdrawn, by operator using mops which had long handles and were soaked in decontaminating reagents. Final decontamination made use of industrial type floor cleaners.

Some problems were experienced with the use of foams to decontaminate the walls and ceiling. Though the foam was removed by swabbing, some liquid containing removed activity was washed through the unsealed benching and high activity levels were found in the cave floor drain lines.

Throughout the decontamination exercise difficulties were experienced with the in-cave radiation monitoring apparatus which was large and cumbersome. It was felt that there is a need for small reliable instruments which are amenable to remote handling.

At the end of the decontamination exercise contamination levels were low enough to allow man access without respiratory protection. However, it was found that once refitting of equipment began, resuspension of residual activity led to high airborne levels and work had to be completed in respirators.

#### 2.4 Harwell

Decontamination of caves and hot cells at Harwell has in the past been carried out using the basic techniques of sweeping and swabbing using remote handling apparatus, followed by final decontamination by operators in pressurised suits.

Some of the shortcomings of the above practices, and problems associated with old facilities were highlighted during the decontamination and decommissioning, during 1977/78, of a lead shielded cutting cell on an alpha, beta, gamma cell line at Harwell in which the initial radiation levels were in excess of 10 Sv/hr gamma.

Small equipment was transferred to other cells and a large (highly contaminated) cutting tool required dismantling and physical breaking-up before it could be disposed of by the normal cell line transfer routes. This was accomplished satisfactorily using the remote handling facilities.

Decontamination of the internal surfaces was carried out as far as possible through use of the remote handling tongs, but it was found that approximately 40% of the interior surfaces were out of tong reach.

The decontamination exercise was eventually completed by strictly controlled man-entry through the roof of the cell (which was removed), during which it was found that a large number of dust traps had been caused by the ventilation, gas supply and electrical fittings inside the cell.

Thus poor design of the cell considerably compromised the operators ability to decontaminate the cell without incurring a significant dose burden.

The design of the shielded cell facilities in building 220.29 at Harwell has largely overcome the above problems.

The stainless steel interior surfaces of the cells are electropolished to minimise the retention of contaminants by the surface and the design has also minimised the number of potential traps for contaminants.

#### 2.5 Windscale Laboratories

A similar decontamination exercise to the the one at Harwell, described previously, was carried out in a large, lead shielded general purpose cell in building B14 at Windscale laboratories.

The 36 ft x 8 ft cell, containing lead glass windows and manipulator tongs had been used over the past twenty years for active machining and also sectioning water reactor fuel pins and uranium bars. Deterioration of the internal cladding and installed services had made refurbishment and modernisation essential.

The majority of the decontamination work was carried out between March 1981 and August 1983 (though equipment and fixtures were removed before this). The initial activity level which was in excess of 1 Sv/hr gamma was reduced as follows:

- (i) Remote cleaning using vacuum suction followed by damp swabs ("Genklene" and detergent). Residual radiation level 30 mSv/hr gamma.
- (ii) Remote application of "Rustless" (an orthophosphoric acid based de-rusting gel). This was applied by brush, left overnight and removed by damp swab. Residual radiation level 5 mSv/hr gamma.
- (iii) Man-entry, detergent application, steam cleaning swabbing. Residual radiation 2 mSv/hr.
- (iv) Abrasive scrubbing and swabbing. Residual radiation level 0.2 mSv/hr.

As found in most other cases, almost all of the activity was on the stainless steel floor, and the major decontamination problems came from cracks, crevices and other such inaccessible areas where material could collect.

During the decontamination operations involving man-entry, 1/4 inch lead sheeting bagged in polythene was used to shield large areas of the floor to minimise the radiation dose from areas that were not being treated.

Monitoring was carried out on a regular basis including use of a trolley mounted directional monitor, obtained from BNFL on loan, which enabled the identification of hot spots.

## 2.6 Summary of Currently Recommended Techniques

Sensible design and good housekeeping will greatly enhance the ease of decontamination in hot cells.

The techniques which have been found to be successful are as follows:

- (i) Removal of all fuel and equipment.  
This is necessary to eliminate the major sources of radiation and allow access to the contaminated floor, bench and wall surfaces.
- (ii) Sweeping and dry vacuuming using MSMs.  
This is a very quick and effective way of removing gross quantities of loose contamination.
- (iii) Swabbing using MSMs.  
Abrasive pads or swabs soaked in a decontaminating reagent. Mechanical devices such as the rotating sander used at Berkeley may aid this operation.
- (iv) Application and removal of strippable coatings using MSMs.  
This will remove loose contamination from areas which are difficult to access eg. corners.
- (v) Foam application and removal using MSMs.  
Foam removal by vacuum suction or swabbing. This gives a high reduction in the levels of airborne contamination and thus reduces the redistribution of contaminants onto decontaminated surfaces.

(vi) Gels and Steam Cleaning.

The application of acidic decontaminant gels followed by steam cleaning will give a useful decontamination on localised "hot spots" and also on any dirty/ greasy deposits.

(vii) Stripping of paint using MSMs.

If the working surface is painted this will give very good decontamination factors on the stripped surface.

(viii) High pressure water jetting using MSMs.

Suitable drainage and effluent treatment facilities must be available.

Having completed some or all of the above operations man-access will probably be acceptable. Subsequent decontamination will be by the manual application of the above techniques. The installation of localised shielding around hot spots may be necessary.

At all times there is a vital need for accurate monitoring to give the overall radiation levels and identify any particular problem areas. Surveys should be carried out between each decontamination stage and in particular before man-access is allowed.

### 3 Strategy for Future Hot Cell Decontamination

With the highlighted concern over acceptable levels of operator dose uptake, and following the principle of ALARP it is increasingly important that future decontamination of hot cells should, as far as possible, be carried out remotely. There is also cost driven pressure to use techniques which generate a minimum of waste.

The following techniques are under development or are being considered for use in addition to the remote techniques as described in 2.6.

(i) Remote controlled floor and wall scabblers.

Such a device is being developed by MacDonald Power Tools for the removal of contaminated uncoated concrete surfaces. Vacuum suction is incorporated to control the large amount of dust produced by the process.

(ii) Remote controlled/automatic grit blasting apparatus with vacuum removal (and recirculation of the grit).

Similar to the above, this is being considered for future use for hot cell decontamination at Harwell.

(iii) Electrochemical "hot spot" decontamination apparatus may be used on stainless steel surfaces. This technique is being developed at Harwell and has been used in the shielded cells, building 220.29.

(iv) Another important future requirement is for improved remote controlled or automatic cave/hot cell monitoring equipment.