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Paper C1 part 3 : "Decontamination and Refurbishment of Hot Cells at Winfrith" by W D Curren and B Longson

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DECONTAMINATION AND REFURBISHMENT OF HOT CELLS AT WINFRITH

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1 INTRODUCTION

The South Cave in the Active Handling Building at Winfrith has internal dimensions of 10.2 m x 3.6 m x 3.3 m high, and is shielded by concrete walls 1.5 m thick (Figure 1). An in-cave bench is installed 1 m above floor level; it consists of a stainless steel sheet 6 mm thick supported on steel framework. The bench surface is coated with epoxy paint. Separated from the cave by a sliding door is a Transfer Chamber which is used for equipment maintenance and waste handling.

The cave has been used for 20 years for the examination of irradiated UO_2 fuel, mainly from the Winfrith SGHW Reactor. The work has included the occasional need to cut fuel specimens. It was last decontaminated in 1981-82. A further refurbishment was planned for 1986 in order to deal with a wider range of future PIE activities. Necessary modifications included the installation of additional zinc bromide windows and substantial changes to the in-cave bench. Several months of in-cave work were estimated, therefore it was necessary to decontaminate cave internals to an acceptable level. The whole operation was planned to be carried out from March to September 1986. This paper describes the decontamination of the cave.

2 ASSESSMENT OF CONTAMINATION LEVELS

The contamination in the cave was known to consist predominantly of irradiated UO_2 particles with a specific activity of about 20 GBq (0.5 Ci) per gram. Housekeeping in the cave during the previous 5 years of operation had been good; nevertheless fuel pin cutting inevitably releases contamination.

A preliminary assessment of the state of the cave suggested the following:-

(a) Fuel particles smaller than 10 microns (100 Bq, 3 nCi) would be levitated by the ventilation system and trapped on the extract filters.

(b) Particles greater than 10 microns would settle under gravity on horizontal surfaces; therefore vertical surfaces would not be contaminated significantly.

(c) Fuel particles greater than 1 mm (100 MBq, 3 mCi) would be detected and removed during normal housekeeping operations.

The contaminant therefore was expected to consist of fuel particles ranging in diameter over 2 orders of magnitude, and to be distributed mainly over horizontal surfaces at low level. Since the bench fits the cave exactly, with no gaps through which fuel could fall, the cave floor was expected to be clean. Therefore decontamination plans focused on cleaning the painted stainless steel surface of the bench.

3 INITIAL CAVE CLEARANCE

All free-standing equipment was removed from the cave, and the bench was brushed, vacuum cleaned, and wiped with damp swabs using the installed manipulators. This work occupied ~ 2 weeks.

4 RADIOACTIVE ASSESSMENT

An initial gamma-dose survey was carried out in-cave using a detector attached to a powered manipulator, used to scan the cave in 3 dimensions. This indicated a gamma doserate in the range 2 to 3 mSv/hr (200-300 mr/hr) at a height of 1 m above the bench. The detection instrument was not collimated, and measurements at varying heights in the cave gave no guidance on whether the contamination was associated with the bench or the floor beneath. Neither was it possible to calculate the total inventory of activity in the cave; a rough estimate of 40 GBq (1 Ci) was adopted for planning purposes. It was resolved that all activity removed from the cave during decontamination would be assayed, and that this data would be correlated with regular radiation measurements.

5 DECONTAMINATION

5.1 Planning

It had been decided before cave shutdown that a man-dose cost in the range 250-500 man mSv (25-50 man rem) for the refurbishment programme could be justified by the benefits which were foreseen. Since in-cave work would result in about 500 man hours of exposure, the initial doserate of 2 to 3 mSv/hr was clearly unacceptable. Decontamination was necessary to reduce radiation levels and to avoid the risk of contamination spread outside the cave. In addition, doses were to be as low as reasonably practicable (the ALARP principle) therefore it was resolved that decontamination should be carried out remotely, even though this would require more time than cleaning by man-entry.

Foam cleaning had been used successfully at Winfrith on a range of surfaces including finned transport flasks, the interior of a PuO_2 - contaminated pressurised suit area, and a stainless steel in-cave bench. Foam is generated from a small volume of liquid which contains detergents plus phosphoric acid, complexing agents, etc. The foam is quickly applied by a lance, allowed to react for several minutes, then retrieved by a 'wet' vacuum cleaner and collected in a tank containing an anti-foam reagent, which collapses the foam to the original volume. Equipment for manual operation is shown in Figure 2. The technique is easy to use, and clearly lends itself to mechanical or robotic operation. Arrangements had been made to clean the cave bench with foam using the powered manipulator.

5.2 Implementation

The bench was foam cleaned, using powered brushes to agitate the foam before retrieval. After repeated foaming over a 3 day period, the bench was visibly cleaner, and air-borne contamination levels in cave fell almost to "free-breathing levels". The total activity collected in the foam however was negligible, and doserates in the cave broadly were unchanged.

This result led to further speculation on whether contamination was associated with the bench or the floor beneath. To answer this question small paint samples 100 mm square were removed from the bench and assayed. The results showed very large variations. Larger samples of paint up to 600 mm square were removed, and activity assays now showed a reasonably constant relationship between activity retrieved and the area of paint removed. Mean results were consistent with the estimated cave inventory of 40 MBq (1 Ci). The next step therefore was the remote removal of paint from the bench.

Liquid paint strippers based on organic solvents (commonly methylene chloride) are not attractive for remote application in-cave. The evaporation rate is high in a ventilated area, and the time between application and stripping needs tight control. Additionally, some paint strippers damage manipulator gaiters, PVC pressurised suits, etc.

An inorganic paint remover was selected. It is delivered as a powder, and before use water is added to form a paste. It contains a strong alkali to attack the paint (sodium hydroxide) and an inert filler (calcium carbonate). The paste is applied in a layer ~ 10 mm thick. The material is collected by mechanical scrapers, lifting the whole paint film at the same time. The filler inhibits evaporation of the liquid, and the time between application of the paint stripper and its retrieval can be varied over the range of 2 to 24 hours. Traces of paint which remain can be washed away with water, or collected on damp swabs.

Paint was removed effectively from all the areas accessible to manipulators - about 95% of the bench area. The contaminated paint stripper was collected in steel waste cans, and dry cement was added to absorb free liquid. On removing this waste from the cave, doserates were low enough for man-entry, which therefore began 7½ weeks after cave shutdown.

All cave entries were carried out by operators wearing pressurised suits. The bench and walls were cleaned manually by foaming, which removed remaining paint. Horizontal surfaces on overhead cranes, etc were swabbed. Dismantling fixed equipment from the cave bench revealed further contamination which had previously been concealed (and partially shielded). Whilst this contamination was significant in quantity, it was removed quickly by swabbing as it was found, and the cost of this additional cleaning in man-dose terms was very low. The decision was taken to re-paint the bench at the end of the refurbishment campaign. Although the presence of paint will reduce the effectiveness of future foam cleaning, a painted bench offers a bright but non-reflective surface, and paint removal has been shown to be feasible and effective as a decontamination process.

The total dose cost of cave refurbishing was 205 man mSv (20.5 man rem).

6 ACTIVITY AND DOSERATE MEASUREMENTS

Measurements of active waste removed from the cave, and of the corresponding reduction in doserates, are displayed simultaneously in Figure 3.

The graph shows in total that the gamma doserate was reduced from 2.6 to 0.45 mSv/hr (a factor of $\sim$ 6) by the removal of 50 MBq (1.5 Ci) of active material.

As noted earlier, foam cleaning was largely ineffective, but paint stripping removed the bulk of the activity.

7 THE COST OF DOSE-SAVING

As noted above, the decision was made to spend time on remote decontamination rather than dose on man-entry and manual cleaning. An approximate estimate of the cost of the dose which was avoided can be made.

Remote cleaning had a zero dose cost, but occupied 26 days. It is estimated that manual cleaning by cave entry would have occupied 9 days, and would have resulted in 72 man hours in-cave working at a dose cost of 9 man rem.

The difference in time between the two methods is 17 days, ie 2 days additional cave shutdown time per man-rem saved.

8 SUMMARY AND CONCLUSIONS

1 The decontamination methods employed reduced contamination to acceptable levels; the methods were operated remotely at zero dose cost.

2 As predicted, virtually all the active material in the cave was associated with the bench surface, and the total corresponded (within a factor of 2) to the initial estimate. Better gamma monitoring equipment is needed to improve the quality of information available, and appropriate action is being taken.

3 The UO_2 particles which contaminated the cave bench after foam cleaning consisted of relatively few large particles (100-1000 microns) randomly distributed over the surface.

4 Foam cleaning invariably reduces airborne activity levels significantly, but is unable to detach hard UO_2 particles from paint.

5 The removal of paint remotely proved straightforward, with corresponding removal of active material. For this reason - and others - the bench was repainted at the end of the refurbishment programme.

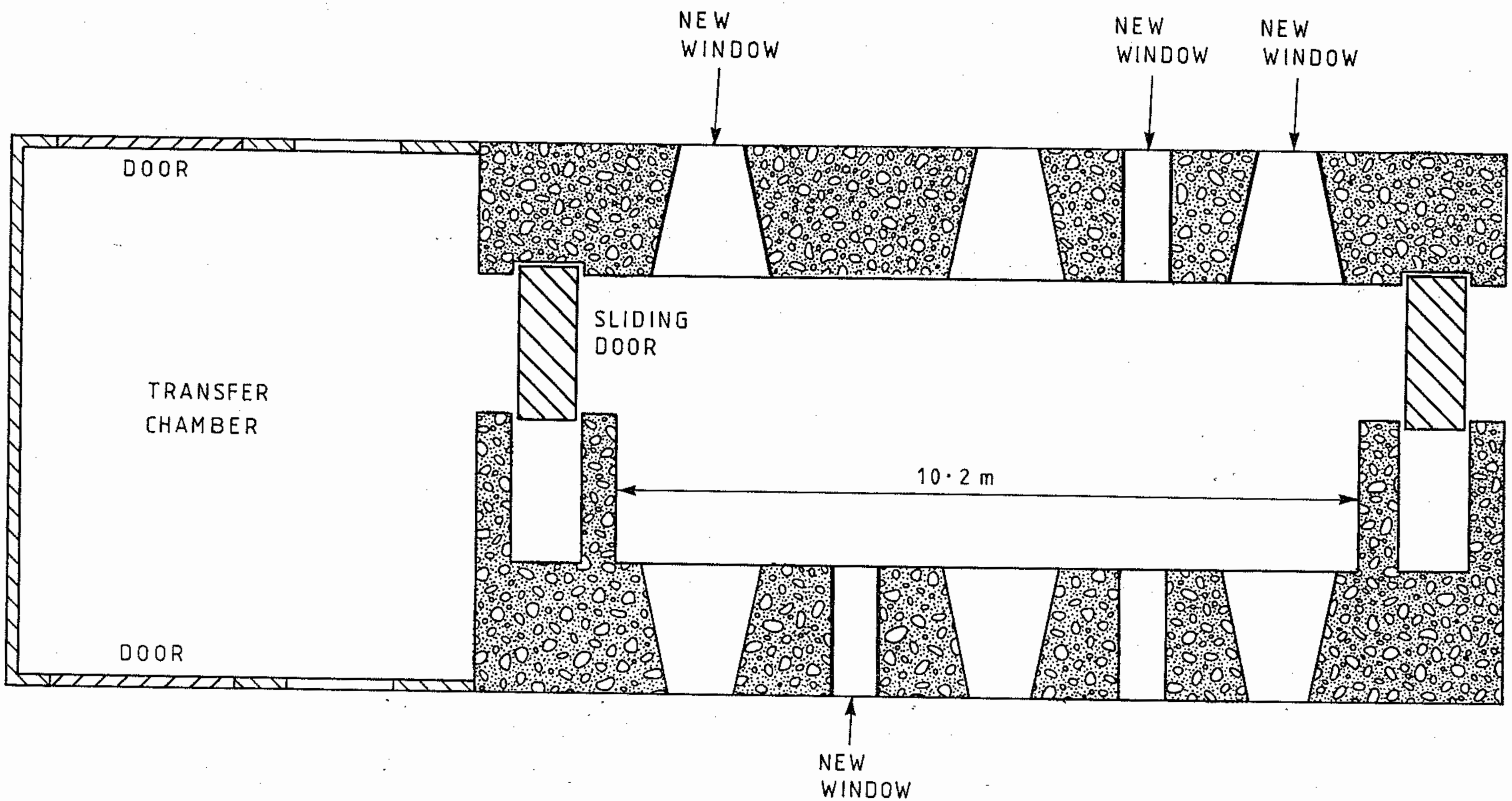

FIG. 1. SOUTH CAVE

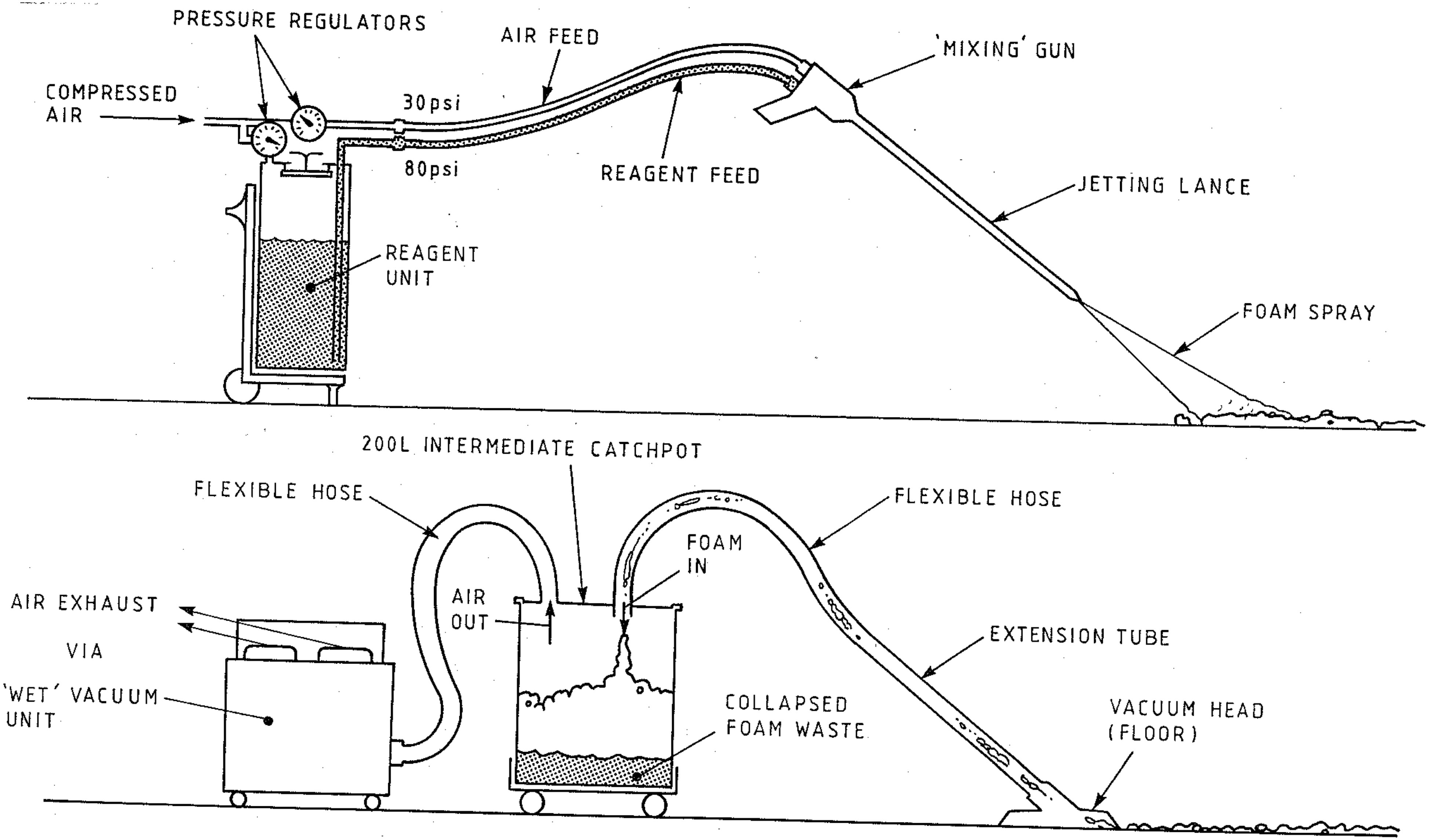

FIG. 2. FOAMING AND COLLECTION EQUIPMENT

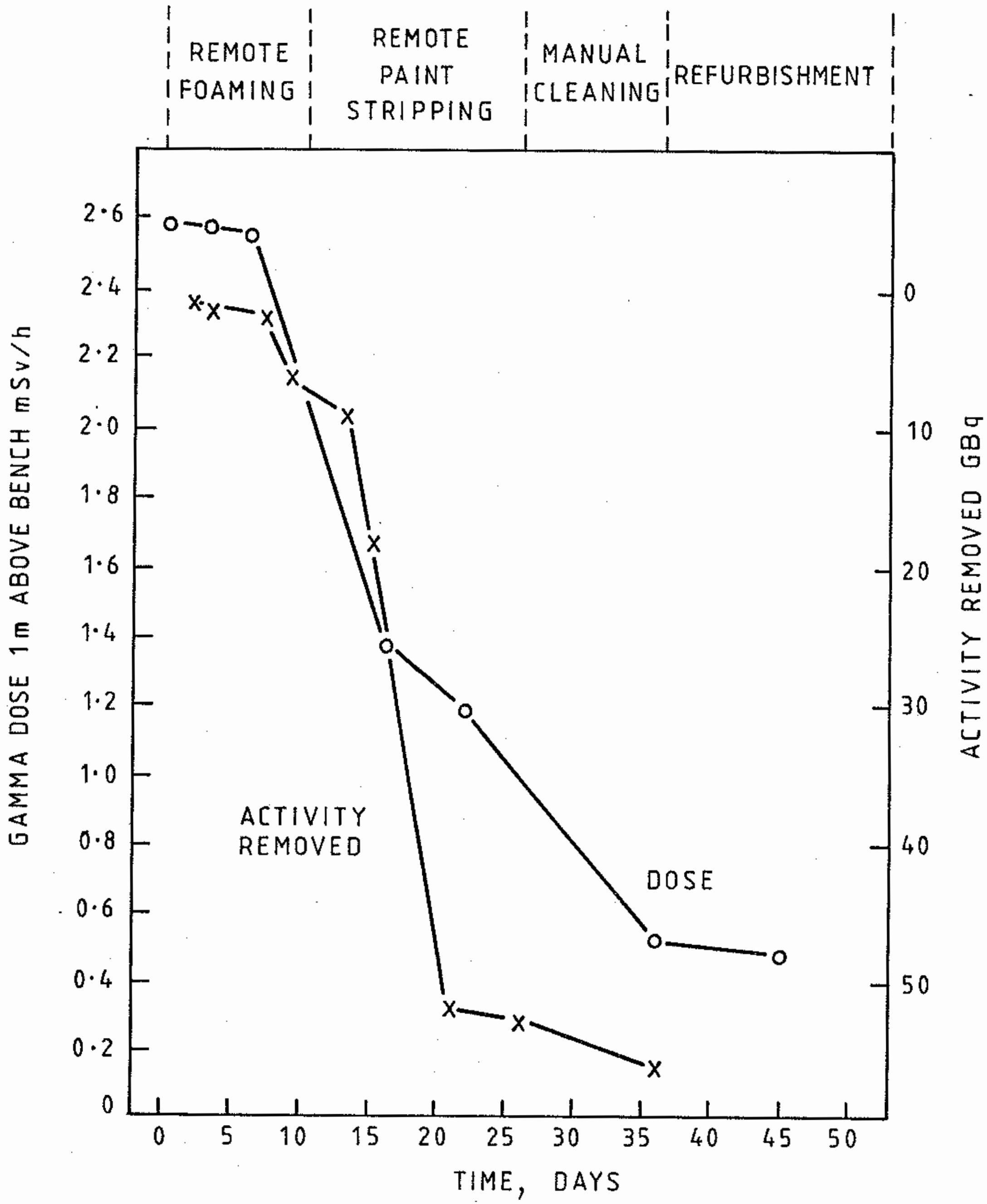

FIG. 3. ACTIVITY REMOVED AND IN-CAVE DOSE MEASUREMENTS