

Decommissioning of the Risø Hot Cell Facility

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Abstract

The Hot Cell facility at Risø, which is the only facility of its kind in Denmark, has been in active use since 1964. Over the years, all types of nuclear fuels have been handled and examined after irradiation by all kinds of physical and chemical, non-destructive and destructive techniques. The facility is now being decommissioned to a level corresponding to stage 2 for reactors, as defined by IAEA. The work started in 1990 and will be completed in 1994.

The object of the decommissioning project is:

- to obtain a safe condition for the remaining contaminated part of the facility, requiring a minimum of the special safety provisions that were necessary for the operation of the building as a hot cell plant;
- to minimize the amount of contamination;
- to release as much clean room as possible for new projects.

The facility comprises six concrete cells, several lead shielded steel cells, and glove boxes; in addition, there is a shielded storage for waste, a remotely operated optical microscope, a frogman area for personnel access to the concrete cells, a decontamination facility, workshops and various installations important for the safe operation of the plant. The concrete cells will be the only structure that will remain contaminated, being left as an enclave in the house and closed for any access. One room will be housing some contaminated equipment.

All steel cells and glove boxes, including the microscope, have been emptied and removed. The concrete cells have been emptied for all fissile material, scientific equipment, and general tools and scrap material. Decontamination was performed primarily to facilitate waste packing, but also to reduce the amount of waste, which is stored temporarily at the Risø Waste Treatment facility, together with the high active waste. The concrete cells have been cleaned remotely by wiping, hot spot removal by mechanical means and by vacuum-cleaning. Finally, the interior of two cells was decontaminated by high pressure water jetting to remove as much loose contamination as possible. All the master-slave manipulators and part of the contaminated ventilation system to the cells were removed. The cells will be left in a non-ventilated state with a connection to the atmosphere through an absolute filter. The degree of contamination and the radiation was measured in each cell before it was closed. The main contaminants were ^{60}Co , ^{137}Cs and α -emitters.

The paper describes the decommissioning tasks, the waste disposal and the received doses. In conclusion, the project was performed without using sophisticated decontamination techniques and required low doses.

Introduction

The Hot Cell facility at Risø has been in active use since 1964. Over the years several types of nuclear fuels have been handled and examined. All kinds of physical and chemical non-destructive and destructive post irradiation examinations have been performed. Besides, different radiotherapy sources have been produced, mainly ^{60}Co sources. Accordingly, many sources have been present and handled to cause contamination, and a variety of contaminated equipment and scrap material existed in the facility.

As nuclear power in Denmark was excluded from the national energy plans some years ago, the interest for Risø in hot cell work has decreased. Therefore, Risø has decided to decommission the Hot Cell facility. The decision has influenced various other research activities at Risø.

Hot Cell Layout

The facility comprises six concrete cells, several lead shielded steel cells, glove boxes, a shielded unit for temporary storage of waste, a tube transfer system, a frogman area, decontamination areas, workshops, various installations important for the safe operation of the plant, offices, etc. A plan of the ground floor, which is 2300 m², is shown in Figure 1.

The ground floor comprises the following red classified areas:

- six concrete cells,
- a sluice cell for transfer of fuel to the concrete cells,
- six lead shielded steel boxes,
- six glove boxes,
- a frogman area,
- a workshop for the master-slave manipulators,
- decontamination rooms,
- changing rooms between blue and red areas,

the following blue classified areas:

- a hall for operation of the concrete cells,
- a hall housing the steel and glove boxes,
- a workshop,
- a control room,
- a room for receipt and dispatch of transport containers,
- changing rooms between white and blue areas,
- stores and offices,

and diverse white classified areas.

The first floor comprises various red and blue classified areas for the technical installations, such as ventilation systems with filter components, pressurized air supply, battery backup for the power supply, etc.

In the cellar the piping for the active drains from the building are found; they lead to two active tanks, which collect contaminated water from the whole department.

Project Description

The object of the decommissioning programme is to obtain a safe condition for the total building that does not require the special safety provisions that were necessary for the operation of the building as a hot cell plant. As a result the Hot Cell building will be usable for other purposes after completion of the decommissioning.

The various decommissioning tasks comprise removal of all irradiated fuel items and all radioactive items and contaminated equipment, decontamination of all the cells, and decontamination with subsequent declassification of all rooms. The goal was to decontaminate the concrete cells to a degree where no loose contamination existed in the cells, and where the radiation level was so low, that total removal of the cell structures could be done any time in the future without significant radiation exposure of the work force.

The project started at July 1990 and was running as a EU-supported project to its planned end at December 1993. It was not, however, finished in the planned period; approximately another seven months are required.

Removal of Fissile Material

The very first step was to remove all fissile material from the cells, boxes and internal stores. This was done as a routine task. Most material was stored temporarily at the Risø Waste Treatment facility.

Removal of Large Contaminated Facilities

One glove box was used for grain growth studies on irradiated fuel. As it was heavily contaminated, it could serve as a container for waste from the remaining boxes and it was transferred to the Risø Waste Treatment facility. The three remaining glove boxes, which were used for isotope analyses, were contaminated with up to 400 kBq/m² after having been emptied of equipment. These boxes were initially cleaned through the attached gloves and while maintaining sub-atmospheric pressure. For cleaning, several cotton cloths impregnated with general household detergents and sponges with mild abrasives were used. A few "hot" spots were removed by sandpaper. A useful technique was to leave the boxes overnight with a detergent covering the bottom; next morning a major cleaning effect was observed. Similar final cleaning after opening of the boxes resulted in clean smear tests, so the boxes could be fully declassified.

Six lead shielded steel boxes were decommissioned. The boxes were bolted together at the connecting posting ports, which required "hands-on" for some time during separation of the boxes in order to reduce the radiation exposure during decontamination. Their use, disposal and final activity level are given in Table I. Box E served as a container for waste from the remaining boxes, but box F could not be separated from it because of the initially high activity in box E. The remaining boxes were cleaned remotely by the attached tongue manipulators and while maintaining sub-atmospheric pressure. The technique used for the cleaning was similar to the one used for the glove boxes. Two boxes were transferred to another active site after minor cleaning. The two remaining boxes were too heavily contaminated to clean by simple means. These were transferred to the Risø Waste Treatment facility (RWT) together with boxes E and F. The isotopes found in the smear tests taken on the boxes were ¹⁵²Eu, ¹⁵⁴Eu, ¹³⁴Cs, ¹³⁷Cs and α -isotopes. Cross contamination between the boxes had occurred for Eu, Gd and Cs, but not for α -isotopes.

At the end of the concrete cell line, a remotely operated microscope was housed in a lead shielded glove box, situated on a reinforced concrete base. The microscope and the glove box were removed as slightly contaminated items. The lead shielding was clean and could be reused. The clean reinforced concrete base had to be transported out of the building as large units by a heavy truck.

Removal of Large Contaminated Equipment and Scrap Material

At time of close-down the concrete cells contained scientific equipment and general tools. All this had to be cut into pieces and packed in containers, which were transferred to the Risø Waste Treatment facility. Over the years, very large amounts of contaminated scrap material have been accumulated temporarily at the DR3 reactor site at Risø. At a late stage of the project it was realized that in order to transfer this material in containers to another site it was necessary to condition the material. As the Hot Cell facility is the only site at Risø, where such conditioning can be done, the decommissioning project was delayed by this unforeseen task. During the processing of all this material the in-cell crane and power-manipulator were used much more than previously; this resulted in some break-downs of the old equipment.

Decontamination of Concrete Cells

Having been emptied for loose equipment, all the concrete cells were thoroughly vacuumed remotely. The internal surfaces of the cells are clad with painted steel plates. Several "hot" spots were removed by grinding. The radiation and contamination levels were then measured by placing several thermo-luminescence dose meters at predetermined locations in each cell. After exposure for one hour the dose meters were processed, and the general radiation levels were calculated, assuming that all activity came from ^{137}Cs . Further, several smear tests were taken at the walls, the table and the floor. Two relatively clean cells (No 5 and 6), which were prototypes for the decontamination procedure, were cleaned by high pressure water jetting performed by frogmen. The pressure of the water was about 200 bar. The pump was placed outside the cells and supplied with water through a plug in the cell wall. At first, water with some detergent was applied to all surfaces in the cell. Next, all surfaces were rinsed by water without detergent, the water being applied first to the ceiling, then going downwards. Special care was taken to hit all joints and other narrow hollows. Finally, all surplus water was pushed by a rubber scraper to the in-cell sump that leads to active liquid tanks at the facility. During the water jetting, some new waste particles were found and more clean surfaces were generally observed; only a few spots of paint were torn off. Monitoring of the outlet water confirmed removal of activity during the operation. The water jetting lasted one hour per cell. After the in-cell cleaning the radiation and contamination levels were measured similarly to the procedure applied before cleaning.

The β/γ -isotopes found in the smear tests were ^{60}Co , ^{134}Cs , ^{137}Cs , ^{152}Eu and ^{154}Eu ; the α -isotopes were ^{235}U , ^{238}U , ^{238}Pu , ^{239}Pu , ^{240}Pu , ^{241}Am , ^{244}Cm and ^{246}Cm . The activity was dominated by ^{137}Cs ; it was heterogeneously distributed being lowest on the walls. Analyses of two air samples taken in the cells before the water jetting showed α -contamination with 0.9 and 114 kBq/m³, and β/γ -contamination with 0.3 and 44 kBq/m³, respectively.

The cell entrances (measurements and the water jetting) required 10 man-hours for the two cells and gave collective doses of 11.8 man-mSv to four persons. The water jetting removed about 40% of the activity in the cells. The main results and the final state for all cells are given in Table II.

Based on the results on cells No 5 and 6 and on the measured radiation levels in the remaining four cells it was concluded that performance of a similar water cleaning of cells No. 1 to 4 would not be justified. The arguments were as follows:

- the "hands-on" work will only transfer the activity to another temporary place, involving estimated doses of up to 20 mSv/man for the available personnel;

- removal of 40% of the activity will be helpful later, but it cannot be regarded as an essential benefit now;
- the radiation levels are now so low that final "hands-on" cleaning can be done, if sufficient personnel are available;
- delay of the final cleaning will result in lower doses.

Between and above neighbouring cells, a shutter is placed in a shutter housing. The shutter can be moved in a vertical direction to give space for the in-cell crane and power-manipulator. Each shutter housing is an integral part of the cell volumes. Initial measurements showed that a major part of the contamination was found on the horizontal surfaces of the shutters. Therefore, these and other surfaces within reach were wiped with wet cloths. The contamination in the shutter housings was determined before and after this wiping operation. The effect of the wiping was that about half of the contamination was removed. Not surprisingly, the final level of contamination in the housings was factors of ten lower than in the main cell volumes.

All the air from ventilation of the cells and the rooms passes absolute filters before it is sent to the chimney. Preliminary smear tests taken in the chimney showed that this is clean.

Preparation of Concrete Cells for Long Time Storage

The concrete cells are now prepared for being left isolated. All master slave manipulators have been removed and all seals at doors and plugs have been checked and/or replaced. All ventilators and ducts for the cells will either be removed from the system or left connected to the cells fully sealed, including tightening of all axle penetrations.

The cells will be left unventilated at atmospheric pressure, supplied with a breathing hole with an absolute filter to allow controlled air flow out of the cells due to variations in atmospheric pressure. As the final step, a leak test will be done on the total remaining cell volume to ensure reasonable tightness of the system.

Collective Doses

The decommissioning project will require doses about 120 man-mSv, given to some 20 persons. The highest yearly man dose was 12 mSv. The doses are mainly caused by the processing of waste, and decontamination of the concrete cells and of the steel and glove boxes. The collective dose can be kept low because much waste material is stored after little or no decontamination, and because the concrete cells are not decontaminated fully using "hands-on" procedures.

Remaining Work

The remaining work at time of writing consists of the following tasks:

- finishing isolation of the cell volume, including work on cell ventilators and ducts;
- checking/removal of box and room ventilation systems and fume cupboards, which may be contaminated;
- checking/decontamination/removal of all equipment/surfaces in classified rooms;
- removal of active drains from the building.

Collaboration

Some tests were performed at BNFL Sellafield on removal by paint strippers of the epoxy painting used in our concrete cells on steel surfaces. The conclusion is that removal is possible on paint hardened in non-active environments. At present polythene oversuits are used by personnel wearing protective clothing to apply the paint stripper by hand, and an applicator system for remote handling should be developed. The technique can be important now or at a later stage.

We performed a few similar tests on originally applied paint in a cell sluice. The stripper was similarly effective. However, it does not remove the chromate primer on the steel surface. Therefore, the risk of contaminating this rough layer during and after the paint stripping operation must be considered.

Conclusions

The following conclusions from the project performance can be drawn, together with a listing of some important observations:

- The project was performed according to the plan, except for
 - a minor time delay;
 - a lower cleaning efficiency of the concrete cells than expected;
 - an extra classified room in the building (on the top of the cells), which was a reasonable change in the plan.
- It appears possible to plan such a complicated project reasonably well. The project was characterized by some very large jobs, which were practically impossible to plan quantitatively in any detail; examples are the decontamination of the boxes and not least the concrete cells. The original plan was based on general experience rather than exact knowledge.
- The collective dose of 120 mSv during the decommissioning work was held at a low level. In only two years of the project period it was higher than during normal operation of the facility. For these two years the collective dose was about double of the normal, but it was distributed among a larger number of people.
- The maximum individual doses per year during the decommissioning work were 10, 11 and 12 mSv. During normal operation of the facility the maximum yearly dose was 8 mSv.
- The efforts on decontamination were kept at a low level. Instead we transferred things directly to the Waste Treatment facility. This is the major reason for the low collective doses.
- We did not have any advanced physical or chemical decontamination procedures at our immediate disposal. This was not critical, because the policy at Risø is not to charge anything for temporary storage of contaminated waste at the Waste Treatment facility, at least as long as the existing facilities are sufficient. The question of final waste disposal will probably first be considered at the time, where the reactors at Risø must be decommissioned. At this time we will have to remove all our waste collected over the years.
- Up to now 31 ton of contaminated waste have been processed, including material not being present in the facility, when the project started.
- The total amount of contamination left in the concrete cells is about 1850 GBq.
- Preliminary smear tests showed that the chimney is clean. It has been in operation for 30 years. All the air coming through it has passed absolute filters. This filtering has been most effective through all the years.

- Taking old, but vital equipment into extensive use in the cells may cause the need for unforeseen manpower for repair work and give extra doses. We had more major break-downs of the in-cell crane and power-manipulator, which both were used much more extensively in the project period than during normal operation.
- When planning to shut down the only facility at a nuclear site, which is able to handle highly active waste material, it is important to include in the planning all potential sources at the site for material, which has to be removed. The unforeseen amount of waste material that had to be packed and removed from outside the facility, caused a major delay of the project.
- During the construction phase of equipment that must be decontaminated later, it is important to bear in mind that it should be built as easily separable modules; this may lower the dose exposure during later clean-up. An example is steel boxes.
- Compaction of waste might have been a useful technique to introduce at this occasion to limit the volume of waste.
- During the project period we had an unusually high rate of replacement of personnel, because people changed to permanent jobs whenever possible. The importance of keeping the experienced staff during decommissioning is often quoted. They know about details, which often have never been written down. We kept our most skilled personnel during the project, and the statement is according to our experience true. It was found, however, that new people, without any veneration for the things to break down, would do the job more efficiently than people, who may have built and operated the equipment for many years. This means that a combination of experienced staff and people new on the job appears the optimal team for decommissioning.
- Although we at some time anticipated some major in-cell work in relatively high activity environments, we did not encounter any bad feelings from our personnel regarding doses for the up-coming work. People did understand that the time for the facility was over, and that we had to leave the remnants in a condition as safe and ethically correct as possible.

Acknowledgements

All measurements and calculations on activity and contamination were performed by the Applied Health Physics Section of the Safety Department, Risø.

Mr J. Heiduk from NUKEM was in charge of preparation of a detailed plan for the remaining work, based on our own coarse plan.

The work was performed under the European Community Research Programme on the Decommissioning of Nuclear Installations, Section C, Research contract No. FI2D-0011-DK.

List of Project Reports

- 1) "Decommissioning of the Risø Hot Cell Facility", Contract FI2D-0011-DK, 1. Periodic Report, Covering July 1 to December 31, 1990, by H. Carlsen, RISØ-HOT-DECOM-P1. February 1991.
- 2) "Decommissioning of the Risø Hot Cell Facility", Contract FI2D-0011-DK, 2. Periodic Report, Covering January 1 to June 30, 1991, by H. Carlsen, RISØ-HOT-DECOM-P2. August 1991.
- 3) "Decommissioning of the Risø Hot Cell Facility", Contract FI2D-0011-DK, 3. Periodic Report, Covering July 1 to December 31, 1991, by H. Carlsen, RISØ-HOT-DECOM-P3. February 1992.
- 4) "Decommissioning of the Risø Hot Cell Facility", Contract FI2D-0011-DK, 4. Periodic Report, Covering January 1 to June 30, 1992, by H. Carlsen, RISØ-HOT-DECOM-P4. August 1992.
- 5) "Decommissioning of the Risø Hot Cell Facility", Contract FI2D-0011-DK, 5. Periodic Report, Covering July 1 to December 31, 1992, by H. Carlsen, RISØ-HOT-DECOM-P5. February 1993.
- 6) "Decommissioning of the Risø Hot Cell Facility", Contract FI2D-0011-DK, 6. Periodic Report, Covering January 1 to June 30, 1993, by H. Carlsen, RISØ-HOT-DECOM-P6. Rev. October 1993.
- 7) "Decommissioning of the Risø Hot Cell Facility", Contract FI2D-0011-DK, 7. Periodic Report, Covering July 1 to December 31, 1993, by H. Carlsen, RISØ-HOT-DECOM-P7. February 1994.
- 8) "Decommissioning of the Risø Hot Cell Facility", Contract FI2D-0011-DK, Final Report, by H. Carlsen, RISØ-HOT-DECOM-FINAL, to be issued 1994.

Table I: Lead shielded steel boxes

Box	Use	Disposal	Radiation at 1 m, [mSv/h]
A	Sep. of Eu/Gd	RWT ^{a)}	3
B	General storage	RWT ^{a)}	0.01
C	General storage	Use at another site	0.01
D	Weighing	Use at another site	0.01
E	Dissolution in acid	Waste container, RWT ^{a)}	12
F	Macrophoto	RWT ^{a)}	0.5

a) Risø Waste Treatment facility.

Table II: Main results for concrete cells

Cell No.	Cell utilization	Dose rate before jetting [mSv/h]	Dose rate after jetting [mSv/h]	Final contam. [GBq]
1	reception and dismantling	6.5	not appl.	604.
2	cutting and ⁶⁰ Co work	6.5	not appl.	393.
3	cutting and ⁶⁰ Co work	11.6	not appl.	689.
4	entrance cell	0.6	not appl.	34.
5	destructive exams.	3.0	2.0	102.
6	destructive exams.	1.0	0.5	24.

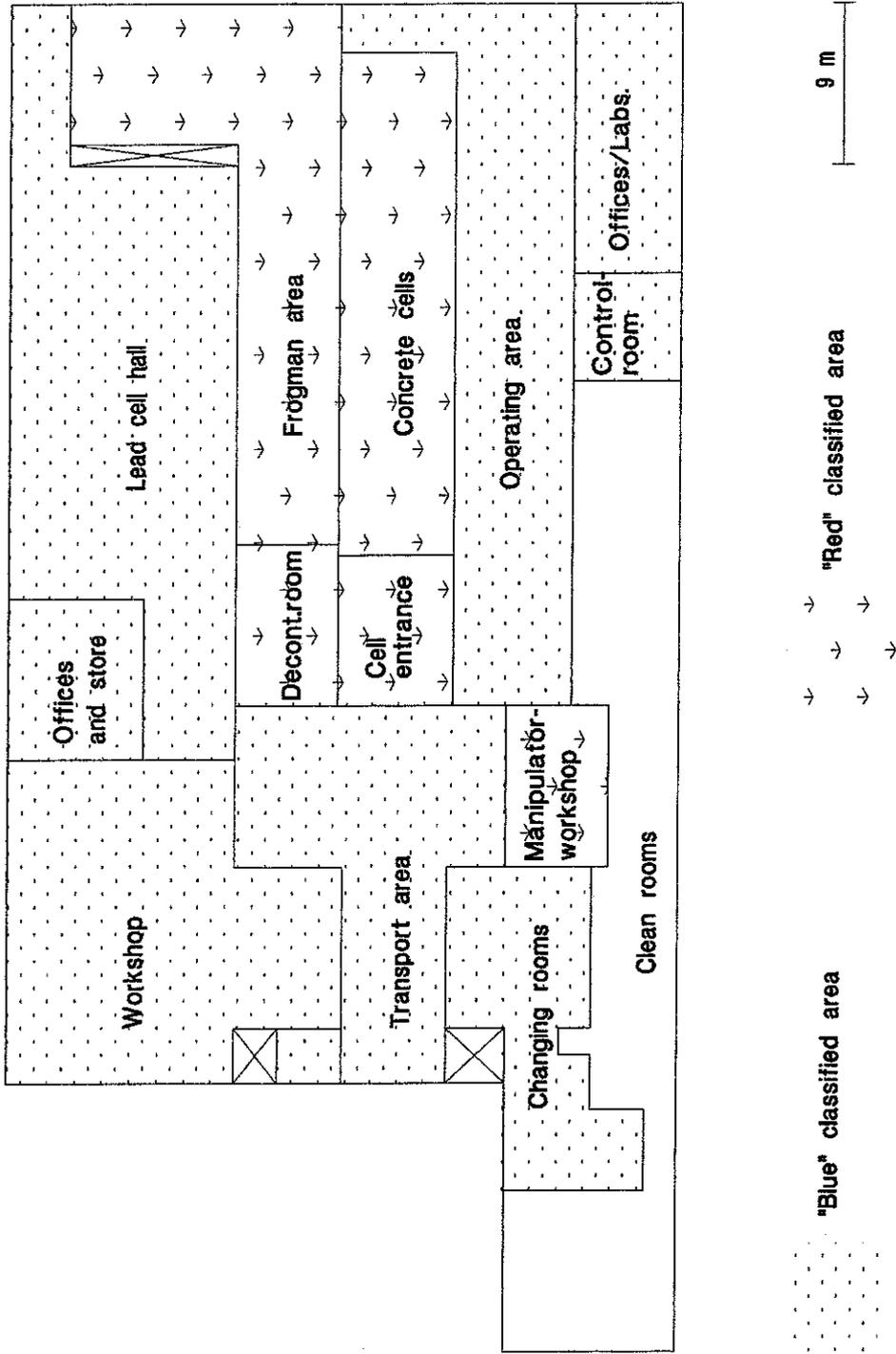


Figure 1: Layout of the Hot Cell facility