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Decommissioning a hot cell used for post irradiation research

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Abstract

The decommissioning of the oldest hot cell of the laboratory for Low, High and Medium Activity (LHMA) at the Study Centre for Nuclear Energy (SCK•CEN) has been completed recently. During 20 years, the cell was used for post irradiation research on irradiated materials and fuel pins. The cell consisted of an L-shaped air-tight alpha-box of 18 m³ surrounded by a biological shield in lead. The cell equipment, including a small lathe and several cutting devices, was operated by 12 tongs and 2 MA11 manipulators.

The decommissioning of the hot cell was characterized by 4 main phases:

- Phase 1: dismantling of the equipment
  The initial volume of the equipment was reduced by 65 %, and the resulting waste was conditioned in tinned cans and transferred to the waste services by means of shielded containers.

- Phase 2: decontamination of the cell
  Mechanical polishing combined with intensive vacuum cleaning was used to reduce the contact radiation levels (down to 1,4 mSv.hr^{-1}).

- Phase 3: dismantling of the cell
  The cell was surrounded by an air-tight construction, seventy tons of lead were removed, and the cell and its working table were cut using a plasma torch.

- Phase 4: waste management
  The decommissioning of the cell resulted in the production of 13 tons of radioactive waste, x tons of material that could be recycled in nuclear industries and y tons to be free released.

This paper discusses the main features of each phase including the techniques used and the dose uptake. The lessons learned by this particular decommissioning are summarised.

1 Introduction

The oldest cell of the hot cell laboratory LHMA needed to be dismantled in order to create space for new projects. This cell was used as a work-shop for fuel pins and irradiated materials.
Up to now, the strategy for decommissioning hot cells of maximum 2 m³ is characterized by removing and reducing the internal parts first, followed by a decontaminating of the internal

surfaces. Both these actions are carried out *hands off.* Subsequently, the shielding is removed, the cell box is packed and finally the resulting waste is transported to the waste services. In our case, the internal parts, such as a lathe and several cutting devices, were removed by this usual scenario, but due to radiological and physical restrictions, the remaining of the decommissioning strategy differs entirely from the usual one, and is best described as in situ dismantling. Dismantling the cell *in situ,* according to the safety regulations for the decommissioning workers and the general safety for the environment, at the minimal cost needed a good preparation and a well-organised waste management. Analysis of the waste streams, prior to the actual dismantling, influenced the choice of the decommissioning techniques. The decommissioning of other cells, also retired from service, made it possible to spread preparation costs.

2 Defining the problem: the first step in the decommissioning strategy

Because the cell was retired from service long time ago, the technical and radiological information was limited and several *black points* beneath the working floor made determination of the problem very difficult. To get a clearer view on the radiological problem, the dose, the activity and the isotopes needed to be determined on the entire surface of the cell. The in situ measurements and the analyses of samples allowed us to put the *pollution* in chart. A map with radiological data was created and could be used furtheron as a guide in the decommissioning strategy and the waste management. A *background* in the cell up to 6 $mSv.hr^{-1}$ (50 cm above the working floor) and hot spots up to 120 $mSv.hr^{-1}$ made the cell unapproachable without shielding and the reachebilety with the 12 old tongs and 2 master slave manipulators were insufficient.

3 First general conclusion in the decommissioning strategy

- Unable to work hands on

The high doses produced by isotopes such as Cs137, Cs134 and Co60 forbade, according to the ALARA-principle, the removal of the shielding. The total activity in the cell caused by toxic isotopes such as Am241 made access too risky for the decommissioning workers.

- Unable to work hands off

The reachebilety of the tongs and manipulators was insufficient to get an adequate decontamination of the entire internal surface.

As a first general conclusion we could summarise that we had to lower the background in the cell, hands off (PHASE I), in order to make dismantling of the cell, hands on, possible (PHASE II).

4 PHASE I: DECONTAMINATION OF THE WORKING FLOOR

The high dose measured in the cell could mainly be attributed to the highly contaminated working floor of the cell. It seemed to be realizable to carry out a decontamination of the working floor with the existing tongs and manipulators.

Phase I was necessary as a first step in the decommissioning strategy to:

- Lower the dose uptake in the second phase

The safety services restricted the collected dose for the decommissioning workers to 1 mSv.man a week. A decontamination of the working floor was going to reduce the dose uptake and therefore fewer personnel would be needed to stagger out the collected dose.

- Reduce the quantity of high active waste

Decontamination reduces the ratio activity to weight, which in this case implied that the quantity of material we could pack in the same barrel increased, thus reducing the number of barrels with high active waste.

- Productivity

Calculations based on the radiological mapping showed that the removal of the shielding, would raise the background in the building to such an extent that the other daily activities in the building during the second phase would not be possible unless a secondary shielding was build to protect environmental personnel.

The floor was polished with a special device that consisted of a pneumatic rotating brush. The brush could be handled with the tongs and manipulators. Intensive vacuum cleaning collected the radioactive particles in a special designed waste barrel.

Although the goal of the first phase, lowering the background in the cell to 0,2 $mSv.hr^{-1}$, was not achieved, the background was finally reduced to 1,4 $mSv.hr^{-1}$. A cost-benefit analysis showed that the dismantling of the cell at this stage was preferred above further decontamination.

5 PHASE II: DISMANTLING THE CELL

The main purpose in this step of the decommissioning strategy was a quick removal of the high active spots, which also includes the removal of the entire working floor. This phase can be described in 5 steps:

- Building an air-tight construction

To keep contamination inside the working area, a ventilated construction was build around the cell. In order to keep the dose uptake as low as possible, this construction needed to be build before the removal of the leaden shielding was started.

- Removing the shielding

The shielding consisted of leaden bricks and plates. Some parts had to be handled by the portal crane and therefor the roof of the air-tight construction needed to be removable. A total of 70 tons of lead were removed, measured and transported outside the building.

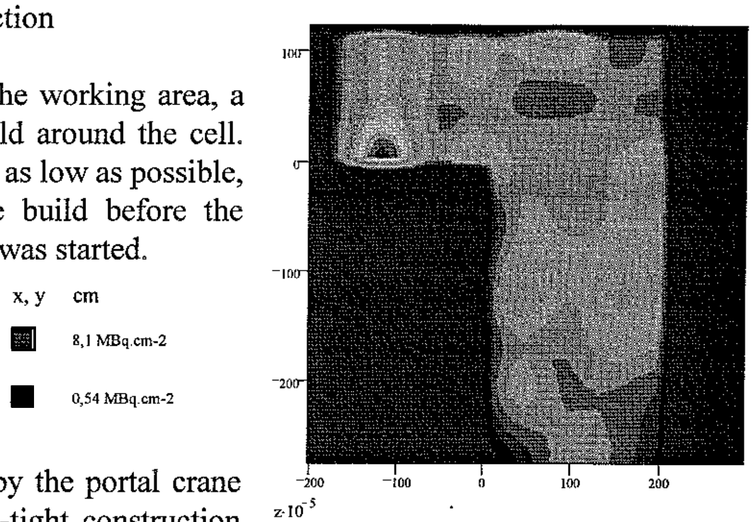

Fig 1: iso-activity plot of the working floor based on in situ dose measurements and characterization of samples.

- Removing hot spots and cutting up the working floor

After removing the shielding, hot spots were marked on the cell box. By means of a plasma torch, the hot spots were cut out and disposed off in a special designed waste barrel. The working floor, which was considered a hot spot too, was cut into smaller parts at the same time.

- Cutting the rest of the cell

At this point, the background in the working area was reduced to an acceptable level, the safety conditions were improved and further dismantling of the cell could be continued.

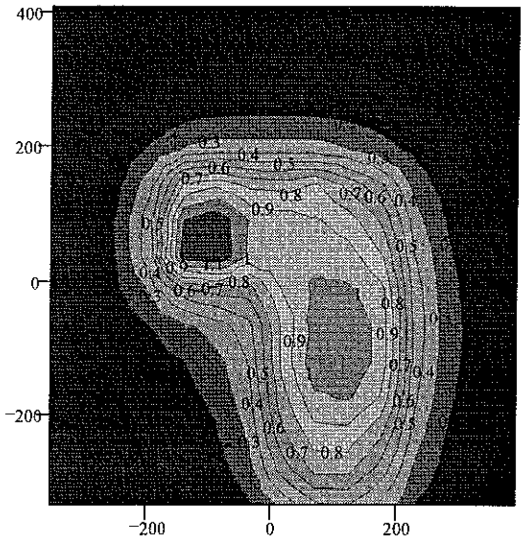

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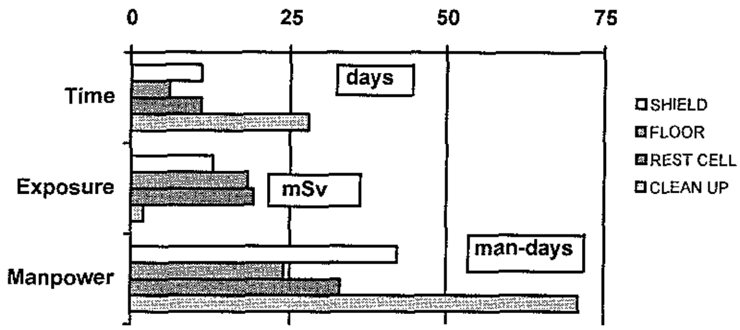
Fig 2: estimated iso-dose plot of the working area when shielding is to be removed (plane 25 cm above working floor in $mSv.h^{-1}$).
This chart was used for safety purposes.

- General clean up of the working area

The concrete floor beneath the cell box was contaminated. Both alpha and beta-gamma contamination was removed by scrabbling the floor a few centimetres. The construction was decontaminated, measured and will be released for unrestricted reuse.



Removing the shielding and cutting up the working floor were the most dose up taking steps. *Much **exposure** in less **time** which increases the **manpower** for these steps.*
(13 different decommissioning workers in 6 days to stagger out the dose uptake within the limit of 1 mSv/man/week)

Fig 3: overview of the manpower and the dose uptake during decommissioning.

6 RADIOLOGICAL MAPPING DEFINES DIFFERENT WASTE STREAMS IN ADVANCE

After the first phase, a second chart with radiological data after decontamination was created and completed with physical information. The main principle in defining the decommissioning strategy is keeping the decommissioning costs as low as possible. Since the decommissioning costs are proportional to the amount of radioactive waste produced, it is necessary to define the different waste types in advance, to estimate their quantities and to select the most efficient technique in order to minimize the waste production. The minimization of the total cost (dismantling + waste treatment) is relating the dismantling techniques with waste production and can be seen as the main purpose of coupling waste management to decommissioning strategy.

Taking into account our specific radiological and physical restrictions, the following waste streams were relevant to our case:

- Free release

Our safety service, in association with the authorised control organisation for radiation protection, specifies the limits for free release of materials at 0,4 Bq/cm² for BG-emitters and 0,04 Bq/cm² for A-emitters.

For each item or group of similar items, a complete file of liberation is composed. Materials for free release will be laid up for approximately 3 months in order to be measured again before a final release can occur.

In our case 70 tons of lead could be free released.

- Restricted reuse (RES)

Within the radiological restrictions like dose, activity and isotopes, steel and stainless steel could be recycled for nuclear industry by melting it. Acceptance criteria for package differ from radioactive waste which results in a supplementary cost reduction.

In our case 5,6 tons were within the specified restrictions for restricted reuse.

- Decontamination (DECON)

Grid-blasting can free release steel and stainless steel. This blasting technique is able to clean only geometrical interesting parts and its efficiency is in inverse ratio related to the surface activity.

A test on two barrels showed us that saturation of the blasting grid raises the secondary costs to such an extent that its total cost breaks even the cost for standard radioactive waste. Nevertheless, 3,6 tons could be considered for restricted reuse. On the remaining 1,5 tons different decontamination tests will be carried out to find a more sufficient technique.

- Radioactive waste (RA)

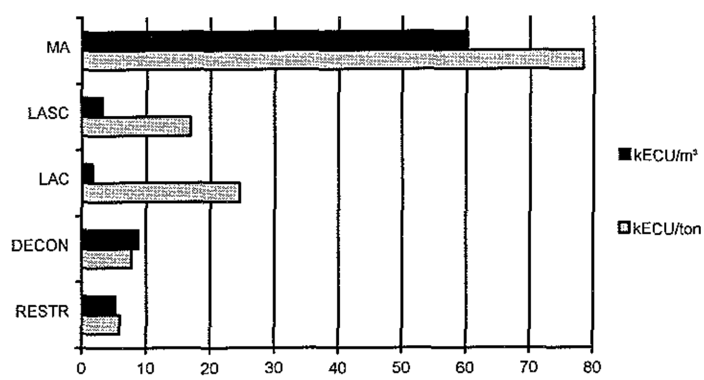
Depending on the radiological and physical criteria we distinguish 25 standard types of radioactive waste. Every type of waste is specified by the National Institute for Radioactive Waste and Enriched Fissile Materials (NIRAS).

The following types are relevant to our case:

Table 1: main radiological restrictions.

Type	max. BG	max. A	max. dose
Low active combustible solid (LAC)	40 GBq/m³	40 MBq/m³	2 mSv/h
Low active super compressible solid (LASC)	40 GBq/m³	5 MBq/m³	2 mSv/h
Medium active solid (MA)	100 TBq/m³	200 GBq/m³	200 mSv/h

A total of 6 tons of radioactive waste (MA, LASC, LAC) were produced.

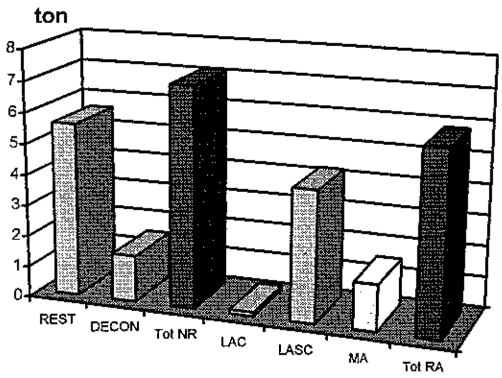


- MA-waste is the most expensive and should be avoided if possible. *Decontamination*
- The unit-price per ton for LASC should be reduced. *Better volume reducing of the materials after dismantling*
- LAC contains mostly clothing with a low ratio weight-volume.

Fig 4: unit-prices for different types of waste based on real costs and real waste production.

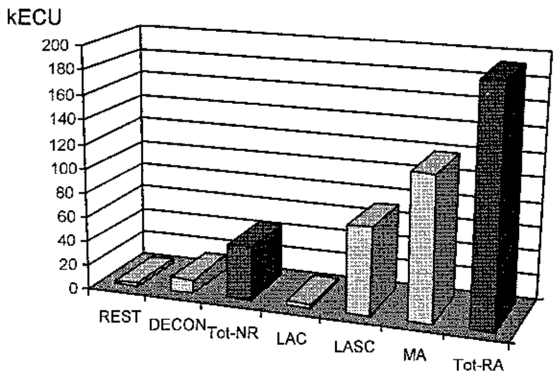
Conclusion

By coupling waste management to the decommissioning strategy, the general decommissioning cost could be reduced, i.e. decontamination of MA-waste could create x kg LASC, y kg RES and z kg free release. Putting up a decommissioning strategy includes trying to find out the best estimate result for the formula Xcost + Ycost + Zcost + ... where decommissioning costs are usually inversely related to waste costs.



- 70 tons could be free released. This material contains the periphery of the cell box that has normally never been in contact with irradiated materials.
- 50 % radioactive.
- 50 % includes radioactive waste from the cell box and secondary waste that was produced during decommissioning.

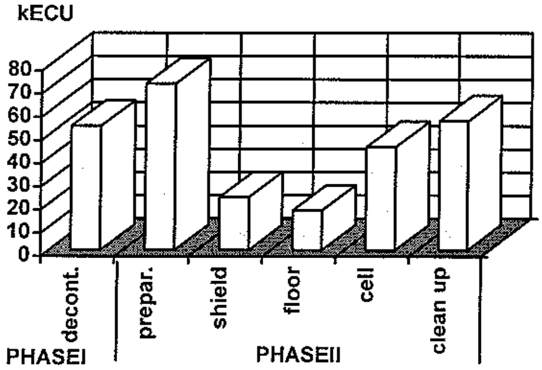
Fig 5: overview of the different quantities of waste produced (except free release).



- Materials for free release will be sold and could refund 21000 ECU.
- Costs for secondary waste mounted up to 25300 ECU or 10 % of the total waste cost.

Fig 6: overview of the costs for the different types of waste[2] (except free release).

7 DECOMMISSIONING COSTS



- All costs include administration, safety control and supervision.
- In the first phase preparation costs are also included.
- Preparation costs in the second phase include also the building of an air tight construction.

Fig 7: overview of the decommissioning costs for phase I and phase II.

In order to spread the preparation costs, which mainly include the design and construction of an airtight construction and ventilation unit, other cells were dismantled as well and cut up in the same area. All cells that were foreseen to be at the end of their life time in the same year as the discussed cell, were dismantled. The removal of their shielding had to be just in time, otherwise the exposure of the boxes would violate the ALARA-principle.

Conclusion

The normal pathway followed for decommissioning a cell could in this particularly case not be followed.

What seemed to be a disadvantage at first glance, turned out to be a big benefit in the decommissioning strategy: dismantling cells in situ is cheaper !

- This strategy can be used furtheron in dismantling smaller cells and glove-boxes.
- Preparation costs can be reduced by an organised planning of the decommissioning in such a way that *batches* of hot cells can be treated leading to the division of the preparation cost over the different cells.
- Dismantling in situ allows the coupling of the waste management to the decommission strategy which should result in finding the *best solution* for each cell.