

Maintenance of three cells in the Hot Cell Laboratory at Studsvik, 1998

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Abstract

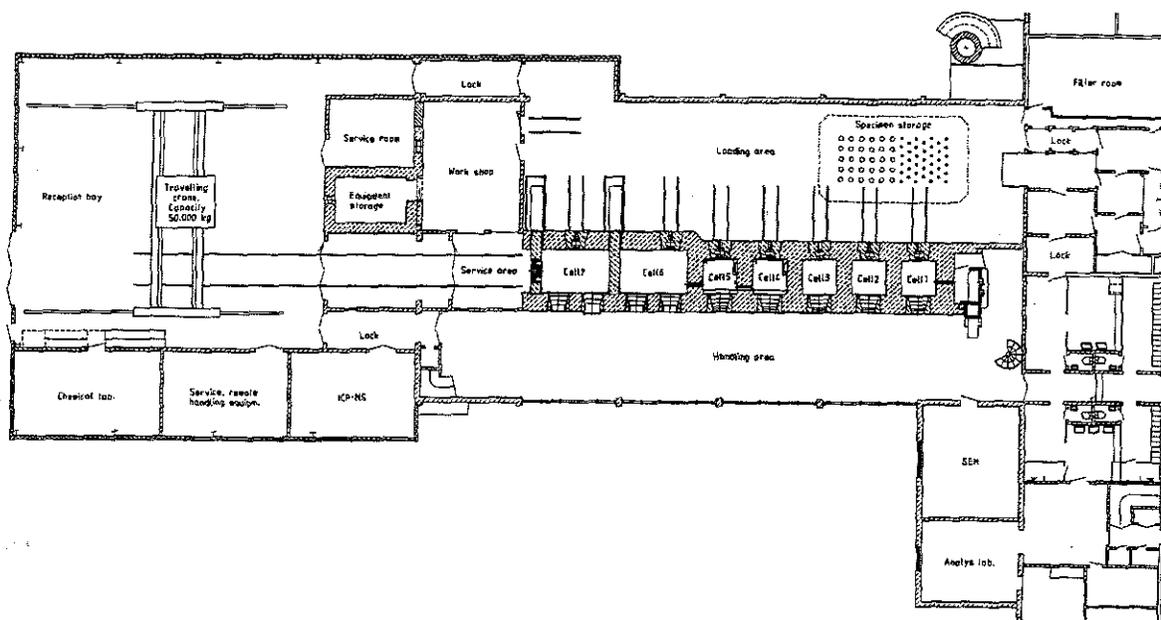
A major maintenance programme was carried out in the last quarter of 1998 on three of the concrete cells in the Studsvik Hot Cell Laboratory. Of these, the two largest, adjoining cells had not undergone a combined maintenance operation since 1981; since these two cells are usually used for storage of significant amounts of spent fuel, extensive preparations had to be made for alternative storage during the maintenance.

The maintenance included emptying of the cells, decontamination, servicing and renovation of installed equipment, installation of new equipment including a new hydraulic table and a sample transfer "train", and painting of cell surfaces.

The entire service was completed on schedule and well within the planned radiation budget.

The HCL building

The main building of the Hot Cell Laboratory has seven concrete hot cells. The two larger cells are 4x2,5 m while the five smaller ones are 2x2 m, all with a height of 4 m. It was cell no 7, 6 and 1 that we serviced at the same time, last autumn. The larger cells are separated by a sliding door. Those cells can be used as one large cell with a length of about 8,7 m. There is also a sliding door between the service area and cell no 7. It is normally always kept closed and fuel and specimens are taken into the cell through the main lock. When opened during service operations, it gives a free passage into the cell, as well as a possibility to transfer heavy equipment to the active workshop. Most of the normal in-cell equipment can be transferred from and to a storage-room, with the help of a moveable shielded transfer-box. The box is connected to the entrance of the cell and loaded with equipment. It is then lifted and moved to a position in front of the service room, where the load is transferred to the storage.



The Hot Cell Laboratory building

Before the service staff enter the classified area, they have to get dressed and equipped for the task and then pass through a lock. The main cell door, at the back of the cellblock, has been driven away on its rails and lifted to another position. A small moveable room, built of stainless steel, is connected to the cell entrance. It's a passage and a lock between the cell interior and the loading area. After every manual in-cell operation, the service staff enters the moveable room, which then is moved and connected to the decontamination area. This procedure makes it easy to keep a low level of contamination at the back of the cellblock.

Background

The two largest adjoining cells hadn't undergone a combined maintenance operation since 1981. At that time, they were serviced separately from each other and the sliding door between them was closed. Spent fuel and equipment could be stored in one cell at a time. Now we had both cells opened and maintained together.

The cell used for storage had to be cleaned and furnished with a new wall finish and a protection cover on one side of the cell table. This cell was heavily contaminated due to the fact that it is also used for all types of segmentation of fuel rods, such as shearing, cutting, sawing and milling.

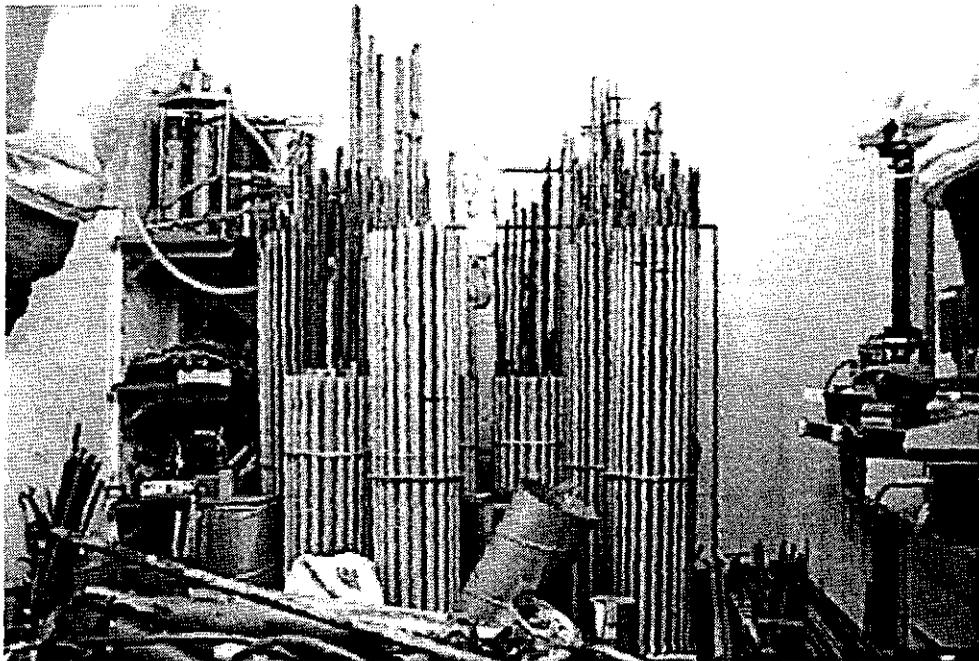
A lot of in-cell equipment, such as filters, lighting appliances, shelves, through-wall-connections, hydraulic lifting tables, power- and master slave manipulators, cables and other fixed installations, had to be changed or repaired.

We have a "train" for transportation of small samples between cells. It is mounted in a channel in the wall of the cellblock and had to be changed since it was of an old design and nearly completely worn-out.

Administrative preliminaries

There were a lot of preliminaries to go through before we even could start thinking about entering the cells. The preliminary work started in June 1998. In the beginning we concentrated our efforts on getting necessary sanctions from proper authorities.

The alternative storage of significant amounts of spent fuel required a new safety report and a time limited authority approval as well as new instruction manuals. We had to consider if the new storage situation was safe. A new criticality study came to the conclusion that it was in fact perfectly safe if the amount of allowable moderator material was lowered to the same level as in the storage cell. It was a normal handling operation to move the spent fuel and it was no danger for higher radiation levels in the surrounding areas. On the basis of those conclusions, we applied for a time limited approval. The Swedish Nuclear Power Inspectorate (SKI) did an on-site inspection and since they were satisfied with our preparations, they approved our application.



Alternative storage for spent fuel in cell no 5

We always work according to the ALARA principal to minimise dose to everyone involved. We made an estimated dose budget and came to the conclusion that the Swedish Radiation Protection Institute (SSI) had to be informed in advance since former services indicated that the collective dose could exceed 100 mmanSv. We estimated that it would reach near 150 mmanSv, on a planned service staff of 22 persons, with individual doses lower than 10 mSv in a 2 months period. It was under those premises we got our approval.

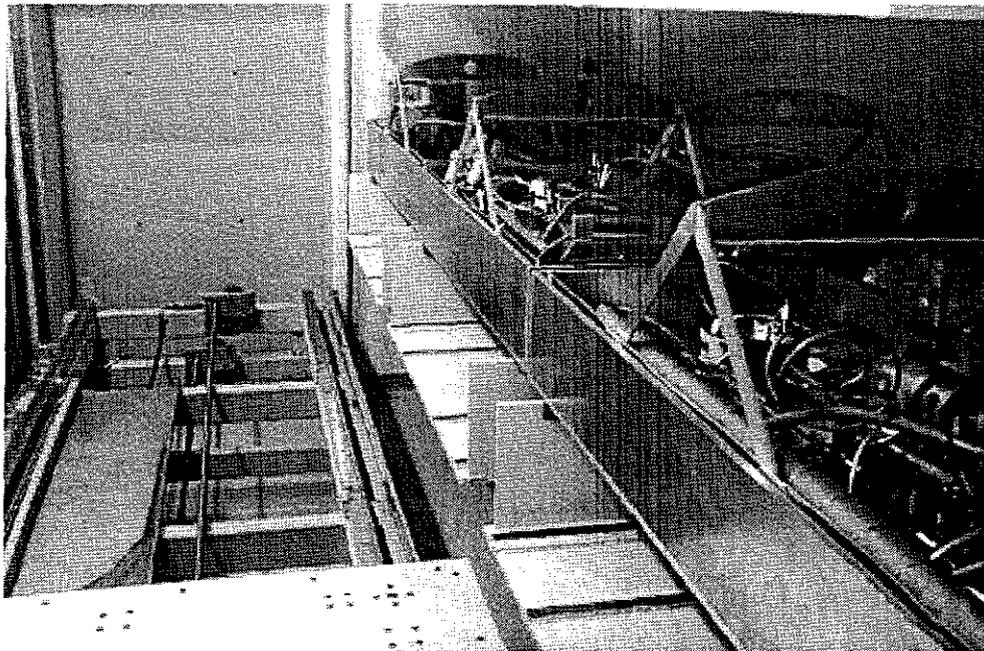
Outside contractors were contacted and scheduled. The first cleaning efforts inside cell, are usually done by hired decontamination and cleaning personnel from The Stensand Group. They are efficient and used to do this kind of work during the annual outages at the Swedish nuclear power plants. We also have good contact with a painter's workshop that is used to our environment.

Finally we worked out a rough timetable. The first planned work started in the middle of August. The end of September was the deadline for all approvals. The service operations inside the three cells had to start in October 1998 and finish before New Year's Eve, with retransfer of everything in January 1999.

Preliminary measures

Our preliminary measures included transportation of waste from cells to proper facilities such as the facility for treatment of solid and liquid, low- and medium-level waste, as well as the facility for dry storage of spent fuel. Both are located on the Studsvik site and owned by Studsvik RadWaste. The waste was taken from one cell at a time and the final transport, from cell no 1, was done in mid-October.

The cells contained a lot of different equipment. After a rough cleaning most of it could be transferred to the storage-room. The storage has nine computer controlled moveable shelves. Each shelf have two open containers with the size of approximately 1,25x0,5 m. The storage can be loaded or unloaded from a control board in the nearby service room and does not need any manual support.

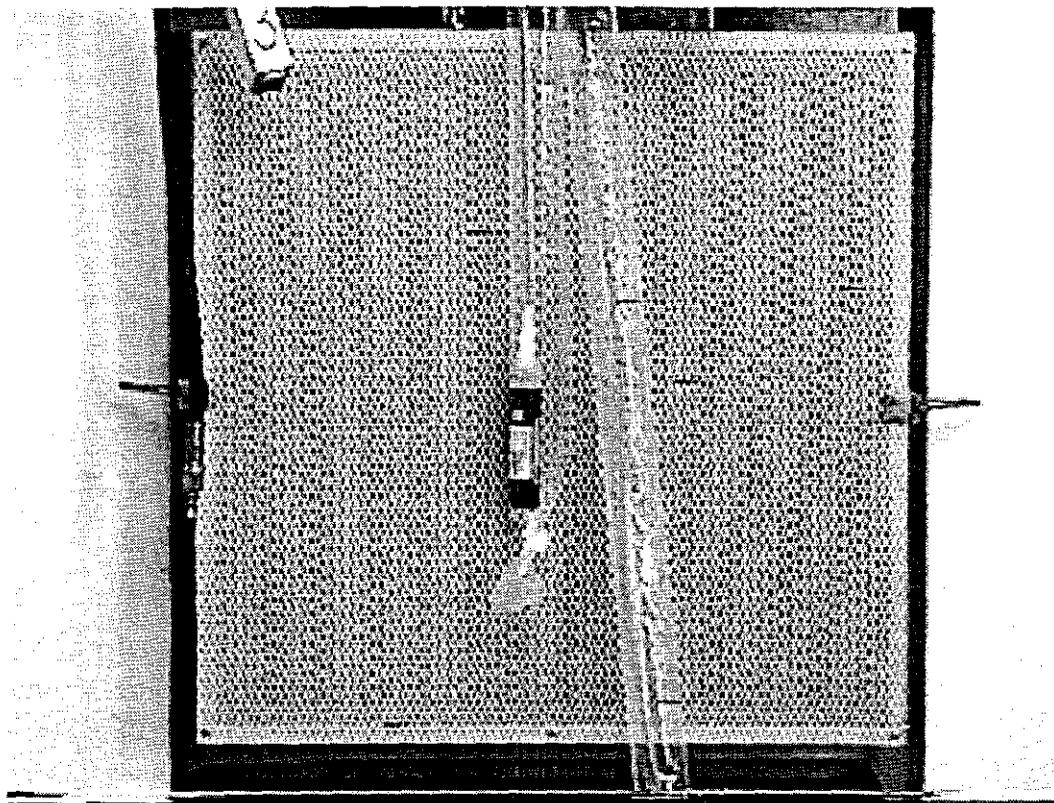


Storage room for contaminated equipment

We had about 130 kg UO₂ in the form of spent fuel inside the storage cell. The fuel that was under investigation was meant to be stored in the neighbouring cell. The rest, about 46kg, had to be transferred to the dry storage within the Studsvik site.

We had to do extensive cleaning operations inside cell, with the help of manipulators and normal cleaning equipment. We have an industrial wet vacuum cleaner at the back of the cellblock. It can be connected to each cell through a rough filter, mounted in the cell wall. The dust is forced to pass the water tank in the vacuum cleaner and the air stream on the outlet of the machine passes a filter. We have used this type of arrangement for many years without any problems. We also use rags or cotton waste wetted in alcohol, white spirit or just plain water with detergent. On metal surfaces, we tried to clean with soaped steel wool for the first time, and it was a success. Decontamination was very easily and quickly done and the soaped steel wool is cheap and easily purchased.

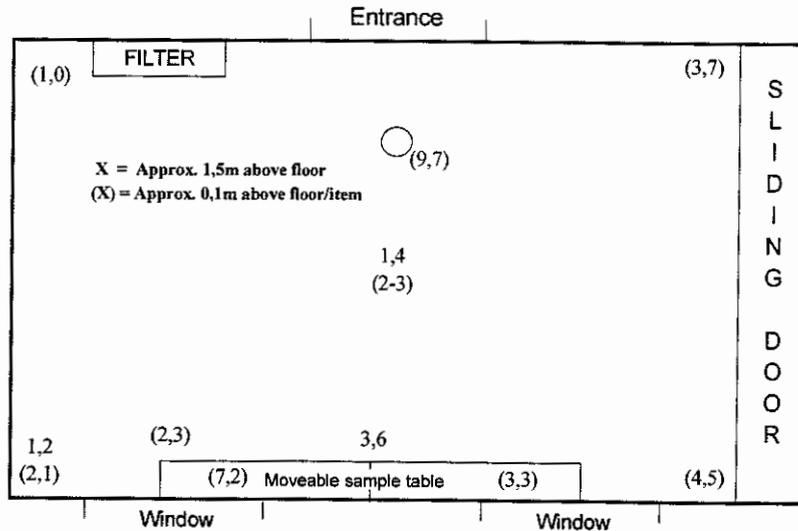
Finally we performed radiation dose rate metering and level mapping of each cell interior. Cell no 1-6 each have a narrow and bent throw-in-channel built into the wall on the right side of the cell. It's a perfect entrance for a cable connected electronic dose-rate meter, enclosed in plastic. It's possible to measure nearly every part of the cell interior with this arrangement and it gives us a good picture of the radiation level.



Dose rate measuring on filter in cell no 7.

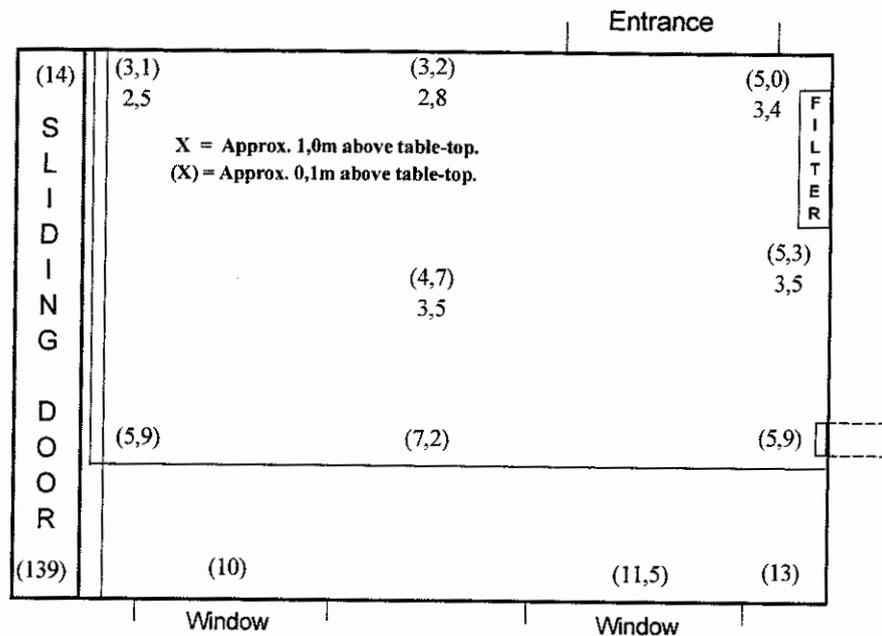
Radiation dose-rates in cell

Cell no 7 was completely renovated in 1995 and was only slightly contaminated when we started to clean it and we got down to a low radiation level in a short time.



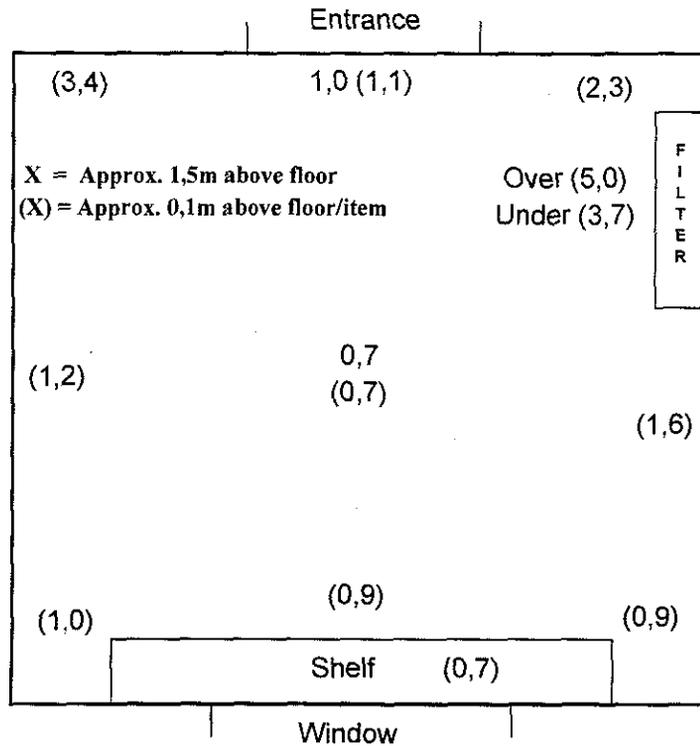
Cell no 7 after manual cleaning

It was 10 years since the last time cell no 6 was cleaned and serviced so it was heavily contaminated. We couldn't change the four filters manually so we did it with the help of an electromagnetic lifting device. The filters were placed in a concrete container for intermediate storage. After nearly two weeks of cleaning action the radiation level had reached a point where it wasn't reasonable to clean any further in cell no 6.



Cell no 6 after manual cleaning

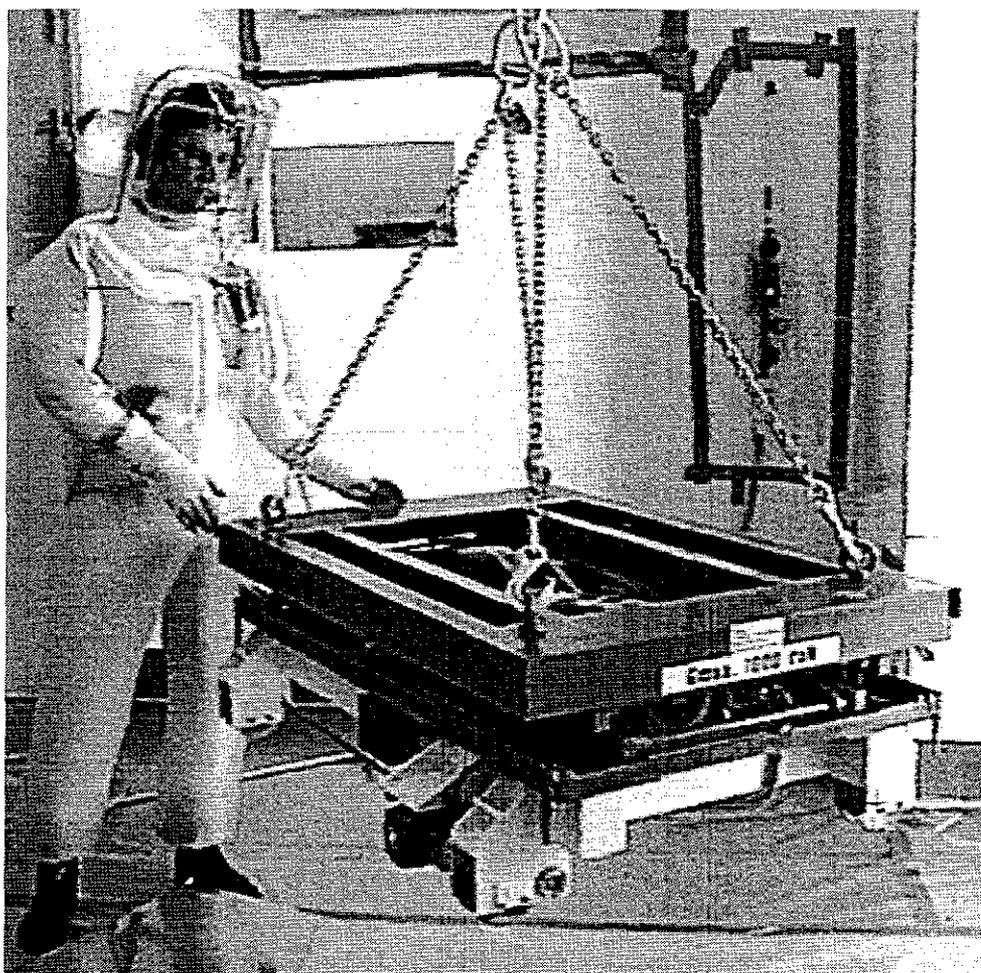
Cell no 1 is a cell used for cutting, grinding, polishing and preparation of samples for surface examinations. It has to be kept fairly clean with respect to the final finish of the samples. The cell is quite easy to decontaminate and needed only two days of cleaning before entrance.



Cell no 1 after manual cleaning

The service operation

The first manual in-cell work with equipment was done the 26 Oct 1998, when we transferred heavy equipment from cell No 7 to the active workshop. Next in-cell effort was done the 3 Nov 1998 and thereafter we worked inside the three different cells almost every weekday. We followed the detailed daily timetable as strictly as possible and we used every opportunity to cut the time spent in cell. It was a real relief the 4 Dec 1998, when finally all work was done, at least one week ahead of the timetable. The service staff of 25 persons had then spent 10850 minutes, more than 180 hours, in classified areas. After retransfer of all equipment the cells were prepared for normal use again during the last week of 1998.



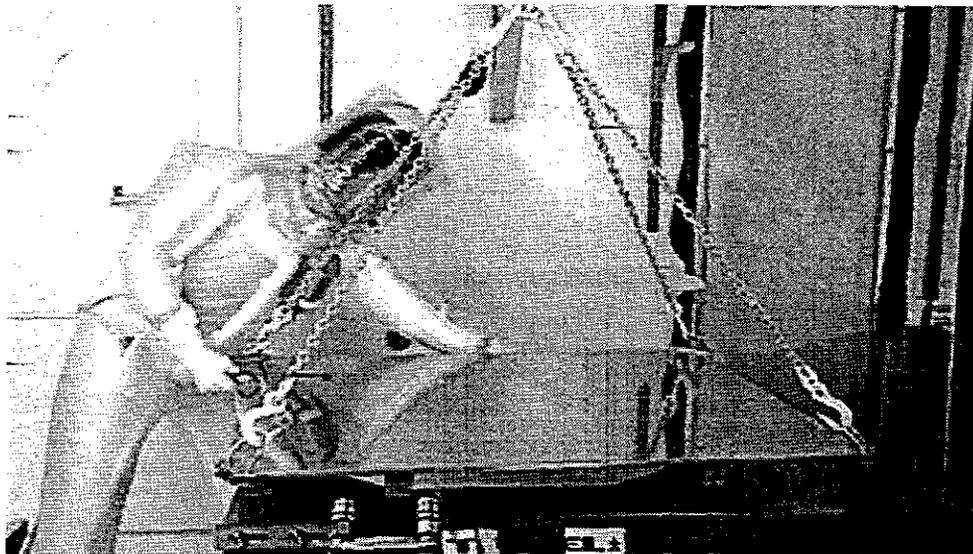
Transfer of heavy equipment

Achieved improvements

We managed to lower the background radiation level in all three cells, but especially in cell no 6, which thereafter was furnished with a new wall finish. Cell no 6 also got a protection cover mounted on the side of the cell table. This will prevent fragments of fuel and other radioactive particles from falling beneath the table and becoming unreachable. These are really very important improvements considering future services.

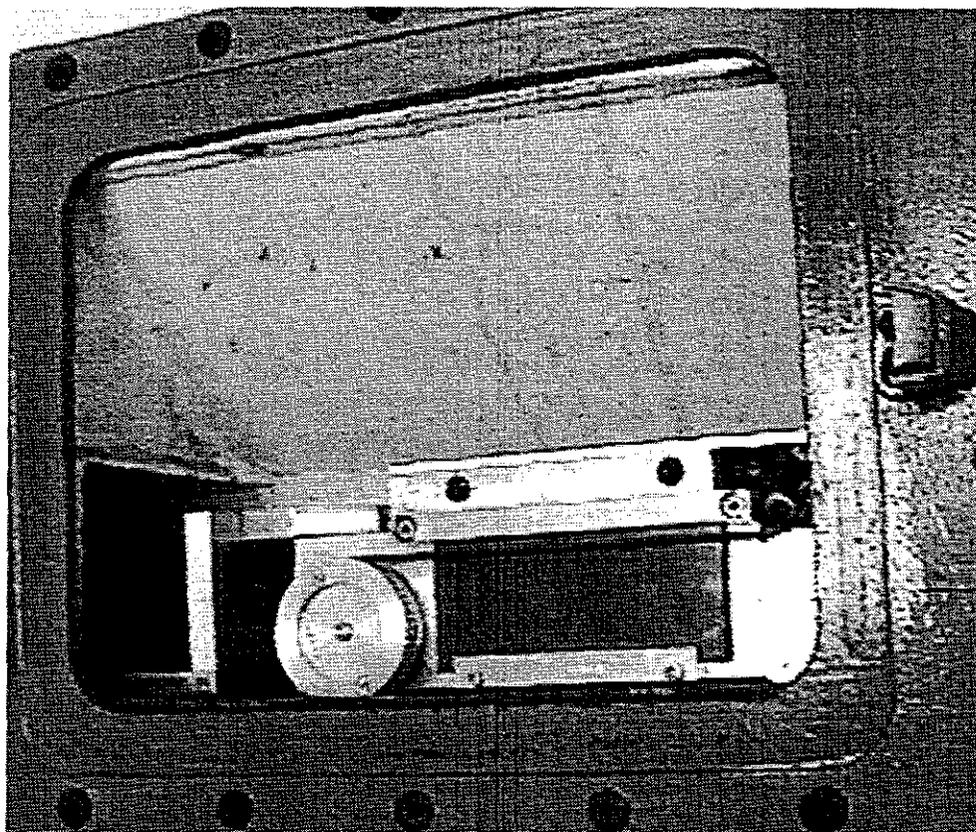
All cells have previously had lighting appliances mounted on the inside of the front wall. They were designed to contain three pairs of a low-pressurised sodium lamp. This arrangement gave a monochromatic light with no chance to distinguish separate colours. It was associated with great efforts to change a broken lamp and it wasn't possible to maintain connections and cables from outside cell. We designed a new type of lighting appliance, mounted on a through-wall-connection. We decided to use a modern high-pressurised sodium lamp with its multicolour spectra and with a much higher luminous flux than the former type of lamp. It was now, for the first time, possible to distinguish colours through the cell windows and we could both change and maintain the new arrangement from outside cell.

Cell no 7 is equipped with three hydraulic lifting tables with fixed tabletops. Fuel rods and other radioactive components are handled on those tables and they become very contaminated and difficult to clean. During services those tables are always guilty of giving high dose-rates to the service staff. We purchased a new type of table and equipped it with a detachable tabletop and a new trolley. This will make future services much easier accomplished.



Installation of detachable tabletop on hydraulic lifting table in cell no 7

For transportation of small samples between cells, we use a train mounted in a channel in the inside wall of the cellblock. Its old design and worn-out power supply made it hard to repair and maintain. Instead of trying to modernise it, we designed a new type of train that is supplied by battery and controlled with infrared light. Since it is equipped with semi-conductor electronics its function and resistance towards radiation was tested inside cell for nearly two years before we finally decided to install it.



The sample transfer train in front of the hatch inside cell no 1

The existing apparatus in cell no 7 for axial gamma scanning of fuel rods was affected by rust and was malfunctioning. We had in advance built a completely new type of apparatus, rust resistant and with fixed motor arrangements. It had been tested and proven to have great advantages in comparison with the existing equipment. It was mounted on the cell wall in a special suspension device that makes it very easy to remove and maintain.

Goliath, a full-length non-destructive examination apparatus for fuel rods, had a leaking hydraulic system. It is very rigid and heavy and weighs about 600kg and had to be moved to the active workshop. It was successfully repaired and returned to the cell.

In addition to all the above, almost every in-cell mounted equipment was examined and tested. Not to mention every master slave manipulator, as well as our power manipulator that all were serviced and returned to the cellblock in renewed condition.

Collective and individual doses

We had expected a staff of 22 but during the work we observed that it would be difficult to keep some individual doses down and we decided to involve another three persons. Included in the total 25 were of course those 10 contractors that participated.

The collective dose (TLD-based) reached 108 mmanSv in 3 months. Those figures include all other everyday work that generates a small portion of dose to everyone in radiological areas. If we instead calculate only the dose measured by the individual instrument (RAD 80) used by everyone inside cell or in the loading area, the collective dose was less than 85 mmanSv for a total period of 181 hours.

The individual doses varied a lot depending on where the person had been and for how long. The individual that got the highest dose, 10,2 mSv, hadn't been in cell at all, but in the loading area for totally 26 hours at the beginning of the service. Another person from the service staff was inside cell 18 hours and totally got 4,3 mSv. The difference is a good example of how important it is to get rid of all small sources in the surrounding areas. The electronic dose-rate meter gave acceptable daily dose-rates for that individual but when the TLD was analysed, it proved to be 3,4 mSv higher than expected. The individual had already got his maximum dose and wasn't allowed to continue work inside radiologically classified areas during the rest of the service operation.

Everyone involved was individually tested in a whole-body counter. These tests were done continuously during the service operation to assure that none was internally contaminated. If the test had been difficult to interpret or if there had been any suspicion that an individual had got internally contaminated with α -emitters, we always have the possibility to send specimens of urine for analysis.

Conclusions

Despite the fact that our Hot Cell Laboratory has been in use for nearly 40 years, its still possible to enter and service every cell from within after a reasonable cleaning effort.

Our small but dedicated, educated and trained staff involves everyone in the organisation and that's a necessity. Otherwise we wouldn't be able to get through with such a maintenance operation and still achieve our targets.

Good planning and preparations is a key to success. Experiences from former service operations had taught us to carefully document every step taken. That is now a source to dig in when it comes to future services.

Extensive cleaning and dose-rate metering must be allowed to take its time, and don't underestimate dose-rates from secondary sources. It's very easy to forget that it's not always the strongest radiation source that gives the highest doses, because, those sources are well known and the staff member keeps away from them. A low-level source can be ignored or believed to be non-dangerous and still, under a long period, give a much higher dose than expected. It's very important that all possible sources are included in the dose budget.

We have learned during the years, that a video or a camera is a very useful tool when one afterwards wants to remember what happened or how things were arranged. This service created nearly two hours of film. Its also important to let everyone involved get a chance to give their point of view on how things were done and what they want to change in future. We always close our service operations with a final and detailed report. It's our deposit in the knowledge bank.

