Radiological survey of the active central laboratory (ACL) in Studsvik, Sweden

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Abstract

This paper gives an overview of the decommissioning activities at ACL, a large laboratory in Studsvik, Sweden, and describes in more detail the issue of radiological survey for clearance of the buildings.

ACL was built around 1960 and has been used for different purposes, such as research on plutonium, experimental reprocessing of fuel, production of radiation sources and treatment of radioactive wastes.

The paper gives a brief description of the facility and its operational history, followed by an overview of the decommissioning project and radiological protection considerations and experiences in connection with the work. The specific conditions for clean-up with anticipated clearance levels are described, as well as the radiological survey for clearance of the buildings. Finally, the regulatory control by the Swedish Radiation Protection Authority (SSI) is described.

Background – the facility and its operational history

The Active Central Laboratory (ACL) is situated in Studsvik, about 100 km south of Stockholm, Sweden. It consists of two buildings – the laboratory itself and a ventilation and filter building (the Active Central Filter building, ACF). ACL is a three-storey building with outer dimensions of 65 times 72 meters. It contains more than 50 rooms that have been used for laboratories, testing of equipment, decontamination, storage of material and waste, etc. There is also a number of rooms for service systems (e.g. ventilation), corridors, culverts, etc. The floor surface is approximately 14000 m^2 (including ACF).

ACL was build around 1960 for research and development of reprocessing and MOX fuel production. During the years, the installations in ACL have also been used for a variety of other activities, such as research on plutonium and enriched fuels, testing of materials in hot cells, production of radiation sources, testing of iodine filters, decontamination of plutonium contaminated equipment, and different kinds of waste treatment (e.g. development of pyrolysis of ion exchanger and supercompaction of waste drums).

During operation, the facility contained several service systems, such as high power electrical systems, three separate ventilation systems (for glove boxes, cells and general ventilation) and three different canalizations for liquid waste (treated in another facility in Studsvik).

Decommissioning project

In the late eighties, some of the laboratories were vacated, decontaminated and measured for free release. In 1994 to 1998, the work was continued to remove equipment and furniture. Finally, in 1998, the owner AB SVAFO decided to go for complete decommissioning with the ultimate goal to demolish the buildings. The main reason for the decision was the low usage of the facility and high costs for heating and ventilation. Studsvik RadWaste AB was contracted for the decommissioning project.

First, a pre-project was carried out, in which about 13 tonnes of insulating asbestos were removed and many surfaces were checked for contamination. Also, interviews were performed with former personnel to gather information about potential contamination. Based on the measurements and the existing knowledge of the historical activities, the main project was planned.

The main project started in February 1999. The major activities were to clean the rooms, remove ventilation drums and perform measurements to detect any residual contamination. After some time, it was realized that the amount of work had been underestimated. Contamination was found more often than expected, and cleaning and measurements often had to be iterated several times.

In 2000, the project was interrupted for renewed planning and cost estimation. In order to speed up the work, it was decided to use two shifts of labour. During the period from January 2001 to June 2003, about 20 people have been involved in the project (except during summers). Currently (autumn 2003), the project runs with one shift and it is scheduled to finish by the end of 2004. Applications for clearance and demolition will be completed and presented to the authorities in 2005.

The general procedure for decommissioning has been as follows (Ref. 1):

1. Probing the contamination level by taking smear samples and making direct measurements with hand-held scintillation counters.
2. Decontaminating the room to levels that permit dismantling of equipment without radiological problems.
3. Dismantling of installed equipment.
4. Cleaning by vacuum cleaning and washing with water and detergents or methylated spirits.
5. Radiological survey (see below).
6. Sealing of the room (restricted access).

The current status is that most of the installed equipment has been removed (except the radiators (water heating) and electrical circuits). The main activities that remain are the continued radiological survey, preparation of clearance application and demolition of the building.

Radiological considerations and experiences

Since 1998, all of the work has been carried out in low-level radiation fields. Some decontamination work has been carried out by personnel using sealed overalls and fresh-air masks, but generally it has been sufficient to use full-face masks during dust-generating activities.

All personnel have been equipped with thermoluminiscence dosimeters and there have been several checks for internal contamination. No external or internal radiation doses above the limits for registration and reporting have been detected.

Conditions for clean-up activities

In 2001, the SSI issued conditions for the clean-up activities in ACL (Ref. 2). The conditions state that the license holder shall

1. perform reasonable clean-up activities,
2. show compliance with EU recommendations RP 113 (Ref. 3, surface activity levels for demolition) for the expected nuclides,
3. make nuclide specific measurements of residual activity,
4. search for spot activity if it is suspected that there are spots exceeding 150 Bq of alpha-emitting nuclides or 1500 Bq of beta- or gamma-emitting nuclides,
5. disregard naturally occurring activity that cannot be attributed to the operations performed in the facility,
6. take measures against re-contamination of cleaned areas.

The SSI has stated that the surface activity levels for demolition given in EU recommendations RP 113 should be applicable for a decision on clearance of the remaining buildings, provided that complete demolition is performed directly in connection with clearance and that surface layers are not removed manually after clearance. This statement was based on an analysis of the scenarios for RP 113 for the nuclides that were expected in ACL. The clearance levels for these nuclides are:

Nuclide	Activity (kBq/m^2)
Co-60	10
Cs-134, Cs-137	100
Sr-90	1000
H-3	100000
Pu-238, 239, 240, 242	10
Am-241	10
Pu-241	1000

The clearance levels are to be applied on each 1 m^2 square. For a mixture of nuclides, the summation over all nuclides of the detected activity divided by the nuclide specific clearance level must not exceed 1.

Radiological survey

Procedure

After removal of equipment, service systems and, in some cases, removal of surface layers such as epoxy, the remaining surfaces are examined for residual activity. The procedure is as follows (Ref. 4):

1. Mapping of all surfaces with a grid of 1 m^2 squares. For each room, every square has a unique label.
2. Measurement of residual activity by a combination of the following methods
   - Direct measurement with hand-held scintillation counter (100 cm^2 sensitive area)
   - Smear samples (smeared area 100 cm^2) for analysis with scintillation counters
   - Alpha, beta and gamma specific analysis of samples
   - In-situ gamma spectroscopic (ISOCS) measurement of several m^2 at once.
3. Documentation of measurement results.
4. Eventual removal of contaminated material to comply with the conditions for clean-up.
5. Eventual complementary scintillation measurements.
6. Confirming in-situ gamma spectroscopic measurements.

The extent of the measurements depends on the historical activities in the room and on the initial probing of the contamination level.

For surfaces where contamination has been removed or might be suspected, 100% of the accessible surface is checked by hand-held scintillation counter and one smear sample is taken from each 1 m^2 square. Finally 100% of the surface is measured by ISOCS. This has been the case for all floors and most of the walls up to 2 m height in the ground floor and in the basement.

For areas where contamination is not expected, only a fraction of the surface is checked. Generally, 10-25% of the squares are checked by hand-held scintillation counter and smear samples, whereas 50% of the surface is checked by in-situ gamma spectroscopic measurements (on the loft and in ventilation and drainage channels, 25% of the surface is checked by in-situ gamma spectroscopic measurements).

Occurring nuclides

Nuclide specific analysis has been performed on several samples that were taken from spots where significant contamination was detected by scintillation techniques. By alpha, beta and gamma specific analysis the following nuclides have been detected: Co-60, Sr-90, Cs-134, Cs-137, Eu-152, Eu-154, Eu-155, U-234, U-235, U-238, Pu-238. Pu-239, Pu-240, Am-241, Cm-244.

By in-situ gamma spectroscopic measurements, Co-60, Cs-137 and Am-241 have been detected. The possibility to detect Am-241 is of great importance, since Am-241 is used as a key-nuclide for other transuranium elements. Based on data from analyses on the material that was handled in ACL, the current relationship between the activity of Am-241 and alpha-emitting plutonium isotopes has been conservatively estimated to 1 to 3. This relationship has been confirmed by alpha spectroscopic analysis on several samples.

Detection limits

The hand-held scintillation counters have a background counting rate of about 15 counts per second (cps) for beta and about 1 cps for alpha. Since the calibration factor is around 1 kBq/m^2 per cps (calibration with Co-60 and Am-241), any contamination above the lowest clearance level (10 kBq/m^2) can easily be detected. When using a detector with 100 cm^2 sensitive detector area, 125 measurements are performed on each 1 m^2. When no activity is found, it takes about 20 minutes to measure 1 m^2.

Each in-situ gamma spectroscopic measurement takes at least 8 hours. For measurements on large surfaces (several m^2), the detection limit for Am-241 is lower than 300 Bq/m^2. The detection limits for Co-60 and Cs-137 are some tens of Bq/m^2.

Documentation of the work

The documentation of the work is of special importance, since it shall serve as a base for a clearance decision for the building. In discussions with the license holder, the SSI has requested that the documentation shall cover

1. a description of activities during operation of the facility and in what rooms they took place,
2. a description of clean-up activities during decommissioning,
3. a description of methods used for measurement of residual activity and a rationale for the selection of methods,
4. transparent measurement results, e.g. it must be possible to study the underlying documentation of the measurement results,
5. an estimation of the residual activity in each room, and
6. a description of measures to prevent re-contamination.

The project has presented such documentation to the SSI for a part of ACL. This has served as a good base for further discussions on the content and for an evaluation of the project performance.

In 2002, the SSI issued regulations on the planning before and during decommissioning of nuclear facilities (Ref. 5). Among other requirements, the license holder is requested to record information needed for a decision on clearance of the facility. The documentation shall contain results from measurements and calculations, as well as a description of decisions and measures taken during decommissioning. The regulations will enter into force on January 1st 2004 and will apply also on measures taken in ACL from that date.

Regulatory control

The project has been closely followed by the SSI. Until today (September 2003), 12 meetings with the project have been held, normally in connection with visits on the site. Information about the intentions of the license holder was presented in advance of the project and discussed in several meetings. The main question in the beginning concerned the clearance levels and the amount of measurements needed to show compliance.

In 1999, the SSI inspected the management of radioactive wastes emerging from the project. The inspection resulted in a clarification of waste management plans and criteria for sorting of waste.

As the decommissioning activities have proceeded, many different issues have been discussed, reviewed and solved. One example is the clearance of scrap PVC materials. The SSI has decided that PVC from the project should not be cleared according to the existing general regulations. Instead, the SSI has later permitted recycling of some tonnes of PVC after application of the license holder. Another question has been the incineration of potentially alpha-contaminated waste in the incineration facility in Studsvik. Yet another question has been the calibration of instruments and limits of detection.

The SSI has also taken about 50 samples for analyses, mainly for gamma emitting nuclides. Both material samples and samples of dust on surfaces (by wiping areas up to 1 m^2 size) have been taken. The analysis has confirmed the expected very low level of contamination. In most cases, the surface activity has been estimated to some tens of Bq/m^2 or less.

The SSI plans to make further measurements in the near future. Methods and scope have not yet been decided.

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