DECOMMISSIONING OF THE ACL AND ACF PLANTS IN STUDSVIK, SWEDEN

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ABSTRACT

ACL and ACF are two buildings at Studsvik in Sweden, a laboratory building (ACL) and a ventilation and filter building (ACF). From the beginning ACL was built for the development of processes for the reprocessing of spent fuel and in connection to that, laboratories for the analyses. During the years ACL became a place suitable for a large variety of projects. In recent times it was used in the development of the pyrolysis technique for ion exchange resins, which was the first step to the THOR plant in TN, USA.

Decommissioning of ACL began at the end of 1998 and has been carried out in two phases, the pre-project and the main project. An important lesson learnt from the main project is the methods for measurements for clearance from regulatory control. The main project is still on going and complete decommissioning is expected to be terminated by 2006 at a total cost of EUR 7.500.000.

INTRODUCTION

ACL and ACF are two buildings, which consist of a laboratory building and a ventilation and filter building. ACL stands for the Active Central Laboratory and ACF for the Filter Building. These two buildings are connected to one another by a culvert system.

AB Atomenergi, the former research centre, in Studsvik, about 100 km south of Stockholm, erected ACL and ACF during 1959 to 1963. The work in the laboratories came to an end on 31 December 1997. On 1 January 1998 the ownership was transferred to AB SVAFO which, at that time, was owned by the Swedish nuclear power utilities. At the same time AB SVAFO was a subsidiary to SKB, the Swedish Nuclear Fuel and Waste Management Company. On May 1st 2003 Studsvik AB bought all the shares in AB SVAFO and is since then the new owner.

The reason for doing the decommissioning work and planning for demolishing was that no experiments or no other use could be seen for the future and the costs for heating and general maintenance work are also high.

BACKGROUND

ACL was built for research and development of reprocessing and MOX fuel production. During the years, the laboratories in ACL have also been used for a variety of other activities, such as:

- Research and analyses on plutonium and enriched fuels
- Production of fuel bundles containing MOX fuel
- Storage of plutonium, uranium and thorium
- Tests of materials in hot cells
- Production of radiation sources, i.e. Ra-226 and Sr-90
- Tests with fuel cladding of zircalloy

- Decontamination (among that waste treatment of about 50 plutonium-contaminated glove boxes and cells has been performed)
- Development of the pyrolysis technique for ion exchange resins. This was the original process that later was further developed and resulted in the pyrolysis plant in Erwin TN, USA.

During 1998 most of the remaining test facilities were dismantled and treated as radioactive waste or free-released.

DESCRIPTION OF THE PLANT

The plant consists of two buildings, one for laboratories (ACL) and the other for filters and fans (ACF). The two buildings are connected to one another by three culverts for the ventilation air systems.

The ACL is a rectangular building in three floors with the dimensions 65 x 72 metres and a floor area of 12 400 m². ACF has also three floors and a floor area of 1 600 m². The material of the buildings is generally concrete, but some of the inner walls are made of bricks.

Laboratories, workshops etc are situated on the ground floor and the loft contains the main part of the auxiliary systems and ventilation channels with some of the primary filters. The basement contains systems and pipes for the liquid waste. There are also rooms used for storing fissile materials and culverts connected to the fan and filter building ACF.

Both buildings had several extensive stationary systems, provided for advanced tests, like

- Three separate ventilation and filter systems for glove boxes, cells and general ventilation.
- Three systems, separated from each other, for liquid waste. The liquids are treated in another facility in Studsvik.
- Electrical systems with four transformers of 1 200 ampere and 400 volts each.
- Auxiliary systems for steam, gas, demineralized water and pressurized air.

There were also alarm systems for criticality radiation, fans, pumps, etc. All the alarms were connected to the control room. Figure 1 below shows a typical view from the inside of the laboratory at the beginning of the project.

Fig. 1 The ACL in the beginning of the decommissioning project

THE DECOMMISSIONING PROJECT

The Pre-project

Investigation about the possibilities of decommissioning and free-release started in 1997 and continued during 1998. In 1998 the owner AB SVAFO decided to go for complete decommissioning with the ultimate goal to demolish the buildings. The same year the pre-project started. Studsvik RadWaste AB was contracted for the decommissioning part of the project.

The status at that time was that six laboratories in area No. 1, see Table I. and Fig. 2. below, were already decommissioned and accepted by the authorities as a free-released area. The decommissioning work in these six rooms was performed during 1988 - 1990.

In the period between 1994 and 1998 some preparatory work had been done. Radiological equipment, more than 50 glove boxes from the performed plutonium work and most of the test facilities had been treated and disposed as waste. Also some of the furniture had been treated and disposed. The costs for the work during this period are not included in the project budget.

The purpose of the pre-project was:

A. Dismantling of all insulation made of asbestos.

B. Radiological mapping to get a first feeling of dose rates, activities and nuclides analyses. The result of this investigation was the basis for the planning of necessary investments in manpower and material for the main project.

C. To carry out an activity plan and a time schedule based on the radiological mapping and results from analyses of samples.

D. To make a budget for the decommissioning part of the project.

The main project

The project divided the buildings into 4 areas for decommissioning. In Table I. below the sizes of the areas are shown and in Fig. 2. their location.

Table I Decommissioning areas in the ACL and ACF buildings

Area no	Ground floor (m^3)	Loft (m^3)	Basement (m^3)	Note
1 ACL	1570	1570	920	
2 ACL	1570	1570	770	
3 ACL	1570	920	770	
Entrance ACL	600	0	600	No active areas
4 ACF	700	200	700	

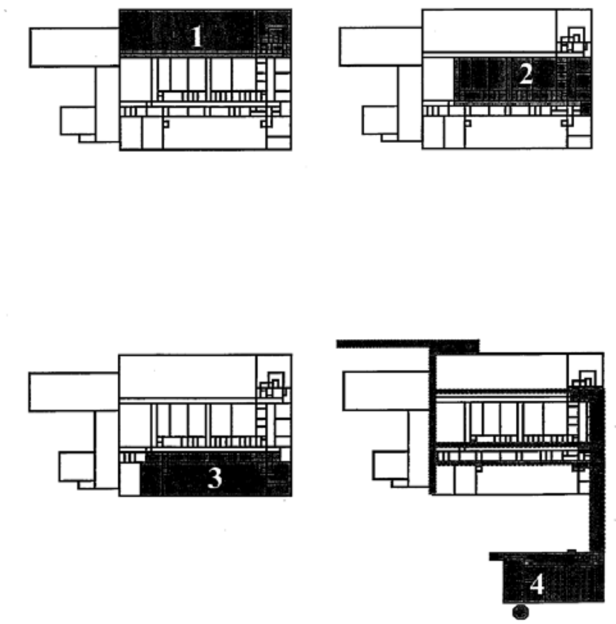

Fig. 2 The Different Areas for Decommissioning in ACL and ACF

Early in 1999 decommissioning of area No. 1 began. As the contamination levels had been underestimated and contamination was often found where it had not been expected, work had to be interrupted between July and September 2000 for planning and cost estimations. The work in area No. 1 could be finished in September 2000.

October 1st 2000 the decommissioning of area No. 2 commenced. A few months later it became necessary to increase the number of staff from 4 to 17 employees working 2-shifts. During summer that year the personnel was reduced to 4. In the autumn the 2-shifts started again with full staff.

In mid-September 2002 the work with the hall in area No. 3 begun with a staff of 16 people. It has continued with the remaining parts of area No. 3 during 2003. As there is not much work left the number of staff has been reduced to half the number, in order to facilitate the decontamination of the remaining areas.

Progress until today

The progress until today is that areas Nos. 1 and 2 are what the project considers as free-released, i.e. the results from the final measurements and analyses are below the clearance levels. The current status in area No. 3 is that the main part of the installed equipment is removed. However, water radiators for (water-) heating and electrical equipment are not removed.

Area No. 2 was decommissioned at the end of last year. The report from that is now nearly finished. Area Nos. 3 and 4 are now in progress. A rough estimation shows that about 90 % of area No. 3 and 20 % of area No. 4 are finished.

PROJECT ORGANISATION

There is an organisation group formed with representatives from the purchaser, main contractors, expert consultants and the leaders from the project. The purpose of this group is to give information about the continuing work including measurements and analyses, problems, contacts with the authorities, the time schedule and the budget. This group has one regular meeting a month.

In the beginning of the project interviews were performed with former personnel to gather information about potential contamination, nuclides etc. Based on the measurements and the existing knowledge of the historical activities some information on how to perform the decommissioning was obtained.

COMMUNICATION WITH THE AUTHORITIES

From the very beginning of the decommissioning project there has been a dialogue between the authorities and the organisation group. The intentions of the group have been presented in advance and discussed in regular meetings. The main concern at the beginning was clearance levels and the number of measurements that had to be made. Another issue was the clearance of PVC materials. According to a decision from SSI (Swedish Radiation Protection Authority) PVC materials were not to be cleared in compliance with the existing general regulations. Following an application from the organisation group SSI later permitted recycling of most of the PVC.

January 1 2004 new regulations from SSI on the planning before and during decommissioning of nuclear facilities entered into force. In order to obtain a clearance decision the regulations stipulate the need to record measurement results with calculations and descriptions of measures and decisions taken during decommissioning.

To confirm the contamination levels SSI has analysed about 50 samples, including both gamma and alpha emitting nuclides. The samples were taken both from materials and from dust.

DOCUMENTATION

The documentation of the work shall serve as a base for a clearance decision for the building. In discussions with the authorities, they have requested that the documentation shall cover:

- A description of the operations that have taken place in the facility and in what rooms they have taken place
- A description of clean-up activities
- A description of the used methods for measurements of residual activity and a rationale for the selected methods
- Transparent measurement results, e.g. it must be possible to study the underlying documentation of the measurements
- An estimation of the residual activity in each room
- A description of actions against re-contamination

The project has presented such documentation to the authorities for two out of four parts of the ACL. This has served as a good base for further discussions on the content and for an evaluation of the project performance.

COSTS

The total cost of the project is now estimated to EUR 7.500.000. This cost does not include the work performed before November 1998 which were:

- Dismantling of glove boxes and cells
- Dismantling and free-release of the test equipment
- Free-release of desks, cupboards, etc.
- Intermediate and final storage of radioactive waste

CLEARANCE LEVELS

In 2001, the authorities issued conditions for the clean-up activities [1]. The conditions state that the project shall:

- Perform reasonable clean-up activities
- Show compliance with EC recommendations RP 113 [2] (surface activity levels for demolishing) for the expected nuclides
- Make nuclide specific measurements of residual activity
- Search for spot activity if it is suspected that there are spots exceeding 150 Bq alpha or 1500 Bq beta/gamma
- Disregard naturally occurring activity that cannot be attributed to the operations performed in the facility
- Take actions against re-contamination of cleaned areas

The SSI has stated that the surface activity levels for demolishing given in EC RP 113 should be applicable for a decision on clearance of the remaining buildings, provided that the complete demolishing is performed directly in connection with clearance and that the surface layers are not removed manually after clearance. This statement was based on an analysis of the scenarios in RP 114 [3] for the nuclides that were expected to be found in ACL. The clearance levels for these nuclides are:

Table II Clearance levels according to RP 113

Nuclide	Activity (kBq/m²)
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

MEASUREMENTS

For performing the measurements four different methods, completing each other, are used. They are:

- Direct measurement (frisking) with scintillation instruments
- Smear samples

- Gamma spectrometry (ISOCS)
- Sample laboratory analysis

Depending on historical activities in the localities of the building the amount of measuring areas are chosen, i.e. laboratories at the ground level:

Floor and wall up to 2 m height

- Frisking: 100 %
- Smear samples: 1 sample per 2 m²
- ISOCS: 100 % up to 4 m height

Walls above 2 m height and ceiling

- Frisking: 10 %
- Smear samples: 1 sample per 10 m²
- ISOCS: 50 % above 4 m height

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 are checked with in-situ gamma spectroscopic measurements (on the loft and in ventilation and drainage channels, 25 % of the surface is checked with in-situ gamma spectroscopic measurements).

Fig. 3 ISOCS Measurement for clearance.

Measurement with ISOCS or mapping

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 has been conservatively estimated at 1 to 3. This relationship has been confirmed by alpha spectroscopic analysis on several samples.

Each in-situ gamma spectroscopic measurement takes at least 8 hours. For measurements on large surfaces (several m²), the detection limit for Am-241 is lower than 300 Bq/m². The detection limits for Co-60 and Cs-137 are some tens of Bq/m².

The hand-held scintillation counters have a background counting rate of 10-16 counts per second (cps) for beta and, less than 1 cps for alpha, with 100 cm² probe DP6AD. Since the calibration factor is around 1 kBq/m² per cps, any contamination above the lowest clearance level (10 kBq/m²) can easily be detected. Normally, it takes about 20 minutes to measure 1 m².

In the area No 1 the remaining radiologically inventory has been calculated to <24 MBq of which maximum 4.3 MBq alpha radiating nuclides at the total area of 10 600 m^2. In area No 2 the corresponding numbers are <25 MBq total activity of which 3.5 MBq alpha radiating nuclides at an area of 11 000 m^2.

WASTE TREATMENT

Equipments from tests and stationary auxiliary systems are dismantled if it is not confirmed that there is any activity above the clearance limits. All equipments are collected and stored in the "big hall", see Fig. 4., where cleaning, measurements and waste disposals are performed.

Before measurement all equipments made of metals or plastics are, to start with, cleaned by a high pressure water jet. Most commonly the waste needs more thorough cleaning after the water jetting and this was done either by rubbing or machining. The waste from the project consists of

- Radioactive waste
- Free-released waste
- Recycled waste
- Combustible waste

Fig. 4 Waste Stored in the Big Hall Awaiting Treatment

The radioactive combustible waste is sent to the incineration facility in Studsvik and consists mainly of materials from cleaning operations. The incineration facility is operated by Studsvik RadWaste. Studsvik RadWaste treats dry incinerable low-level waste for a variety of international customers, such as nuclear power plants, fuel fabrication plants and Swedish hospitals and institutions. After treatment the customer receives the ashes and filter dust in return. A volume reduction factor of up to 97 % can be achieved which gives important cost savings for interim or final storage. At this stage 30 tons combustible waste from the decommissioning of ACL has been sent to incineration. Having completed the incineration the ashes and secondary waste are conditioned in compliance with the Swedish rules for final storage.

Scrap metal, mainly consisting of steel and aluminium, is sent to Studsvik RadWaste's melting facility and currently 86 tons have been treated. At the melting facility carbon steel, stainless steel, aluminium, copper and brass is segmented, decontaminated and melted to ingots. The purpose is to free release the metal after treatment. Studsvik RadWaste can also provide an optional ingots storage for a maximum of 20 years awaiting radioactive decay. Studsvik RadWaste applies the European Commission's recommendations for nuclide specific free release, Radiation Protection 89 [4] (RP-89). Approximately 95 % of the metal is free released and recycled by the steel industry.

Non-combustible waste, which mainly consists of concrete from machining operations, is so far stored in 200 litre drums. Today the amount of concrete is 16 tons.

Some waste categories have been free released and sent to municipal dump. That is so far asbestos, insulation and plaster to an amount of 22 tons. Hazardous waste is cleared and sent to destruction at a special plant in Sweden and PVC is recycled, since it unsuitable for incineration.

DECOMMISSIONING THE STUDSVIK WAY

The general procedure for decommissioning of any contaminated room step-by-step is as follows

- Mapping, i.e. spot tests, of the walls, ceiling and floor manually with a scintillation instrument and smear tests to find out the contamination condition of the room.
- If the contamination is low, the permanently installed equipment can be dismantled. If the contamination is too high, a pre-decontamination has to be performed before dismantling of the equipment.
- Transport of the equipment to the "big hall" as an interim storage for decontamination or waste disposal.
- Cleaning of the room by a vacuum cleaner and washing with water and detergents or, if necessary, denaturated ethanol.
- Marking all surfaces in the room in 1 m squares. Every square is numbered for future identification.
- Measuring with a hand-held scintillation instrument according to the predecided amount. If the contamination shows unexpectedly high values, 100 % of the remaining surfaces are also measured.
- When there are spots or areas of activity the estimated size is marked with a pen and the activity written in counts per second (cps). The clearance level valid for the project is 8 cps. Areas with

higher levels have to be decontaminated, either cleaned or machined and then manually measured again. The project goal is that the contamination values shall reach background level.

- All squares that have been measured with scintillation instruments are also measured by at least one smear test.
- The final measurements are carried out with a gamma-spectrometric instrument ISOCS. The instrument is used for areas like walls, floors, etc. The measured areas are, depending on the object, normally between 9 and 16 m^2.
- Sealing of the room (restricted access).

On several occasions the ISOCS has detected activities that have not been detected by the scintillation instruments. Then it has been necessary to measure smaller areas and move the instrument closer to the activated area and perhaps cover adjacent areas with carpets of lead. When the contaminated surface is detected, it can be machined. This sequence has to be repeated until activated concrete has been taken away.

NEXT PHASE

The decommissioning work and the manual measurements follow the project plans, but more ISOCS measurements remain than was earlier expected. The measurements will hopefully be finished during the first half of 2005.

The project has been going on for more than 5 years and more than 85 % of the total decommissioning has been carried out. With one more gamma spectrometric instrument will be delivered during the spring of 2004. Still the plan is to have the practical work finished during the autumn of 2004. A final report is planned to be finalised during the first half of 2006.

Estimated time schedule

2004	Decommissioning of the remaining parts of areas Nos. 3 and 4. Preparation of report from area No. 4.
2005	Final measurement
2005-2006	Preparation of the final report to the authorities for application for "free-release"
2006	Authorities' decision for acceptance that ACL and ACF become free-released
2006-2007	Demolishing

SUMMARY

The ACL and ACF plants consist of two buildings, one for laboratories (ACL) and the other for filters and fans (ACF). Three culverts for the ventilation air systems connect the two buildings to one another. ACL and ACF were built from 1959 to 1963 with the purpose to use ACL for research and development in connection with MOX fuel.

The ACL is a rectangular building in three floors with the dimensions 65 x 72 metres and a floor area of 12 400 m². ACF also has three floors and a floor area of 1 600 m². The material of the building is generally concrete, but some of the inner walls are made of bricks.

Following some preparatory decommissioning work during 1994 to 1998 AB SVAFO, the new owner of ACL and ACF, commenced the decommissioning project in late 1998. Firstly, a pre-project started. The purpose was to dismantle all insulation made of asbestos and to do radiological mapping. Based on the obtained information an activity plan, time schedule and a budget for the decommissioning were put together.

From the very beginning of the decommissioning project there has been a dialogue between the authorities and the organisation group.

By in-situ gamma spectroscopic measurements. Co-60, Cs-137 and Am-241 have been measured. Each in-situ gamma spectroscopic measurement takes at least 8 hours. For measurements on large surfaces (several m²), the detection limit for Am-241 is lower than 300 Bq/m². The detection limits for Co-60 and Cs-137 are some tens of Bq/m².

Combustible waste and scrap metals are sent to Studsvik RadWaste's facilities for incineration and melting. 30 tons of combustible waste and 86 tons of metal, mainly steel and aluminium have been treated so far.

Non-combustible waste, which mainly consists of concrete from machining operations, is currently stored in 200 litre drums. Today the amount of concrete is 16 tons.

The project has been going on for more than 5 years and more than 80 % of the total decommissioning has carried out. The total cost of the project is currently estimated to EUR 7.500.000. Complete decommissioning and demolishing is expected by 2006.

REFERENCES

1 Radiation protection conditions for clean-up activities in ACL and ACF, issued by SSI on 4 May 2001

2 RP 113 - "Recommended radiological protection criteria for the clearance of buildings and building rubble from the dismantling of nuclear installations"

3 RP 114 – "Definition of clearance levels for the release of radioactively contaminated buildings and building rubble"

4 RP 89 – "Recommended radiological criteria for the recycling of metals from the dismantling of nuclear installations"