LICENSED NUCLEAR FACILITY 41
HARMONIE DECOMMISSIONING PROGRAM

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ABSTRACT

The HARMONIE reactor, a French licensed facility (n°41), was started up in the southeast sector of the CEA Cadarache Research Centre (France) in 1965.

HARMONIE was part of the joint achievements between Euratom and the CEA on the study and development of Fast Reactors (RAPSODIE-MASURCA-HARMONIE).

Of low power (2 kW), it was intended to provide a hard neutron spectrum for the development and calibration of nuclear instruments. It was also meant to be used for experiments with degraded and thermal spectra.

It was officially closed in 1995 and finally shutdown in 1997 after the removal of nuclear fuel and start up sources.

The CEA then wished to dismantle the facility so that it would qualify for ex- decommissioning level 3, defined by the IAEA classification. The purpose was restoration of the "green field".

INTRODUCTION

The Harmonie reactor (licensed facility n°41) is located in the Cadarache research center, 50 kms north of Aix en Provence.

The facility consists of two main parts:

- the reactor hall including the reactor block (dimensions 26 m x 14 m for a height of 8 m)
- the basement consisting of the reactor mechanism pit, ventilation room, control building (control room, offices, electrical installations)

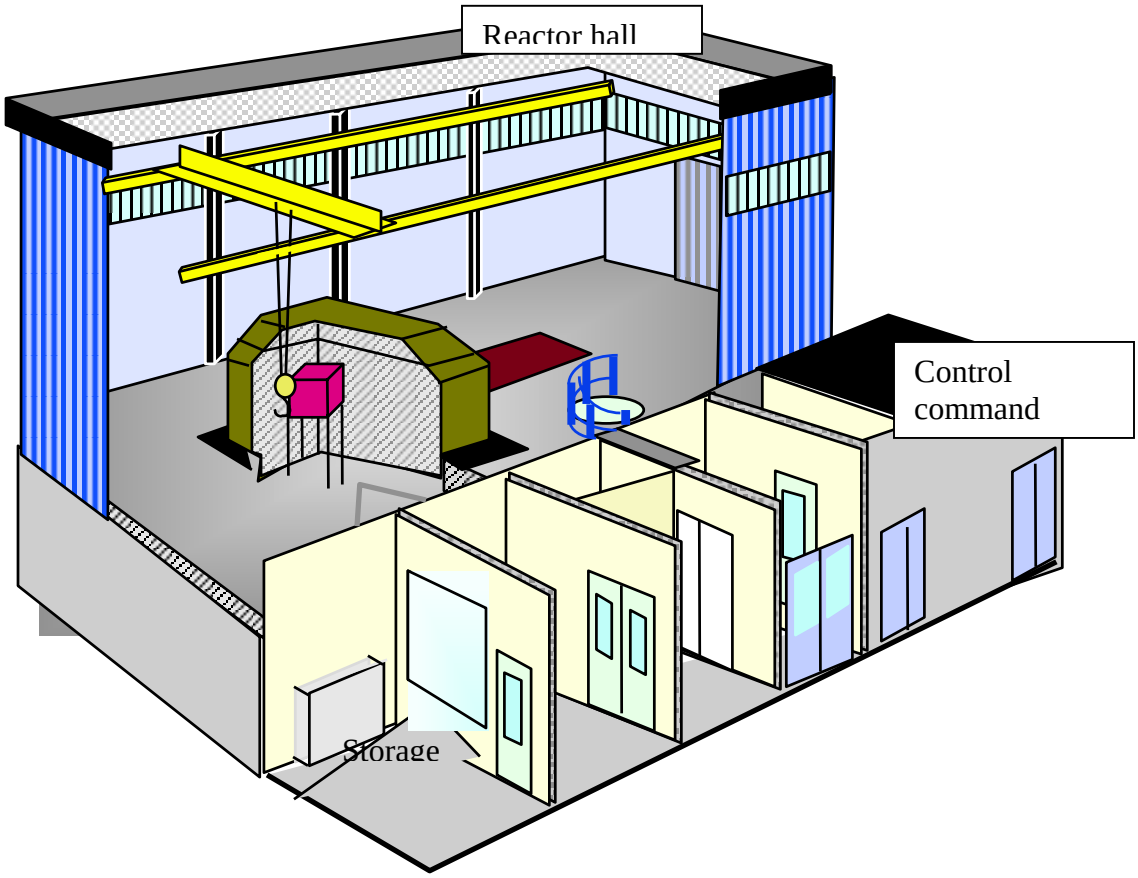

Fig. 1. The HARMONIE Reactor

Brief History

1965: Startup of HARMONIE.

29 March 1995: Date of last rod drop and final shutdown of production.

18 December 1997: Final Reactor Operation Shutdown and removal of nuclear materials and startup source.

31 January 2003: Letter DGSNR/SD3/0062/03 from the Safety Authorities authorizing the anticipation of the first 5 phases of operations for the final shutdown and dismantling of licensed facility 41

From 03/02/2003 to 07/03/2003: Achievement of first phases in dismantling operations (work outside controlled zone).

9 January 2004: Decree n°2004-24 of 8 January 2004 authorizing the CEA to proceed with the final dismantling

December 2005: Demolition of the building

Dismantling

Downgrading work includes the decommissioning and the radiological characterisation of both the materials removed from and the facility itself. This is carried out in several steps, depending on the associated radiological risks involved. A study pertaining to the optimisation of protection against radiation was carried out in order to check the usefulness of the different steps in the selected scenario

A reference dismantling scenario was defined in 3 phases:

Phase 1: treatment of the zones containing conventional waste (rooms and materials in non-contaminated zones and without an added radioactivity zone)

Phase 2: treatment of the zones containing nuclear waste (rooms and materials in the contaminated zone) and an estimation of the residual activity in view of decommissioning it down to an un-contaminated zone.

Phase 3: complete demolition of the building structure and the drafting of a decommissioning report for a regulated nuclear facility.

These successive steps are summarized in the table below.

PHASE 1	
Step 1	Preparation of the building site.
Step 2	Sampling for the characterisation of the activity levels in the facility elements
Step 3	Removal of the electricity supply and fluid networks
Step 4	Decommissioning of inactive equipment
Step 5	Inspection of conventional zones
PHASE 2	
Step 6	Decommissioning of the activated or contaminated equipment
Step 7	Cleaning of the contaminated zones
Step 8	Radiological monitoring of the facility
Step 9	Dismantling of the equipment maintained for the building site
Step 10	Assessment of residual activity for downgrading into a conventional zone
PHASE 3	
Step 11	Demolition of the building and the drafting of a decommissioning report for the downgrading of the facility

Radiological State of the Facility

Activation of structures

The radiological state of licensed facility 41 prior to its dismantling was taken into account through the zoning of reference wastes (difference between nuclear waste zones and conventional waste zones). This was based on an analysis of the different historical events of the facility and describes the state of the facility prior to dismantling.

The external sides of the reactor's biological protection were, in activation terms, a limit between the nuclear waste zone (reactor with biological protections) and the conventional waste zone (reactor hall and all adjacent rooms).
After dismantling the equipment, the civil engineering structures potentially contributing to the residual activity of the building were defined as:

- The concrete slab under the former core location,
- The concrete of the floors, walls and ceiling of the mechanism pit,
- The reactor roof (above the reactor),
- The IPN beams above the irradiation channels.

Accurate activation calculations were carried out on these elements so as to confirm the radiological state.

The calculations were carried out using three codes, each of which being a reference in its area: the Monte-Carlo code for the transport of neutrons in the geometrical model to be built of the HARMONIE reactor: TRIPOLI 4 (CEA/SERMA) or MCNP 4c (LANL).
The European reference code for the evaluation of the activation based on the operating history of HARMONIE and its fluence flow rates in the concerned structures generated by the Monte-Carlo code: FISPACT-2001 (EURATOM/UKAEA).
Code XSDRMPM (SCALE4.4a)

Contamination of structures

The contaminating radioactive substances introduced in the facility during its operation were reactor core fuel, the matter used for radial and the axial covers of the core as well as the start up source. These elements were removed during the final operating shutdown process.

The different nuclear materials contained in the fuels and the sources were processed and confined in stainless steel claddings. Specific confinement procedures were used for the management and handling of these fuels and sources.

During the 30 years of operation, the reactor was cooled by air directly in contact with fuel elements. The history of reactor operation shows the absence of radioactive gas detection at the stack and of detectable radioactivity on the HEPA filters of the core cooling circuits.

The absence of contamination products in the cooling loops thus excludes the risks of contamination of the rooms with nuclear wastes of licensed facility 41, which could have been due to the presence of nuclear material used for reactor operation.

However, with respect to the principle of precaution, majoring hypotheses were made stating that the dusts and aerosols emitted by the activated materials present in the nuclear waste zones could generate contamination.

After the POCO phase, radiological contamination map was drawn up and showed that the surface activity was lower than $1{,}6.10^{-3}$ Bq/cm^2 in alpha and to1, 7.10^{-3} Bq/cm^2 in beta.

Cleaning Methodology

The cleaning methodology, whose aim is to reach the decommissioning of the nuclear facility, is applied at the end of the dismantling process.

Based on the historical and theoretical analysis supported by activation calculations and after dismantling operations, a classification of the different surfaces (total or in part of walls, floors, ceilings…) is drawn up into 4 categories.

Moreover, radiological characteristics were determined. The latter thus allow an approach of the type and depth of the cleaning up operations in order to reach a radioactivity level below the "target" values".

A new measurement campaign is then carried out to justify the return of the rooms affected by operational zoning to non-nuclear waste zones and to check the residual radiological state of nuclear rooms after the dismantling and cleaning operations have been carried out.

Classification of surfaces and structures

At the end of the dismantling process, the equipment involved in the licensed facility (remote surveillance, radioprotection and confinement) is kept operational, the other materials, electrical and mechanical, were removed and disposed of. There are also materials involved in the civil engineering structures as well as the chimney and large handling operation tools to be dealt with.

The classification of the facility surfaces consists in classifying all or part of the walls, floors, ceilings, walls or even some materials left, in one of the four surface categories (Sn) defined below.

In case of any doubt on the classification of a surface, additional expertise must be carried out and if not possible, the principle of precaution is applied by classifying it in a higher category.

Category S0

Surface for which:

The analysis of the operating history does not show the presence of contamination, the analysis of the dismantling phase does not demonstrate the presence of contamination induced by an incident due to a confinement breach (incidental field), the position, in view of the process used, excludes the activation of its structure.

Category S1

Surface for which:

The analysis of the operating history does not show the presence of contamination, the analysis of the dismantling history can show the presence of a non-penetrating contamination (dusts, aerosols) induced by dismantling operations, the position, in view of the process used, excludes the activation of its structure.

Category S2
Surface for which:
The analysis of the operating and dismantling history can show the presence of penetrating contamination induced by a contact with a contaminated liquid, the analysis of the dismantling history can show the presence of a non-penetrating contamination on the surface (dusts, aerosols) induced by dismantling operations, the position, in view of the process used, excludes the activation of its structure.

The analysis of the S2 surface states contributes to guaranteeing the homogeneous nature on the surface of the penetrating contamination and the absence of deeper local penetration of this contamination.

Category S3
Surface for which:
The analysis of the operating and theoretical history (activation calculations) can show the presence of radioactive substances in its structure, induced by "particle-matter beam" interactions.

Cleaning of walls and structures.

The aim of cleaning operations is to treat the surfaces, surface parts or residual materials on which a contamination and/or activation has been identified by means of thorough characterizations. These are necessary when the results of a thorough characterization reveal a contamination and/or activation greater than the following "target" values:

0,4 Bq/cm^2 and/or 0,4 Bq/g in beta gamma radionuclides or in alpha r radionuclides of low toxicity (uranium).

The type of cleaning treatments, defined by a specific procedure is specific to the category of surfaces inventoried during classification.
Four cleaning treatment categories (An) are defined as follows :

Category A0
This treatment is applied to surfaces classified S0 :
No specific treatment is used.

Category A1
This treatment is applied to surfaces classified S1. This means :
Cleaning the surfaces by vacuuming,
Cleaning the localized contamination spots with aqueous and/or organic solvent (CLEANOX or ALCINOR,
Locally remove if needed the paint (in the case of concrete or painted steels) or locally removing the hot spots (concrete or mortar).

Category A2
This treatment is applied to surfaces classified S2. It consists in:
Removing a thickness of the wall from a few millimetres to a dozen depending on the contamination depth, defined by the expertise, and according to the treatment technique defined

Category A3
This treatment is applied to surfaces classified S3. It consists in:
Removing the activated concrete surface down to the activation depth defined by the expertise and according to the treatment technique defined

Checking wall cleaning

The specific cleaning operations (An) lead to a radiological control of second level, which checks its efficiency.

These radiological controls are made during Stage 8. They guarantee the clean nature of the residual elements treated, by displaying radiological values lower than the "target" ones. These will be of the same type as those used during the surface expertise and will consist in directly measuring the beta and gamma surface activities.

Depending on the cleaning and decommissioning verification operations, the surface category of the rooms classified in the nuclear zone evolve towards the S0 category. All of the characterization results are then collected to establish the residual waste zoning and the general residual radiological map of licensed facility 41.

The end of this consolidation phase is reached when all the surfaces of all the rooms in licensed facility 41 are brought down to category S0. Then it is considered that all the rooms in licensed facility 41 are of conventional type.

After the last post-cleaning verifications and the declassification of the radiological zone, the materials contributing to facility safety, in other words the remote surveillance system and the radioprotection devices are removed.

Decommissioning of nuclear zones

The methodology proposed consists in the drawing up of a file for the Nuclear Safety Authorities, which is submitted along with the request to declassify the nuclear waste zones registered in the operational zoning of licensed facility 41.

This file will include:

- a summary of the historical and theoretical approach (activation calculations) on the radiological level of licensed facility 41.

- The radiological mapping prior to cleaning of contaminating zones of the operational waste zoning along with a summary of the first level characterization results.
- The radiological mapping after cleaning of the contamination zones of the operational zoning, along with a summary of second level characterization results.
- The document for the update of the waste zoning of licensed facility 41.
- The list of differences noted.

The authorization for decommissioning of the contaminating zones of licensed facility 41 is a time of waiting before starting to destroy the decommissioned buildings.re

Preparation of Building Destruction

The preparation of the building destruction required a precise inventory of future wastes generated.

The inventory of wastes originating from the demolition of licensed facility HARMONIE 41v is included in Phase 11 «Destruction of the entire civil engineering and writing up of decommissioning file». Thus, the waste inventory is made for the destruction operations of the civil engineering structures. This inventory includes:

Civil engineering,
External fluid networks
A wall crane, a stack,
The ventilation system
A sanitary pit
A travelling crane of 20DaN

Progress Report

The first phase of the work (steps 1 to 5) took place between March 2003 and July 2003. This work was done with an anticipated authorization granted by the Safety Authority.

The second phase (steps 6 to 11) started on 19 July 2004 and is ongoing with the decree 2004-24 obtained on 8 January 2004.

The first part of the work consisted in creating work hatches around the reactor block and the mechanism pit.

From September to November 2004, the characterization of the reactor block with sampling of different materials (graphite, black steel, concrete) was carried out. The purpose of the analysis of these samples was to determine the Beta/Gamma ratios, which will then allow the wastes to be characterized by simple measurement with Gamma spectrometry (the estimate of the overall activity is done by calculations based on these ratios).

CONCLUSIONS

The aim of this document was to present the methodology used to decommission licensed facility 41.

In the final configuration of the facility, the radiological state of the nuclear waste zones, materialized by the mechanism pit and the reactor mounting base, condition the facility decommissioning.

Obtaining the authorization from the Nuclear Safety Authorities to decommission the nuclear waste zones, based on all the documents justifying the respect of the target values proposed, is a period of waiting prior to the destruction of the buildings.

The choice of « target » values proposed will be supported by the acceptable nature of the results on the impact on people and the environment, obtained from a study on the residual impact due to the destruction conditions and to the management of building demolition wastes.

It is to be noted that the «target» values proposed in this document are close to the values chosen for regulations on radioactive material transport or for removing tools from nuclear facilities.