A Rinsing Effluent Evaporator for Dismantling Operations - 13271

Rachel Rives *, Marielle Asou-Pothet ** and Frederic Chambon ***
* AREVA BE/NV, Marcoule, France, rachel.rives@areva.com
** CEA DEN/DPAD, Marcoule, France, marielle.asou-pothet@cea.fr
*** AREVA FEDERAL SERVICES, Columbia, MD, frederic.chambon@areva.com

ABSTRACT

Between 1958 and 1997, the UP1 plant at Marcoule – located in the south of France – reprocessed and recycled nearly 20,000 MT of used fuel from special defense applications reactors, as well as fuel from the first generation of electricity generating reactors in France (natural uranium fuel, CO2-cooled, graphite-moderated).

Decommissioning and Dismantling of the UP1 plant and its associated units started in 1998. Since 2005, the UP1 facility has been operated by AREVA as the Marcoule Management & Operation contractor for French Atomic Energy Commission (CEA).

An important part of this decommissioning program deals with the vitrification facility of Marcoule. This facility includes 20 tanks devoted to interim storage of highly active solutions, prior to vitrification.

In 2006, a rinsing program was defined as part of the tank cleanup strategy. The main objective of the rinsing phases was to decrease activity in order to limit the volume of “long-life active” waste produced during the decommissioning operations, so the tanks can be dismantled without the need of remote operations.

To enable this rinsing program, and anticipating large volumes of generated effluent, the construction of an evaporation unit proved to be essential. The main objective of this unit was to concentrate the effluent produced during tank rinsing operations by a factor of approximately 10, prior to it being treated by vitrification.

The evaporator design phase was launched in September 2006. The main challenge for the Project team was the installation of this new unit within a nuclear facility still in operation and in existing compartments not initially designed for this purpose.

Cold operating tests were completed in 2008, and in May 2009, the final connections to the process were activated to start the hot test phase.

During the first hot test operations performed on the first batches of clean-up effluent, the evaporator had a major operating problem. Extremely large quantities of foam were produced, affecting the evaporator operation, and creating the risk of a reduction in its capacity and throughput performance. A task force of AREVA process, operations, and safety experts from Marcoule and the La Hague reprocessing complex was assembled. New operating parameters were defined and tested to improve the process.

Since then, the evaporator has performed very satisfactorily. The foam buildup phenomenon has been brought under complete control. All the different types of effluents produced during cleanup operations have been concentrated, and the results obtained in terms of quality and throughput, have ensured a consistent supply to the vitrification unit.

The evaporator was operated until the end of April 2012, and enabled the production of 500 cubic meters of very high activity effluent, concentrating the fission products rinsed from the storage tanks.

The evaporator will now be deactivated and decommissioned, with the first rinsing and cleanup operations scheduled to begin in 2014.

INTRODUCTION

From 1958 to 1997, the UP1 plant at Marcoule – in the south of France – reprocessed and recycled nearly 20,000 tons of spent fuel used in special defense applications reactors as well as fuel from the first generation of electricity-generating reactors in France (natural uranium fuel, CO2-cooled, graphite-moderated).

Decommissioning and Dismantling of the UP1 plant and the associated units started in 1998. Since 2005, the UP1 facility has been operated by AREVA as Management & Operation contractor to the French Alternative Energies and Atomic Energy Commission (CEA).

An important part of this decommissioning program concerns the vitrification facility in Marcoule (Fig. 1.).

Fig.1: The vitrification facility

This facility includes 20 tanks devoted to interim storage of highly active solutions, awaiting vitrification.

In 2006, a rinsing program was defined. The main objectives are:

- To decrease activity in equipment in order to reduce the volume of “long-lived active” waste generated by decommissioning operations,

- For some equipment, to decrease activity so that the tanks can be dismantled without remote-handled operations.

To enable this rinsing program, given the large volumes of effluent generated, as well as the decommissioning of the UP1 plant facilities, it was essential to build an evaporation unit, to the detriment of maintaining operating at the former UPI plant facility, which was judged to be obsolete and larger than required, resulting in delays in decommissioning this workshop.

The main purpose of this unit was to concentrate the effluent produced during tank rinsing phases by a factor of approximately 10 prior to it being treated by vitrification.

DESCRIPTION

In September 2006, based on the basic designs already drawn up, the detailed designs to construct an evaporation unit were launched. The main challenge for the Project teams was related to the installation of this new unit:

- in existing compartments not designed for this purpose,
- at a facility that was still in service.

Installation conditions

At the fission product storage facility, a compartment identified as '226G' was reserved for the installation, if necessary, of an additional tank for storing fission products.

Since this extra storage capacity had never been used, it was decided, during the design phase of the project, that this compartment would be the most appropriate space to use.

The Figure below (Fig.2) shows the location of the evaporation unit.

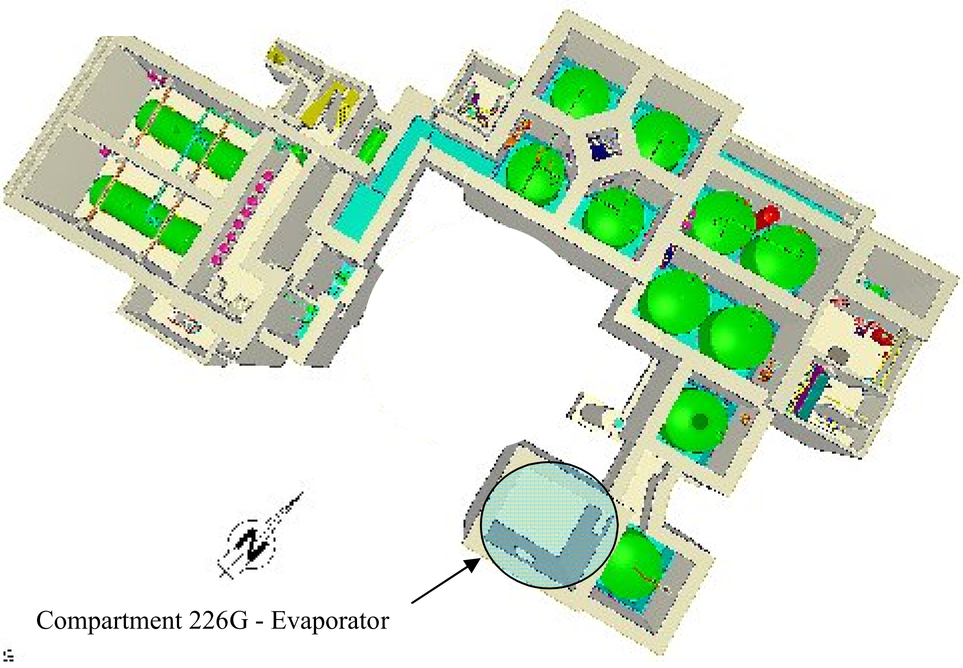

Fig.2: Location of the new Evaporation unit in the Fission Product Storage building

The evaporator and the related equipment (tanks, transfer equipment, etc.) were pre-assembled on different skids and the subassemblies were placed in the compartment using cranes. The equipment was then assembled together inside the compartment (Fig.3). Piping, all the electrical and I&C systems were then installed, once all the equipment was in place in the compartment.

The compartment 226G is divided into two parts: one part is above ground and the other is below ground. The dimensions of compartment 226G, housing the evaporation unit, are as follows:

- overall length: 10.40 m,
- overall width: 8.90 m,
- height above ground: ~9.35 m,
- total height (including part below ground): 21.15 m.

Regulatory information

In regards to regulatory requirements, building this unit was subject to a local inquiry by the Nuclear Facility Operator itself, the CEA. Commissioning the unit was subject to an authorization from ASDN, France’s Nuclear Safety Authority for Defense-related facilities and activities.

The design, construction and operating safety provisions defined for this evaporation unit were presented in a Preliminary Safety Analysis Report, which was subject to the following authorizations:

- mid-2007, for the construction license,
- end of 2008 to authorize ‘hot connections’,
- beginning of 2009 to authorize hot tests,
- and mid-2009 for the operating license.

Processes

The evaporation process retained consists in concentrating solutions with low free acidity to reduce the risk of corrosion in “pot” evaporators. The solutions to be concentrated are sent in batches from a fission product storage tank (B) via a feed tank (A) with a capacity of approx. $10m^3$.

The solutions to be processed are then continuously transferred from the feed tank to the boiler part of the evaporator ($2m^3$) where they are heated to boiling in order to concentrate them. The evaporator has a nominal flow rate of 150L/h. The concentrates collected at the base of the evaporator are transferred in batches to the Vitrification facility via a fission product storage tank.

The distillate passes into the evaporator’s wash column (C). Gases from the evaporator’s column are drawn into a condenser/cooler (D). Nitrous fumes from the condenser recombine in an absorber column. The acidic solution is purified of any remaining traces of nitrous fumes (E) in a bleaching column, and then transferred to the Liquid Effluent Treatment and Storage workshop via a buffer storage tank (F).

The operating principles are shown in the Figure below (Fig.3).

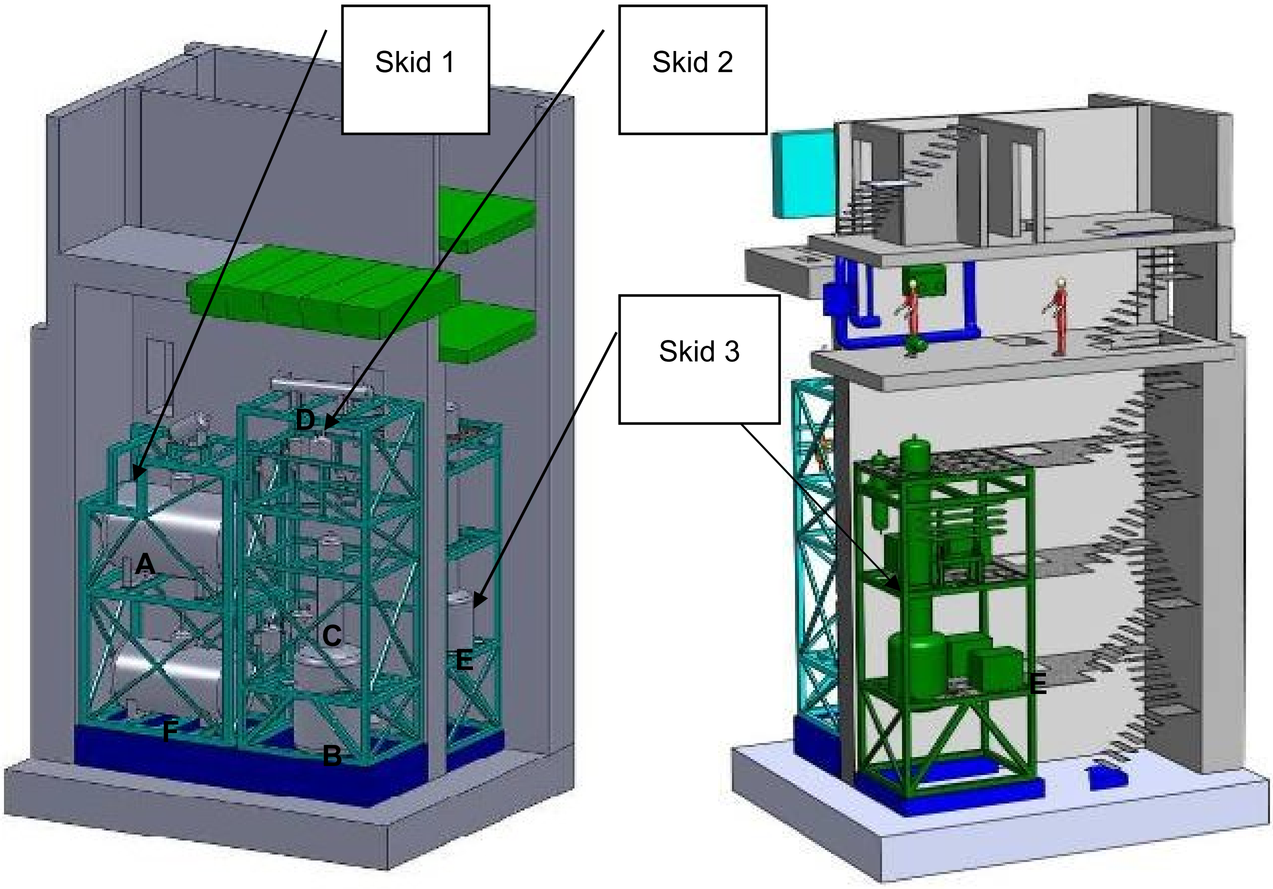

Fig.3: The equipment in compartment 226G

Project data

Cold operating tests and studies were completed in 2008. In 2009, the final hot connections to the process were activated and it was possible to start hot test phases in May the same year. Due to operating difficulties caused by excessive production of foam, it was necessary to extend the period required to fine-tune the process, which, in the end, lasted nearly a year.

The evaporator then functioned satisfactorily, with an availability rate of over 90%, up to the end of April 2012.

Construction work cost approximately 20 million euro. This sum includes all works and the related prime contractorship. It should be mentioned that a significant percentage of the cost of the works went on installation of the I&C system and the dedicated control panel in the existing control room.

RESULTS

During the first hot test phases performed on the first batches of cleanup effluent, the evaporator ran into a major operating problem: extremely large quantities of foam were produced, affecting operation of the evaporator (frequent emergency trips due to a drop in negative pressure caused by clogging in the measuring probes and the column).

In this context, all the AREVA Group's available expertise was quickly called upon to find a solution. Thanks to a task force made up of process experts, operators (from Marcoule and also from the processing plant at La Hague) and safety experts, it was possible to set new, safe operating parameters and improve the operating process. The main solutions to improve the process entailed reducing the level of liquid in the boiler and raising the high-level detection thresholds. These simple solutions ensured a reliable availability rate for the evaporator, by significantly reducing the frequency of automatic outage to restore the facility to a safe operating mode.

In addition, cold foaming tests were performed on the pilot equipment to provide a better understanding of the phenomenon and ensure that the solutions implemented would satisfactorily deal with the phenomenon and control the process safely and effectively.

This testing was performed in the AREVA Hall of Research Beaumont (HRB) near the La Hague processing plant. HRB is a Full scale inactive testing facility which develops and validates new processes and equipment (or implements modifications) for highly radioactive environments.

The tests consisted in reproducing the foaming phenomenon using a half scale evaporator model and a simulant whose components corresponded to that used in actual situations.

These tests revealed a direct relation between the foam creation and the presence in the solution of some organic species (Tributyl-phosphate and its derivatives). Indeed, these species link themselves to metal particles in the solution to form organometallic compounds, real tensio-active foam creators and stabilizers. Their presence in the precipitates collected from active reactor walls of La Hague, confirms their direct correlation with the phenomenon.

Moreover, this testing exposed the fact that a precise piloting of the free acidity in the boiler contributed to reduce disruptions while conducting the process and also revealed that the heating power constituted an interesting parameter in regulating the foam level.

The use of an anti-foaming agent has been considered but not implemented because of a lack of knowledge about its radioactive behavior.

It was also decided to bring in operators with experience of operating evaporators from the La Hague site, to train personnel at Marcoule on how to use this new evaporator.

Treating the effluent produced by the rinsing operation of the former fission product storage tanks in the new evaporator was completed at the end of April 2012. The evaporator had thus taken less than two years to concentrate over 500 m^3 of Very High Activity effluent produced by rinsing the fission product tanks.

CONCLUSION

The evaporator has fulfilled its task as part of the AVM facility cleanup projects: over 500m^3 of concentrates produced and an availability rate of 90%.

The evaporator has been undergoing rinsing since the beginning of October 2012. These rinsing operations are required prior to decommissioning. These operations are part of a program defining the deployment of specific reagents in order to attain an appropriate decontamination factor for dismantling to go ahead without requiring remote-handled equipment.

Dismantling operations are scheduled to start in 2014.