VITRIFICATION 2010 - A CHALLENGING FRENCH VITRIFICATION PROJECT TO RETROFIT A COLD CRUCIBLE INDUCTIVE MELTER AT THE LA HAGUE PLANT - 10382

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ABSTRACT

Vitrification of high-level waste is the internationally recognized way to minimize the potential environmental impact of waste disposal and the volume of packaged waste requiring disposal. AREVA successful operation of AVM at the Marcoule Plant, and R7 and T7 at the La Hague plant demonstrates the capabilities and experience of AREVA to deploy innovative high-level waste processing technologies in industrial facilities, thanks to its collaboration with the CEA for R&D. AREVA and the CEA have continuously improved the induction-heated metal melter vitrification technology through operational feedback and ongoing research and development. They have led the way in the development and implementation of Cold Crucible Induction Melter technology (CCIM).

The cold crucible is a compact cooled melter in which the radioactive waste and the glass are melted by direct high frequency induction healing. This technology can handle highly corrosive solutions and high operating temperatures, which offers a number of interesting opportunities:

- new glass compositions can be made (which was not economically reasonable with the Joule heated melter),
- glass production capacity can be increased.

In order to take advantage of CCIM, a new project, known as “Vitrification 2010”, was launched in 2005 with the objective of putting a CCIM into commercial operation in one of the existing R7 vitrification lines in 2010. The main challenge for the project team was to replace the existing Joule heated melter with a CCIM while complying with the principle of the R7 two-step vitrification process (calciner and melter). A similar CEA prototype used to qualify the process has shown that the glass throughput of the R7 vitrification line CCIM could reach 40 kg/h, representing a potential line capacity increase of 100%. CCIM is a major technological breakthrough representing significant AREVA and CEA investment in extensive research and development programs. It is combined with the application of experience gained in more than 30 years of HLW vitrification operations in nuclear facilities.

This paper will illustrate the two-step CCIM vitrification process and the various complementary prototypes and mock-ups used to qualify the new process. The project team is organized in such a way as to promote the synergies needed to perform simultaneous qualification, improvement and implementation of the new equipment. This achievement is a great industrial milestone. The paper will provide a status report on the industrial project.

I. INTRODUCTION

Vitrification of high-level liquid waste is the internationally recognized standard to minimize both the environmental impact of waste disposal and the volume of packaged waste. Many countries such as the United States, France, the United Kingdom, Germany, Belgium, Japan and Russia, have vitrified high-level waste and a number of other countries are studying the possibility of using vitrification technology. In France, high-level liquid waste from nuclear fuel treatment operations has been successfully vitrified for more than 30 years, with three major objectives: sustainable containment of long-lived fission products, minimization of final waste volume, and operability in an industrial context. As a result, AREVA and the CEA have integrated their unique experience in the field of high-level waste vitrification through:

- The design and operation of facilities with an outstanding track record in the areas of safety, reliability and product quality, in line with efficient treatment plants.
- The design of various glass formulations, including those used in the AVM, R7 and T7 facilities, which together have produced more than 17,200 glass canisters to date (corresponding to more than 238.10^6 TBq immobilized in 6,711 tons of glass).
- Ongoing efforts to simultaneously improve the technology and the associated matrix formulations, with constant emphasis on quality and volume reduction.

Using CCIM to vitrify high-level waste solutions is a major technological breakthrough representing significant AREVA and CEA investment in extensive research and development programs. However, CCIM is a highly appropriate technology for the vitrification of medium-level waste also. In 1999 it was introduced in Korea by the AREVA group and the CEA for the combustion and vitrification of low and medium-level waste such as rags, plastic and latex. In order to take advantage of CCIM for high-level waste vitrification, a new project, known as "Vitrification 2010", was launched in 2005 with the objective of putting a CCIM into commercial operation in one of the existing R7 vitrification lines in 2010. The main challenge for the project team was to replace the existing Joule heated melter with a CCIM while complying with the principle of the R7 two-step vitrification process (calciner and melter).

II. THE CCIM - A STEP FURTHER IN VITRIFICATION EXCELLENCE

II. A. Direct induction vitrification principles

The direct induction process is characterized by currents directly induced inside the molten glass by a coil (Figure 1.) These electromagnetic currents heat the glass inside the melter by the Joule effect.
The segmented structure of crucible enables penetration of electromagnetic field into its volume. Absorption of electromagnetic radiation allows the glass to be heated directly without heating the crucible. In addition, the walls of the crucible are cooled and sectorized to make them transparent to the electromagnetic field.

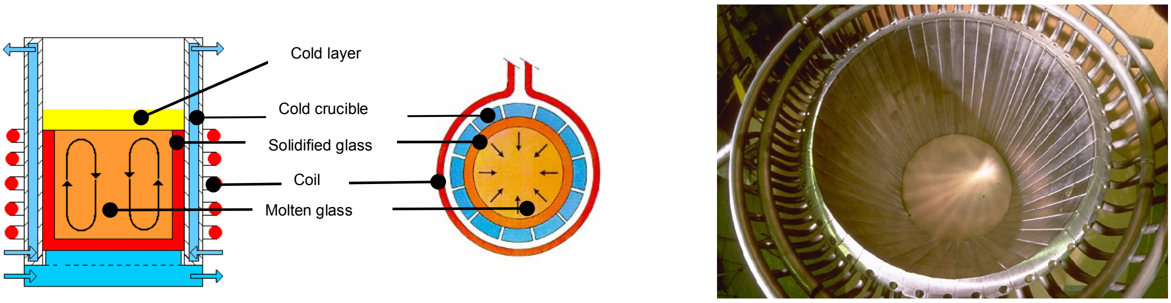

Figure 1 - View of the inside of the CCIM - Direct induction melting principle

II.B. Advantages

The CCIM technology is an evolution of the Joule heated melter technology currently in operation in the La Hague Plant's vitrification lines. This new technology presents a number of major advantages.

Firstly, cooling of the crucible causes a thin, solidified layer of glass to coat the surface of the crucible in contact with the glass, thereby protecting it from the corrosive melt and its corrosive gas. Secondly, the direct induction heating method allows the temperature to be increased (to up to 1300°C for some new matrix formulations still being tested) making it possible to obtain new waste containment matrices which would have been impossible to produce with the Joule heated melter.

This technology can be used to vitrify many varied types of chemical waste. By allowing higher waste loadings it also minimizes the volume of packaged waste, which would otherwise have to be disposed of. Furthermore, the composition of the waste has no impact on the lifetime of the crucible.

Finally, when integrated into the two-step vitrification process (calcination and vitrification), as is the case in the R7 facility at La Hague, the CCIM technology allows the industrial vitrification capacity throughput to be significantly increased, since the higher the temperature, the faster the calcine digestion by the glass; moreover continuous feeding is also operated.

II. C. Design principles

The CCIM comprises the following elements (Figure 2):

- The metallic crucible shell, which is a segmented structure, transparent to the electromagnetic field. The cooled sectors are separated by electrical insulators.
- The crucible bottom, which includes the pouring valve. Behind the pouring valve, there is a pouring duct which links the crucible to the container.
- The crucible is topped by a dome which supports a mechanical stirrer.
- Glass level and temperature are measured by specific sensors.

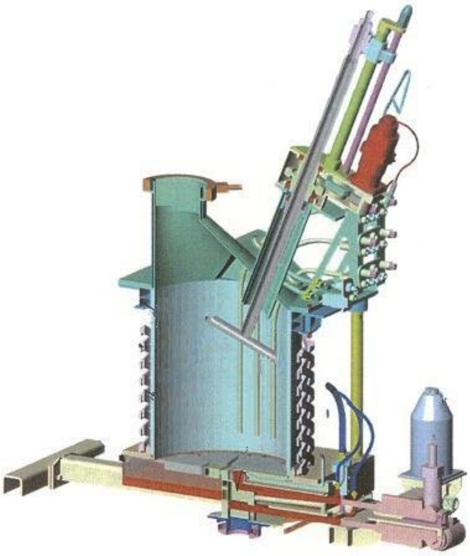

Figure 2 - Schematic drawing of a CCIM

The crucible power supply is based on:

- A high frequency generator with an output of around 400-600 kW.
- A high frequency power line.
- A copper coil which surrounds the crucible.

III. VITRIFICATION 2010 PROJECT - SCOPE AND OBJECTIVES

The “Vitrification 2010” project was a strategic project for AREVA, requiring heavy investment, a solid organizational structure and impeccable leadership. It brought together numerous players from the CEA and AREVA. approximately 100 people were staffed in La Hague, including the project owner, the AREVA La Hague Programs Department, and the prime contractor, SGN, a fuel cycle engineering company of AREVA. A further 50 researchers from the CEA worked on the Marcoule site, with 10 members of AREVA Innovation, Research and Projects Department in Paris coordinating the research by interfacing with Marcoule and the industrial project team in La Hague.

The project team, the operator, the engineering team and the research and development team worked together closely to optimize their relations and share their knowledge to better control all aspects of the project.

The “Vitrification 2010” project comprised three main sub-projects:

- The first was to increase the flexibility to vitrify various types of waste and the capacity of facility R7 (by putting the CCIM into service).
- The second was to renovate some of the operation equipments in R7 so that the CCIM could be integrated in the best possible conditions.
- And finally, the third was to manage industrial commissioning of the CCIM.

These three sub-projects were supported by the R&D Department whose objectives were to qualify the process used and the end product, i.e. the glass. To this end, the department worked to develop three new glass specifications for the production of vitrified waste canisters in the CCIM:

- A medium level borosilicate glass for the vitrification of corrosive flushing solutions used for pre-dismantling clean-up of the UP2-400 plant at La Hague. These are known as CSD-B canisters.
- A high level glass-ceramic for the vitrification of legacy, highly-corrosive UMo fission products (from recycled GCR fuel). These are known as CSD-U canisters.
- A high level borosilicate glass for the vitrification of UOX fission products (fission product solutions derived from the processing of LWR fuel), with a high throughput (the capacity of the vitrification line is doubled by retrofitting a CCIM). These are known as CSD-V canisters.

The design phase kicked off in 2005 after a series of feasibility studies.
The project deployment stage ran from 2007 to 2010 and included:

- preparatory work to upgrade the operation equipments in the area in which the CCIM was to be installed,
- construction in the Beaumont Testing and Development Laboratory of a full-scale test platform identical in every way to the radioactive environment of facility R7, used to carry out tests outside the nuclear zone and train personnel in 2008 and 2009,
- actual installation of the CCIM and its ancillaries in the radioactive contaminated zone. This began in 2008.

Industrial commissioning of the CCIM has been scheduled for 2010 when the first radioactive canisters should be produced.

IV. THE STAGES OF AN INDUSTRIAL PROJECT

IV.1. Accompanying R&D

The CEA has been at the forefront of nuclear processing technology since the 1950s when it identified borosilicate glass as the most suitable containment matrix for waste from used nuclear fuel. In the 1960s, the CEA focused on vitrification technology to immobilize this waste, building small vitrification pilots including the small-scale PIVER facility featuring a single induction-heated, liquid-fed, batch-operated melter. In parallel, separate pre-treatment by calcination was investigated, which led to the continuous process with a rotary calciner. This technology was coupled with a Joule heated melter and integrated into the AVM vitrification facility. It started active operation in 1978, vitrifying the backlog of waste stored at Marcoule and the high-level waste solutions resulting from the treatment of Gas Cooled Reactor (GCR) fuel. The CEA then began developing the glass formulation suited to the waste resulting from the treatment of light water reactor (LWR) fuel. This resulted in the R7T7 glass composition which is used today at La Hague.

Today, the CEA is a committed key player with AREVA for the continuous improvement of vitrification technology. Development tests for the CCIM began in the 1980s at the CEA's Marcoule plant. A CCIM technology development program has been ongoing since 1984. Several retrofitting mock-ups were tested. While developments were being made to the prototypes, the technology itself was becoming more industrialized and better adapted to application within the nuclear industry:

- 1981 - The 1st CCIM mock-up was put into service (350 mm in diameter).
- 1983 - The feasibility of vitrification by electromagnetism was demonstrated. The reliability and endurance of the process were demonstrated by 800 hours of re-melting glass.
- 1985 - Industrialization phase 1. A larger CCIM was built (550 mm in diameter).
- 1987 - The continuous two-step vitrification process of the R7T7 glass was demonstrated with a reduced capacity mock-up with 175 hours of melting.
- 1997 - A 650 mm diameter CCIM was built and tested with an industrial capacity for almost 3,000 hours.
- 2000 - Industrialization phase 2. A specific CCIM prototype was designed and built for the vitrification of highly corrosive UMo fission product solutions resulting from the recycling of old GCR fuels.
- 2006 - Industrialization phase 3. A "nuclearized" CCIM prototype was built, adapted to the La Hague vitrification process and environment. This CCIM was designed to vitrify a large variety of waste. It was used to qualify the process and glass quality. More than 6,000 hours of testing have been conducted on this platform.

- 2008 - Industrialization phase 4. A nuclearized industrialised CCIM prototype was built to be implemented in the R7 facility. This one was used to qualify the equipment.

The CEA facility in Marcoule owns and operates several CCIM demonstration platforms including an industrial-sized, fully nuclearized 650 mm diameter CCIM demonstration platform. This unit is a full-scale prototype of the two-step vitrification process (rotary calciner and CCIM) that is currently being deployed in the AREVA high-level waste vitrification facility at La Hague..

Figure 3 shows the general methodology followed to produce all the data guaranteeing the production of glass with the accepted characteristics at all stages of its production. This is a fully iterative process between the material studies, its long term behaviour studies and process development. This qualification leads to the production of two fundamental documents integrating all the knowledge of the material (acceptable composition range with its physical properties) and of the process requirements; the Glass Booklet and the Process Data Book.

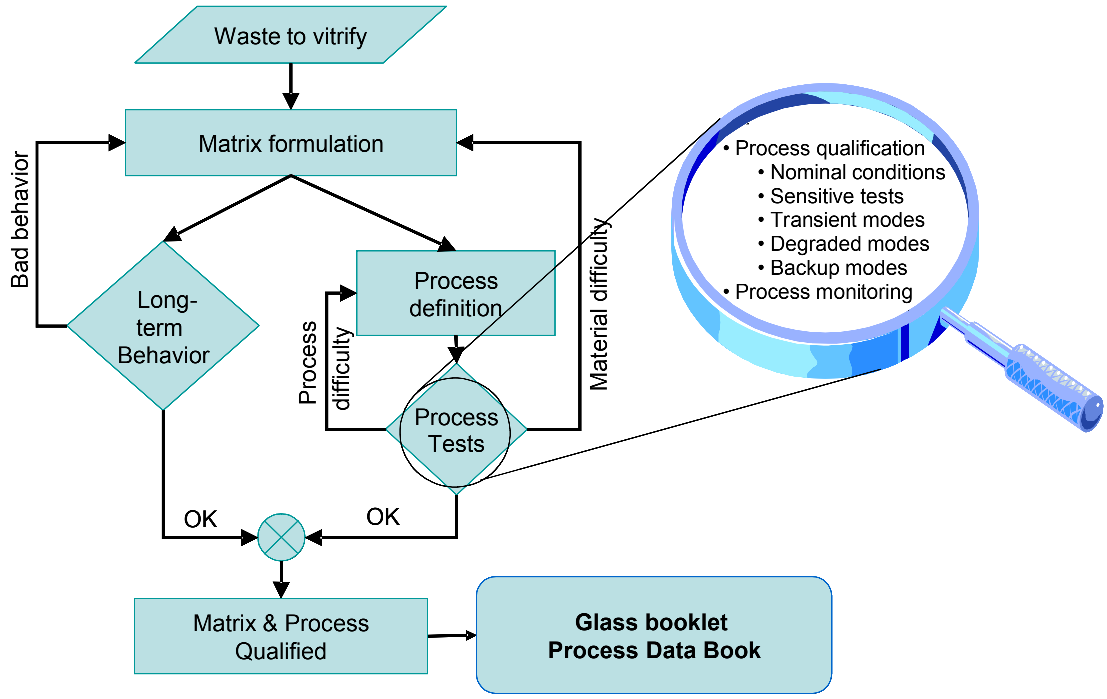

Figure 3 - Process and matrix qualification methodology

The containment matrix composition is first determined through laboratory tests. During this stage, the leaching properties of the glass and the physical properties of the molten material (thermal conductivity, electrical conductivity, viscosity, crystallisation, etc) have to be taken into account. The target is to maximize waste loading while ascertaining that leaching behaviour is acceptable and that the physical properties of the glass are appropriate for the process. At this stage, preliminary tests are performed on a full scale prototype to check feasibility. After a nominal composition has been selected, a “sensitivity to composition” program is performed which accounts for the expected variability of the effluent to be processed and the unavoidable uncertainties associated with any industrial operation. As a result, final composition boundaries can be set for each element. Inside the glass composition domain, the physical properties are modelled. All these results are compiled to form the Glass Booklet.

The aim of the process qualification program is to demonstrate the feasibility of producing glass with the same properties as those determined in the laboratory. This includes different types of tests to:

- specify the necessary operating conditions, for exemple temperature range in the calciner and the melter, molten bath stirring and sparging parameters,
- establish the process data (decontamination factors of equipment, material balance, thermal balance),
- establish the recovery procedure for returning to nominal conditions in the event of a disturbance in the process.

Five different types of tests are performed on the full scale prototype. Each test is followed by an extensive sampling and characterization program (glass in canister, molten glass during pouring, deposits, off gas treatment system effluents, etc.). The duration of each test is around 100 hours continuously. Together, the results of these tests determine the operating parameters that are detailed in the Process Data Book.

- Tests to determine the nominal operating parameters (e.g. maximum and minimum temperature, maximum and minimum sparging, maximum and minimum stirring velocity) guaranteeing the quality of the material produced in the full-scale pilot by final characterization of its physical and chemical properties compared with the same material produced in the laboratory. Before testing, various numerical models (electromagnetic 3D modeling, thermal and hydraulic 3D modeling) are used to pre-set the parameters.

- Two types of sensitivity tests:
  - Chemical composition sensitivity tests. These are intended to check the feasibility of the potentially most difficult glass compositions chosen from the glass domain (determined on a laboratory scale) considering the technological performance of the process. Depending on the waste, the criteria can be viscosity, electrical conductivity, crystallization tendency, etc.
  - Operating conditions sensitivity tests to specify acceptable parameter variation ranges for the material and for the process: temperature, stirring velocity and sparging flow rate.

- Transient mode tests to determine melter control parameters: process startup and shutdown, and calciner standby periods.

- Degraded mode tests to identify procedures for offsetting or mitigating the impact of incidents on safety, on the process equipment, and on the material. The following degraded modes are investigated:
  - Impact on the product of an interruption in the glass frit feed.
  - Consequences of restarting a full melter, to demonstrate that under the rated operating conditions, a melter full of solidified glass can be restarted, and to determine the impact on the product and on the process.
  - Impact on the process of liquid feed coming from the calciner onto the molten glass surface.

- Extended long-term testing (500 hours) with the main objective of demonstrating that process operation is stable, that the operating conditions specified for nominal operation and transient phases are applicable, and that the material properties remain constant over time.

From the time waste composition is known to a completed specification (material and process) to produce a glass, at least 4 years of R&D are required in the most simple case, with several dozen lab glasses produced and characterized and around 30 full scale tests.

In addition to specification R&D, a number of basic R&D programs are also performed continuously to obtain a better understanding of particular glass properties or to develop tools to support melter design; for example glass redox, behavior of elements in the glass matrix, changes in physical properties induced by changes in chemical and radiological composition, numerical simulation and hydraulic simulation.

IV.2. Prime contractor organization for the “Vitrification 2010” project

At the end of 2004, AREVA selected SGN, a fuel cycle engineering company of AREVA, to manufacture the CCIM and install it in the R7 facility in the La Hague plant. This choice was motivated by it’s experience in conducting nuclear projects.

The main stages of the project corresponded to the following engineering phases:

- 2005 – summary design phase,
- 2006/2007 – detailed design phase,
- 2008/mid 2009 – phase covering manufacturing and installation in the R7 facility,
- 2nd half of 2009 – tests in R7.

Throughout these different phases, between 40 and 60 people worked in the engineering teams, representing a wide range of expertise and know-how in various engineering specialties, such as mechanical and chemical processes, nuclear safety, electricity, I&C and equipment and piping lay-out.

The results of research carried out by the CEA were taken into account constantly throughout the project, be it for the design work, equipment manufacture or on-site construction. To ensure that these modifications were incorporated successfully in real time, the engineering drew on its experience and knowledge of change management and tracking. The use of this methodology in the nuclear facilities was one of the keys to the success of the project.

The project owner and the engineering worked closely together at all stages of the project, the industrial operating experience of the one guiding the design work of the other. In addition, the AREVA group chose to keep the manufacture of the mechanical parts and equipment in-house. This was entrusted to two group companies; a turnkey integrator of mechanical equipment, MECACHIMIE, carried out the detail design work and manufacture of certain parts of the CCIM; and a welded equipment manufacturer, MECAGEST, to manufacture the welded parts.

Thanks to these AREVA group synergies, the new process developed and qualified by the CEA could be integrated into a radioactive environment in the La Hague plant.

IV.3. Adaptation of the CCIM to a nuclear environment for use on an industrial scale

A) Dimensional constraints

The main challenge for the engineering team was to put in place a new, innovative process in a radioactive facility that had been in operation for 20 years. Installing the CCIM on one of the existing vitrification lines in facility R7 meant complying with strict dimensional constraints:

- The CCIM had to be installed in place of a Joule heated melter without impacting the existing masonry structures and upstream or downstream equipment. The connections with other equipments had to comply with the dimensional constraint of the previous process.
- The production line also had to be adapted to accommodate the CCIM power supply and cooling system. This had to be done in compliance with the dimensions of the existing wall penetrations between the highly radioactive and contaminated zone and the non-radioactive zone.
- Furthermore, since the CCIM was installed in a highly radioactive cell into which human access was prohibited (Zone IV), the work had to be carried out remotely (using remote handling arms, cranes, etc.). This required very precise validation of the CCIM installation and maintenance operations.

Thanks to all of these measures, the CCIM was installed smoothly in the radioactive cell of R7 in just a few days.

B) Selection and qualification of materials

Every time a new piece of equipment is installed in a radioactive cell, the materials used must be qualified as being irradiation-resistant. Qualification is based on previous experience in Zone IV, on bibliographical data, and, in the case of new materials, on configured tests in irradiators.

The vitrification cells are characterized by an environment which is penalizing from a thermal and chemical point of view. These constraints had to be included in the design studies to ensure that the appropriate materials were used. Certain materials had to be specially qualified as regards their heat and/or corrosion resistance.

One of the main technological challenges of the CCIM was to ensure that all the materials in contact with the molten glass were cooled. To optimize cooling, thermal modeling of the CCIM components was undertaken, including parameters such as cooling temperature and flow rate, materials used and equipment design.

The parameters and rules used to design and manufacture the CCIM were optimized for two reasons: to ensure a service life that is sufficiently long as to be compatible with operation and to optimize management of the technological waste volumes generated when it is dismantled in the future.

C) Manufacture of a CCIM to nuclear standards

Once the ambitious design objectives had been met, the project team had to rise to yet another challenge: manufacturing the CCIM to nuclear and industrial standards.

To ensure that the CCIM was manufactured to the highest standards, the project team opted to use the skills of AREVA group companies. The selection of some sepcific materials (for example copper) induced a number of manufacturing and assembly problems. A considerable amount of research and development was performed by MECAGEST to ensure that these materials could be welded and worked with precision (in strict compliance with internal and external dimensions) without losing any of their specific properties. Furthermore, the dimensions along the entire length of the high frequency power line were scrupulously checked, running as it did through the existing wall penetrations. The operations to assemble the crucible's shell also had to be monitored carefully to ensure that it did not lose any of its electrical, cooling or tightness properties.

There can be no doubt that the equipment could not have been manufactured without the know-how and high-quality work of our partners within the AREVA group.

IV.4. CCIM development and qualification tests

The studies carried out by the engineering team involved cold tests which supplemented those already carried out by the CEA's R&D team. These tests were run on a full-scale prototype in AREVA's Beaumont Testing and Development Laboratory. A team of 15, including members of engineering's Testing division and a number of AREVA teleoperators, were involved.

The prototype was a true reflection of the actual facility in several ways:

- the cold crucible itself,
- the cooling loops,
- the operating system,
- the electrical power supply provided by the high-frequency generator and the high-frequency power line,
- the dimensions and the configuration of the industrial vitrification cell (remote operation).

The tests were conducted to:

- validate the process,
- qualify the equipment prior to its installation in Cell Z4,
- train the operators in an environment and conditions similar to those of industrial operation.

The key figures for this important test phase are as follows:

- 25 weeks of testing,
- 240 elementary tests and 70 integrated tests
- 580 hours of training spread over 18 months,
- 70 non-radioactive glass canisters produced,
- 45 operators and remote operators trained.

IV.5 Industrial start-up of the CCIM

A) Preparatory work

The CCIM was installed on a production line in a 20-year old facility which had already produced several thousands CSD-V canisters of high-level waste using Joule heated melter technology. It took almost six months to dismount the old equipment, remove it, and clean up the area in which the CCIM was to be installed. Most of the work was carried out remotely. The cleaning operations ended with chemical treatment of the cell, restoring it to a level of cleanliness that was very close to its original level when it was brand new. A new calciner and dust scrubber were installed in the cleaned-up zone along with the CCIM.

At the same time, curative maintenance was carried out to clean, upgrade and/or repair other pieces of equipment that had been in use in a highly radioactive atmosphere for 20 years. More than 1000 hours of work were carried out in compliance with the ALARA principle. Thanks to the clean-up operations, the length of time maintenance personnel can stay in the radioactive zone has been multiplied by 10.

The preparations for CCIM testing on the La Hague site began in early 2009. The commissioning tests took place in the second half of the year, without having to shut down the other vitrification lines in the plant. The operator was kept thoroughly informed at all times. AREVA operating personnel joined the testing teams to benefit from their experience in industrial operation of a vitrification line in a radioactive facility, and to continue their training in the new CCIM technology.

This preparatory work – including dismantling, cleaning, repair and tests – was carried out in the R7 facility, on the vitrification line which is located between the two others (Cell B Fig. 4.). The challenge was to successfully manage this preparatory work on schedule in a hostile layout while both the other lines were in production. In 2008/2009, the production at facility R7 was as high as in previous years.

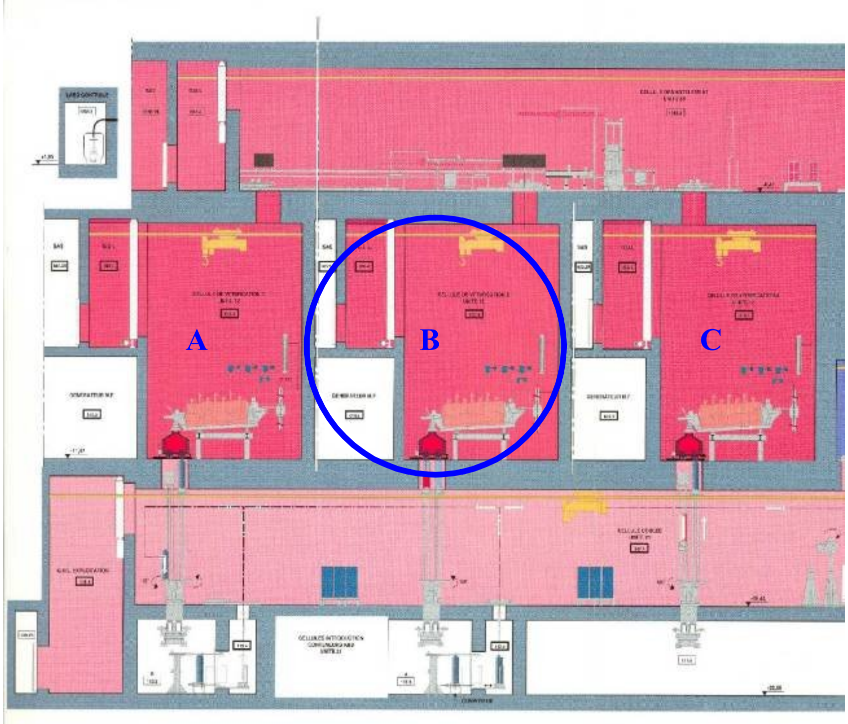

Fig. 4. Design of industrial vitrification facility R7

<u>B)– Putting a new process, equipment and glass specification into practice</u>

To put a new process, new equipment or a new glass formulation into practice, the La Hague plant has to meet two requirements:

1. "The glass specification approval" has to be obtained from the French Nuclear Safety Authority (ASN), based on the specification file which includes details of the process qualification and the glass performance qualification. The latter includes the chemical and radiological formulation, as well as a description of the long-term behaviour of the glass made. These qualifications are made by the R&D laboratory, i.e. the CEA. Finally, the specification file is compiled by AREVA and sent to the Safety Authority to be approved.
2. "The industrial start-up authorization" granted by the ASN, based on the safety analysis of the facility involved in the engineering.

These changes in process require considerable preparation before the industrial plant can be put into service. This preparatory stage involves about ten different technical sectors, for example the vitrification producer, the analysis laboratories, the process and glass quality inspection sector, the glass product canisters management sector, industrial maintenance, IT, the plant program sector, and the safety sector.

Apart from the technical preparation required for the physical installation of the CCIM, a certain number of organizational details had to be finalized in preparation for commissioning.
As early as 2007, work began to draw up a personnel training plan, devise a maintenance and spare parts program, and draft procedures and operating documents.

- As far as training is concerned, a total of 8000 hours will be dispensed to 300 people to ensure that top-quality glass can be produced to the highest occupational and nuclear safety standards. The training programs will also cover the process, the new heating technology and CCIM maintenance.
- New maintenance programs have been put together and almost 140 spare parts files have been prepared for hot cell equipments.
- During the three years period, all documents included in the operation or maintenance reference base needed to be upgraded. About 560 documents were revised, e.g. calculation methodology, analysis protocols, process control.
- The software used by the operating support department needed to be upgraded or redeveloped, e.g. composition glass calculation which involves several sectors from the producer to the canister return department, via quality control and the analysis laboratory for example.
- Preparations for qualification of the procurement of new raw materials (glass frit and reagents).
- Compilation and approval of the operating quality reference base by an external auditor mandated by AREVA's customers.

This is an intensive, complex process involving a large number of specialized areas and as such needs to be carried out several years in advance.

When the CCIM is up and running on an industrial scale, it will be possible to produce glass using several types of solution, a variety of fission products and flushing effluents from facilities being cleaned up and dismantled. This offers considerable operating flexibility but requires full mastery of the transition phases, as well as meticulous management and monitoring of raw materials, the process and the equipment used. Campaign changes are possible and could take place several times a year.

V. CONCLUSION

The industrial commissioning of a CCIM on an existing vitrification line in the R7 facility is the successful outcome of an innovative, complex and ambitious 5-year project, preceded by intense R&D. It is the result of very close collaboration between the CEA and AREVA. AREVA's experience in project management, which has already been demonstrated through numerous industrial achievements in France and throughout the world, was key to keeping the La Hague vitrification facilities in operation while integrating the major investment program, "Vitrification 2010", perfectly on schedule and within budget. This was the first time that such complex operations were carried out in highly radioactive cells. These operations were completely successful. This proves the ability of AREVA to retrofit a process in existing highly radioactive cells with no down-time in the vitrification facility.

The project is a world first in two respects. Not only is it the first time a CCIM has been commissioned to vitrify high-level solutions, it is also unique in that an innovative technology was successfully integrated into an existing cell that had not changed in 20 years of high-level solution vitrification. The innovative nature of the project is also reflected in the numerous patents filed by AREVA for the technology in question.

Thanks to the CCIM, a bright future lies ahead for industrial vitrification at La Hague. First of all, it will be possible to vitrify larger volumes of waste. Secondly, more compact equipment and a more efficient process will be possible by feeding the solutions directly into the vitrification furnace. This will also lead to a considerable increase in vitrification capacity and flexibility.

ABBREVIATIONS

CCIM – Cold Crucible Induction Melter
CEA – The French Atomic Energy Commission, AREVA's R&D and R&T provider
R7 and T7 – vitrification facilities at the AREVA La Hague Plant
AVM – Macoule Vitrification Facility at the UP1 AREVA Marcoule Plant
GCR – Gas Cooled Reactor
CSD-U – UMo Waste Standard Canister
CSD-V – Vitrified Waste Standard Canister
CSD-B – "B" Waste Standard Canister
UOX – Uranium Oxide fuel
LWR – Light Water Reactor
ASN – French Nuclear Safety Authority

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