

**Decommissioning, Dismantling and Disarming:
a Unique Information Showroom Inside the G2 Reactor at Marcoule Centre (France) - 12068**

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ABSTRACT

The paper aims at presenting the new information showroom called “Escom G2” (for “Espace Communication”) inaugurated by the French Atomic Energy and Alternative Energies Commission (CEA) in spring 2011. This showroom is settled directly inside the main building of the G2 nuclear reactor: a facility formerly dedicated to weapon-grade plutonium production since the late 1950’s at the Marcoule nuclear centre, in south of France. After its shutdown, and reprocessing of the last spent fuels, a first dismantling step was successfully completed from 1986 to 1996.

Unique in France and in Europe, Escom G2 is focused on France dismantling expertise and its action for disarmament. This showroom comprises of a 300-square meters permanent exhibition, organized around four themes: France strategy for disarmament, decommissioning and dismantling technical aspects, uranium and plutonium production cycles. Each of these topics is illustrated with posters, photos, models and technical pieces from the dismantled plants. It is now used to present France’s action in disarmament to highly ranked audiences such as: state representatives, diplomats, journalists...

The paper explains the background story of this original project. As a matter of fact, in 1996 France was the first nuclear state to decide to shut down and dismantle its fissile material production facilities for nuclear weapons.

First, the paper presents the history of the G2 reactor in the early ages of Marcoule site, its operating highlights as well as its main dismantling operations, are presented. In Marcoule, where the three industrial-scale reactors G1, G2 and G3 used to be operated for plutonium production (to be then reprocessed in the nearby UP1 plant), the initial dismantling phase has now been completed (in 1980s for G1 and in 1996 for G2 and G3). The second phase, aimed at completely dismantling these three reactors, will restart in 2020, and is directly linked to the opening of a future national storage facility for irradiated graphite waste.

Then, the paper recalls communication events and official visits hosted in Pierrelatte and Marcoule, following a formal invitation from the French President Mr. Nicolas Sarkozy. These visits, which were organized in order to illustrate the irreversibility of these dismantling operations, allowed visitors to discover places that used to be former highly classified areas. Three official visits were organized in 2008 and 2009 for representatives of the Conference on Disarmament Member States, non-governmental experts and journalists.

All participants visited the dismantled uranium enrichment plant in Pierrelatte, the G2 reactor and the UP1 plant in Marcoule. The visits were successful and visitors were especially impressed by the G2 reactor and its massive industrial architecture, symbolic of the early ages of nuclear history. In late 2010, this feedback convinced CEA Military Application Directorate (CEA DAM) that a permanent showroom could be installed inside the reactor, making it possible to preserve the cultural value of this historical landmark, and to continue its ongoing effort of communication & outreach. The paper explains the design of this concept: the museography project with a professional designer, the communication material conception and the features of such an original place.

INTRODUCTION

At the creation of the French atomic energy commission (CEA) in 1945, Charles de Gaulle, acting as the head of the Provisional Government of the French Republic, expressed the wish that France would quickly master the atom and its applications in several fields, including the ability to build nuclear reactors, as well as to have a nuclear deterrence. CEA was then created as the public body in charge of this mission.

After World War 2, the country had no industrial capacity to produce enriched uranium or plutonium. This is why France chose to develop nuclear power plants based on the use of natural uranium as fuel. After an initial experimental atomic pile built in Fontenay-aux-Roses, and called "ZOE", then the heavy water reactor "EL2" located in Saclay, the CEA could move up a gear and start the production of nuclear material which France needed for both civilian and military applications. The so-called "G" reactors ("G1", "G2" and "G3") were dedicated to that goal. They all were to be constructed in a brand new place: the Marcoule nuclear centre.

Actually, after the G1 industrial prototype, the G2 reactor is then one of the very first nuclear facilities at the origins of the creation of Marcoule nuclear centre. At this stage these three reactors became the symbols of the beginning of an emerging national nuclear industry, with the choice of the so-called "GCR" technology that used natural uranium (as fuel), graphite (as a neutron moderator) and a gas as coolant (air for G1 and carbon dioxide for G2 & G3).

THE HISTORY OF THE G2 REACTOR CONSTRUCTION AND OPERATING

In 1953, head of government Felix Gaillard ordered the construction of the Marcoule centre, which would host the three "G" reactors plus a reprocessing plant for the spent fuel: the UP1 facility. The mission of these facilities is then considered very large, since they are expected to produce a few tens of kilograms of plutonium per year per reactor, "for all practical purposes". French researchers selected graphite as neutron moderator, thus eliminating the use of heavy water which, at that time, was not easily available in Europe.

Marcoule nuclear center's official existence begins in October 1955. The reactors construction is completed very quickly. G1 begins operating in January 1956 after only 15 months of work. Just over two years turned out to be necessary for G2's construction which officially began in March 1956 and ended in July 1958. If some components of the emblematic G2 and G3 reactors sometimes came from across the country (like heat exchangers, many of the critical operations were carried out on location, in Marcoule. This was for instance the case of the graphite blocks preparation.

For the time, G2 and G3 could be considered as industrial cathedrals. The hangar-like structures, of about 50 meters high, were made of metal frames. They were built with very large dimensions, because the precise size of the reactors themselves was not yet known at the start of construction! For the latter, entirely new technologies were required, both for civil work and for nuclear technology themselves. Both reactors blocks were cylinders 34 m long and 20 m overall diameter. With a thickness of 3 m, their walls consisted of prestressed concrete, using 161 massive steel cables exerting a very strong pressure.



Fig. 1 and 2 : Operating G2 facility: reactor (left) and control room (right)

The use of carbon dioxide (CO₂) under pressure (15 atmospheres) for cooling was also an innovation, compared to G1 which so far, had used natural air.

The graphite moderator block of G2, which weighted 1,200 Tons, was drilled by 1,200 horizontal channels for fuel, and 51 vertical wells for control and safety rods. The total length of the CO₂ cooling circuits was 1672 m. The diameter of these pipes ranged from 0.5 to 1.6 meters.

With a thermal power of 250 megawatt each, reactors G2 and G3 were respectively operated from 1958 to 1980 and from 1959 to 1984. During these periods, they produced the plutonium for national defense and also provided 11 billion kilowatt-hours, to the grid of “Electricite de France” (EDF).

DISMANTLING G2: A BRIEF TECHNICAL AND PROJECT OVERVIEW

The dismantling of the G2 reactor began in 1986 under supervision of CEA's Military Applications Division (CEA/DAM) acting as the decommissioning Authority. The last fuel was unloaded and evacuated to the UP1 reprocessing plant, also in Marcoule. The first phase of decommissioning consisted in the dropping of all external circuits, including the cooling one to ensure containment of the reactor block. It was completed in 1996. This step allowed CEA teams to validate on site decontamination processes, notably including mechanical and thermal cutting of pipes, with large diameter parts such as the ones used for the CO₂ cooling. Containment of internal structures of the reactor is now provided by metallic plugs which seal all openings in the concrete structure.



Fig. 3 and 4: view of G2 and G3 reactors in 2009 (left) and dismantling operations (right)

Between 1991 and 1996, specific steel plant was used (with on site furnace) allowing processing of 4,000 tons of metal waste produced by the dismantling of the CO₂ circuits. Eventually, the ingots were evacuated to the ANDRA (France's radioactive waste national storage centers operator) storage facility, in Morvilliers in northeast of the country.

The second dismantling phase, still to come, should lead to the complete dismantling of the three reactors. It is scheduled to resume in 2020. By then, the residual radioactivity of cobalt 60 (due to the activation of internal metallic structures of the reactor block) will have declined substantially. The short period of this radionuclide (5.2 years) allows to take advantage of its natural decay prior to decommissioning, so as to reduce the doses received by workers. This natural decrease will also allow removal of the scrap metallic waste, to be sent to the ANDRA's Aube storage centre. In addition, a future national repository site for irradiated graphite waste is to be built in France. A law, voted by the national parliament on June, 28, 2006 focused on the sustainable management of nuclear materials and radioactive waste, urges for such storage service to start no later than 2019. Upon completion of the program in 2035, the total cost of decommissioning of Units G1, G2 and G3 will be of 500 million Euros.

DISMANTLING G2: A SYMBOL OF THE FRENCH STRATEGY ON DISARMAMENT

Dismantling of the G1, G2 and G3 reactors can directly be linked to the action of France in the field of weapons control and disarmament. This action is guided by principles such as to work towards a safer world and a more balanced international order based on the rule of law and collective security, to prevent threats against peace, to respect the right to self-defense, to deny the weapons race and to move towards global and complete disarmament.

This is why France decided in 1996 to dismantle its production facilities for fissile material for weapons, as well as its nuclear test sites. These dismantling operations began in 1997. In the meantime, France also decided a moratorium on fissile material production for weapons, and decided to give proofs of better transparency, whether on the doctrine, the arsenals or concrete disarmament efforts.

In 2008, President Sarkozy signaled his commitment to transparency by inviting international experts to discover by themselves the dismantling of the facilities in Pierrelatte (uranium enrichment plants) and Marcoule (plutonium production and processing), dedicated to the production of fissile material for nuclear weapons.

In response to this presidential request, the CEA, working closely with the Ministry of Foreign and European Affairs and under coordination of the French Presidency, has organized three visits. On Sept. 16, 2008, representatives of more than forty countries, all members of the UN's Conference on Disarmament, were the very first to attend. A second visit, scheduled on March 16, 2009 gave thirty non-governmental experts the opportunity to visit. And on July 3, 2009 twenty international journalists were also taken to the facilities. Between July 2009 and April 2011, additional visits were organized for French officials.

Throughout the visit, participants had access to the dismantling and decommissioning facilities: the former uranium enrichment plant in Pierrelatte, G2 reactor and UP1 reprocessing plant at Marcoule. These visitors were able to see by themselves the concrete and effective decision taken by France in 1996 to end production of fissile material for its nuclear weapons.



Fig. 5 and 6: International visitors at the G2 reactor, 2008

In the context of the Review Conference of the Nuclear Non-Proliferation Treaty (NPT, New York, NY, May 2010), all these visits have been featured with photos and reports in the national and international press, which praised the French initiative.

These events needed intense preparation in terms of organization and logistics: definition of the path in the facilities involved, preparing messages, participants' management, authorizations associated with this type of visits.

THE SHOWROOM PROJECT

For the CEA, it was of prime importance to maintain this communication effort, thus being able to continue to welcome State representatives, diplomats, journalists, among other opinion leaders and visitors. The CEA also wanted to promote and preserve the cultural heritage of the G2 reactor, which is characterized by a remarkable architecture, a symbol of the 50's industrial era.

CEA quickly decided that the so-called "loading platform" in front of the reactor block, characterized by a surface of 300 Sq.m. would be the ideal place to welcome visitors on a permanent basis. A showroom could be built at this precise location. The first step in the design of this space required structuring of information to be delivered to visitors. Four themes were identified for which the messages had to be developed: disarmament, dismantling, the uranium cycle, the plutonium cycle.

Basically, an intensive archives exploration work had to be completed so as to set up a database of pictures that could be used for the project, such as pictures showing the G2 reactor in operation in the late 50's. In the old control room of G2 reactor (demolished late 2009) an impressive detailed make-up of the G2 reactor was available for the project. A model-maker undertook a major renovation of this masterpiece, which required several months before it regained its original colors and patterns.

The current operator of the former uranium plant in Pierrelatte, the AREVA group, provided artifacts from the enrichment process of the plant, such as compressors and diffusers tubes, spare parts which were never used. These very heavy pieces (several hundred kilograms each) of large dimensions got a formal radioprotection clearance before reaching the showroom site. Make-ups of Marcoule and Pierrelatte centres were designed and manufactured by the same provider, based on the center plans, pictures and data.



Fig. 7 and 8: general view of showroom (left) and focus on reactor make-up (right)

A very complete specification draft was developed and a contractor, in charge of museography and spaces design, was chosen (DECORAL, Paris). The Project team by the contractor was heavily involved with several on-site travels to soak up the place, consider the requirements for the architecture.

After several iterations and adjustments, a definitive layout was chosen and design & fabrication

phase could to start. Design of posters quickly had to be launched: the CEA provided texts and pictures and a graphic designer was responsible for the layout to fit the visual identity developed by DECORAL.

On location construction started in September 2010 with a complete cleaning of the facility. During the installation of the showroom, G2 remained a nuclear installation. This means that all the workers on the project were to be equipped with dosimeters regularly inspected.

The first phase of work, launched in October, was devoted to patching the surface of the platform and its paintings, as well as electrical wiring to power the four thematic blocks. Paintings were also renovated on elevators and stairs since the platform stands at a height of about 20 meters above ground level. The Elevator itself was checked so as to become a mean of transporting visitors to the showroom.

A second phase of work began with the delivery of the platform models and objects, booths structures and media. This required a very accurate coordination of construction: delivery of the G2 renovated model, delivery of heavy pieces from Pierrelatte and installation of all these elements on the platform using a crane before assembly.

GENERAL LAYOUT AND MAIN CONTENTS OF THE SHOWROOM

The four informative thematic blocks, materialized by the use of specific color set on the gray platform ground, are also identified by painted discs. They allow easy movement from a part of the exhibition to another. Each block consists of a wall on which visuals (posters and photos) are displayed, a “totem”, and make-ups protected by glass / Plexiglas covers. The global view of the G2 reactor block has been preserved and can be approached. Projectors have been added at the base of the reactor. Three high power braziers are expected to warm the place which, during winter can get very cold especially on windy days.

The first block gives information on France's strategy for disarmament: the nuclear non-proliferation and the commitment of France in disarmament general information, the dismantling of reactors and plants in Marcoule and Pierrelatte, and also the dismantling of the French nuclear test site in French Polynesia. The second block is a bit more technical, with information on dismantling techniques and technologies. In the third block, which includes the renovated G2 reactor make-up, the plutonium cycle is described to the visitors. The model was placed in the reactor axis, and the view of the block has been preserved. Basic data focused on the G1, G2 and G3 plutonium production mission, as well as some information about the UP1 reprocessing plant are provided. The fourth block gives details about the uranium cycle, illustrated with posters devoted to uranium enrichment by gaseous diffusion at the former plant in Pierrelatte, and its dismantling operations. In this part of the exhibition, compressors and a diffuser tubes are presented. These impressive pieces were placed in glass or Plexiglas covers.

The average visit duration can be estimated from 40 minutes up to one hour. The platform can welcome groups up to 30 visitors. A tour guide from CEA is always present to manage the groups. Reservation and tour bookings are managed through CEA communications teams.

CONCLUSION AND PERSPECTIVES

In February 2011, after several months of assembly, the latest posters were installed and the protective covers were removed... The first informal visits were organized to test the messages and the tour circuit. The area was officially inaugurated on April 21, 2011, by Bernard Bigot, chairman of the CEA, in the presence of representatives of the Ministry of Foreign and European Affairs and of the Ministry of Defense.

Since the visits have officially started, whether for French officials, scientists, students or other

groups, and feedbacks are excellent as visitors do enjoy both the scenography and content of the information provided. Currently in Marcoule, additional visitors' tours are to be implemented on other former facilities currently under dismantling operations. The UP1 reprocessing plant, also an historical landmark of France's early nuclear history, is due to be the next.