MAJOR CHANGES OF CORE COMPONENTS IN OSIRIS AND ORPHÉE FOR MAINTENING HIGH SAFETY LEVEL

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Abstract

OSIRIS and ORPHÉE research reactors are operated by the French Atomic Energy Commission (CEA) at Saclay (France) since 1966 and 1980 respectively. These reactors were in particularly designed to deliver very high flux of neutrons to perform experiments for basic research or development of new materials and fuels. Unfortunately these neutrons are also imposed to the main structural components in the vicinity the fuel elements of the reactors. This can lead to ageing effects on the materials used for their construction : aluminum alloy AG3 NET and zircaloy.

Extensive and deep safety re-evaluations of both reactors demonstrate, in particular, that it was necessary to change the main core components because the integrated doses may reach, in the future, values where the reduction of ductility of the material becomes significant.

Important works were done on both reactors to change those components in order to re-install new ones made of virgin materials.

For OSIRIS, the changes were done in two phases : firstly in 1997 for the lattice structure and secondly in 2002 for the core tank. For ORPHÉE, the core housing was changed in 1997.

All the operations were managed under very high level of safety, security and quality. The teams normally involved in the operation of the reactors were also involved in the dis-assembly and assembly operations. Particular attention (Alara approach) was devoted to the biological protections against irradiation of the workers to minimize absorbed doses. These operations leads to shut downs of reactors that last only 8 months at most in the case of OSIRIS reactor.

Safety authority gave allowances to restart the reactors from the evaluation of informations describing the planning of the operations and the various results of tests performed at different phases of the works. As a matter of fact, both reactors are now normally operating and delivering neutrons for the experiments since more than 8 months for OSIRIS and more than 4 years for ORPHÉE.

The removed components were also examined, specimens were extracted from them and tests are carrying on to evaluate the actual level of ageing.

The operations demonstrated that it is possible (technically and economically) to change very important components in these reactors to extend their operating life and improve their safety.

1 – INTRODUCTION

The reactors OSIRIS and ORPHÉE are operated by the french Atomic Energy Commission in Saclay since 1966 and 1980 respectively. The ORPHÉE reactor is a reactor devoted to fundamental research. The core is made of 8 fuel assemblies and a central reflector made of beryllium. Beams of neutrons are distributed out of the reactor by various guides. OSIRIS is a material testing reactor which the core is loaded with 38 standard combustible elements, 6 of control and 9 reflecting elements in beryllium (located on one side). The core diffuses its flux of neutrons to various experimental devices which can be installed in the core or around it. On the whole about thirty experimental sites are available. These experiments relate to technological irradiations for the needs for the nuclear industry, or to production irradiations (artificial radioisotopes for the needs for medicine, silicon doping) or finally for the activation analyses

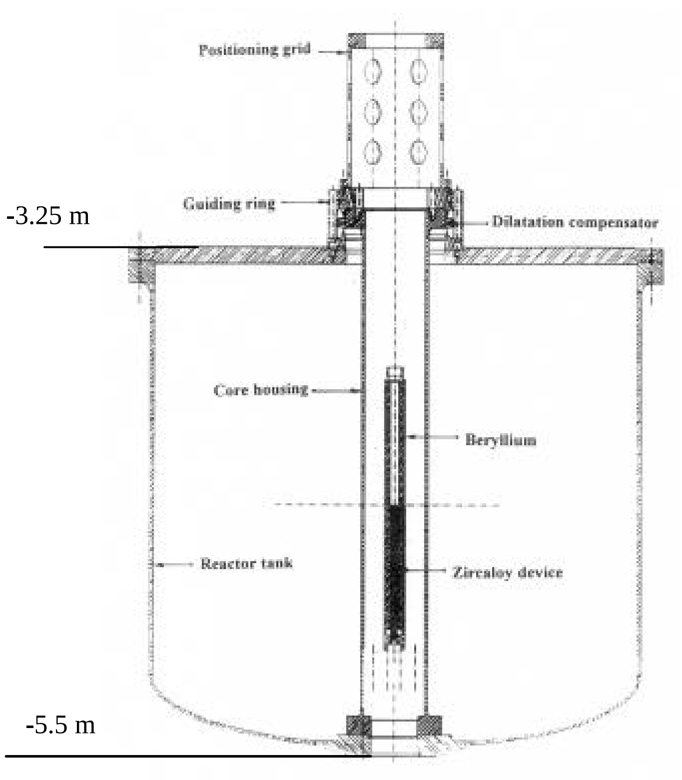
1.1 - Objectives of the changes of components

These reactors were built with an aim of providing particularly dense flux of neutrons to the experiments installed in the vicinity. Unfortunately these neutrons touch also the principal components surrounding the core of these reactors. They are able to cause ageing effects on the materials which constitute them: aluminum alloy AG3 NET, zircaloy or austenitic steels (screws and bolts). Re-evaluations of safety, carried out periodically showed, in particular, that it was necessary to replace some components because the amounts of irradiation accumulated since the first divergence could in an immediate future reach values where the modifications of the properties of materials became unacceptable. These changes led to very significant works ever carried out since the construction of the reactors and which were made under constant surveillance of the safety Authority . They were preceded by very meticulous preparations which used as much as possible the knowledge gains from operations carried out until now. They relate to the manufacturing of the new components, the disassembling and the re-assembly of the components and finally the various tests and measurements realized all along these works to check the conformity of the operations.

2 – DESCRIPTION OF WORKS

2.1 - Change of core housing in ORPHÉE

The core housing surrounds the core of the reactor as indicated on figure 1. It is located inside the heavy water tank. The lowest part is on the level –5.5m. It is a component made of zircalloy2 which is a cylindrical shell of 2 m height and 250 mm diameter and fixed by two rows of screws in parts higher and lower. The principal difficulties came from the operations of assembly and disassembling to be realized on bolts and nuts under more than 5 meters of water. The new core tank was manufactured with a new material taking into account the ageing of the zircaloy under irradiation. It should be noted that vibratory measurements were made for checking the good behavior of the new arrangement. The total operation lasted less than 3 months in 1997.

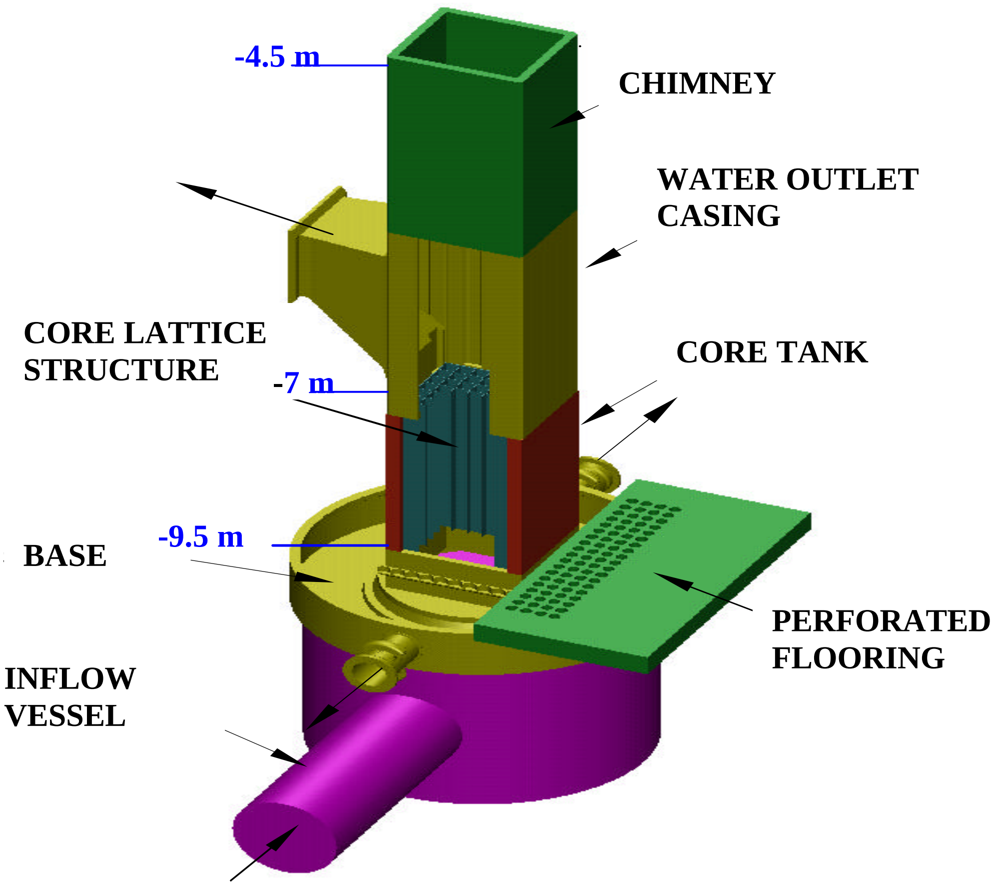


2.2 - Change of the core assembly in OSIRIS

2.2.1 - Components concerned

The whole core assembly represented on figure 2 was replaced: base, core tank, water outlet casing. This assembly contains the core of the reactor and its system of cooling. To fix the ideas the core tank has a square section of 700X700 mm^2. The levels of different locations on the core assembly are given on the drawing. Level 0 m is the level of water in the pool under normal operation.

CORE ASSEMBLY



2.2.2 - Works management

The general organization of the works was based on different parts concerning :

- the supply , the manufacture and the control of the new components,
- the management of the fluids for the different water movement in the pool and reduction of liquid waste
- handling operations, storages, assemblies and disassembly
- the metrology and inspection of the walls of the pool
- the radioprotection.

These activities were carefully defined to be realized then by manpower inside the company or outside it.
Seven different phases were defined to plan work. They correspond to assembly or disassembly operations where the level of the pool is adapted and kept constant in order to carry out the operation

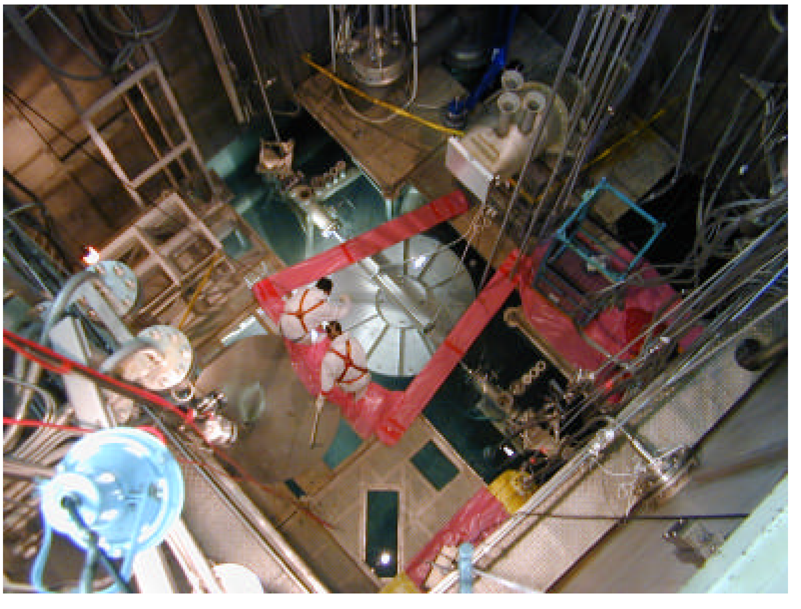
(for example screwing or handling) with sufficient water height for the biological shielding of the workers.

Phase 1. Level 0 m.
Is first removed the fuel elements and the experimental devices then the control rods, the higher grid and the chimney.

Phase 2. Level -4.5 m.
During this phase, are withdrawn the core lattice structure , then the water outlet casing and finally the core tank.

Phase 3. Level -7 m.
After the disassembly of the 2 fastening devices (3 screws had to be broken to carry out disassembling), the higher part of the base was finally removed. Beyond that, there were a thorough cleaning of the internal faces of the pool and clearing of other side components. A cartography of the hot points was done to lower a last time the level of the pool.

Phase 4. Level -9.5 m.
During this phase, was carried out a thorough inspections of the higher grid and bottom of the pool faces. See the photograph of figure 3 taken at the time when two operators are cleaning the bottom of the pool.



Phase 5. Level pool -7 m.
The experimental external grids were re-installed then the new water outlet casing and the new core lattice structure.

Phase 6. Level -4.5 m.
The systems of connection of standard fuel elements were reloaded. During this phase the chimney and the higher grid were positioned back

Phase 7. Level 0 m.
The control rods were reloaded before reloading the 38 standard fuel elements. Many controls and tests were carried out during this phase before asking the allowance to restart the reactor to safety authority.

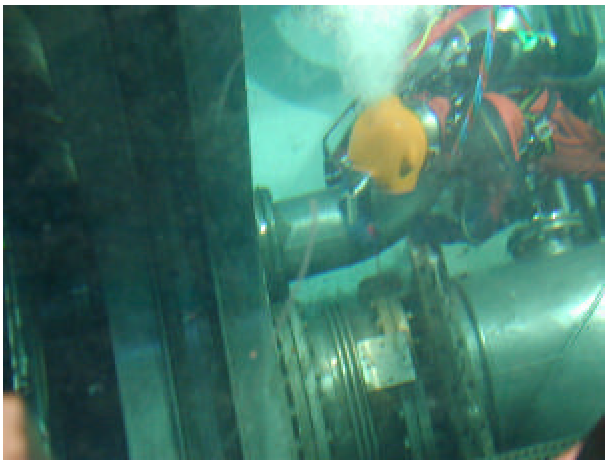
2.2.3 - __Some particular features__

In order to lower as much as possible the amounts of radiations for the personnel engaged in the works an Alara approach was applied. The scenario of reference is based on the knowledge gained from the works made in 1966 for the first replacement of the core lattice structure and also from usual operations during current operation of the reactor. The optimized scenario was achieved, when it was necessary, by using lead covers, adapting remote tools, cleanings frequently hot points, disassembling irradiant components and measuring frequently radiation fluxes. The doses accumulated by each operator for each operation were noted every day with the help of individual system of measurement. The maximum objective dose rate was fixed to 100 ? Sv/h. Thus 203 tasks were identified. The 22 workers led to a forecast volume of work of 5022 H.h for a volume actually carried out of 4793 H.h. The cumulated individual maximum dose was of 1.7 mSv. The estimated collective amount of dose was 29 H.mSv and it was actually carried out: 16 H.mSv.

The major differences between forecast and actual values come from the overestimation of forecast dose rates and the under-estimation of durations for some disassembly tasks. From a human point of view, this approach was a good mean to sensitize the workers with the radiobiological risks. It should also be noted that this study was frequently taken into account during discussions with safety authority when dealing with different options to perform the works.

One can note that to reduce the volume of waste water when the level of water in the pool was the lowest it was used 4 rubber inflatable capacities and which allowed to store temporarily 100 m^3 of the pool water (figure 3).

In the same way, to avoid emptying the channel close to the pool where many removed dismounted and irradiant components were stored, the tightenings of joints on the primary circuit were realized by plungers (figure 4).



It is also worth noting that a significant share of work consisted in making many measurements and controls to check the satisfactory behavior of components and systems before proceeding to the various phases of assembly and ultimately before reactor restart. One can note in particular, controls of leak-tightness of the circuits, the verticality of the block pile, the drop times of the control rods and the vibratory signature of the block pile,

3 - CONCLUSIONS

These operations were carried out with an organization of the quality which allowed to reach and demonstrate a high level of safety and security throughout these works. The broad implication of the teams usually operating the reactors in the new operations of disassembly and assembly was an important point.

In term of radioprotection , the Alara approach made it possible to reach doses that are within values usually obtained during normal operation of the reactors.

The two operations carried out into 1997 had a duration lower than forecast. The operation of 2001-2002 for OSIRIS lasted 8 months instead of the 7 months initially envisaged.

Following the authorizations of restarting given by safety authority both reactors are operating normally since many months.

The old withdrawn components are currently under examination in order to evaluate precisely the level of ageing really reached.

All these operations prepared with care have reached their objectives: to guarantee a reliable and safe operation for the next years. Operation lives at least equal to those actually obtained by old removed components could be anticipated.

From an economical point of view, the cost of all operations remained in an acceptable level to perform a continuous upgrade of the reactors.