HOT CELLS INSIDE THE BUILT-UP JULES HOROWITZ REACTOR

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ABSTRACT

In southern France, in the area of research institutes CEA in Cadarache, a new 100 MW research reactor Jules Horowitz (JHR) is under construction to be put into operation in 2014.The JHR is being built by an international consortium gathering research labs and industrial organizations who will share the benefit of the JHR functioning. Within the JHR consortium, the Czech Republic is supplying a hot cells complex according to a CEA/AREVA design proposal. These cells have been designed to support JHR operations, experimental devices handling (material and fuel samples) and radiopharmaceuticals production. Hot cells complex consists of four large cells (inside height 10m), equipped with remote handling devices (cranes, light and power manipulators …) and three associated small cells, dedicated to non-destructive samples examinations. The presentation deals more precisely with the hot cells conception and briefly also with the conception of the reactor itself.

1. Introduction

Material Testing Reactors (MTRs) are necessary for the development and qualification of new materials and nuclear fuels foreseen to be used in the nuclear industry. The studies performed on the MTRs contribute to the safety and to the optimisation of existing or coming nuclear power reactors and to the development of the future reactor types. Furthermore, the MTRs can also serve for production of radioelements for medical use or as a fast and thermal neutron source for various scientific applications as neutron diffraction analysis, activation analysis, and neutron capture therapy.

Most of the irradiation tools used by industry are getting old in the western world [1]. The sustainability of a high performance experimental capacity and the related expertise are mandatory. These were the main reasons for decision to study and build a new pan-European MTR – the Jules Horowitz reactor (JHR). The JHR is built in one of the areas of the French atomic research institute, the CEA (Commissariat à l'Energie Atomique), in Cadarache in southern France. The global design has been made by an engineering team (AREVA/EDF), under the supervision of CEA. The construction was launched in 2007 and the reactor is scheduled to be put into operation in 2014.

The JHR is build and will be operated in the framework of an international cooperation between several organizations gathered in a Consortium. The present Consortium partners are as follows [1]: CIEMAT (Spain), SCK (Belgium), NRI / RC (Czech Republic), VTT (Finland), CEA (France), DAE (India), JAEA (Japan), EDF (France), AREVA (France), VATTENFALL (Sweden), EURATOM (European Commission).

The Czech Republic, represented by the Nuclear Research Institute Řež plc (NRI), provides for JHR an in-kind supply of a complex of hot cells according to a CEA/AREVA design proposal. Research Center Řež Ltd. (RC), a 100% daughter company of NRI, is an operating agent for realization of the NRI in-kind contribution to the JHR project.

2. The JHR hot cells complex

2.1 In general

JHR hot cells will be used on one hand in the experimental process before and after sample irradiation, and on the other hand for the nuclear unit operations. Furthermore, the hot cells will play a key role during the reactor decommissioning phase after its expected 50 years of operation.
The JHR hot cells complex includes four large cells (ECA, ECC, ECD, and ECR) located at the ground level and raises up to the first floor, where three small cells are localized. The small cells (ECS, ECE, and ECM) are dedicated to non destructive tests on irradiated materials and fuel and will be also used as service cells for maintenance operations on large cells equipment. Table 1 summarizes the expected usage of all hot cells.

Hot cell	Mainly used for
ECA	Operations on contaminated devices
ECC	Material and fuel operations
ECD	Material conditioning, waste conditioning, works on irradiation test devices
ECR	Spent fuel transport, radioelements expedition, waste storage and expedition
ECS	Maintenance operations on ECA equipment
ECE	Non-destructive tests on fuel
ECM	Non-destructive tests on materials

Table1: Expected usage of particular hot cells

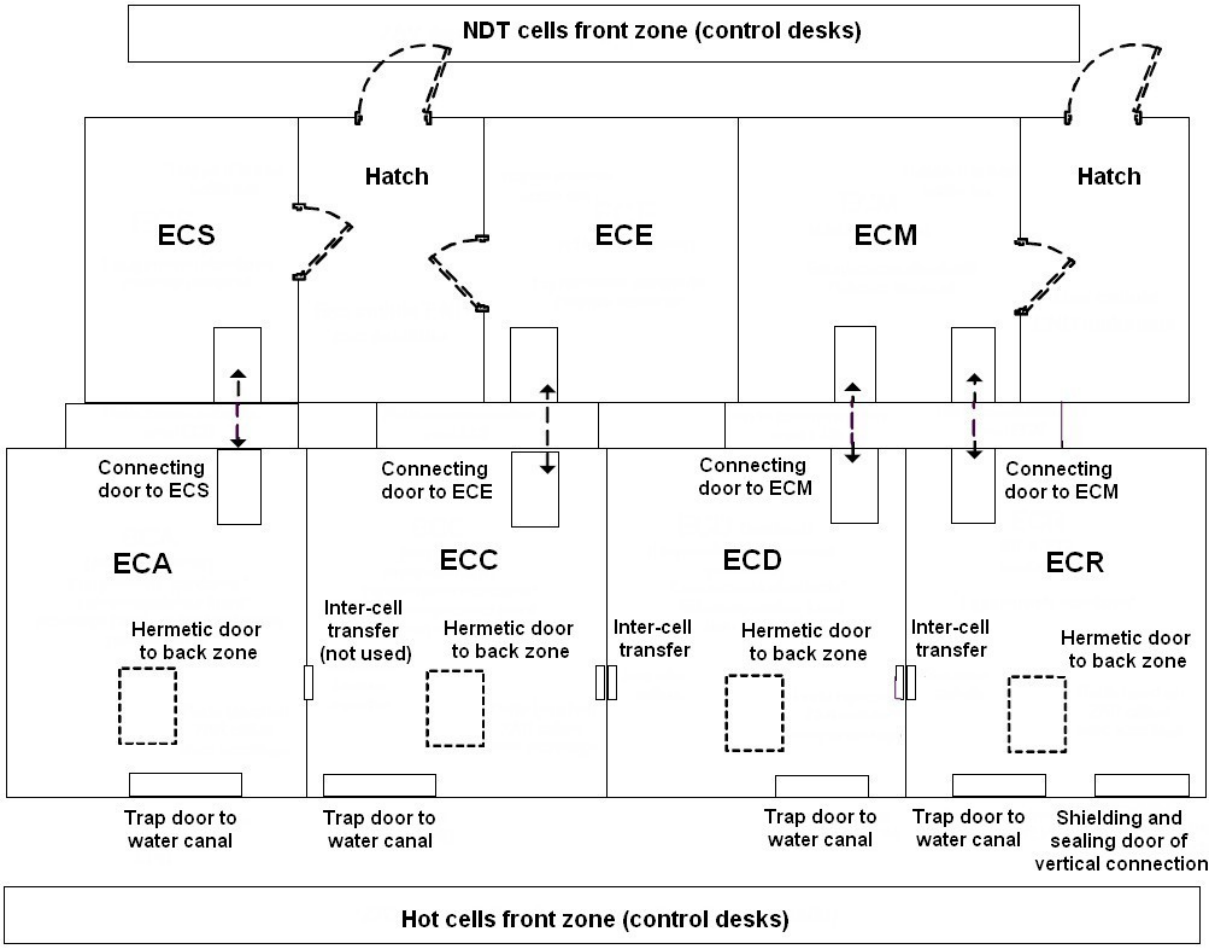

Fig 1. Functional schema of the JHR hot cells complex

Two water canals connect the hot cells complex with pools and the reactor just below the cells ground level. Figure 1 shows the functional schema of the hot cells complex.

2.2 Main parameters of the cells inside environment

The maximum temperature inside the cells should be 45°C (58°C in case of a cell with an inert nitrogen atmosphere) during normal operation and 65°C in case of an accidental situation. The inside relative air humidity should vary from 30% to 70%. A dynamic containment is ensured by a cascade of underpressure. The normal pressure difference between the cells interior and the surrounding rooms will be 500 Pa, while on emergency conditions it may reach up to 3500 Pa.

2.3 Large cells

The typical inner height of large cells is approx. 10 m, their inner width is between 3 m and 4 m and the depth is 2.5 m. For manipulation with irradiation experimental devices, waste containers, samples etc. all large cells are equipped with a crane and a pair of master-slave manipulators. Moreover, all large cells, except for ECR, dispose of a power manipulator (capability of 200 kg) and a manipulation well with a lifting support for irradiation experimental devices.
For under-water transport of fuel elements and irradiation experimental devices, each cell disposes of a trap door to water canal. The alpha cell (ECA) trap door is equipped with a special type of a DPTE transfer system, which enables contaminated samples to be inserted without contamination the surface of the irradiation experimental device.
For material and equipment transfers inside/outside, all the large cells dispose of a hermetic door to the back zone with a DPTE transfer system for cask connection, a small material hatch from the back zone and a connecting door to a small cell in the upper part of large cells.
Furthermore, inter-cell transfer tunnels between ECC-ECD and ECD-ECR are implemented. There are two slipways (mechanical transfer system for small capsules containing, e.g., samples) connecting ECD and ECR with the small cell ECM. In addition, the ECD cell is equipped with a pneumatic post station which enables to send samples directly into the dosimetric laboratory. The ECR cell is equipped with a vertical connection for casks to be used for expedition of radioelements, spent fuel, and waste. This vertical connection is covered by a shielding and a sealing door.

2.4 Small cells

The JHR hot cells complex includes also three small cells localized on the upper floor. These small cells (ECS, ECE, and ECM), as already said, will be used for non destructive tests on irradiated materials and fuel and will be also used as service cells for maintenance operations of large cells equipment.
Typical height of small cells is approx. 4 m, their width is 2.3 m or 4 m and the depth is 2.7 m. For manipulation, small cells are equipped with a crane and a pair of 12 kg master-slave manipulators. These manipulators can be replaced by 20 kg manipulators for maintenance operations. Each small cell is also equipped with shielded entrance rotation door and a small material hatch from the front zone. The rotation doors connect the cells with two hatches (transfer rooms) adjacent to small cells, as can be seen in the Fig. 1. Interventional ECS cell is dedicated to ECA cell support only but could be used, in the future, as an experimentation hot cell.

3. Hot cells design

The general overall design of the hot cells has been made by an engineering team of AREVA/EDF, under the supervision of CEA. The first RC task is to expand the general overall design into a detailed design. A complete qualification of each supplied component is an integral part of the detailed design process.
The main used design tool is a 3D digital mock-up of the hot cells complex. The mock-up is created and continuously managed in CATIA V5 R18 software environment. Figure 2 shows a general view of the hot cells complex in CATIA.
In order to proper dimensioning biological protection of relevant components, computations using the MCNPX 2.5.0 software are performed.
Another software tool SCIA ESA PT 7.1.170 is used for necessary static calculations. Although, the embedded pieces supplied by RC don't carry big static loads within operation, they must withstand loading occurring during their transport, on-site installation, and concrete pouring.
All anchors and equipment not embedded into concrete must be qualified for a case of earthquake. FEM modelling in ANSYS is used for the necessary seismic calculations.

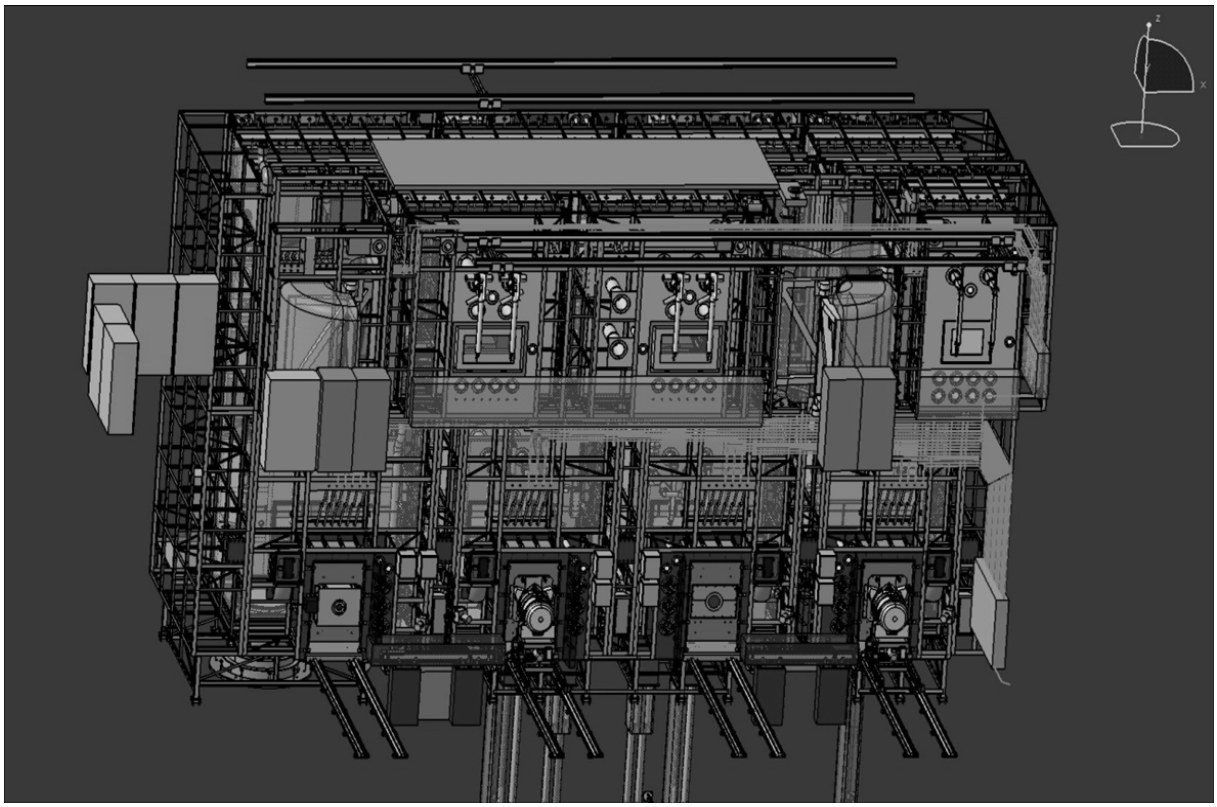

Fig 2. General view of the hot cells complex in CATIA. Large cells back zone is visible at the bottom, small cells front zone at the top.

3.1 Actual state of hot cells design

At present time (end of August 2009), the qualification of embedded pieces for cell floors segments is almost completed. The first version of manufacturing drawings was handed over to the civil work company which will provide the heavy concrete pouring. The qualification of remaining embedded pieces is still in progress. The qualification of the inside equipment is scheduled to start soon. These components will be qualified in groups depending on the particular sub-supplies, e.g., the cranes, I&C components, bushings, stainless steel liner etc.

3.2 Design of irradiation experimental devices

A growing activity is dedicated to the development of JHR experimental devices. CEA is setting up a scientific and technical team to define, develop, and construct a first fleet of experimental devices meeting users´ needs up to 2020. CEA is gathering European and international community around these devices and manages the integration (and related interfaces) of these devices in JHR.
Several irradiation test devices are under development now. They are intended for material (Calipso, Mica…) and fuel (Madison, Adeline, Lorelei…) irradiation experiments [2]. Their length reaches up to 5 m and the weight of 500 kg.

4. Conclusion

JHR will be a 100 MW material testing reactor of pan-European importance located in Cadarache, France. Its construction was launched in 2007 and the reactor is scheduled to be put into operation in 2014.
The Research Center Řež Ltd. provides for JHR an in-kind supply of hot cells complex according to a CEA/AREVA design proposal. An important task within the detailed design is the proper qualification of all supplied components. At present time, the detailed design of the hot cells complex is in progress, while the manufacturing of any components hasn't started. The first section, whose design and qualification is almost completed, comprises the embedded pieces for cell floors. Detailed design and qualification of the other embedded pieces will follow soon. Beginning of concrete pouring of the hot cell walls is supposed in the end of the year 2010.

5. Acknowledgement

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6. References

[1] Jules Horowitz Reactor Status Report 2008 (CEA, Cadarache, June 2009).
[2] Jules Horowitz Reactor Governing Board Meeting Presentation (CEA, Cadarache, April 2009).