# JULES HOROWITZ REACTOR: ORGANISATION FOR THE PREPARATION OF THE COMMISSIONING PHASE AND NORMAL OPERATION

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## ABSTRACT

The Jules Horowitz Reactor (JHR) is a new modern Material Testing Reactor (MTR) currently under construction at CEA Cadarache research centre in the south of France. It will be a major research facility in support to the development and the qualification of materials and fuels under irradiation with sizes and environment conditions relevant for nuclear power plants in order to optimise and demonstrate safe operations of existing power reactors as well as to support future reactors design. It will represent also an important research infrastructure for scientific studies dealing with material and fuel behaviour under irradiation. The JHR will contribute also to secure the production of radioisotope for medical application. This is a key public health stake.

The construction of JHR which started in 2007 is going-on with target of commissioning by the end of 2017. The design of the reactor provides modern experimental capacity in support to R&D programs for the nuclear energy for the next 60 years.

In parallel to the facility construction, the preparation of the future staff and of the organisation to operate the reactor safely, reliably and efficiently is an important issue. In this framework, many actions are in progress to elaborate:

- the staffing and the organisational structure for the commissioning test phases and also for normal operation,
- the documentation in support to the reactor operation (safety analysis report, general operating rules, procedures, instructions, …),
- the maintenance, in service and periodic test programs,
- staff training programs by using dedicated facilities (simulator,…)
- commissioning test programs for ensuring that the layout of systems and subcomponents is completed in accordance with the design requirements, the specification performances and the safety criteria.

These commissioning tests will also be helpful for transferring the knowledge on the installed systems to the operating group.

This paper gives the description of the main tasks to prepare the organisation to commission and operate the Jules Horowitz Reactor.

## 1. Introduction

This paper provides a description of the organizational structure, responsibilities and main actions for the Jules Horowitz (JHR) Material Testing Reactor (MTR) commissioning and routine operation.

Its construction, started in 2007, is going-on with target of commissioning by the end of 2017. It will be operated by CEA, as an international user's facility on the CEA Cadarache site. The design of the reactor will provide modern experimental capacity in support to R&D programs for the nuclear energy for the next 60 years. It will also supply radio-isotopes used for medical applications.

JHR will be a modern MTR. It is a pool-type reactor; the maximum power will be 100 MWth. Its design allows a large experimental capability inside and outside the reactor core. Due to the high power density, the core primary circuit is slightly pressurized. Several equipments will be implemented in the reactor building and be used in support to the experimental programs (7 hot cells will allow the preparation and examination of test devices before and after irradiation, non-destructive examination benches (gamma spectrometry, X tomography, neutron imaging system) and specific laboratories (fission product lab, chemistry lab and dosimetry lab).
In parallel to the construction of the reactor, the future staff training and the preparation of the organization, to operate the reactor safely, reliably and efficiently is a key item. In this framework, many actions are on-going to elaborate:

- the staffing and the organizational structure for the commissioning test phases and also for routine operation,
- the documentation in support to the reactor operation (licensing documentation, procedures, instructions, …),
- the maintenance, in-service and periodic test programs,
- staff training programs by using dedicated facilities (simulator…)
- commissioning test programs for ensuring that the layout of systems and subcomponents is completed in accordance with the design requirements, the specification performances and the safety criteria,

CEA has also to design and implement the experimental devices.

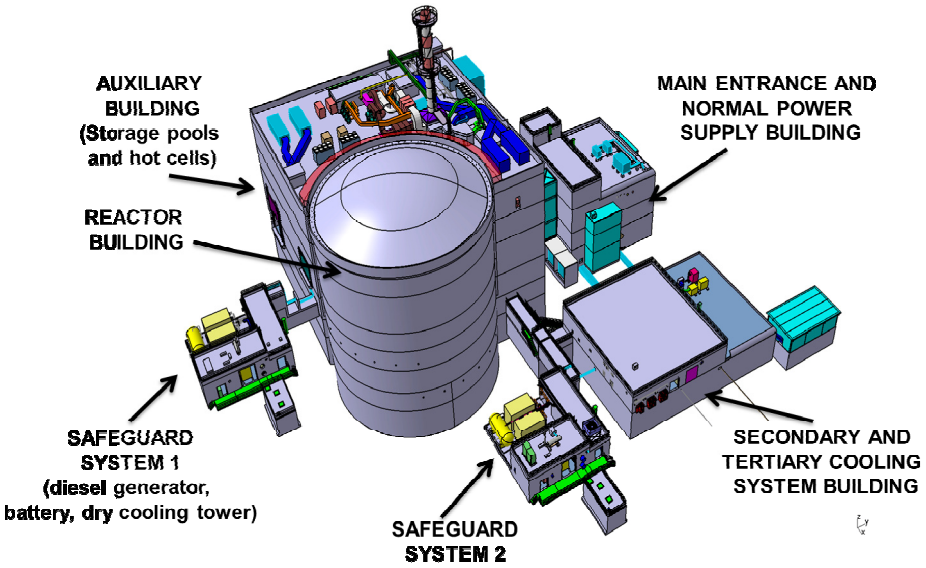



Fig. JHR Facility

## 1 Organization of the JHR project

The complexity of this unit, the organization of the JHR project and the safety requirements require a specific organization to prepare the facility commission. Concerning the organization of JHR project:

- The primary contractor, AREVA [12], has to design and to construct the future unit except the different equipments or systems in support to the experimental programs,
- CEA has :
    - to install and commission the experimental devices and equipments,
    - to operate the reactor and the different system during the commissioning test phases and then the routine operation.

In 2010, a specific JHR section was set-up with 5 mains missions:

- Human Resources management to prepare the future operator,
- Setting-up the operating referential (Safety Analysis Report, General Operating Rules…),
- Training and qualification of control room operator,
- Setting-up of the major contracts linked to the JHR operation (fuel assemblies, equipments, sub-contractors…),
- Design, manufacturing follow up, implementation and commissioning of the first fleet of experimental devices and associated equipments (non destructive examination benches, laboratories…).

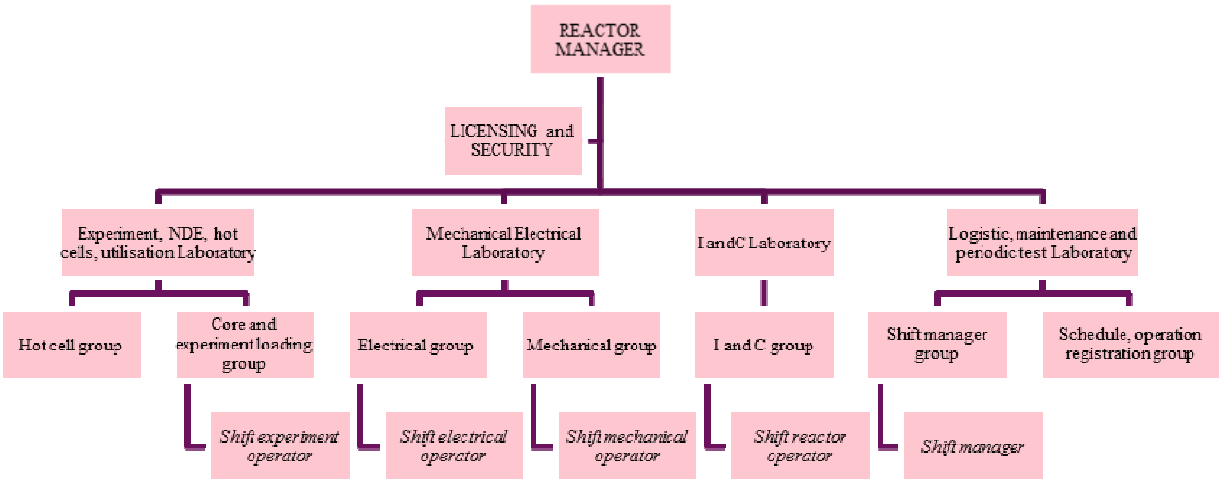
The future reactor operation and experimental systems operation staffs belong to this section to prepare the operation of the reactor and the nuclear auxiliaries as well as the integration of the test devices. These “mixed” staffs will contribute to enhance efficiency during this commissioning period but also for the future regular operation (existence of means shared between the operation and the experimental staffs to create a unique culture around the JHR).

## 2 Mains topics in preparation to start and operate JHR

### 2.1 Proposal of staffing and organizational structure

Based on the others research reactors feedback, the project of organization is also adapted to the reactor mission (neutrons for industry and medical application). This structure takes into account the future schedule of the reactor in operation and the maintenance and periodic test programs. The objective is to define clearly the responsibilities and the technical skills of each staff member (reactor manager, operation manager, shift manager and reactor operator) from the commissioning test phase to the routine operation.

JHR section and JHR project are also preparing the organization that will take place for the commissioning test program phase. The aim is to define the liability of each actor (main contractor, JHR project, future operator, contractors and sub-contractors).



## 2.2 Elaboration of the licensing and the operating documentation

### 2.2.1 Elaboration of the licensing documentation

Regarding the licensing documentation, CEA has to complete the project of Safety Analysis Report, provided by the primary contractor, with the test devices specifications (specific licensing document for each of them) and also with the largest possibilities of core configurations (number of fuel assemblies (34 to 37), enrichment (19.75 and 27% U235), thermal power (70 to 100 MWth)…) and the associated safety studies. For example, the PASSERELLE project is the safety report of the first « core » of the JHR (36 fuel assemblies, 19.75 % U235). The aim is to study the «best» loading of the core with a fuel «consumption» optimization. It ensures the safety criteria and the core performances respect.

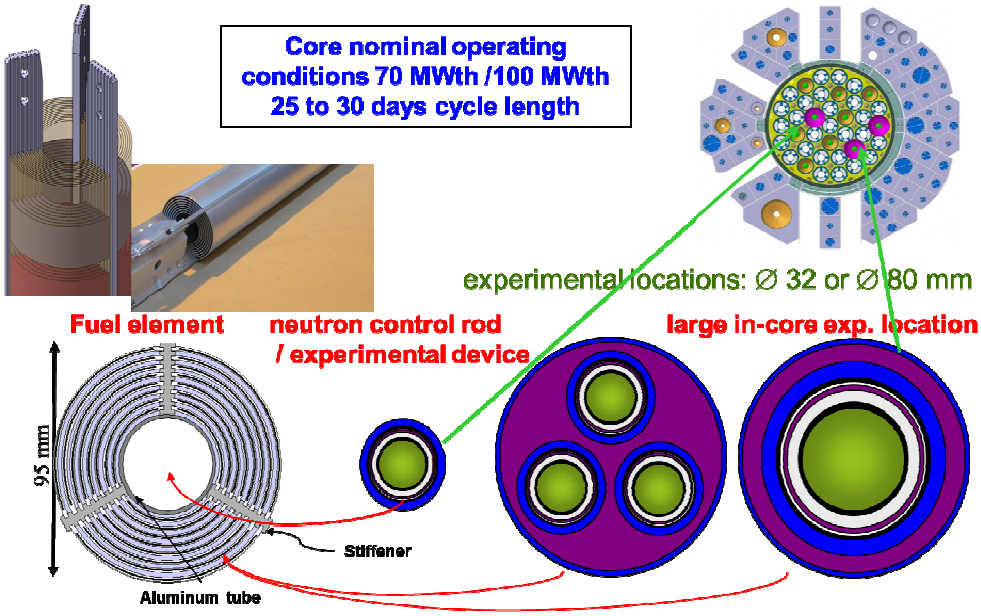



Fig. JHR core

This Safety Analysis Report is completed by General Operating Rules (description of reactor operations, strategy in case of incidental or accidental situations, periodic test and maintenance programs…).

### 2.2.2 Elaboration of the operating documentation

To elaborate the different documents in support to the commissioning test program and the future operation (routine operation), CEA has defined the operating documents structure based on the feedback of nuclear power plants, taking into account the specificities of experimental reactors. Three types of documents will be established:

- management and JHR safety and security referential documents (licensing),
- operating procedures (reactor and test devices),
- others activities (waste and nuclear materials management, transportation…).

JHR section is in support to the JHR project to follow the construction studies or the tests of the main utility equipments (primary pumps, the fuel handling machine, the hot cells equipments…) mainly for the operation and maintenance items. Through the documentation and the studies on going, the JHR section analyses the systems and the equipments to establish the maintenance and periodic test program but also begins to elaborate the reactor operating rules.

Approximately, 6000 documents will be mandatory to operate the reactor and the experimental hosting systems. Most of them will be validated during the commissioning test program, others by using the simulator (most of the incidental and accidental situations).

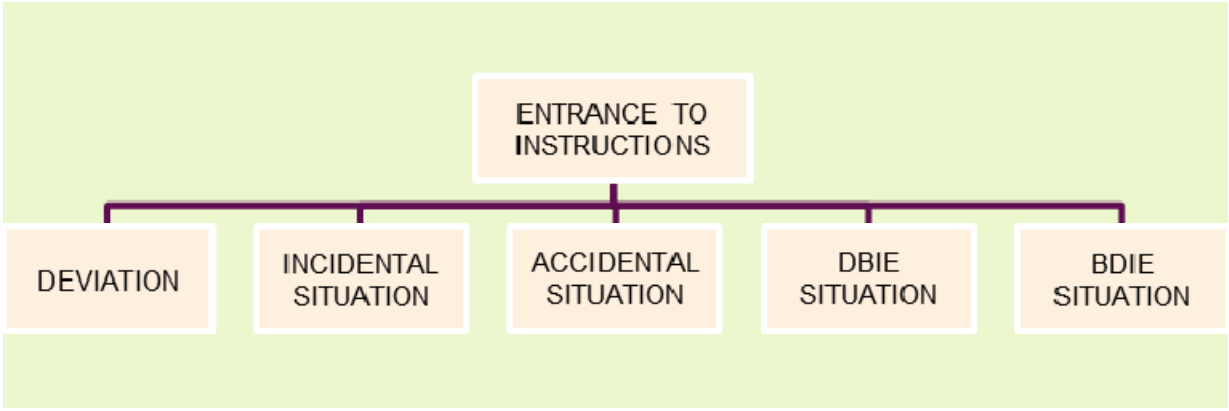
Operational procedures must provide direction and guidance to the reactor staff in the

performance of operational activities, including the conduct of test devices but also for the technical and administrative support activities (training, waste management, human resources, nuclear materials management…). They are in accordance with the safety requirements.
Concerning the operating procedures, there are rules and instructions:

- the rules: these documents identify the requirements, the limit conditions to operate, the strategy to conduct the operation,
- the instructions: these documents are associated to the rules ; they provide step-by-step actions for accomplishing a specific task within that activity.

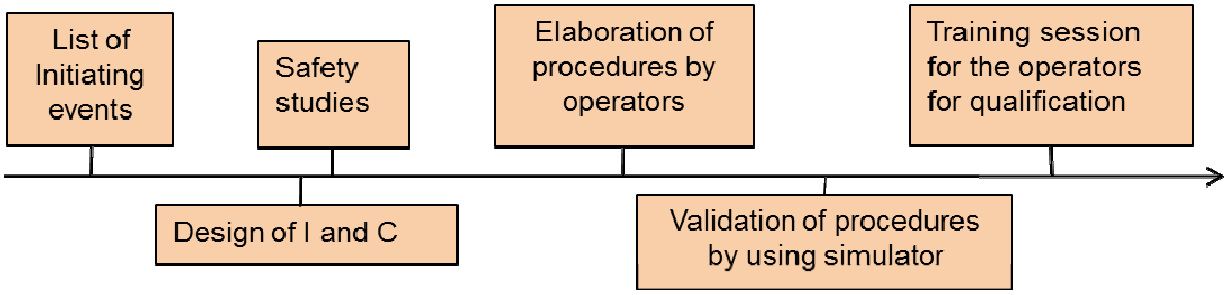
A specific item concerns the definition of the conduct strategy in incidental and accidental situations. The conduct strategy proposal, in incidental and/or accidental situations, is based on the feedback of the strategies applied in nuclear power plants, taking into account the specificities of experimental reactors and the specific conception of the command control of JHR. All the incidental and accidental situations were identified; more than 200 Postulated Initiating Events (PIE), will be taken into account. The proposed strategy consists in separating the complex situations from the simple ones. For the complex situations, a document of «entrance to instruction » will allow:

- to confirm the expected automatic actions,
- to check the safety functions parameters,
- to realize a diagnosis with the aim of an orientation towards the adapted instruction.




The orientation will be just a deviation situation (D), an incidental (I) or accidental (A) situation or Design AND Beyond Design Basis Accident (H and U) situations.

The sequence of events includes the actuation of the Safety Category 1 systems that control the process initiated by the Design Basis Initiating Events (DBIE). Where prompt reliable action is required to deal with DBIE, the reactor design includes the means to automatically initiate the operation of the necessary safety systems. This ensures that the three main safety functions, namely: reactor shutdown, core cooling, and radionuclides confinement are carried out with a high degree of reliability. The design reduces demands on the operator as far as feasible, particularly for the period during and following an accident condition (within 30 minutes). This period is devoted to use «entrance of instruction».
The next step will be to elaborate the first procedure and perform the study to identify the best strategy. The final step will consist in validation by using a simulator.




### 2.3 Elaboration of the maintenance, in-service and periodic test programs,

After identifying the main Systems, Structures and Components (SSC), important to safety, a first inventory of maintenance, surveillance, inspection and testing activities has been performed. Taking into account the project of organization of the operator staff (number of operator and competences), an optimization of the maintenance plan has been proposed in three categories:

- the maintenance program will be done by the operator,
- the maintenance program will be done by a specific sub-contractor,
- the maintenance program will be done by general sub-contractors managed by the Cadarache research center.

The objective of this categorization is also to optimize the maintenance subcontracting of a limited number of SSCs, to limit the risk of external compromises which would impact the reactor safety and the reliability.

This maintenance program should be reviewed since each contractor will send its own maintenance program strategy to confirm or modify the current project of maintenance plan. This part of activities has a huge impact on the reactor operation cost.

The in-service inspection and periodic test program will be in compliance with the requirements associated to the SSCs and depends on the different categories of classification (safety category 1 to 3). This program is adapted and optimized also with the schedule of the reactor in operation.

### 2.4 Elaboration of staff training program

Basis of the future organizational structure, this training program for the future operators has been elaborated taking into account the feedback of of similar worldwide nuclear facilities and the project of JHR organization structure. The strategy to establish this training plan was:

- identify the different requirements to work in a nuclear unit (occupational health and safety, radiation protection, nuclear safety culture, waste management, nuclear materials management…),
- identify the needs of competences to operate the reactor and the different circuits and establish the corresponding training program.

The training program preliminary inventory has identified approximately 130 different training courses. This program includes the JHR specificities. For the different phases of the project (commissioning test program, first start-up...) a schedule of the training sessions will be established in agreement with the actual annual recruitment of the reactor operation staff.

Fig. JHR Control room

## 2.5 Elaboration of commissioning test programs

The elaboration of the Commissioning Test Program consists to identify the needs of tests, instrumentation and/or calculations to verify the safety criteria and the performance of each Systems, Structures and Components (SSC) during the commissioning phases. The approach is a “step by step” one:

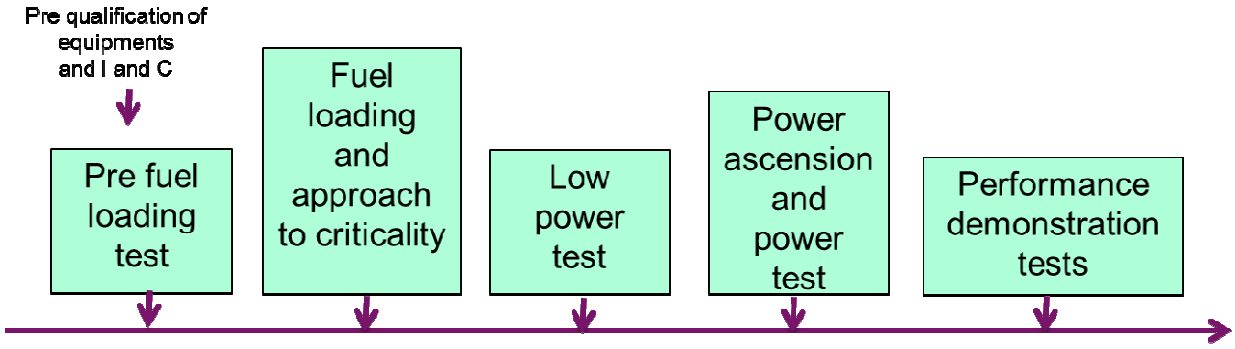
- Step 1: test assembly for each SSC,
- Step 2: functional test,
- Step 3: individual integration test,
- Step 4: global integration test.

Following some on-going studies (neutronic and thermal hydraulic calculations) specific devices/instrumentation, in support the first core loading and the first start-up, will be developed. The aim is to check the JHR nominal performances and safety criteria (neutron and gamma detectors, temperature or flow sensors…).

The commissioning phases have been divided into stages:

- Stage A: test of the required SSC before fuel loading
- Stage B: fuel loading and approach to criticality tests
- Stage C: power ascension, step by step, and power tests.

These commissioning tests will also be helpful for transferring to the operating staff the knowledge on the installed systems.




## 2.6 Design and implementation of the experimental device

CEA has to design and implement the first fleet of test devices expected at the reactor start-up. JHR safety requirements are used also to design these experimental hosting systems. An important issue is the implementation of theses test devices in the reactor: for each device, the implementation in the reactor building is studied to identify, for example, the power supply and instrumentation and control cabinets needs and also the impact on the venting and effluents

facility networks. The equipments in each experimental cubicle and the implementation of electrical cabinets are defined. The studies include also the using of hot cells, handling systems and temporary storage area. The JHR section uses the same “integrated system” (the CATIA software) as the primary contractor.

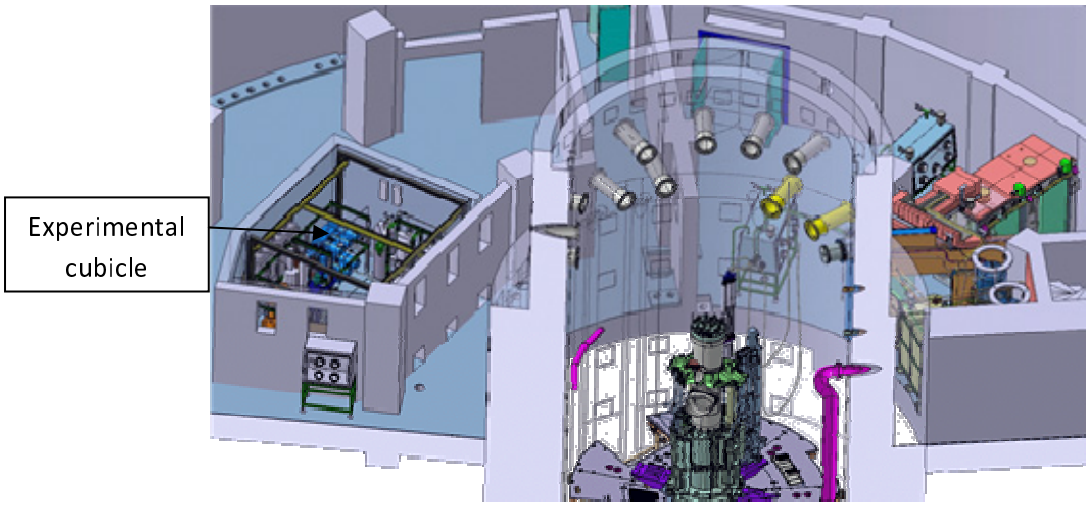



Fig. Layout of the experimental device in an experimental bunker

## 3 Conclusion

The construction of JHR which started in 2007 is going-on with target of commissioning by the end of 2017. In parallel to the construction of the reactor, the preparation of the future staff and of the organization to operate the reactor safely, reliably and efficiently is an important issue. This paper gives an overview of these actions to prepare the commissioning phases and the routine operation.


Fig. view of JHR site – September 2013

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