JULES HOROWITZ REACTOR PROJECT: PREPARATION OF THE COMMISSIONING PHASE AND NORMAL OPERATION

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ABSTRACT

Jules Horowitz Reactor (JHR) is a new modern Material Testing Reactor (MTR), currently under construction at CEA Cadarache Research Center in south of France.

It will be a major research facility providing experimental irradiation possibilities to optimize existing power reactors as well as to support the future reactors design.

It will allow:

- to study the behavior of materials and fuels under irradiation for development and qualification needs of nuclear power plants,
- to contribute and to secure the European production of radioisotope for medical use, (25% up to 50% of European needs).

The JHR is funded and steered by an international consortium gathering the following partners: European Commission and its JRC(EU), EdF (France), AREVA SA (France), FRAMATOME (France), CEA (France), SCK•CEN (Belgium), NRI-CVR (Czech Republic), CIEMAT (Spain), VTT (Finland), Studsvik (Sweden), DAE (India), IAEC (Israel), NNL (United Kingdom).

The CEA is the owner and the nuclear operator.

The construction of JHR is going on with target for a first criticality by second semester of 2021.

The design of the reactor provides modern experimental capacity which will be in support to nuclear energy R&D programs for the next 60 years.

In parallel to the facility construction, the operation, in order to be safe, reliable and efficient, needs to be prepared. It is also necessary to design and implement the first experimental devices for the reactor start-up in order notably to check the performances of the reactor.

In this framework, many actions are in progress:

- staffing and organizational structuring for the commissioning test phases and for operation,
- elaboration of the documentation to operate the reactor (safety analysis report, general operating rules, procedures, instructions…),
- writing of maintenance and periodic test programs,
- staff training by using dedicated tools (simulator…),
- performing commissioning test programs to ensure that the layout of systems and subcomponents fulfill the design requirements, the specification performances and the safety criteria.
- designing and implementing the first fleet of experimental devices in support to the commissioning test program and the future experimental programs.

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

The paper will present in more details this important phase of the JHR project.

1. Introduction

The construction of Jules Horowitz Reactor (JHR) is going-on and the facility would be operational at the beginning of the next decade. It will be operated by CEA, as an international users facility on Cadarache CEA site. The reactor design will allow providing modern experimental capacity in support to R&D programs for the next 60 years nuclear energy. It will also supply radio-isotopes for medical use.

JHR is a modern Material Testing Reactor (MTR). It's a pool-type reactor designed to reach a maximum power of 100 MWth. Its design allows a large experimental capacity (up to 20 devices) inside and outside the reactor core (in the Be reflector). Due to the high power density, the core primary circuit is slightly pressurized.

The nuclear unit includes a reactor building and an auxiliary building. The auxiliary building hosts:

- 3 storage pools for spent fuels irradiated, experimental devices and handling of core big component during maintenance phases,
- 4 main hot cells for irradiated fuel and waste management but also preparation, conditioning of experiments and non-destructive examinations on irradiated samples.

A transfer channel between the reactor building and the auxiliary building allows underwater transfers of spent fuels and experimental devices between the two buildings.

In parallel to the facility construction, it's necessary to prepare the commissioning test programs to ensure that the layout of systems and subcomponents fulfill the design requirements, the specification performances and the safety criteria.

These commissioning tests will also be essential to transfer the knowledge on the systems to the operating team.

2. Organization of the JHR project

The prime contractor, TechnicAtome, is responsible of the JHR design, manufacture and commissioning tests.

CEA is the owner but also the future operator. CEA organization gathers several teams:

- A team responsible of the project coordination: managing the design, the manufacturing phase and commissioning tests. This team is notably in charge of supervising the prime contractor,
- A team representing the future operator,
- A team in charge of the first fleet of experimental devices: managing the design, the manufacturing of the devices and associated equipments (non-destructive examination benches, laboratories…).

Of course, there are many interactions between these different teams.

3. JHR update status

JHR construction is currently under progress.

An important step in 2017 was the end of the civil works, with the auxiliary building closure in March, after the hot cells main structures introduction.

Factory acceptance tests of many components (like core block, fuel rack, control rod drive mechanism…) are ongoing.

The development of control and instrumentation systems is under progress.

Hot cells and pools liners are also ongoing.

Fig. 1: Hot cells liner

Fig. 2: Pools liner

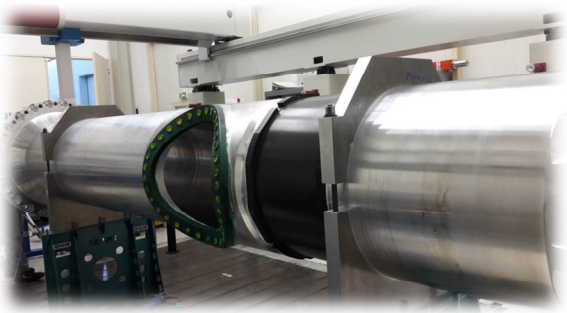

Fig. 3: Core block dimensional controls

Fig. 4: Core block assembly in factory

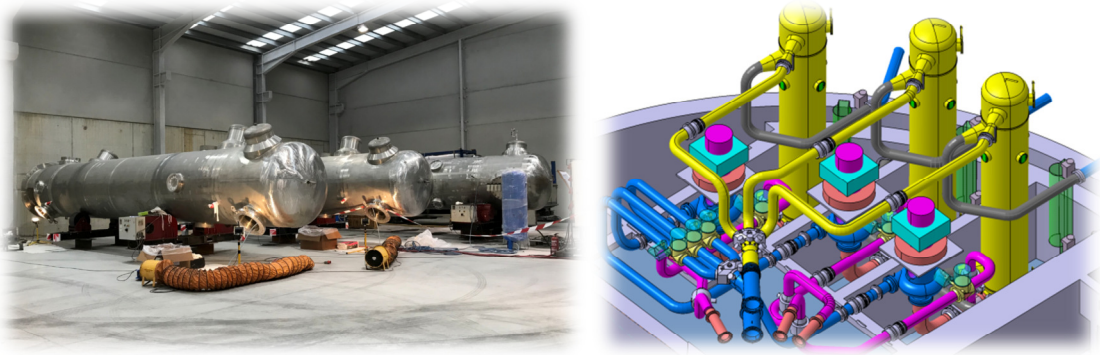

Fig. 5: Primary heat exchangers in factory

Fig. 6: One-site pool crane commissioning tests

2017 saw also the beginning of fuel manufacture.

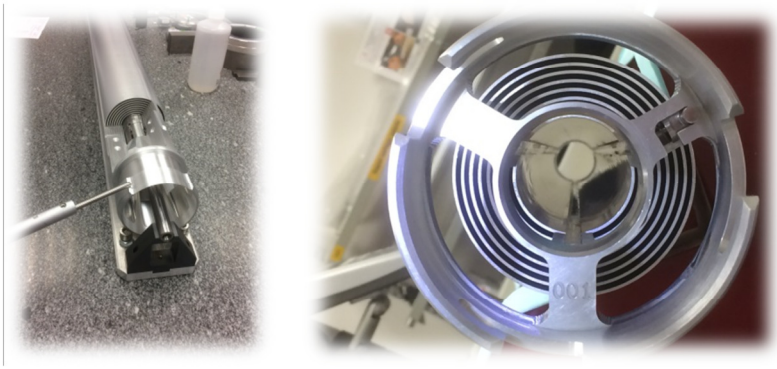

Fig. 7: Dimensional controls of a dummy fuel assembly

4. Preparation of operation

To be ready to operate JHR reactor, CEA needs to deal with several topics, particularly:

- Staffing: CEA has to hire many people (mainly technicians) until the commissioning to reach an operation team around 80 people (shift teams and normal operation teams). This hiring has to be progressive in connection to the need of operators for the commissioning tests and with the necessity to train people before being operational,
- Staff training, requiring participation to the commissioning tests,
- Operation documentation writing: around 4000 documents such as operating rules, instructions, and forms… have to be drafted for the commissioning tests.

5. Commissioning test process

5.1. Commissioning test scope

Commissioning tests include testing of all JHR infrastructures (reactor equipments but also experimental devices), as well as interfaces between JHR facility and CEA Cadarache center. They must enable to:

- check that the expected performances, as required in functional specifications, have been reached,
- verify the compliance to the regulatory framework,
- ensure that equipments meet the safety requirements,
- allow the future operator to take ownership of the facility operating.

Commissioning tests begin with first equipments fine-tuning tests and end with the delivery of tests results files, and after global testing with nuclear fuel.

5.2. Tests classification

On-site tests of equipments or functional systems are classified as following.

Type 0 tests:	Tests at the end of the on-site assembly work.
Type 1 tests:	Fine-tune tests of systems to check individual functionality of equipments.
Type 2f tests:	Commissioning tests involving the first in-systems performances check.
Type 2i tests:	Integrated commissioning tests covering several systems in order to check their simultaneous behavior to demonstrate that required performances are met.
Global tests:	Overall tests involving simultaneously most of functional systems (inter-connection systems), without fuel in core.
Fuel loaded tests:	These tests are carried out after core loading. They particularly relate to core –physic and thermohydraulic performances validation of systems needed to operate reactor. The current work deals with the optimization of the strategy for the start-up tests (timing of the tests, accuracy, power level, reactor configuration...).

This tests classification need to identify different functional phases, as detailed hereafter.

5.3. Operational division of commissioning tests

JHR work is divided in the following phases:

- assembly phases, corresponding to equipments assembly,
- Several testing phases, linked to tests progress (individual systems functional tests phase, inter connection tests phase, general operation phase).

So these phases match a functional division (phasing), not a geographic one. The following diagram shows the steps for equipments and functional systems testing.

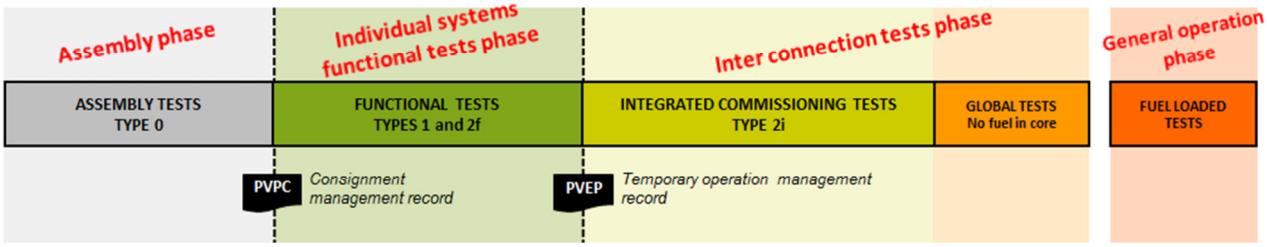

Fig. 8: Operational steps of commissioning tests

5.3.1. Assembly phase

This phase gathers systems for which assembly process or end of assembly checks are in progress. These type 0 tests are performed by industrial contractors.

During the assembly phase:

- Prime contractor is responsible for safety and work coordination on site,
- Industrial contractors are in charge of their equipments assembly,
- Future operator can attend equipments assembly process, in order to understand their operation and to be sure of their operability and maintainability.

5.3.2. Individual systems functional tests phase

This phase relates to the systems that met assembly checks. It allows carrying out type 1 and type 2f tests.

Transferring a system in this phase results in a PVPC (consignment management record) validation (see the process diagram below).

During this phase:

- Prime contractor goes on managing safety and work coordination on site. It also provides tests general supervision,
- Industrial contractors are in charge of their equipments tests,
- Future operator begins to take part to tests process by performing the safety procedures to :
    - Either configure safely an equipment or a set of equipments to forbid a specific handling (consignment, electrical and/or mechanical lock-out),
    - Or make an equipment or a set of equipments available (tag-out) for a testing or a work process.

This activity allows the future operator to learn about systems and to train to their operating. It also enables, in parallel, to validate control and operation documentation.

5.3.3. Inter connection tests phase

This phase is related to systems that met type 1 and type 2f tests, which need to be kept in service to carry on type 2i and global tests.

A system transfer in this phase is formalized by a PVEP (temporary operation management record).

During this phase:

- Prime contractor goes on managing safety and works coordination on site. It increases its responsibilities by supervising tests, then industrial contractors only give assistance,
- Future operator, as during the tests phase, is in charge of performing safety procedures. It carries on its technical training through systems temporary operating that it also controls under the prime contractor supervision.
  Moreover, future operator gradually deals with maintenance and regulatory checks.

5.3.4. General operation phase

General operation phase begins before loading fuel in reactor, at the end of global tests.

JHR facility responsibility is transferred from the Prime contractor to CEA, which becomes then nuclear operator.

During the general operation phase:

- Future operator is totally responsible of the facility; it manages especially safety coordination and controls the facility.
- The Prime contractor is only responsible for tests supervision,
- Industrial contractors do not operate any more.

The following diagram shows assignments and responsibilities of the Prime contractor, industrial contractors and CEA, particularly the future operator.

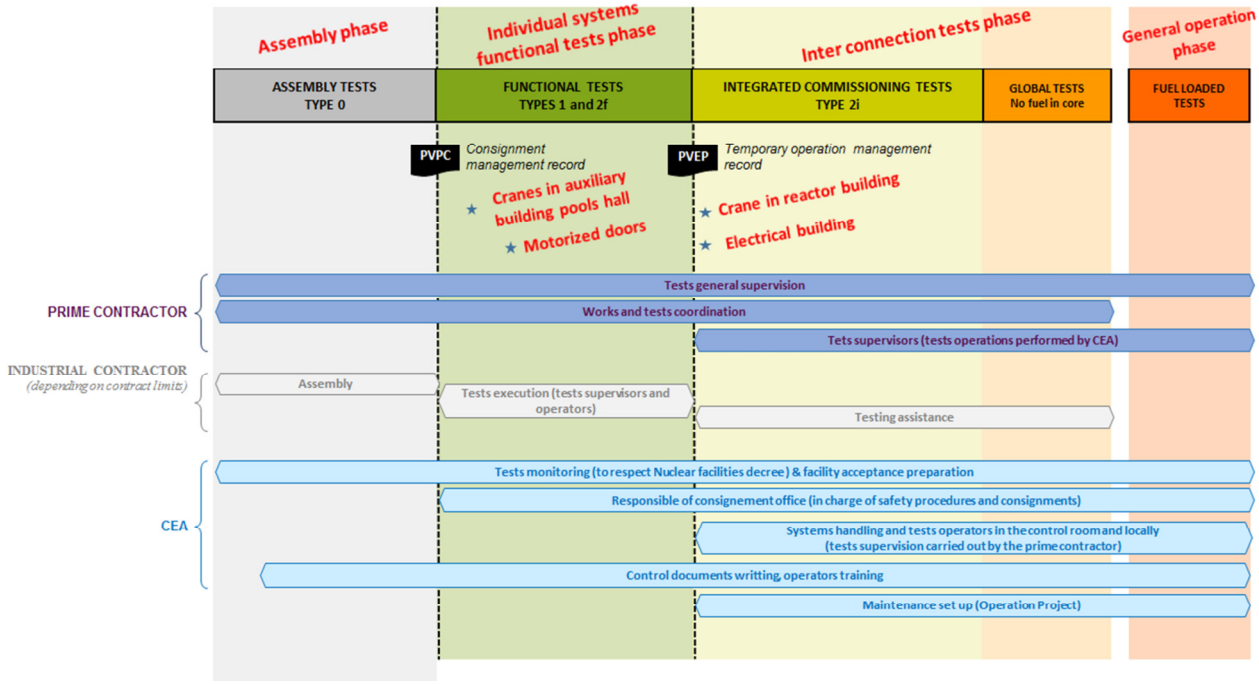

Fig. 9: General operation phases

6. Conclusion

The construction of JHR is ongoing and the reactor would be operational at the beginning of the next decade.

In parallel to the facility construction, it's necessary to prepare the commissioning tests which are essential to ensure that the layout of systems and subcomponents fulfill the design requirements, the specification performances and the safety criteria, but also to transfer the knowledge of the systems to the operating team.

This paper gives an overview of the JHR commissioning tests organization with the progressive implication of the future operator, beginning by performing the safety procedures, up to the facility operation.

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