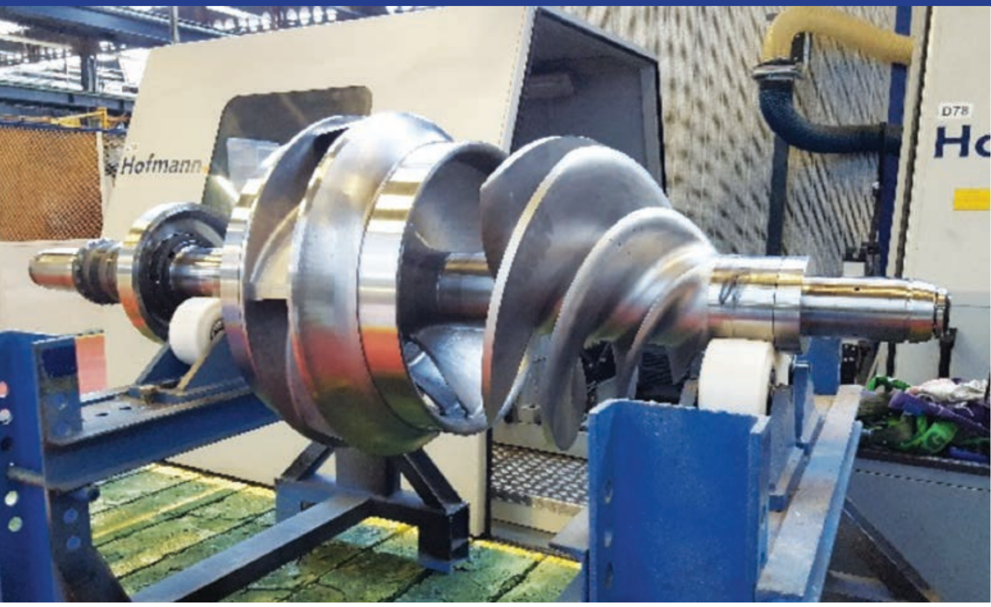
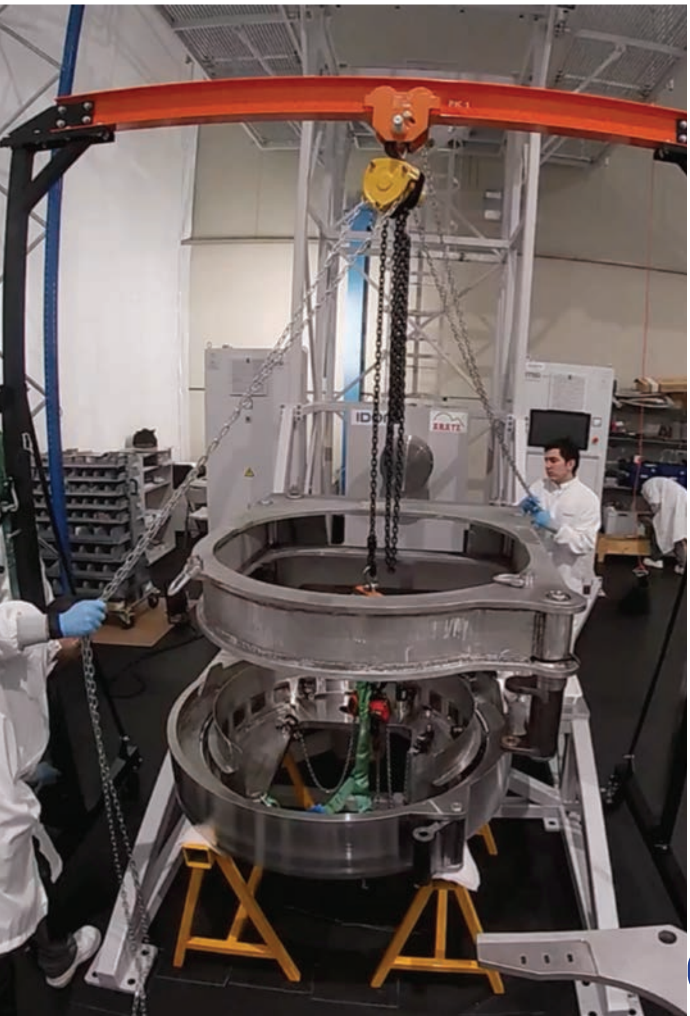
JHR

Activities Report 2018





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2018 JHR Activities Report

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The Jules Horowitz Reactor *Project*

The year 2018 was marked by further progress on JHR construction. It was also a year of continuing actions working towards setting up experimental capacities.

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FOREWORD

First and foremost, 2018 was marked by further progress in JHR construction. A key construction milestone was the final acceptance of the civil works of the nuclear buildings in April 2018 after strong involvement from all parties. Installation of metallic liners in the various pools and in the transfer channel was continued and will be completed in 2019. As regards in-factory manufacturing, several key-components such as the reactor pile-block, were completed and successfully passed the factory acceptance tests (FAT). In addition to these tests, the final packaging of the three heat exchangers for the primary system was completed. Finally, the installation and welding operations on the metallic liners for the hot cells are nearing completion.

It was also a year of continuing actions in setting up experimental capacities, with progress made with the UGXR and HGXR benches (under fabrication up to now) as well as the ADELINE, MADISON, MICA, LORELEI and CLOE irradiation devices.

These events were only possible thanks to the unstinting efforts of the technical teams.

Though faced with a number of technical, scheduling and cost-related construction challenges, the team dynamics and output have nonetheless managed to meet expectations, with outstanding achievements and ever-strong partnerships - the key to a successful JHR project.

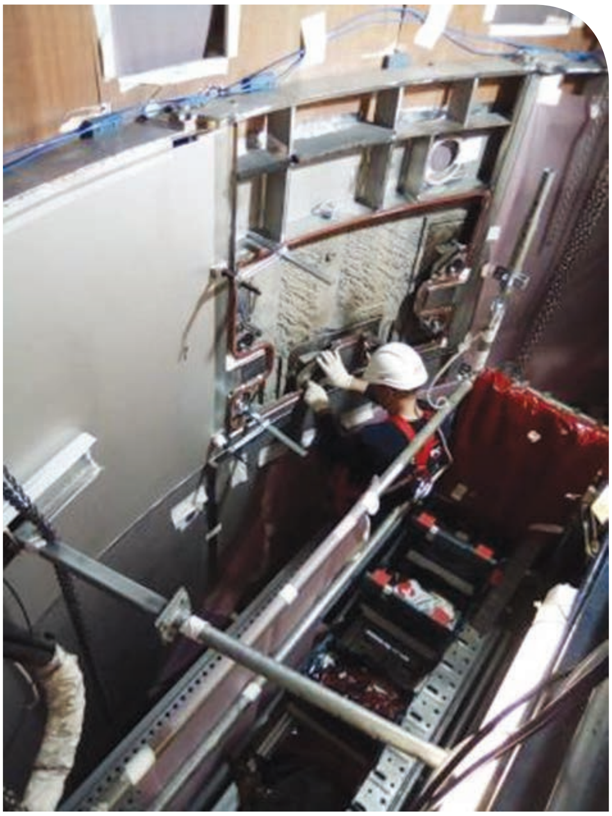
Régis Vallée
JHR Project leader

JHR *facility design and construction status*

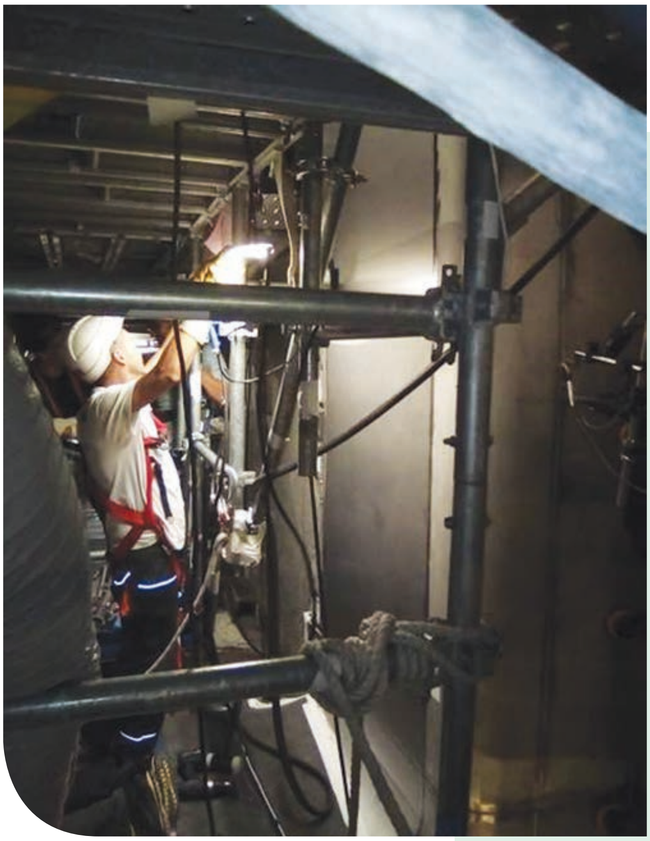
1 JRH CONSTRUCTION STATUS

1.1 Pool liners

The major activity in 2018 was the installation of the reactor pool liner.



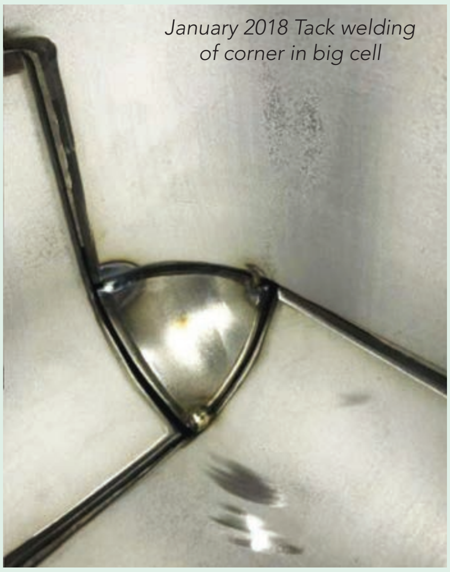
Several metallic plates forming the water transfer channel between the reactor pool and the interim storage pools were also welded.



1.2 Hot Cells: NRI/CVR contribution

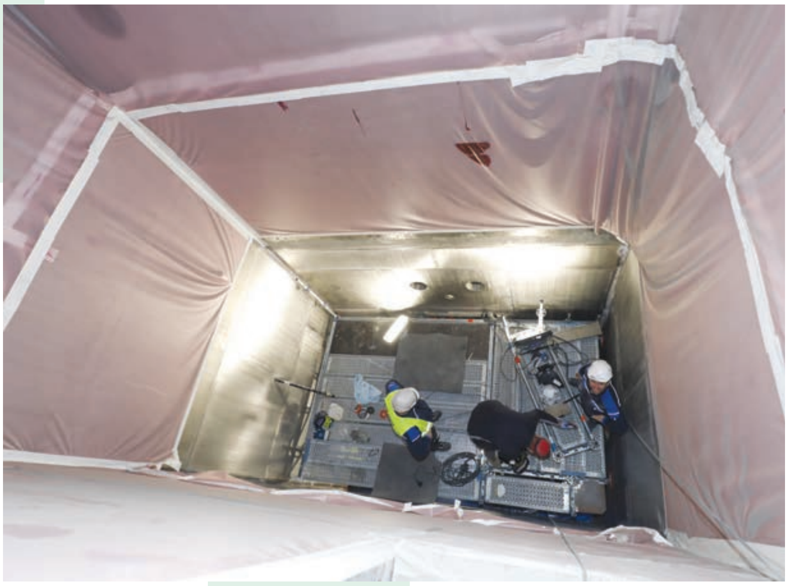
In 2018, major progress was made in the construction of the four large hot cells and the three small hot cells: their liners were completed. The liner leak-tightness test of the four large hot cells has been checked. The biologically shielded doors have been installed in their specific channels. The hinges and the sliding doors have been equipped and loaded with lead and HDPE.

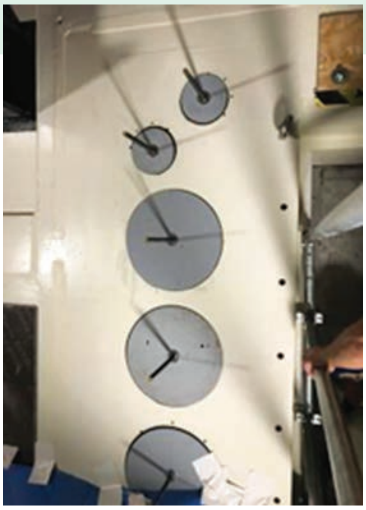
The factory manufacturing of the loading equipment has been finalised and the onsite assembly is underway for testing.



January 2018 Tack welding of corner in big cell

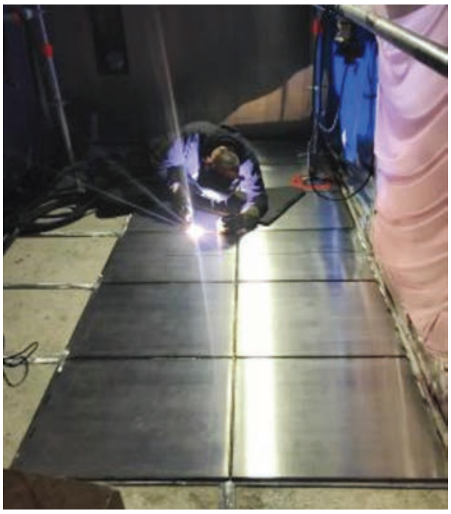
27/04/18 liner ECR level 5





August 2018 leak test of the big cell liner

Plancher ECD sept 2018



ECS Liner on the floor November 2018

The pre-manufacturing of several pipes continued in 2018 with the sub-contractor.
The supply of DN 400 and DN 600 flanges for the primary system also continued in 2018.
The DN 600 flanges to be mounted in the pool have been manufactured and the FATs are in progress.
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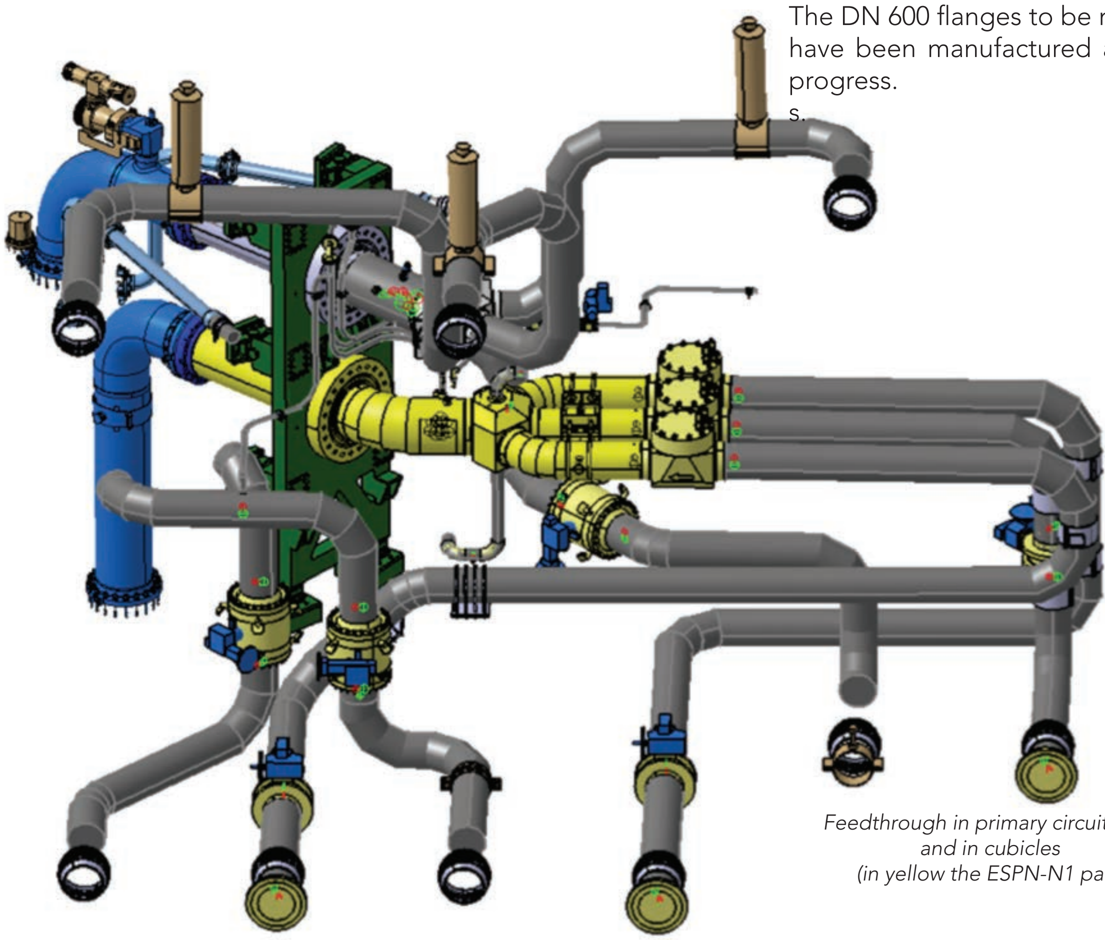
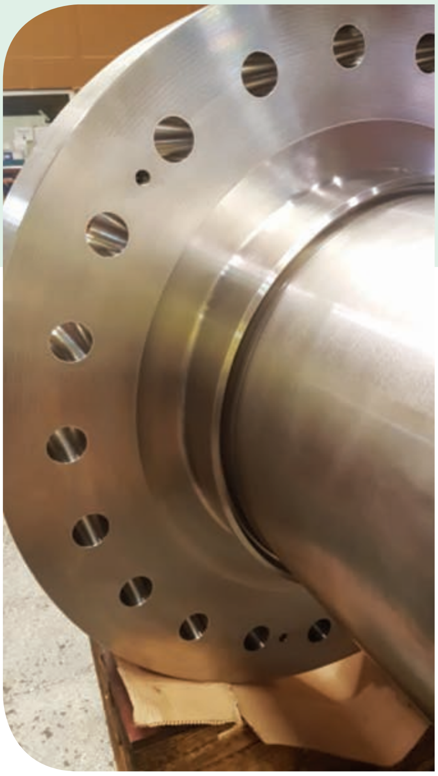


Feedthrough in primary circuit pool and in cubicles (in yellow the ESPN-N1 part)



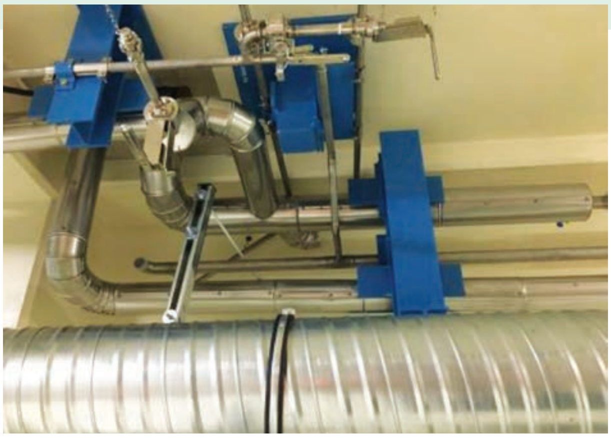
Ring of the feedthrough ESPN N1 after welding and machining

off-shout of components ESPN N1 under manufacturing and during the FAT (Factory Acceptance Tests)

1.3 Fluid Circuits

The main activities in 2018 for this topic were: Anchor structures in the nuclear Auxiliary Building were installed in the floors to secure the various vessels. This concerns a total of 8 vessels for liquid waste (active liquid waste, special effluents and suspect effluents) and the vessel for the ultimate system for reactivity control, gaining some advance on the schedule for the benefit of the general civil works.

In the electrical supply and wardrobe building, the lines for several fluids have been installed (nitrogen, pressurised air and water). Hydraulic tests were also successfully performed and some of the fluid lines have since been insulated.



Path of utility lines in the wardrobe building

In a dedicated room, the sub-contractor has manufactured and mounted a structure on the floor to host a sanitary water tank.

Mounting of planking

Sanitary water tank

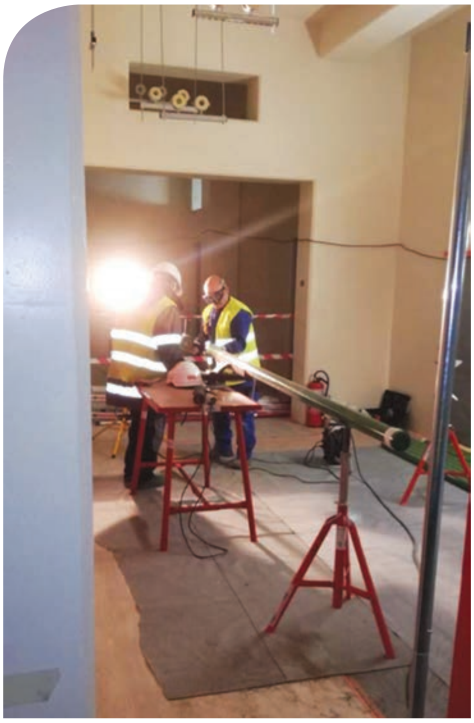
1.4 HVAC

The scope of the HVAC work consists in installing systems and equipment to ensure the ventilation of the electrical supply and wardrobe building (called BAV).

These systems were installed as they were delivered, area by area.

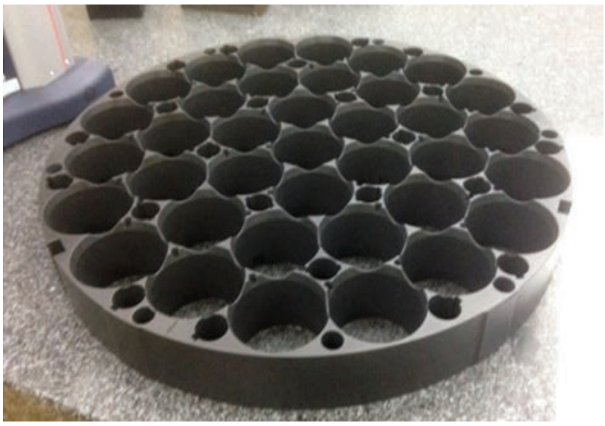
The following operations were performed on each level of the BAV building:

- *Supply and installation of support parts and ventilation systems*



2.1 Fuel rack

The fuel rack is designed to hold the fuel elements, inter-element mandrels, and irradiation test specimens. It must withstand core pressure loss and output pressure measurements.



The aluminium forged blank of the upper part of the body was welded to the lower cylindrical shell (final thickness: 7 mm) using an electron beam method.

A deep drilling technique (over a length of 900 mm) was used to create the bore holes. The sub-contractor demonstrated that the specified tolerances (location of the ∅) were met in terms of the input and output and straightness of the bore holes thanks to the machining of a demonstrator.

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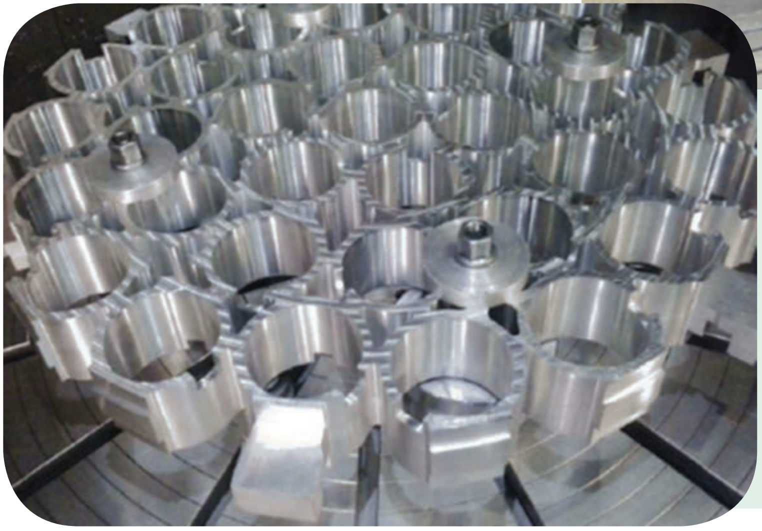


A deep drilling technique (over a length of 900 mm) was used to create the bore holes. The sub-contractor demonstrated that the specified tolerances (location of the ∅) were met in terms of the input and output and straightness of the bore holes thanks to the machining of a demonstrator.

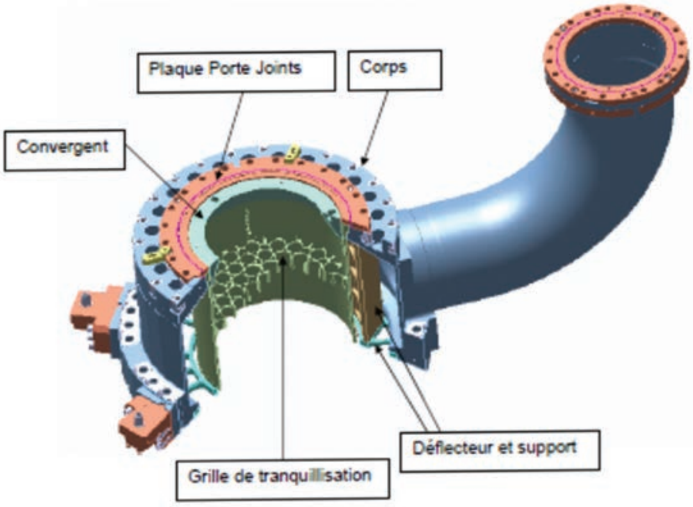
A mock-up of low grid was made to validate the manufacturing procedure and the development of the machining processes (water jet cutting, milling, and surface treatment).

2.2 Water Box (primary cooling system)

The primary cooling water box (ESPN N II) distributes the fluids to the core vessel. It is also used to position and support the core vessel, the reflector water box and the displacement system with chairs and anchor interfaces. It accommodates the convergent as well as the stilling grid, which is designed to homogenise the velocity of the fluid before its change of direction.

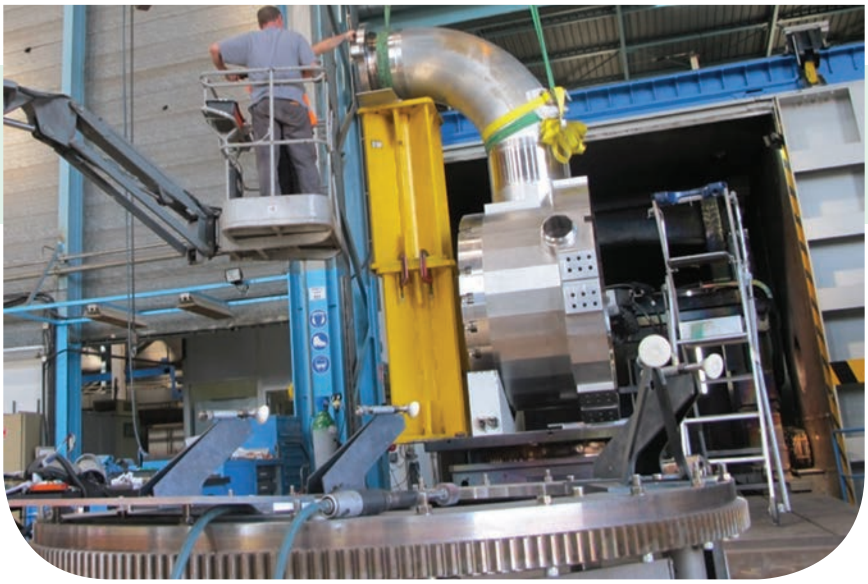
Manufacturing difficulties occurred due to the complexity of the parts to manufacture and the size of the blank body which involved a significant number of machining hours.

The stilling grid has 17,000 calibrated holes.



The DN 600 elbow was welded to the body of the stainless steel bushing using an electron beam method, the elbow positioning was checked by a laser tracker.

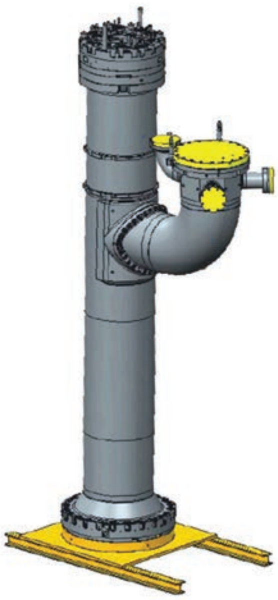
The DN 600 elbow was welded to the body of the stainless steel bushing using a high-quality process. The reflector water box is designed to cool the pool and experimental devices.



2.3 Hydrostatic test

It supports the displacement systems with chairs and anchor interfaces.

ESPN-classified components underwent a hydrostatic strength test at 23 bar.



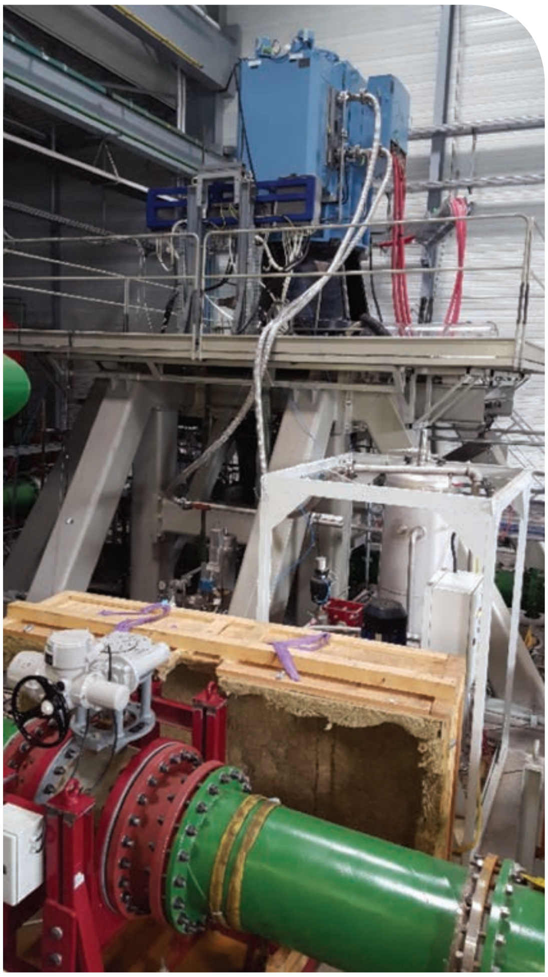
Core vessel and closure head

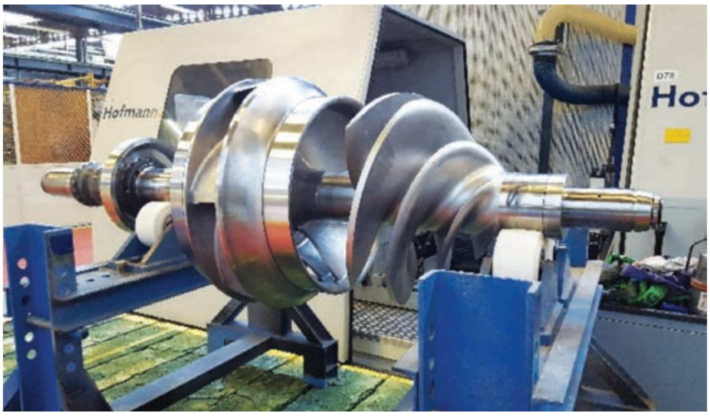
Primary water box and plug

2.4 Primary pumps

The supplier of the primary pumps is providing three systems for the JHR. This includes the supply of the pumps, associated engines, speed variators and transformers.

The first-of-a-kind pump has to undergo endurance tests. The first of these tests were performed at the end of 2017. They resulted in some modifications made to the hydraulic part, which were done in the first semester of 2018. This allowed us to resume such tests in autumn 2018: the pump functioned continuously for 800 hours without any issues: the detailed expertise is on going.



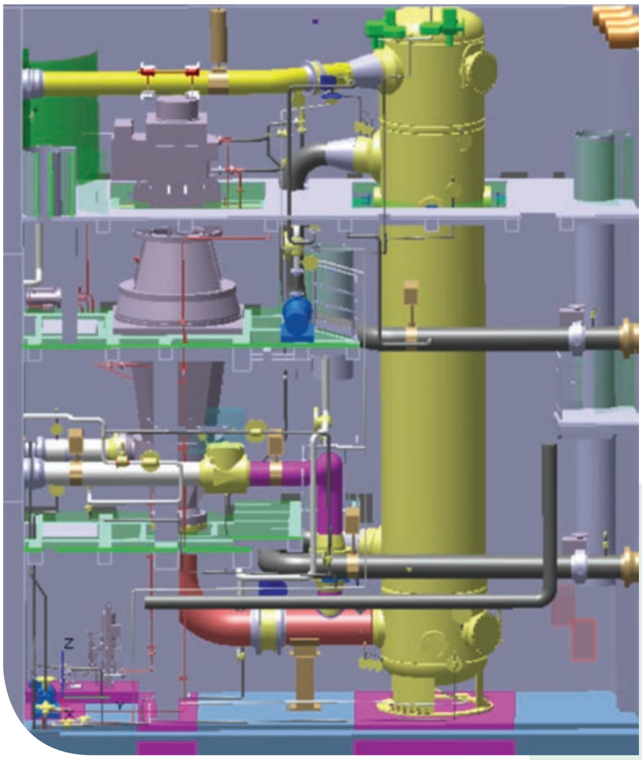


2.5 Primary system heat exchangers (CIEMAT contribution)

During the year 2018, the following activities were performed:

- *Finalization of the hydraulic tests.*
- *Completion of inerting, packaging and storage of the three heat exchangers.*

Exchanger fully packed

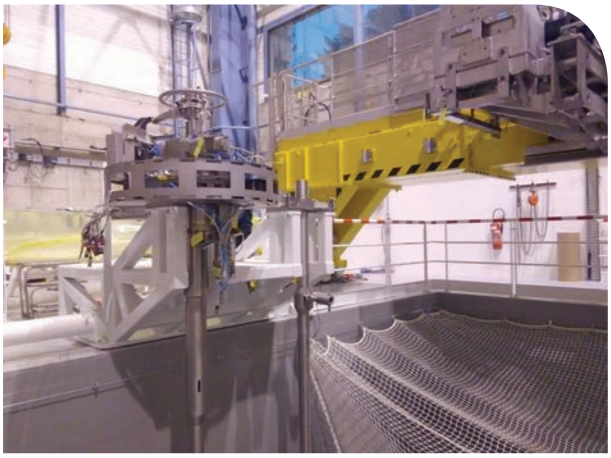


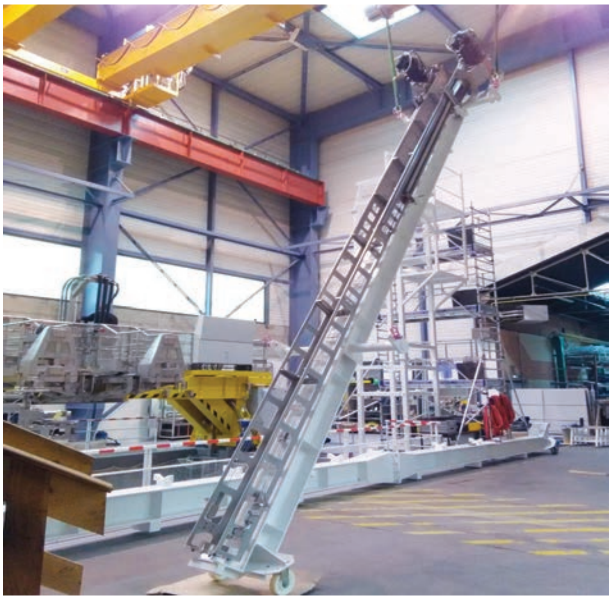
Mounting in the primary cubicles

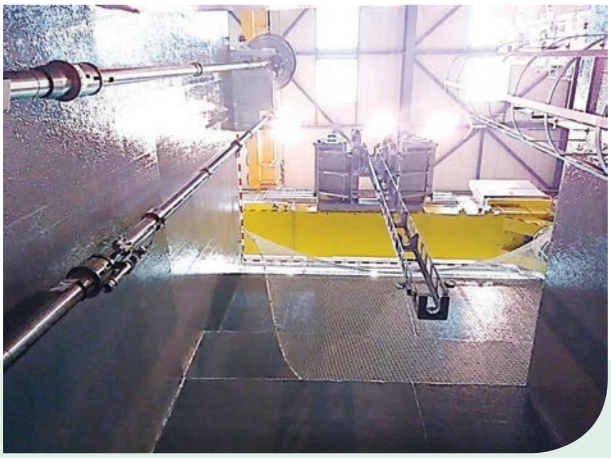
2.6 Loading Machine

The year 2018 has been marked by the end of the manufacturing of mechanical components for the loading machine, the access path and its hook.
The non-classified part of the I&C system has been integrated. Equipment has been transferred and assembled in the sub-contractor's pool for tests.
The photos below show different test of the loading machine.

Several view below of the loading machine under tests







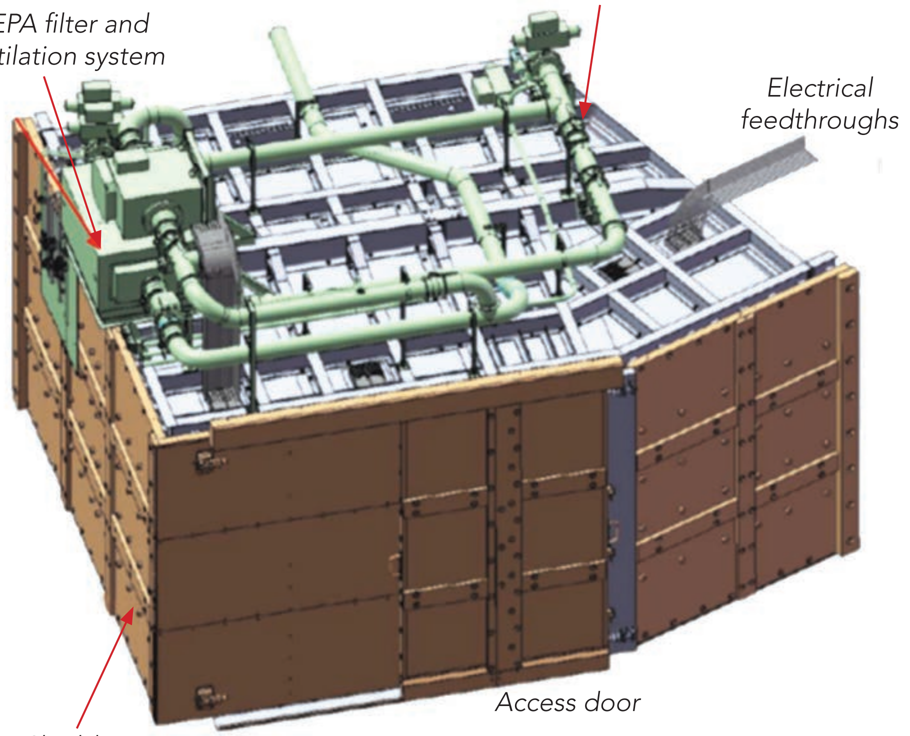
Experimental devices

2.1 MADISON

Dedicated to LWR fuel experimental needs:
The MADISON device will provide the nuclear industry (utilities, research institutes, fuel vendors, etc.) with a facility dedicated to testing **LWR fuel samples** under normal operating conditions of power plants:
- **An in-pile part** located on a displacement system in the JHR reflector will provide neutron flux conditions required for any type of experimental programme. Fuel linear power and transient scenarios will be representative of the normal operation of power reactors to guarantee that no clad failure can occur.
- **A water loop** implemented in the JHR reactor building will supply the in-pile part with the thermal-hydraulics and chemical conditions specified by customers.

The CEA plans to have this device available for JHR start-up.

Main achievements in 2018
This year has seen rather positive developments for the MADISON device.
The final cubicle design was approved and the structural steel procurement process was completed.
This heavy structure (about 40 tonnes, stainless steel liner, reinforced by steel beams, able to withstand 1 bar of internal overpressure and equipped with biological shielding) is to mitigate consequences in case of a hypothetical breach in the high-pressure primary system.

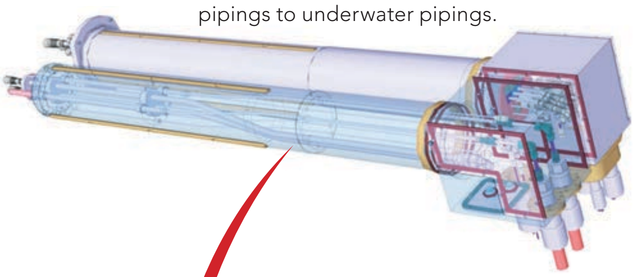


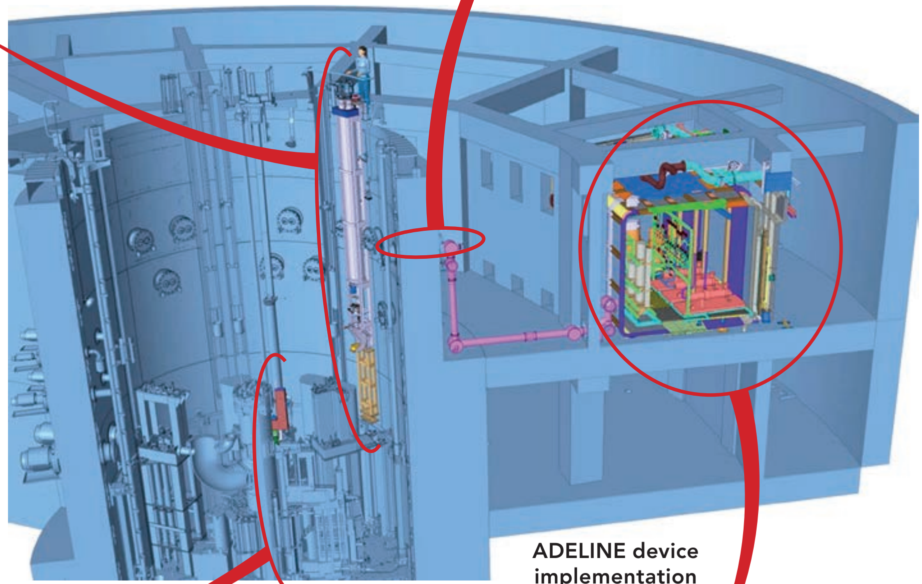
Cubicle cutaway view
in the reactor experimental area

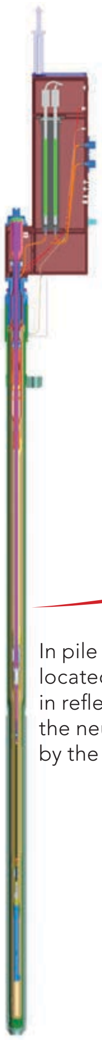
2.2 ADELINE

This equipment can be described as a one-rod loop device to test the irradiation limits of LWR fuel samples. The first version of ADELINE (Advanced Device for Experimenting up to Limits Nuclear fuel Element) to be taken into account by the project is dedicated to power ramp testing.

Description of the ADELINE irradiation loop (latest design)







During 2018, it has been carried on its multidisciplinary definition design of the ADELINE loop. This involved checking and integrating design compatibility with the overall RJH constraints. Images below are examples of those studies.

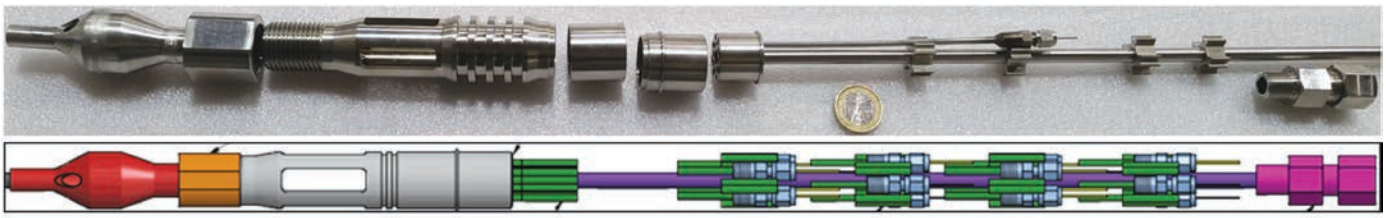
2.3 MICA

MICA is in-core test devices dedicated to material irradiations. The principle of these devices consists in obtaining the target temperature of the experimental samples via the equilibrium between gamma heating and heat losses through the containment walls of the test device. Homogeneous temperature and high heat losses are obtained by immersing the samples in NaK liquid metal. The possible chemical reaction between NaK and water requires double-wall containment with permanent control of the leaktightness of the two walls. The temperature is controlled accurately by using electrical heaters located on the inner tube.
MICA operates with radial heat losses in front of the samples; the maximum ageing rate possible is about 10 to 12 dpa/y because of gamma heating.

Mechanical studies on design and structural analyses continued in 2018, to be able to reach a complete technical solution before the tender consultation process. Detailed technical solutions have been defined, and stress analysis requirements have been fully met.

- **Feedthroughs**

Prototype of the feedthroughs located on the sample holder (Techno Plus Industrie – studies performed in 2017 – prototype manufactured in 2018).



Prototype of the sample holder feedthroughs

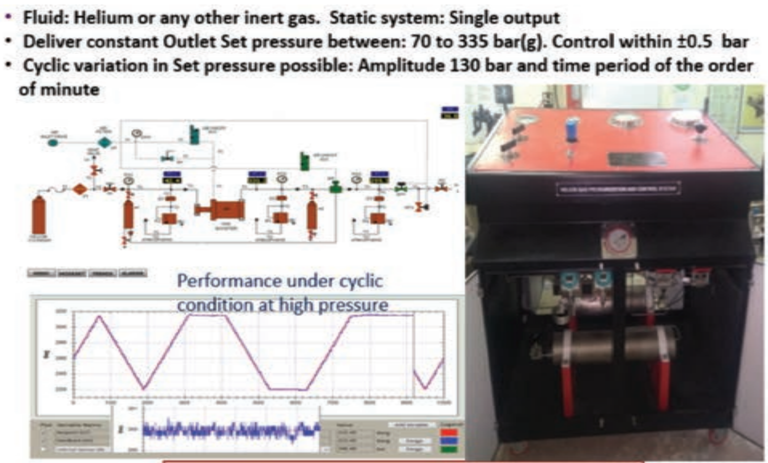
3.1 CLOE

Due to the ageing of NPPs, stainless steel core components are subjected to higher radiation doses, making them more prone to local corrosion known as irradiation-assisted stress corrosion cracking (IASCC). To be representative of LWR environments, IASCC studies need to be supported by integral tests taking into account irradiation effects, thus requiring a MTR and a specific experimental device. To meet these industrial needs, the design of CLOE (Corrosion LOop Experiments) is being carried out in collaboration with the DAE-BARC teams.

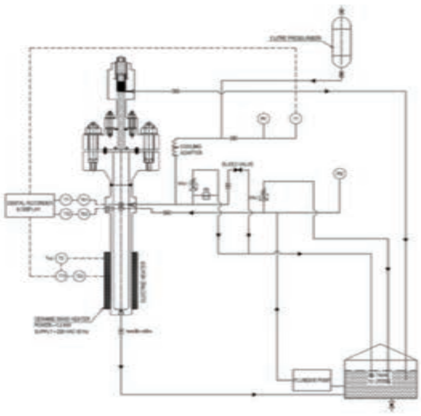
Main achievement in 2018

The preliminary design of CLOE has been finalized with modifications to the in-pile device head to take into account JHR interfaces. The first version defining the limits of contribution and supply in the framework of the DAE in-kind contribution has been finalized. The BARC developed an autoclave test facility and a He gas pressurization system to qualify critical components like instrument feedthroughs and bellows and for DCPD calibration. Experiments have been performed to qualify flow amplifiers including their nozzle tip coating to study its erosion behaviour.

Test Set ups for Mock-ups & Qualification of CLOE Components



Bellows pressure control system



Experimental shed for 1:1 Prototype Process Loop_CLOE

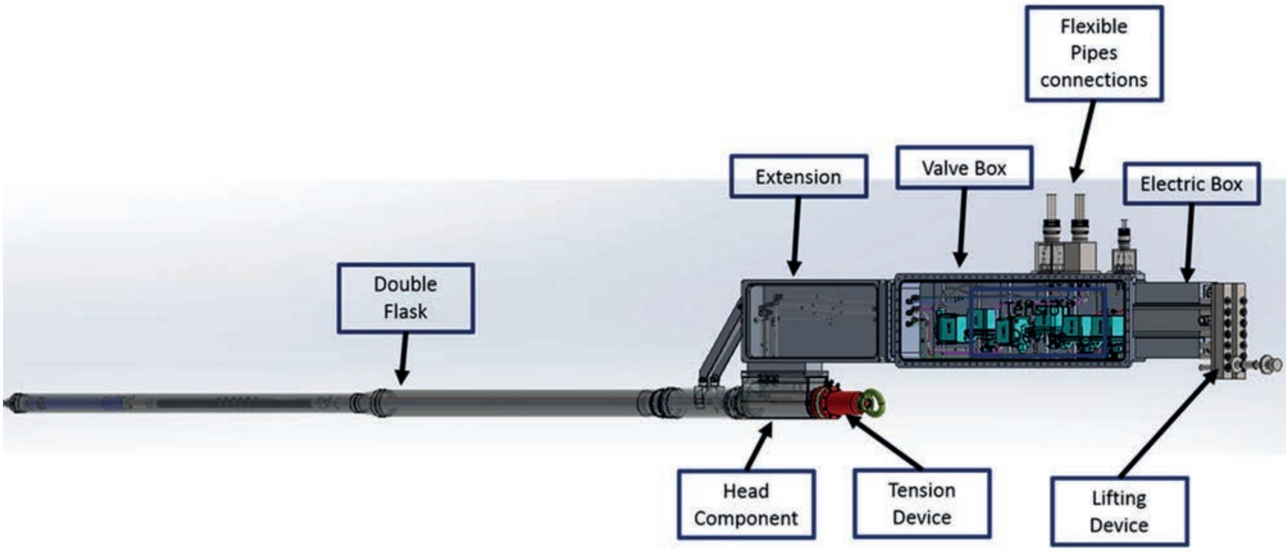
Autoclave Test Facility

3.2 LORELEI

The LORELEI (Light water One-Rod Equipment for LOCA Experimental Investigations) test device is designed to study the thermomechanical behaviour of a fuel rod and fission products (FP) released under loss-of-coolant accident (LOCA) conditions.
The device is a single-rod closed loop system placed on a displacement device inside a defined channel in the reflector. This equipment will consist of a pressurized in-pile thermo-siphon able to cool a single fuel sample for fuel re-irradiation before triggering the LOCA sequence. It will be equipped with a gas injection system able to rapidly dry-out the fuel rod and simulate a LOCA transient.
The device will be used to investigate fuel cladding ballooning and burst, as well as cladding corrosion phenomena (oxidation and hydrating), post quench behaviour and fission gas releases.
The design and manufacturing of LORELEI constitutes the in-kind contribution of the Israel Atomic Energy Commission (IAEC).

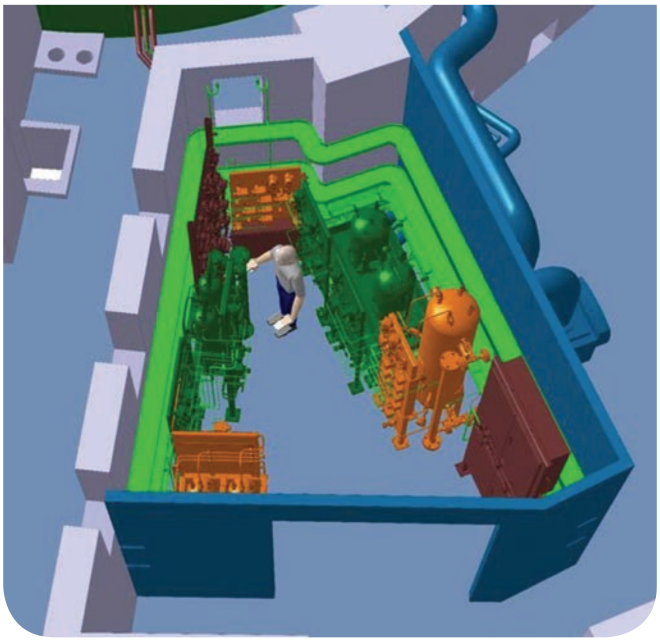
Achievement in 2018:
The production readiness phase started in 2017 and will continue in 2019. At the beginning of 2018.

LORELEI in-pile part (presented in horizontal position, vertical position in operation).



An example of a LORELEI component: the tensile device designed to generate controlled stress on the cladding during the quenching phase:

The LORELEI cubicle



2 NON-DESTRUCTIVE EXAMINATION DEVICES

2.1 Introduction

Within the framework of JHR construction, non-destructive examination (NDE) systems have been required for:

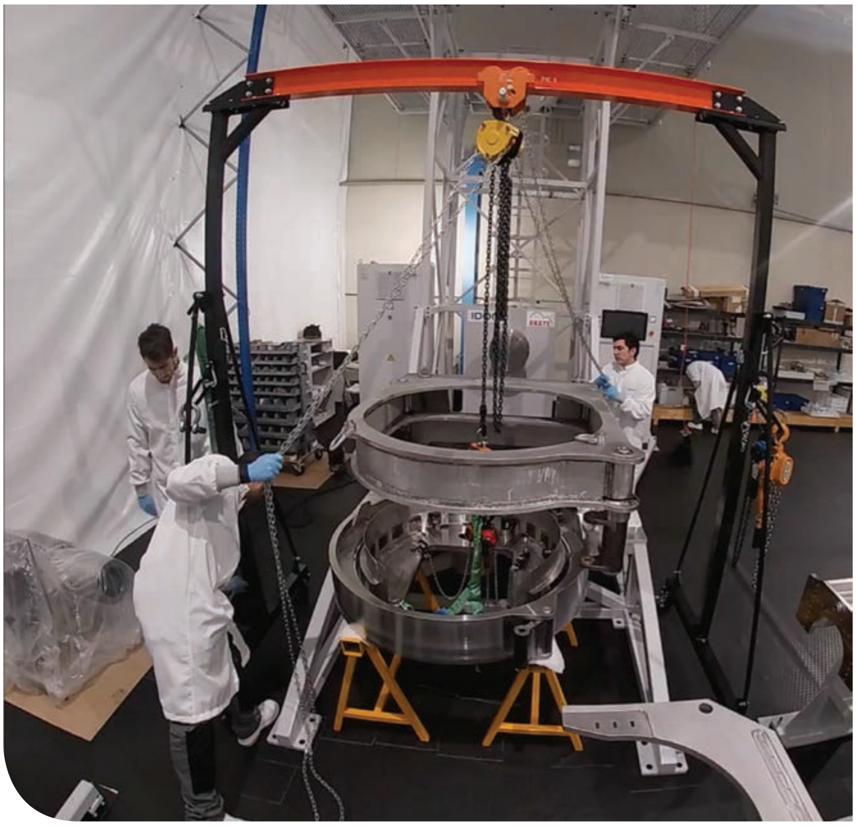
- *Underwater examinations on integral devices (in-pools).*
  - o Neutron imaging system (reactor pool).
  - o Gamma and X-ray scanning systems (UGXR system), one for reactor and one for storage pools.
- *In-air examinations on samples (hot cells).*
  - o Gamma and X-ray scanning system (HGXR system).
  - o Neutron imaging system (NIS).

2.2 Gamma and X Ray scanning system VTT Contribution

2.2.1 Construction of UGXR benches

In 2018, the manufacturing of the bench components was finalized. Some of the components needed further modifications, as it was noted at a very late stage that the operation area of the largest expected test device was too limited for rotational movements inside the bench, but modifications were performed successfully. VTT's sub-contractor, prepared themselves for the assembly and testing phases by constructing a specific clean area at the workshop and finalizing all the procedures for the factory acceptance tests. In addition, the testing tower and other auxiliary constructions for the bench testing were finalized.

The assembly of the two benches is currently in progress. For the I&C of the benches, the alpha and beta versions of the software were tested and all electromagnetic compatibility tests were successfully performed.



UGXR benches rotating & floating frame assembly on the fixed frame.

June 2019

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