IGORR - New Research Reactor JHR (France)

Irradiation Devices « ADELINE type »

Preliminary Qualification Tests

DE LA RECHERCHE À L'INDUSTRIE

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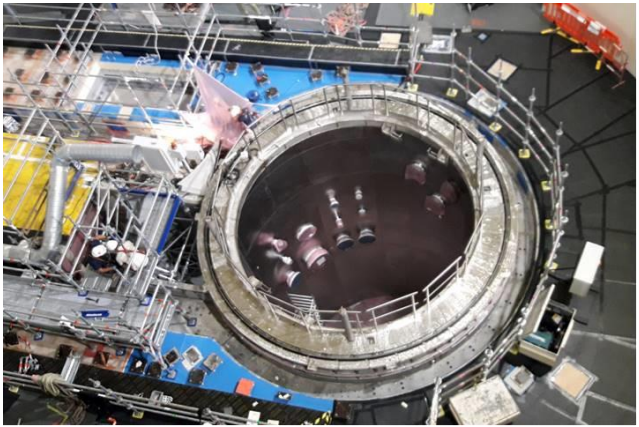
REMINDER OF THE CONTEXT

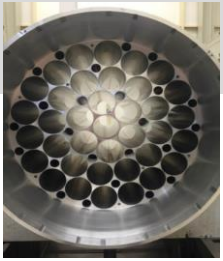
The Jules Horowitz Reactor which is currently under construction at the CEA Cadarache centre (South of France) is a Material Testing Reactor (MTR).

It will be used to perform irradiation tests on Fuels and Materials samples as part of support programmes for current Nuclear Power Reactors (Gen II and III) and future Reactors (Gen IV and fusion).

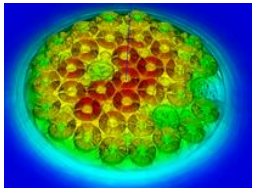
This reactor will also be used to produce radioelements (mainly Mo-99) for medical purposes and will meet 50% of the European demand in this field.

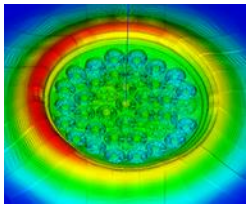


JHR MAIN CHARACTERISTICS



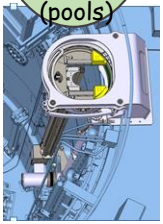
- ✓ Compact core is designed to generate
  a nominal power up to 100 MW_{th},
- ✓ Cylindrical in shape,
  with a diameter of 60 cm and a height of 60 cm,
- ✓ The reactor is immersed
  under 9.3 m of water in a pool that is 12 m deep,
- ✓ The core is under-moderated
  in order to generate strong fast neutron fluxes,
  up to 5.10^{14} $n.cm^2.s^{-1}$, E > 1MeV,
- ✓ The primary system is closed and slightly pressurised
  12 bar upstream of the core
- ✓ The cooling water in the core flows upwards
  at a velocity of about 10 m/s,
- ✓ Gamma heating in the core is about
  15 to 20 W/g (maximum local value),
- ✓ The beryllium reflector is 30 cm thick and surrounds the core vessel.
- ✓ The thermal neutron flux in the reflector is 3.10^{14} $n.cm^{-2}.s^{-1}$.



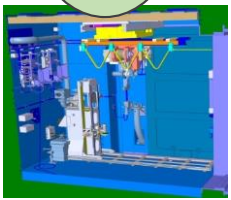


JHR EXPERIMENTAL FLEET

UGXR
(VTT-IDOM)
X+gamma rays examinations systems
(pools)



HGXR
(VTT-IDOM)
X+ gamma rays examination
(hot cells)



MOLY SECTOR
Medical application

OCCITANE
Vessel Samples irrad.

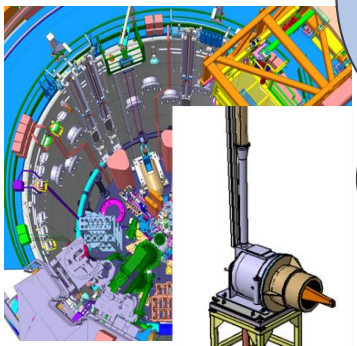
ADELINE
LWR power ramps tests

MICAs
Ageing materials
Tests

CLOE
(BARC-IGCAR)
Materials corrosion studies

JHR main characteristics

NORTH



LORELEI
APRP studies tests

NIS
Neutron Imaging System

MADISON
LWR cooking test

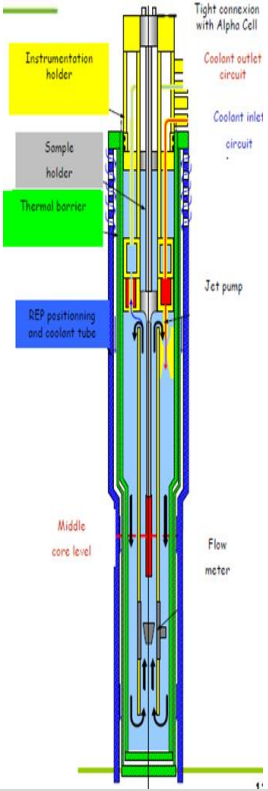
JHR-CARMEN & other Start up DEM devices
core characterisation

JHR FACILITY BNI n°172

JHR ADELINE EXPERIMENT

CUSTOMER: FRENCH NUCLEAR OPERATOR (EDF)

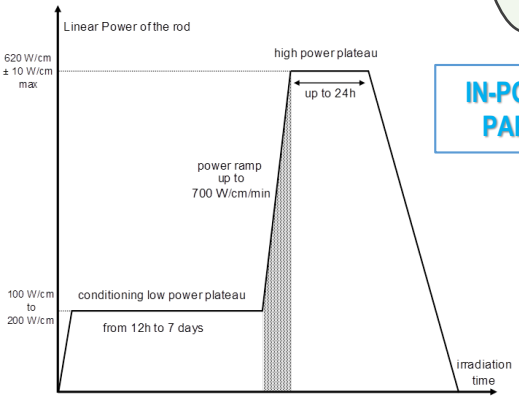
FUEL IRRADIATION LOOP
DEVOTED TO POWER RAMPS TESTS TRANSIENTS



TH conditions : LWR

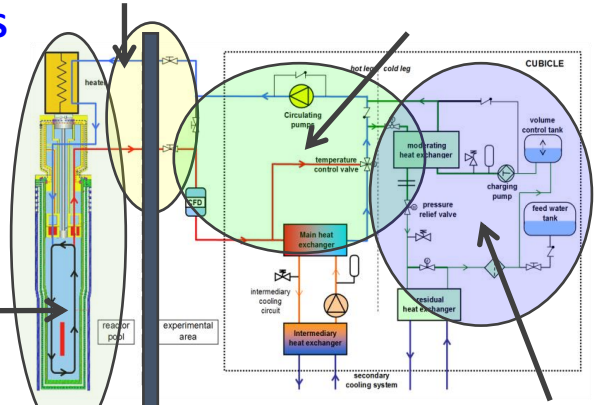
PWR : 155 bar , 320° C,

BWR : 75-80 bar , 295° C.



CONNECTING LINES

MAIN COOLANT LOOP

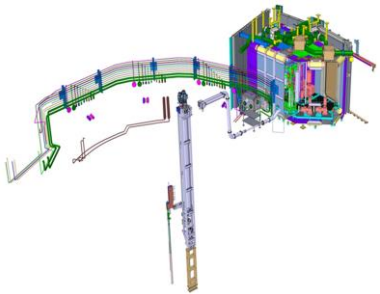


IRRADIATION DEVICE

IN-POOL PART

OUT-OF POOL PART (CEDE)

CHEMISTRY CONDITIONNING FLUID SUPPLY LOOP

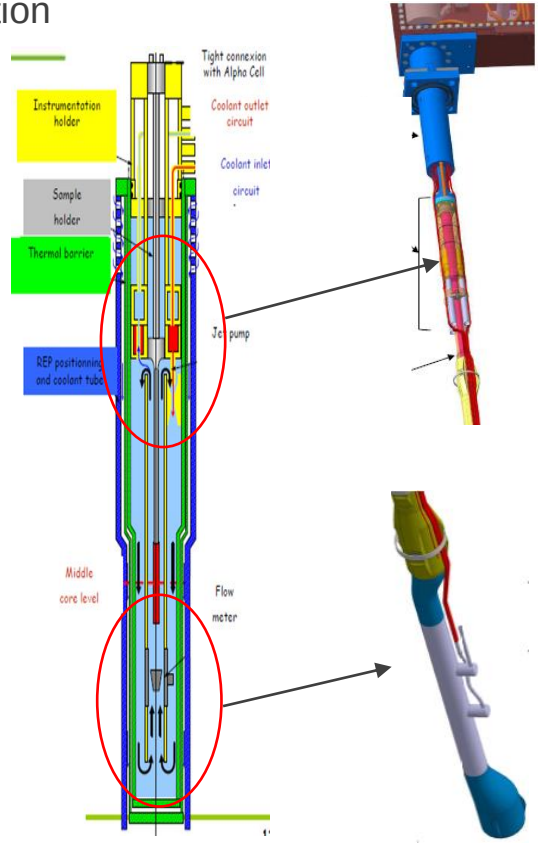


ADELINE QUALIFICATION TESTS

Defined critical components, requiring a qualification phase, concern, in priority :

The flow amplifier module located in the upper part of the in pile part of the device.
This injection block has a role of amplifier (accelerator) fluid flow into the device. This fluid flow is necessary to ensure proper cooling of the fuel rod in the test section.

The second qualification test concerns the calibration of a flow meter located in the test section downstream of the fuel rod. The planned flowmeter is a VCône type (compact VENTURI type).
It will provide a measure of the cooling flow in the test channel. This measurement occurs in the thermal balance of the experimental rod.
The cooling flow require high accuracy (objective dQ/Q < 1%).



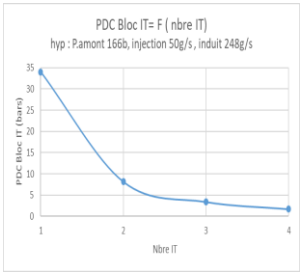
FLOW AMPLIFIER MODULE

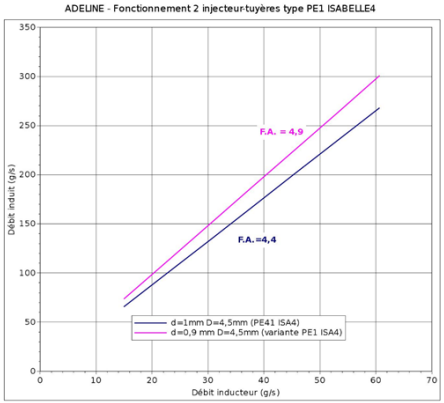
The flow amplifier block is composed of a metallic body equipped with two injectors associated with two nozzles.

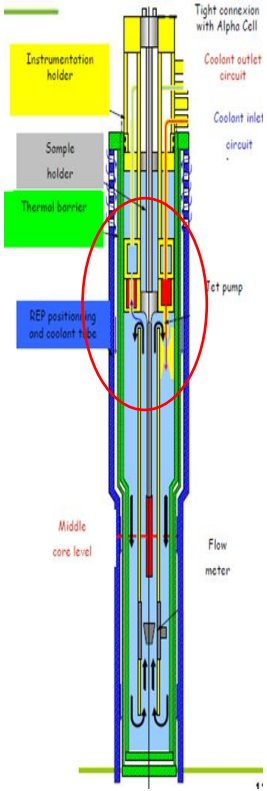
With this configuration, it make possible to create a dynamic movement of the fluid inside the test device (flow recirculation using the pressure energy of injected flow throw the amplifier block).

The advantage of implementing this type of component is to limit the injected flow rate (inductor) in the device by a factor of about 2 to 4.

This type of injectors-nozzle system had been already implemented in the past on the ISABELLE irradiation device used on the OSIRIS reactor (Saclay-France) or on the Jet pump device used on the SILOE reactor (Grenoble-France).

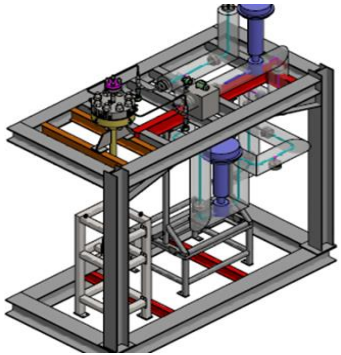






TEST GRID PROPOSAL

Location	Thermal Hydraulics conditions	Temperature	Flowrate
amplifier system inlet	P = 1 to 190 bar (ou P. max operating pressure)	T = 20 to 350°C	Injection flow Q = 0 to 100 g/s
amplifier system outlet	P = 1 to 169 bar. Nominal conditions PWR: 155 bar, T = 320°C. BWR: 80 bar, T = 280°C.	T = 20 to 350°C	Amplified flow Q = 0 to 300 g/s (PWR) Q = 0 to 350 g/s (BWR)



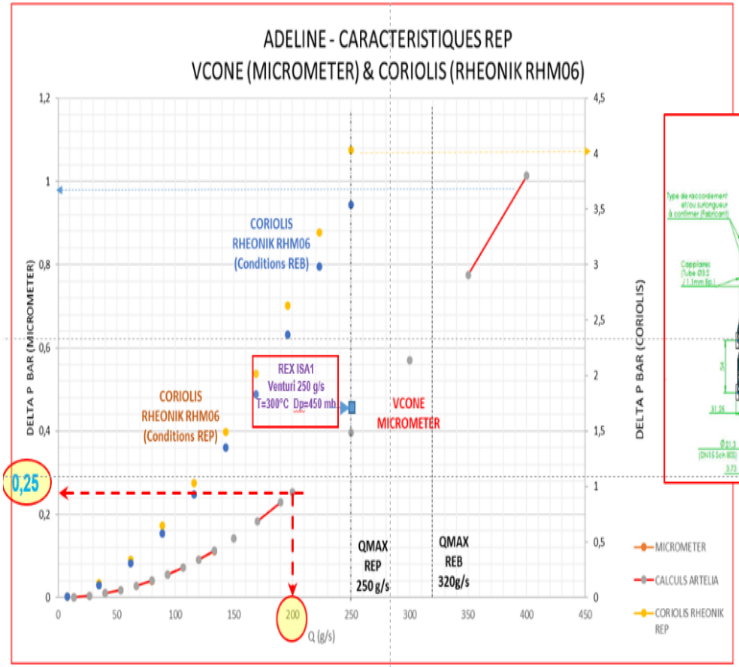
VCONE FLOWMETER

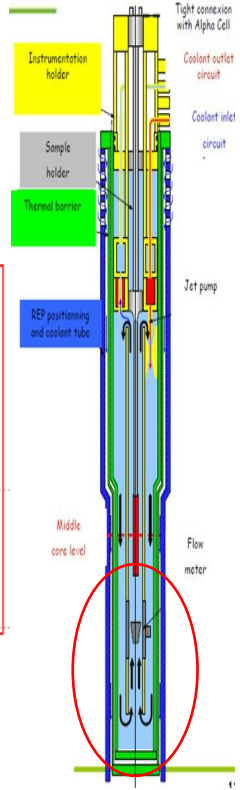
The test section will be equipped in the lower part with a VCône or a Venturi flowmeter (induced flowrate).

This instrumentation will be also calibrated in LWR conditions (PWR & BWR).

The calibration of the flowmeter will consist of a comparison of experimental value given by the VCône or Venturi & compared with values given by a reference flowmeter located on the loop (CORIOLIS type).

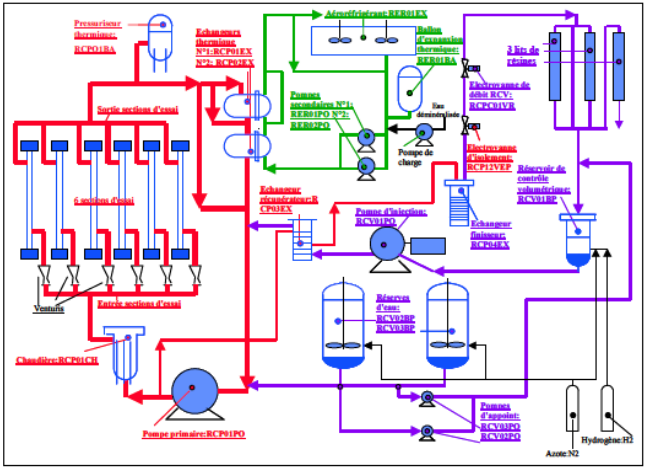
Note: the interest of the use of VCône flowmeter comparing to a Venturi is its compact geometry.

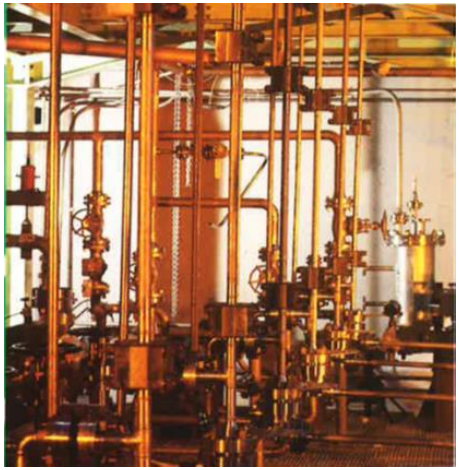




EXPERIMENTAL FACILITY

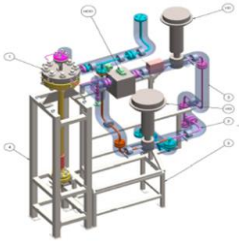
The fluid supply for the qualification test section will be obtained by an experimental loop called CORAIL which reproduces the thermal-hydraulic conditions.





Hereafter are given the main TH characteristics of the CORAIL test loop:

- *Fluid: demineralised water*
- *Pressurisation: 155-190 bar*
- *Inlet temperature: 250-350°C, Outlet Temperature = 250-362°C. Void fraction <40%*
- *Total Flow rate (6 channels) : 30m^3/h ,*
- *Chemical skid: B (0-1000ppm) ,Li (0-350ppm),O_2,H_2*



CONCLUSION

In the process of the development of experimental devices for the JHR project, qualification tests of critical components are necessary.

The tests presented in this paper concern preliminary qualifications tests such as :

- the validation of a fluid flow amplifier system for the “ADELINE type “device,

The system to be tested consists of a set of two injectors and nozzles.

- The flow rate obtained by the amplifier system permit to cool correctly the test rod.

Its performance and reliability have to be guaranteed.

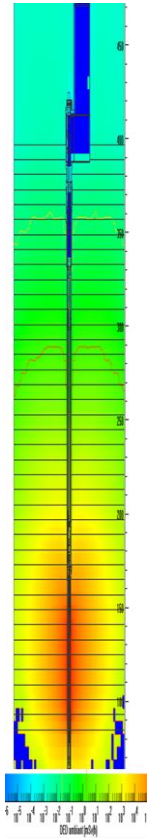
The out-of-pile qualification test section will make it possible to reach the conditions necessary to verify the thermal-hydraulics of the system.

The results, which will obtained will depend strongly of the manufacturing precision of the components (injectors geometries in particular).

Other qualifications tests are foreseen in the process of development of ADELINE loop:

electrical connectors, mechanical tests of flexibles lines, operation procedures

training …



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