The Jules Horowitz Reactor (JHR) Project

Experimental capabilities

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Introduction

The Jules Horowitz Reactor (JHR) is a modern experimental capability for studying materials and fuels behaviours under irradiation:

- Supports to Nuclear Power Plants of generations II and III,
- Developments for future generations of reactors (Gen IV, Fusion),
- Radio-isotopes production for medical applications.

The conception takes into account:

- Fast flux performances in the core able to perform important damages on materials,
- Thermal flux performances in the reflector to reach high power on fuel samples,
- Integration of equipments allowing carrying out complete experimental irradiation operations.
Irradiation experiments requirements

Experiment process phase
- Consignment of samples
- Assembly of devices: samples, sample older, irradiation rig
- Handling, connecting, and preliminary test
- Irradiation phase: irradiation condition management, on the measurement and sampling system
- Non destructive examination of irradiation device
- Recovery of samples
- Recovery of dosimeters
- Non destructive examination in hot cells
- Conditioning and evacuation of the samples

Facility equipment
- Relevant Hotworkshop or cell
- In the relevant hot cell or in NAB device pool
- In the reactor pool
- In the reactor (core or reflector), irradiation device & associated circuits Fission product laboratory
- Gammaemetry and neutronography device in the reactor pool
- In the relevant hot cell
- In the relevant hot cell, analyse in the dosimetry laboratory
- Measurement cells
- Hot cells

Support function processes
- Irradiation device commissioning
- Transport cask accommodation and shipping
- Preparation and distribution of sample coolant
- Waste treatment and shipping
- Irradiation device intermediate storage, recycling, test and maintenance
- Experimental cubic/s coolant management circuit assembly
- Irradiation device & coolant circuit dismantling

Inputs
- Customer's experimental requirements

Outputs
- Irradiated samples and irradiation reports

TRTR-2005 / IGORR 10 Joint Meeting
September, 12-16 2005, Gaithersburg, Maryland - USA
JHR capabilities

A driver core

An experimental area:
- located around the core,
  ✓ 14 experimental cubicles,
  ✓ I&C rooms surfaces on 2 floors,
  ✓ 11 penetrations penetrations with the reactor pool.

Four hot cells:
- ✓ Pre-and post irradiation operations (conditioning, examinations),
- ✓ Alpha cell for experiments with contamination risks.

Dosimetry laboratory:
- ✓ Quick access of the fluence integrated by the samples.

Differents utilities supports (workshops)
- ✓ Experiments preparation with limital external transports.
Phase 1, Reception and preliminary tests

- **Irradiated samples** (fuels and materials):
  - Back zone of the cells:
    - Vertical and horizontal connections,
  - Storage pool of components:
    - Possibility to accept casks for underwater loading.

- **Devices**:
  - **Cold workshop**:
    - Final assembling,
    - Controls,
    - Test benches.
  - **Hot workshop**:
    - New fuel loading operations,
    - Device transfer in the facility,
    - Recovery of irradiated components for re-using.
Phase 2, Irradiation phase (1/3): Driver Core

Main design features:

- Pool research reactor operating up to $100\text{MW}_{\text{th}}$.
- Cooling and moderate by forced circulation of light water in pressurised circuit.
- Surrounded by a modular reflector of beryllium cooled by the pool water.
- Fully compatible with radial power ramps on the fuels samples in the reflector.

Reference core configuration

High fluxes requirements for high dpa irradiation (up to 16 dpa/y).

- 10 irradiations inside the core
  - 7 small (32mm) in the center of fuel element
  - 3 large (50mm) instead of a fuel element
- 6 in the reflector on displacement systems
- 6 in the reflector on fixed positions
- 9 radio isotopes production devices in the reflector
Phase 2, Irradiation phase (2/3): Irradiation devices

- **Displacement systems**
  - Performances:
    - Maximal linear power: 600 W.cm\(^{-1}\)
      (1% \(U_5\) fuel enrichissement)
    - Power ramps:
      200 to 600 W.cm\(^{-1}\).min\(^{-1}\)

Fuel power = \(F(\text{location})\)

analytical studies

In pile experiment
connections
out of pile components

Fluid utilities (cubicles), experimental measurements (PF,...)

6 systems around the core

- 1.00%
- 2.25%
- 4.00%
- 6.00%
- 8.25%

![Graph showing fuel power distribution](image-url)
Phase 2, Irradiation phase (3/3): Experimental area

• A Fission products laboratory

✓ FP activities measurements in water:
  - Following on line the releases of FP of non tight fuels rods,

✓ FP activities measurements in gases:
  (high levels countings):
  - On line fission gas releases,
  - Activity release in case of accidental scenario,...

✓ FP fission gases measurements
  (low activities):
  - Fission gas releases from HTR or GFR during stable or specific transients,

✓ Post-experiments measurements:
  - Activities of liquid and fission samples during a long period (few days to few months),
Phase 3, Recovery of the samples

- **Hot cells**
  - One for radio-isotopes recuperation and conditioning.
  - Two polyvalent hot cells for experiments on materials and not damaged fuels,
  - Alpha cell.

- **Alpha cell**
  - Fuel experiment with clad failure in normal conditions (alpha device),
  - Fuel experiment in degraded situation (standard device - non alpha),
  - Devices dismantlement with contamination risks,
  - Re-use of some parts of the alpha device (sample holder, device envelopes).

→ **Specific tight-interface at the inlet of the cell,**

Decontamination systems inside the cell
Phase 4: Non Destructive Examinations (NDE)

- Control of the global aspects of the fuel rods or material samples after the transport or after irradiation sequences,
- Burn-Up & Fission Products inventory determination,
- Fission gas releases determination in the top of the device (LOCA experience),
- Verification of REA qualities,…

- In the hot cells,
  - Gamma-scanning
  - Neutronography,
  - Visual,
  - Microscopy,
  - Eddy currents,…

- In the pools,
  - NDE equipments in the hot cells

[Diagram of CORE, Collim, Displacement and rotation system]
Conclusion:

The Jules Horowitz Reactor, modern and performant has the capabilities to:

✓ Manage multiple and various experiments,

✓ Offer global prestations and equipments adapted with the customers needs.

✓ Equiped with specific alpha cell and on-line fission products laboratory allowing to drive and characterise experiments on non tight samples,

With a international users-facility vocation,

the JHR will statisfy the irradiations requirements of the MTR community in the next decades.