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## #04-26 JHR Irradiation Devices. Inspection Methods proposal

*Thursday, June 24, 2021 2:00 PM (20 minutes)*

JHR irradiation test devices must undergo a periodic inspection every 40 months (French Regulation rule). The first step of inspection proposal for application of non-destructive techniques (NDT) for these devices is presented, through examining the possible methods and locations that could be utilized in the reactor.

The selection of NDT methods depends mainly on the device geometry, material and access: main body of the device consists of two vertical nested tubes to be inspected. Once in use, due to deformations of thermal and radiation origins, these tubes are likely impossible to be separated (removal and re-assembly in a hot cell during inspection phase). Material is Zircaloy-4. The length of the tubes is about 3700 mm, with tubes diameter ranging from about 40 mm to 110 mm and thickness ranging from about 4 to 10 mm.

Some narrow electron beam welds will have to be controlled according to French nuclear pressure equipment regulation rules: thus, the inspection must respect the requirements of RCC-MRx code.

While ultrasonic volumetric inspection is selected for inspecting the tube bodies for checking no crack type of defects, Eddy current examination should be very efficient in finding surface defects.

Simulations are performed with CIVA software platform in order to select the best conditions for Ultrasonic testing (UT) and Eddy current (EC) inspection. Suitable sensors are especially selected to optimize the propagation of ultrasonic waves in the tube. Ultrasonic pulse-waves with center frequencies ranging from 0.1-15 MHz are transmitted to detect internal flaws: the beam-defect interaction allows predicting the amplitude and the time of flight of various echoes: direct echo, corner effect, tip diffraction echo, etc. and also echoes scattered back by the geometry (backwall, entry surface and interior specular interfaces echoes) with acoustic mode conversions.

The initial conclusions of this work are the following:

- Two inspection methods are likely needed.
- Eddy current is likely suitable for surface examination while volumetric ultrasonic inspection can be used for tube bodies.
- Inspection under-water in a storage pool is likely the best option for location in the JHR.
- Some automation and remote controls will be needed during the inspection process.

The next step for experimental reference will be a critical step of the work to assess and qualify the inspection methods: a qualification phase will be launched, performing inspection of representative dedicated mock-ups made of Zircaloy-4 material. For ultrasonic reference, a representative mock-up of the cylinder with a weld and artificial defect(s) will be used. The mock-up testing will provide an experimental reference to CIVA software platform simulations.

This study has been performed in collaboration between VTT Technical Research Centre of Finland Ltd and French CEA Alternative Energies and Atomic Energy Commission.

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