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NUMERICAL AND EXPERIMENTAL PARAMETRIC INVESTIGATION OF RAREFACTION WAVE
PROPAGATION ACROSS AN ORIFICE PLATE

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ABSTRACT

Loss Of Coolant Accident in a Pressurized Water Nuclear Reactor consists in a brutal and total opening (guillotine break) of one of the main coolant pipes. The transient rarefaction wave generated by the break propagates within the primary circuit and, when reaching the reactor core, crosses two zones displaying different geometric characteristics: the reactor core itself (fuel assemblies) and the by-pass zone between the baffle and the core barrel where several perforated reinforcement plates are arranged. This difference leads to nonidentical travel times of the rarefaction wave in the two zones, causing a transient pressure load between the two sides of the baffle.

As all the details of the primary circuit cannot be modeled, simplified models are used to represent the flow in some areas, such as between the perforated plates. Some of these models are implemented in the fast-transient fluid-structure dynamics software EUROPLEXUS, developed at DYN (CEA), and validated through experimental facilities.

In this paper Finite Elements simulations of a rarefaction wave propagating across an orifice plate with varying diameter and thickness are presented and compared with experimental results obtained on the MADMAX facility (also developed at DYN) in order to assess the accuracy of some simplified models.

The MADMAX experiment consists of two connected parallel pipes: a main *core pipe* representing the reactor core and an auxiliary *by-pass pipe*, equipped with several orifice plates, representing the by-pass and perforated reinforcement

plates. The pipes are initially filled with water that is then pressurized until it triggers the bursting of a failure disk located at the bottom of the core pipe. Pressure sensors placed along the pipes allow to study the pressure loads on the structures due to the different travel times of the rarefaction wave in the two pipes.

In 2010 the by-pass pipe is removed and a thick orifice plate is placed in the middle of the core pipe, to produce simpler solutions for the analysis of waves propagating through geometric obstacles.

In the novel 2022 experiments a *modular* orifice plate is installed, with diameter that can be changed to parametrically assess the geometry influence on wave propagation. Experiments are simulated using EUROPLEXUS with two different models: a 2D axisymmetric reference model with the obstacle fully described, and a 1D model with the obstacle replaced by suitable impedance relations. A detailed analysis of these simplified models' accuracy will be presented and discussed at the Conference.

Keywords: LOCA, simulation, experiment, perforated plates, rarefaction wave, Finite Elements, 2D axisymmetric, 1D, impedances.