EUROSAFE

Towards Convergence of Technical Nuclear Safety Practices in Europe

R&D ON REFLOODING OF DEGRADED CORES IN **SARNET** - FOCUS ON **PEARL** NEW **IRSN** FACILITY

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An essential severe accident (SA) management measure in a LWR is the core reflooding since injecting water should slowdown/stop the progression of the accident and delay/avoid reactor pressure vessel rupture that may endanger the containment integrity by dynamic loads. But the efficiency of reflooding is not demonstrated for all situations (it might even be counter-productive...) and the physical models in simulation codes still suffer a lack of validation. The European network of excellence SARNET (created in 2004 and currently backed by the EC in the frame of a 4 year FP7 contract 2009-2013, named SARNET2) gathers 41 organisations (from Europe plus Switzerland, Canada, USA and Korea) in order to resolve the most important remaining safety issues and uncertainties on SA in existing and future water-cooled nuclear power plants. A consistent work programme includes experimental and analytical work on the above high priority issue, in particular in IRSN (France), KIT and IKE (Germany). The joint interpretation and the modelling work will contribute to improve the IRSN-GRS ASTEC European reference integral code that is the backbone of the network.

EXPERIMENTS ON REFLOODING OF DEGRADED CORES

PEARL PROGRAMME (IRSN, CADARACHE)

The prime objective is the validation of numerical tools able to predict the consequences of the reflooding of a severely damaged reactor core, in particular the ICARE/CATHARE and ASTEC IRSN codes. A two-dimensional configuration in a cylindrical geometry will be used to understand the processes of lateral water ingression along zones with a higher porosity.

A preliminary program, named PRELUDE, is ongoing to test the performance of the induction heating system on stainless steel particles, in order to optimize the instrumentation in a two-phase flow. The debris bed in PRELUDE will be one-dimensional, with a smaller size, at atmospheric pressure and up to temperatures 1000°C. The PEARL facility should be ready in the 2nd half of 2010.

TWO OTHER EXPERIMENTAL PROGRAMS ARE UNDER WAY

QUENCH-Debris (KIT in Karlsruhe): modifications of the QUENCH existing facility (see scheme) to study debris formation and coolability within a rod bundle. Two tests are planned during the SARNET2 timeframe.
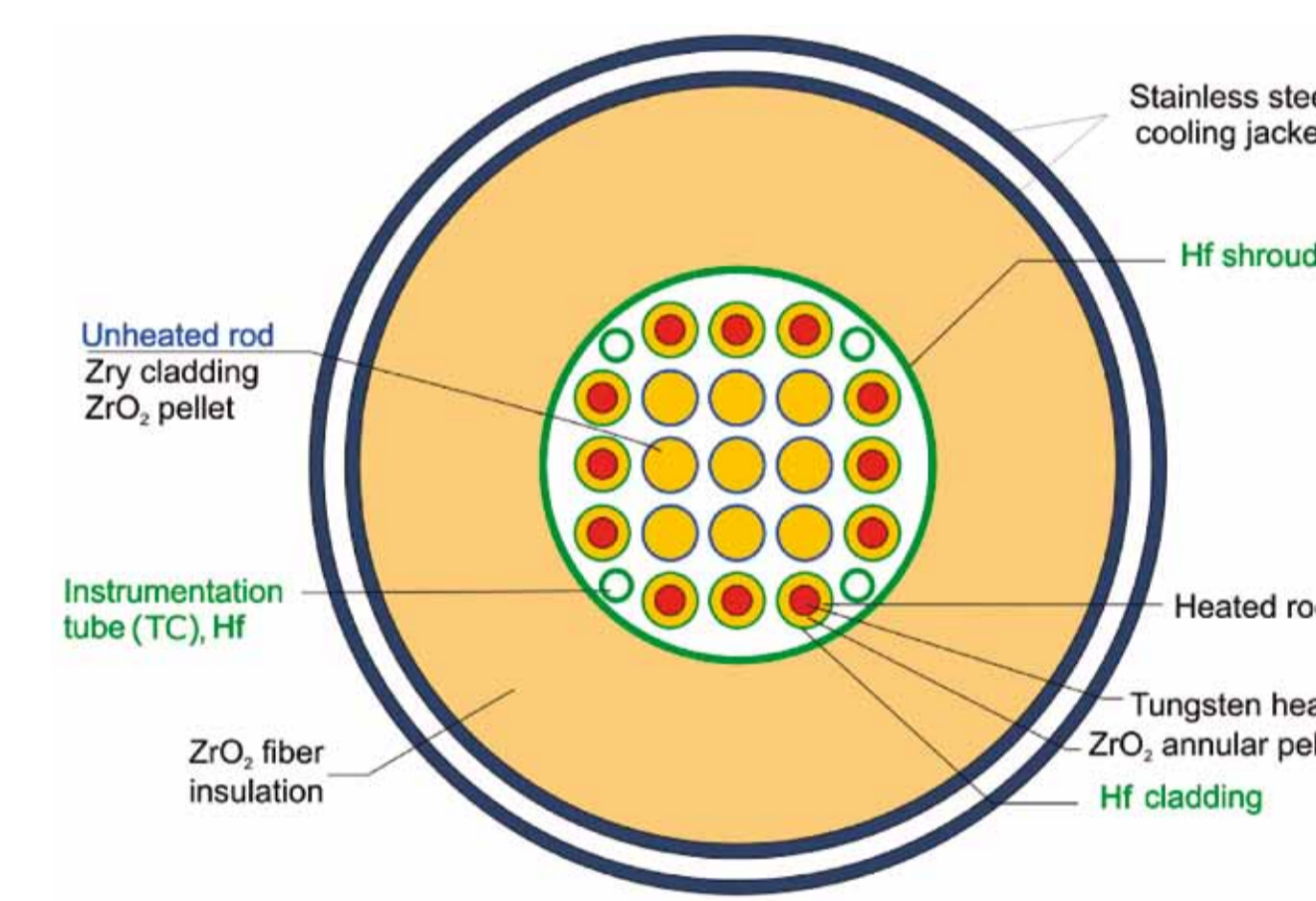
DEBRIS (IKE in Stuttgart): model-oriented experiments for improvement of constitutive laws for friction and heat transfer as well as study of specific two-dimensional effects under top and bottom flooding conditions at different system pressures.


PRELUDE picture
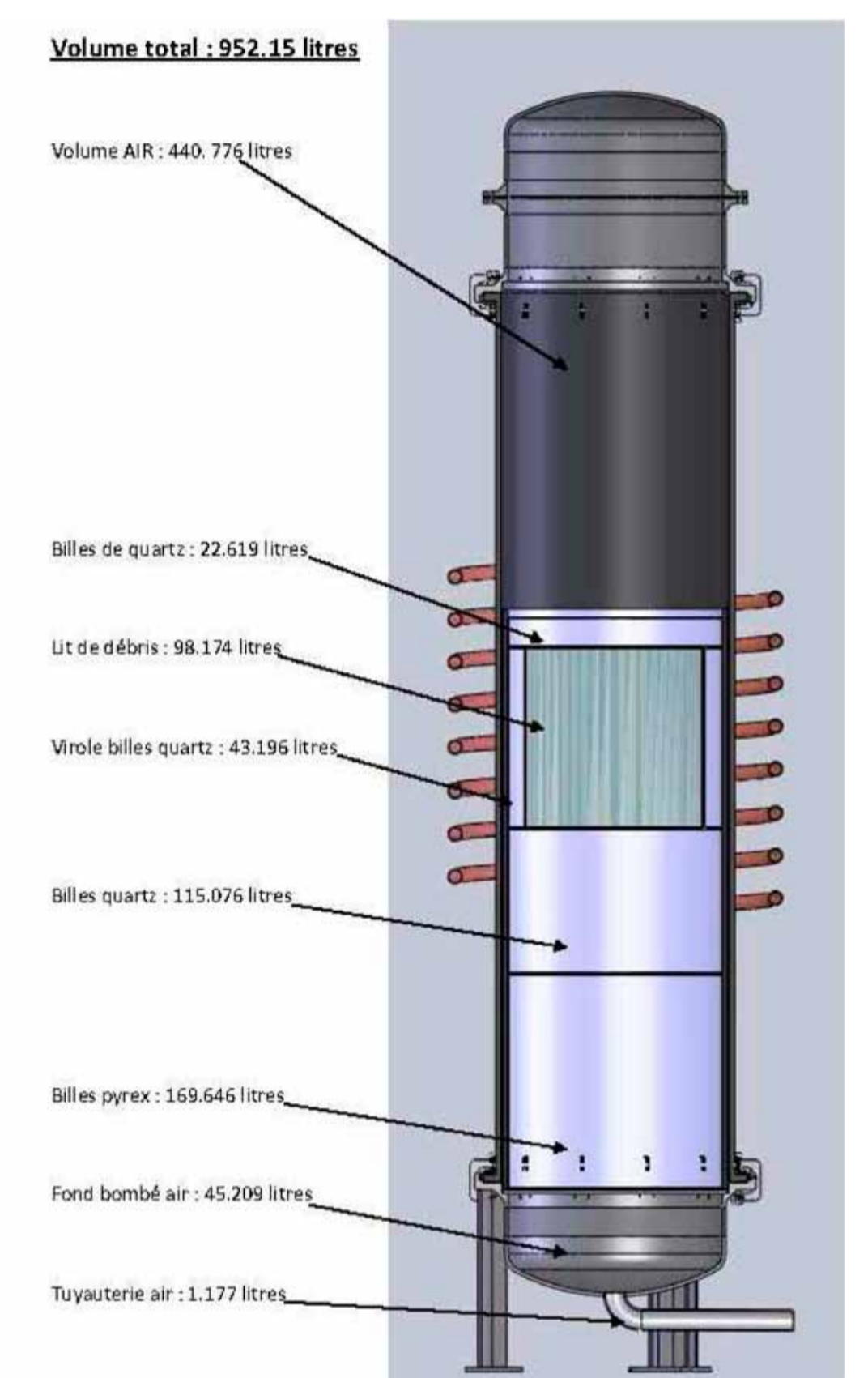
PEARL scheme

QUENCH-debris: outer hafnium fuel rod simulators as heaters, inner ones unheated and with zirconia pellets

MODELLING AND NUMERICAL SIMULATION

The codes below aim at a detailed understanding and simulation of the physical phenomena. Models will be derived from these codes for implementation into the ASTEC integral code as repository of knowledge.

ICARE/CATHARE ADVANCED MODELLING

This mechanistic IRSN code covers all kinds of accident sequences, from the initial phases (for instance a break in the primary circuit) to the LOCA phase and eventually to the core degradation and melting, up to vessel failure. It includes in particular models based on porous medium approach to describe debris beds, allowing to simulate multi-dimensional flows taking into account local variations (porosity, debris size, ...) as well as the global shape (e.g. curved bottom head of reactor pressure vessel). An example shows (at right) a calculated scenario of reflooding of a large debris bed formed in the lower plenum.
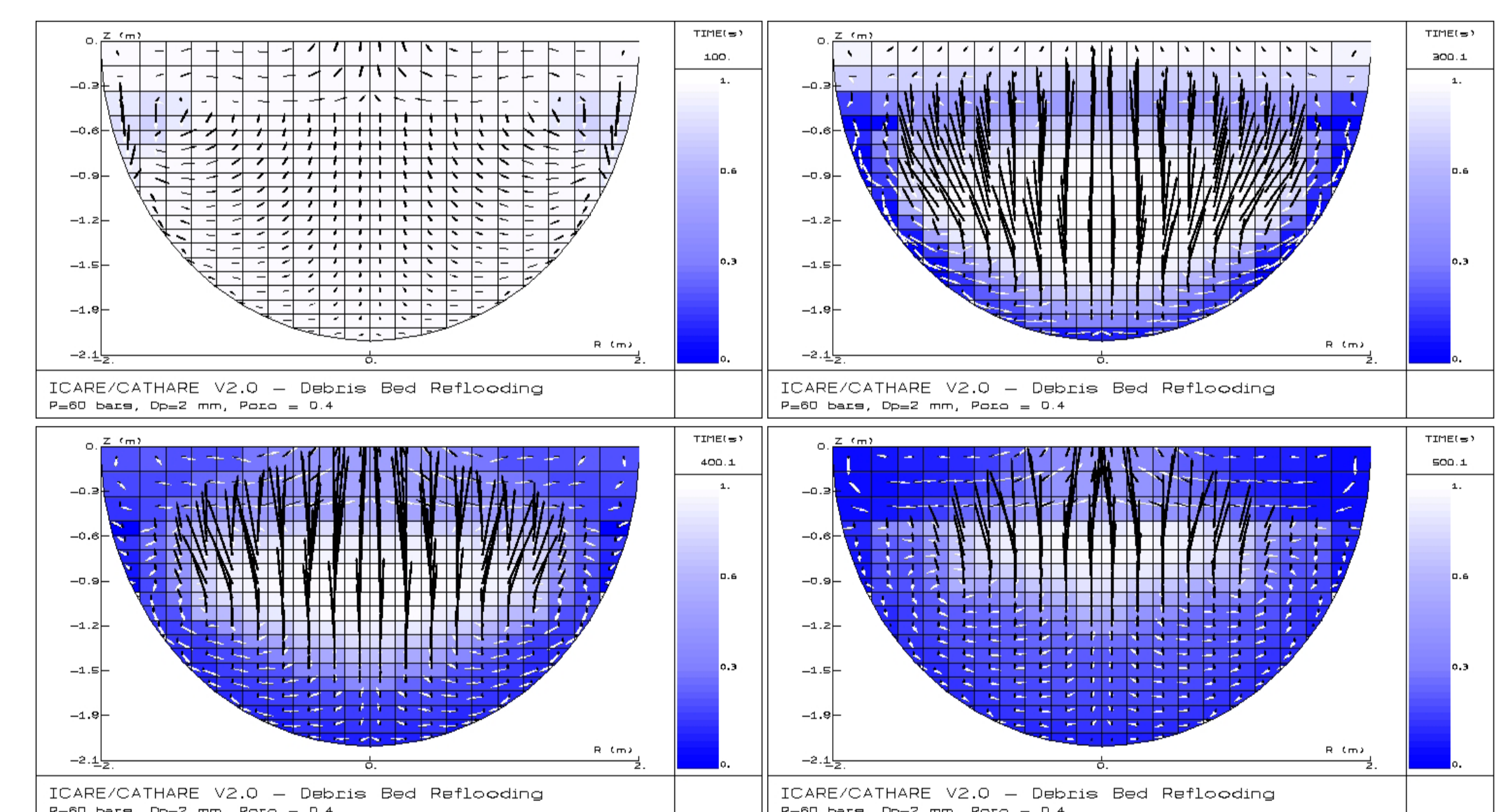

ICARE/CATHARE V2 : Void fraction and velocity fields during reflooding of a large debris bed formed in the lower plenum of the reactor pressure vessel (at 100s, 300s, 400s and 500s).

IKE WORK ON MODELLING

In the German system code ATHLET-CD, IKE develops the MEWA module which describes the late phase of core degradation taking into account effects of possible core reflooding.

Map of water distribution (at saturation) in the flooded vessel with debris in the lower plenum.
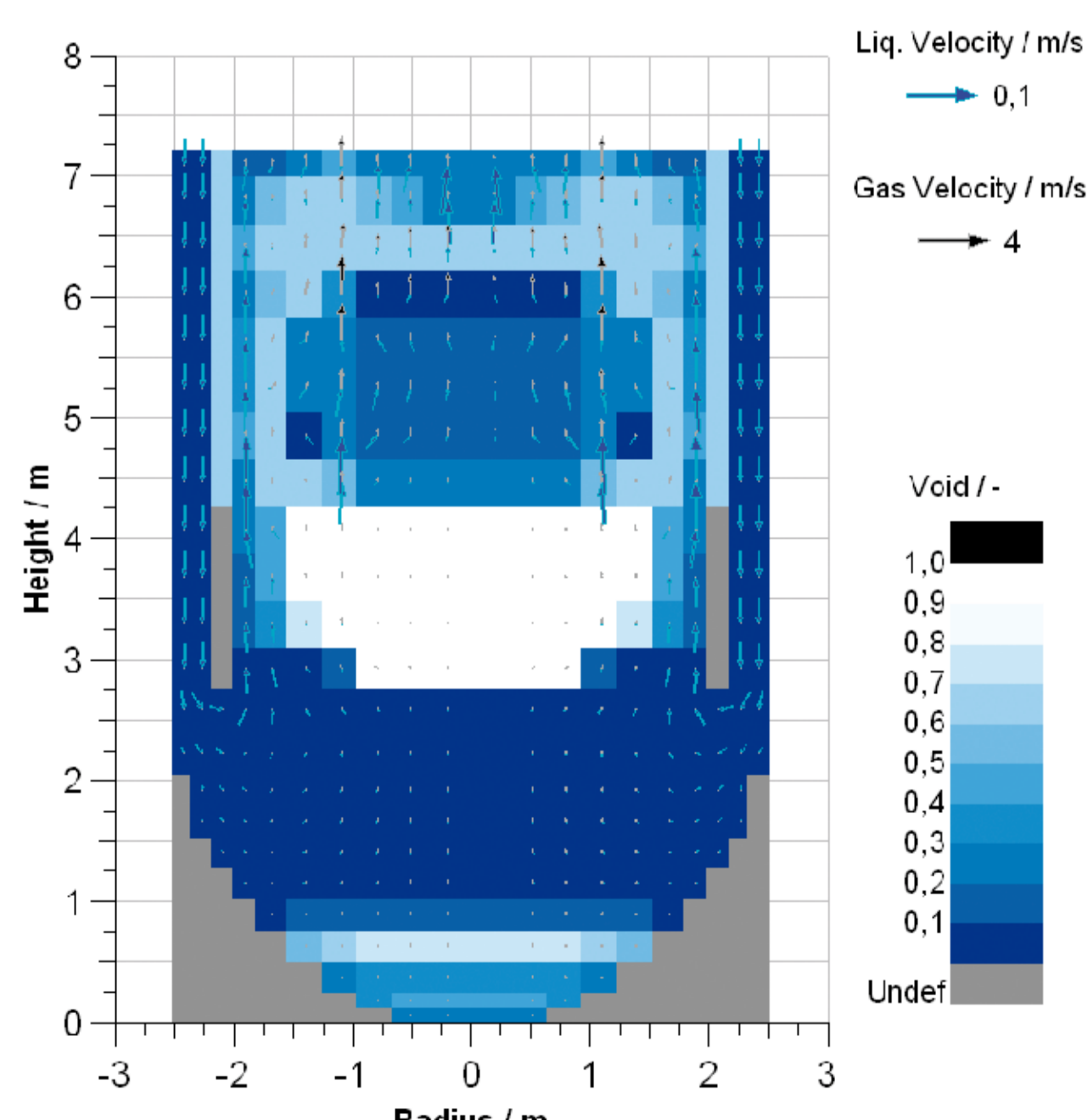
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