MODELLING OF WATER LEAK RATES THROUGH CREVICES

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One of the key issues to be managed for ITER operation is a high availability of the machine. The ITER vacuum vessel will have an actively cooled first wall and divertor structure and operational water leaks into the vacuum are expected to account for a significant loss of operational time if timely localization (and repair) of the leak cannot be performed. To assess the viability of proposed water leak localization methods it is required that the evolution of a water leak through a crevice is fully understood.

The calculation of the leak rate of water is complex because, depending on the conditions, a phase change can happen before a crevice in the cooling system, inside the crevice, or in the vacuum chamber. The molecular mean free path of vapour varies in a wide range along the tube so that the flow changes from the hydrodynamic to the free-molecular regime. Only recently, a first theoretical model based on the hydrodynamic and kinetic equations was proposed [1], which will be discussed in this paper.

This paper describes how to quantify the relation between the leak size (crevice), the water conditions, and the water leak rate. In practice, a crevice has a very complicated shape. For the purpose of this paper, a crevice is considered as a long circular tube (Length L >> Diameter D). Under this assumption the end effects can be neglected and the flow in the crevice becomes one-dimensional. In the inlet cross-section, the water is maintained at liquid phase (pressure p_1 and temperature T_1). At the outlet section, the vapour has the pressure p_2 and temperature T_2. The liquid phase of water is described by the Navier-Stokes equations, while the gaseous phase is modeled on the basis of rarefied gas dynamics using solutions obtained by kinetic theory.

As a result, the leak rate was numerically calculated for various values of the channel size and for several values of pressure p_1 and p_2 and temperature T_1 and T_2. The pressure distribution along the tube is also reported.

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