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Corium Behaviour and the Lower Head Thermal Response after a Core Meltdown

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During a severe accident in a PWR plant, core degradation and melting could result in slumping of the molten material to the lower head. The relocated material will be composed of ceramic (UO_2, ZrO_2) and metallic (Zr, Fe, Ni) materials whose chemical composition depends on the reactor design, the accident scenario, the core heat-up rate and availability of coolant during core degradation processes, thus, on thermal-hydraulic behaviour of the reactor coolant system (RCS). If the temperature of that mixture is higher than its liquidus temperature (2800-2900 K), the mixture will be in the liquid state. The mixture of molten core materials is known as corium.

Production of decay heat will cause intense natural circulation. Although ceramic and metallic melts are immiscible, turbulent nature of the flow will prevent stratification, which might occur due to density difference, and result in negligible spatial temperature variations. The reactor pressure vessel (RPV) lower head wall in contact with the melt will be heated up depending on the energy balance between the heat flux from the molten pool and the heat losses on the outside RPV wall surface. Cooling of the melt results in formation of a crust surrounding corium which acts as a heat insulator. Therefore, the wall temperature increase will be slowed down by the presence of the crust. Nevertheless, in the case of a large molten pool present in the lower head, there is a high probability of the wall melt-through or rupture.

In the presented analysis, corium mass and composition corresponded to a prototypic PWR core. ANSYS code was used for the study of corium natural circulation (FLOTRAN) and for the analysis of the RPV wall thermal behaviour.

Keywords: *severe accident, RPV lower head, corium natural circulation, RPV wall thermal behaviour*