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Influence of the CVCS Modelling on Results of the Loss of Offsite Power (LOOP) Safety Analysis for NPP Krško

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A Loss of Offsite Power (LOOP) transient scenario is based on a complete loss of non-emergency AC power that results in the loss of all power to the plant auxiliaries, i.e., the Reactor Coolant Pumps (RCPs), condensate pumps, etc. An actual LOOP event would cause a loss of all feedwater, a loss of forced Reactor Coolant System (RCS) flow and a reactor trip within less than 2 seconds as a result of either loss of power to the rod cluster assembly gripper coils or any RCS flow trips. For safety analysis purposes the LOOP event is conservatively modelled as a Loss of Normal Feedwater (LONF) transient with a subsequent loss of offsite power as a result of a reactor trip. The reactor trip followed by RCP trip are delayed until a low-low Steam Generator (SG) level signal is reached. This is a more conservative scenario than the LOOP event because the least amount of SG secondary side water mass available for heat removal and the increased amount of the stored energy in the primary circuit at the time of the loss of RCS flow result. The standard LOOP safety analysis is aimed to demonstrate the natural circulation capability of the RCS to remove residual and decay heat from the core aided by Auxiliary Feedwater in the secondary system. In addition to this goal the presented work is aimed to resolve the potential safety issue resulting from the influence of the Chemical and Volume Control System (CVCS) operation during LOOP event for NPP Krško. The potential safety concern for the LOOP analysis is that the loss of instrument air system may occur thus leading to the CVCS charging and letdown flow imbalance. A net RCS inventory addition may result with water solid pressurizer condition. Water discharge through the pressurizer relief and safety valves could lead to overpressurization of the Pressurizer Relief Tank (PRT) and rupture of the PRT rupture disks. Additional concern is that pressurizer relief and safety valves may fail to properly reseat when exposed to water relief causing the American Nuclear Society (ANS) condition II to progress to the more severe condition III small break Loss of Coolant Accident (LOCA).

To address the pressurizer water-solid concern for NPP Krško RELAP5/MOD3.3 analyses of the LOOP event for best-estimate and USAR based scenarios have been performed. Different CVCS charging and letdown operation modes including the most conservative case with CVCS charging flow at maximum and letdown flow isolated were analyzed.

Keywords: loss of offsite power, pressurizer water-solid, RELAP5/MOD3.3, safety analyses