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THERMAL-HYDRAULIC ANALYSIS OF IGNALINA NPP COMPARTMENTS RESPONSE TO GROUP DISTRIBUTION HEADER RUPTURE USING RALOC4 CODE

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Introduction

The Accident Localisation System (ALS) of Ignalina NPP is a containment of pressure suppression type designed to protect the environment from the dangerous impact of the radioactivity. The failure of ALS could lead to contamination of the environment and prescribed public radiation doses could be exceeded.

The purpose of the presented analysis is to perform long term thermal-hydraulic analysis of compartments response to Group Distribution Header (GDH) rupture and verify if design pressure values are not exceeded.

Short description of ALS and RALOC4 model

The condensing pools form a barrier dividing the whole ALS into two distinct parts. The compartments before condensing pools are designed to withstand high pressure. The steam generated by the accident condenses while bubbling through the water resulting in the lower pressure beyond condensing pools. A part of clean air is released to the environment in the initial phase of the accident. This is achieved by the discharge pipes that are closed in 5 min after accident start to prevent radioactivity release to the environment. The release of clean air helps to reduce the peak pressure in the ALS compartments.

The condensing pools are cooled by the Condenser Tray Cooling System (CTCS). During long-term transients CTCS becomes a major energy sink. The CTCS pumps deliver water to the condensing pools and sprays. RALOC4 code applied for thermal-hydraulic analysis of compartments response to the break. The RALOC calculation model of ALS include all the accident affected compartments, the structures for consideration of heat sinks/source and condensation, simple junctions between compartments for gas and water flows, special junctions with specified pressure difference for opening and other features. The RALOC model consists of 26 nodes, 84 junctions of different type, 10 pump systems and 89 structures (heat slabs).

The correct simulation of the structures is of great importance because they play an important role in the long-term analysis of the accident. The orientation (wall, floor, ceiling) and shape (plate, cylinder) of structures are considered in the model.

Condenser tray cooling and spray systems are modelled in detail because these systems have big influence to the energy balance in long term. The make-up of condensing pools from deaereator considered as well.

Results and discussion

The maximum pressure in break node occurs at about 15 s and reaches 142 kPa (abs.). After reaching the maximum value the pressure reduces due to: the decrease of energy release from the break, condensation of steam in the condensing pools and the release of clean air into the environment in the initial phase of the accident.

The closure of the flaps on connections to the environment after 300 s leads to pressure increase in the whole ALS.

Later on the accident-generated energy exceeds the capacity of the energy sinks (mainly the active CTCS and heat transfer by walls) and pressure increases again. After about 2000 s the pressure in compartments before the condensing trays equalises as well as the pressure in the compartments behind it.

After about 3.5 hours the energy discharged by the break and the energy removed by active systems and structures equalises and a further pressure peak of 139 kPa (abs.) occurs.

Later on the thermal energy of the graphite stack has been largely dissipated and decay heat has diminished. The capacity of the energy sinks in the ALS exceeds the release from the break and, consequently, pressures in compartments before condensing trays decrease. The pressure in compartments behind the condensing traysdecreases slower.

The maximum pressures calculated for the compartments of ALS are below the design pressure values and the failure of ALS is not expected.

Conclusions

The behaviour of the Accident Localisation System of the Ignalina NPP, unit 2, in the case of Group Distribution Header break was investigated for a time interval of 24 hours applying the RALOC4 code. Special attention was paid to the detailed and realistic simulation of engineering systems and heat transfer structures.

The RALOC model was set up in correspondence to the assumptions applied in the determination of the mass and energy release rates, calculated with RELAP5 code.

All pressures calculated for the ALS compartments are below the maximum allowed design pressures.