Experience in Modeling the Zaporizhzhya Nuclear Power Plant Using RELAP5 [1]

Vyacheslav V. Sverdlov, Alexey V. Sverdlov
Joint Stock Enterprise, Ltd. “EIS”
Energodar, Zaporozh'ye Region, Ukraine 71502
Tel: 380-06139-19327, Fax: 380-06139-17551
Email: m_vsverdlov@enertek.zp.ua

Abstract:

Unit 5 of the Zaporizhzhya Nuclear Power Plant (ZNPP5) equipped with a VVER-1000/320 reactor has been modeled using the RELAP5/MOD3.2 thermal-hydraulic system code. Primarily, the RELAP5 model is used to support justification of the new - symptom-oriented - set of emergency operating instructions. It represents a significant extension of the RELAP5 model previously used to determine success criteria for PRA Level 1 analysis performed for ZNPP5. The new model has been successfully validated using three ZNPP5 transient events. Its major features are summarized below.

Configuration Fidelity

The present model has four loops, therefore, offering a complete fidelity with ZNPP5 in terms of the location of all safety and support systems, such as emergency core cooling and make-letdown systems. This facilitates preparation of analysis simulating failure of specific systems and greatly contributes to transparency when presenting the results of analysis to the operation personnel.

(Quasi) 3-D thermal-hydraulic Modeling Approach

The reactor vessel and steam generators were nodalized in a quasi 3-dimensional fashion allowing to capture asymmetric effects in the main reactor system components. The 3-D nodalization provides for "hi-fi" modeling, for example, of coolant mixing due to slightly different operation of loops (a real situation) and the system response during various asymmetric transient events such as tripping of some of the main coolant pumps. It also provides a better and more realistic representation of the horizontal steam generators capturing the so-called "hot" and "cold" collector regions and bypass. The paper describes experience gained during the modeling process. Details of specific modeling problems and methods used to overcome them are presented.

Other Modeling Features

Model of a turbine (main) feedwater pump was constructed using a widened pump curves simulation, load controller, and the re-circulation line. ZNPP5 makes use of both digital and analog controls. They have been modeled in the RELAP5 model, which allows to analyze in detail workings of the key plant equipment during transients. In addition, it allows analyzing and making recommendations related to tuning of certain coefficients in the ZNPP5 control algorithms.

Validation against ZNPP5 Events

The results of validation calculations obtained for full-power operation in steady-state and during three actually occurring ZNPP5 events are in excellent agreement with the plant design parameters and the measured plant response.

[1] Some of the presented work was sponsored in 2000-2001 by the U.S. Department of Energy within the Zaporizhzhya In-depth Safety Analysis (ZISA) project.