BWR LOCA Analysis

Background

Westinghouse offers engineering services in various areas related to boiling water reactor (BWR) safety analysis. These include fast and slow transients, stability, loss-of-coolant accident (LOCA), and containment analysis. LOCA analysis is performed using the Westinghouse BWR Emergency Core Cooling System (ECCS) Evaluation Model. This model uses GOBLIN series of codes and complies with the NRC 10CFR50, Appendix K requirements; it was initially approved by the NRC in 1989. Since then, the methodology has been improved and adapted for a range of fuel types. Several supplements have been submitted to the original topical report with the most recent supplement extending the capabilities to SVEA-96 Optima2 fuel. This supplement was submitted and approved by the NRC in 2004.

Description

The GOBLIN series of codes is a system of computer codes that uses one-dimensional assumptions and solution techniques to calculate the BWR transient response for both large- and small-break LOCAs. The system of codes comprises three major computer programs to include GOBLIN, DRAGON, and CHACHA-3D. The functions of the individual computer programs are as follows.

- GOBLIN performs the thermal-hydraulic calculations for the entire reactor primary system, including interactions with the various safety systems. The four primary sections of the GOBLIN code include:

- The hydraulic model, which calculates the basic mass, energy, and momentum balances, together with the equation of state for each sub-volume

- The system models of the various safety systems, which are activated after a LOCA, such as high low pressure core spray and coolant injection systems, and the automatic depressurization system

- The fuel thermal model, which calculates the heat transferred from the fuel rods to the coolant

- The pressure vessel and internals thermal model, which calculates the heat transferred from the pressure vessel and the internal surfaces to the coolant

- DRAGON (a subset of the GOBLIN code) performs the thermal-hydraulic calculations for a specified fuel assembly in the reactor core. DRAGON uses the necessary boundary conditions from GOBLIN, and is used to calculate the effect of bundle power and bundle power axial distribution on the cladding temperature distribution.

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- CHACHA-3D calculates the detailed temperature assembly analyzed by DRAGON. CHACHA-3D uses the boundary conditions from GOBLIN and DRAGON. The CHACHA-3D code predicts the thermal behavior of the fuel rods in the assembly and the channel throughout the accident sequence.

Benefits

LOCA analysis provides the necessary safety limits for NRC 10CFR50.46 compliance. It additionally provides flexibility by supporting various options, such as singleloop operation and different equipment out-of-service scenarios.

Experience

In the U.S., the following BWR units were analyzed using the Westinghouse BWR ECCS Evaluation Methodology:

- Columbia (BWR/5)
- Hope Creek (BWR/4)
- Quad Cities 1 & 2 (BWR/3)
- Dresden 2 & 3 (BWR/3)

Westinghouse also has LOCA analysis experience with European plants, such as Leibstadt, Oskarshamm, Ringhals,