Use of COMPAR2 and CRAFT2 for SMR-300 LOCA Load Analysis

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Introductions

- ◼ NRC Staff

- ◼ Holtec Staff

- ◼ Framatome Staff

Meeting Agenda

■ Purpose & Outcome

■ Overview

■ Discussion on use of COMPAR2 and CRAFT2

■ Open Forum

Purpose and Outcome

■ Purpose: To review Holtec's plan for use of CRAFT2 and COMPAR2 software tools for SMR-300 loss-of-coolant accident (LOCA)-induced load analysis without additional tool-specific validation activities.

■ Outcome: To obtain feedback on the use of historical NRC acceptance of CRAFT2 and COMPAR2 tools without the need for SMR-300-specific code validation.

Overview

- Holtec will be contracting Framatome to conduct system level analysis on the Reactor Coolant System (RCS) during various loading conditions. Analyses include:

  ➢ Primary side blowdown and loading

  ➢ Secondary side blowdown and loading

  ➢ Asymmetric cavity pressurization and loading

Overview

- Two of the software tools planned for use for the scope of the analyses:
  - ➤ CRAFT2
  - ➤ COMPAR2
- Additional software tools planned for use for this scope include:
  - ➤ ANSYS FLUENT
  - ➤ AFT-FATHOM
  - ➤ BWHIST (Scaling/conversion tool)

CRAFT2 Overview

- CRAFT2 performs hydraulics analysis of subcooled water, two-phase steam-water, and steam systems. The piping and component system is modeled as a series of control volumes and flow paths such that the behavior of a pressure wave caused by a pipe break can be predicted. Pressure or force time histories can be obtained at changes in area or changes in flow direction.

- The NRC has approved CRAFT2 for use in simulating the effect of pipe ruptures on the RCS.

- CRAFT2 is certified for use by comparing results obtained from analyses of test configurations to actual test data and to hand calculations. As additional options were added to the code, test cases were run to confirm that results did not change from the previous version.

CRAFT2 Overview

■ Historically accepted by the NRC for:

> ➢ RCS pipe rupture analysis

> ➢ Pressure and force time history generation

■ Certified through:

> ➢ Comparison to test data

> ➢ Hand calculation benchmarks

> ➢ Regression testing for code revisions

COMPAR2 Overview

- COMPAR2 performs hydraulics analysis of fluid systems (generally containment cavities broken into sub-compartments). The system is modeled as a series of control volumes and flow paths, so that the behavior of a pressure wave caused by a pipe break can be predicted. Pressure time histories can be obtained for any structure included in the model.

- COMPAR2 is the AREVA NP version of COMPARE-MOD1, which is described in NUREG-0609 as being applicable and conservative for use in Asymmetric Cavity Pressurization analyses.

- No difference exists between these two codes except that COMPAR2 provides an additional output file containing a tabulation of nodal pressures for subsequent input to BWHIST (simple scaling/conversion tool).

- COMPAR2 is certified by comparing results obtained from analysis of test configurations to actual test data and to hand calculations.

COMPAR2 Overview

- Lineage directly traceable to COMPARE-MOD1

- Described in NUREG-0609 as applicable and conservative for asymmetric cavity pressurization

- Additional functionality limited to output formatting; no changes to governing equations

- No new validation class is introduced by:

  - Reactor size
  - Power level
  - Structural configuration

Governing Physics of LOCA-Induced Loads

- LOCA-induced loads are governed by:
  - ➢ Compressible fluid dynamics
  - ➢ Two-phase steam-water behavior
  - ➢ Pressure wave propagation and reflection
  - ➢ Momentum change at geometric discontinuities
- These phenomena are independent of reactor power level and are instead driven by:
  - ➢ Fluid properties
  - ➢ Local geometry
  - ➢ Break size and location

Governing Physics of LOCA-Induced Loads

■ Pressure wave propagation depends on:

➢ Acoustic velocity

➢ Fluid compressibility

➢ Local geometry at breaks, elbows, and area changes

■ Reduced system size associated with an SMR does not invalidate pressure-time or force-time predictions.

Applicability to SMR-300 design

■ Analyses will:

➢ Evaluate bounding break sizes and locations

➢ Apply conservative assumptions consistent with prior light-water reactor (LWR) practice

➢ Generate time histories used as inputs to structural evaluations with ASME Code margins

■ Use of CRAFT2 and COMPAR2 for SMR-300 LOCA loads is inherently conservative and consistent with established regulatory practice.

Applicability to SMR-300 design

- SMR-300 LOCA conditions remain fully within the validated modeling domain of CRAFT2 and COMPAR2:

    ➤ LWR coolant operating at similar pressure and temperature

    ➤ Subcooled → two-phase → steam blowdown

    ➤ Pressure and temperature ranges bounded by historical LWR experience

- SMR-300 does not introduce new physical phenomena relevant to LOCA load generation.

Planned Licensing Approach

■ Justification for use of CRAFT2 and COMPAR2 will be:

➢ Documented in the SMR-300 safety analysis report licensing submittal

➢ Provided in the context of RCS LOCA-load methodology

■ No separate topical report is proposed.

Open Forum

Backup Slides

BWHIST Overview

■ BWHIST converts pressure time histories generated by CRAFT2 and COMPAR2 into force time histories by integrating the pressures over the component area on which the pressure acts.

■ Earlier versions of BWHIST were certified for use within Framatome by comparing the output from the analysis of sample problems to the results obtained from hand calculations for the same sample problems. As additional options were added to the code, test cases were run to confirm that results did not change from the previous version.