www.holtec.com
www.smrllc.com

# NRC Meeting:
# Deterministic Safety Analysis Codes and Methods Overview

February 15th, 2023

# Meeting Agenda

- Introductions
- Purpose and Outcomes
- Computer Codes
  - Basis
  - Validation Plans
- Methods
  - Event Identification and Classification
  - Acceptance Criteria
  - Single Failures
  - LOCA Methods
  - Non-LOCA Methods

# Introductions

- NRC Staff
- Holtec Staff

# Purpose and Outcome

**PURPOSE**: To provide a high-level overview of the computer codes and methods used to perform transient and accident analyses.

**OUTCOME**: To obtain feedback from the NRC staff on the high-level overview and identify specific topics that the NRC would like to discuss further in future meetings.

# Computer Codes Bases

- SMR-160 has materials, components, and operating conditions similar to licensed/operating nuclear power plants, therefore computer codes used for analyses of these plants are generally applicable to the SMR-160.
- Neutronics
  - Studsvik's CMS5 Suite – CASMO5, SIMULATE5, SIMULATE-3K
- Subchannel Analysis
  - Framatome's COBRA-FLX
- System Thermal Hydraulics
  - Idaho National Laboratory's (INL) RELAP5-3D
- Containment (Chapter 6.2)
  - Electric Power Research Institute's GOTHIC
- Radiological Consequences
  - Source Terms - SCALE, TRITON, ORIGEN
  - Dispersion Factors – ARCON96
  - Dose - RADTRAD

# Generic Computer Code Validation Plan

- The Evaluation Model Development and Assessment Process (EMDAP) described in Regulatory Guide 1.203 will be followed for each computer code
- Holtec will leverage existing validation work of vendors where applicable

# Studsvik CMS5 Validation Plan

- The validation plan of CMS5 is being developed
- Validation of CMS5 will consist of the following:
  - Code-to-Code benchmarks
  - Experimental and operational benchmarks applicable to the SMR-160
  - Holtec may leverage validation support from Studsvik
    - For example, Topical Report SSP-14/P01-028-TR-NP-A (ML15355A285)

# COBRA-FLX Validation Plan

- SMR-160 uses Framatome's GAIA fuel assembly
- Framatome is leading the effort to validate their COBRA-FLX code for the SMR-160 application range
  - COBRA-FLX was approved by NRC for analysis of existing PWRs (Topical Report ANP-10311, ML18103A141)
  - Applicability assessments of models and correlations to the SMR-160 geometry and operating conditions have been performed and confirm COBRA-FLX is adequate for modeling the SMR-160
  - Additional experimental benchmarks for COBRA-FLX have been identified
  - Critical Heat Flux (CHF) testing will be performed at Framatome's KATHY facility to develop an SMR-160 specific CHF correlation

# RELAP5-3D Validation Plan

- Holtec is working with INL to develop a version of the RELAP5-3D that is adequate for simulating the thermal hydraulic response of the SMR-160 for both LOCA and non-LOCA initiating events
- Steps 1 through 4 of Element 1 of RG 1.203 have been performed
  - ✓ PIRTs have been performed for various accident scenarios
  - ✓ Scenarios were selected to challenge all figures of merit while ensuring a wide range of phenomena and component configurations were observed
  - ✓ Scenarios included LOCAs, main steam line break, turbine trip coincident with loss of off-site power, and steam generator tube rupture
- The PIRTs and review of legacy experiments identified the need for integral and separate effect test (ISET) facilities of the SMR-160

# SMR-160 ISET Facilities

- Integral Effects Test (IET) facility consisting of the reactor coolant system (RCS), steam generator (SG), passive core cooling system (PCCS), and containment
- Separate Effects Test (SET) facility consisting of the SG
- SET of containment can use IET containment facility
- IET and SET will be constructed and operated at INL
- Scaling analysis of the SG SET is complete
- Scaling analysis of the IET is being revised

# Testing Programs Overview

[[

]]

# GOTHIC Validation Plan

- The SMR-160 containment operating conditions, materials, configuration, and phenomena are similar to existing PWRs
- GOTHIC has been extensively tested and validated for numerous phenomena occurring inside containment
- Applicability assessments have been performed to assure that GOTHIC accurately models all high-ranking PIRT phenomena related to the SMR-160 containment

# Methods – Event Identification and Classification

- Initiating events are identified by considering the similarities and differences between the SMR-160 and existing plants
  - All events for PWRs in NUREG-0800 Chapter 15 SRP are applicable to SMR-160
    - Pump failures would only apply to when startup pumps are in service
  - Reactor stability (Chapter 15.9 SRP) is applicable (similar to NuScale)
  - Inadvertent actuation of primary decay heat removal (PDHR) system included in Chapter 15.1 (similar to AP1000 PRHR actuation)
- Nearly all initiating events of the SMR-160 use the same classifications as those described in Chapter 15 SRP
  - Anticipated Transients Without SCRAM (ATWS) is classified as a beyond design basis accident

# Methods - Acceptance Criteria

- Non-LOCA thermal hydraulic acceptance criteria use the acceptance described in Chapter 6.2 and Chapter 15 SRPs
  - Reg Guide 1.236 used for control rod ejection
- LOCA thermal hydraulic acceptance criteria will bound 10 CFR 50.46 acceptance criteria
  - [[

    ]]
  - [[

    ]]
  - [[

    ]]
- Radiological consequences can be discussed later with NRC

# Single Failures

- Active and passive single failures are applied per 10 CFR 50 Appendix A and SECY-77-0439
- Check valves will follow SECY-94-084 with some check valves classified as active components
  - Check valves that have a large pressure gradient (accumulator or initial injection from passive core make up water tank) will not be considered for active failures
  - Check valves with small pressure gradient (recirculation mode from passive core makeup water tank) will be considered for active failures
- Safety systems of SMR-160 are designed with redundancy such that a single failure of an active component does not prevent a system from performing its function

# LOCA Methods

- RELAP5-3D LOCA evaluation will use 10 CFR 50.46(a)(ii) which endorses the conservative Appendix K requirements
- Due to the large water volume to power ratio and elimination of large pipe breaks, only a subset of Appendix K phenomena are applicable to the SMR-160
- During the recirculation phase (long-term cooling) following a LOCA, the RCS and containment are tightly coupled.
  - [[ ]]
  - [[ ]]
  - [[ ]]

# NON-LOCA METHODS

- RELAP5-3D will predict the thermal hydraulic response from the initiating event
- RELAP5-3D will confirm margins to the RCS and SG design pressures and temperatures
- COBRA-FLX will receive input data from RELAP5-3D to confirm margin to MDNBR

# Questions for NRC

- [[

]]

- [[

]]

- [[

]]