TRACG Analysis Results – Application for ESBWR

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Outline

- **Background**
- **ECCS/LOCA Analysis**
- **Containment/LOCA Analysis**
- **Demonstration Calculations for ESBWR AOOs**
- **Summary**

Background

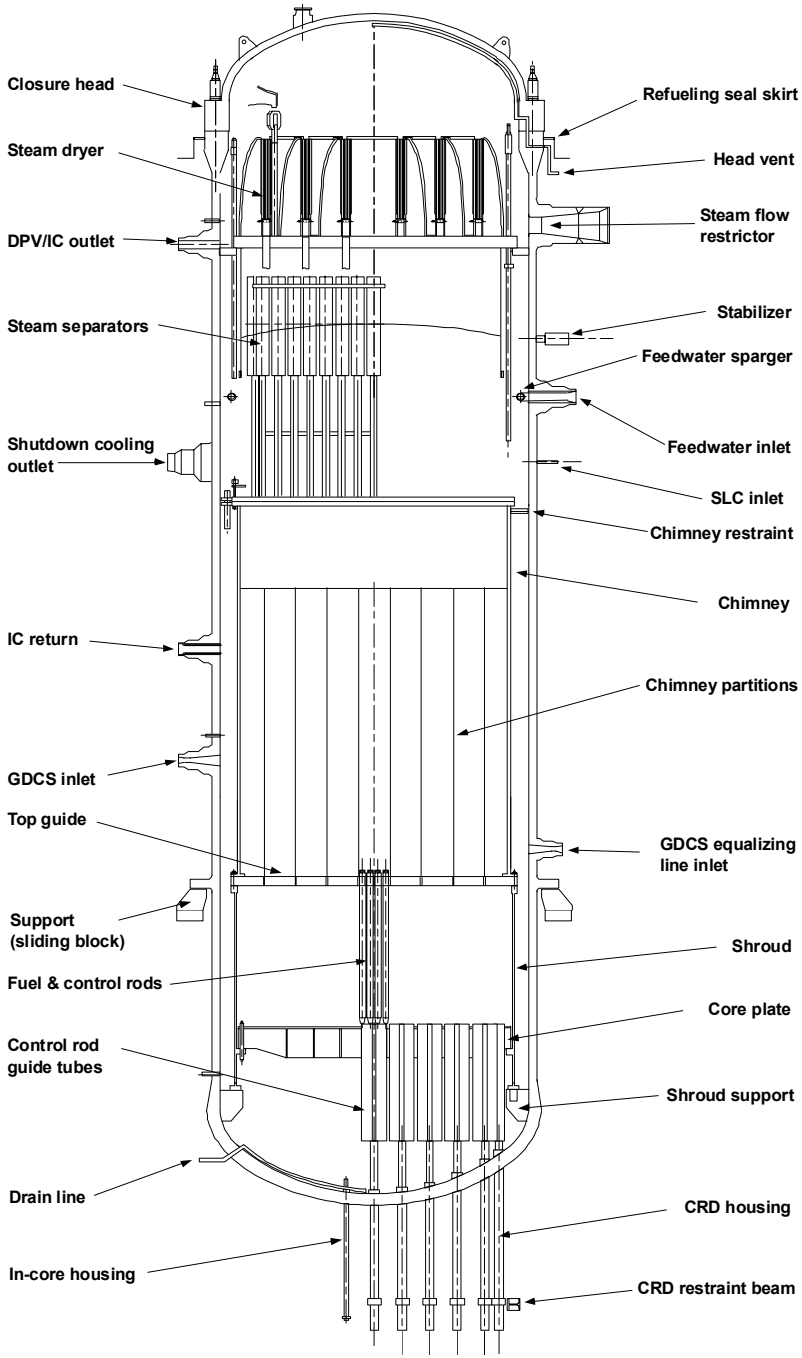
- **For ECCS/LOCA Analyses (0 ~ 2000 seconds)**
  - Fine nodalization in RPV, coarse nodalization in containment to provide system responses to the RPV
  - Key output: mixture level inside shroud and Peak Cladding Temperature
- **For Containment/LOCA Analyses (0 to 72 hours)**
  - Fine nodalization in containment, coarse nodalization in RPV to provide system responses to the containment
  - Key output: Long term containment pressure
- **For AOO Analyses**
  - Sample results for typical AOOs
- **This presentation summarizes the analysis results submitted in the TRACG Application Report**

ECCS/LOCA Analyses

- **Key design objectives**
  - Core covered by mixture at all time
  - No core heatup
- **Outline**
  - Nodalization
  - Sensitivity Study
  - Baseline Analysis
  - Bounding Analysis
  - Summary

ECCS/LOCA Analyses (Flow Chart)

RPV Key Features



Containment Key Features

ECCS/LOCA Nodalization

- Fine nodalization in RPV
- Coarse nodalization in containment

ECCS/LOCA Nodalization – Steam Line System

ECCS/LOCA Analyses (Flow Chart)

Scoping ECCS/LOCA Break Spectrum Analysis (Sec. 2.4.4.1)

- **Performed for a representative spectrum of break locations and sizes**
  - Main steam line break, GDCS injection line break, and Bottom drain line break
- **Performed in combination with a postulated single failure**
  - 1 SRV, or 1 DPV, or 1 GDCS injection valve
- **A total of 9 cases, run with**
  - Nominal RPV pressure (1040 psia) and initial water level
  - Initial power of 4000 MWt
  - 4 PCCS
  - No credit for ICs

GDCS line break with GDCS injection valve failure

RPV Inventory Distribution

Scoping ECCS/LOCA Break Spectrum Analysis (Cont.)

- **GDCS line break with GDCS injection valve failure**

- **2-phase level above TAF**
  - The key measurement for core coverage
- **Static head inside the chimney is selected as the figure of merit for comparison for the scoping analysis**
- **9 cases performed to identify the limiting case for minimum post-LOCA mixture level inside the chimney**

Scoping ECCS/LOCA Break Spectrum Analysis (Cont.)

ECCS/LOCA Analyses (Flow Chart)

Sensitivity Study on PIRT Parameters (Sec. 2.4.4.2)

- **Sensitivity study performed on the limiting case - GDCS line break with 1 GDCS injection valve failure**

- **Figure of merit for comparison – minimum static head inside the chimney**

Chimney Static Head Sensitivity to Uncertainties in PIRT Parameters

- **For all case, Static head margin to TAF > 2 m,**
  => No core heatup
- **Maximum impact is –0.3 meter**

Chimney Static Head Sensitivity to Uncertainties in PIRT Parameters

- **6 parameters with negative impact on minimum chimney static head level**

PCT Sensitivity to Uncertainties in PIRT Parameters

ECCS/LOCA Analyses (Flow Chart)

Sensitivity Study on Interactions between ECCS and Containment (Sec. 2.4.4.3)

Sensitivity Study on Interactions between ECCS and Containment (Sec. 2.4.4.3)

Sensitivity Study on Interactions between ECCS and Containment (Cont.)

(Fig. 2.4-15)

Sensitivity Study on Interactions between ECCS and Containment (Cont.)

ECCS/LOCA Analyses – Plant Conditions for Base Line Calculations

ECCS/LOCA Analyses – Uncertainties in Plant Parameters/Initial Conditions

ECCS/LOCA Analyses (Flow Chart)

Sensitivity to Plant Parameters/Initial Conditions

- **Sensitivity study performed on the limiting case**

Chimney Static Head Sensitivity to Plant Parameter Uncertainties

ECCS/LOCA Analyses (Flow Chart)

ECCS/LOCA Baseline Case

Results for Baseline ECCS/LOCA Analysis (Sec. 2.7.1.2)

Figure 2.7-4. RPV Pressure Response (Base Case)

Figure 2.7-5. RPV, Drywell and Wetwell Pressure Response (Base Case)

Figure 2.7-6. Two-Phase Levels in Downcomer and Inside Core Shroud (Base Case)

Figure 2.7-7. Two-Phase Level and Static Head In Chimney (Base Case)

ECCS/LOCA Analyses (Flow Chart)

Bounding ECCS/LOCA Analysis (Sec. 2.7.2)

Results for Bounding ECCS/LOCA Analysis (Sec. 2.7.2.2)

Figure 2.7-8. RPV Pressure Response (Bounding Case) **

Figure 2.7-9. RPV, Drywell and Wetwell Pressure Response (Bounding Case) **

Figure 2.7-10. Two-Phase Levels in Downcomer and Inside Core Shroud (Bounding Case) **

Figure 2.7-11. Two-Phase Level and Static Head In Chimney (Bounding Case) **

ECCS/LOCA Analyses - Summary

Containment/LOCA Analyses

- **Key design objectives**
  - Peak DW pressure below the design value (60 psia) with adequate margin
- **Outline**
  - Nodalization
  - Baseline Analysis
  - Sensitivity Study
  - Bounding Analysis
  - Summary

Containment Key Features

Containment/ LOCA Nodalization

- Fine nodalization in containment
- Coarse nodalization in RPV

Containment/LOCA Analyses – Plant Parameters

Table 3.5-1

Containment/LOCA – Baseline Analyses

- **Main Steam Line Break with 1 DPV failure**
- **Case assumptions**
- **Conservative modeling assumptions**
  -

Results for Baseline Containment/LOCA Analysis (Sec. 3.7.2)
Figure 3.7-2. Containment Pressure Response (Base Case)

Figure 3.7-3. Drywell Noncondensible Partial Pressures (Base Case)

Figure 3.7-4. 3 PCC Pool Level (Base Case)

Figure 3.7-5. GDCS Pool Level (Base Case)

Figure 3.7-6. PCCS Heat Removal vs. Decay Heat (Base Case)

Figure 3.7-7. Suppression Pool Temperatures (Base Case)

Figure 3.7-8. Wetwell Gas Space temperature Response (Base Case)

Figure 3.7-9. Drywell Temperature Response (Base Case)

Containment/LOCA – Sensitivity Study

Containment/LOCA – NC gases transport rate Sensitivity Study

Containment/LOCA – Bounding Analyses

- **Main Steam Line Break with 1 DPV failure**
- **Case assumptions**

- **Conservative modeling assumptions**

- **Bounding Case**

Table 3.7-1. Model Parameters for Bounding Case

Results for Bounding Containment/LOCA Analysis (Sec. 3.7.3)

Figure 3.7-11. PCCS Heat Removal vs. Decay Heat (Bounding Case)

Figure 3.7-12. Suppression Pool Temperatures (Bounding Case)

Figure 3.7-14. Wetwell Gas Space Temperature Response (Bounding Case)

Figure 3.7-15. Drywell Temperature Response (Bounding Case)

Figure 3.7-13. Drywell Pressure Response vs. Design Limit

Containment/LOCA Analyses Results

Demonstration Calculations for ESBWR AOOs

- **Baseline Analysis**

- **Large steam volume in ESBWR chimney region, milder transient responses comparing to operating plants**
- **Key objective**
  - To illustrate the transient responses in ESBWR

Generator load rejection with failure of all bypass valves to open (LRNB)

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Generator load rejection with failure of all bypass valves to open (LRNB)

Feedwater controller failure at maximum demand (150% of rated) (FWCF)

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Closure of all Main Steamline Isolation Valves (MSIVF)

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Closure of all Main Steamline Isolation Valves (MSIVF)

Summary

- **ECCS/LOCA analyses**
  - **Sensitivity studies performed, all conservative parameters and range of value identified and used in the bounding calculation**
- **Containment/LOCA analyses**
- **Demonstration Calculations for ESBWR AOOs**