Idaho National Engineering and Environmental Laboratory

SCDAP/RELAP5-3D®
- CONTAIN Linkage

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Objective and Outline

• **Objective**
  – To discuss motivation and plans for linking SCDAP/RELAP5-3D© with CONTAIN 2.0

• **Outline**
  – Motivation for improved SCDAP/RELAP5-3D© - CONTAIN 2.0 linkage
  – Existing linkage using PVM and test case results
  – Proposed improved linkage
  – Summary
References


Linked mechanistic vessel/containment response analysis tool important for advanced reactors.

- Increased dependence on passive systems
  - ERVC
  - IRWST
  - PCCS
- Requires analyses with increased fidelity in heat and mass transfer between RCS and containment
Motivation
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SCDAP/RELAP5-3D© - CONTAIN linkage provides mechanistic tool for vessel/containment analysis.

Integrated Codes

MAAP
MAAP4-DOSE
MELCOR
MACCS

Detailed Mechanistic Codes

SCDAP/RELAP5-3D©
VICTORIA
CONTAIN
MACCS

Accident Progression Phenomena

Thermal hydraulics
Core melting
Release from fuel
Transport in RCS
RCS failure
Concrete interactions
Release from debris
Transport in containment
Containment loads
Containment performance
Off-site consequences
CONTAIN provides mechanistic containment analyses tool.

**Motivation**

**AEROSOLS**
- Particle size distribution
- Material composition
- Deposition

**FISSION PRODUCTS**
- Radioisotope inventory
- Decay and heating
- Release and acceptance

**THERMAL HYDRAULICS**
- Gas and liquid flow
- Heat transfer
- Thermodynamics
- Engineered safety features
- Debris fields

- Distribution of fission products
- Evaporable coolant inventory
- Heat to gas, walls, pool
- Transport of gas or fission products
- Intercell transport
- Deposition/agglomeration rates
**CONTAIN provides mechanistic containment analyses tool. (continued)**

<table>
<thead>
<tr>
<th>Code Function</th>
<th>CONTAIN</th>
<th>MELCOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport of Direct Containment Heating (DCH) materials throughout the containment</td>
<td>Mechanistic models</td>
<td>Parametric models require user specified transportation</td>
</tr>
<tr>
<td>Radiation from corium to containment structures</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Film flow modeling on structure walls</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Coupling containment sprays with direct impingement on containment structures</td>
<td>No, but could be added</td>
<td>No</td>
</tr>
<tr>
<td>Flow solver</td>
<td>Advanced hybrid solver that automatically mitigates overmixing and allows stratification.</td>
<td>Flow path approach requiring judicious nodalization to prevent over-mixing</td>
</tr>
<tr>
<td>Local time-dependent velocities for calculating convection heat transfer coefficients</td>
<td>Flexible input allowed</td>
<td>Difficult to simulate</td>
</tr>
<tr>
<td>Inertial impact of aerosols</td>
<td>Yes</td>
<td>None</td>
</tr>
<tr>
<td>Variable solubility of aerosols</td>
<td>Yes</td>
<td>To be added in MELCOR 1.8.5</td>
</tr>
</tbody>
</table>
User modeling and input influence CONTAIN and MELCOR results.

Wide range of MELCOR temperature predictions observed for BMC/VANAM M-3 (ISP 37)
CONTAIN results better matched HDR Test E11.2 data.

MELCOR and CONTAIN results calculated by AEA for ISP 29
CONTAIN results better matched HDR Test E11.2 data. (continued)

MELCOR and CONTAIN results calculated by AEA for ISP 29
CONTAIN with new hybrid flow solver better matches HDR Test E11.2 data.
Initial SCDAP/RELAP5-CONTAIN PVM linkage completed by PSU.

- Used PVM software to link SCDAP/RELAP5/MOD3.0 and CONTAIN 1.1.

- “Limited” linkage:
  - Transfers break flowrates, SRV discharges, pool injection sources
  - Heat transfer from selected structures
  - Instantaneous flowrates, rather than integrated flowrates
  - Doesn’t transfer non-condensable gases (hydrogen), fission products, aerosols, or discharged corium

- Demonstrated capabilities by analyzing Brown’s Ferry ATWS
Calculation results illustrate feasibility and importance of linkage.

- **Fully linked**
  - Coupled with PVM software

- **Stand-alone**
  - SCDAP/RELAP5 containment conditions taken from CONTAIN input deck and assumed to remain constant;
  - SCDAP/RELAP5 output entered as tabular data into CONTAIN
Similar reactor power results predicted by linked and stand-alone SCDAP/RELAP5.
Linked code predicts higher LPCI flow into RCS.
Linked code predicts higher containment temperatures and pressures.

More defensible vessel/containment response achievable through fully-linked analysis.
Proposed PVM linkage will improve upon previous linkage efforts.

- Integrate SCDAP/RELAP5-3D© and CONTAIN 2.0 codes using PVM software and Executive Program

- Use insights gained from previous linkage efforts:
  - Relative time for calculations to advance (and relative timestep)
  - Form of variables for data transfer (enthalpy and mass flowrate)
  - Subroutines selected for extracting and receiving data
  - Review previous coding and improve, as needed

- Compare advanced reactor plant analysis with and without integrated code
  - AP600 analysis performed for DVI “3BE” LOCA scenario
Proposed PVM linkage will improve upon previous linkage efforts. (continued)
Summary

• **SCDAP/RELAP5-3D** and **CONTAIN** embody state-of-the-art thermal-hydraulic and severe accident models for mechanistic analyses

• **SCDAP/RELAP5-3D** and **CONTAIN** results consistently serve as reference for comparison

• Proposed PVM linkage of **SCDAP/RELAP5-3D** and **CONTAIN 2.0** will provide a state-of-the-art mechanistic tool needed for coupled vessel / containment analyses