RELAP5-3D Simulations of Hot Leg Break LOCA Scenarios

International RELAP5-3D User’s Group Meeting
Idaho Falls, ID
October 6-7, 2016

Presenters: Rodolfo Vaghetto and Alessandro Vanni
Content

- Intro
- Input Model Description
- Simulation Results
- Core Exit CCFL Sensitivities

No Proprietary Information Disclosed
ML15246A126 – A129
LOCA Long Term Core Cooling (LTCC)

- Emergency Core Cooling System – ECCS - pumps deplete RWST
- Water from the containment sump is injected into the primary system
- Debris is carried into the primary system
- Core coolability may be compromised
- Alternative flow paths
GSI-191: Cold Leg Break Scenarios
GSI-191: Hot Leg Break Scenarios
GSI-191: Hot Leg Break Scenarios
Core Coolability

- Counter Current Flow at core exit
- Pass / Fail Criterion?
CCFL Experimental Data

Wallis [2]
single tube - sharp edges
\( j_g^{1/2} + j_f^{1/2} = 0.725 \)

<table>
<thead>
<tr>
<th>d(cm)</th>
<th>t(cm)</th>
<th>n</th>
<th>p(cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1</td>
<td>4</td>
<td>9.6</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>4</td>
<td>9.6</td>
</tr>
<tr>
<td>2.86</td>
<td>2</td>
<td>2</td>
<td>3.58</td>
</tr>
<tr>
<td>1.05</td>
<td>2</td>
<td>3</td>
<td>1.43</td>
</tr>
<tr>
<td>1.05</td>
<td>2</td>
<td>15</td>
<td>1.43</td>
</tr>
<tr>
<td>2.93</td>
<td>1.27</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>1.05</td>
<td>2</td>
<td>25</td>
<td>1.43</td>
</tr>
<tr>
<td>1.2</td>
<td>0.12</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2.0</td>
<td>0.2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td>2</td>
<td>52</td>
<td></td>
</tr>
<tr>
<td>3.6</td>
<td>7.2</td>
<td>3</td>
<td>11.6</td>
</tr>
<tr>
<td>3.6</td>
<td>72</td>
<td>3</td>
<td>11.6</td>
</tr>
</tbody>
</table>

d: hole diameter
t: plate thickness
n: number of holes
p: pitch between neighboring holes
## CCFL Coefficients

<table>
<thead>
<tr>
<th>Case</th>
<th>$\beta$</th>
<th>$c$</th>
<th>$m$</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>LTCC EM - Base</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>Wallis – Smooth-edges. Bounding condition</td>
</tr>
<tr>
<td>Sensitivity 1</td>
<td>0.038422</td>
<td>2</td>
<td>1</td>
<td>Bankoff – STP Geometry</td>
</tr>
<tr>
<td>Sensitivity 2</td>
<td>0</td>
<td>0.725</td>
<td>1</td>
<td>Wallis – Sharp-edges. Worst Condition</td>
</tr>
</tbody>
</table>

The graph illustrates the relationship between $j^*{1/2}$ and $j_g$, with key points marked at $c=0.725; m=1$, $c=2; m=1$, and $c=1; m=1$. The data points represent experimental results, and the lines are theoretical models.
Input Model Description
System Nodalization

Loop 1
Upper Plenum Nodalization
Break and ECCS Nodalization

3 SI Trains  HL Large Break (16’’)

Diagram showing the flow and connections between different components, such as hot leg, cold leg, SI lines, valves, accumulators, pumps, and containment sump.
Core Blockage Approach

- Full Core Blockage (Both core and core bypass blocked)

- 360s after the sump switchover time, 456 and 457 trip valves closure occurs
Simulation Results
Core PCT and CLL
ECCS Water Flow Path – Broken Loop
ECCS Water Flow Path – Broken Loop

Loop 1
ECCS Water Flow Path – Intact Loops
ECCS Water Flow Path – Intact Loops

Loop 1
ECCS Water Flow Path – Intact Loops

Loop 1
Core Axial Temperature Profile

Temperature (F)

Elevation (ft)

- Average Assembly
- Hot Assembly
- Hottest Rod

large HL-LOCA
Core Axial Temperature Profile

large HL-LOCA + CB
Core Axial Temperature Profile

large HL-LOCA + CB + CCFL
Cumulative CCFL-limited Time
Core Exit CCFL Sensitivities
## Sensitivity Table

<table>
<thead>
<tr>
<th>Case</th>
<th>$\beta$</th>
<th>$c$</th>
<th>$m$</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>LTCC EM - Base</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>Wallis – Smooth-edges. Bounding condition</td>
</tr>
<tr>
<td>Sensitivity 1</td>
<td>0.038422</td>
<td>2</td>
<td>1</td>
<td>Bankoff – STP Geometry</td>
</tr>
<tr>
<td>Sensitivity 2</td>
<td>0</td>
<td>0.725</td>
<td>1</td>
<td>Wallis – Sharp-edges. Worst Condition</td>
</tr>
</tbody>
</table>
CCFL Comparison
CCFL Coefficients
Render unto Caesar

Dr. Shin Kang
Mr. Ernie Kee
Mr. Timothy Crook
Questions?