OVERVIEW OF MELCOR ACTIVITIES IN CIEMAT (2011)

C. Lopez, M. García, B. Otero, LE. Herranz

Unit of Nuclear Safety Research

CIEMAT, SPAIN
Scenarios Addressed

• Plant analysis.
  BWR3 (Spanish CSN) → MELCOR 1.8.6 YV 3084

• Fuel degradation in the presence of air.
  SFP (OECD-SFP project) → MELCOR 1.8.6 YV 3084 SFP

• Containment thermal-hydraulic and aerosol behavior.
  SFR (CP-ESFR project) → MELCOR 1.8.6 YV 3084
  LWR (Phebus-FP project) → MELCOR 1.8.6 YV 3084
Inputs updating

- Plant analysis BWR
  184 ➔ ✓ 185 ➔ ✓ COR ➔ ✓ Converter ➔ ✗ On it ➔ 2.1 ➔ ✗ SNAP

- SFR-ABCOVE
  186 ➔ ✓ 2.1.1576

- Phebus FPT3
  ✓ SNAP running
  ✗ SNAP post pro
Further work and final remarks

- OECD-SFP project: extension to PWR fuel assemblies
- Phebus-FPT3 Benchmark (Sarnet 2)
- Extension of validation against SFR available data (source term)

- Analysis of SGTR scenarios

✓ Stress the need of a SNAP course, not easy to handle
THANK YOU FOR YOUR ATTENTION
**Inputs updating:**

v2.1.1576  
(Unoptimized)  

Melgen OK!  
ERROR-melcor  

<Diagnostic Message>  
Time = 3.6644E+04  
Dt = 9.4609E-01  
Cycle = 36593 (CVH)  
Attempted cycle advancement was unsuccessful - DT reduced to = 4.4202E-01

v2.1.4206  

ERROR-melgen  

<Diagnostic Message>  
Time = 3.6644E+04  
Dt = 9.4609E-01  
Cycle = 36593 (CVH)  
Attempted cycle advancement was unsuccessful - DT reduced to = 4.4202E-01

WWW...  
Diagnostics during input processing TF package:  
NO errors during input processing TF package  
WWW...  
Diagnostics during input processing COR package:
1. BWR3-Mark I

Accident Sequence

- SBO
- High pressure (~75 bar)
- 6 SRVs available
- High pressure ECCS and IC unavailable
1. BWR3-Mark I

- Updating with the MELCOR BMP (Nureg/CR-7008)
- Revision of the aerosol characterization:
  Range of size, shape factors, sticking coefficient…..

![Graph of MMD over time for RPV and WW](image)

- RPV
  - MMD_DOME C1
  - MMD_DOME C2
  - 1-50 μm
  - 0.1-10 μm

- WW
  - MMD_WW C1
  - MMD_WW C2
1. BWR3-Mark I

<table>
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<th>DTMAX</th>
<th>DTMIN</th>
<th>DTEDIT</th>
<th>DTPLOT</th>
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</tr>
</tbody>
</table>

** DTmax, DTplot
2. SFP

- Zr air oxidation leading to cladding ignition
- Prototypic BWR FAs (electrically heated with MgO fuel substitute) in prototypic SFP racks (SS walls with neutron absorber layer - Boraflex)
- Assemblies arrangements
  - 1x1: “hot-neighbor” situation → ignition axial propagation
  - 1x4: “cold-neighbor” situation → ignition radial propagation
2. SFP: Modeling studies

Base Case

Hydraulic model

\[ k^* = k + \frac{S_{lam} \cdot L}{Re \cdot D_H} \left( \frac{F}{A_s} \right) \]

CVH nodalization

Coarse

Fine

n = 6

n = 13

Oxidation model

Breakaway Transition

Pre-rate

\[ k_{Trans} = \alpha \cdot k_{pre} + (1 - \alpha) \cdot k_{post} \]

\[ \alpha = \frac{LF_{max} - LF}{LF_{max} - 1.0} \]

\[ LF = \int_0^t \frac{\tau'}{T} dt' \]

\[ \tau \approx 10 \frac{42.04}{T^{12.58}} \]
2. SFP: CVH nodalization and hydraulic model

The coarse nodalization leads to different results in spite of preserving total hydraulic losses.

The variation of $S_{LAM}$ in the range of the experimental uncertainty slightly affects the results.

The variation of $k$ in the range of the experimental uncertainty hardly affects the results.
2. SFP: Zr air oxidation model

Heavily parametrized (slight variation of $\tau$ correlation)
The BC does not seem to represent the actual oxidation phenomena
Best estimate is achieved by accelerating pre-breakaway kinetics and making abrupt transition

BWR 1x4
3. SFR

**Project:** EU-ESFR (SP3 - Safety)

**Focus:** In-containment Aerosol dynamics

**Scenario:** ABCOVE Program

- **AB5** Na spray fire
- **AB6** NaI + Na spray fire
- **AB7** Na pool fire – NaI injection
3. SFR: modeling challenges

\[ CB \]

\[ Q_{ch} + Q_s \to 100\% \text{ atm} \]

\[ Q_{ch} \]

\[ 2\text{Na} + \text{O}_2 \to \text{Na}_2\text{O}_2 \quad \Delta H = -124 \text{kcal/mol} \]

\[ \text{HOH} + \text{Na}_2\text{O}_2 \to 2\text{NaOH} + \frac{1}{2}\text{O}_2 \quad \Delta H = -85 \text{kcal/mol} \]

\[ Q_s \quad \text{To account for the } \Delta T \text{ between the aerosols and the atmosphere} \]
3. SFR: modeling challenges

CIEMAT

\[ Q_{ch} \rightarrow 50\% \text{ atm} + 50\% \text{ ‘Fire ball’} \]

(HS) (TF)

**Fire ball hypothesis** (HS rectangular, vertical)

- Shielding effect
- HS surface
- HS thickness
- HS density

\{ A dense & compact mass to preserve the thermal capacity and thermal inertia of the hot aerosols cloud \}
3. SFR: modeling challenges
4. Phebus-FPT3

FPT3 test:

<table>
<thead>
<tr>
<th>Flow</th>
<th>Fuel</th>
<th>Containment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam poor (steam starvation)</td>
<td>BR3 24.5 GWd/tU B₄C control rods</td>
<td>Evaporating acidic sump Recombiners</td>
</tr>
</tbody>
</table>

Objective

- Uncertainty analysis to the Th’s and aerosol modeling of FPT3

\[ Th's: 24 \text{ var} \]

\[ Rh_o \quad T_{\text{wet-cond}} \]

Aerosols

- Iodine source
- Particle size
- Density

Uncertainty
4. Phebus-FPT3: User tool kit for uncertainty analysis

Stochastic approach: Wilks Theory
“93 samplings determine a 95% of the CI with a 95% of CL”

Fortran Applications:
Specific for Phebus-FPT3

n inputs: • n samples
• Different distributions
• Time dependent profiles BC

Postprocessing:
• n output files
• Defined output variables
4. Phebus-FPT3: On going analysis

MELCOR
93 runs