CASMO-5/5M Code and Library Status

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Arizona 2008
CASMO Methodology Evolution

**CASMO-3**
Homo. transmission probability/external Gd depletion

**CASMO-4 up to version 1.2**
1x1 Method of Characteristics and 2x2 HETRAP
In-line Gd depletion
L-library/2-grp data for SIMULATE-3

**CASMO-4 version 1.3 to 2.05**
1x1 and 2x2 Method of Characteristics
L-library/2-grp XS data for SIMULATE-3

**CASMO-4E version 2.10**
MxN Method of Characteristics
Pn-scattering/Generalized racks
New numerical models
70 grp JEF 2.2/E6 Libs./2-grp XS data for SIMULATE-3

**CASMO-5/5M**
MxN Heterogeneous Method of Characteristics
Pn-scattering
Generalized racks
New numerical models
Updated geometry models
Spent Nuclear Fuel edits
586 grp ENDF/B-VII library
Multi-group XS data for SIMULATE-4
CASMO-5 Versus CASMO-5M

• CASMO-5
  Single assembly cross section generator for SIMULATE with advanced single assembly numerical models

• CASMO-5M
  Perform additional calculations not directly related to XS generation:
  – Explore multi-assembly effects
  – Fuel storage pool calculations
  – Higher order scattering calculations
New/Updated CASMO-5/5M Models

• Resonance Calculation
  – Characteristics based Dancoff calculation
  – More nuclides with shielded data, (including Zr)

• Pin Cell Calculation
  – Performed in 586 energy groups (CASMO-4 was a 70 group calculation)

• 2D Transport Calculation
  – Performed in 19 energy groups (CASMO-4 was an 8 group calc.)
  – Optimum 3 polar angle scheme (T-Y quadrature)
  – Updated geometry models, e.g., BWR control blades, SVEA water diamond
New/Updated CASMO-5/5M Models

• Depletion Calculation:
  – Quadratic Gd depletion model
    • Improved accuracy for given depletion step size

• Back End Edits:
  – Generate multigroup XS and DFs for SIMULATE-4
  – Spent Nuclear Fuel (SNF) edits – heat generation rates, neutron and photon source strengths, etc

• New Neutron and Gamma Data Libraries
ENDF/B-VII R0 Neutron Data Library

- Evaluation released Dec. 2006
- 446 nuclides/materials (CASMO-4 L-lib had 103)
- Shielded data for 112 nuclides (incl. major fission products)
- Pn data for 66 nuclides (many up to order 5)
- Greatly extended depletion chains (no lumped F.P.’s)
- 586 energy groups:

<table>
<thead>
<tr>
<th>42 groups (Thermal)</th>
<th>375 Groups (Reso. Fine Groups)</th>
<th>41 Groups (Reso. Shielded)</th>
<th>128 Groups (Fast)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.625 eV</td>
<td>10 eV</td>
<td>10 kEV</td>
<td>20 MeV</td>
</tr>
</tbody>
</table>
What are we trying do with all these groups?

![Graph showing cross section vs. incident energy for Pu239, Pu240, U235, U238 with labels for fine groups and shielded regions.]

- Pu239
- Pu240: 6.67, 20.87, 36.7 eV
- U235
- U238

Fine groups  Shielded
CASMO-4 L-Library

Very simple chains!
Greatly enhanced detail!
Updated CASMO Geometry Models

Material Layout

Diamond rotated 45 degrees, and clad on control rod absorbers

Flat Source Regions
Additional CASMO-5M Models: Multi-assembly PWR/BWR Capability
Additional CASMO-5M Models:

Generalized Storage Rack Model

&

Higher Order Pn-scattering
Recent CASMO-5/5M Development:

- All new CASMO development is taking place in CASMO-5 to ensure that it remains state-of-the-art:
  - New Gamma Library
  - New Energy Release per Fission Model (ERF) (Thurs.)
  - New Resonance Upscatter Model (Thurs.)
CASMO-5/5M Gamma Library

• 18 gamma energy groups
• 70 group production matrices
  – Previous CASMO-4 gamma library had 25 grp prod. matrices
• 214 nuclides/materials
  – Previous gamma library had 19 nuclides/materials
• ENDF/B-VII based
  – Previous CASMO-4 gamma library was ENDF/B-IV based
• Embedded directly in CASMO-5/5M
CASMO-5/5M Benchmarking

• Historically:
  – 2-D CASMO vs. criticals
  – CASMO Pin-cell/bundle vs. measured isotopics

• Currently:
  – 3-D, continuous energy Monte Carlo criticals analysis (BOL)
    • KRITZ Criticals (Hot and cold, temperature coefficients)
    • B&W Criticals (eigenvalues and fission rate comparisons)
    • Other UO2 and MOX criticals
  – 2-D Monte-Carlo international depletion benchmarks
    • Pin-cells
    • Bundles
  – Monte Carlo pin-cell/bundle depletions vs. measured isotopics
## CASMO-5 Versus MCNP-5: Coefficients

<table>
<thead>
<tr>
<th>ENDF/B-VII R0</th>
<th>CASMO-5</th>
<th>MCNP-5 (+/- 15 pcm)</th>
<th>Δ PCM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Boron Worth:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CZP (0→1000 ppm)</td>
<td>7378</td>
<td>7391</td>
<td>-13 (-0.18%)</td>
</tr>
<tr>
<td>HXP (0→1000 ppm)</td>
<td>5650</td>
<td>5668</td>
<td>-18 (-0.32%)</td>
</tr>
<tr>
<td>HFP (0→600 ppm)</td>
<td>3437</td>
<td>3434</td>
<td>+03 (+0.09%)</td>
</tr>
<tr>
<td><strong>Void Defect:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0→40</td>
<td>5054</td>
<td>5035</td>
<td>+19 (-0.38%)</td>
</tr>
<tr>
<td>40→80</td>
<td>13486</td>
<td>13379</td>
<td>+107 (-0.80%)</td>
</tr>
<tr>
<td><strong>Doppler Defect:</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>550 K→900 K</td>
<td>682</td>
<td>671</td>
<td>+11 (1.6%)</td>
</tr>
</tbody>
</table>
B&W 1810 Series

• PWR-style arrangement 15x15 or 16x16

• Central Assembly:
  – AIC or B4C control rods
  – Gd pins as well

• Cores 1-10: Single-Region
  (2.459 wt%) 

• Cores 12-20 Two-Region
  (4.02 wt% driver, 2.459 wt% surrounding)
B & W Criticals (1810 Series)

Core 01

Single Region

Core 12

Two Region
B& W Simple Criticals (1484 Series)

Core I

K-eff=1.00027 (95 Grp)

Core II

K-eff=0.99952 (95 Grp)
Dimple Criticals

Core S06a (No Baffle)

K-eff=1.00149 (95 Grp)

Core S06B (Baffle)

K-eff=1.00108 (95 Grp)
Criticals Results

CASMO-5 Criticals

Ave = 1.00041, S.D. = 0.00065
CASMO-5 Benefits:

• Code is dedicated to XS generation

• Improved quality through simplification

• Use of new data libraries conforms to what will be the industry standard in the near future

• Improved methods $\rightarrow$ improved results

• Set the stage for the introduction of SIMULATE-4
Downstream CMS Compatibility:

- Great care has been taken to ensure that CASMO-5 will work with either SIMULATE-3 or SIMULATE-4

- Current CASMO-4 input decks will run just fine in CASMO-5

- Updated version of CMS-Link
Additional Data for SIMULATE-4

- Multigroup, macroscopic and microscopic cross sections and discontinuity factors (instead of just two group data)

- Control rod depletion data

- Sub-mesh data over the assembly (typically 5x5 for BWR and 9x9 for PWR)

- Expanded case matrix for SIMULATE-4 (S4C)
CASMO to SIMULATE

Yesterday

Today

Tomorrow

CASMO-5 is SSP’s lattice physics code and is now available on all major platforms!