3KEYSAA™

Severe Accident Analysis Modeling

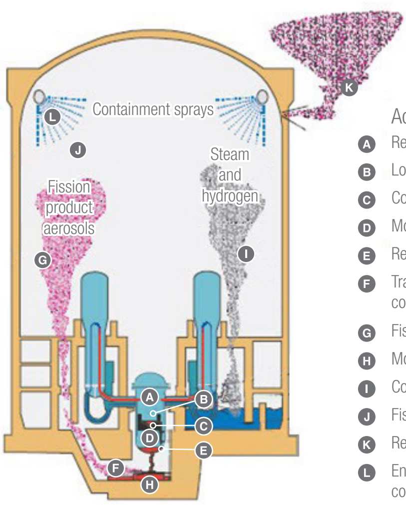
CURTISS-WRIGHT

Nuclear Power Products and Services

Since the Fukushima Dai-Ichi Nuclear Power Plant accident in Japan, the nuclear industry has placed greater focus on understanding plant behavior during severe events and making sure operations teams are fully prepared. There's a growing need for more realistic training that reflects what staff may face during high-risk scenarios.

Regulators like the NRC have encouraged the use of tools like Emergency Operating Procedures (EOPs), Severe Accident Management Guidelines (SAMGs), and Extensive Damage Mitigation Guidelines (EDMGs) to improve how teams respond to emergencies – both on-site and off-site. These strategies aim to strengthen decision-making in high pressure situations.

To help meet these evolving standards, Curtiss-Wright's Simulation Group* has reviewed and integrated today's top Severe Accident modeling tools – SCDAP (from INL), MAAP (from EPRI), and MELCOR (from the NRC). These are now built into our simulation platforms, making it easier for training teams to include realistic, hands-on severe accident scenarios in their programs. It's a smarter, more forward-looking approach to nuclear power plant simulation and emergency preparedness.



Accident Initiation

- A Reactor coolant thermal hydraulics
- B Loss of core coolant
- C Core meltdown and fission product release
- D Molten fuel/coolant interactions
- E Reactor vessel failure
- F Transport of fission products in RCS and containments
- G Fission product aerosol dynamics
- H Molten core/basemat interactions
- I Containment thermal hydraulics
- J Fission product removal processes
- K Release of fission products to environment
- L Engineering safety systems - sprays, fan coolers, iodine chemistry, etc.

What is 3KEYSAA™?

3KEYSAA™ is our Simulation Group's adaptation of the Severe Accident code to run in the 3KEYMASTER™ environment integrated with RELAP5, in **real-time** mode with **graphical visualization**.

3KEYSAA™ Severe Accident Model Features

- Thermal-hydraulic response of the primary reactor coolant system, reactor cavity, containment, and confinement buildings
- Core uncovering (loss of coolant), fuel heatup, cladding oxidation, fuel degradation (loss of rod geometry), and core material melting and relocation
- Heatup of reactor vessel lower head from relocated fuel materials and the thermal and mechanical loading and failure of the vessel lower head
- Transfer of core materials to the reactor vessel cavity
- Core-concrete attack and ensuing aerosol generation
- In-vessel and ex-vessel hydrogen production, transport, and combustion
- Fission product release (aerosol and vapor), transport, and deposition
- Behavior of radioactive aerosols in the reactor containment building, including scrubbing in water pools, and aerosol mechanics in the containment atmosphere

*: WSC, a legacy brand of Curtiss-Wright's Simulation Group, headquartered in Frederick, MD, is a global simulation and services company. Acquired by Curtiss-Wright in 2024, WSC is recognized for the quality and efficiency of their products and flexible team-oriented approach to serving its customers.

3KEYSAA™

Severe Accident Analysis Modeling

3KEYSAA™ Advantages

- Transition between RELAP and Severe Accident model is performed seamlessly
- All physical parameters specific to the current simulation state (fuel temperatures, moderator densities, etc.) are communicated to the Severe Accident model
- Ability to simulate severe accidents in real-time and fast time
- Ability to simulate all main phenomena during severe accidents with a comprehensive verification matrix proving its accuracy
- Easily integrated with the best-estimates code, RELAP5-3D, providing advantages for both design specific accidents and severe accidents
- Ability for “on the fly” transition between RELAP5-3D and our FlowBase Containment with Severe Accident Model
- The MELCOR Severe Accident model Input deck is similar to the RELAP5 code, which allows for excellent synchronization of the models during the switching process
- MELCOR and MAAP4/5 are backed by the US NRC (Sandia National Labs) and EPRI respectively with users worldwide providing feedback on code robustness and accuracy

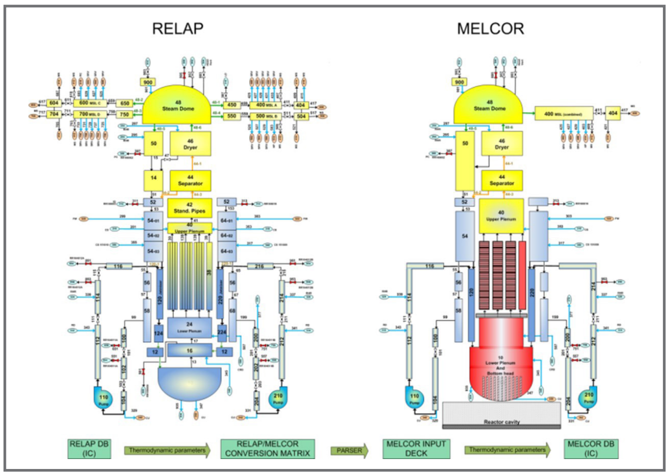
3KEYSAA™ Severe Accident Model Progression of Events

- Loss of Coolant; duration in seconds to minutes
- Core Uncovered; duration in seconds to hours
- Volatile Fission Products Released to Upper Part of Vessel/ Internals and Containment; duration in minutes to hours
- Lower Vessel Internal Structures Fail; duration in minutes to hours
- Core Debris Interaction with Residual Coolant in Vessel Lower Head; duration in hours
- Vessel Lower Head Fails; duration in hours
- Core Debris Interaction with Reactor Cavity (Wet or Dry); duration may extend to 24 hours
- Core Debris and/or Activity Release from Cavity; duration 12-24 hours
- Containment Leakage; duration 12-24 hours
- Containment Failure; duration 12-24 hours

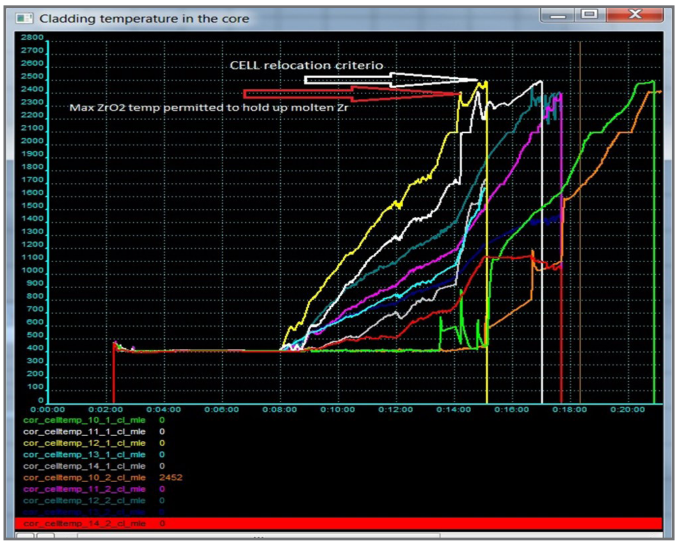
The flexibility to choose any 3KEYSAA™ variable that is available in shared memory allows the generation of trends and tabular displays for analyzing model response and benchmarking against available data.

Benchmarking

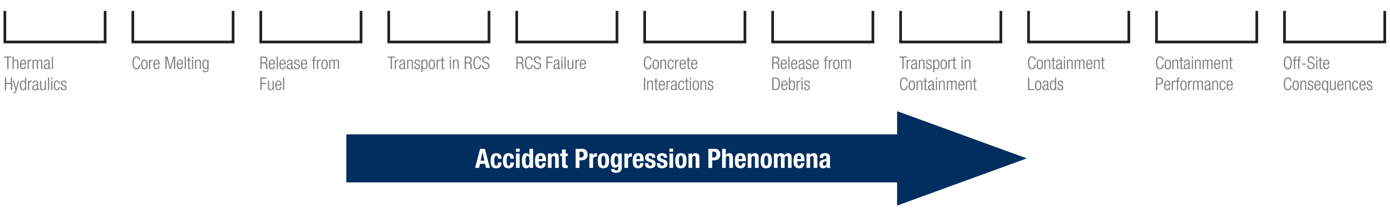
There are no changes made to the MELCOR, MAAP5 or RELAP5 thermal-hydraulics codes when integrating with 3KEYMASTER™; therefore, 3KEYSAA™ inherits the extensive benchmarking previously completed against test facility results and other industry recognized codes.



Typical Nodalization



Example trend shows seamless transfer between RELAP5 and 3KEYSAA™ Severe Accident Analysis model



CONTACT INFORMATION: 7196 Crestwood Blvd., Suite 300, Frederick, MD, 21703 USA
simulation@curtisswright.com | +1.301.644.2500