Sandia National Laboratories

Energy, Climate & Infrastructure Security

MELCOR

MELCOR is a fully integrated, engineering-level computer code designed to analyze severe accidents in nuclear power plants and nuclear fuel cycle facilities.

Modeling Accident Progression

Created at Sandia National Laboratories for the U.S. Nuclear Regulatory Commission (NRC), MELCOR's primary purpose is to model the progression of accidents in light water reactor nuclear power plants. Development of MELCOR was motivated by Wash1400, a reactor safety study produced for the NRC, and the Three Mile Island nuclear power plant accident. Since the project began in 1982, MELCOR has undergone continuous development to address emerging issues, process new experimental information, and create a repository of knowledge on severe accident phenomena.

Three Mile Island nuclear power plant

MELCOR: A Unique Code

MELCOR models a broad spectrum of severe accident phenomena, both in boiling water and pressurized water reactors, in a unified framework.

These phenomena include:

- Thermal-hydraulic response in the reactor coolant system, reactor cavity, and the containment and confinement buildings
- Core heat-up, degradation, and relocation
- Core-concrete attack
- Hydrogen production, transport, and combustion
- Fission-product release
- Transport behavior

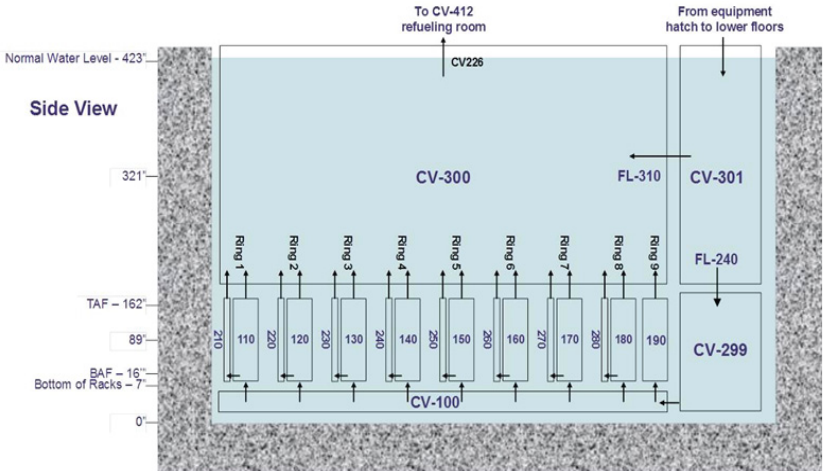
Spent fuel pool assembly similar to those modeled by MELCOR

MELCOR applications estimate severe accident source terms and their associated sensitivities and uncertainties in a variety of regimes and scenarios.

Modeling Spent Fuel Pools

The Fukushima reactor accidents demonstrate the importance of modeling accidents in reactor spent fuel pools (SFPs). To facilitate SFP accident scenario analyses, Sandia added several code enhancements. Operators can use these new MELCOR features to perform three SFP calculation types:

- SFP in normal operating conditions
- Partial loss-of-coolant inventory accident
- Complete loss-of-coolant inventory accident



MELCOR nodalization of a spent fuel pool

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U.S. DEPARTMENT OF ENERGY

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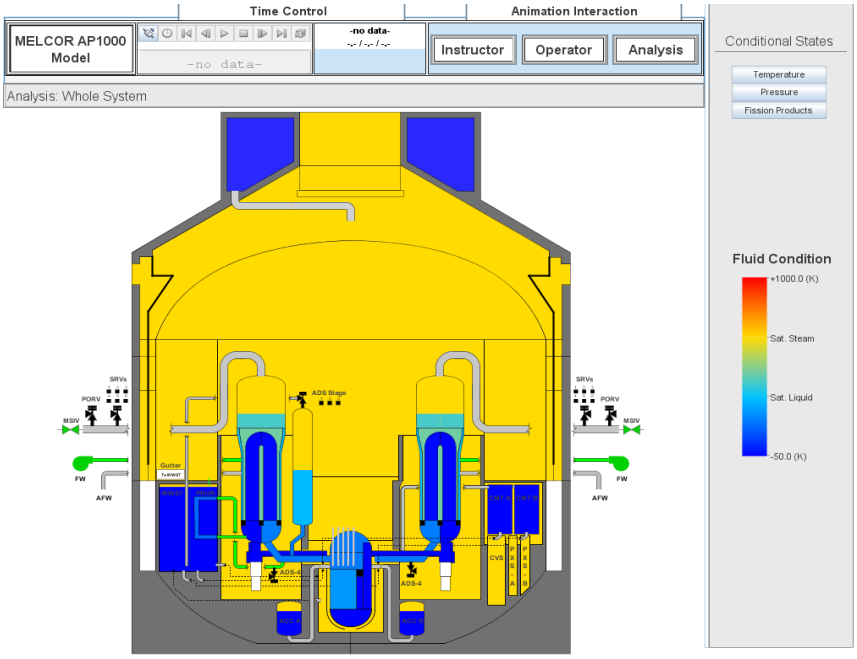
Modeling High-Temperature Gas Reactors

As the Next Generation Nuclear Plant Project progresses in its regulatory review, the NRC must be able to evaluate proposed high-temperature gas reactor (HTGR) designs from a safety standpoint. To support the NRC review, MELCOR code developers enhanced the code to model:

- Pebble-bed reactor (PBR) and prismatic block reactor (PMR) core designs
- Fission product release from tristructuralisotopic (TRISO) fuel particles in fuel pebbles or compacts
- Fission product and dust transports in the primary system

These enhancements allow MELCOR to model HTGR systems in both normal, steady-state operation, and transient accident scenarios.



An underlying MELCOR model drives the graphical user interface of a nuclear reactor simulator, providing modelers and customers with visual depictions of accident progression.

Integrating the Symbolic Nuclear Analysis Package

The Symbolic Nuclear Analysis Package (SNAP) provides a suite of graphical plug-ins for interfacing with various engineering analysis codes developed for the NRC (i.e. TRACE, RELAP5, PARCS, CONTAIN 2.0). With an easy-to-use graphical user interface (GUI) for simulating and visualizing accidents, the GUI serves as a convenient and intuitive resource for modifying or creating input decks — particularly desirable for new MELCOR users. For experienced users, SNAP provides a powerful post-processing capability to depict results and create advanced animations. It also has the capability to convert input decks from MELCOR 1.8.6 to MELCOR 2.1 and a kiosk mode to create a high-level engineering interface.

Nuclear Facility Applications

MELCOR has been the accident modeling code of choice for the NRC for over 30 years. It is currently used in uncertainty analyses and sensitivity studies. To facilitate these uses, many of the mechanistic models are coded with optional adjustable parameters. This does not affect the model's mechanistic nature, but it allows the analyst to easily address questions of how particular modeling parameters affect a calculated transient's course. MELCOR modeling is general and flexible, using a "control volume" approach to describe the plant system and has been successfully used to model East European reactor designs such as the Russian VVER and RMBK-reactor classes.

Non-Nuclear Reactor Applications

MELCOR is widely used both nationally and internationally for nuclear reactor accident analyses. In addition, MELCOR is used for non-reactor applications, such as estimating the amount of radioactive or other harmful materials released from a facility, building, or a confined space structure by organizations such as the Department of Energy (DOE). To assess the release of these materials, MELCOR is often used by safety basis (SB) analysts to perform the leak path factor (LPF) calculation. SB analysts use LPFs to estimate a material-of-concern release fraction from a facility to the environment via leak paths including door gaps, penetrations, door openings during evacuation, and door openings due to an energetic event during an accident.

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