Sandia National Laboratories

Energy, Climate & Infrastructure Security

Severe Accident Modeling

Sandia National Laboratories leverages severe accident modeling to support its nuclear energy efforts by developing risk margins, creating risk assessments, sequencing nuclear reactor accident progression, and performing reactor consequence modeling.

Dynamically Modeling Severe Accidents

Sandia draws on capabilities developed through severe accident modeling to support its nuclear energy efforts. In addition to developing risk margins, dynamic probabilistic risk assessments, and deterministic risk assessments, Sandia is able to sequence nuclear reactor accident progression as well as reactor consequence modeling. Severe accident modeling phenomena include thermal-hydraulic response; core heat-up, degradation, and relocation; hydrogen production; transportation; combustion; and fission product release and transport behavior.

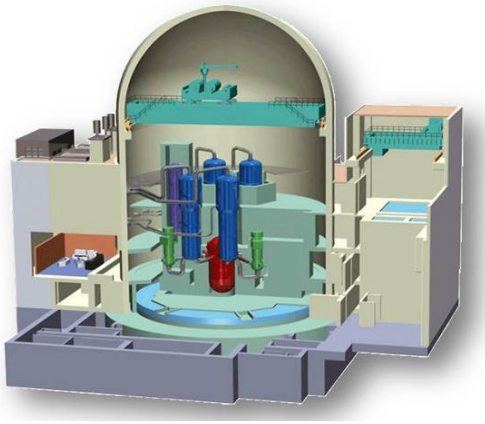
Damaged reactor buildings from the Fukushima Daiichi Nuclear Power Plant

Computer codes such as MELCOR and MACCS dynamically model sequences of radioactive material release from inception through potential radiological release allowing estimations of atmospheric dispersion, as well as economic and health consequences.

Systems-Based Capabilities

Supporting the modeling and analysis of accidental nuclear and hazardous material releases from nuclear power plants, Department of Energy facilities, and other hazardous facilities, Sandia draws on its legacy weapons-based mission work in support of the nation's evolving needs. Though capable of performing analysis on specific aspects of a severe accident situation, Sandia's strength lies in applying a comprehensive, systems-based approach to modeling and simulation analysis.

- Comprehensive Event Modeling and Analysis: Accident modeling from event inception through the potential radiological release is critical in creating useful, realistic simulations. These comprehensive simulations model multiple critical elements of the situation including variants such as atmospheric dispersion, economic consequences, and health consequences with enhanced detail. This ultimately creates an increasingly robust and reliable set of information for analysis.
- Uncertainty Analysis and Sensitivity Studies: As accidents represent a convergence of any number of situational variants, uncertainty analysis and sensitivity studies prove instrumental in producing useful, representative models and simulations. Applying degrees of measurement and statistical models to uncertain elements and potential variation attribution enhance and refine the models and the resulting analysis.
- MELCOR: A fully integrated, engineering-level computer code designed to model accident progression in light water reactor (LWR) nuclear power plants, MELCOR models a broad spectrum of severe accident phenomena through a unified framework. MELCOR applications estimate severe accident source terms and their associated sensitivities and uncertainties in a variety of regimes and scenarios.



A MELCOR model of a pressurized water reactor, containment, and auxiliary building.

- MACCS2: Developed to analyze the off-site consequences of an accidental atmospheric release of radioactive material, MACCS2 provides detailed analysis of an accident by calculating a radiological release's atmospheric transport and environmental dispersion. Designed primarily as a probabilistic risk assessment (PRA) tool, MACCS2 analysis results include land contamination levels and areas, doses to individuals and populations, health effects and risks, and economic losses resulting from an accident.

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U.S. DEPARTMENT OF ENERGY

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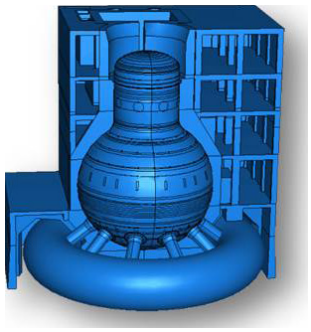
Accident Planning, Preparation, and Management

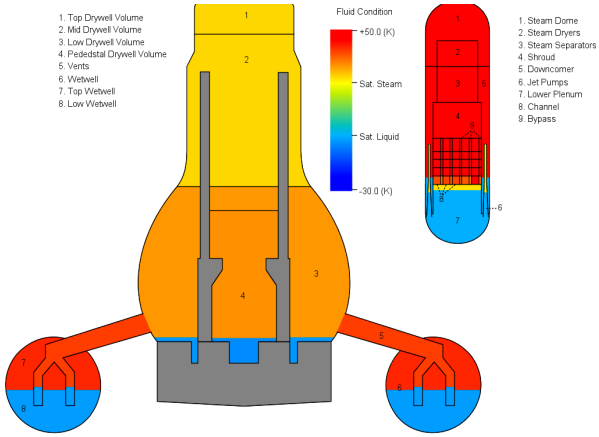
The analysis of severe accident models and simulations provides input that can be used for a variety of purposes. For example, Sandia uses this type of analysis as support for its nuclear power plant risk assessments. Accounting for complex systems-based variables including situational dimensions such as human reliability, emergency preparedness and response, physical security, and cyber security, accident modeling illuminates and identifies areas of potential vulnerability informing both probabilistic and deterministic risk analyses.

Once vulnerabilities are identified, comprehensive accident modeling also plays an important role in designing and carrying out accident management and mitigation measures. Accident management requires strategic preparation based on many situational factors that can be simulated through accident models. Creating a variety of accident scenarios accounting for specific conditions, Sandia assesses the severity of the modeled accident and a number of potential recovery options are devised.

Sandia also assists regulatory agencies in decision processes and negotiation using its severe accident modeling capabilities. As a Federally Funded Research and Development Center (FFRDC), Sandia occupies a position of trust and independent technical judgment for the federal government. This allows it to leverage its expertise in accident modeling to inform and educate decision makers in addition to lending knowledge and analytical results to numerous tactical applications.

As an example, Sandia has worked with the Nuclear Regulatory Commission (NRC) to apply modern analysis tools and techniques in the State of the Art Reactor Consequence Analysis (SOARCA) project. The SOARCA project developed a body of knowledge regarding the realistic outcomes of severe reactor accidents and integrated modeling of accident progression and offsite consequences using both state of-the-art computational analysis tools and best modeling practices from the severe accident analysis community. This study focused on providing a realistic evaluation of accident progression, source term, and offsite consequences. By using the most current emergency preparedness practices, plant capabilities, and best available modeling, these analyses are more detailed, integrated, and realistic than past analyses.





A detailed model of the BWR MarkI containment and reactor building similar to those at the Fukushima Dai-ichi Nuclear Power Station.

Sandia and the Fukushima Reactor Crisis

In the face of a series of equipment failures, nuclear meltdowns, and releases of radioactive materials at the Fukushima Nuclear Power Plant, Sandia was engaged to provide severe accident modeling support to the NRC and the Department of Energy. First, the Sandia-developed MELCOR computer code was used to develop baseline models. Reactor damage was estimated using these models to include fraction core damage and source term release. Additionally, forecasting was used to predict the outcome of future events.

Over a number of months, Sandia provided daily consults and assistance to U.S. government officials. Offering incident interpretation, results explanations, and exploration of mitigation options, Sandia played an active and important role in understanding the accident at Fukushima.

Publications

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