Nuclear Services/Engineering Services

Modular Accident Analysis Program

BACKGROUND

Following the accident at Three Mile Island Unit 2, the nuclear power industry developed the Modular Accident Analysis Program (MAAP) computer code as part of its degraded core rulemaking program. The industry's objective was to provide a useful tool for analyzing the consequences of a wide range of postulated plant transients and severe accidents for current plant designs and advanced light reactors. MAAP5 is the latest version in the suite of MAAP computer codes (following, for example, MAAP3B and MAAP4) designed to perform severe accident analyses for numerous nuclear plant designs. MAAP5 is an Electric Power Research Institute-owned and -licensed computer software developed and maintained by Fauske & Associates, LLC, an affiliate of Westinghouse Electric Company LLC.

Description

MAAP5 can predict the progression of accident scenarios to a safe, stable, coolable state within the core. It also can predict the occurrence of vessel failure and can model the containment performance with successful debris cooling or pressurization of containment to a predefined failure condition.

MAAP5 contains engineered system and operator action models that allow detailed simulation of emergency operating procedures and severe accident management guidelines. It also contains enhanced graphics models (MAAP5-GRAPH) as well as code enhancements to MAAP4 for best-estimate and design basis analysis- (DBA)-type modeling for the reactor core, reactor coolant system, containment and used fuel pool.

Common to the BWR and PWR core modeling, MAAP5 contains the following:

- Both a point kinetics (PWR only) and a one-dimensional core neutronics model
- Natural circulation flow models in RCS (or vessel)

Together these improvements allow simulation of anticipated transient without scram conditions.

Improvements to PWR reactor coolant system (RCS) models include the following:

- Upgraded steam generator modeling for tube rupture, steam line break and loss of coolant analyses
- Detailed models for core debris in the reactor pressure vessel lower plenum, with consideration of layers of heavy metal, oxide and light metal
- Ex-vessel heat transfer models for in-vessel retention evaluation
- Explicit representation of up to four independent coolant loops to assess asymmetries and mid-loop operation status

Together these improvements provide a fast-running, best-estimate RCS representation.

Improvements to containment models are generic for BWR and PWR applications, as follows:

- Heat transfer models are upgraded and can be used to assess containment pressure margin
- All fission products needed for alternate-source term models are explicitly considered
- Extensive validation has been performed for PWR full-scale tests

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- A radiological dose model (compliant with Regulatory Guide 1.183), capable of dose calculations for any room (i.e., control room) in the model as well as at off-site locations

In addition, MAAP5 has models for hydrogen stratification, potential global mixing and localized burning.

Finally, a new used fuel pool model has been generically added to the program for BWR and PWR applications. This model can assess:

- The time pool uncovers by boiling or leakage (or both)
- The time scale for fuel heating, hydrogen generation and fission product release
- The extent of melting and relocation under extended loss-of-coolant conditions

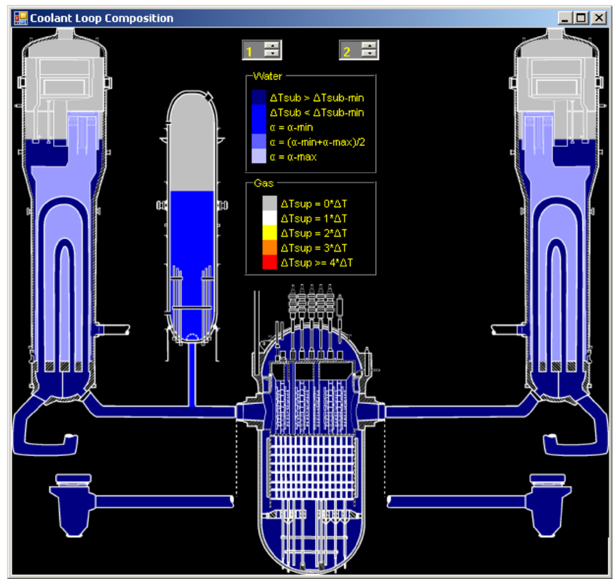
Coupled with the MAAP5 containment models, this program allows assessment of flammability potential and the consequences of combustion within and above the used fuel pool.

Benefits

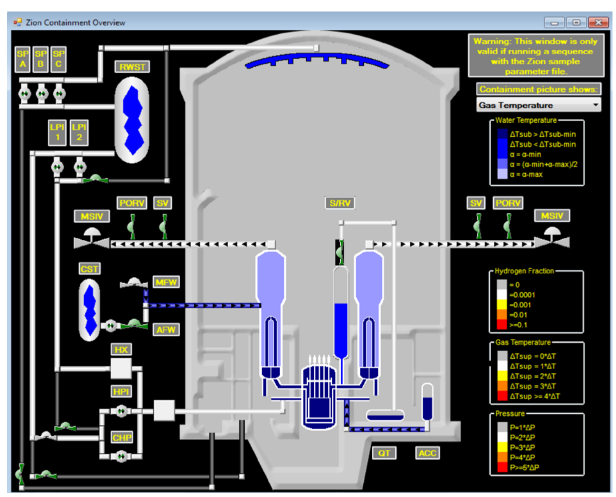
The MAAP5 software package provides engineers with a tool to rapidly evaluate the progression of an accident in terms of the reactor core (Is the fuel damaged or not?), the containment (Is containment integrity being challenged?) and radiological consequences (Do the dose rates inside the plant or in the population areas present concerns in terms of taking precautionary measures such as shelter or evacuation?). MAAP5 also can model the progression of an accident in a plant's used fuel pool. The MAAP5 code can calculate the time to boil away the pool water inventory, model the heating and relocation of the used fuel, calculate the potential for the release of hydrogen from the used fuel cladding due to zirconium oxidation (due to steam), and determine the potential for any type of hydrogen combustion event in the used pool room/enclosure, and model the potential for a zirconium fire. Due to its rapid computation speeds and its ability to model all types of reactor transients, loss of coolant accidents and loss of AC/DC power events, MAAP5 is a powerful tool that can be used to develop a plant's severe accident management strategies.

Experience

MAAP5, and its predecessors MAAP4 and MAAP3B, have been used exclusively by the global nuclear industry for more than two decades as an engineering tool for severe accident analysis.
The MAAP code has been used to perform analyses associated with severe accident phenomena (e.g., hydrogen generation and combustion, direct-containment heating, rapid pressurization due to steaming, core concrete interactions, fission product releases, transport and deposition). It is also used extensively in the probabilistic risk and safety assessment arena for success criteria evaluations,



MAAP5 RCS screenshot



MAAP5 containment screenshot

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