International Workshop on Multi-Unit Probabilistic Safety Assessment (PSA), Nov. 17-20, 2014, Ottawa, CANADA

A Methodology for Performing Consequence Analysis for Multi-Unit/Spent Fuel Pool Source Terms

Nathan E. Bixler
Sandia National Laboratories
Albuquerque, NM 87185-0748

Modeling capabilities in earlier versions of the MELCOR Accident Consequence Code System (MACCS) code were not sufficient to treat multiple accident initiation times and separate core inventories for multiple units, nor was it able to treat accidents for which releases exceed a week. While the accident at Fukushima Daiichi has unique characteristics that are unlikely to be replicated in the US or in many other countries, it has pointed to the need to prioritize development of a multisource modeling capability in MACCS.

An additional concern during the Fukushima Daiichi accident was that the earthquake had damaged a spent fuel pool and potentially initiated an accident therein. Although this concern proved to be unwarranted, the possibility of a spent fuel pool accident occurring simultaneous with a single- or multiple-unit event also needs to be considered.

The US Nuclear Regulatory Commission therefore asked National Laboratories to create models that could evaluate simultaneous accidents in one or more reactor units and/or spent fuel pools collocated at a site. To create a general and an accurate model, multiple accident initiation times at the collocated reactor units had to be accommodated. Furthermore, each unit could have its own distinct fission product inventory, so this capability must also be included in the model. Finally, a spent fuel pool should be able to be evaluated with multiple inventories to reflect the different ages of fuel that it contains. The expectation is that the central portion of the spent fuel pool would typically heat up and degrade more rapidly than the perimeter, and that the ages and other characteristics of the spent fuel could be distributed differently in the different regions of the pool. This distinction can be important, especially for some of the shorter-lived isotopes that would only be present in recently offloaded fuel.

To accommodate the relatively complex set of options that might need to be considered, modifications to three codes were implemented. These are MelMACCS, a preprocessor that digests the MELCOR output (a source term code that can be used to support Level-2 analyses), WinMACCS, an interface code to MACCS, and MACCS itself.

MelMACCS now supports multiple fission product inventories for a single MELCOR result file. This extension is necessary for spent fuel pool calculations that represent multiple ages of fuel. MelMACCS can be run for a set of reactor units and spent fuel pools and those individual source terms can be integrated into a single source term by WinMACCS. This capability does not currently allow for multiple release locations, but treats all releases as emanating from the same latitude and longitude. Future advances that are being pursued will relax the condition that the releases are from collocated units and/or spent fuel pools.

Finally, release and accident durations have been extended in the WinMACCS and MACCS codes to allow evaluation of a multisource accident where releases continued for more than one week. The upper bound for the period over which releases might occur is now 30 days

and the maximum duration of the emergency phase is now 40 days. Other delay times have also been increased.