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Organization: ILLINOIS EMERGENCY MANAGEMENT
Relevant Guidance: NEI 99-01 REV. 6, RTM-96
Applicable Section(s): Fission Barrier Matrix
Status: Public Comment Period

QUESTION OR COMMENT:

The guidance provided for determination of loss or potential loss of the three fission product barriers in NEI [Nuclear Energy Institute] 99-01, Revision 6 [“Development of Emergency Action Levels for Non-Passive Reactors”], is based on several plant variables. The plant high-range containment radiation monitor is one of the variables used in the calculation. Initiating conditions are shown for BWRs [boiling water reactors] on page 83 (example 4) and PWRs [pressurized water reactors] on page 98 (example 3.A). These conditions reference the determination of a site-specific value that is calculated based on a percentage of fuel clad damage. Many licensees have referenced the graphs in RTM-96 [NUREG/BR-0150 Vol. 1, Rev. 4, “RTM-96 Response Technical Manual”], as listed in Figures A.5- A.12. In an attempt to clarify the values, these figures were reproduced in RTM-2002 [a training manual version of RTM-96 with updates] with percent fuel melt/clad damage values added to relate with the dose rates on the ordinate axis. Despite this clarification, some licensees continued to use a logarithmic relationship between percent clad damage and containment radiation reading in their core damage procedure. This was contrary to the fact that the percentage of fuel clad failure is understood to be directly proportional to containment radiation reading. This relationship is demonstrated by the equations in the following guidance documents:

1. Westinghouse Owners Group Core Damage Assessment Guidance (WCAP-14696-A, Revision 1, 1999), p. 3

$$\textbf{\% Clad Damage(CRM)} = \frac{\textbf{Current Containment Radiation Level}}{\textbf{Predicted Containment Radiation Level at 100\% Power}}$$

2. BWR Owners’ Group Guidance Methods of Estimating Core Damage in BWRs (NEDC-33045P, Revision 0, July 2001), p. B-11

% Cladding Damage= Indicated Radiation Level 100%/ Clad Damage Radiation Level *X 100*

Does the NRC agree that there is a direct proportionality in the amount of fuel clad damage and the containment radiation monitor reading? Does the NRC also agree that the figures for clad damage in the RTM should be read that way?

PROPOSED SOLUTION:

To assist the staff with their deliberations, the following points are noted.

1. The question refers to Westinghouse Owners Group Core Damage Assessment Guidance (WCAP-14696-A, Revision 1, 1999), and specifically to a formula found on page 1 of 2 in Section A, Fuel Rod Clad Damage. The question asserts that this formula implies a “directly proportional” relationship between the predicted damage and the damage that would be expected for 100% damage as derived from Figure 3. Figure 3 is a graph entitled,

"Containment Radiation Level vs. Time for 100% Clad Damage Release," which plots the Containment Dose Rate (Rad/hr) as a function of Time Since Shutdown (hours). The graph indicates that the containment dose rates decrease in an exponential manner (reflecting the expected rate of radioactive decay). The graph's y-axis plots these values using a logarithmic scale. Therefore, while a direct proportionality does exist for purposes of estimating damage at any particular time after shutdown, the containment dose rates decrease in a time-dependent exponential manner.

2. In a letter dated August 20, 2001, the NRC staff approved a request by the BWROG [BWR Owners Group] to withhold NEDC-33045P, "Methods of Estimating Core Damage in BWRs," from public disclosure pursuant to 10 CFR 2.790 since the document contains trade secrets or proprietary commercial information (reference ML012320276). Although the document is not available for public viewing, the core damage assessment methodologies of several BWR sites that reference NEDC-33045P as a source document are publicly available, and these were reviewed. Similar to the Westinghouse approach cited above, the BWR core damage assessment methodology relies partly on the comparison on an actual containment dose reading to a time-dependent reading determined from a graph. Like the observation above, the applicable graph indicates that the containment (drywell) dose rates decrease in a time-dependent exponential manner with the y-axis plotting these values on a logarithmic scale.

NRC RESPONSE:

1. Does the NRC agree that there is a direct proportionality in the amount of fuel clad damage and the containment radiation monitor reading?

The NRC agrees that there is a direct proportionality between the amount of fuel damage and the containment radiation monitor reading. However, the proportionality could be either logarithmic or linear depending on the underlying algorithm. The user of the graph needs to remain alert to whether the graph axes are logarithmic or linear when reading the graph.

2. Does the NRC also agree that the figures for clad damage in the RTM should be read that way?

The NRC notes that the axis in the graphs in RTM 96 have a logarithmic axis for the radiation monitor reading and accordingly, treating the data as logarithmic is appropriate. The staff notes, however, that the data presented in these graphs (Figures A-5 to A-11) was only intended to provide a coarse core damage state indication (i.e., In-vessel melt, gap, spiked coolant, and normal coolant). It was not intended to be used to obtain point values of core damage percentage. (See text on page A-13 of the RTM for conditions of use.)

The objective of the RTM was to provide the NRC Operations Center personnel with a method to perform a rapid independent evaluation of the event at any U.S. plant to assess the appropriateness of licensees' emergency classification levels and, as applicable, protective action recommendations. The RTM methods do not represent any particular plant configuration. Before using the RTM graphs, a licensee should confirm their representativeness for its facility.

The questions appears to imply a greater accuracy for the containment monitor versus core damage estimate than can generally be realized. The relationship between the amount of core damage within the reactor pressure vessel and a containment dome monitor is subject to several independent variables, some of which are plant, site, or accident-specific, and cannot be accurately reduced to a direct proportionality between two variables, regardless of whether they are plotted on a logarithmic scale or linear scale. Some of these variables include the:

- power history of the core,
- release fraction from the fuel to the reactor coolant system (RCS),
- rate of the RCS leakage to the containment,
- plant-specific homogeneity of the distribution of the radioactive material through the containment,
- plant-specific impact of containment sprays on that distribution,
- plant-specific stratification within the containment,
- decay time since the reactor tripped, the time since the leak started, and,
- plant-specific exposure geometry for the containment dome monitor(s).

In developing the graphs presented in the RTM and the owner groups' core damage estimation, the analysts assumed certain fixed values for the various variables. The developed graphs are accurate only to the extent that the assumed values are representative of the plant, site, or accident for which they are being used. As an example, consider the NEI 99-01, Revision 6, Developer Note for BWR Fuel Barrier, which states, in part, "The [radiation monitor] reading should be determined assuming the instantaneous (1) release and (2) dispersal of the reactor coolant noble gas and iodine inventory with RCS radioactivity concentration equal to 300 μCi/gm dose equivalent I-131, into the primary containment atmosphere." Each licensee must make site-specific allowances for determining these values, subject to NRC approval, as part of the site's emergency action level scheme.