OPTIONS FOR DEFINING LRF FOR APPLICATIONS TO THE LEVEL-2 PRA AND LICENSING OF SMRS

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Objectives

- Large Release Frequency (LRF) is the risk metric to be used for advanced LWR Design Certification (DC) and Combined Construction and Operating License (COL) applications
- No unique regulatory definition for LRF exist
- This paper highlights options for LRF measures

Background

- Do the current numerical risk metrics, CDF and LERF applicable to new advanced SMRs?
- Should we define alternate metrics for CDF and LRF?
- NRC staff has provided early discussions in SECY-93-138, “Recommendation on Large Release Definition”
- Staff recommended to the Commission that work on a LRF definition be terminated
- The staff more recently has offered some good discussions of this subject. For example: Donald A. Dube, U.S. NRC, White Paper on Options for Risk Metrics for New Reactors, February 2009.
- NRC Public Meeting Regarding Risk Metrics for New LWR Risk-Informed Applications, February 18, 2009

Options

- What is meant by “large” in LRF?
- Three options are possible:
  - number of fatalities
  - amount of radionuclide release, and
  - state and integrity of the reactor pressure boundary and containment at the time of release
- Is LERF<LRF or the reverse?

Option 1: Number of Fatalities Option

- A conservative option define ‘large’ as the amount of release that would result in at least one early fatality.
- ASME/ANS Standard for PRA (RA-Sa-2009) defines LERF as a “rapid, unmitigated release of airborne fission products … such that there is a potential for early health effects.”
- NUREG/CR-6094 (1994) defines a release as large when it leads to an early fatality “with high probability” for a stationary individual standing one-mile from the site.
- So, a hypothetical site along with subjective meteorological data constitutes a “high probability”
- Neglects positive attributes of the reactor design with ambiguous features of meteorology and site location.

Option 2: Amount of Radionuclide Release

- Typically done for a few isotopes that tend to dominate estimates of offsite health effects, such as I-131 or Cs-137.
- Fraction of inventory release of various radionuclide groups and the timing of the release may be specified.
- NUREG/CR-6595(2004) suggests release fractions considered as large (e.g., release of 2-3% of the iodine inventory.)
- This option is simple, but selection of the total amount of release or release fractions is highly subjective.
- Measuring ‘large’ in terms of release fraction is problematic for SMRs since large release in these terms are based entirely on severe accidents research for large (3000+ MWth) LWRs.
- Should release amounts or release fractions be associated with one module or all modules?

LERF vs. LRF

- The concept of LERF developed using level 3 PRA to roll back to the level 2 release categories to see which ones contribute to early deaths and find the corresponding contributing plant states found to have the characteristics that have become known as early core melt (NUREG/CR-6596).
- Recent NEI calculations uses five NUREG-1150s by defining LRF as the frequency of one or more deaths show LERF>>LRF.
- Because not all LERF contributors cause deaths as weather and population don't align, but all LRF involves deaths.
- So LERF is very conservative and can be calculated from the design features long before Level 3 calculations.

Option 3: State and Integrity of RCS Boundary and Containment

- LERF-Type conservative options representing LRF.
- SMR Physical condition of systems, pressure boundaries and radionuclide barriers at the time release begins.
- Large release might be considered as one involving failure of the RPV and containment pressure boundaries due to isolation failure(s), bypass, or structural damage within a few hours of core melting and fission product release from fuel during which opportunities for attenuation of the airborne concentration are minimal.
- While this method is certainly conservative for a single module, it can be extended and justified as an appropriate measure for simultaneous events in multiple modules.

Conclusions

- Acceptable LRF Definition unavailable
- Three options discussed for definition of “large”
- This paper recommends use of a LERF-type approach where the system state prior to release define large