Draft Rule Language for 10 CFR 50.46

NOTE: The availability of this draft rule language is intended to inform stakeholders of the current status of the NRC's activities regarding development of a proposed rule to modify the emergency core cooling system (ECCS) acceptance criteria at 10 CFR 50.46. This draft rule language may be incomplete or in error in one or more respects and may be subject to further revisions during the rulemaking process. The NRC is not soliciting formal public comments on this draft rule language, and is under no obligation to respond to any comments that are submitted at this time. Public comments may be provided when the NRC publishes the proposed rule in the *Federal Register*.

The draft rule language provided below contains some text in black font and some portions in gray. The gray text indicates language that remains substantially unchanged from the existing language and the black text is intended to highlight new or modified language.

§ 50.46 Requirements **for emergency core cooling systems for light-water nuclear power reactors.**

(a) *Applicability*. The requirements of this section apply to each holder of an operating license for any light water nuclear power reactor (LWR), regardless of fuel design or cladding material, except for a licensee who has submitted the certifications required under § 50.82(a)(1) to the NRC.

(b) *Definitions*. As used in this section:

(1) Loss-of-coolant accidents (LOCA's) are hypothetical accidents that would result from the loss of reactor coolant, at a rate in excess of the capability of the reactor coolant makeup system, from breaks in pipes in the reactor coolant pressure boundary up to and including a break equivalent in size to the double-ended rupture of the largest pipe in the reactor coolant system.

(2) An evaluation model is the calculational framework for evaluating the behavior of the reactor system during a postulated loss-of-coolant accident (LOCA). It includes one or more computer programs and all other information necessary for application of the calculational framework to a specific LOCA, such as mathematical models used, assumptions included in the programs, procedure for treating the program input and output information, specification of those portions of analysis not included in computer programs, values of parameters, and all other information necessary to specify the calculational procedure.

(c) *General performance requirements.* Each LWR must be provided with an emergency core cooling system (ECCS) designed so that, following a postulated loss-of-coolant accidents (LOCA), the following performance requirements are satisfied:

(1) Core geometry remains amenable to cooling;

(2) Generation of combustible gas is limited to the maximum extent practicable

(3) Core temperature is maintained at a value sufficient to ensure compliance with criteria in paragraphs (c)(1) and (2) of this section; and

(4) Decay heat is removed for the extended period of time required by the long-lived radioactivity remaining in the core.

(5) ECCS cooling performance must be calculated in accordance with an acceptable evaluation model and must be calculated for a number of postulated loss-of-coolant accidents of different sizes, locations, and other properties sufficient to provide assurance that the most severe postulated loss-of-coolant accidents are calculated. The evaluation model must include sufficient supporting justification to show that the analytical technique realistically describes the behavior of the reactor system during a loss-of-coolant accident. Comparisons to applicable experimental data must be made and uncertainties in the analysis method and inputs must be identified and assessed so that the uncertainty in the calculated results can be estimated. This uncertainty must be accounted for, so that when the calculated ECCS cooling performance is compared to the applicable specified and acceptable analytical limits there is a high level of probability that the limits would not be exceeded. Appendix K, Part II Required Documentation, sets forth the documentation requirements for each evaluation model.

(d) *Requirements for fuel designs consisting of uranium oxide pellets within zirconium cladding alloys.* Each LWR fueled with an acceptable fuel design consisting of uranium oxide pellets within cylindrical zirconium alloy cladding must be provided with an ECCS designed so that its calculated cooling performance following postulated LOCA satisfies the following requirements.

(1) *Coolable geometry*. Calculated changes in core geometry shall be such that the core remains amenable to cooling.

(i) *Peak cladding temperature*. Except as provided in paragraph (d)(1)(ii) of this section, the calculated maximum fuel element cladding temperature shall not exceed 2200º F.

(ii) *Cladding embrittlement*. The preservation of cladding ductility provides assurance that fuel rods will not experience gross failure as a result of combined thermal and mechanical loads anticipated during a postulated LOCA. To achieve this objective, specified and acceptable analytical limits on peak cladding temperature and time at elevated temperature shall be established which correspond to the measured ductile-to-brittle transition for the zirconium cladding alloy based upon an acceptable experimental technique.

If the peak cladding temperature established to preserve cladding ductility is lower than the 2200º F limit specified in (d)(1)(i), then the lower temperature shall be used in place of the 2200º F limit.

Phase transformation and delamination of the zirconium dioxide layer during prolonged exposure to a high temperature steam environment promotes loss of cladding ductility. To ensure that the zirconium cladding alloy's susceptibility to this phenomenon, known as breakaway oxidation, is beyond the realm of postulated LOCA core temperature excursions, the total accumulated time that the cladding is predicted to remain above the zirconium alloy's as-fabricated $\alpha \rightarrow \alpha+\beta$ phase transition temperature shall not be greater than a specified and acceptable limit which corresponds to the measured onset of breakaway oxidation for the zirconium cladding alloy based upon an acceptable experimental technique. The onset of breakaway oxidation shall be measured periodically and any changes in the time to the onset of breakaway oxidation shall be reported at least annually as specified in § 50.4 or § 52.3 of this chapter, as applicable, and shall also be addressed in accordance with § 21.21 of this chapter.

(2) *Maximum hydrogen generation*. The calculated total amount of hydrogen generated from the chemical reaction of the cladding with water or steam shall not exceed 0.01 times the hypothetical amount that would be generated if all of the metal in the cladding cylinders surrounding the fuel, excluding the cladding surrounding the plenum volume, were to react.

(3) *Long-term cooling*. After any calculated successful initial operation of the ECCS, the calculated core temperature shall be maintained at an acceptably low value and decay heat shall be removed for the extended period of time required by the long-lived radioactivity remaining in the core.

(4) *Evaluation model*. ECCS cooling performance must be calculated in accordance with an acceptable evaluation model and must be calculated for a number of postulated loss-of-coolant accidents of different sizes, locations, and other properties sufficient to provide assurance that the most severe postulated loss-of-coolant accidents are calculated. Except as provided in paragraph (d)(4)(i) of this section, the evaluation model must include sufficient supporting justification to show that the analytical technique realistically describes the behavior of the reactor system during a loss-of-coolant accident. Comparisons to applicable experimental data must be made and uncertainties in the analysis method and inputs must be identified and assessed so that the uncertainty in the calculated results can be estimated. This uncertainty must be accounted for, so that when the calculated ECCS cooling performance is compared to the analytical limits established in accordance with paragraph (d)(1), (2), and (3) of this section, there is a high level of probability that the limits would not be exceeded. Appendix K, Part II Required Documentation, sets forth the documentation requirements for each evaluation model.

(i) Alternatively, an ECCS evaluation model may be developed in conformance with the required and acceptable features of appendix K ECCS Evaluation Models.

(ii) Oxygen diffusion from the cladding inside surfaces will reduce the allowable time at elevated temperature to nil ductility. If cladding rupture is calculated to occur, the effects of oxygen diffusion from the cladding inside surfaces in the region surrounding the rupture shall be considered in the evaluation model. In addition, if an oxygen source is present on the inside surfaces of the cladding at the onset of the LOCA, the effects of oxygen diffusion from the cladding inside surfaces shall be considered in the evaluation model.

(e) [Reserved]

(f) [Reserved]

(g) [Reserved]

(h) [Reserved]

(i) [Reserved]

(j) [Reserved]

(k) *Reporting*.

(1) Each applicant for or holder of an operating license or construction permit issued under this part, applicant for a standard design certification under part 52 of this chapter (including an applicant after the Commission has adopted a final design certification regulation), or an applicant for or holder of a standard design approval, a combined license or a manufacturing license issued under part 52 of this chapter, shall estimate the effect of any change to or error in an acceptable evaluation model or in the application of such a model to determine if the change or error is significant. For this purpose, a significant change or error is one which results in a calculated peak fuel cladding temperature different by more than 50 °F from the temperature calculated for the limiting transient using the last acceptable model, or is a cumulation of changes and errors such that the sum of the absolute magnitudes of the respective temperature changes is greater than 50 °F.

(2) For each change to or error discovered in an acceptable evaluation model or in the application of such a model that affects the temperature calculation, the applicant or holder of a construction permit, operating license, combined license, or manufacturing license shall report the nature of the change or error and its estimated effect on the limiting ECCS analysis to the Commission at least annually as specified in § 50.4 or § 52.3 of this chapter, as applicable. If the change or error is significant, the applicant or licensee shall provide this report within 30 days and include with the report a proposed schedule for providing a reanalysis or taking other action as may be needed to show compliance with § 50.46 requirements. This schedule may be developed using an integrated scheduling system previously approved for the facility by the NRC. For those facilities not using an NRC approved integrated scheduling system, a schedule will be established by the NRC staff within 60 days of receipt of the proposed schedule. Any change or error correction that results in a calculated ECCS performance that does not conform to the analytical limits established in accordance with this section, as applicable, is a reportable event as described in §§ 50.55(e), 50.72, and 50.73. The affected applicant or licensee shall propose immediate steps to demonstrate compliance or bring plant design or operation into compliance with § 50.46 requirements.

(3) For each change to or error discovered in an acceptable evaluation model or in the application of such a model that affects the temperature calculation, the applicant or holder of a standard design approval or the applicant for a standard design certification (including an applicant after the Commission has adopted a final design certification rule) shall report the nature of the change or error and its estimated effect on the limiting ECCS analysis to the Commission and to any applicant or licensee referencing the design approval or design certification at least annually as specified in § 52.3 of this chapter. If the change or error is significant, the applicant or holder of the design approval or the applicant for the design certification shall provide this report within 30 days and include with the report a proposed schedule for providing a reanalysis or taking other action as may be needed to show compliance with § 50.46 requirements. The affected applicant or holder shall propose immediate steps to demonstrate compliance or bring plant design into compliance with § 50.46 requirements.

(l) The Director of Nuclear Reactor Regulation may impose restrictions on reactor operation if it is found that the evaluations of ECCS cooling performance submitted are not consistent with the requirements of this section.

(m) The requirements of this section are in addition to any other requirements applicable to ECCS set forth in this part. The analytical limits established in accordance with this section, with cooling performance calculated in accordance with an acceptable evaluation model, are in implementation of the general requirements with respect to ECCS cooling performance design set forth in this part, including in particular Criterion 35 of appendix A of this part.