U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Office of Nuclear Regulatory Research

Risk-Informed Fracture Toughness Requirements for Normal Operational Conditions

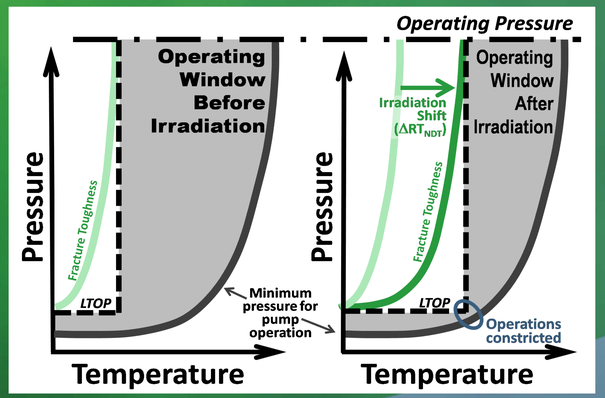
Development of the technical basis for a risk-informed revision to Title 10 of the Code of Federal Regulations Part 50 Appendix G, "Fracture Toughness Requirements"

Motivation

Radiation damage to the reactor pressure vessel (RPV) steel during service decreases its resistance to fracture. This decrease constricts the pressure-temperature (P-T) operating envelope through which the plant must pass during startup and shutdown.

At high levels of embrittlement, the operating envelope may become very constrained at low temperatures, making it difficult to operate within the envelope given the pressure perturbations that occur during reactor coolant pump operation. If the envelope is too narrow, the pressure may be insufficient to maintain a seal on the reactor coolant pump, resulting in a loss-of-coolant accident.

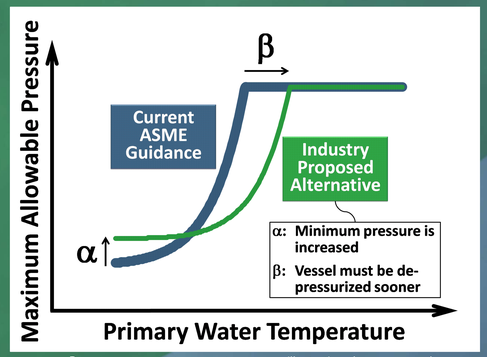
The NRC is using probabilistic fracture mechanics (PFM) to develop options for a risk-informed revision of 10 CFR Part 50 Appendix G. The objective of this research is to increase operational flexibility while maintaining, or reducing, the current risk level by adopting more realistic models of the RPV than is currently the norm.



Reactor pressure vessel steel embrittlement reduces reactor operating envelope during normal operation conditions (heating and cooling).

Proposed Revisions to Pressure-Temperature Limits

P-T limits are currently determined using the procedure in ASME Code Section XI Appendix G "Fracture Toughness Criteria for Protection Against Fracture". Industry has proposed changes to the ASME code that allow an increase in allowable pressure at low temperatures, and a reduction in the amount of time the plant can stay at full pressure while the temperature is permitted to decrease. The NRC is evaluating this proposal. Preliminary evaluations indicate that these changes may REDUCE the risk of vessel fracture during routine heat up and cool down relative to currently accepted requirements.



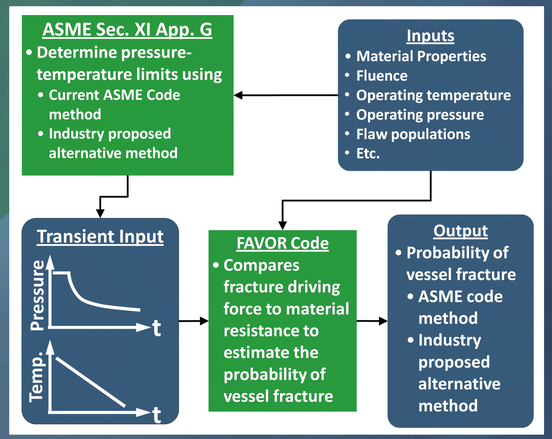
Reactor pressure-temperature curve illustrating the proposed 10 CFR Part 50 Appendix G revisions.

THE BOTTOM LINE

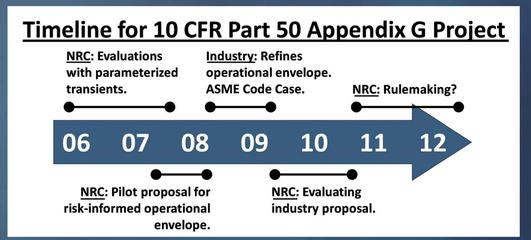
Current analyses indicate that it may be possible to revise 10 CFR Part 50 Appendix G to BOTH increase operational flexibility AND reduce risk of vessel fracture.

Assessing the Effect of P-T Limit Changes on Vessel Failure Risk

The NRC evaluation of ASME Code Section XI Appendix G featured a PFM assessment using the computer code FAVOR developed by the Oak Ridge National Laboratory.



Flowchart Illustrating NRC evaluation of the industry's proposed changes to ASME Section XI Appendix G.



Knowledge for Today and Tomorrow