

U.S. Nuclear Regulatory Commission
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Enclosure

cc (Enclosure):

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Enclosure

Conservatism in P-T Limit Curves

There are significant conservatisms in the ASME P-T limit curve development process, and this technical note will describe them in summary form. First there are three key safety margins built into the process:

- Assumption of a large flaw (25% of the RV wall thickness)
- Application of a safety factor of 2 on the primary, or pressure stresses
- Use of a lower bound fracture toughness

An illustration of the impacts of these margins was given some years ago in a paper by Chirigos and Meyers, as shown below. Here we have a typical P-T curve, shown at the bottom of the figure, and then a series of curves above it with the various margins removed. We will pay special attention to the lower portion of the curve, which allows 400 psi at room temperature. This curve was generated using the same margins as the Watts Bar curves.

Removing the safety factor on pressure obviously doubles the allowable pressure to 800 psi in the low temperature range. Next, using a realistic lower bound toughness, K_{ic} , instead of the code-required K_{Ia} at the time, improves the allowable to about 1000 psi. The next step, using a postulated flaw that is still very large (1 inch, not 25% of the thickness) raises the allowable to 1425 psi. Changing the postulated flaw to 0.5 inches deep brings us to nearly full pressure (2200 psi) at room temperature. The paper goes on to illustrate other margins, which add up to a factor of approximately nine in the low temperature range. Therefore, it can be clearly seen that the P-T curve process is very, very conservative.

It is worthy of note that the Code was changed recently, as a result of a Westinghouse action, to allow the use of the more realistic toughness, K_{ic} , instead of K_{Ia} . This alone would add about 200 psi to the allowable pressure, so there is additional margin over and above your existing curves, which were generated using the old rules.

Therefore there should be no concern with respect to the structural integrity of the reactor vessel, as a result of the recent event at WBN. In fact, the event demonstrates the usefulness of the overpressure mitigation system, which has reduced the probability of a violation of the P-T curve significantly.

During a recent simulation conducted on the Watts Bar simulator, the worst case that occurred was a pressure of 841 psi, which occurred at a steady state condition, and a temperature of 126F. This condition was the result of a relatively low probability event, but it will be instructive to assume that it happened at the plant.

The P-T curve for the Watts Bar plant is provided in figure 2, shown below. As described above, there are three clearly specified margins inherent in these P-T curves: a large postulated flaw (25% of the vessel wall, or 2.15 inches deep), use of a lower bound fracture toughness, and a factor of two on the pressure. If we keep the first two margins, and eliminate the third one, the allowable pressure for Watts Bar in this scenario is 1180 psi. This seems to be a reasonable assumption, given that the initiating event is a low probability to start with. Therefore there was clearly no concern about the integrity of the reactor vessel in this case, even though the allowable P-T curve was postulated to be exceeded.

Indicated System Pressure (PSIG)

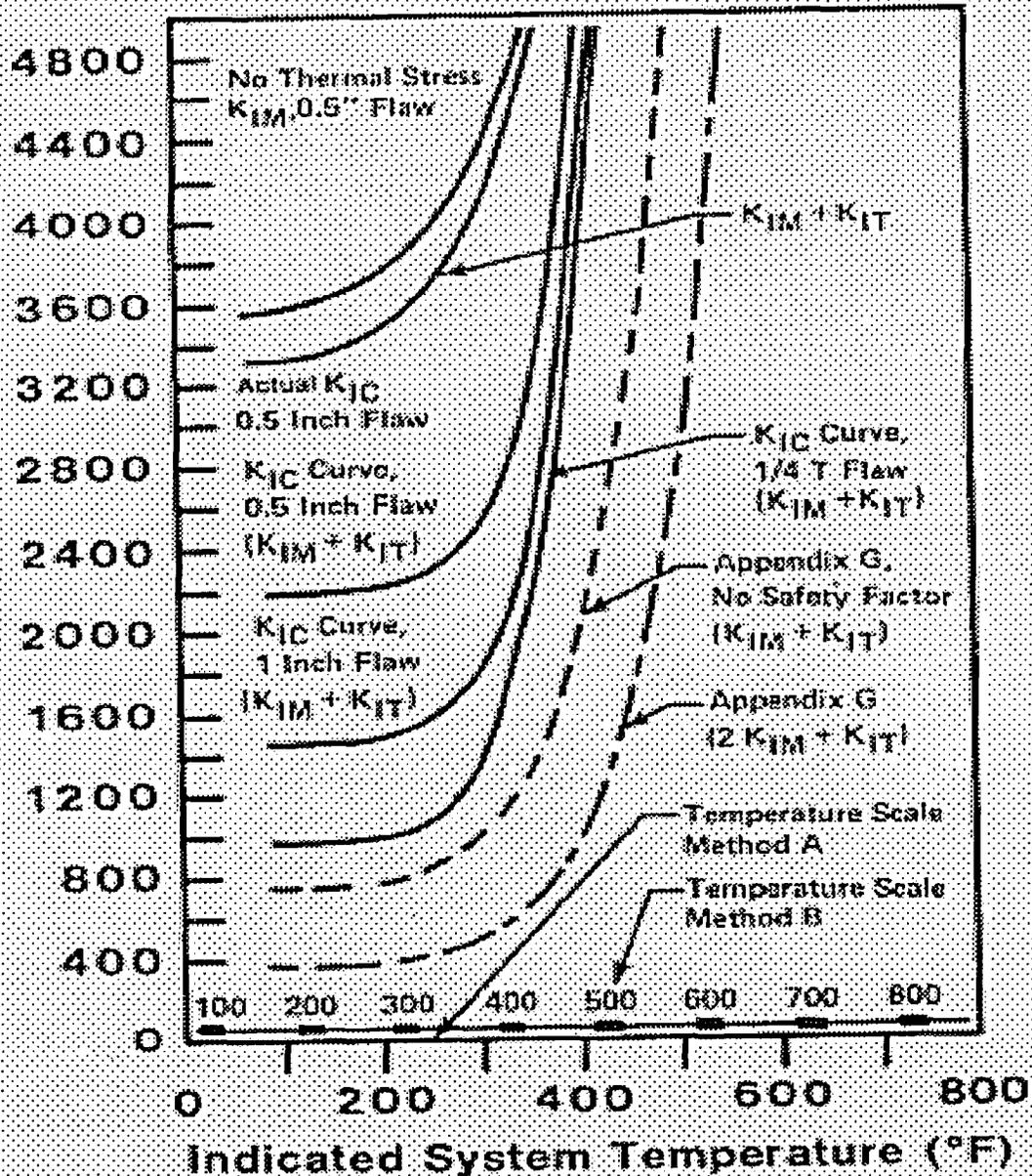


FIG. 5—Reactor vessel cool-down limit curves. $\Delta T/\Delta t$, maximum $33^{\circ}\text{C}/\text{h}$ ($60^{\circ}\text{F}/\text{h}$) [$1 \text{ psig} = 6.9 \text{ kPa}$; $1 \text{ in.} = 25.4 \text{ mm}$; $^{\circ}\text{C} = (^{\circ}\text{F} - 32)/1.8$].

Reference: Chirigos, J.N., and Meyer, T.A., "Influence of Material Property Variations on the Assessment of Structural Integrity of Nuclear Components", Journal of Testing and Evaluation, Vol.6, No. 5, Sept. 1978, pp. 289-295.

Pressure Temperature Limits Report

MATERIAL PROPERTY BASIS

LIMITING MATERIAL: INTERMEDIATE SHELL POKING 05

INITIAL REACT = 47 °F

LIMITING ART AT 16 EPFI: 1/4-E, 191.7 °F

3/4-E, 156.2 °F

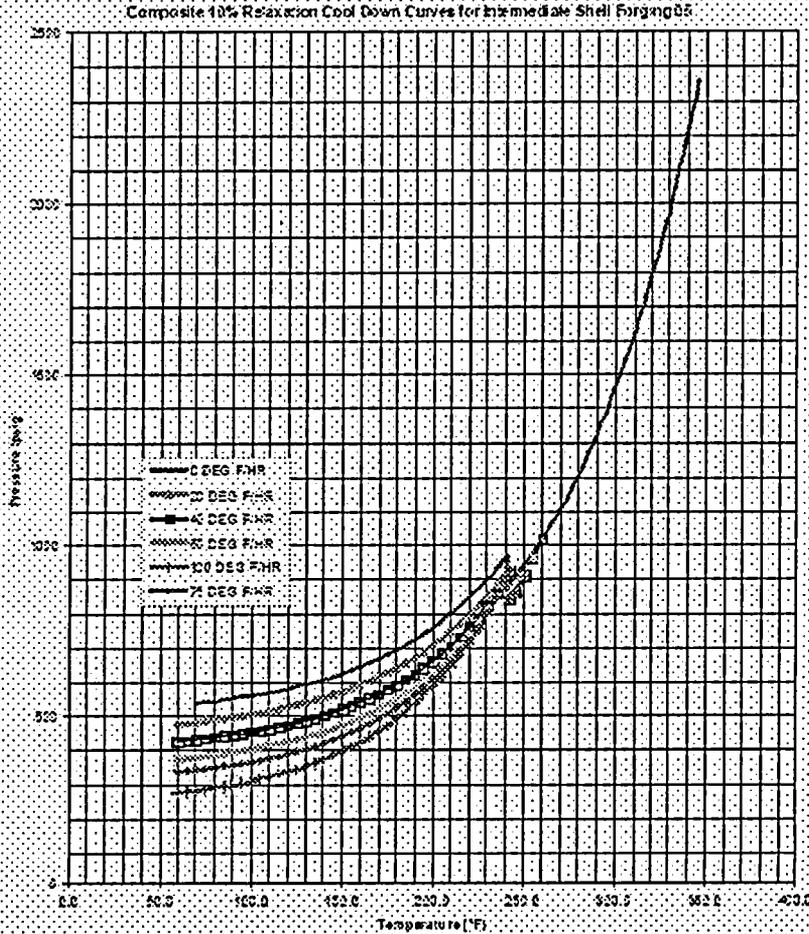


Figure 2: P-T Limits for Watts Bar Unit 1 [WBN Reactor Coolant System Description, N3-68-4001, Revision 24, 4/7/2005]