CT-1494
PDR

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26 August 1982

Mr.E.Igne
ACRS, Nuclear Regulatory Comm.
Washington, D.C.

Dear Mr.Igne:

In your memo to me of 19 August you said Dr.Shewmon wanted my comments on the CE "Evaluation of NRC Fracture Analysis" with regard to use of the "Pellini Diagram, etc.". My comments are given in the following paragraphs.

The references in the CE discussion, based upon the Pellini Diagram, do not have persuasive value. For example, in a 1960 Lehigh Un. report, Gerridge and Slutter described large specimen crack arrest tests for a 1.75 inch thick plate of HY-80 steel. The specimens were of duplex type. A relatively brittle steel plate, serving to provide a fast cleavage crack, was joined by welding to the HY-80 plate. Two tensile tests were done at zero degr. F, 190 degr. F above NDT. In the first test the crack arrested in the HY-80 plate just beyond the weld. In the second test, the fraction of the width occupied by the crack starter plate was larger and crack arrest did not occur. Obviously the result depended upon specimen design as well as upon compliance of the grip fixtures and testing machine. From the Pellini Diagram, shown in the CE discussion, crack arrest was expected at a temperature above NDT plus 60 degr.F, or at least above NDT plus 120 degr.F. Actually the conditions for crack arrest cannot be specified in terms of temperature. Also, a sufficient elevation of temperature to change the mode of separation from dominant cleavage to fibrous (hole-joining) does not necessarily cause crack arrest. The HY-80 non-arresting fracture,described in the Lehigh Un. report, showed no evidence of cleavage. Other examples of this type could be presented, for service components as well as for test specimens.

Crack arrest predictions in the "shelf" region of temperature may be helped by the development of suitable elastic-plastic analysis methods but may not require that technology to the degree suggested in the 21 July Bender-to-Shewmon letter. When the crack tip plastic zone is enclosed by a linear-elastic stress field, linear-elastic analysis methods are still applicable and useful. Rough estimates suggest that, for an 8 inch vessel wall, the enclosed plastic zone condition is maintained when the crack is half through the wall, with $K = 300$ ksi$\sqrt{\text{in}}$, and when the crack is 80 percent through, with $K = 200$ ksi$\sqrt{\text{in}}$. Loss of this condition due to general yielding will result in some loss of constraint. However, the corresponding expected increase of toughness my be matched by the increase of J. In summary, if the arrest toughness at and above NDT plus 180 degr.F is no more than 200 ksi$\sqrt{\text{in}}$, conservative predictions of arrest, or non-arrest, across a large range of crack depth can be made using linear analysis.

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At the present time, the largest acceptable measurement of crack arrest toughness* was obtained in ORNL test TSE-5a at 108 dgr.F above NDT. For the A508, 6 inch wall, test cylinder at that temperature, the arrest toughness was 118 ksi$\sqrt{in}$. Extrapolation of the upward trend with temperature of the arrest toughness values obtained in this experiment to NDT plus 180 degr.F suggests an arrest toughness (at that higher temperature) of about 200 ksi$\sqrt{in}$. Extension of the K_{IR} curve to the same temperature provides a similar result. It seems unlikely that larger values of shelf region arrest toughness can be justified, in deterministic calculations, until a much more complete testing program has been accomplished.

Since you added "etc." to the subjects on which comments were desired, I will risk one general comment. The Bender-to-Shewmon letter contains a suggested message for the Commissioners and for the Public. The message is brief and word meanings are important. For this reason, I suggest replacement of the word "faith" by the word "trust". Trust is more commonly regarded as something which must be earned and preserved and seems to be of unusual importance relative to PTS accidents at nuclear plants.

Sincerely,

George R. Irwin

George R. Irwin
Vs. Prof. of Mech. Eng.
Un. of Maryland

* for nuclear reactor vessel steels.