

FRACTURE BEHAVIOR OF REACTOR PRESSURE VESSEL STEEL IN THE FRANGIBLE, TRANSITIONAL AND TOUGH REGIMES

F.J. WITT,

*Heavy Section Steel Technology Program,
Oak Ridge National Laboratory, Oak Ridge, Tennessee, U.S.A.*

As a result of the growth of the nuclear power industry and the limited operating experience with nuclear power systems, the United States Atomic Energy Commission is sponsoring extensive research to assess the safety of these plants. One of the larger research programs is the Heavy Section Steel Technology (HSST) program which is being carried out under the direction of Oak Ridge National Laboratory. A primary objective of the HSST program is to develop a technology that can be used to establish the margin of safety against failure of the large heavy section primary reactor pressure vessels. It is the intent of this paper to review the several test programs which have been carried out on large specimens up to 12-in. thick and to summarize how the results from such tests relate to the several methods which have been set forth for accomplishing the primary objective identified above.

Extensive test results have been obtained on dynamic tear specimens and compact tension specimens in thicknesses up to 12 in. and at temperatures resulting in frangible through tough behaviors (that is, from considerably below room temperature up to 550°F). Large flawed 6-in.-thick tensile specimens have also been tested from below room temperature to over 200°F. Several series of small flawed pressure vessels have been tested and a series currently in progress features vessels up to 6 in. thick. The results from all these tests are compared on a common basis.

Subsequently linear elastic fracture mechanics as well as elastic-plastic methods of analyzing for other than frangible behavior are reviewed and the data obtained to date are interpreted on the basis of these methods. The methods included are the transition temperature approach (including the Ratio Analysis Diagram procedure), the gross strain approach, the crack opening displacement approach and the equivalent energy approach. Special attention will be devoted to the equivalent energy approach since it has been successfully used in predicting and interpreting the fracture behavior of the thick section tests performed under the HSST program.