

Wilkowski, G., Rudland, D., Wang, Y.-Y., Horsley, D., Glover, A., and Rothwell, B.,  
“Determination of the Region of Steady-State Crack Growth from Impact Tests,” Proceedings of  
4th International Pipeline Conference, Calgary, Alberta, Canada, 2002, Paper No. IPC2002-  
27132

## **Abstract**

Large-diameter gas pipelines typically have a design requirement to ensure that the toughness is sufficient to avoid brittle or ductile fractures from occurring. New pipeline design requirements with richer gases, higher-grade steels, higher operating pressures, and in some cases lower operating temperatures require considerable extrapolation of the current ductile fracture design equations. To obtain a better understanding of ductile fracture arrest toughness, TCPL has funded efforts to assess the steady-state fracture toughness from specimens that can be used in mill applications. This paper reviews past efforts to assess the regions of steady-state ductile crack growth in test specimens, as well as current test results from numerous highly instrumented impact specimens. The new test results were for X52, X70, and X80 linepipe steels, whereas the past efforts were from linepipe steels, aerospace materials, as well as ferritic and austenitic nuclear piping steels. All of these results show that there is a limited region over which the steady-state fracture resistance can be determined. The fracture energy associated with steady-state fracture is the total energy minus; (1) the energy associated with initiation of the crack (including indentation energy and global yielding of the specimen), (2) the transient crack growth from initiation to reaching steady-state fracture, and (3) a non-steady-state fracture region at the end of the test record. Instrumented load versus load-line displacement data were linked to high-speed digital video data of the crack growth, crack-tip-opening angle (within 2 mm of the crack tip), and crack-mouth-opening displacement. These data allowed for comparison of J-R curves and crack-tip-opening angle values during crack growth to help determine the regions of steady-state crack growth. The results from these efforts are an important consideration in the development of a single test specimen method that can be used for determining the ductile fracture resistance of high-strength and high-toughness linepipe steels.

### **Keywords**

Fracture (Materials), Impact testing, Steady state