The Safety Board also studied API loading practices for rail transportation to determine the static stresses in pipe loaded for transportation. API RP 5L1 provides an equation for calculating the peak circumferential tensile stress in a pipe at a bearing strip as a function of the geometry of the loading. API RP 5L1 does not indicate the source of the equation. The purpose of this equation is to calculate the number of flat bearing strips needed to keep the stress below a specified level. The stress determined from the finite element model was compared to the stress calculated by the equation from API RP 5L1 under the same conditions. For a 40-foot-long, 34-inch-diameter, 0.300-inch-wall thickness pipe, the comparison indicates that the equation from API RP 5L1 underestimates the peak circumferential tensile stress by a factor of approximately 2.

The API has also published guidelines for loading pipe for transport onboard marine vessels, API RP 5LW, *Recommended Practice for Transportation of Line Pipe on Barges and Marine Vessels*. API RP 5LW also includes an equation for calculating the peak circumferential tensile stress in a stack of pipe supported by bearing strips. However, this equation differs significantly from the API RP 5L1 equation, and no source is given for the equation. The stress determined from the finite element model was also compared to the stress calculated by the equation from API RP 5LW under the same conditions. For a 40-foot-long, 34-inch-diameter, 0.300-inch-wall thickness pipe, the comparison indicates that the equation from API RP 5LW also underestimates the peak circumferential tensile stress by a factor of approximately 2.

The Safety Board also evaluated the pipe movement attributed to the nearby excavation on February 5, 2002. The pipeline moved down and laterally a maximum of 18 inches. The deflection of the pipe led primarily to longitudinal tension and compression stresses that would not have affected the fatigue crack (oriented on a plane radially outward along the welded seam). Circumferential tensile stresses and shear stresses associated with the pipe deflection were calculated to be in the range of 1 to 10 psi in comparison to the circumferential tensile stress of 29,750 psi caused by the internal pressure of the oil in the pipe at the time of the rupture.

RSPA Postaccident Corrective Action Order

On July 5, 2002, RSPA issued to Enbridge a corrective action order that required the pipeline operator to conduct a detailed metallurgical analysis of the July 4 failure to determine the cause and contributing factors. The corrective action order also prohibited Enbridge from operating the pipeline until it had submitted a return-to-service plan, which was to incorporate a program to verify the integrity of the 34-inch pipeline from the Deer River Pump Station to Superior Terminal. The plan was to include, if relevant, an in-line inspection survey using a technologically appropriate tool capable of assessing the type of failure that had occurred, including the detection of longitudinal cracks, and remedial action. If relevant, the return-to-service plan was to include an evaluation of the pipeline coating system, a hydrostatic pressure test of the line segment, and a review of all available pipeline data and records.