

NATIONAL TRANSPORTATION SAFETY BOARD

Office of Research and Engineering
Materials Laboratory Division
Washington, D.C. 20594



January 5, 2021

MATERIALS LABORATORY FACTUAL REPORT

Report No. 21-085

A. ACCIDENT INFORMATION

Place : Hillsboro, Kentucky¹
Date : May 4, 2020
Vehicle : 30-inch diameter pipe operated by Enbridge Inc. (Enbridge)
NTSB No. : PLD20LR001
Investigator : Sara Lyons

B. COMPONENTS EXAMINED

Pipe segment that fractured around the entire circumference at the girth weld.

C. REFERENCE REPORT

Metallurgical Analysis of Failure of Girth Weld on 30-Inch Diameter Line 10 (Fleming County), Report No. E-AK-PI/DNOR (10244271), prepared by DNV for Texas Eastern Transmission, LP (Enbridge), dated November 1, 2021.

D. DETAILS OF THE REFERENCE REPORT

An NTSB Materials Laboratory Group was formed to oversee examination and preservation of the fractured girth weld, selection of samples to be tested, and monitor testing related to the pipe involved in the accident. The group consisted of the following individuals:

Frank Zakar	Materials Laboratory Group Chair	NTSB
Gery Bauman	Member	PHMSA
Gary Vervake	Member	Enbridge

NTSB accident investigators conducted the investigation virtually via teleconference communication (live-video conference calls), in keeping with NTSB social distancing guidelines to prevent the spread of the Covid-19 virus.²

Norske Veritas GL (DNV), Columbus, Ohio, was contracted by Enbridge Incorporated (operator of the pipeline) to examine the fractured girth weld involved in the Hillsboro, Kentucky, accident and prepare a final written report that summarizes its

¹ Also referred to by Enbridge as accident occurring in Fleming County, Kentucky.

² NTSB investigators did not physically visit the accident site or facilities that conducted fracture examination and testing of the pipe.

observations of the fractured weld joint. Selection of DNV was reviewed and approved by PHMSA and NTSB. The work was completed with oversight by NTSB and PHMSA. DNV issued final report No. E-AK-PI/DNOR (10244271) indicating that the pipe fractured around the entire circumference at the girth weld at milepost (MP) 509.9 girth weld BHGE GW 11330 as a result of ductile tensile failure (overstress separation) with no evidence of fatigue cracking.³ Two incomplete penetration and lack of root fusion defects were identified on the fracture surface of the failed girth weld. One defect was about 7 inches in length and 0.130 inches in depth. The other defect was about 4.9 inches in length and 0.100 inches in depth. See attached reference report. Tensile properties, toughness properties, and chemical composition for the pipe (base metal) were all in accordance with standards in API 5L grade X-52 requirements, as of the time of construction.

To assess the structural integrity of a pipeline against large ground movement, it was necessary to determine the magnitude of girth weld tensile strain demand and the girth weld tensile strain capacity.⁴ As part of the overall test program, DNV was assigned the task of determining the girth weld tensile strain demand whereas Stress Engineering Services was assigned the task of determining the girth weld tensile strain capacity. As indicated in the final report, the estimated tensile strain demand for the girth weld was determined to be approximately 3.0% in 2020, prior to the failure. Several assumptions went into this analysis, including an assumption that there were no defects present.

The tensile strain capacity was estimated by evaluating exemplar girth welds which were retained from the failed pipeline. Curved wide plate specimens were fabricated and tested. A full circumferential pipe finite element analysis (FEA) model was developed that included the flaws from the specimen that failed at the lowest strain.⁵ Using these results, the contractor calculated the crack driving force for three selected curved wide plate specimens and estimated the strain capacity for the weld to be between 1.3-2.0% at 936 psig (the pressure in the pipeline at the time of the accident). The final report indicated that pipe displacement caused by land movement was most likely sufficient to exceed the tensile strain capacity of the girth weld at MP 509.9 (BHGE GW 11330).

Prepared by

Frank Zakar
Senior Metallurgist

³ Weld location number/designation created by Baker Hughes General Electric (BHGE), the in-line inspection vendor.

⁴ The *tensile strain demand* is the amount of strain that is being asked of the system or material to accommodate, whereas the *tensile strain capacity* is the amount of strain that the system or material is able to achieve.

⁵ No weld flaws were included beyond the 4-inch curved wide plate region.

ATTACHMENT

Report No. E-AK-PI/DNOR (10244271)
Prepared by DNV for Texas Eastern Transmission, LP (Enbridge)
Dated November 1, 2021

This report was inserted into the NTSB public docket as a separate document.