



National Transportation Safety Board

Pipeline Accident Brief

TransCanada Corporation Pipeline (Keystone Pipeline) Rupture Amherst, South Dakota

The Accident

On November 16, 2017, at 4:34 a.m. mountain daylight time, a TransCanada Corporation, Keystone Pipeline (Keystone) ruptured near Amherst, South Dakota, between the Ludden, North Dakota, (Ludden) and Ferney, South Dakota, (Ferney) pump stations. Keystone's Operational Control Center (OCC), in Calgary, Alberta, Canada, was monitoring Keystone's Supervisory Control and Data Acquisition system that detected the leak and shut down the pipeline. Keystone's field staff traveled to the indicated leak location, confirmed that the pipeline had ruptured, and initiated their spill response plan. The approximate spill area was comprised of about 5,000 barrels of crude oil. (See figure 1.)



Figure 1. Accident scene in Amherst, South Dakota taken on November 16, 2017.
(source: <https://twitter.com/TransCanada>)

When notified about the accident, the National Transportation Safety Board (NTSB) coordinated with the Pipeline and Hazardous Materials Safety Administration (PHMSA) to conduct a metallurgical examination of the pipe to establish a probable cause of the pipeline

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rupture. As part of its comprehensive investigation of Keystone's operations and practices leading up to the pipeline rupture, PHMSA provided oversight of Keystone's excavation, removal, and shipment of the failed pipe section to the NTSB laboratory in Washington, DC.¹

At the time of the pipeline rupture, Keystone was conducting an in-line inspection (ILI) using a cleaning tool (pig) and an acoustic leak detection tool (SmartBall).² Prior to the rupture, both the cleaning pig and the SmartBall leak detection tool had traveled past the nearest block valve downstream of the rupture location (Ludden + 28). The tools were run in a light-sweet blend batch of crude oil, followed by a batch of sour crude. In preparation for the tools to bypass the next downstream pump station in Ferney, a bypass operation of the Ferney pump station was initiated at 5:03 a.m. The bypass of the Ferney pump station was fully executed at 5:24 a.m. The pump station bypass resulted in a gradual and anticipated pressure increase at the discharge of the upstream station in Ludden. The pressure records from Ludden indicated that the pressure had increased from 1,170 pounds per square inch gage (psig) to 1,352 psig when the rupture occurred. Since the pipeline installation, no ILI tools for detecting cracks had been used.

The first indication of the pipeline rupture occurred at 5:33 a.m., when an abrupt drop in discharge pressure and a corresponding increase in flow rate were observed at the Ludden pump station. In addition, at 5:34 a.m., a corresponding pressure drop was observed at the Ferney pump station. The controller at Keystone's OCC initiated an emergency shutdown of the pipeline at 5:36 a.m. and commenced isolation of the pipeline. By 5:45 a.m., the failure location had been isolated by using remotely operated valves. Keystone personnel were dispatched to investigate the pipeline right-of-way for signs of a release and confirmed oil on the ground about 9:15 a.m. Keystone personnel then notified Marshall County emergency services; the Britton Fire Department and Marshall County Sheriff responded within minutes of notification. The incident commander established and maintained a 1-mile safety zone during the response.

The Pipeline System

The Keystone Pipeline originates in Hardisty, Alberta, Canada, and delivers crude oil to terminals in Patoka, Illinois, and Cushing, Oklahoma. The rupture occurred downstream of the Ludden pump station, at milepost 234.2, in Marshall County, South Dakota. The pipe at the rupture location was constructed during the fall of 2008 and was commissioned in 2010. The ruptured pipe was 30 inches in diameter with a 0.386-inch wall thickness and was manufactured by Berg Pipe to American Petroleum Institute Specification 5L grade X-70 product specification level 2, using a double submerged arc-welded (DSAW) longitudinal weld seam and fusion bonded epoxy (FBE) coating. The pipeline was constructed and operated under a special permit, which allowed operation at pressures up to 80 percent of specified minimum yield strength (SMYS).³

When the pipe was excavated, concrete weights installed during construction were found at the rupture location. The ruptured pipe piece along with a portion of one concrete weight were

¹ As of the date of this report, PHMSA has not yet completed its investigation.

² Registered trademark of Xylem Inc. Edmonton, Alberta, Canada.

³ Pipeline and Hazardous Materials Safety Administration, Special Permit PHMSA-2006-26617 (Washington, DC: US Department of Transportation, Pipeline and Hazardous Materials Administration, 2006) https://www.phmsa.dot.gov/sites/phmsa.dot.gov/files/docs/TC_Keystone_2007-04-30_508compliant.pdf

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shipped to the NTSB materials laboratory for examination. Figure 2 shows the ruptured pipe after excavation and prior to shipment to the NTSB.

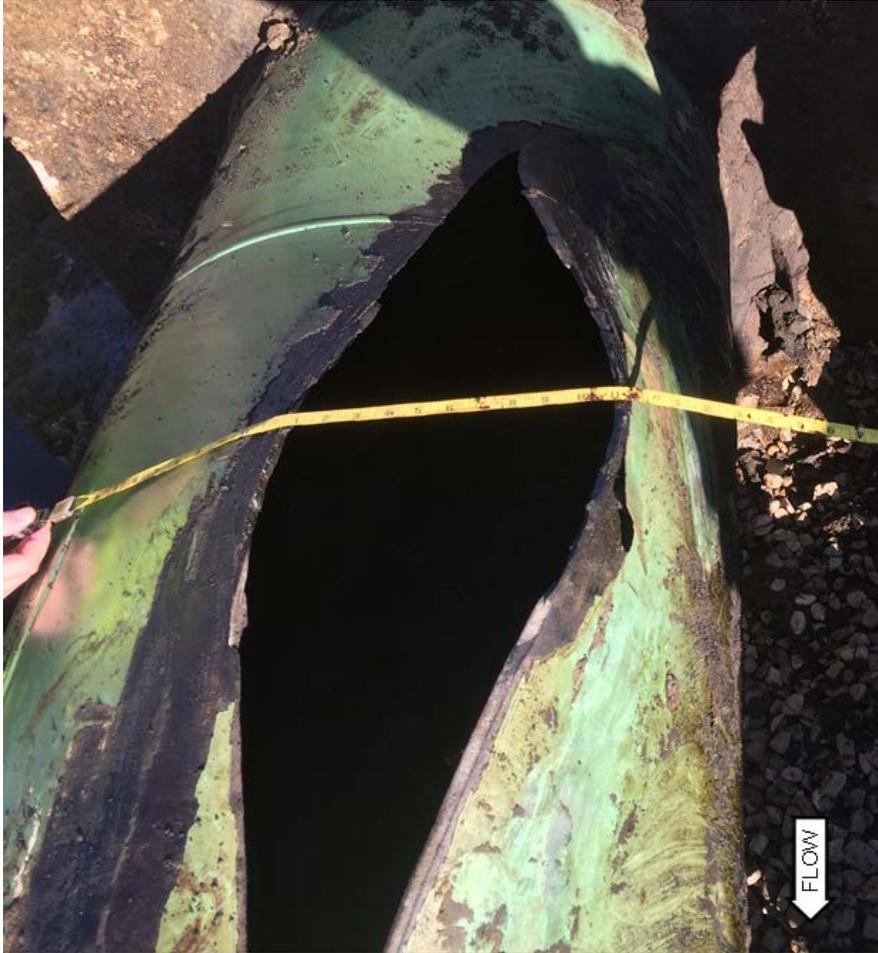


Figure 2. Ruptured pipe.

At the NTSB materials laboratory, the ruptured pipe piece was cleaned and visually examined. The metallurgists found midway along the length of the fracture face (a region of 5.52 inches long), ratchet marks, crack arrest lines, and other features consistent with a multiple-origin fatigue fracture that originated at an external groove in the pipe wall. (See figure 3.) The fatigue origin area was located near the top of the pipe about 6.5 inches away from the longitudinal seam. The pipe exterior exhibited areas of exposed metal and grooves formed by sliding contact that aligned nearly parallel to the pipe axis on the exterior surface coinciding and adjacent to the length of the fracture. Coating material was present and intermixed with the sliding contact marks, and many edges of the remaining coating adjacent to individual contact marks were curled and rounded consistent with sliding contact deformation. As shown on the right side of figure 3, a larger cluster of grooves was present toward the upstream end of the fracture.

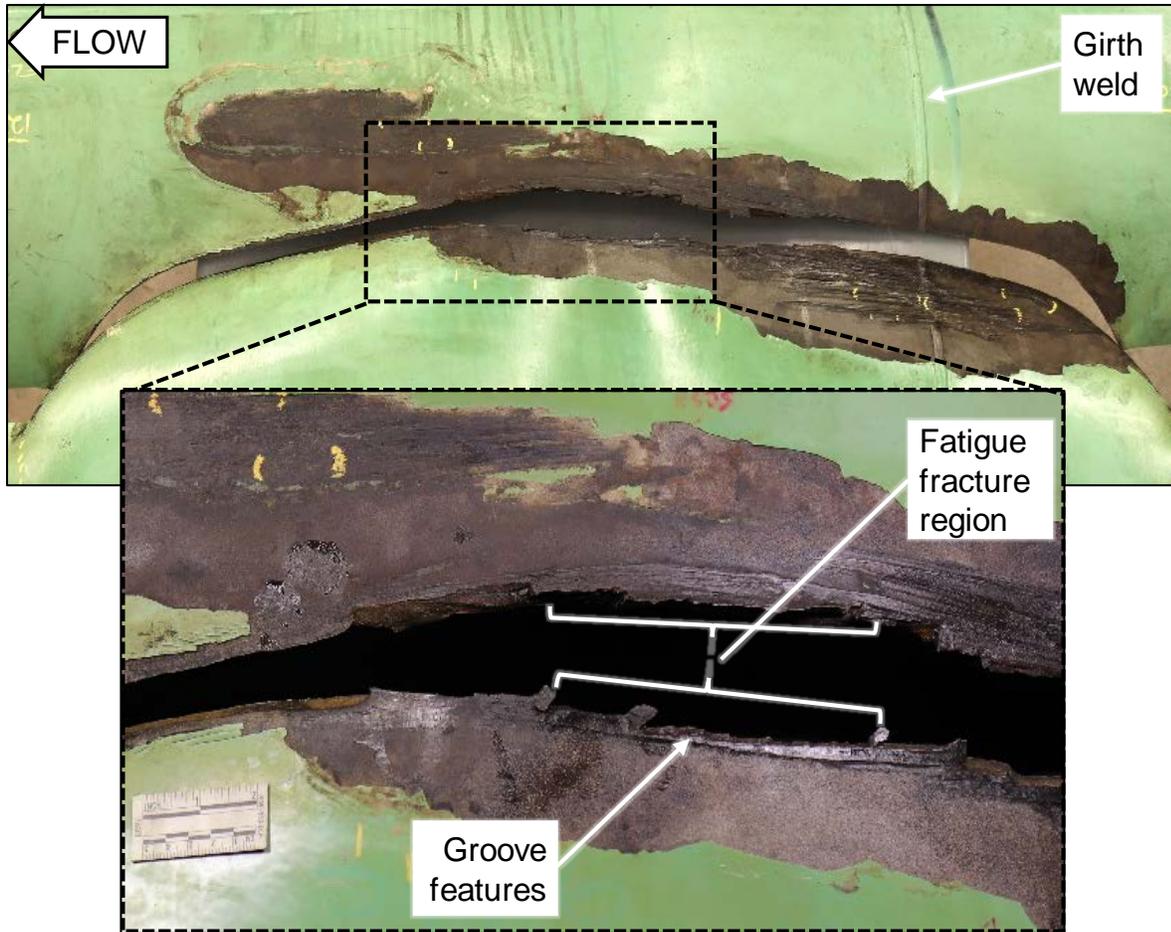


Figure 3. Overview of the pipe fracture with mating sides of the fracture placed adjacent to each other. The inset image shows a closer view of the fatigue fracture initiation region and a colony of sliding-contact grooves.

Compositional analysis of the grooved surfaces and of cross-sections through the grooves near the fatigue crack origin area revealed that smeared metal in the trough of the sliding contact-grooves contained higher concentrations of chromium than the pipe material (as determined by energy dispersive spectroscopy and backscattered electron microscopy). This was consistent with the presence of a deposited layer.

The composition of the deposited metal in the grooves, and the morphology of the groove colonies is consistent with damage that would result from the pipe being run over by a metal-tracked construction vehicle. The composition of the concrete weights was examined and ruled out as a source of the mechanical damage to the pipe. A full report of the metallurgical examination can be found in accident docket PLD18LR001.

Probable Cause

The NTSB determines that the probable cause of the failure of the Keystone Pipeline was a fatigue crack, likely originating from mechanical damage to the pipe exterior by a metal-tracked vehicle during pipeline installation, that grew and extended in-service to a critical size, resulting in the rupture of the pipeline.

For more details about this accident, visit www.nts.gov/investigations/dms.html and search for NTSB accident identification PLD18LR001.

Adopted: July 5, 2018

The NTSB has authority to investigate and establish the facts, circumstances, and cause or probable cause of a pipeline accident in which there is a fatality or substantial property damage, or significant injury to the environment. (49 U.S. Code, Section 1131 - *General authority*)

The NTSB does not assign fault or blame for an accident or incident: rather, as specified by NTSB regulation, “accident/incident investigations are fact-finding proceedings with no formal issues and no adverse parties...and are not conducted for the purpose of determining the rights or liabilities of any person.” Title 49 *Code of Federal Regulations*, Section 831.4. Assignment of fault or legal liability is not relevant to the NTSB’s statutory mission to improve transportation safety by investigating accidents and incidents and issuing safety recommendations. In addition, statutory language prohibits the admission into evidence or use of any part of an NTSB report related to an accident in a civil action for damages resulting from a matter mentioned in the report. 49 U.S. Code, Section 1154(b).
