Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

PIPELINE INVESTIGATION REPORT
P09H0006

SOUR GAS PIPELINE SENDING BARREL RUPTURE

WESTCOAST ENERGY INC., CARRYING ON BUSINESS AS SPECTRA ENERGY TRANSMISSION
18-INCH ALASKA HIGHWAY PIPELINE
KILOMETRE POST 0.0
NEAR WONOWON, BRITISH COLUMBIA
20 FEBRUARY 2009

Canada

Pipeline Investigation Report

Sour Gas Pipeline Sending Barrel Rupture
Westcoast Energy Inc., Carrying on Business as Spectra Energy Transmission
18-inch Alaska Highway Pipeline
Kilometre Post 0.0
Near Wonowon, British Columbia
20 February 2009

Report Number P09H0006

Summary

At approximately 0800 Mountain standard time on 20 February 2009, the sending barrel of the 18-inch Alaska Highway Pipeline, owned by Westcoast Energy Inc, carrying on business as Spectra Energy Transmission, ruptured while a two-person crew was preparing to launch a cleaning tool (pig). Both crew members evacuated the site and called for help at a nearby plant at Mile 111 on the Alaska Highway, several hundred metres from the sending barrel yard. The crew was taken by ambulance to Fort St. John Hospital, British Columbia. One crew member was assessed and released immediately. The other crew member, a contractor's employee, was treated for exposure to hydrogen sulphide and for minor injuries and was released the following day.

Ce rapport est également disponible en français.

Other Factual Information

On 19 February 2009, the day before the rupture, an employee of Westcoast Energy Inc., carrying on business as Spectra Energy Transmission (Westcoast), and a contractor's employee working for Westcoast, arrived at the fenced launching and receiving compound to retrieve a cleaning tool (pig) from the 12-inch Alaska Highway Pipeline and to load another cleaning pig in the 18-inch Alaska Highway Pipeline sending barrel. Approximately 40 litres of methanol was added to the sending barrel in accordance with the launching procedure. The methanol acts as a water scavenger and helps break down hydrates that would restrict gas flow. However, if methanol is left in the sending barrel for a long period of time, it will remove any traces of corrosion inhibitor in the line. The cleaning tool was placed just past the kicker valve and the barrel was pressurized and left at 4550 kilopascals (kPa) in preparation for launching the pig the following day. Pre-loading a pig is not included in Westcoast's operations and maintenance manuals, although it has become a common practice followed by Westcoast field employees since the mid-1990s.

At 0730 [1] on 20 February 2009, the same two employees arrived at the fenced launching and receiving compound to ship the pre-loaded cleaning pig on the 18-inch Alaska Highway Pipeline. The pressure in the sending barrel was higher than the previous day and was now at approximately 5515 kPa, but still within acceptable limits. The two employees continued with the launching procedure but the pig would not launch. This was not an unusual occurrence and the Westcoast employee took the necessary step to build up pressure behind the pig by closing the kicker valve. The valve had been closed for approximately 30 seconds when the rupture occurred (see Photo 1). An unknown amount of sour gas was released. There was no gas present in the vicinity before the pipe failed. After the rupture, both employees were exposed to the sour gas, self-evacuated from the site and were transported to the Fort St. John Hospital for assessment.

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[1] All times are mountain standard time (Coordinated Universal Time minus seven hours).

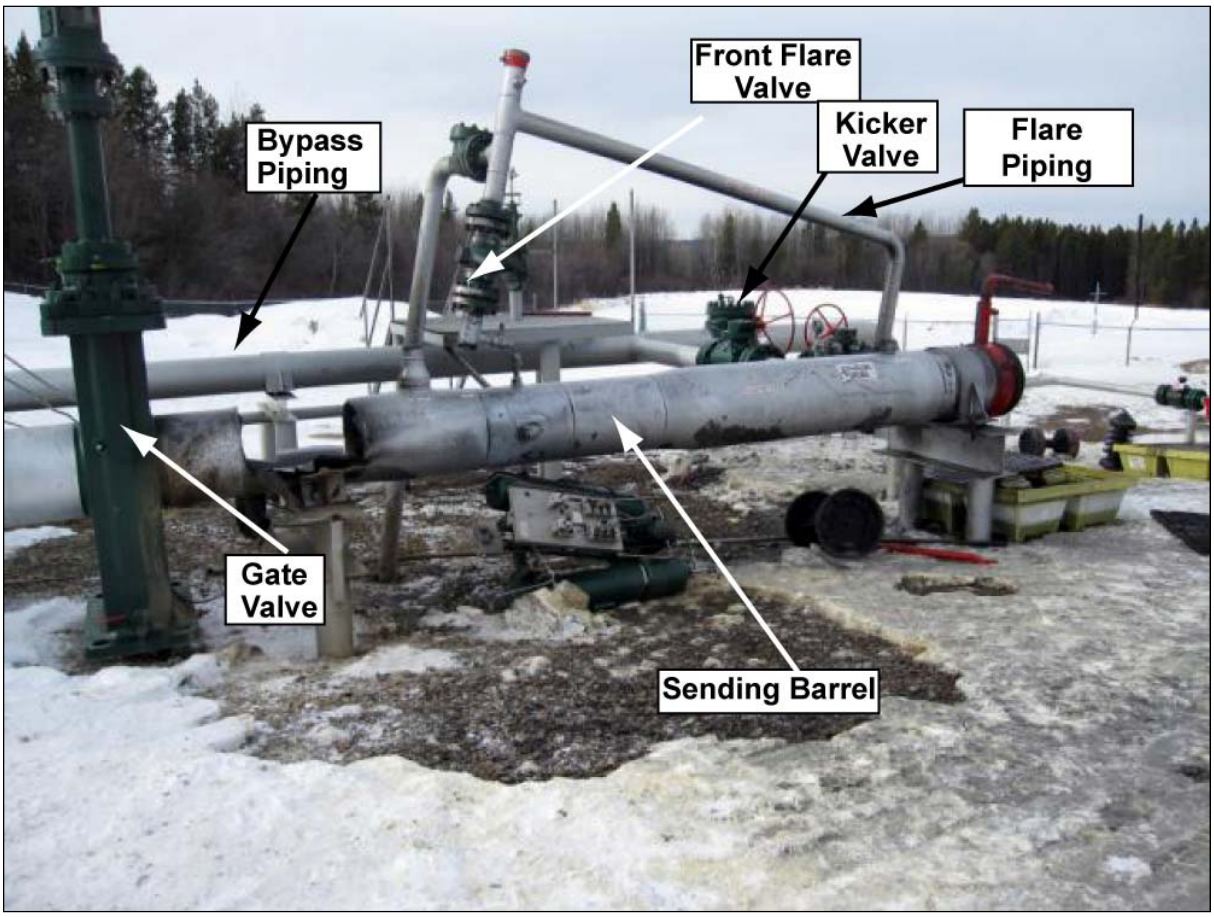

Photo 1. Failed sending barrel

Fort St. John Sour Gas Gathering System

Westcoast owns and operates the Fort St. John sour gas gathering system in northern British Columbia. The 18-inch Alaska Highway Pipeline was constructed in 1957 as part of this gathering system. The pipeline has a diameter of 457.2 millimetres (mm) (18 inches) and a wall thickness of 8.74 mm (0.344 inches) and is 28.8 kilometres (km) long. It originates at the termination of Westcoast's 12-inch Alaska Highway Pipeline, which is also part of the sour gas gathering system, and ends at Westcoast's Kobes Booster Station. The sending barrel of the 18-inch Alaska Highway Pipeline is located at kilometre post (KP) 0.0, in the same fenced compound as the receiving barrel of the 12-inch Alaska Highway Pipeline. Since the sending barrel operates at a lower stress level than the pipeline, the sending barrel has a nominal wall thickness of 9.52 mm (0.375 inches). There are two remotely operated isolation block valves on the 18-inch Alaska Highway Pipeline, which are located at KP 10.7 and KP 13.0.

The 10-inch Gundy Pipeline, 16-inch Beg Pipeline, and 3-inch Aitken Creek Liquids Pipeline, all part of Westcoast's Fort St. John sour gas gathering system, feed into the 18-inch Alaska Highway Pipeline immediately downstream of the sending barrel. In addition, there are three producer receipt points in the same general area. Westcoast does not analyze the gas at each sending barrel, but is provided a monthly gas analysis from each producer's receipt point indicating the percentage of carbon dioxide and hydrogen sulphide in the gas by volume from that producer. The amount of water in the gas is contractually regulated by the producers to

ensure a level that is less than four pounds per million cubic feet of gas. Gas flowing from the 12-inch Alaska Highway Pipeline into the 18-inch Alaska Highway Pipeline has a weighted average (by volume) of four per cent carbon dioxide and two per cent hydrogen sulphide.

Westcoast's Pipeline Cleaning Procedures

A cleaning pig is sent through the 18-inch Alaska Highway Pipeline five days per week to clean the inside surface of the pipe and to remove liquids to allow the maximum volume of gas to flow with minimum friction and pressure drop.

Westcoast has written procedures that field personnel must follow to safely launch and receive cleaning pigs. The latest revision to these procedures is dated 11 June 2007 and is contained in Westcoast's Pipeline and Operations Maintenance Manual. The written procedures were developed by the Operations Group, or in some instances by the System Integrity Group in conjunction with the Operations staff and Operations Engineering staff. Practices within the manual are approved by Operations supervisors before being posted on the company local area network. Implementation of procedures and practices is the responsibility of the respective operations groups.

The sending barrel launching procedure provides step-by-step instructions for loading and launching pigs and includes the requirement to inject the prescribed amount of methanol with each launch. Although the procedure does not explicitly state that loading and launching a cleaning pig should be completed the same day, it is implied in the steps of the procedure.

Since 2004, the procedure has called for the injection of a vapour phase corrosion inhibitor in the sending barrel following the launch of each cleaning pig. A vapour phase corrosion inhibitor is a chemical substance that neutralizes the pH of any free water and has a high vapour pressure capable of forming a relatively stable bond on the inside surface of the pipe, thus producing a protective layer against internal corrosion. Vapour phase corrosion inhibitors have an offensive odour and are toxic. Therefore, for these corrosion inhibitors to be handled safely, personnel need to use extensive personal protective equipment. Westcoast's field personnel typically do not inject the vapour phase corrosion inhibitor as required.

Employee Information

The Westcoast employee had been working for the company for approximately two years and his duties included launching and receiving cleaning pigs from between 6 and 12 locations per day. He had undergone in-house training consisting of viewing a 35-minute video and a review of Westcoast's written launching and receiving procedures followed by on-the-job training with an experienced technician. Following this training, Westcoast had qualified the employee as an experienced technician who could supervise and lead junior technicians and contractors during pig launching and receiving operations.

The other crew member, a contractor's employee, had been working with a senior Westcoast field technician for approximately two years, launching and receiving cleaning pigs at between five and seven locations per day. Before assisting in the field, he had viewed the Westcoast training video and had been made aware of Westcoast's written launching and receiving procedures.

Laboratory Analysis of Failed Sending Barrel

The failed sending barrel was sent to the Acuren Group Inc. (Acuren) laboratory in Richmond, British Columbia, for a visual examination, non-destructive inspection, and destructive metallurgical testing. The laboratory analysis determined that the sending barrel failed in an overload condition that developed during launching operations. Internal corrosion had occurred on the top half of the barrel. The wall thickness at the failure location had been reduced by the corrosion to the extent that local permanent yielding had occurred at normal operating pressures. Fatigue cracks had formed due to pressure cycling during the cleaning pig launching process. TSB's Laboratory reviewed the results of the Acuren failure analysis report and determined that the nature of the work performed and methodologies were consistent with good failure analysis practice (LP 064/2009).

Construction and Maintenance of Sending Barrel

In 2005, Westcoast had reconstructed the sending barrel to relocate the isolation valve above ground. In February 2006, after approximately 10 months of service, a leak occurred at a transverse crack on a reducing tee of 457.2 mm by 254 mm (18 inches by 10 inches) on the sending barrel. The tee was cut out and replaced. Although Westcoast's unwritten practice was to internally pre-coat new pipe material with corrosion inhibitor before placing new sections into service, this was not done with the replacement tee. In 2007, the Canadian Standards Association (CSA) made it mandatory to pre-coat new pipe material with corrosion inhibitor.

Following the leak in February 2006, Acuren examined the tee and determined that the crack resulted from an inappropriate manufacturer's welding procedure. Westcoast conducted a visual examination of the sending barrel at that time and found no evidence of internal or external corrosion.

There were no further maintenance issues with the sending barrel until August 2008, when Westcoast replaced the front flare valve. Gas had been leaking through this valve to the flare stack for the previous eight months. The valve was examined after removal and it was determined that the valve had been incorrectly set up at the factory and could not seal properly.

Barrel Assembly Inspections

Launching and receiving barrel assemblies in Westcoast's sour gas gathering system have an annual safety inspection. These inspections document the general condition of the barrel site, ensure proper signage is in place and record any potential safety issues, such as valves that malfunction. During the previous annual visual inspection that was conducted on 08 September 2008, no corrosion or malfunctions were noted at this location.

Integrity inspections are also conducted on launching and receiving barrel assemblies. These inspections include the ultrasonic thickness measurements of selected components. Integrity inspections, which are performed at a maximum interval of five years, help ensure the integrity of the barrel and associated high-pressure piping. In this occurrence, since the 18-inch Alaska Highway Pipeline sending barrel had not reached the five-year mark, an integrity inspection had not yet been completed.

All Westcoast sour gas gathering pipelines, including the 18-inch Alaska Highway Pipeline, have corrosion coupons and hydrogen probes that are reviewed at a minimum every six months. When these coupons and probes are located near sending barrels, they are located on the pipeline side of the barrel isolation gate valve. There was no corrosion on the pipeline side of the barrel isolation gate valve on the18-inch Alaska Highway Pipeline.

Analysis

The Accident

Internal corrosion had thinned the upper quadrant of the sending barrel to the extent that local permanent yielding had occurred at normal operating pressures, leading to the rupture. The relatively uniform nature of corrosion on the upper half of the sending barrel and the absence of corrosion products indicate an acidic vapour phase attack.

The gas flowing into the 18-inch Alaska Highway Pipeline from the 12-inch Alaska Highway Pipeline contains approximately four per cent carbon dioxide and two per cent hydrogen sulphide and may also contain up to four pounds of water vapour per million cubic feet of raw gas. The carbon dioxide in the gas is more aggressive than the hydrogen sulphide alone. The corrosion would have been caused by the condensation of water vapour in the gas stream inside the sending barrel. Condensation of the water vapour would have occurred due to a drop in pressure and/or a drop in temperature, which would take place with each launch.

The isolation gate valve is designed to seal completely when there is a pressure differential across it. However, when the sending barrel is left pressurized and the gate valve closed for an extended period of time, as had been common practice for many years during the launching of cleaning pigs on the 18-inch Alaska Highway Pipeline, there may not have been sufficient pressure across the valve to ensure a complete seal. Because the front flare valve on the sending barrel had been leaking for at least eight months, the barrel side of the isolation gate valve would have been under a slightly more negative pressure relative to the pipeline side of that valve. This would have promoted a constant flow of gas into the barrel during the time that the barrel was left at pipeline pressure.

Use of Corrosion Coupons

All Westcoast's sour gas gathering pipelines, including the 18-inch Alaska Highway Pipeline, have corrosion coupons and hydrogen probes that are reviewed at a minimum every six months. When these coupons and probes are located near sending barrels, they are normally located on the pipeline side of the barrel isolation gate valve. With respect to the Fort St. John facility, there were no corrosion coupons established on the barrel side of the isolation gate valve. When corrosion coupons, which provide indications of internal corrosion, are not established on both the pipeline side and the barrel side of the isolation gate valve, an incomplete corrosion assessment of the sending barrel system may occur, increasing the risk of a corrosion-based rupture.

Awareness of Internal Corrosion Control Procedures

Although there were approved written pig launching procedures, which would have provided a defence against internal corrosion, some of these procedures had not been followed for several years. The risks associated with deviating from those procedures had not been recognized. The senior employee on site, as well as the contractor's employee, had undergone their field training during the time that approved procedures were not being followed, and the risks associated with that practice had not been recognized.

One of the non-approved practices that had become well established was the practice of leaving a sending barrel pre-loaded at pipeline pressures for at least 24 hours before the cleaning pig was launched. With the addition of methanol in the barrel for that length of time, the corrosion inhibitors would be deactivated or removed.

Another defence to mitigate internal corrosion, the requirement established in 2004 to inject vapour phase corrosion inhibitor following each launch, had not been well understood nor routinely followed. When company guidelines related to internal corrosion controls (for example, the addition of a vapour phase corrosion inhibitor after the launch of each cleaning pig) are not well understood, the procedures may not always be followed, resulting in an increased risk of a corrosion-based rupture.

Internal Coating of New Pipe Material

Westcoast's practice of internally pre-coating material with corrosion inhibitor before service, a further defence against internal corrosion, had not been followed at the time the sending barrel's tee and transition piece were replaced in 2006.

Findings as to Causes and Contributing Factors

1. Internal corrosion had thinned the upper quadrant of the sending barrel to the extent that local permanent yielding had occurred at normal operating pressures, leading to the rupture.

2. Fatigue cracks had developed and grown due to the normal pressure cycles associated with pig launching operations.

3. The internal corrosion likely occurred due to acidic vapour phase attack resulting from the condensation of water vapour within the gas stream.

4. Methanol, which was in the sending barrel for at least 24 hours as part of the non-approved pre-loading process, minimized the effectiveness of the corrosion inhibitor on the internal surface of the sending barrel.

5. Due to the leaking front flare valve, continual product migration past the pipeline isolation gate valve and into the sending barrel had been occurring for at least eight months before the occurrence.

Findings as to Risk

1. When corrosion coupons, which provide indications of internal corrosion, are not established on both the pipeline side and the barrel side of the isolation gate valve, an incomplete corrosion assessment of the sending barrel system might occur, increasing the risk of a corrosion-based rupture.

2. When company guidelines related to internal corrosion controls (for example, the addition of a vapour phase corrosion inhibitor after the launch of each cleaning pig) are not well understood by those in a supervisory role as well as those performing the work, the suggested procedures will not always be followed, resulting in an increased risk of a corrosion-based rupture.

Other Finding

1. The company practice of internally pre-coating new metal with corrosion inhibitor to mitigate internal corrosion was not followed when the tee on the sending barrel was replaced in 2006. Since 2007, the Canadian Standards Association has made it mandatory to pre-coat new pipe material with corrosion inhibitor.

Safety Action Taken

Following the occurrence, Westcoast has taken the following actions:

- It conducted ultrasonic thickness testing on each section of every sending and receiving barrel in its sour gas gathering systems.

- It completed an integrity inspection, including an external visual inspection and ultrasonic inspection and radiographs of suspect locations, on all sending and receiving barrels in its sour gas gathering systems, as well as an internal visual inspection on most barrels in its Grizzly Valley sour gas system. Since specialized equipment is required to complete an effective internal visual inspection of the remaining Grizzly Valley barrels, this inspection will be completed by July 2010 in coordination with the scheduled Pine River Plant outage.

- It added vapour phase corrosion inhibitor to all barrels in wet sour gas service after launching and receiving operations.

- It prohibited the pre-loading of sending barrels with methanol.

- It reduced the barrel integrity inspection interval within its Fort St. John sour gas gathering system from five years to one year, and within its other gathering systems, from five years to three years.

- It installed corrosion coupons on all sending and receiving barrels in wet sour gas service, on a priority basis, and mandated that the coupons be evaluated on a three-month basis.

- It provided an information session to all field staff on the use of vapour phase corrosion inhibitors.

- It initiated an independent inhibitor testing program to verify the suitability of the current inhibitors.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 26 January 2010.

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