Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

PIPELINE INVESTIGATION REPORT
P06H0061

IN-LINE TOOL OCCURRENCE

ENBRIDGE PIPELINES (WESTSPUR) INC.
323.9-MILLIMETRE OUTSIDE DIAMETER PIPELINE
RECEIVING TRAP AT CROMER TERMINAL
NEAR CROMER, MANITOBA
23 NOVEMBER 2006

Canada

The Transportation Safety Board of Canada (TSB) investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

Pipeline Investigation Report

In-Line Tool Occurrence
Enbridge Pipelines (Westspur) Inc.
323.9-Millimetre Outside Diameter Pipeline
Receiving Trap at Cromer Terminal
Near Cromer, Manitoba
23 November 2006

Report Number P06H0061

Summary

At 1624 central standard time, on 23 November 2006, the last in a train of four displacement pigs arrived in the receiving trap of the 323.9-millimetre outside diameter Enbridge Pipelines (Westspur) Inc. pipeline located within Enbridge Pipelines Inc. Cromer Terminal. The receiving trap was isolated, bled down to flare and purged with nitrogen. When the crew believed that all pressure had been bled off, the receiving trap blind was removed.

The first two displacement pigs were removed. The third displacement pig was located approximately 7.6 metres back from the opening of the receiving trap. The crew attempted to hook onto the displacement pig using a 9.1-metre puller with a "T" handle. When the displacement pig was hooked, three crew members positioned themselves on the puller and the displacement pig started to move. However, when the crew stopped pulling, the displacement pig continued to move. The third and fourth displacement pigs were expelled from the receiving trap, striking and injuring two of the crew members before coming to rest approximately 9.1 metres from the end of the receiving trap. Two of the crew members were transported to hospital. One was seriously injured and remained in hospital for several days; the other was treated and released the same day. The third crew member, a contractor's employee, was treated in hospital for shock and released the same day.

Ce rapport est également disponible en français.

Other Factual Information

The injuries occurred during the completion of an in-line inspection (ILI) of the 323.9-millimetre (mm) outside diameter (OD) Enbridge Pipelines (Westspur) Inc. (EPWI) pipeline. The pipeline transports natural gas liquids (NGLs) from the BP Canada Energy Co. Ltd. Steelman Gas Plant to the Enbridge Pipelines Inc. (EPI) Cromer Terminal for transportation to the United States and eastern Canada via connecting pipeline systems.

EPWI also owns a 406.4 mm OD pipeline that transports light and medium crude oil, as well as approximately 100 kilometres (km) of gathering lines ranging in diameter from 114.3 mm OD to 219.1 mm OD. The EPWI system, which is federally regulated, is owned by Enbridge Pipelines (Saskatchewan) Inc. (EPSI). EPSI also owns other crude oil pipeline systems in Saskatchewan and Manitoba. These pipeline systems are provincially regulated. Employees of Enbridge (Saskatchewan) Operating Services Inc. (ESOSI) provide services to EPSI and EPWI for operational purposes through an intercorporate services agreement.

The ILI of the 323.9 mm OD pipeline consisted of running a train of six in-line tools (a caliper tool, a magnetic flux leakage [MFL] tool, and four displacement pigs) through the pipeline to assess the integrity of the line. The caliper tool, the MFL tool and the first three displacement pigs were launched in NGLs, while the fourth displacement pig was launched in natural gas. The entire train was pushed through the pipeline under pressure using natural gas because there was not sufficient NGL supply to provide an acceptable transit time for the caliper and MFL tools.

The purpose of the caliper tool was to provide information about the presence of dents and ovality on the pipeline. The MFL tool was to detect areas of corrosion on the pipeline, and the displacement pigs were to ensure that a buffer between the NGLs and the natural gas was established and maintained.

A temporary receiving trap, as shown in Figure 1, had been constructed for this ILI. The outside diameter of the oversize pipe of the receiving trap was based on EPSI standards for gathering lines and was 355.6mm OD with an inside diameter of 336.55 mm. Each displacement pig had an outside diameter of 323.85 mm. Since the oversize pipe was long enough to accommodate the four displacement pigs simultaneously, a puller that could reach towards the back of the oversize pipe and remove the last displacement pig had been constructed for this project. It was 9.1 metres (m) long and made of square metal tubing with a 12.7 mm hook inserted into the end. There was no detailed written procedure for the use of this puller.

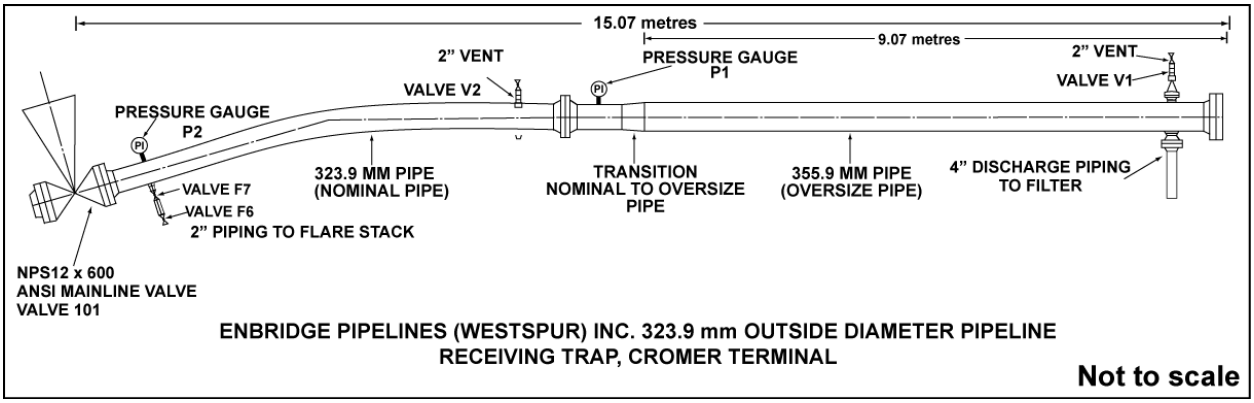

Figure 1. Temporary receiving trap

On 20 November 2006, a pre-job meeting was held to review the scope of the project, the ILI procedure, and the manpower requirements. One of the crew members was not present and the site-specific information for receiving the tools was relayed to that crew member by a member who had been at the pre-job meeting.

There was no written procedure for removing the tools from the receiving trap for this specific project. Instead, the procedures contained in Enbridge Book 3: Pipeline Facilities, 08-03-02, Procedures, Operating Receiving Traps, were to be used. Although the three basic steps for operating a receiving trap (isolate the header, depressurize and verify that the pressure has been relieved) are outlined in these procedures, the procedures are specific to a pipeline in crude oil service, not to a pipeline in NGL service. The procedures contain a warning that opening a receiving trap attached to a pressurized pipeline exposes workers to many hazards and provides the precaution to avoid standing in line with the trap.

Safe work permits are issued to contractors performing work on EPWI facilities as well as ESOSI personnel performing hot work on EPWI facilities in hazardous or restricted areas. The safe work permits issued on 23 November 2006 provided a general description of the work but did not engage the workers in breaking down the work procedure into key tasks or identifying hazards and controls.

On 23 November 2006, at approximately 0635 central standard time,[1] the caliper tool arrived in the receiving trap, which was then isolated, bled down to flare, and purged with nitrogen before the caliper tool was removed. At approximately 0815, the MFL tool arrived in the receiving trap, which was again isolated, bled down to flare, and purged with nitrogen before the MFL tool was removed. The tracker, the contractor's employee in charge of tracking the MFL, caliper and displacement pigs, verified the arrival of the first, second and third displacement pigs in the receiving trap at 1202, 1224 and 1438, respectively.

Between the arrival of the second and third displacement pigs, a decision was made to direct the product to the flare pit through the filter flare piping, since the NGL batch was beginning to show signs of contamination from the natural gas. However, when the valve was swung to

---

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

direct the flow through the filter flare piping, the flow was initially unimpeded, but slowly became blocked due to a build-up of ice in either the flare line or the filter system. The crew injected methanol into the filter flare piping at two locations. The blockage cleared and product was directed to the flare through the filter flare piping.

At 1624, the fourth displacement pig arrived at the receiving trap and the tracker confirmed the location of the transmitter at the back of that tool to be at the transition between the nominal and oversize pipes. The main isolation valve, valve 101, was left open for approximately five minutes after the displacement pigs were verified in the receiving trap to ensure that they remained towards the front of the receiving trap. Valve 101 was then closed.

The crew then began to follow the same procedure of isolating the receiving trap, bleeding to flare and purging with nitrogen that they had followed earlier in the day. When valve 101 was closed, venting of the receiving trap continued for a short time through the filter flare piping. Valves F6 and F7 were then opened, and the valves to the filter system were closed, thereby isolating the filter. Flaring continued through the back of the receiving trap until the pressure was reduced to about 689.5 kilopascals (kPa) at which point the nitrogen purge began and flaring continued. The crew monitored the flare until it began to die down, indicating that the receiving trap had been depressurized and purged of product. Valves F6 and F7 were then closed and valve V2 was opened to verify that the receiving trap was depressurized. When valve V2 was initially opened, some pressure was relieved and a small amount of black liquid was expelled.

At this time, pressure gauges P1 and P2 on the receiving trap, which were scaled from 0 to 6895 kPa, were reading 0 kPa, valves F6 and F7 were closed, isolating the receiving trap from the flare line, and valve V2 was open to the atmosphere and no longer venting pressure from the receiving trap. Pressures from 103 to 138 kPa are sufficient to move a displacement pig. A small amount of nitrogen at low pressure was flowing into the front of the receiving trap through valve V1 to ensure that an explosive environment would not be present when the receiving trap was opened.

The crew began to loosen the bolts on the receiving trap blind to remove the four displacement pigs. When one of the last four bolts was being loosened, pressure began to vent. The crew tightened up the bolts, removed the nitrogen line from valve V1 and opened that valve to vent the remaining pressure to atmosphere. They then removed the trap blind to remove the four displacement pigs.

The first two displacement pigs were removed with little effort. The third displacement pig was located approximately 7.6 m further down the receiving trap near the transition of the nominal and oversize pipes and the crew attempted to hook onto this tool using the 9.1 m puller. After several attempts, this tool was hooked. Two workers positioned themselves on the puller and felt the displacement pig move a little. A third worker assisted and the displacement pig started to move. When the crew stopped pulling, the third and fourth displacement pigs continued to move. Black fluid was expelled from valve V2 and the third and fourth displacement pigs were launched from the receiving trap, striking and seriously injuring two of the crew members, before coming to rest approximately 9.1 m from the end of the trap. Black fluid and black powder were also expelled from the receiving trap at the same time as the third and fourth displacement pigs.

EPWI runs a monthly cleaning program through the 323.9 mm pipeline using an internal cleaning tool to remove pipeline contaminants found in NGL pipeline systems. The last cleaning tool run took place several weeks before the ILI of the 323.9 mm pipeline.

Black powder, however, is a solid contaminant found worldwide in natural gas transmission and distribution systems but not in crude oil or NGL lines. It can create wear and reduced compressor efficiency, clogged instrumentation and valves, and flow losses in long pipelines. It can be wet, with a tar-like appearance, or dry and be a fine powder. During the planning and preparation of the ILI project and the design of the receiving trap, the introduction of black powder into the 323.9 mm OD EPWI pipeline had not been anticipated and its impact on the displacement pigs had therefore not been identified as a safety concern.

Personnel on site immediately began administering first aid to the injured workers. A 911 call was made and ambulances were requested. The injured workers were transported to the hospital in Virden, Manitoba. A contractor's employee, exhibiting signs of shock, was taken to hospital by a colleague, and was treated and released the same day.

Analysis

The black powder in the receiving trap was probably introduced into the 323.9 mm OD pipeline with the natural gas that was pushing the train of six tools.

The contamination of the NGL by the natural gas, as evidenced between the arrival of the second and third displacement pigs at Cromer, would have resulted in the accumulation of black powder. Contaminants may have been left in the pipeline following the last cleaning run. The black powder along with other contaminants and the natural flaring of the displacement pig cups from the back pressure in the pipeline combined with the small spacing around the displacement pigs could have created an effective seal around the third and/or fourth displacement pigs so that pressure from the nitrogen purge or any entrapped NGLs could not dissipate around those tools. The resulting pressure differential was sufficient to move the third and fourth displacement pigs backwards in the receiving trap until the third displacement pig became lodged at the transition between the nominal and oversize pipes and the fourth displacement pig was in the nominal pipe of the receiving trap, either just upstream of, or spanning, valve V2.

Following the closure of valves F6 and F7, a small amount of liquid NGLs probably remained in the receiving trap behind the fourth displacement pig. With the pressure in the trap less than 689.5 kPa, the NGLs would have gasified at a ratio of approximately 255:1. Since the fourth displacement pig was either just upstream of, or spanning, valve V2, the pressure could not dissipate through that valve and the valve could not function as designed in ensuring that the receiving trap was depressurized. The third displacement pig became dislodged when the crew pulled on it with the puller. Once the third displacement pig had become dislodged, the pressure behind the fourth displacement pig was sufficient to expel both displacement pigs from the receiving trap.

Since the crew believed that the third and fourth displacement pigs were in the oversize pipe of the receiving trap, they were not aware that valve V2 was blocked and could not function as designed in ensuring that the receiving trap was depressurized. In addition, once the crew was aware that the third and fourth displacement pigs had moved out of the oversize pipe of the receiving trap, they did not recognize the hazards associated with this change in location.

Although the crew verified that pressure gauges P1 and P2 were reading 0 kPa, those gauges were scaled from 0 to 6895 kPa and may not have been capable of displaying the relatively low pressures of 103 to 138 kPa required to move the displacement pigs.

The use of a puller, although not included in the written procedure for operating receiving traps, is an industry practice. However, despite the warning in the general procedures for operating receiving traps, depending on how the puller is used, crew members may put themselves in the line of fire should an in-line tool be expelled from the trap.

Findings as to Causes and Contributing Factors

1. Contaminants including black powder were introduced into the receiving trap during the in-line inspection procedure.

2. The contaminants accumulated around the third and/or fourth displacement pigs to the extent that a seal was created between those tools and the receiving trap.

3. A pressure differential across the third and fourth displacement pigs, probably as a result of entrapped natural gas liquids (NGLs), the nitrogen purge, or a combination of the two, moved those tools backwards until the third displacement pig became lodged at the transition between the nominal and oversize pipe.

4. Because the fourth displacement pig had become lodged either upstream of, or spanning vent V2, that vent could not function as designed.

5. Pressure built up behind the fourth displacement pig, possibly due to the gasification of NGLs behind it, until the pressure differential was sufficient to expel the third and fourth displacement pigs from the receiving trap.

6. The crew did not recognize the hazards associated with the third and fourth displacement pigs no longer being in the oversize portion of the receiving trap, as intended by the in-line inspection procedure.

7. The safety of the crew was compromised when they followed the common industry practice adopted by the company of using the puller to remove displacement pigs from the receiving trap.

8. The possibility of contamination of the pipeline to the extent that pressure could build up behind any of the displacement pigs or of the displacement pigs moving backwards in the receiving trap had not been identified as safety concerns during the design of the receiving trap or the planning and preparation of the in-line inspection procedure.

Other Finding

1. The black powder was not associated with normal operations of the Enbridge Pipelines (Westspur) Inc. 323.9-millimetre outside diameter pipeline.

Safety Action Taken

Following an internal investigation by Enbridge Pipelines Inc. and Enbridge (Saskatchewan) Operating Services Inc. of the events surrounding the November 2006 occurrence, the 355.6-millimetre (mm) temporary receiving trap was replaced by a 406.4 mm temporary trap to land the four displacement pigs that were used when the 323.9 mm outside diameter mainline was re-filled with natural gas liquids (NGLs). A detailed procedure for loading and removal of those tools was developed. Enbridge Pipelines (Westspur) Inc. (EPWI) has indicated that it is committed to implementing the following recommendations made by the internal investigation team:

- adopt a new gathering system standard that requires 101.6 mm oversizing of traps for all lines of 323.9 mm or greater and ensure that existing traps meet this new standard;
- continue to implement a hazard assessment program;
- develop formal procedures for verifying the isolation and depressurization of receiving traps when NGLs and natural gas have been used;
- review existing manuals to ensure that proper procedures and guidance is provided when considering all aspects of the operation of NGL pipelines;
- initiate training for all operations personnel on the policies and procedures, both new and existing, relating to the operations of NGL pipelines; and
- ensure that policies, procedures and facilities cover the formation of hydrates and how to eliminate or deal with them and that personnel are trained with regard to hydrates.

EPWI developed a corrective action plan identifying those responsible for the various actions as well as targeted and actual completion dates. The action plan and all related work will be reviewed quarterly by the company's Environmental Health and Safety Committee as well as during regular meetings of the Gathering Systems Management Committee.

In March 2007, the TSB sent a Pipeline Safety Information letter to the National Energy Board (NEB) advising that, when in-line tools are not in their intended position in a receiving trap, the trap may not depressurize as designed and sufficient pressure may remain or develop behind tools to expel them from the trap.

In April 2007, the NEB sent a safety advisory to all companies under its jurisdiction, the Canadian Energy Pipeline Association, the Canadian Association of Petroleum Producers and provincial regulators warning of factors that contribute to occurrences associated with running tools through a pipeline and providing them with a list of some preventive actions.

The NEB is also planning a workshop for industry that will focus on the hazards that could be encountered when running tools through a pipeline.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 18 July 2007.

*Visit the Transportation Safety Board's Web site (**www.tsb.gc.ca**) for information about the Transportation Safety Board and its products and services. There you will also find links to other safety organizations and related sites.*