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Keeping Pipelines Safe from Harm

Third-party damage is often to blame for pipeline failure. Operators can do more to protect their assets — and the environment

Brian Payne, EDM Services, Inc.

Two recent pipeline incidents have brought renewed public and political attention to pipeline safety. The first occurred on June 10, 1999, in Bellingham, Wash., on an Olympic Pipeline Co. line carrying refined petroleum products. This accident resulted in the loss of roughly 230,000 gal of gasoline into Watcom Falls Creek. The fuel was ignited, resulting in a large fire along the creek, three deaths and eight injuries. The National Transportation Safety Board (NTSB; Washington, D.C.) has not published the results of its investigation, which will indicate the probable cause of this incident. However, preliminary indications are that the line may have been damaged by construction activities, which occurred five years before the incident took place, when a water line was being constructed. Thus far, the U.S. Dept. of Transportation, Research and Special Programs Administration, Office of Pipeline Safety (OPS; www.ops.dot.gov) records list the cause of this incident as “other.”

The second incident occurred on August 19, 2000, near Carlsbad, New Mexico. An El Paso Natural Gas pipeline ruptured. The gas was then ignited, resulting in an explosion and an 86-ft. wide crater. Twelve fatalities resulted. The NTSB’s investigation report is still pending. However, investigators observed internal corrosion on the section of pipe that failed.

Since these incidents occurred, a number of new regulations have been proposed in both the U.S. House and Senate. Notices of Proposed Rulemaking (www.ops.dot.gov/regulate.htm) have been issued, describing new regulations that will impact hazardous-liquid pipeline operators with more than 500 miles of line; hazardous-liquid pipeline operators with less than 500 miles of line; and natural gas pipeline operators. These three sets of rules will apply to pipeline segments in so-called “high-consequence areas (HCAs),” which include populated areas, those that may be unusually sensitive to environmental damage, and commercially navigable waterways.

The proposed rules will require a baseline assessment of covered pipeline segments through internal inspections, pressure tests, or the use of other technologies that are capable of equivalent performance. These baseline assessments must be completed within a specified period once the final rule becomes effective. The rules further propose that, after these assessments, operators be required to periodically reassess and evaluate their pipeline segments, to ensure their integrity.

This article discusses some common causes of hazardous-liquid pipeline incidents, share trend data on recent incidents, and explore methods available to pipeline operators to reduce the likelihood and severity of pipeline incidents that are not covered by the proposed federal regulations.

Failure is not an option

Figure 1 characterizes all U.S. hazardous-liquid pipeline incidents from 1994 through 2000, in terms of the eight most common failure modes. The proposed pipeline-integrity regulations mentioned above address many of these modes.

In particular, new proposed requirements are expected to reduce the frequency of incidents related to external and internal corrosion. The requirements are also designed to help prevent some pipe- and weld-related failure incidents (for example, pipe anomalies such as cracks or slag), and to slightly reduce the risk of third-party damage. For example, a third party may scratch a portion of pipe coating, or gouge the pipe wall, when excavating near an existing pipeline. This can result in the formation of an external corrosion cell or other pipe anomaly. An internal inspection tool, such as a smart pig, may detect the defect before pipeline failure occurs.

Third-party incidents currently account for more than a third of all pipeline failures from 1994 through 2000, and are responsible for considerable property damage, injuries, fatalities and lost product (Figure 1). Unfortunately, the proposed federal rulemaking mentioned above does not specifically address the
prevention of third-party incidents. Operators can use additional mitigation measures, not required by federal or state regulations to protect their assets, their workers, and the environment, and to minimize the risk of liability and product loss associated with pipeline failures resulting from third-party damage. These measures can be applied to an entire line, or to only those portions in highly populated or environmentally sensitive areas.

It should be noted that the actual portion of third-party incidents is even higher than that shown in Figure 1. For instance, within the OPS database, many of the incidents whose causes were classified as "other" have notations associated with them: "third-party damage; line was punctured by farm equipment; backhoe hit line; contractor hit line; road grader" and so on. Such incidents clearly point to third-party damage.

As shown in Figure 2, the cost of property damage resulting from third-party incidents is very high, according to an analysis of OPS data gathered between 1994 and 2000. To generate these figures, all property damage values from the OPS database were converted to $U.S. for year 2000, using the domestic consumer price indices. These data reveal that in 1986, the average reportable third-party incident resulted in roughly $100,000 in property damage (in 2000 $U.S.). By 2000, this figure had increased to over $600,000 (in 2000 $U.S.).

A similar analysis was performed for spill volumes. The third-party spill volumes tend to be higher than the average for all causes. As shown in Figure 2, between 1994 and 2000, the average spill size for all causes was 35,000 gal, while it was 53,000 gal for those incidents that were caused by third-party damage. From 1986 through 2000, the average spill volumes have remained essentially constant, with some annual variations.

Figure 3 shows the overall incident rates associated with hazardous-liquid pipelines since 1986. The upper line shows the raw data, as presented in the OPS database. It suggests that the incident frequency has been decreasing steadily since the early 1990s.

However, these data do not reflect a change in the reporting criteria, which occurred in June 1994. Prior to this date, leaks larger than 50 barrels, resulting in greater than $5,000 property damage, fire, or explosion were required to be reported to OPS. However, for incidents that occurred after this date, the property damage reporting floor was increased to $50,000.

To evaluate the frequency of leaks using consistent criteria, all leaks of less than 50 barrels, which reportedly resulted in less than $50,000 in property damage, and did not result in a fire or explosion, were deleted from the database. The normalized line, shown in red on Figure 3, shows the resulting data. As indicated, the frequency of incidents fell sharply in the late 1980s, most likely as a result of so-called "one-call regulations," which were implemented in most states during this timeframe. (One-call systems generally require excavators to mark the boundaries of their proposed excavation, and to notify regulators 48 hours prior to the excavation. The regulators then notify owners of structures within the zone, so that they can mark their facilities to minimize the chance of damage; for more, see CE, July 2000, pp. 97–102.) Since this time, however, the normalized data show that the overall frequency of pipeline incidents has remained essentially constant, with some annual variation.

Figure 4 is similar to Figure 3, except that only third-party incident data are shown. The effect of one-call systems in reducing third-party incidents during the late 1980s is readily apparent. In the coming years, we will see if the decreased incident rates during 1999 and 2000 are reductions, or anomalies.

Operators must take charge
Due to the significant consequences of third-party damage, and the fact that the majority of these incidents will not be prevented by the proposed changes to the existing pipeline regulations, operators should consider incorporating specific mitigation measures to

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**U.S. HAZARDOUS LIQUID PIPELINE INCIDENTS, 1994 THROUGH 2000**

<table>
<thead>
<tr>
<th>Overall data</th>
<th>Third-party damage only</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average damage per incident</td>
<td>$255,000</td>
</tr>
<tr>
<td>Average spill size, gallon</td>
<td>35,000</td>
</tr>
<tr>
<td>Injuries</td>
<td>1,913</td>
</tr>
<tr>
<td>Fatalities</td>
<td>16</td>
</tr>
</tbody>
</table>

Source – Raw Data, Office of Pipeline Safety Database

**Figure 2 (above).** In general, the OPS data show that pipeline incidents caused by third-party damage tend to result in larger spills with greater attendant costs and injuries, compared to other types of pipeline failures.

**Figure 3 (right).** This graph shows the overall incident rates associated with hazardous-liquid pipelines since 1986. As shown by the bottom trend line (for data that has been normalized to reflect a change in reporting criteria for pipeline incidents), the frequency of incidents has remained essentially flat since the early 1990s.

**Figure 4.** Incident Rate: All Causes U.S. Hazardous-Liquid Pipelines

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**Incident Rate: All Causes U.S. Hazardous-Liquid Pipelines**

- Raw data - USDOT database
- Reportable incidents - Current reporting criteria

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**Figure 4.** Incident Rate: All Causes U.S. Hazardous-Liquid Pipelines

- Raw data - USDOT database
- Reportable incidents - Current reporting criteria
guard against third-party damage. These measures include the use of:
- One-call systems to prevent excavation damage
- Line markers and marker tape
- Fiber-optic or metallic trip wire
- Concrete barriers or concrete-coated pipe
- Increased burial depth
- Increased pipe-wall thickness
- Better public education
- Improved right-of-way inspection and maintenance

Each of these techniques is discussed in detail in an earlier article by this author (CE, July 2000, pp. 97–102), and we summarize several of them in the paragraphs below. Many of these techniques will be included in the American Petroleum Institute (API) Standard 1160, “Managing System Integrity for Hazardous Liquid Pipelines.” API, in coordination with OPS, created a coalition of technical experts to develop this standard. A final draft is currently undergoing peer review, and is scheduled for publication by late summer.

**Pipeline marker tape.** For new construction, polyethylene marker tape, in varying widths and colors, can be inexpensively installed 12 to 24 in. above the pipeline. Bright colors, with the operator’s name and 24-h phone number imprinted, are most effective. The installed cost is typically $0.50 to $2.00 per linear foot.

**Fiber-optic or metallic trip wire.** This patented-pending system, developed by the author’s firm, consists of a fiber-optic or metallic cable that is installed 12 to 48 in. above the pipeline. The cable integrity is continuously monitored. Should the cable become damaged, the monitoring equipment shows the location of the intrusion within seconds. This allows the operator to immediately dispatch maintenance and inspection personnel. As shown in the Bellingham incident, knowing that a contractor is working adjacent to your line is critical. This knowledge allows an operator to perform immediate inspections, which may prevent a third-party damage incident today from becoming a pipeline rupture months or years from now.

These systems can also be used to stop an excavator before the pipeline is damaged. In the event of a third-party-induced spill, the availability of immediate location information can greatly enhance emergency-response efforts.

The cost to install these systems during initial construction varies significantly, depending on pipeline length, configuration, and the pipeline control system. However, for new cross-country pipelines with modern control systems, such trip-wire systems can be installed for less than $1.00 per linear foot. These systems can also be installed on existing pipelines by plowing or trenching to install the cable. In these installations, two cables can be used—one on each side of the pipeline, to avoid trenching directly over an operating pipeline.

**Concrete barrier.** A concrete cap, 2–4 in. thick, can be installed 12–24 in. above the pipeline. Alternately, applying concrete coating around the pipe circumference can protect it from excavation activities. For new construction, the costs of this mitigation option vary widely, depending on pipe diameter, terrain, availability of concrete, etc. Costs range from several dollars to tens of dollars per linear foot.

**Additional pipe wall.** For small-diameter pipelines, a thicker or additional pipe wall can be provided at relatively minimal additional cost. However, for major cross-country, large-diameter pipelines, the increased costs become impractical. Additional pipe thickness may be appropriate for certain high-risk locations that are subject to higher damage potential (for example, river crossings, roadways and urban areas).

**Increased pipeline burial depth.** For new construction, burying a pipeline deeper can place it out of harm’s way, beneath the typical digging depth of many excavation activities. The cost of this approach varies. For excavations less than 5 ft in depth, the additional cost can be as low as a few dollars per linear foot. When the excavations exceed 5 ft, the additional costs increase significantly, due to ditch-stabilization problems, shoring and sloping requirements, and similar concerns.

**Increased line marking.** Making a pipeline more visible to the public is a simple way to help prevent third-party intrusions. Placing line markers more closely together, especially in areas that are subject to increased third-party activities, can accomplish this objective. Markers should be located such that at least two are visible from any location along a line.

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**Author**

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