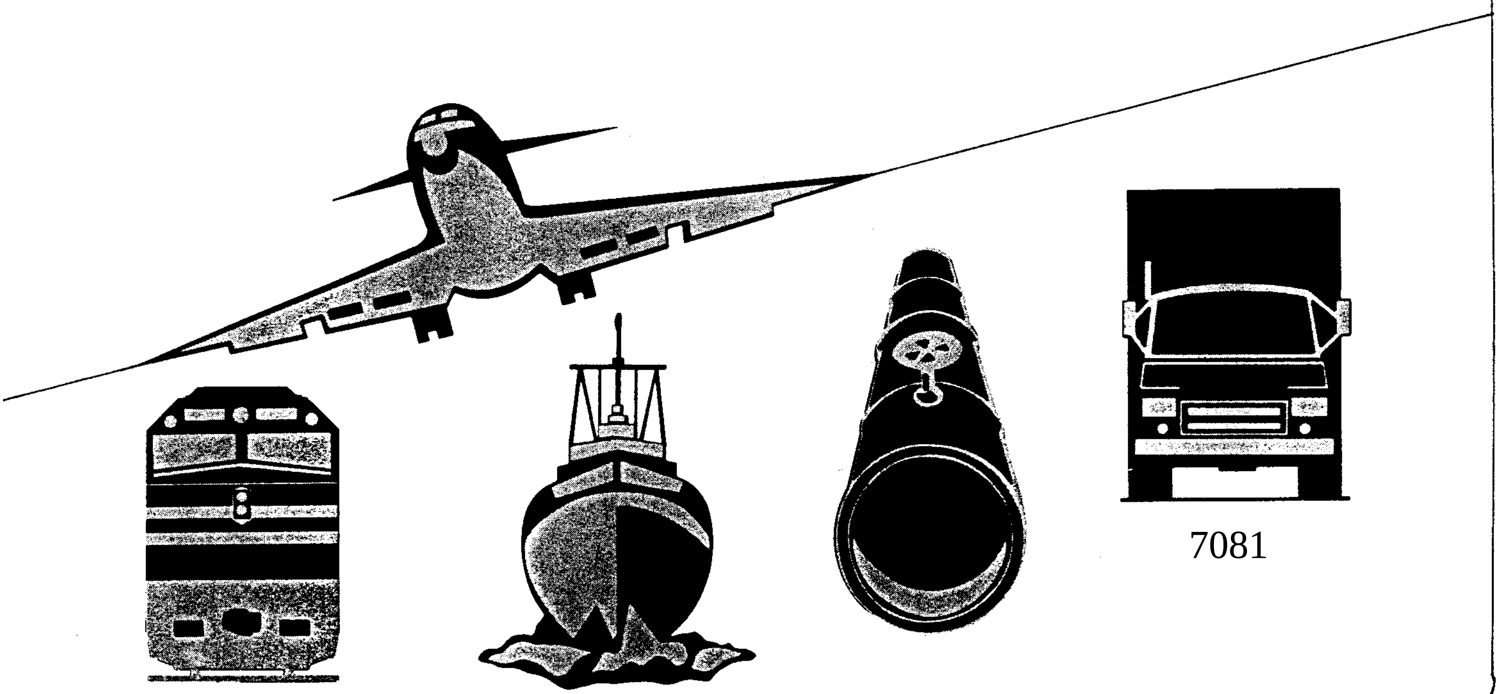
PB98-916503
NTSB/PAR-98/02/SUM

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

PIPELINE ACCIDENT SUMMARY REPORT

PIPELINE RUPTURE, LIQUID BUTANE RELEASE, AND FIRE
LIVELY, TEXAS
AUGUST 24, 1996



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Abstract: This report explains the August 24, 1996, rupture of a steel pipeline operated by Koch Pipeline Company, LP (Koch), which sent a butane vapor cloud into the surrounding residential area. The butane vapor ignited as two residents in a pickup truck drove into the cloud. The occupants of the truck died from thermal injuries. About 25 families were evacuated from the area. Damages related to the accident exceeded $217,000.

From its investigation of this accident, the Safety Board identified safety issues in the following areas: the adequacy of Koch's corrosion inspection and mitigation actions, and the effectiveness of Koch's public education program, particularly with respect to educating residents near the pipeline about recognizing hazards and responding appropriately during a pipeline leak.

As a result of its investigation of this accident, the Safety Board issued recommendations to the Research and Special Programs Administration, Koch, and NACE International.

The National Transportation Safety Board is an independent Federal agency dedicated to promoting aviation, railroad, highway, marine, pipeline, and hazardous materials safety. Established in 1967, the agency is mandated by Congress through the Independent Safety Board Act of 1974 to investigate transportation accidents, determine the probable cause of accidents, issue safety recommendations, study transportation safety issues, and evaluate the safety effectiveness of government agencies involved in transportation. The Safety Board makes public its actions and decisions through accident reports, safety studies, special investigation reports, safety recommendations, and statistical reviews.

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PIPELINE ACCIDENT SUMMARY REPORT

Pipeline Rupture, Liquid Butane Release, and Fire
Lively, Texas
August 24, 1996

NTSB/PAR-98/02/SUM
PB98-916503
Notation 7081
Adopted: November 6, 1998

National Transportation Safety Board
490 L'Enfant Plaza, S.W.
Washington, D.C. 20594

Executive Summary

On Saturday, August 24, 1996, about 3:26 p.m., an 8-inch-diameter steel LPG (liquefied petroleum gas) pipeline transporting liquid butane, operated by Koch Pipeline Company, LP (Koch), ruptured near Lively, Texas, sending a butane vapor cloud into a surrounding residential area. The rupture occurred under a roadway in the Oak Circle Estates subdivision.

The butane vapor ignited as two residents in a pickup truck drove into the vapor cloud. According to the sheriff's report, they were on their way to a neighbor's house to report the release to 911. The two people died at the accident site from thermal injuries. No other injuries were reported at that time; however, about 25 families were evacuated from Oak Circle Estates.

Koch estimated its direct pipeline losses, including the loss of product from the line, to be about $217,000. Other property losses included damage to the roadway under which the rupture occurred and damage to a pickup truck, a mobile home, several outbuildings, and adjacent woodlands.

The National Transportation Safety Board determines that the probable cause of this accident was the failure of Koch to adequately protect its pipeline from corrosion. The major safety issues identified by this investigation are as follows:

- Adequacy of Koch's corrosion inspection and mitigation actions, and

- Effectiveness of Koch's public education program, particularly with respect to educating residents near the pipeline about recognizing hazards and responding appropriately during a pipeline leak.

As a result of its investigation of this accident, the Safety Board issued recommendations to the Research and Special Programs Administration, Koch, and NACE International.

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Factual Information

Accident Narrative

On Saturday, August 24, 1996, about 3:26 p.m.,[1] an 8-inch-diameter steel LPG (liquefied petroleum gas) pipeline transporting liquid butane,[2] operated by Koch Pipeline Company, LP (Koch),[3] ruptured near Lively, Texas, sending a butane vapor cloud into a surrounding residential area. The rupture occurred under a roadway in the Oak Circle Estates subdivision (figure 1).

The butane vapor ignited (figure 2) as two residents in a pickup truck drove into the vapor cloud. According to the sheriff's report, they were on their way to a neighbor's house to report the release to 911. The two people died at the accident site from thermal injuries. No other injuries were reported at that time; however, about 25 families were evacuated from Oak Circle Estates.

Koch estimated its direct pipeline losses, including the loss of product from the line, to be about $217,000. Other property losses included damage to the roadway under which the rupture occurred and damage to a pickup truck, a mobile home, several outbuildings, and adjacent woodlands.

Preaccident Events

At 2:05 p.m. on the day of the accident, Koch's Cleveland pump station (see figure 3 for station locations) experienced an automated shutdown due to the activation of a hydrocarbon vapor detection alarm in the station. A technician who was called out to check the station found no vapor or evidence of a leak at the station. Cleveland pump station is about 200 pipeline miles downstream of the accident site, and this shutdown reduced flow through the pipeline. Corsicana station, the first pump station upstream of Cleveland station, automatically shut down at 3:05 p.m. because the rising pipeline pressure activated a high-discharge pressure alarm.[4] The Corsicana pump shutdown created a

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[1] Times given in this report are central daylight time.

[2] Liquid butane is a highly volatile liquid (HVL) petroleum product that vaporizes at atmospheric pressure and room temperature. Upon release, the liquid vaporizes into a highly flammable white or nearly transparent fog-like cloud. Because the vapor is heavier than air, it stays close to the ground and settles into low-lying areas. While the liquid is not odorized, it has a faint but noticeable petroleum-like smell. Observation of a vapor or a fog-like cloud is typically how butane is detected in the atmosphere near a release.

[3] Koch Pipeline Company, LP (Limited Partnership), is owned by Koch Industries, Inc.

[4] A high-discharge pressure alarm is triggered when the station discharge pressure to the pipeline rises above the set-point limit; the instrument's switch will shut down the station.

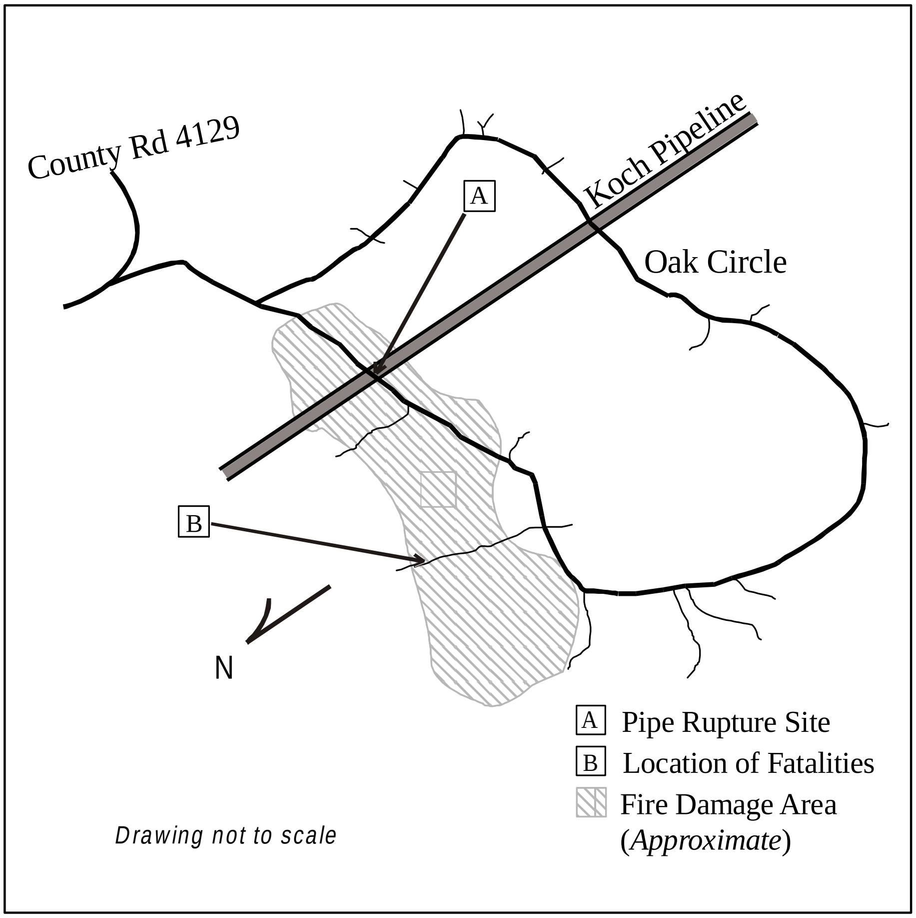

Figure 1. Sketch showing area of butane vapor dispersement and corresponding fire

Figure 2. Accident site before the butane fire was extinguished

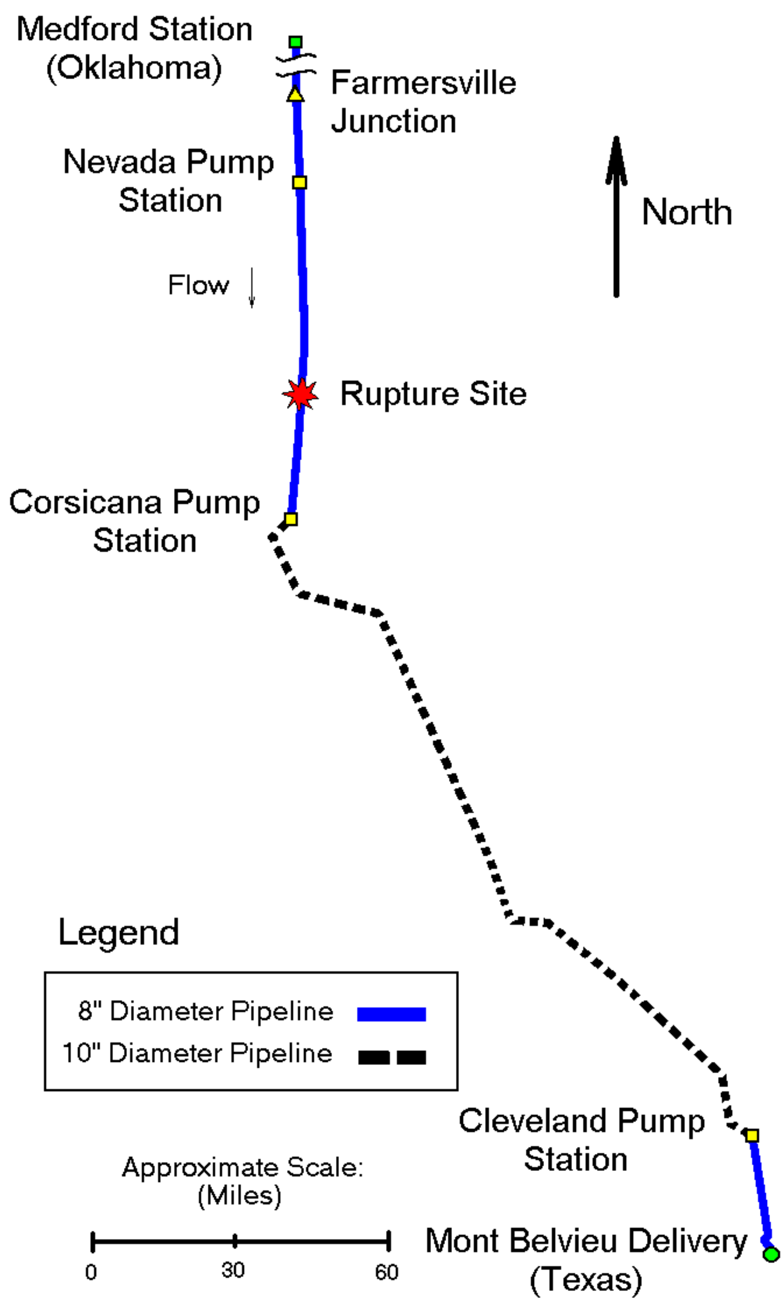

**Figure 3. Koch Pipeline Company—
Medford, Oklahoma, to Mont Belvieu, Texas**

pressure surge[5] in the pipeline that traveled upstream to the previous station, Nevada pump station. The rupture occurred between Nevada and Corsicana pump stations.

The maximum operating pressure (MOP) established by Koch for this pipeline was 1,440 pounds per square inch, gauge (psig).[6] After the accident, Koch calculated the highest surge pressure at Nevada pump station to be 1,448 psig based on pipeline pressure and flow conditions before the rupture. The pipeline discharge pressure was throttled to 1,438 psig by the pump station control valve, and the pump continued to operate. The highest surge pressure at the pipeline rupture location after the Corsicana station pump shut down was calculated by Koch to be 1,273 psig at 3:14 p.m.

Postaccident Events

At 3:29 p.m., Koch's supervisory control and data acquisition (SCADA) system generated a discharge pressure rate-of-change alarm[7] at Nevada pump station. At 3:36 p.m., another rate-of-change alarm was generated at Nevada pump station, and the pipeline controller shut down the pump because of the unexplained pressure loss. At 3:39 p.m., Koch received a telephone call from an Oak Circle Estates resident reporting a pipeline leak near his home. Koch immediately began shutdown procedures for the entire pipeline, dispatched an employee to the accident site, and called the Kaufman County sheriff's department. During its call to the sheriff's department, Koch learned that the butane had ignited. The sheriff's department and 911 each received a call about the release at about the same time that Koch received its call.

Following the shutdown of its pump stations, Koch began to isolate the ruptured section of the pipeline by closing the manual block valves upstream (4:20 p.m.) and downstream (4:37 p.m.) of the rupture. At 5:25 p.m., Koch reported the release to the National Response Center. By 6:00 p.m. the next day, line-plugging equipment[8] had been installed and used to isolate a section of pipeline about 100 yards on either side of the rupture. With the closing of the line-plugging equipment, the fuel was cut off and the fire extinguished within minutes. The pipeline remained shut down until March 1997.

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[5] A pressure surge is a transient or temporary increase in pressure caused by a change in flow conditions on a pipeline such as a valve closing or a pump shutting down.

[6] The Federal pipeline safety regulation in 49 *Code of Federal Regulations* (CFR) Part 195.406(b) requires that the pressure in a pipeline during surges not exceed 110 percent of the MOP.

[7] A rate-of-change alarm is generated when station discharge pressure decreases a preset amount within a specific time as previously determined by the pipeline operator.

[8] Line-plugging equipment can be installed even when the pipeline contains product without exposing that product to the atmosphere.

Investigation

The National Transportation Safety Board was notified of the accident on August 24, 1996, by the National Response Center. The Office of Pipeline Safety, Research and Special Programs Administration, conducted the on-scene investigation. Segments of the pipeline, including the ruptured pipe, were shipped to the Safety Board Materials Laboratory in Washington, D.C., for metallurgical examination.

Personnel and Toxicological Information

The pipeline controller, who had been on duty for about 8 1/2 hours when the accident occurred, had been employed with Koch for 6 1/2 years. About 2 hours after the accident, the controller was tested for drugs and alcohol; both test results were negative.

Pipeline Information

When the accident occurred, Koch's Sterling I pipeline system was transporting liquid butane from Medford, Oklahoma, to Mont Belvieu, Texas (about 570 miles). This pipeline system contains sections of 8- and 10-inch-diameter pipe.

The 10-inch-diameter portion of the pipeline between Corsicana and Cleveland pump stations (see figure 3 pipeline map) was constructed in 1929 and later purchased by Koch. In April 1995, Koch completed replacement of the original 1929 section with new 10-inch-diameter epoxy-coated pipe to improve this section's integrity.

The pipeline rupture occurred in the 70-mile section of 8-inch-diameter pipeline between Nevada and Corsicana pump stations. The ruptured line, originally constructed in 1981, was a nominal 8-inch outside diameter, American Petroleum Institute (API) Specification 5L, Grade X-46, 0.188-inch wall thickness, Electric Resistance Weld steel pipe. The pipe was externally field coated with spiral wrapped polyolefin tape to protect it from corrosion. In the early 1990s, the road for the housing development was constructed over the 8-inch-diameter pipeline at the accident site.

During construction of the 10-inch-diameter pipe in 1995, Koch shut down the pipeline from Farmersville Junction (north of Nevada pump station) to Cleveland pump station. Before moving LPG products again, the 8-inch-diameter section from Farmersville Junction to Corsicana pump station was hydrostatically pressure tested in two segments to confirm its integrity. Three failures were documented during the pressure testing. The northern segment failed two times: the first time due to external corrosion at 1,941 psig and the second time due to a longitudinal weld seam failure at 1,938 psig. The failure in the southern test segment, about 1.5 miles north of the accident site, occurred because of external corrosion. The pipeline pressure when the southern segment failed was 1,400 psig, which was less than the previously established maximum operating pressure of 1,440 psig.

Internal Pipeline Inspection

May 1995 Internal Inspection

In May 1995, after the three hydrostatic pressure test failures, Koch had an internal inspection performed to determine the pipeline's condition. An internal inspection tool (also known as a "smart pig") was run through the 8-inch-diameter pipeline to determine the condition of 46 miles of pipeline in the southern section. A metal-wall-loss inspection was performed using a low-resolution magnetic-flux-leakage (MFL) internal inspection tool. This inspection identified numerous sites of external corrosion for possible repair.

Actual corrosion pit depths were measured on pipe excavated for correlation digs and then compared with the log of corrosion indications from the May 1995 internal inspection. All of the pipe-wall-thickness loss indications were graded by the internal inspection tool company as being light (15 to 30 percent loss), moderate (> 30 and < 50 percent loss), or severe (≥ 50 percent loss). The log results were reported by individual pipe length[9] and the grade of the maximum corrosion anomaly.

The May 1995 internal inspection log identified 62 moderately and 18 severely corroded pipe lengths. According to Koch, the company excavated all pipe lengths graded as having moderate or severe wall-thickness loss. Excavated pipe was either recoated, repaired, or replaced. Koch took action based on its determination of the effect of corrosion on remaining pipe strength and allowable operating pressure using ASME/ANSI B31G.[10] The pipe that ruptured in 1996 was not excavated in 1995 because the associated pipe length was identified by the internal inspection tool as having light corrosion.

Comparisons of the wall-thickness measurements of the pipe lengths excavated during the repair digs with the inspection log results revealed few discrepancies. Koch's records from the repair digs indicate only three instances of a discrepancy between the inspection log and actual dig report measurement. In each case, the internal inspection tool predicted a pipe-wall-thickness loss greater than was actually measured.

The minimum hydrostatic test pressure required by pipeline safety regulations is 125 percent of the MOP. In this case, the MOP was 1,440 psig, making the minimum test pressure for the line 1,800 psig. After pipeline repairs based on data from the internal inspection had been completed, the line was hydrostatically tested without failure to 1,855 psig on August 18, 1995, and subsequently returned to service.

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[9] In this pipeline, the individual 8-inch-diameter pipe lengths were about 59 feet.

[10] *Manual: Determining Remaining Strength of Corroded Pipelines: Supplement to B31 Code-Pressure Piping (B31G).* American Society of Mechanical Engineers/American National Standards Institute, Inc., New York, August 30, 1991.

Postaccident Internal Inspection

On September 23, 1996, about 1 month after the accident, a 10-mile section of Koch's pipeline around the rupture site was inspected using a high-resolution MFL internal inspection tool. (The inspected section did not include that segment of pipe around the rupture that was removed after the accident.) The internal inspection was required by Hazardous Facility Order (HFO) CPF No. 46510-H that was formally issued on October 7, 1996, by the Office of Pipeline Safety (OPS), Research and Special Programs Administration (RSPA). The inspection identified numerous areas that were graded by the internal inspection company as having moderate and severe corrosion. Indications of severe corrosion were identified in about 15 lengths of pipe. These areas were not identified during the May 1995 inspection as having either moderate or severe corrosion.

External Corrosion Control

Koch uses an impressed current cathodic protection[11] system to mitigate corrosion on this pipeline. The *Koch Procedure Manual* (section 4.8.1) for this pipeline defined the minimum acceptable pipe-to-soil potential[12] level for adequate cathodic protection as at least -0.85 volts (V).[13] To comply with 49 CFR 195.416(a), pipeline operators must perform annual testing to determine whether cathodic protection is adequate to control external corrosion. The regulation does not provide criteria for "adequate cathodic protection." Company corrosion technicians performed annual surveys[14] of the cathodic protection system. Koch personnel also recorded cathodic protection readings on its field reports.[15]

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[11] Cathodic protection is a corrosion mitigation method used by the pipeline industry to protect underground metal pipes using rectifier stations along the pipeline that supply protective electrical current. Cathodic protection current is forced to flow in the opposite direction of currents produced by corrosion cells. A rectifier converts alternating current from the utility service to direct current and supplies it to a ground bed that typically contains a string of suitable anodes, with soil as an electrolyte, to provide a path for the current from the rectifier to the pipeline. A cable connected to the pipeline provides the return path to the circuit.

[12] Defined as "the voltage difference between a buried metallic structure [pipe] and the electrolyte [soil], measured with a reference electrode in contact with the electrolyte [soil]." From Gordon, H. L., *Cathodic Protection*, Power Plant Electrical Reference Series, Project 2334, Electric Power Research Institute, Palo Alto, California, 1991, vol. 11, p. 11.2.

[13] One of the cathodic protection criteria for pipelines transporting gas listed in 49 CFR 192, appendix D, is maintaining cathodic protection of at least -0.85 V pipe-to-soil potential to a saturated copper-copper sulfate half cell.

[14] Pipeline companies perform pipe-to-soil potential surveys by measuring and recording the voltages and currents at test stations along the pipeline and at rectifiers. Measurement intervals vary widely from less than 100 feet to miles apart.

[15] Koch refers to the company form used for field reporting of aerial, foreign crossing, exposed pipe, and pipeline revisions as a "4-in-1" report.

Preaccident Inspections and Action

Before the accident, six rectifiers were used in the pipeline cathodic protection system from Nevada to Corsicana pump stations. In the first quarters of 1994 and 1995, Koch personnel conducted an annual corrosion control survey that indicated the pipeline met the company standard for cathodic protection (pipe-to-soil potentials at least as negative as -0.85 V). During the annual survey in February 1996, potentials below the company's accepted protection level were recorded between rectifiers M-7 and M-10. The pipeline rupture occurred between rectifiers M-9 and M-9.5, which were the existing units on either side of the rupture location. (Figure 4 shows the location of the rectifiers and the rupture.)

In field reports completed after the May 1995 internal pipeline inspection, some readings indicated potential levels that did not meet the company standard. For example, records show that on August 28, 1995, an area about 1/4 mile south of the rupture had an approximate pipe-to-soil potential of -0.59 V and on August 24, 1995, an area 7/8 mile north of the rupture had a potential of -0.59 V. Similar low potentials were recorded up to 50 miles north of the rupture site to an area upstream of Nevada station.

On February 6, 1996, during Koch's 1996 annual survey, the output of rectifier M-8 was increased to improve pipe-to-soil potentials. On February 13, 1996, potentials as low as -0.68 V were recorded between rectifiers M-7 and M-8. Additionally, seven of nine readings taken on that date between rectifiers M-8 and M-9 were less negative than -0.85 V. These low potential measurements were in the -0.62 to -0.72 range.

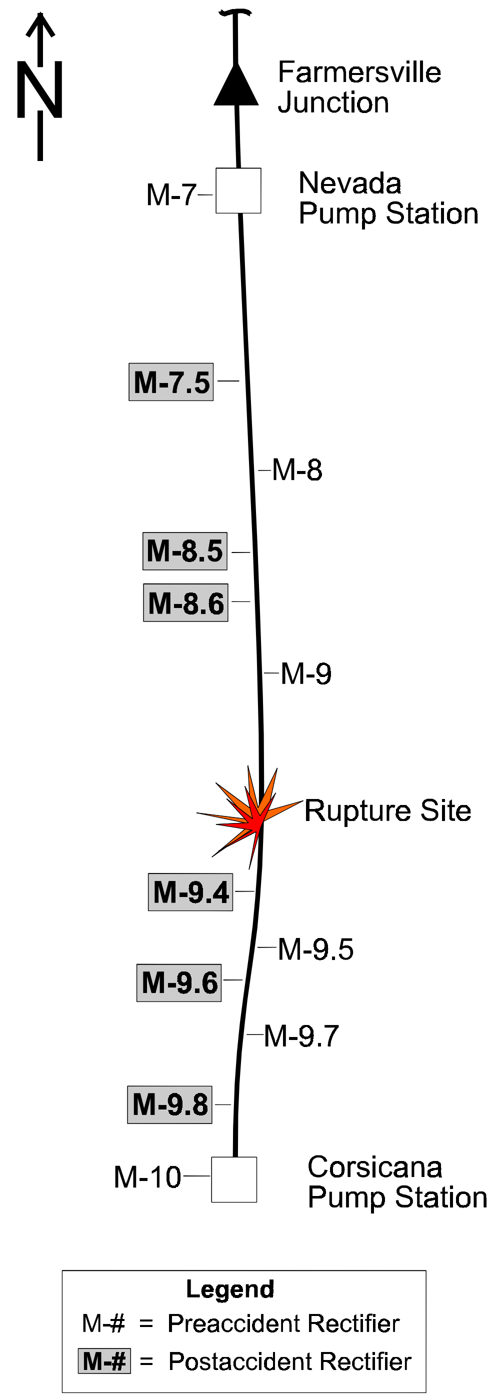

Figure 4. Koch pipeline rectifier sites M-7 through M-10

Potential measurements taken between rectifiers M-9 and M-10 on February 13, 1996, were -0.815 V about 1.3 miles north of the rupture location and -0.827 V about 1.5 miles south. In addition to these readings, the lowest potential recorded on that date between rectifiers M-9 and M-10 was -0.78 V.

In a memorandum dated February 19, 1996, the corrosion supervisor recommended that a new rectifier be installed north of the eventual rupture site between M-8 and M-9. The area from rectifiers M-9 to M-10 was reported by the corrosion supervisor as having "good" readings. On February 26, 1996, Koch division personnel authorized installation of a new rectifier, which was initially labeled M-8.5 but was subsequently redesignated M-8.6.

On March 29, 1996, rectifier M-9 was not operating at its designated level and its ground bed needed replacement. No recorded pipe-to-soil readings are available for that date. Koch Division personnel discussed whether M-9 should be moved or the ground bed replaced. They decided to wait until the new rectifier was installed to verify its cathodic protection coverage and to determine how M-9 would be repaired.

Postaccident Inspections and Action

According to Koch, pipe-to-soil potentials were measured but not recorded for the accident site after the rupture on August 24, 1996. However, potential readings recorded 500 feet north and south of the rupture site on August 27 ranged from -0.49 V to -0.52 V. Shortly after the accident, on September 4, 1996, Koch replaced the ground bed for rectifier M-9. Koch installed the new rectifier (M-8.6) and activated it on September 11, 1996. Pipe-to-soil potentials taken during the close-interval survey[16] in the rupture area remained low, about -0.65 V, after these rectifiers were activated.

After the rectifiers were activated, pipe-to-soil potentials were obtained during repair digs made following the September 23, 1996, internal inspection. Readings recorded on the field reports at several dig locations up to 1 1/4 miles north of the rupture ranged from -0.70 to -0.75 V and up to 1/4 mile south of the rupture ranged from -0.59 to -0.73 V. These areas were reported on the 1995 internal inspection survey as having either light (15 to 30 percent) or no reportable corrosion (< 15 percent). When the pipe was excavated after the accident, corrosion pinholes (very small-diameter holes through the pipe wall) were found, and corrosion pits greater than 0.180-inch deep were measured at several locations along the pipeline. These reports also noted that the pipeline coating

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[16] In a close-interval survey, pipe-to-soil potential is measured every few feet (typically every 2.5 feet). This survey is useful for identifying cathodic protection problems such as low potentials between established test points, the presence of stray currents, and areas of gross coating loss.

had some "holidays" (breaks or bare spots), stress cracking, wrinkles, and disbonded areas.[17] Tree roots were also observed in the backfill next to the pipe in one of these areas.

In October 1996, Koch completed a close-interval survey of the 10-mile section around the rupture site. Potentials less negative than -0.85 V were recorded in many areas during this survey. In addition, some areas of missing coating were noted. No indications of stray currents were found.

Additional rectifier installations were proposed for five new locations between Nevada and Corsicana pump stations as well as for other locations in the pipeline system. The last rectifier of this group was activated on February 17, 1997.

After the accident, the soil resistivity near the accident area was measured. Soil resistivity data are useful for determining corrosive characteristics of the soil and estimating their impact on cathodic protection. Low soil resistivity readings of 507 ohm-cm at the rupture site, 862 ohm-cm 50 feet north of the rupture site, and 1,149 ohm-cm 50 feet south of the rupture site were recorded. Soil resistivity values at these levels generally indicate highly corrosive soil.[18]

Pipe Examination

After the fire was extinguished, the accident site was excavated and the ruptured pipe exposed. The backfill contained partially decomposed organic material including tree roots and had a sewer-like odor. Shortly after the accident, about 95 feet of pipe was removed from the pipeline. A 46-inch section containing the rupture (figure 5) and three nearby sections (6 to 7 feet long) were examined at the Safety Board's Materials Laboratory in Washington, D.C.

The pipe rupture was longitudinal, approximately 12.5 inches long (figure 5, right to left). The rupture occurred at the 4 o'clock circumferential position relative to the pipe's position in the ground, with 12 o'clock being the top of the pipe. Significant corrosion was found at the center of the pipe rupture. Most of the tape coating on the ruptured segment was destroyed in the fire, thus the coating condition before the rupture could not be determined.

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[17] Cathodic protection current requirements are significantly reduced when buried pipeline is properly coated using an effective barrier coating. However, factors such as overprotection (potentials significantly more negative than -0.85 V), inadequate coating selection, improper surface preparation or application of the primer or coating, or soil stresses may result in coating disbondment. If soil or moisture is present on the pipe surface underneath the disbonded coating, the pipe could corrode even in a cathodically protected system. Because the disbonded coating acts as an electrical shield, the amount of current reaching the metal underneath the disbonded coating depends upon the resistance of the soil or water present in the gap created by the disbonded coating. Though some current may flow to the pipe surface in this space, more current goes to other, more easily accessible, areas (low resistance path). Typically, the current density underneath the disbonded coating is insufficient to provide adequate corrosion protection.

[18] *Corrosion Control/Systems Protection.* Volume VI—*Technical Services*, Book TS-1, American Gas Association, Arlington, Virginia, 1986, p. 79.

Figure 5. Pipe section containing 12.5-inch rupture

The center of the rupture contained an area of corrosion about 5 inches long by 3 inches wide. In the rupture area, corrosion pits appeared to have substantially penetrated the pipe wall indicating nearly 100-percent wall-thickness loss. No other pitting was observed on the remainder of the 46-inch section of pipe containing the rupture. No evidence of a material flaw or of mechanical damage (dents, gouges, or scrapes) to the pipe was observed. Figure 6 is a composite of two photographs, one of each side of the rupture, constructed to show the two sides of the corroded area in proximity. The arrows in the photo indicate where corrosion pitting had substantially penetrated the pipe wall.

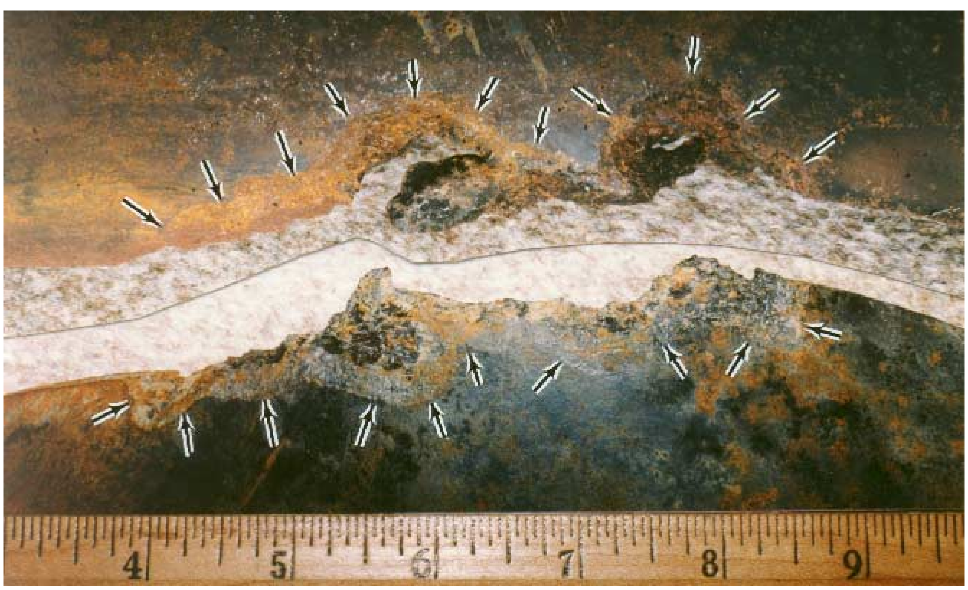

Figure 6. Composite photograph showing corroded area at center of rupture

Coating damage as observed in the field is shown in figures 7 and 8. The three pipe sections (both upstream and downstream of the rupture) brought to the Materials Laboratory for testing had disbonded and cracked spiral wrapped tape coating at several locations. Mechanical damage to the tape coating similar to damage caused by a pipe-locating probe was also observed. Scratches were found on the pipe at several of the coating tears. Corrosion was observed on the exposed pipe surfaces at the damaged areas.

Figure 7. Disbonded tape coating on 8-inch pipe extracted at accident site (Arrows show disbonded area under tape coating.)

All of the nearby pipe segments examined by the Materials Laboratory displayed corrosion damage, from 30- to 64-percent wall-thickness loss. Five principal areas of corrosion damage correlated with five corrosion areas on the 1995 inspection log; however, these areas had been graded as having less than 30-percent pipe-wall-thickness loss in 1995.

A consultant for Koch performed testing and analysis for bacteria[19] on the pipe using a procedure similar to NACE International Standard TM 0194-94.[20] An area selected for bacteria testing included one of the corrosion areas containing rust tubercles[21]

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[19] Microorganisms, such as bacteria and fungi, can cause underground corrosion.

[20] NACE International Standard TM 0194-94, *Field monitoring of bacterial growth in oil field systems.* NACE International (formerly National Association of Corrosion Engineers—NACE), Houston, Texas, 1994.

[21] Knob-like mounds formed on the pipe as the result of localized corrosion.

within 20 feet of the rupture. The consultant's report provided the following laboratory analysis results:

- Pipe surface samples were acidic with a pH of 5 to 6,
- Sulfides were present in small amounts,
- Sulfate-reducing bacteria were present in insignificant amounts,
- Anaerobic acid-producing bacteria were present in small amounts (100 bacteria/ml), and
- Aerobic acid-producing bacteria were "strongly present" (10,000 bacteria/ml).

The consultant's report concluded, "The results of the testing performed here indicate that Aerobic Acid Producing bacteria are the main contributor to the corrosion found on this pipe."

Concerning the testing, the consultant's report said the results "may not be representative of bacteria activity" because of the inadequate sampling techniques and handling time. The report further noted, "Bacteria typically have a life of 30 to 40 hours and can change their populations significantly in 2 days if their environment is changed." In this instance, Koch had cleaned the pipe when it was removed from the ground, and laboratory tests were not performed until about 48 hours later. The consultant used tap water for sample preparation instead of the phosphate-buffered saline solution recommended in NACE International Standard TM 0194-94.

Figure 8. Cracks in the tape coating on 8-inch pipe excavated at accident site

Public Education

Preaccident Public Education Mailings

In 1991, Koch conducted a public education program for people living within 1/4 mile of the pipeline. In 1991 and 1992, public education materials were hand-distributed door to door by company representatives. In 1992, Koch produced a report that included tabulations of the total number of material packets issued and the response cards returned to the company.

From 1993 through early 1996, Koch distributed its public education materials by annual mailings, using addresses compiled from returned response cards, from lists developed by company representatives canvassing the area, and from property right-of-way records. Koch solicited and received public education information from other pipeline companies for comparison with its program. Koch representatives also attended industry meetings where public education information was reviewed.

An "Information Bulletin" was provided as part of the 1996 public education materials mailed to residents before the accident. (See appendix A.) The bulletin highlighted telephone numbers for notifying Koch before performing excavation near the pipeline or during a pipeline emergency. The bulletin discussed the propane-butane family of products transported by the pipeline, how to recognize a product release, and the importance of keeping "sources of ignition" away from liquid spill areas. In addition, the 1996 mailing included a calendar bearing a warning not to perform excavation near the pipeline until Koch is notified. Recipients also received response cards for providing their addresses and address corrections or for requesting additional information.

In 1996, about 45 families lived on two roads in the area of the accident, Oak Park Circle and County Road 4129 (figure 1). Of the 45 residences listed on the two roads, only 5 addresses appeared on Koch's 1996 preaccident mailing list. The two families that suffered fatalities were not on the mailing list. The person who called Koch to report the release was on the mailing list.

Koch's public education program provided educational materials to public offices and emergency response organizations serving the areas in which the pipeline was operated. The head of the Kaufman County Emergency Management Office indicated that Koch had provided information and communicated with the office. The Kaufman County Sheriff's Department was on Koch's mailing list and had been invited to yearly governmental liaison meetings in 1995 and 1996.

Industry Public Education Program Standard

American Petroleum Institute (API) Recommended Practice 1123, *Development of Public Awareness Programs by Hazardous Liquid Pipeline Operators*,[22] provides information on reaching the public, safety message content, communications methods, and program evaluation. API Recommended Practice 1123 provides some information on resources available to companies for developing and distributing their own safety materials and on other methods of providing information. Section 6.8 of the publication states that "Operators that use their own mailing lists when they mail public awareness materials to the public should maintain up-to-date lists" and that response cards "permit the recipients to notify the operators of any changes of address and could measure the effectiveness of the safety message." Section 9 provides information that a pipeline operator can use to evaluate the effectiveness of its public awareness program, including scientifically based evaluation techniques available to ensure that program objectives are being met (section 9.4).

Postaccident Public Education Mailing

As a result of an HFO issued after the accident by the OPS, Koch revised and reformatted its public education materials (appendix B). Some of the changes Koch made to its public education program include:

- Replacing its previous mailing list for residents along the pipeline right-of-way with a mailing list developed using mapping grid databases.

- Revising safety information to include pertinent information on detecting a pipeline leak and actions to take when a leak is suspected.

- Prominently highlighting material in the new safety brochure on:

    1. how to identify Koch's pipelines,
    2. precautions to take around Koch's pipelines during excavation activity,
    3. how to identify a pipeline leak and a highly flammable vapor cloud, and
    4. actions to take in addition to notifying Koch, when a leak is suspected or a vapor cloud is detected.

[22] Recommended Practice 1123, *Development of Public Awareness Programs by Hazardous Liquid Pipeline Operators*, American Petroleum Institute, Washington, D.C., August 1996.

Regulations and Orders Governing Pipeline Operation

External Corrosion Control Safety Regulation

Title 49 CFR 195.416 contains a number of requirements concerning safe pipeline operations:

> (a): Each operator shall, at intervals not exceeding 15 months, but at least once each calendar year, conduct tests on each buried, in contact with the ground, or submerged pipeline facility in its pipeline system that is under cathodic protection to determine whether the protection is adequate.
>
> (e): Whenever any buried pipe is exposed for any reason, the operator shall examine the pipe for evidence of external corrosion. If the operator finds that there is active corrosion, that the surface of the pipe is generally pitted, or that corrosion has caused a leak, it shall investigate further to determine the extent of the corrosion.
>
> (g): If localized corrosion pitting is found to exist to a degree where leakage might result, the pipe must be replaced or repaired, or the operating pressure must be reduced commensurate with the strength of the pipe based on the actual remaining wall thickness of the pits.

This regulation does not provide specific criteria for “adequate cathodic protection” for liquid pipelines. Specific criteria for cathodic protection can be found in appendix D of the gas pipeline safety regulations, 49 CFR 192.

Public Education Safety Regulation

Title 49 CFR 195.440 requires that pipeline operators establish a continuing education program to enable the public, appropriate Government organizations, and persons engaged in excavation-related activities to recognize a hazardous liquid or a carbon dioxide pipeline emergency and report it to the operator or to fire, police, or other appropriate officials. The regulation does not specifically identify the information that must be provided or require that the pipeline operator periodically evaluate the effectiveness of its public education program. The OPS inspection of Koch’s public education program before the accident in May 1993 identified no deficiencies.

Office of Pipeline Safety Hazardous Facility Order

On October 7, 1996, about 6 weeks after the accident, the OPS issued an HFO that directed Koch to submit written plans, to include performing corrective actions concerning pipeline operation and public education. The HFO’s requirements include but are not limited to the following provisions:

> Submit for approval by the Regional Director, within 30 days after an Order is issued, a written plan addressing a program of tests or studies that will identify the extent of and propose a solution to the external corrosion problem on the HVL line and allow for verification and maintenance of the HVL line. The plan is to include, at minimum, provisions and time frames for identifying the extent of corrosion and correcting the external corrosion problems on the HVL line. The plan should address, at minimum—
>
> *The 8-inch [diameter] pipeline section [containing the accident location] between block valves at stations 17316+16 to 17849+48 (approximately 10 miles).*
>
> i. Run an ultrasonic "smart" pig or high resolution magnetic flux "smart" pig [internal inspection instrument] to determine pipe wall condition.
>
> ii. Complete installation of new ground bed and test, and activate rectifier.
>
> iii. Perform a close interval survey.
>
> iv. Retain any exposed pipe removed from the line during preparation for the "smart" pig run [internal inspection] for OPS examination. Provide a detailed pipe and coating condition report.
>
> v. Notify the appropriate public officials of Henderson and Kaufman Counties whenever tests are performed involving the movement of HVLs through the pipeline.
>
> vi. Expose anomalies indicating 20 percent or greater wall loss, and repair or replace areas of 20 percent or greater wall loss, or as may be agreed upon with the Regional Director.
>
> vii. Determine MOP subject to final approval by the Regional Director.
>
> viii. The Corrosion mitigation measures must conform with approved industry standards such as NACE Standard RP-0169-92, *Recommended Practices for Control of External Corrosion on Underground or Submerged Metallic Piping Systems*.
>
> ix. Results of test and metallurgical and chemical analysis of pipe now underway.

Except for items ii, iii, and ix, the above requirements also apply to the remainder of the 8-inch and 10-inch-diameter sections of Koch's HVL pipeline. In addition, the HFO modifies item v for those pipeline sections as follows: "Notify the appropriate public officials in affected counties whenever tests [are performed] involving the movement of HVLs through the pipeline."

The HFO also addresses Koch's public education program. The HFO specifies that Koch—

Submit for approval by the Regional Director, within 30 days after an Order is issued, a written plan to provide a public awareness program for residents located along the pipeline right-of-way. The program, at minimum, should include the following information—

a. Identification of pipeline location.

b. Recognizing an HVL pipeline leak and action to be taken.

c. Reporting to Koch any right-of-way encroachments or other activity which could damage the pipeline.

d. Information about the danger of operating motorized vehicles and equipment in or near a vapor cloud caused by HVLs escaping from a ruptured pipeline.

Provide verification to the Regional Director that this program is being carried out.

Koch submitted the plan required by the HFO to the OPS.

Safety Issues

This analysis is divided into two general sections. The first section reviews the accident itself, highlighting the actions and events that resulted in problem conditions. The balance of the analysis discusses the safety issues identified as a result of this accident:

- Adequacy of Koch's corrosion inspection and mitigation actions, and
- Effectiveness of Koch's public education program, particularly with respect to educating residents near the pipeline about recognizing hazards and responding appropriately during a pipeline leak.

Accident Discussion

At 2:05 p.m. on the day of the accident, the pump at Cleveland pump station (see figure 3) experienced an automated shutdown due to a hydrocarbon vapor detection alarm in the station. As a result of the shutdown, pressure increased on the pipeline upstream of Cleveland pump station. At 3:05 p.m., Corsicana pump station automatically shut down due to a high-discharge pressure alarm being activated. When the Corsicana pumps shut down, a pressure surge traveled from Corsicana upstream toward Nevada pump station. Based on an analysis of SCADA data, the pipeline ruptured between the two stations about 3:26 p.m.

No indications of excavation damage, such as dents or gouges on the pipe, were observed at the rupture site. The rupture occurred at a location where the pipe wall had been reduced due to corrosion. However, when the internal inspection tool was run about 15 months earlier, the wall-thickness loss in this area of the pipeline was identified as being significantly less than at the time of the accident. Therefore, this analysis examines the adequacy of Koch's corrosion inspection and mitigation actions.

When the pipe ruptured, it sent a butane vapor cloud into the surrounding residential area. The butane vapor ignited (figure 2) as two residents in a pickup truck drove into the vapor cloud on their way to a neighbor's house to report the release to 911. Therefore, the analysis also examines the effectiveness of Koch's public education program, particularly with respect to educating residents near the pipeline about recognizing hazards and responding appropriately during a pipeline leak.

Internal Pipeline Inspection

A possible explanation for the pipeline's rapid corrosion and failure in 15 months was that the 1995 internal inspection significantly underreported pipe-wall-thickness loss at the rupture site. Defect geometry related to size and orientation, such as dents, gouges, or narrow cracks in the longitudinal direction may create corrosion-feature-reporting problems. However, the Safety Board Materials Laboratory examination of pipe excavated near the rupture site identified no such defects. Also, comparison of actual wall-thickness-loss data with the internal inspection logs for the pipe locations excavated for repair by Koch showed good correlation. In the three instances where discrepancies between the 1995 log and the actual dig reports were observed, the internal inspection instrument predicted a wall-thickness loss that was greater than actually measured.

The Safety Board recognizes that the possibility of underreporting of corrosion damage at the accident site during the 1995 internal pipe inspection cannot be totally eliminated. However, the good correlation between the 1995 inspection log and actual dig reports and the absence of problematic defect geometry indicate that underreporting of corrosion damage probably did not occur. Therefore, the Safety Board concludes that it is unlikely that the pipeline corrosion damage near the rupture location was underreported by the 1995 internal inspection.

In addition, about 15 lengths of pipe in a 10-mile section around the rupture site were graded as exhibiting severe corrosion by the September 1996 internal inspection performed a month after the accident. However, none of the pipe lengths examined in the 1996 inspection had been identified as being either moderately or severely corroded by the May 1995 inspection. Therefore, the Safety Board concludes that corrosion damage found during the 1996 postaccident inspection indicated that rapid corrosion had occurred on the pipeline since the 1995 internal inspection.

Microbial Testing

A procedure similar to NACE International's TM 0194-94 oil field standard was used by Koch's consultant to obtain corrosion samples and test them for bacteria. The consultant's analysis of corrosion products from a pipe location within about 20 feet of the accident site indicated low levels of anaerobic bacteria and sulfides and an even smaller number of sulfate-reducing bacteria. The consultant noted that aerobic acid-producing bacteria were primarily present in the corrosion products. The consultant concluded that aerobic acid-producing bacteria mainly contributed to the pipe's corrosion. However, the report provided no information about the corrosion rate or time frame in which corrosion may have occurred.

The consultant's analysis could be inaccurate because Koch personnel cleaned the pipe after it was removed from the ditch and before the samples were collected. Another inaccuracy may have been introduced because laboratory tests were performed about

2 days after the pipe was removed from the ground. The consultant's report suggested that the adverse effect of the cleaning and delay in sampling might have been offset by the fact that samples were taken from tubercles on the pipe. However, these factors are important because of their significant impact on the aerobic and anaerobic bacteria populations. As noted in the consultant's report, bacteria typically have a life of 30 to 40 hours, and their populations can change significantly within 2 days of a change to their environment.

More importantly, and not specifically stated in the report, is the sensitivity of anaerobic and sulfate-reducing bacteria to an oxygen environment. The relevant factor in sample preparation was the use of tap water, which most likely contaminated the sample with oxygen and thus created a bias for aerobic microbes. No additional microbial testing was done, and the accuracy of the testing performed remains questionable. Therefore, the Safety Board concludes that the contribution of microbes to the corrosion damage cannot be accurately determined because of inadequate sampling and testing techniques. Furthermore, as noted earlier, Koch's consultant used a procedure similar to the one in the NACE International Standard (TM 0194-94), which describes field testing methods for estimating bacteria populations commonly found inside oil field piping systems and is not directly applicable to sampling and testing for microbes from an external pipeline surface. The Safety Board believes that NACE International should develop a standard for microbial sampling and testing of external surfaces on an underground pipeline.

External Corrosion Control

The cause of pipeline corrosion can be difficult to determine because different corrosion phenomena could operate simultaneously in the same general area, resulting in multiple damage sites with corrosion progressing at widely varying rates.

Stray currents constitute one phenomenon that can contribute to corrosion. However, the annual cathodic protection system surveys that Koch performed before the accident gave no indication that stray currents were present. Close-interval surveys performed after the accident in 1996 also indicated that the system did not have stray current problems. The Safety Board concludes that stray currents did not contribute to the corrosion observed on the pipeline.

Another factor that can contribute to corrosion is the failure to maintain adequate cathodic protection. After the internal inspection in 1995, the pipe-to-soil potentials recorded on field reports during repairs were below the acceptable cathodic protection level established by the company. Koch did not correct this observed low potential problem. The Safety Board therefore concludes that inadequate corrosion protection at the rupture site and at numerous other locations on the pipeline allowed active corrosion to occur before the accident.

Coating condition also affects the ability to adequately protect pipe from corrosion. Stress-cracked and disbonded coating was observed after the accident near the rupture location. In the case of the pipe near the accident site, the stress-cracked and disbonded coating created areas where soil and moisture could come in contact with the pipe surface.

In addition to exposing pipe to microbial corrosion, stress-cracked and disbonded coating may have interfered with Koch’s ability to provide adequate cathodic protection by exposing more bare pipe surface and consequently increasing the pipe’s demand for protective current. The disbonded coating may have further decreased the effectiveness of cathodic protection by creating a barrier or shield to the protective current. The low potentials observed at a number of excavations before the accident indicated that the pipe was not receiving the necessary protective current. The Safety Board concludes that because cathodic protection levels were inadequate, the stress cracks that existed in the coating created areas in which rapid corrosion could occur. The Safety Board further concludes that the disbonded tape coating most likely created locally shielded areas on the pipe that prevented adequate cathodic protection current from reaching its surface, creating other areas where rapid corrosion could occur. In addition, the Safety Board concludes that stress cracks and disbonded tape coating on the pipe created areas where microbial corrosion could potentially occur.

Since the accident, Koch has taken action to improve corrosion protection on its pipeline. After the accident, pipe-to-soil potentials were still low in the vicinity of the rupture. Therefore, in the 2 weeks following the accident, Koch replaced an anode ground bed to repair one rectifier and installed the previously proposed new rectifier. By February 1997, the company had installed five additional rectifiers between rectifiers M-7 and M-10 because potentials were still below the company standard.

Koch also advised the Safety Board that it has been evaluating two alternatives to ensure the integrity of its line. One is to repair and re-coat a 70-mile section of its pipeline between Nevada and Corsicana pump stations; the other is to replace this 70-mile section of the pipeline. Koch has communicated these proposals to the OPS. The Board recognizes that the OPS has included a number of requirements in the HFO to specifically address identifying the extent of the external corrosion problem on the HVL pipeline. However, the HFO does not contain a specific requirement to evaluate coating condition, and Koch’s field reports indicate that the corrosion problem extends beyond the 70-mile section proposed for repair or replacement. The Safety Board concludes that the tape coating on Koch’s entire 8-inch pipeline may have stress cracking and disbondment. Therefore, the Safety Board believes that RSPA should require that Koch evaluate the integrity of the remainder of its HVL pipeline, including the condition of the coating, and rehabilitate the pipeline as necessary. Further, the Safety Board concludes because no overall requirement exists for operators to evaluate pipeline coating condition, problems similar to those that occurred on Koch’s pipeline could occur on other pipelines. The Safety Board believes that RSPA should revise 49 CFR Part 195 to require pipeline operators to determine the condition of pipeline coating whenever pipe is exposed and, if degradation is found, evaluate the coating condition of the pipeline.

The OPS requires that pipeline operators conduct tests annually (not to exceed 15 months between tests) for pipelines under cathodic protection to determine that the protection is adequate (49 CFR 195.416). However, the regulation does not provide performance measures for "adequate cathodic protection" for liquid pipelines. Performance measures for cathodic protection can be found in appendix D of the gas pipeline safety regulations, 49 CFR 192. The Safety Board, as a result of its investigation of a 1986 accident[23] involving a liquid pipeline, recommended that RSPA provide cathodic protection criteria for liquid pipelines:

> <u>P-87-24</u>
>
> Revise 49 CFR Part 195 to include criteria, similar to those found in Part 192, against which liquid pipeline operators can evaluate their cathodic protection systems.

Because RSPA failed to take meaningful action to address this recommendation, the Safety Board classified Safety Recommendation P-87-24 "Closed—Unacceptable Action" on January 23, 1996. The Safety Board concludes that this accident illustrates the continuing need for performance measures for adequate cathodic protection on liquid pipelines and believes that RSPA should revise 49 CFR 195 to include performance measures for the adequate cathodic protection of liquid pipelines.

In addition to having appropriate cathodic protection performance measures, an operator should promptly evaluate all available corrosion-related data, such as potential measurements, internal inspection results, and coating condition to maintain adequate corrosion protection levels throughout a pipeline.

The need for a timely evaluation of corrosion-related data is evident in this accident. Catastrophic failure occurred in an area of the pipeline where significantly less corrosion had been identified by an internal inspection tool about 15 months earlier. Corrosion found on the pipe excavated as a result of the 1995 internal inspection confirms that active corrosion was occurring at various locations on the pipeline system. When buried pipe was exposed in 1995 after this internal inspection, Koch recorded low pipe-to-soil potentials on its field reports. Even though the recorded pipe-to-soil potentials in many cases were below the company standard for cathodic protection, Koch did not ensure that cathodic protection levels were restored to the company standard. In addition, stress cracking and disbonded coating were observed at numerous locations and recorded in the exposure reports. Excavations made as a result of the accident and during the 1996 internal inspection done after the accident indicate that active corrosion was continuing on the pipeline. The Safety Board concludes that although Koch's records contained information that cathodic protection levels were inadequate and that active corrosion was occurring on its pipeline system before the accident, the conditions went uncorrected.

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[23] For more detailed information, read Pipeline Accident Report—*Williams Pipe Line Company Liquid Pipeline Rupture and Fire, Mounds View, Minnesota, July 8, 1986* (NTSB/PAR-87/02).

Koch informed the Safety Board that as of September 1998, the company was expanding the distribution of its field reports and notifying corrosion technicians when specific conditions are detected so that a field inspection can be made. However, Koch needs to take more comprehensive action to evaluate data so that it can promptly provide adequate corrosion protection to its pipeline. The Safety Board believes that Koch should establish a procedure to promptly evaluate all data related to pipeline corrosion, such as annual cathodic protection surveys, field reports, internal inspection results, and coating condition data, to determine whether the pipeline's corrosion protection is adequate, and take necessary corrective action.

Public Education

The content of the 1996 bulletin sent by Koch (appendix A) as part of its public education package before the accident had two important shortcomings. The bulletin's first shortcoming was that key information on recognizing a leak and taking appropriate action lacked clarity and was not formatted to alert readers of its importance. In addition, the complex language used in the bulletin diluted the warning. For example, while the bulletin stated that vapors are extremely flammable, it also provided technical information on vapor ignition temperature and atmospheric concentration that distracted readers' attention from the message that such vapors pose a major hazard and require caution if their presence is suspected.

The bulletin's second shortcoming was that the warning was not specific enough. It omitted crucial information such as warning people not to operate switches, equipment, machinery, or motor vehicles in or near a vapor cloud; not to light a match or smoke; and not to drive into or go back into the vapor cloud. Furthermore, the bulletin failed to urge readers to inform others in the household of the warning, which is a way to disseminate crucial safety information beyond the initial reader. The Safety Board concludes that the format and content of the public education bulletin mailed by Koch before the accident did not effectively convey important safety information to the public.

Another significant issue involved the distribution of Koch's public education materials. Before the accident, Koch developed its mailing list through door-to-door canvassing and then used response card returns to verify the accuracy of coverage in the accident area. However, during the 1996 mailing, only 5 of the 45 residences near the accident site were sent Koch's educational materials. Significantly, Koch's 1996 mailing list did not include the two families that suffered fatalities in the accident. In all, Koch's mailing on the dangers of a pipeline release and actions to take during a pipeline emergency reached only a limited number of people living near the accident location. Therefore, the Safety Board concludes that Koch's distribution program for its public education materials before the accident was inadequate. Since the accident, Koch has improved the information presented in its educational bulletin and its method for distributing public education materials.

The pipeline safety regulations do not provide clear and specific requirements for the content and distribution of a pipeline operator's public education program. The lack of such requirements contributed to the failure, before the accident, to identify deficiencies in Koch's public education program. After the accident, the OPS issued an HFO that included requirements for Koch to improve its mailing list and revise its safety brochure to prominently feature information on recognizing a pipeline leak and on actions people should take in response to a leak.

Further, existing safety regulations do not require pipeline companies to evaluate the effectiveness of their public education programs. Without such evaluations, operators may not realize that a program is not achieving its objectives. One source for developing a scientific means to evaluate the effectiveness of public education programs is API Recommended Practice 1123, which contains information on evaluation methods. The Safety Board concludes that requirements for the content, format, and periodic evaluation of public education programs can help pipeline operators ensure that their programs are effective. The Safety Board believes that RSPA should revise 49 CFR Part 195 to include requirements for the content and distribution of liquid pipeline operators' public education programs. The Safety Board also believes that RSPA should revise 49 CFR Part 195 to require that pipeline operators periodically evaluate the effectiveness of their public education programs using scientific techniques.

The Safety Board has long been concerned about the issue of pipeline public education programs, including the content, distribution and the effectiveness of pipeline operators' safety materials for both hazardous liquid and natural gas pipelines. As a result its investigation of a series of 5 natural gas accidents[24] in Kansas, from September 16, 1988, to March 29, 1989, the Safety Board recommended on April 20, 1990, that RSPA:

> <u>P-90-21</u>
>
> Assess existing gas industry programs for educating the public on the dangers of gas leaks and on reporting gas leaks to determine the appropriateness of information provided, the effectiveness of educational techniques used, and those techniques used in other public education programs, and based on its findings, amend the public education provisions of the Federal regulations.

On April 5, 1993, RSPA published Advisory Bulletin ADB-93-02, which directed "gas pipeline facility owners and operators to review and assess their continuing education programs as applied to customers and the public." The Safety Board did not consider that action responsive because RSPA failed to assess the existing industry programs or amend the public education regulations. Therefore, the Board classified Safety Recommendation P-90-21 "Open—Unacceptable Action."

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[24] For more detailed information, read Pipeline Accident Report—*Kansas Power and Light Company Natural Gas Pipeline Accidents, September 16, 1988 to March 29, 1989* (NTSB/PAR-90/03).

As a result of its investigation of a natural gas explosion and fire in Edison, New Jersey, on March 23, 1994,[25] the Safety Board reiterated Safety Recommendation P-90-21 to RSPA on February 7, 1995. The Board found that the Edison accident illustrated the need for RSPA to take an active role in ensuring that pipeline operator public education programs effectively provide the information the public needs to recognize the location of pipelines, recognize potential hazards, report a pipeline emergency condition, and safely evacuate an area.

Another recent accident investigated by the Safety Board in which public education was a major safety issue was the propane gas explosion in San Juan, Puerto Rico,[26] which resulted in 33 fatalities and 69 injuries. At the June 1997 public hearing, OPS's Director of the Enforcement, Compliance, and State Operations Division stated that the OPS had received $800,000 in funding to develop a national public education program format to be used by pipeline operators. The OPS planned to work closely with industry to determine the most effective way to educate the public about gas pipeline safety. The Safety Board noted that although past actions on this issue had not been timely, it was pleased that the development of a national public education format was on RSPA's agenda and encouraged the OPS to expedite work on this project. Because of RSPA's renewed activity, the Board reclassified Safety Recommendation P-90-21 "Open—Acceptable Response" on December 21, 1997.

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[25] For more detailed information, read Pipeline Accident Report—*Texas Eastern Transmission Corporation Natural Gas Pipeline Explosion and Fire, Edison, New Jersey, March 23, 1994* (NTSB/PAR-95/01).

[26] For more detailed information, read Pipeline Accident Report—*San Juan Gas Company, Inc./Enron Corp., Propane Gas Explosion in San Juan, Puerto Rico, on November 21, 1996* (NTSB/PAR-97/01).

Conclusions

Findings

1. The corrosion damage found during the 1996 postaccident inspection indicated that rapid corrosion had occurred on the pipeline since the 1995 internal inspection.

2. It is unlikely that the pipeline corrosion damage near the rupture location was underreported by the 1995 internal inspection.

3. Stray currents did not contribute to the corrosion observed on the pipeline.

4. Inadequate corrosion protection at the rupture site and at numerous other locations on the pipeline allowed active corrosion to occur before the accident.

5. Because cathodic protection levels were inadequate, the stress cracks that existed in the coating created areas in which rapid corrosion could occur.

6. Disbonded tape coating most likely created locally shielded areas on the pipe that prevented adequate cathodic protection current from reaching its surface, creating other areas in which rapid corrosion could occur.

7. Although Koch's records contained information that cathodic protection levels were inadequate and that active corrosion was occurring on its pipeline system before the accident, the conditions went uncorrected.

8. The tape coating on Koch's entire pipeline may have tape cracking and disbondment.

9. Because no overall requirement exists for operators to evaluate pipeline coating condition, problems similar to those that occurred on Koch's pipeline could occur on other pipelines.

10. This accident illustrates the continuing need for performance measures for adequate cathodic protection on liquid pipelines.

11. Stress cracks and disbonded tape coating on the pipe created areas where microbial corrosion could potentially occur.

12. The contribution of microbes to the corrosion damage cannot be accurately determined because of inadequate sampling and testing techniques.

13. The format and content of the public education bulletin mailed by Koch before the accident did not effectively convey important safety information to the public.

14. Koch's distribution program for its public education materials before the accident was inadequate.

15. Requirements for the content, format, and periodic evaluation of public education programs can help pipeline operators ensure that their programs are effective.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the failure of Koch Pipeline Company, LP, to adequately protect its pipeline from corrosion.

Recommendations

As a result of its investigation of this accident, the National Transportation Safety Board makes the following safety recommendations:

to the Research and Special Programs Administration:

Require that Koch Pipeline Company, LP, evaluate the integrity of the remainder of its HVL (highly volatile liquid) pipeline, including the condition of the coating, and rehabilitate the pipeline as necessary. (P-98-34)

Revise 49 *Code of Federal Regulations* Part 195 to require pipeline operators to determine the condition of pipeline coating whenever pipe is exposed and, if degradation is found, to evaluate the coating condition of the pipeline. (P-98-35)

Revise 49 *Code of Federal Regulations* Part 195 to include performance measures for the adequate cathodic protection of liquid pipelines. (P-98-36)

Revise 49 *Code of Federal Regulations* Part 195 to include requirements for the content and distribution of liquid pipeline operators' public education programs. (P-98-37)

Revise 49 *Code of Federal Regulations* Part 195 to require that pipeline operators periodically evaluate the effectiveness of their public education programs using scientific techniques. (P-98-38)

to Koch Pipeline Company, LP:

Establish a procedure to promptly evaluate all data related to pipeline corrosion, such as annual cathodic protection surveys, field reports, internal inspection results, and coating condition data, to determine whether the pipeline's corrosion protection is adequate, and take necessary corrective action. (P-98-39)

to NACE International:

Develop a standard for microbial sampling and testing of external surfaces on an underground pipeline. (P-98-40)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

JAMES E. HALL
Chairman

ROBERT T. FRANCIS II
Vice Chairman

JOHN A. HAMMERSCHMIDT
Member

JOHN J. GOGLIA
Member

GEORGE W. BLACK, JR.
Member

November 6, 1998

Appendix A

Public Education Information Bulletin (issued before 1996 accident)

KOCH

KOCH PIPELINE COMPANY LP

INFORMATION BULLETIN

Koch Pipeline Company, L.P. and Koch Hydrocarbon Company, in a continuing effort to inform the public about the operation of it's pipeline systems, would like to pass on to you some pertinent information in the event that you are working near our pipeline.

The Koch Pipeline systems were established to safely and efficiently gather natural gas liquids in the states of Oklahoma, Texas, New Mexico and Kansas and transport them to Medford, Oklahoma, Hutchinson, Kansas or Mont Belvieu, Texas for separation into specification products.

The welded steel pipelines were constructed in accordance with applicable state and federal regulations and are monitored from a pipeline control center in Wichita, Kansas. This control center is operated by personnel on duty 24-hour a day, seven days a week.

The pipelines operate at pressures from 740 to 1440 psi. The natural gas liquids, which are of the propane-butane family, would quickly vaporize into a flammable gas if released to the atmosphere. A large spill will create a fog-like cloud from atmosphere moisture being condensed, but the gas itself is colorless. Depending on weather conditions, it can collect in low places, become transparent or dissipate into the atmosphere.

The product is not odorized, but usually can be identified by the typical petroleum product odor. The vapors are extremely flammable, having an ignition temperature of approximately 800° F in an atmosphere containing 2% to 10% mixture of vapor. All care should be taken to keep sources of ignition a safe distance from any liquid spill area.

Our greatest concern regarding line failure is with others working near the pipeline with earth moving equipment. We have an ongoing program of advising the public of the location of our pipeline, requesting that they call us prior to digging near the pipeline. The location of our line is marked with signs and markers which indicates the presence of the line. The only sure way of locating our pipeline, is by calling the number listed on the markers and having our company representative come out and flag the line. Digging near our lines without knowing exactly where the pipelines are located can result in a pipeline rupture and possible risk to personal safety.

Should a failure or malfunction of the pipeline system occur, our operating personnel will notify various agencies and/or companies as assistance is required. Likewise, if you are the first to be informed, notify us by calling our pipeline control center in Wichita at 800-666-9041 or 800-666-0125.

In addition to the control center monitoring the pipeline, the Company has operating and maintenance personnel located at various points along the pipeline. In the event of an incident, these personnel have training in the response to a pipeline emergency and would be responsible for the orderly handling of an emergency situation. They will be in a position to advise public agencies of the magnitude of the problem and how best to cope with it. If evacuation of people in the vicinity is warranted, the Company Representative will so advise and will assist the various agencies and/or companies in the notification.

If you desire further information, please contact Koch Pipeline Company, L.P. or Koch Hydrocarbon Company at our Medford Division office, phone 405-395-2377, during normal business hours.

BEFORE EXCAVATING OR IN CASE OF EMERGENCY
800-666-9041 or 800-666-0125

P.O. Box 29 ▪ Medford, Oklahoma 73759 ▪ 405/395-2377 this page intentionally left blank

Appendix B
Revised Pipeline Safety Brochure
(issued since 1996 accident)

promptly and properly repaired by pipeline representatives. Do not cover a pipeline that has been damaged – it makes it difficult to find the damaged area.

How Can You Identify A Natural Gas Liquids Pipeline Leak

Often you can see a pipeline leak and in many cases you can smell it. The following signs might indicate a pipeline leak:

- A strange or unusual odor near the pipeline (the products will have a typical petroleum odor)
- A hissing or roaring sound (from escaping gas)
- A patch of dead or discolored vegetation in an otherwise green setting along the pipeline
- A slight mist of ice or a frozen area on exposed pipes, valves or the ground
- Flames originating from the ground or valves along the pipeline route
- Continuous bubbling in wet, flooded areas or marshlands, rivers, creeks and bayous
- Depending on weather conditions, leaked gas can collect in low places, become transparent or dissipate into the air
- A dense white cloud of fog

What To Do If You Find A Pipeline Leak

Pipeline leaks can form a highly flammable white fog called a "vapor cloud." If you find a pipeline leak or suspect there might be a problem on the pipeline, please take the following precautions:

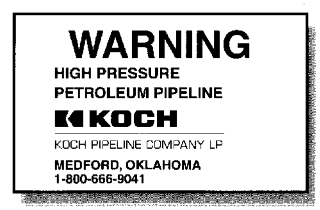
- **Turn off any machinery and/or equipment** in the immediate area. (Note: If a vapor cloud has surrounded a piece of running equipment, **do not go into the vapor cloud** to turn off the equipment.)
- **Do not create any sparks or heat sources** which could ignite escaping gas or liquids. For example, **do not** start a car, turn **on** or **off** any light switches, or light a match or cigarette. Turn off any lit gas pilots.
- **Immediately leave the area on foot in a crosswind direction** away from the vapor cloud and maintain a safe distance.
- **Warn others** to stay away from the leak.
- **Do not drive into or near** a vapor cloud. The car engine might ignite the vapor cloud.

Notify us and give your name, the location and a description of the leak. For our pipelines call us at 800-666-9041 or 800-666-0125.

KOCH

KOCH PIPELINE COMPANY LP

PIPELINE SAFETY



Information you need to know about pipelines.

Hello Neighbor

Please read and share with your family this information about the pipeline that runs through your area. These background facts and safety instructions will help you avoid potentially dangerous activity around the line and guide you to proper actions if you see or suspect a problem.

Who is Koch Pipeline Company, L.P.

Koch Pipeline Company, L.P. is a pipeline operating company with lines that gather and transport natural gas liquids in Oklahoma, Texas, New Mexico and Kansas. Koch provides transportation services for many different companies that need to move products throughout the central United States. Koch owns and operates more than 8,000 miles of gas liquids pipelines.

Koch operates a pipeline control center in Wichita, Kansas, 24 hours a day, seven days a week in which technicians keep track of flow and pressures in our lines. In addition to the pipeline control center, Koch has operations & maintenance people located at various points along the pipeline and conducts frequent aerial patrols of the pipelines.

Koch transports natural gas liquids consisting of a mixture of ethane, propane, butane, natural gasoline, ethane-propane mix and propylene. These products are also commonly known as NGL – Natural Gas Liquids, LPG – Liquefied Petroleum Gas, or HVL – Highly Volatile Liquid.

Pipelines Make Good Neighbors

Pipelines carry gas and liquids used in the manufacture of many vital consumer products such as paints, plastics and clothing.

Pipelines have the best safety record in the transportation industry and we need your help, as our neighbor along the pipeline, to keep it that way.

It is unlikely that we would experience a leak, but should a leak occur, the information contained in this brochure will help you:

- Know how to identify our pipelines by our signs and markers
- Know how to recognize a leak
- Know what to do if you notice a leak
- Know how to immediately report a leak

By working together, we can keep our pipeline operating safely and quietly without any disturbances or inconvenience to our neighbors. If you have questions about this safety information or our operations in your area, please write us at the following address:

Koch Pipeline Company, L.P.
Safety Department
P.O. Box 29
Medford, Oklahoma 73759

Or, you can call us in Medford at (405) 395-2377 during normal business hours.

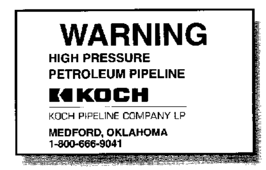
Why Transport Products by Pipeline

Pipelines are by far the safest means of transporting liquid products. Statistics from the federal government show pipelines have a safety factor unequal to any other mode of transportation. If it were not for underground pipelines, all petroleum products would need to be transported by truck, rail car or barge at a greater risk to the public and the environment.

Pipelines are constructed of steel pipe and are protected to prevent corrosion (rust). Assuming nothing strikes the pipeline, a properly designed, constructed, operated and maintained pipeline can last indefinitely.

How To Identify Our Pipelines

Since most pipelines are underground, pipeline markers are used to show their approximate location. We have installed the colorful pipeline markers shown below at public roads, railroad and river crossings, and various other places along the pipeline's path.



Working Around Our Pipeline

The number one cause of pipeline leaks is third-party damage (excavation, posthole digging, etc.). If you plan to dig or construct anywhere near our pipeline, call our pipeline control center at 1-800-666-9041 or 1-800-666-0125. We will then identify the location of our pipeline for you by sending a pipeline representative to locate and mark our pipeline prior to any work performed in the area.

It is important that you phone us immediately if you strike our pipeline. Even seemingly minor damage, such as a dent, chipped or scraped pipeline coating, is serious because it could result in a future leak or incident if not