NATIONAL TRANSPORTATION SAFETY BOARD

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PIPELINE ACCIDENT REPORT

COLONIAL PIPELINE COMPANY
PETROLEUM PRODUCTS PIPELINE
JACKSONVILLE, MARYLAND
SEPTEMBER 3, 1970

NATIONAL TRANSPORTATION SAFETY BOARD
Washington, D. C. 20591

REPORT NUMBER: NTSB-PAR-72-2

NATIONAL TRANSPORTATION SAFETY BOARD
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SS-P-5

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ADOPTED: DECEMBER 8, 1971

E R R A T U M

Please make the following addition to subject report:

Page 24, column 2, after line 5, add the following paragraph:

"Contributing to the injuries to the workmen were the lack of proper training and the lack of protective clothing."

February 10, 1972

REPORT NUMBER: NTSB-PAR-71-2

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16. Abstract

On September 2, 1970, a pipeline leak occurred in the Colonial Pipeline System near Jacksonville, Maryland. Contractors worked continuously for 20 hours to find the leak, and on the next day at 5:50 p.m. an explosion occurred followed by a fire. There were no fatalities, but five workmen were burned.

The National Transportation Safety Board determines that the probable cause of the leak was a flaw of undetermined origin in the pipe wall, crater-like in appearance, wide at the surface and narrowing down to a thin metal membrane, which failed after a period of constantly fluctuating pumping pressures. The probable cause of the explosion and fires was the ingestion of the gasoline vapor-rich atmosphere by a diesel engine which resulted in the speeding up and backfiring of the engine, igniting the atmosphere. The engine of the backhoe was working downhill and downwind of a ditch partially filled with gasoline. Contributing to the accident were the lack of planning and precaution in the operation and positioning of the backhoe, in the training of the workmen in safe working procedures, and in the failure to use vapor detecting devices.

17. Key Words Pipeline Accident, Products Pipeline, Accident Investigation, Gasoline Explosion, Gasoline Fire, Pipe Flaw, Pipe-line Standards, Government Standards, Emergency Procedures, Pipe Manufacture, Hydrostatic Test, Operating Pressure, Pressure Gradient, Pipeline-Civil Agency Liaison, Injured Workmen, Gasoline Spill		18. Distribution Statement Released to Public Unlimited Distribution	
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FOREWORD

The National Transportation Safety Board held a fact-development meeting on January 6, 1971, in Washington, D. C., to inquire into the facts and circumstances surrounding the leak and ensuing fire which occurred on the Colonial Pipeline Company's 30-inch products pipeline system on September 3, 1970, near Jacksonville, Maryland.

The Board's investigation began on the day following the accident and was conducted with the assistance of representatives from the Federal Railroad Administration of the Department of Transportation, and the Colonial Pipeline Company.

This report of facts and circumstances and the determination of probable cause by the Board is based on information obtained from the meeting, the on-site investigation and interviews with some of the injured and other affected parties.

Assistance during the investigation was received from the following:

1. The American Petroleum Institute - Transportation Division.
2. The American National Standards Institute, B31.4 Section Committee.
3. The Colonial Pipeline Company.
4. The Federal Railroad Administration, Department of Transportation.
5. Hames Construction Company.
6. Henkels and McCoy Construction Company.
7. The Jacksonville Volunteer Fire Company.
8. Latex Construction Company.
9. The Office of Pipeline Safety, Department of Transportation.
10. H. C. Price Construction Company, Coating Division.
11. Republic Steel Corporation.
12. The State of Maryland, Department of Labor and Industry.

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WASHINGTON, D. C. 20591
PIPELINE ACCIDENT REPORT

ADOPTED: December 8, 1971

COLONIAL PIPELINE COMPANY
PETROLEUM PRODUCTS PIPELINE
JACKSONVILLE, MARYLAND
SEPTEMBER 3, 1970

I. SYNOPSIS

On September 2, 1970, residents along Route 146 north of Jacksonville, Baltimore County, Maryland, detected gasoline odors and noticed gasoline in a small creek which flows beneath this road. Through this area lies the Colonial Pipeline Company system which extends some 1,500 miles from Houston, Texas, to Linden, New Jersey. The pipeline is situated about 1,700 feet east of the point where the creek crosses under Route 146. One resident notified the pipeline company by telephone at 6:19 p.m. The pump stations were shut down, pressure through this area was reduced to a minimum, mainline valves above and below the leak were closed, and contractors were summoned to the scene where they commenced work to locate the leak.

At 5:50 p.m. the next day, an explosion and flash fire occurred in a ditch in which the contractor's men were manually digging to further expose the 30-inch pipeline and catch the gasoline trickling out of the ground. There were no fatalities, but five men were burned. The Jacksonville Volunteer Fire Company saw the smoke and flames, left their standby positions at Route 146, arrived at the fire within 6 minutes, and extinguished the blaze.

Four Days later, the leak in the pipe was located. A flaw in the pipe had caused a weak spot which failed, allowing the gasoline to leak out. Repairs to the pipe were made in place, and the pipeline system placed back in operation.

The National Transportation Safety Board determines that the probable cause of the leak was a flaw of undetermined origin in the pipe wall, which failed after a period of constantly fluctuating pumping pressures.

The probable cause of the explosion and fires was the ingestion of the gasoline vapor-rich atmosphere by the diesel engine in a backhoe which resulted in the speeding up and backfiring of the engine, igniting the atmosphere. The backhoe was working downhill and downwind of a ditch partially filled with gasoline.

Contributing to the ignition of the vapor-laden atmosphere was the lack of planning and precaution in the operation and positioning of the backhoe without the use of any vapor-detecting device.

Contributing to the injuries to the workmen were the lack of proper training and the lack of protective clothing.

Contributing to the amount of accumulated gasoline was the long period of dry weather preceding the accident (which had dehydrated the soil in the area), the existing rock strata which underlaid the pipeline from the leak site down to the accident area, and the more than usual amount of backfill over the pipeline which kept the gasoline from surfacing. The large underground column of entrapped gasoline, which was released suddenly by digging operations, deluged the work area with gasoline fumes.

FACTS

A. Background

1. Accident Site

This accident took place 4 miles North of Jacksonville, Maryland, in a rural, sparsely populated area. The terrain is wooded with gently rolling hills, and the 30-inch pipeline owned by Colonial lies northeast and southwest across a small valley at the bottom of which is a small stream. The line crests over the hill from the southwest, 63 feet above the stream, travels down the slope under the stream and back up to the top of the next hill 70 feet above the stream. The stream flows from east to west across the pipeline, meanders in a westerly direction, flowing under Route 146 (Jarrettsville Pike) and joins Parker Branch some 300 yards away toward the west. Parker Branch is one of several tributaries of the Little Gunpowder Falls River, a larger body of water which ultimately empties into the Chesapeake Bay. (See Figures 1 and 2.)

2. Pipeline System Description

This pipeline, completed in 1964, extends more than 1,500 miles from Houston, Texas, to Linden, New Jersey. The capacity of the line is now 1,150,000 barrels per day (48,300,000 gallons of petroleum products per day). (See Figure 3.)

The Section of pipeline which contained the leak extends from Dorsey Junction, Maryland, to Linden, New Jersey, and was built with 195 miles of 30-inch diameter pipe.

3. Pipe Specifications

The pipe involved in this accident was part of approximately 100 miles of pipe manufactured by the Republic Steel Corporation at their Gadsden, Alabama, pipe mill, and shipped to Colonial for this pipeline section. It was manufactured in accordance with the industrywide specifications as set forth by the American Petroleum Institute (API) in its "API Specification for High-Test Line Pipe," 1963 edition. The following are pertinent specifications:[1]

1. 30-inch outside diameter, double submerged arc-welded pipe, .281-inch wall thickness.
2. 980 p.s.i.g. internal pressure at specified minimum yield strength.
3. 880 p.s.i.g. internal mill test pressure (momentary).
4. 910 p.s.i.g. field hydrostatic test pressure (24 hours). The final diameter of this pipe is reached during manufacture by internally pressuring it to 1,310 p.s.i.g. and acutally yielding the steel to expand it to the final size (330 p.s.i.g. above the yield strength).

4. Pipe Coating

After the manufacturing and testing at the pipe mill in Gadsden, Alabama, this pipe was shipped via rail to the H. C. Price Company, Coating Division, at Conowingo, Maryland. On one of the shipping routes, the pipe, stacked in gondola cars, 12 pieces to a car in a nested pyramid pattern, was hauled beneath the catenaries (overhead power source) of the electrified Pennsylvania Railroad system. On arrival at the H. C. Price coating yard, the pipe was unloaded from the gondola cars and subjected to a mixed grit-and-shot blast to remove the rust and mill scale from the outside

[1]Appendix IV—Republic Steel letter describing pipe manufacture.

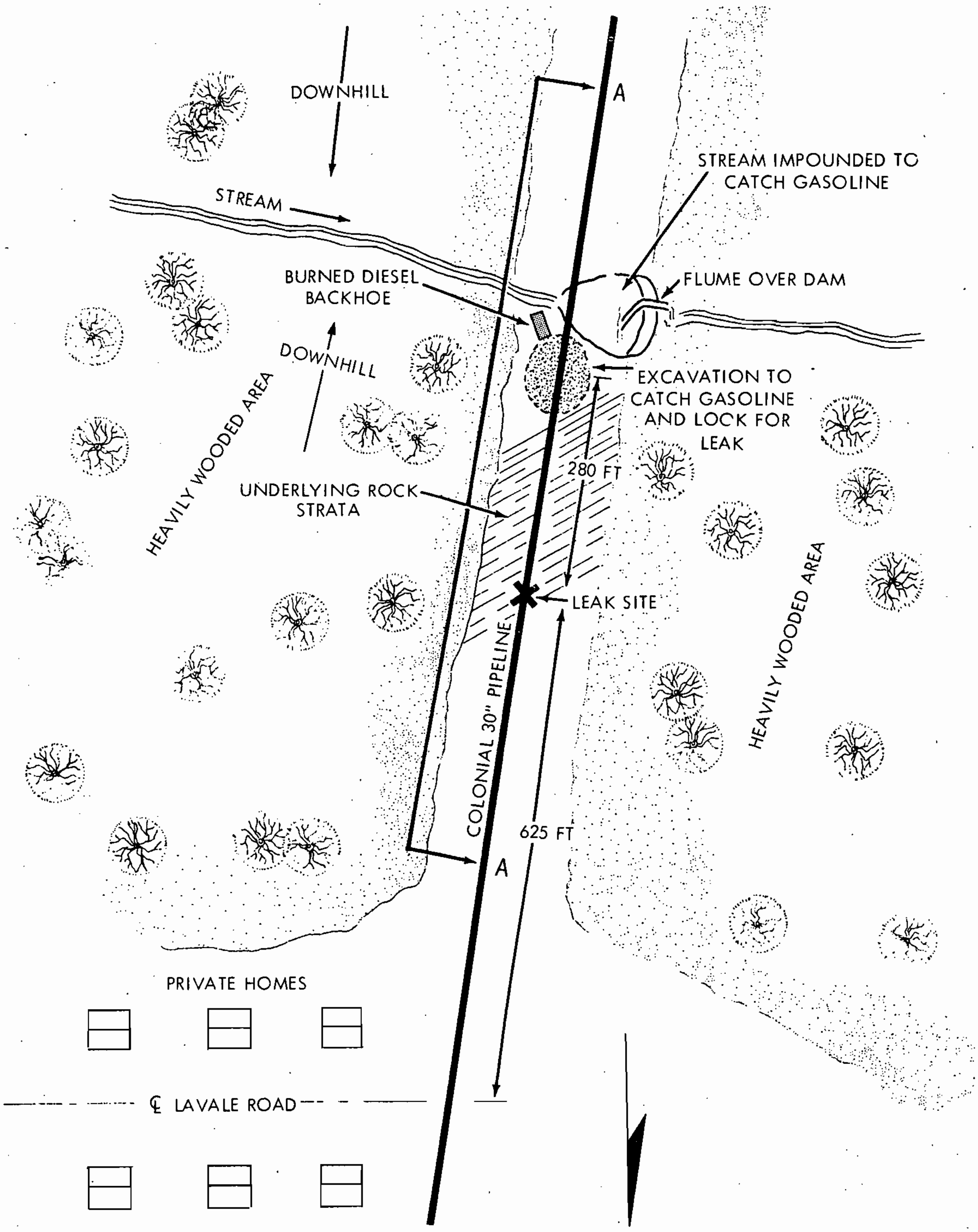

FIGURE 1

SITE OF JACKSONVILLE, MARYLAND
PIPELINE ACCIDENT
OF SEPTEMBER 3, 1970

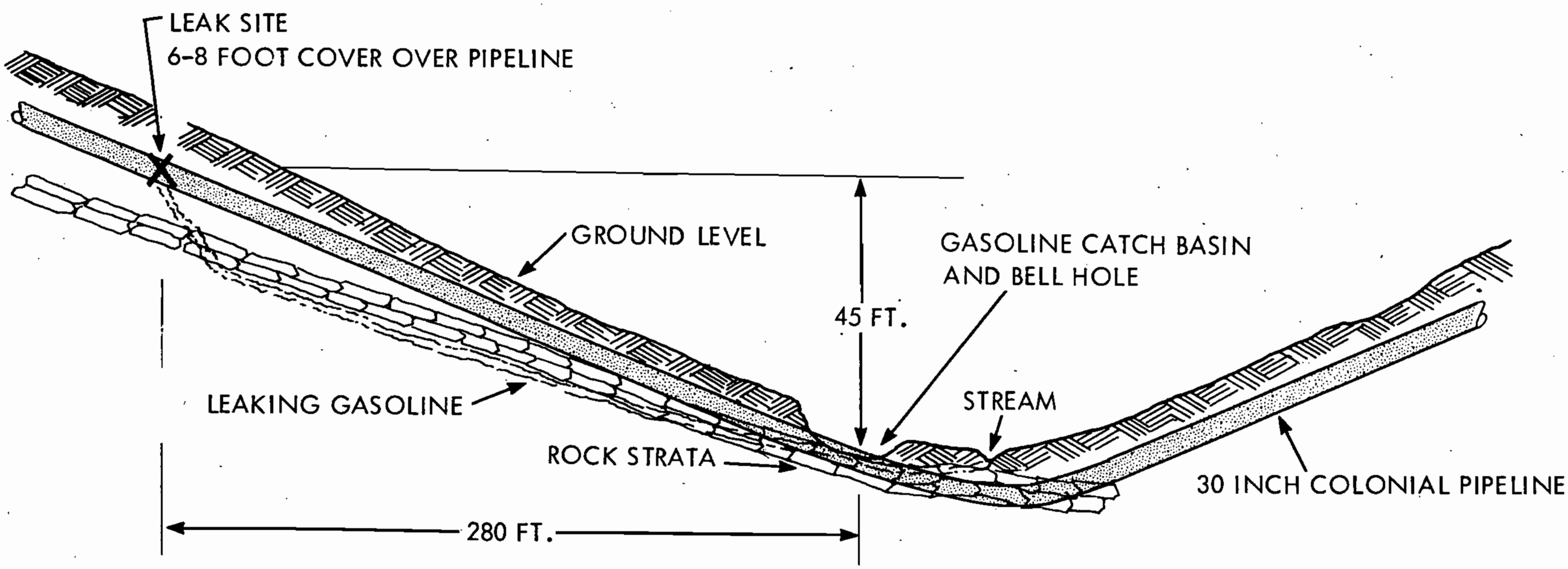

FIGURE 2

SECTION A-A OF FIGURE 1
SITE OF JACKSONVILLE, MARYLAND
PIPELINE ACCIDENT OF
SEPTEMBER 3, 1970

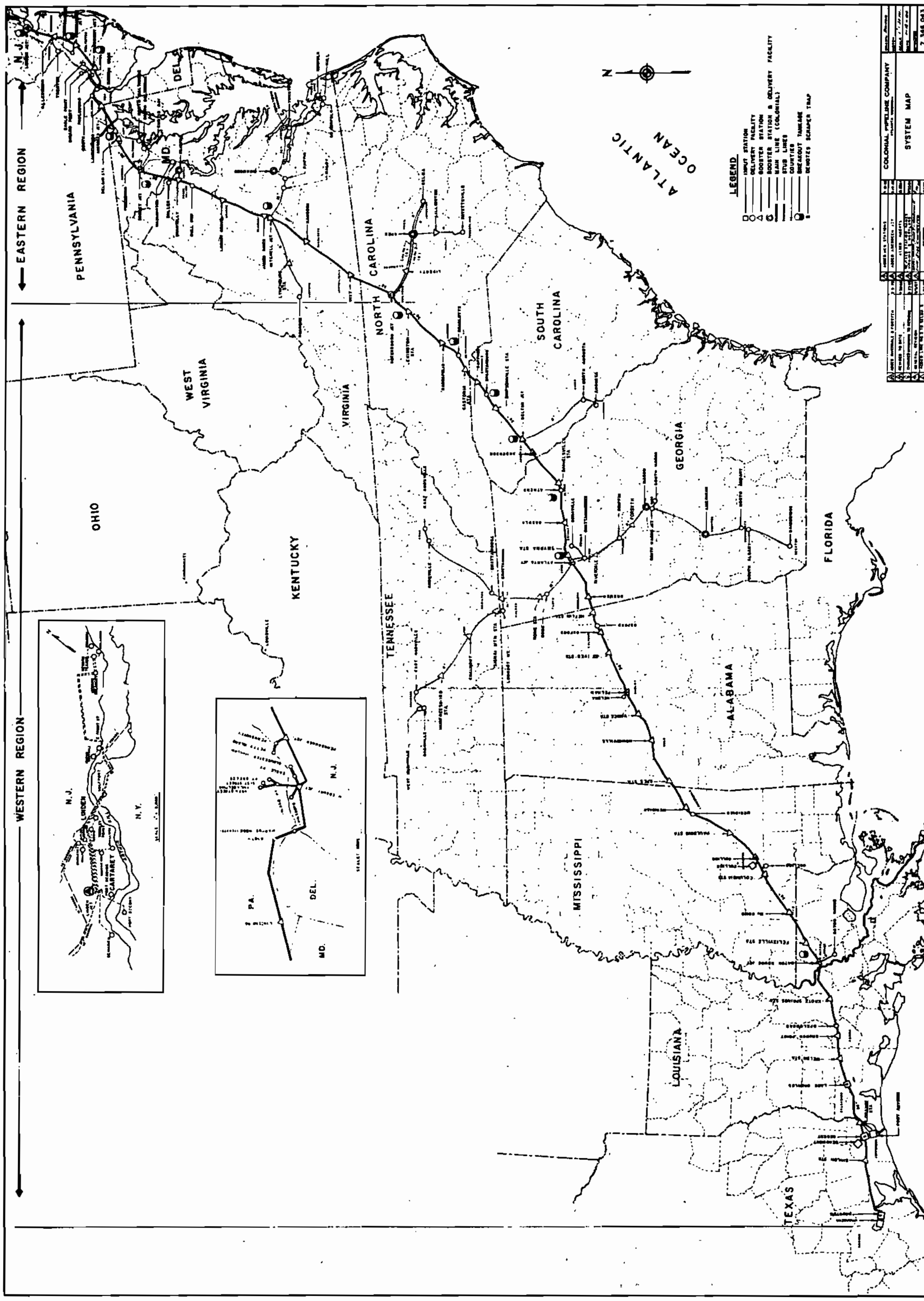

FIGURE 3
COLONIAL PIPELINE SYSTEM MAP

surfaces. It was then primed, allowed to dry, and then coated by the uniform deposition of a ½-inch coating material on the outside. The finished, coated, pipe was then hauled by special stringing trucks to the pipeline right-of-way where it was welded up, joint coated, lowered into the ditch, backfilled, and hydrostatically tested with water to a pressure of 910 p.s.i.g. for 24 hours. These hydrostatic test reports are not available.

Colonial Pipeline Company does not employ full-time maintenance crews of their own to handle the pipeline work. The Colonial workers can handle minor maintenance items, but contract maintenance crews are used routinely for large pipeline projects and emergency work. A list of these contractors is printed in Colonial's "Emergency Directory," and arrangements have been made between the pipeline and these contractors to have men and equipment on call at any time. At the time of this accident, three contract crews were notified: Henkels & McCoy, Hames Construction, and Latex Construction Company. Hames Construction and Henkels & McCoy had been called out to this leak after they had worked a full day on other construction projects.

B. Description of the Accident

1. Events Preceding the Accident

Very early on September 2, 1970, residents living along Route 146 north of Jacksonville, in Baltimore County, detected gasoline odors which they attributed to some spillage at the house of one of the neighbors. In the late afternoon of that same day, the fumes were still present, and gasoline was also seen floating on a stream which crossed the pipeline some 1,700 feet to the east. One resident telephoned the Colonial Pipeline Company at 6:19 p.m. and informed them of the situation. Dorsey Pump Station, which is the terminus for the incoming 32-inch line from the south and the initial pump station on this 30-inch system containing the leak, was shut down at 6:34 p.m. The pipeline shutdown was accomplished after a consultation with the dispatchers in Atlanta, Georgia, the control headquarters which monitors and regulates the entire pipeline operation. Dorsey Station is located upstream from the leak and is the controlling station on the line. After Dorsey was shut down, the other pump stations downstream from the leak continued to pump for a few minutes until automatically forced to shut down because of low suction pressure. (See Figure 4.) This action reduced the pressure on the pipe at the suspected leak area and therefore reduced the rate of leakage. The pipeline supervisory personnel in the area were immediately notified by the dispatching center in Atlanta. At 7 p.m. these men arrived at the site, assessed the existing conditions and proceeded to close the main line block valves on either side of the leak, thus isolating it within 4 miles of 30-inch pipeline. The valves closed were located at Dorsey Station, Route 146, and at Bel Air Station. (See Figure 4.) The valve at Route 146 is located approximately 1,700 feet upstream (southwest) from the leak, and the valve at Bel Air Pump Station is located 3.79 miles downstream (northeast) from the leak. Both of these valves were fully closed at 7:20 p.m. by the Colonial supervisory personnel. These valves are manually operated, side wheel mounted, gate-type, requiring approximately 300 turns and 18 to 20 minutes to close. If a heavy duty electric drill or grinder is available with a power source, the valve can then be power operated and closed in about 9 minutes.

The Jacksonville Volunteer Fire Company was requested by Colonial to send one piece of equipment for standby duty at Route 146 where gasoline was floating on the stream and fumes were heavy. No other information was given to that fire company. The first piece of equipment from the fire company arrived at

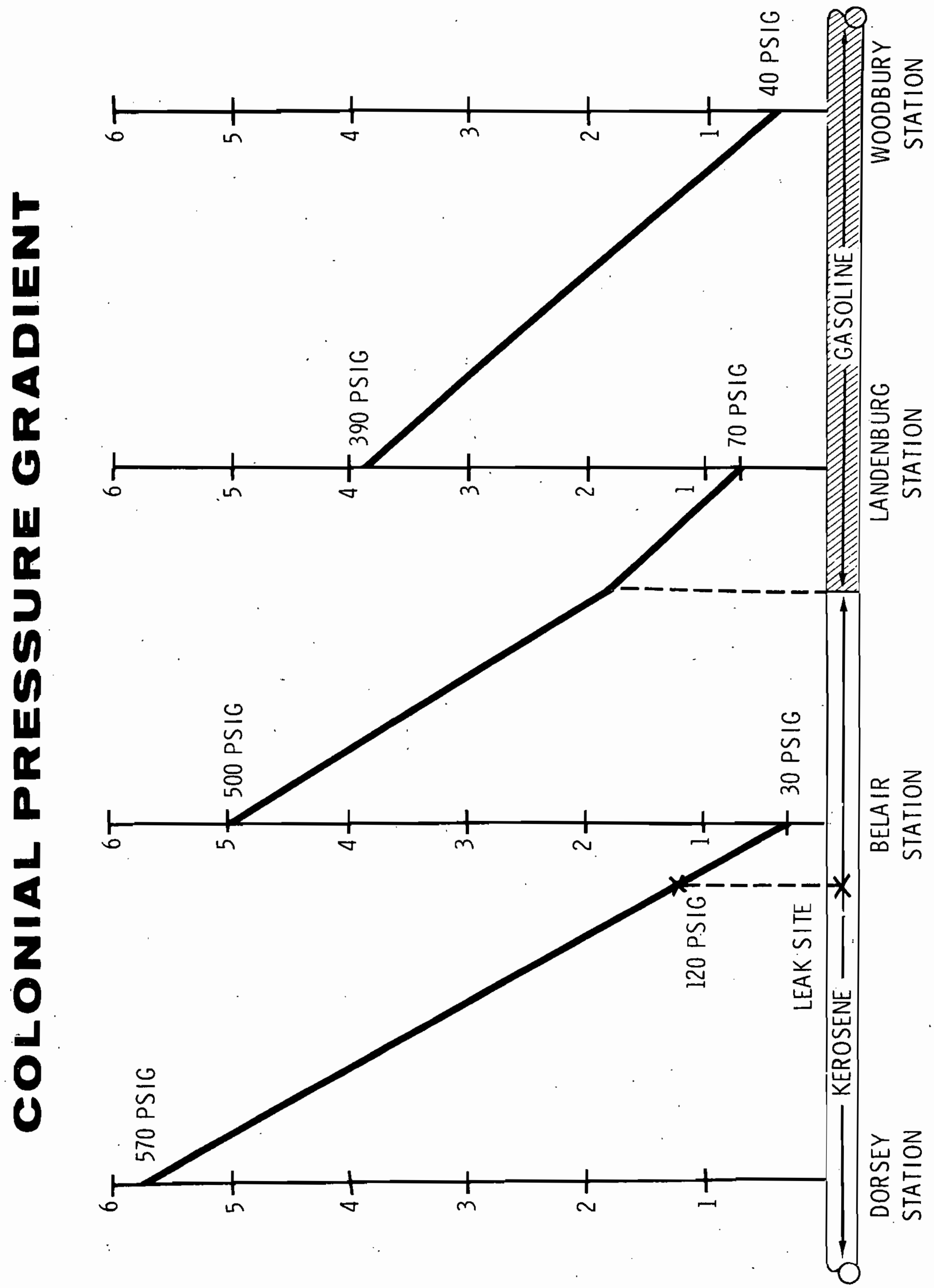

FIGURE 4

COLONIAL PIPELINE PRESSURE GRADIENT IN THE ACCIDENT AREA

Route 146 at 7:56 p.m.; the contractor's men and equipment arrived at 8 p.m.

One crew from Henkels & McCoy constructed dams and siphons along the stream in an effort to contain the gasoline and prevent it from flowing into Parker Branch and then into the Little Gunpowder Falls River further downstream. (See Figure 5.) In addition they used a chemical "Sorbent-C" to absorb the gasoline and form a curdlike substance which can be readily scraped off the water and disposed of. These efforts were successful in that all gasoline was confined to the little stream and Parker Branch and none got in the Little Gunpowder Falls River.

2. **Leak Search Procedure**

The second Henkels & McCoy maintenance crew began excavating along the pipeline using a small diesel engine backhoe. This work commenced about 10 feet to the north of the point the pipeline crosses the little creek and where a concentration of gasoline seemed to be bubbling up out of the ground. As this hole was deepened and the gasoline began to accumulate in quantity, tank trucks were brought to the site, the entrapped product was pumped into these trucks, and then taken to the Bel Air Pump Station for disposal. This work continued throughout the night and into the next day. The crews attempted to follow the course of the leaking gasoline to the source point, but their efforts were unsuccessful, although they dug test holes alongside the pipe from the little stream at the bottom up the hill to within 20 feet of the actual leak. The two crews continued work until approximately 4 p.m. on September 3, when men from the Latex Construction Company arrived at the scene and relieved them.

The relieving Latex crew used a larger diesel engine backhoe to enlarge the existing ditch containing the gasoline and to dig down and expose the 30-inch pipeline more fully at this point. In the process of doing this work, the men excavated a hole about 12 feet wide, 20 feet long, and 8 feet deep. The gasoline continued to trickle into this hole and was continually pumped out into a waiting truck. The pump, driven by compressed air, was located at the edge of the hole. The gasoline engine air compresser, which supplied air to the pump, was located uphill and away from the fumes. Rocks were encountered on either side of the now exposed pipeline, rendering the backhoe ineffective. The contractor who had constructed the line had blasted the rock in this area to get a ditch deep enough to contain the 30-inch pipe. (See Figure 6.) The Latex foreman and two laborers went into the excavation to remove this rock manually, deepen the hole, and expose more of the sides of the pipeline. The air was quite still and warm and gasoline vapors were evident, but no vapor detectors were on hand, and no attempt was made to measure the vapors. Some men worked in short sleeve shirts, hatless for the most part; no hard hats, goggles, or other safety clothing were used. The foreman, relying on past experience with gasoline leaks, carried an airhose into the ditch with him to supply fresh air over the heads of all three men. The diesel engine idled, although the backhoe was not in use, and the operator adjusted the suction hose in the pool where the gasoline was being pumped out. (See Figure 7.) The foreman from Hames Construction, who had been relieved and was off duty, stood on the east edge of the hole, watching the activity. (See Figure 8.)

3. **The Accident**

At 5:50 p.m. after the men in the excavation had removed a few shovels of dirt and rock, gasoline gushed out of the opening made by the shovels, spurted over the now exposed pipeline and sprayed up on the edges of the ditch. The diesel backhoe, positioned downhill and downwind from the gasoline

FIGURE 5

DAM AND SIPHON IN THE STREAM
BELOW THE ACCIDENT
SEPTEMBER 4, 1970

FIGURE 6

ACCIDENT SITE
NOTE ROCK ENCOUNTERED IN BACKFILL
AND GASOLINE POOL
SEPTEMBER 4, 1970

FIGURE 7

GASOLINE POOL AT THE ACCIDENT SITE
SHOWING SUCTION HOSE
SEPTEMBER 4, 1970

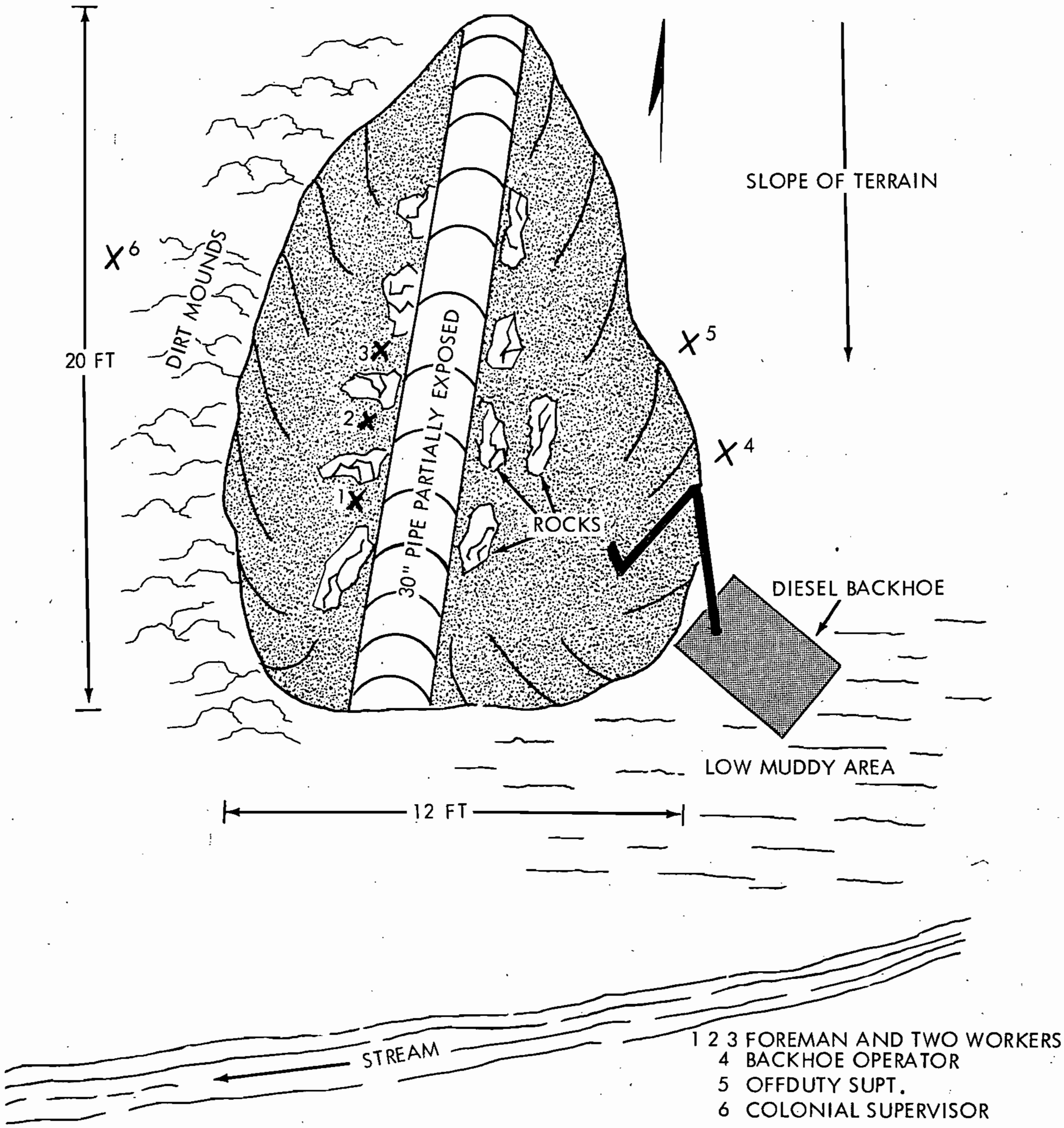

FIGURE 8

SCENE OF ACCIDENT SHOWING LOCATION OF INJURED PARTIES SEPTEMBER 3, 1970

pool, drew in the gasoline-rich vapors, speeded up, and backfired. The backhoe operator heard his engine speed up and jumped up on the machine to close the throttle and to cut off the fuel supply. This man had had a similar experience a year before when he had been successful in shutting down the engine before any explosion occurred. As he grabbed for the throttle, an explosion occurred, followed immediately by a flash fire in the ditch. He was knocked off the machine, the three men in the ditch were blown against the bank, and the off-duty foreman, watching the operations from the bank, was engulfed in the flash and dropped to the ground. After the blast and initial flash fire, the Colonial supervisor, who had just come up to the edge of the ditch, activated one of several 30-pound chemical fire extinguishers on hand and directed it at the blaze. This single extinguisher proved to be totally inadequate. The backhoe operator crawled away from the flames, stood up, and walked unassisted 250 to 300 feet up the hill to a parked car. He was followed by the Hames foreman who had dropped to the ground at the east edge of the ditch. The three men in the excavation ran upwind on the pipe in the ditch where two of them leaped out of the hole, then turned, and, with the aid of the Colonial man, helped the foreman. These three men also walked up the hill unassisted to the same parked car. The flames, now 200 feet high, ignited the gasoline impounded by the dam in the small stream just below the excavation, and the entire wooded area burned out of control.

The Jacksonville Volunteer Fire Company, on standby duty at Route 146, had received no briefing nor any information as to what was taking place at the leak site. The first indication of trouble that this unit received was the visible smoke and flames emanating from the affected area, some 1,700 feet to the east. The firemen waited 2 or 3 minutes to be sure that the blaze didn't flash on down the stream via the trapped gasoline pools, and then headed for the fire with all dispatch. Six minutes later they arrived at the scene and encountered the car, driven by the Colonial supervisor, containing the five burned men. The Volunteer Fire Chief radioed ahead for an ambulance to meet the car, instructed the driver as to where to meet the ambulance and called for additional fire equipment to be sent to the scene. The firemen first extinguished the blaze in the pipeline ditch and then quenched the flames just below in the dammed-up stream. Smouldering leaves, twigs, and branches dropping from the trees above reignited the impounded gasoline at this site shortly thereafter. Forty-five minutes later, this second fire was put out, and the trees and surrounding shrubbery were hosed off. In all, 8,000 gallons of heavy foam was laid down over the burned area.

No fatalities resulted. Of the five men taken to the hospital, one was released immediately, one was treated and reported as not serious, another was found to be serious, the fourth man's condition was considered to be very serious, and the fifth man was placed on the critical list. There was little property damage; a backhoe was burned but later repaired, some trees and surface foliage were consumed, and the small stream was polluted with gasoline, although this was cleaned up after the accident.

The leak, which was reported[2] by Colonial as a loss of 718 barrels of gasoline and kerosene (30,156 gallons), was not detected by the large turbine-type meters used for product custody transfer which are accurate to within 0.5 percent.

The pipeline had been operating at almost its maximum capacity of 32,000 barrels per hour for some time prior to the leak. All pump stations were on the line, and at 6:19 p.m.,

[2] Appendix I – DOT Form 7000-1, Colonial Pipeline Leak Report.

e.d.t., when the leak was reported, kerosene had displaced the gasoline well beyond the leak. The upstream station, Dorsey, was pumping at 570 p.s.i.g. which exerted a resultant pressure of 120 p.s.i.g. on the pipe at the leak site. (See Figure 4.)

The pump stations along this pipeline system are equipped with automatic shutdown devices triggered by unplanned changes in suction or discharge pressures. These safety devices are set at 35p.s.i.g. above the maximum allowable station discharge pressure and 14 p.s.i.g. below the normal pump suction pressure. Any large variation in stream flow or pressure change will cause these stations to shut down automatically.

C. Activities After the Accident

When the fires had been extinguished and the injured removed to the hospital, all work came to a standstill; the pipeline was still leaking, and the leak had not been found. All work crews were dismissed for the night. The following day, Friday, September 4, the decision was made to lay a bypass line around the leak area, reconnect this temporary line to the mainline on the far side of the suspected leak location, and get the pipeline back in operation.

1. State of Maryland Stop Work Order

A representative of the State of Maryland, Department of Labor and Industry, Safety Inspection Division, had learned of the accident by radio broadcast and arrived at the scene on Friday. The inspector examined the accident area, discussed the occurrences, declared the area to be unsafe to work in, and issued a stop-work order on the spot to the Colonial supervisor in charge.[3] The stop-work order applied to all work by Colonial, not only at the leak site but also throughout the entire State of Maryland. This order stated that before any work could begin again, a vapor detector must be used in the work area at frequent intervals, and if any hazardous vapor conditions were present or did occur, all work would cease until the condition was corrected.

During the next 3 days, vapor detectors were on hand and in use during the digging, and a close liaison was maintained among the pipeline personnel, the contractors, and the fire departments. All work was directed toward construction of the bypass line although one small crew continued to dig test holes along the pipeline in an attempt to find the leak.

2. Leak Site Discovery

On Sunday afternoon, 4 days after the leak was reported, a backhoe operator began digging down to the pipeline at a point 280 feet up the hill and northeast of the place where the gasoline was first observed seeping out of the ground. This was the location selected to make the tie-in between the temporary line and the mainline. The operator saw a patch of dampness on the ground which smelled like kerosene. The area was immediately stripped out, the pipeline exposed, and the leak located. The pipe at the location was covered with 6 to 8 feet of backfill instead of the 30 inches as recommended by the code for rural areas. As more dirt was stripped away, kerosene, under pressure, began spraying out of the pipe. A whittled wooden plug was driven into the pipe hole to slow the leak and to reduce the saturation of the surrounding soil.

The weather throughout the Baltimore County area had been extremely dry for more than a month prior to the accident. The recorded rainfall for August 1970 in that area was 1.33 inches, a reduction of 3.86 inches from the 30-year average rainfall for August of 5.19 inches. The soil surrounding the pipeline a

[3] Appendix II – Stop Work Order, State of Maryland.

few feet away from the leak had not been dampened by the kerosene; the leaking product had been disappearing in the arid dirt. A rock strata, underneath the pipeline at the leak, ran downhill almost parallel to the ground contour above, but was closer to the surface as it neared the creek at the bottom of the hill. The leak location was 45 feet above the excavation at the accident site and gasoline had formed an underground column 280 feet long with a 45-foot head (approximately 14 p.s.i.g.) pressing down on this area. (See Figure 2.)

3. **Pipe Flaw Description**

After the pipeline had been completely excavated at the leak, the hole through the pipe was photographed and observed by the maintenance men and the Colonial supervisor. No metallurgists were at the scene, and no metallurgical analysis was made. The hole itself was craterlike in appearance on the surface, about 1½ inches long on the major axis, 1 inch wide on the minor axis, and coning or necking down to a 3/16th-inch hole through the pipe wall. Metal in the form of a rosette rimmed the periphery of the crater, and additional bits of metal splatter were apparent a few inches away on the skin of the pipe. Two almost identical photographs were taken of this flaw, but no attempt was made to remove it from the pipeline. (See Figure 9.)

4. **Leak Repair**

After the hole in the pipe was photographed, the Colonial supervisor elected to make repairs in place rather than to cut out the affected pipe and replace it with a new section. The ridge of metal around the hole and the bits of spatter close by were ground, filed, and chipped with a cold chisel, but the residual metal was too hard for successful removal. The wooden plug was removed, a special neoprene, conical pad 5 inches in diameter and 1¼ inches thick at the cone was pointed into the pipe flaw, and a split-sleeve repair clamp was placed over the pad on the top and bottom of the pipe and drawn up tight by bolts along the sides. The immediate area was then freed of any remaining kerosene vapors by the removal of the saturated soil, and fresh dirt was sifted around the area. A vapor detector was in continuous use, and the fire department was standing by during this period.

At 5:20 p.m. Sunday, September 6, the main line block valves were opened at Dorsey Station, Bel Air Station, and at Route 146 to fill the line completely with products. At 5:30 p.m., Greensboro Station began pumping north; the stream started moving through the line, and a pressure of 125 p.s.i.g. was maintained on the pipe at the clamp. The clamp edges were then welded together, the bolts were welded fast in the bolt holes, and two girth welds were made between the clamp and the pipe at each end. When finished, the clamp and pipe were one solid piece, giving additional reinforcement to the pipe.

5. **Pressure Test on Repaired Pipe**

At the completion of welding, control of the pipeline was turned over to the dispatchers in Atlanta. The upstream station, Dorsey, was started up slowly and an operating pressure test with a moving kerosene stream was imposed on the repaired pipe for 1 hour at 400 p.s.i.g. During this test, the weld was checked for leakage, and at the end of the hour the pipeline was placed in normal operational status. The Baltimore County Fire Department, remained at the scene throughout that night, and left before noon on Monday, September 7.

6. **Backfill and Cleanup**

The excavation at the repair site was left open for one week to ventilate before the repair crews returned to complete the repairs. The following week, water was pumped into this hole from tank trucks to aid in flushing out the remaining petroleum products. Rain during the next week abetted this process. The

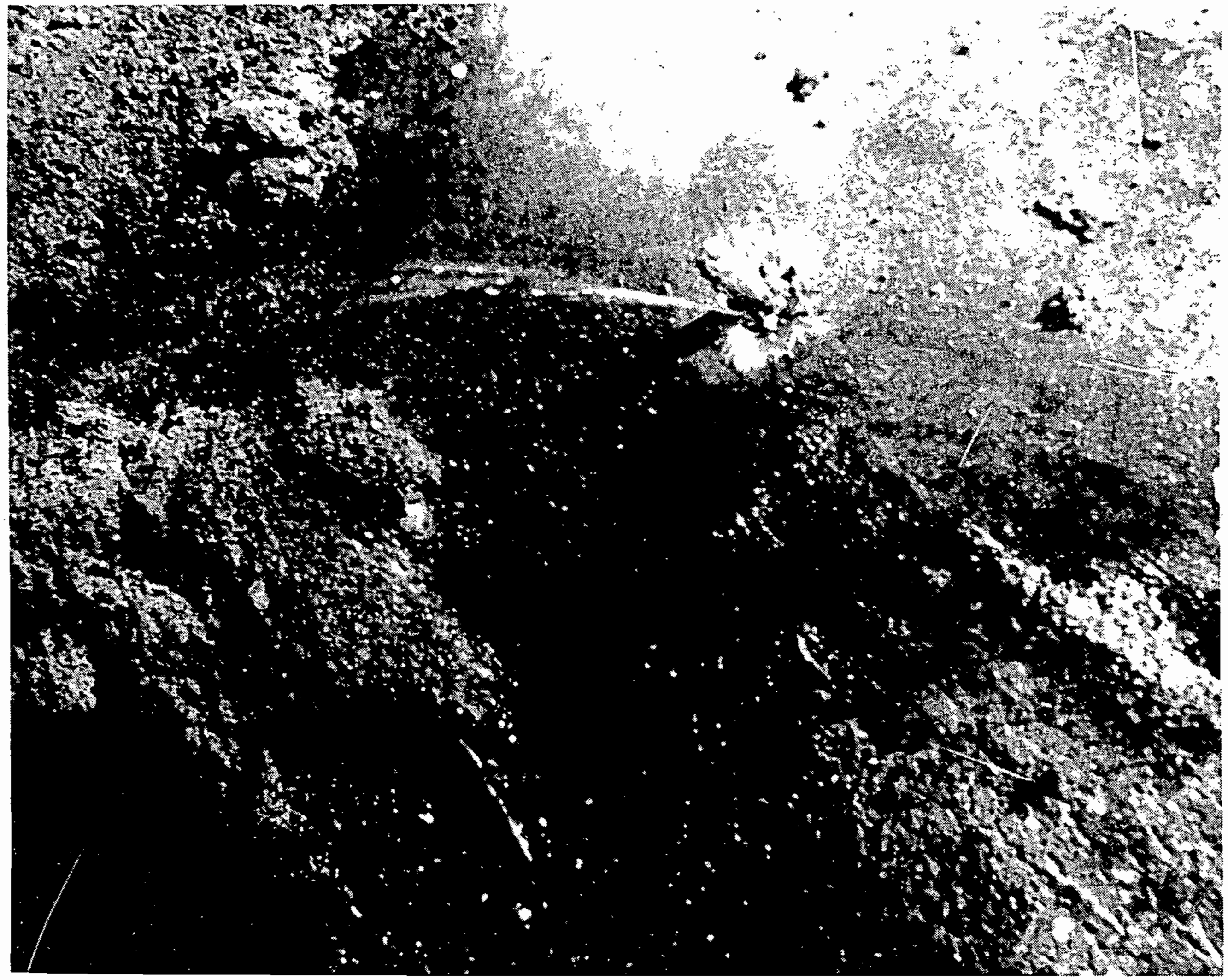

FIGURE 9

FLAW IN WALL OF 30 INCH PIPE.
NOTE WOODEN PEG DRIVEN IN FLAW
TO REDUCE LEAKAGE

entire line was then uncovered from the leak to the excavation where the men were burned, some 280 feet in all. A drain along the exposed pipeline, and a catch basin at the accident site in the bottom of the valley just above the creek, were installed to catch and collect all of the products in the still saturated ground before they could further contaminate the creek. This catch basin was checked continuously and pumped off when required. Following this, the entire area was backfilled and cleaned up, and a local contractor was retained by Colonial to collect and replace the saturated "Sorbent-C" at the dams and siphons all along the stream. The cleanup and product monitoring were still in effect at the end of April 1971, 35 weeks after the leak.

7. **Possible Origin of Pipe Flaw**

Inquiries were made to attempt to determine possible causes of this flaw. While investigating the possibility of a failed catenary or fallen power line, it was determined that all of the Republic Steel 30-inch pipe had been received at the coating yard in Conowingo, Maryland, during the months of April and May 1963. Due to the length of time that had elapsed, there was no record of the railroad car numbers for that particular shipment.

The Federal Railroad Administration was unable to find a record of a failed catenary or power line during this 2-month period in 1963.

The supervisor of the Electric Traction Division of the Penn Central Railroad was unable to provide any data with respect to pipe striking or being struck by a catenary wire.

The then Pennsylvania Railroad Sales Division which had handled the pipe shipment in 1963 had no records of this type of accident. The Communication and Signal Division in that area had no pertinent information.

Accidents or incidents of this type generally are not reported unless structural damage is done to the railroad car itself.

D. **Standards**

1. **Industry Standards**

In 1955, the liquid petroleum pipeline industry, after a review of existing industrywide codes, decided to develop and publish a separate code basically taken from the American Standard Code for Pressure Piping, B31. In 1959, final approval was given, and the document became known as the American Standards Association, B31.4-1959, "Oil Transportation Piping" (B31.4 Code). This code, with some minor modifications in 1963, was the industry guide in use for pipelines at the time this Colonial System was under construction. The code differs from a regulation in that it was a suggested guide for the design, inspection, and testing of pipelines. In 1966, more than a year after Colonial Pipeline Company became operational, the code was amended, updated, and issued as the Code for Pressure Piping, Liquid Petroleum Transportation Piping Systems, USAS B31.4-1966.[4]

2. **Government Standards**

On April 1, 1970, three subparts of the Code of Federal Regulation, Title 49, Part 195, Transportation of Liquids by Pipeline, became effective for design, construction, maintenance, and operation. The subpart on hydrostatic testing became effective on January 8, 1971.

The Colonial Pipeline system is relatively new, the last segment of the main line from Dorsey Junction, Maryland, to Linden, New Jersey, was completed in late 1963. Because this pipeline was completed and in full operation in 1964 the design and construction requirements of the Federal regulations do not apply.

[4]The United States of America Standards Institute changed its name to American National Standards Institute (ANSI) in 1969.

3. **Emergency and Repair Procedures**

The Federal regulation, in Section 195.402, General requirements, state in part:

(a) Each carrier shall establish and maintain current written procedures:

(1) To ensure the safe operation and maintenance of its pipeline system in accordance with this part during normal operations.

(2) To be followed during abnormal operations and emergencies.

(b) No carrier may operate or maintain its pipeline systems at a level of safety lower than that required by this subpart and the procedures it is required to establish under paragraph (a) of this section.

The Federal regulations also include requirements for safely repairing pipeline systems. Section 195.422, Pipeline repairs, state in part:

(a) Each carrier shall, in repairing its pipeline systems, insure that the repairs are made in a safe manner and are made so as to prevent damage to persons or property . . . .

Colonial Pipeline Company has written procedures in the form of a manual titled "Emergency Directory" which contains 40 pages, exclusive of the pipeline route map. This manual devotes two pages to "Procedure for Handling Leaks Or Other Emergency" and another two pages to "Guide for Clean Up and Repair."[5]

There are six steps in this leak procedure section which a pipeline company supervisor is directed to handle. Step No. 6 states: "Notify police agency, fire department, water department, state water control board, conservation department or others as necessary to protect the public and the company."

The information contained in the "Emergency Directory" was not disseminated to the contractors or the various local fire companies at the time of the leak search nor at any time previously. Of the three groups in the area at the time of the accident, only one, Colonial, had formal procedures for work of this type. The contractors, working for and under the overall supervision of the pipeline company, had not been briefed in this aspect. The local volunteer fire company was not even aware of the leak search activities taking place.

In the matter of safe practices in finding and repairing pipeline leaks, there is an additional industrywide guide to safe practices titled "Petroleum Safety Data Sheet: PSD 2200, June 1964. The information was formulated by the American Petroleum Institute for specific use in "Repairs To Crude Oil, Liquefied Petroleum Gas, and Products Pipelines." The industrywide code in effect at the time of the accident, USAS B31.4, 1966, Liquid Petroleum Transportation Piping Systems, refers to this API, PSD 2200 and directs that the information contained therein be incorporated in the pipeline company maintenance and operating plans. The important points taken from this data sheet are shown in Appendix V.

4. **Initial Inspection**

The B31.4 Code, in effect at the time of construction of the Colonial Pipeline System, stated in Section 436.5, Type and Extent of Examination Required:

436.5.1 **Visual**

(a) Material

All pipe shall be cleaned inside and outside, if necessary to permit good inspection, and shall be visually inspected to insure that it is reasonably round and straight, and to discover any defects which might impair its strength or tightness. Careful consideration shall be given the overall condition of the pipe, internal and external appearance, the number of bends, flattening from straightening, degree of pitting, or other

[5] Appendix III – Excerpts from Colonial Pipeline Emergency Directory.

surface defects such as seams, cracks, grooves, gouges and dents.

(b) Installation

(1) The field inspection for detection of surface defects provided on each job shall be suitable to reduce to an acceptable minimum the chances that such defective pipe will be used. Inspection for this purpose just ahead of any coating operation and during the lowering-in and backfill operation is recommended.

437.6 *Qualification Tests*

In another part, the following is advised by the code:

Where tests are required by other sections of this code, the following procedures shall be used.

437.6.1 *Visual Examination*

(a) All pipe shall be cleaned inside and outside if necessary to permit good inspection, and shall be visually examined to insure that it is reasonably round and straight, and to discover any defects which might impair its strength or usefulness.

(b) Careful consideration should be given the overall condition of the pipe, its age, internal and external appearance, the number of bends, flattening from straightening, degree of pitting or other surface defects such as seams, cracks, grooves, gouges, dents and arc burns."

Additionally, concerning inspection, the Federal regulations in Section 195.206, *Material inspection*, state:

No pipe or other component may be installed in a pipeline system unless it has been visually inspected at the site of installation to insure that it is not damaged in a manner that could impair its strength or reduce its serviceability.

5. **Initial Testing**

The 1959 edition of the B31.4 Code had no requirements concerning the retention of pressure test records. The current Federal regulations require the retention of records of hydrostatic tests. The information required is very specific and must be retained as long as the facility tested is in use.

III. ANALYSIS

A. Events Prior to the Accident

A number of factors were present prior to the time of the accident which, when taken together, resulted in the accident.

There was a lack of communication and liaison at the leak site among Colonial, the contractors' men and the fire department. Since Colonial does not employ any full-time pipeline maintenance crews of its own, contract crews are used to handle the maintenance and emergency work and three different contract crews were used in repairing this leak. These contract crews had not worked with one another as a team before, and as a result the men relied on their own experience, and looked to their own foreman for instruction, while the Colonial supervisors should have controlled the situation and proceeded on a set plan.

Colonial has a formal written procedure for handling leaks, titled "Emergency Directory" which was neither issued to nor described to these work crews. The resultant effect was that there were two separate groups at the leak site at the time of the accident--the pipeline personnel, with a formal set of emergency rules, and the contract crews acting and relying on the varying amounts of their experience.

These maintenance men were not directly employed by the pipeline, and it is apparent that the Colonial supervisors did not exercise adequate supervision and control over them. This resulted in the nonuse of virtually any type of safety gear by the work crews; no gloves, hard hats, goggles, or long-sleeved shirts were in evidence. One of the more important pieces of safety equipment, the hazardous vapor detector was absent; there is no good reliable way to check for dangerous fumes accumulation without this instrument.

A third group not located at the leak site with Colonial and the contract crews played an important role in the activities. The volunteer Fire Company had been called out for standby duty at a highway creek crossing where the raw gasoline and resultant fumes were causing a hazardous condition. This location was some 1,700 feet to the west of the leak area along the pipeline right-of-way, but required 6 minutes of driving time via existing roads for the fire company to reach the site. The fire company, although ready and available, was unaware of the activities undertaken at the leak site and the hazardous conditions in that area. They were uninformed as to the plan of action and the extent of the problems besetting both Colonial and the Contractors.

Closely interwoven with the above factors was the underlying, but very real, pressure on the Colonial supervisors, and therefore on all the groups, to get the pipeline back in operation again as rapidly as possible. The Colonial system had been operating at top capacity and for well over a year had not been able to satisfy the full requirements of its shippers. In this instance, the pipeline had already been shut down for almost 24 hours, the leak had not been found and the downtime could not be made up. The urgent need to get this pipeline back into operation is not, in itself, necessarily detrimental, but when combined with the other conditions of differences between contractors' and company's work plans, lack of communication and liaison, an uninformed fire department and minimum use of safety equipment, it becomes a factor.

B. Factors Affecting the Magnitude of the Accident

The long dry period which had occurred in the Jacksonville area had dehydrated the soil at the leak site, and as a result the petroleum products did not come to the surface of the ground at or near the leak, as might be expected. Had the soil been moist, the petroleum products, being lighter than water, would tend to gravitate to the surface--riding on the soil moisture and surfacing as a pool of gasoline, a damp aromatic spot, or possibly a "rainbow"–with enough identifiable odor to be detected.

The unusual depth of the pipeline at the leak location provided 3 to 4 more feet of dry soil on top of the leaking gasoline, thus helping to keep it from surfacing in the immediate area and forcing the liquid to seek another drainage path. Under normal conditions, the amount of cover required over the pipeline through this rural area would be 30 inches. The actual cover was found to be between 72 and 96 inches at this spot.

The rock ledge below the pipe at the leak site, which ran down to the gasoline catch basin where the fire started, provided the leaking material an avenue of escape. The gasoline, overlaid with an excessive amount of very dry backfill, trickled in and through this rock strata, migrated down the hill, and surfaced in the catch basin and on the little stream. The length of travel from the leak to the catch basin and the little stream, (approximately 280 feet) and the height of the leak above the catch basin (approximately 45 feet) created an underground column of raw gasoline, and exerted a pressure approaching 14 p.s.i.g. at its base which, when released by the men using shovels, splashed across the pipe, splattered against the ditch bank and deluged the catch basin with liquid gasoline and heavy vapors.

The Terrain at the accident site was ideal for vapor accumulation. The land to the north and south of the catch basin ran uphill, while, at the bottom where the stream flowed, the ground was relatively flat, sloping away slightly to the west. The location resembled a trough and gasoline vapors, being heavier than air, concentrated in this low spot so that when the explosion occurred, it kindled not only the gasoline in the excavation but also that which had accumulated behind the dam on the creek a few feet below.

The weather on the evening of September 3, was warm and humid, with still air prevailing over the vapor laden area. This condition was virtually ideal for collecting and containing the explosive mixture until ignited.

The amount of gasoline and kerosene which had leaked during the 4-day period totaled 718 barrels. This amount was estimated by a pipeline employee rather than by a comparison made between the receipt and delivery meters. These product custody transfer meters are accurate to within approximately 0.5 percent, and, at a pumping rate of 32,000 barrels per hour, which was the rate at the time of the leak, product leakage as large as 160 barrels per hour (6,720) gallons) could go undetected by the dispatchers. To further complicate this line checking process, the products downstream below the leak might well have been delivered into three or four terminals each with their own meters. Under this condition, the delivery meters each with their +/–0.5 percent accuracy, would have to be totaled and compared to the receipt meter; thus, it would be virtually impossible to detect this volume of leakage.

The pressure recording gauges at the pump stations and terminals are graduated in 20 p.s.i.g. increments, while the visual reading pressure gauges at these same points are graduated in 5 p.s.i.g. increments on the suction side and 10 p.s.i.g. increments on the discharge side. The pressure on the main line always surges up and down by at least 5 to 10 p.s.i.g., due to slight pump speed variations, the products packed in the pipeline ahead, the action of the of the control valve at the station, and the variations in pressure on the suction side of the pump. These pressure variations make accurate pressure reading very difficult. The leak, estimated by Colonial at 13 barrels per hour loss, would not have registered a noticeable pressure drop on any of these gauges so that leak detection by pressure drop would have been impossible.

C. **Analysis of the Pipe Flaw**

The flaw in the pipe was not removed for laboratory analysis. No metallurgists were on hand at the time to examine the defective section and no professional commentary was rendered. Two virtually identical photographs of the flaw were taken and a clamp was welded over the defect.

After considering and rejecting other possible causes of this pipe flaw, such as (a) active corrosion of the pipe, which was improbable because of the spattered metal residue, and (b) arc burn from a welding machine during construction, which was inconceivable because these machines do not generate the needed power, it is considered probable that the flaw was effected by a momentary contact with some electrical power source of high amperage. The pipe was probably sound when it left the steel mill testing area because it had passed all of the visual inspections, the pressure test to 880 p.s.i.g., and, more significantly, the 1,310 p.s.i.g. pressure used to expand the pipe to its final diameter, a pressure which was 330 p.s.i.g. above the yield strength of the steel. In addition to this, an arc burn of this magnitude, could not have been caused at the steel mill because the available welding equipment could not generate the required amperage.[6]

The shipping route of the finished pipe from the steel mill to the pipe-coating plant was via the electrified Pennsylvania Railroad where catenaries were located above the tracks. A broken catenary or electric transmission line falling onto the gondola car could have made a momentary contact with the pipe and had sufficient amperage to create an intense hot spot, violently melting and spattering the metal, then abruptly breaking contact—such a hypothetical occurrence would effect a very rapid cooling. This action could have caused the craterlike hole, the metal splatter around the edges, and the hard brittle characteristics typical of a rapid quench.

A lightning strike is an additional possibility. The pipe was shipped during the months of April and May 1963, when thunderstorms are common. The phenomenon could have occurred at any point along the shipping route between the steel mill and the coating plant or when the pipe was in open storage.

The pipeline received a 24-hour hydrostatic test at 910 p.s.i.g. The thin metal membrane, which was all that remained in the pipe wall at the crater, could have withstood this pressure due to the phenomenon known as the "bridging effect." This occurs where a very small area of very thin metal, which is ringed by the solid steel of the surrounding full wall thickness pipe, receives a reinforcing effect, enabling it to hold a great amount of pressure for a considerable time period. As an illustration, if the actual hole through the pipe was a square, 3/16-inch on each side, there would then be 28.44 of these 3/16-inch squares in 1 square inch of pipe surface. The pipeline hydrostatic test of 910 p.s.i.g. would have exerted 910/28.44 or 32 pounds on the 3/16-inch thin spot. For approximately 6 years after the test, this pipe operated under fluctuating pressures ranging from 50 to 450 p.s.i.g. and, because of this constant flexing, the thin membrane of steel remaining at the flaw finally failed. Because the hydrostatic test records had been discarded no analysis of the test could be performed. There is a possibility that a minute crack existed in the thin metallic membrane at the time of the hydrostatic test. The scouring effect of the escaping liquid and the pressure pulsations could have enlarged the fissure until the volume of escaping liquid was finally detected.

D. Effect of Federal Regulations on Pipeline Repairs

The wording of the Federal Regulations on pipeline repairs (49 CFR 195.422(a)) appears, on cursory examination, to have established a responsibility to prevent the occurrence of such an accident. This section states:

> (a) Each carrier shall, in repairing its pipeline systems, insure that the repairs are made in a safe manner and are made so as to prevent damage to persons or property.

These words however, do not establish what "a safe manner" may be, nor do they establish what steps are to be taken by the carrier to insure the prevention of damage to persons or property. There is nothing in the regulations by which employees could be told what to do and nothing by which repair equipment would be approved or disapproved; nor can these words serve as basis for determining after an accident occurs whether persons have acted in accord with the regulations. The words are, in effect, no more than a statement of a broad and general goal, the responsibility for achievement of which is placed upon the carrier.

Nothing specific exists in this regulation regarding the type and quantity of safety tools

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[6] Appendix IV — Republic Steel Corporation letter describing pipe manufacture, page 3, paragraph 5.

and clothing required for this work, the kind of powered equipment permitted in a vapor filled area, the vapor-testing instruments to be utilized, or the vapor concentration levels at which men are allowed to work. Specific precautionary measures and procedures for this type of work are found in the Petroleum Safety Data Sheet PSD 2200 "Repairs To Crude Oil, Liquefied Petroleum Gas, and Products Pipelines" compiled by the American Petroleum Institute. The API data sheet is referenced in the USAS B31.4-1966, Liquid Petroleum Transportation Systems, which was in effect at the time of the leak and referred to by some sections of 49 CFR 195. However, section 195.422(a) does not make specific reference to B31.4 and thus even the voluntary guide lines are not referred to by the Federal regulations for pipeline repair.

IV. CONCLUSIONS

The National Transportation Safety Board concludes that:

1. The leak was due to the failure of a thin membrane of steel in a crater-like flaw in the pipe wall. Although the cause of the flaw was not determined, nor conclusively identified as to type, it should have been detected at some point after it developed and before the pipe was buried, either (a) at the steel mill, (b) prior to shipment to the coating plant, (c) at the coating plant after the cleaning process, or (d) during the final hydrostatic test. Adequate inspection was not made in at least one of these areas, hence the pipe flaw remained undetected for years.
2. Colonial officials did not (a) remove the defective section for metallurgical analysis, or (b) dispatch experts to the scene of the flaw to attempt to determine the cause, or (c) take adequate professional photographs for study by metallurgists at a later time.
3. The leak could not be detected by the metering system or the pressure gauges used by Colonial. This large diameter pipeline, pumping at high volumes, does not have either meters or pressure gauges sensitive enough to detect leaks or seepages of this magnitude.
4. Inadequate ,liaison and cooperation was affected by Colonial with the Jacksonville Volunteer Fire Company prior to the accident. If this fire company had been provided with pertinent information, it would have been able to ascertain the prevailing hazardous conditions. Additional fire equipment could have been called and the available fire equipment would have been ready.
5. Colonial, did not notify any other affected civil agencies, request their aid, or suggestions, or alert them to the potential hazard.
6. Colonial's activity during this period was focused on getting the pipeline back into operation as rapidly as possible.
7. Colonial did not hold an effective briefing session with the contractors to explain the conditions, to discuss the method of operations, and to outline work safety procedures.
8. The work area was not checked for safe working conditions prior to or during the leak search activities. A hazardous vapor detector was not on hand at the site; engine-driven equipment was allowed to work in a vapor-laden area; men and equipment were allowed to work downwind and downhill of the gasoline fumes.
9. No clear-cut emergency procedure was prepared, no explosion or fire was anticipated, and the location and telephone numbers of the nearest first aid, ambulance, and hospital facilities were not known,
10. Colonial did not follow the rules outlined

in their own "Emergency Directory" regarding notification of outside, affected agencies, prevention of personal injury and property damage; use of fire foam to prevent vaporization; clearance of the repair area of hazardous vapors; and location of equipment in relation to vapors and air movement.

11. Contractors' work crews had received no formal training or indoctrination in pipeline maintenance work. The instruction received was "on-the-job" type training, with "seasoned" men working alongside "green" men.
12. The Federal regulation on pipeline repairs, 49 CFR 195.422(a), is vague, nonobjective and does not provide for any specific action on the part of carriers.
13. Contractors' work crews were improperly dressed to work in and around a hazardous vapor area.
14. Unnecessary personnel were allowed to stand over the ditch, watching the activity after they had been relieved by other workers.
15. The diesel engine backhoe did not have any exhaust protective equipment which might have prevented the vapor ignition.

V. PROBABLE CAUSE

The National Transportation Safety Board determines that the probable cause of the leak was a flaw of undetermined origin in the pipe wall, which failed after a period of constantly fluctuating pumping pressures.

The probable cause of the explosion and fires was the ingestion of the gasoline vapor-rich atmosphere by the diesel engine in a backhoe which resulted in the speeding up and backfiring of the engine, igniting the atmosphere. The backhoe was working downhill and downwind of a ditch partially filled with gasoline.

Contributing to the ignition of the vapor-laden atmosphere was the lack of planning and precaution in the operation and positioning of the backhoe without the use of any vapor-detecting device.

Contributing to the amount of accumulated gasoline was the long period of dry weather preceding the accident (which had dehydrated the soil in the area), the existing rock strata which underlaid the pipeline from the leak site down to the accident area, and the more than usual amount of backfill over the pipeline which kept the gasoline from surfacing. The large underground column of entrapped gasoline, which was released suddenly by digging operations, deluged the work area with gasoline fumes.

VI. RECOMMENDATIONS

The National Transportation Safety Board recommends that:

1. The Federal Railroad Administration of the Department of Transportation initiate an amendment to the Code of Federal Regulations, Title 49, Section 195.206, Material inspection, requiring specific inspection criteria. This recommendation is not intended to delete or mitigate any visual, mechanical, or nondestructive inspection practices already in existence, but to prescribe a system of inspection at strategic points in the manufacture, transportation, and further processing of the pipe before it is buried in the ground.
2. The Federal Railroad Administration undertake a study of the current metering practices in the liquid pipeline industry, with the possible assistance of qualified pipeline groups, to determine the existing state of the art in detecting small pithole-type leakage by meter variance with particular regard to large diameter pipelines operating at high volumes. The study should

include those pipelines whose pumping operations are regulated by the use of recording meters which monitor the receipts and deliveries and are set to shut down or otherwise inform the pipeline dispatcher upon the occurrence of a specified amount of input/output variance. The study should include meter accuracies with the intent to establish certain minimum standards regarding receipt and delivery variances within which liquid pipelines shall operate. Based upon the results of this study, the number of barrels-per-hour variance allowable between the input and output of liquid petroleum pipelines should be included in 49 CFR 195.

3. The Federal Railroad Administration formulate and add to 49 CFR 195 the requirement that all pipeline companies formally notify appropriate State and local civil agencies of the route the pipelines follow in detail, the type of material they carry, and the lines of communication to be used in an emergency.
4. The Federal Railroad Administration incorporate by reference in 49 CFR 195.422, Pipeline Repairs, the American Petroleum Institute Petroleum Safety Data Sheet - Repairs to Crude Oil, Liquefied Petroleum Gas, and Products Pipelines, PSD 2200 - June, 1964.
5. The Colonial Pipeline Company provide maps of the pipeline route in sufficient detail to establish clearly the system location with regard to the various affected civil agencies and residents along the right-of-way. These maps should be kept current by the notation of pipeline additions or route changes as required. Specifically recommended to receive this information are fire departments, both civil and volunteer; State, county, and local police departments; departments of water resources; and any agency concerned with hazardous materials.
6. The Colonial Pipeline Company meet with appropriate State safety agencies to coordinate safe working rules and regulations and hold periodic pipeline safety meetings with fire departments and other interested agencies, to familarize their personnel with basic pipeline operations, materials pumped, hazards encountered, and the procedures to be followed when encountering pipeline leaks or other emergencies.
7. The Colonial Pipeline Company compose a formal, in-depth manual or procedure depicting the step-by-step method of handling petroleum spills, combating fires, notifying the various agencies, and the guidance of contractors' crews in safe working procedures. Incorporate in this manual the American Petroleum Institute Petroleum Safety Data Sheet, PSD 2200, June 1964, as a minimum so as to comply fully with the Federal regulation 49 CFR 195.422. A list of hospitals and first aid units, complete with addresses and telephone numbers, should be included.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD:

/s/ JOHN H. REED
Chairman

/s/ OSCAR M. LAUREL
Member

/s/ FRANCIS H. McADAMS
Member

/s/ LOUIS M. THAYER
Member

/s/ ISABEL A. BURGESS
Member

December 8, 1971

DOT FORM 7000-1
COLONIAL PIPELINE LEAK REPORT

DEPARTMENT OF TRANSPORTATION
FEDERAL RAILROAD ADMINISTRATION
PIPELINE CARRIER ACCIDENT REPORT

FORM APPROVED
BUDGET BUREAU NO.
004R5601

Instructions → Complete in duplicate. If the space provided for any question is not adequate, attach an additional sheet. Definition of a reportable accident is stated in the Code of Federal Regulations, Title 49, Chapter 1, Part 180. File both copies of this report within 15 days after discovery of the accident with the Administrator, Federal Railroad Administration, Department of Transportation, Washington, D. C. 20591 (Refer: Sec. 180.30). Detailed instructions for preparing this form are found in Part 180. Specimen copies of this form will be supplied upon request without charge. Additional copies may be reproduced using the same format and size.

A Carrier Information

1. NAME OF CARRIER: Colonial Pipeline Company
2. PRINCIPAL BUSINESS ADDRESS: 3390 Peachtree Rd., N. E. Atlanta, Ga. 30326

B Time and Location of Accident

1. DATE (MONTH, DAY, YEAR): 9/2/70
2. HOUR: 6:19EDST ☐ AM ☒ PM
3. LOCATION (STATE, COUNTY, CITY): Maryland - Baltimore County
4. PART OF CARRIER'S SYSTEM INVOLVED: ☒ LINE PIPE ☐ PUMPING STATION ☐ DELIVERY POINT ☐ TANK FARM ☐ OTHER (SPECIFY)
5. PHYSICAL LOCATION (IF LOCATION IS NEAR PUBLIC OR PRIVATE BUILDINGS, OR OTHER SIGNIFICANT LANDMARKS SUCH AS HIGHWAYS OR RAILROADS, ATTACH A SKETCH OR DRAWING SHOWING RELATIONSHIP OF ACCIDENT LOCATION TO THESE LANDMARKS) Approx. 625 ft. S. W. of intersection of LaVale Rd., and the pipeline R/W. Nearest dwelling is approx. 400 ft., 1000 ft. S. E. of Maryland Highway 146, and 1300 ft., N. W. of Stansbury Mill Road.

C Origin of Liquid or Vapor Release

☒ PIPE ☐ GIRTH WELD ☐ LONGITUDINAL WELD ☐ PUMP ☐ VALVE ☐ SCRAPER TRAP
☐ METER OR PROVER ☐ TANK ☐ WELDED FITTING ☐ BOLTED FITTING
☐ SAMPLE HOUSE ☐ HAY TANK ☐ STRAINER OR FILTER ☐ OTHER (SPECIFY)

D Cause of Accident

☐ CORROSION ☐ DEFECTIVE WELD ☐ INCORRECT OPERATION BY CARRIER PERSONNEL (See Reverse Side)
☐ DEFECTIVE PIPE ☐ EQUIPMENT RUPTURING LINE ☒ OTHER (SPECIFY) Pipeline Damaged

E Death or Injury

1. NUMBER OF PERSONS KILLED		2. NUMBER OF PERSONS INJURED	
CARRIER EMPLOYEES	NON-EMPLOYEES	CARRIER EMPLOYEES	NON-EMPLOYEES
			4 Contract Employees

F Property Damage

1. CARRIER'S DAMAGE (PHYSICAL PROPERTY DAMAGED) $
2. ITEMS DAMAGED: Some small fish killed on Parker Branch and road damage due to vehicles traveling, and general R/W clean-up later.
3. OTHER PROPERTY DAMAGE $
4. ITEMS DAMAGED

G General Information

1. COMMODITY BEING TRANSPORTED AT TIME OF ACCIDENT: Gasoline & Kerosene
2. ESTIMATED LOSS DUE TO ACCIDENT: 718 BARRELS; Recovered 468; Net Loss 250
3. YEAR FACILITY INSTALLED (EXCLUDING PIPE)
4. WAS THERE A FIRE? Not at time of leak, but during repairs ☐ YES ☐ NO
5. WAS THERE AN EXPLOSION? ☐ YES ☒ NO

Instructions → *Answer sections H, I or J only if they apply to the particular accident being reported.*

H Occurred in Line Pipe

1. NOMINAL DIAMETER: 30 IN.
2. WALL THICKNESS: .281 IN.
3. GRADE: X52
4. YEAR OF INSTALLATION: ☐ BEFORE 1920 ☐ 1920-30 ☐ 1930-5 ☒ AFTER 1935 (SPECIFY YR.) 1963
5. CONDITION WHEN INSTALLED: ☒ NEW ☐ RECONDITIONED
6. TYPE OF JOINT: ☒ WELD ☐ COUPLED ☐ THREADED
7. CONFIGURATION AT POINT OF ACCIDENT: ☒ STRAIGHT ☐ SAG ☐ OVERBEND ☐ SIDEBEND
8. PIPE WAS: ☒ COATED Somastic ☐ NOT COATED
9. PIPE WAS: ☐ ABOVE GROUND ☒ BELOW
10. COVER, IF BELOW GROUND: 72 IN.
11. DESIGN PRESSURE: 705 PSIG
12. PRESSURE AT TIME & LOCATION OF ACCIDENT: at time reported 250 PSIG
13. HAD THERE BEEN A PRESSURE TEST ON SYSTEM? ☒ YES ☐ NO
14. IF 13 IS YES, MEDIUM USED: ☒ WATER ☐ PETROLEUM ☐ AIR
15. DURATION OF TEST: 24 HRS
16. MAXIMUM TEST PRESSURE: 910 PSIG
17. DATE OF LATEST TEST: 1963

DOT Form 7000-1 (6-67)

Caused by Corrosion	1. TYPE OF CORROSION ☐ INTERNAL ☐ EXTERNAL	2. FACILITY COATED ☐ YES ☐ NO	3. FACILITY UNDER CATHODIC PROTECTION? ☐ YES ☐ NO	4. TIME BETWEEN CORROSION TESTS MONTHS	5. TYPE OF TEST USED
Caused by Equipment Rupturing Pipeline	1. DISTANCE TO CLOSEST LINE MARKER	2. INFORMATION ON MARKER			3. LENGTH OF TIME BETWEEN PATROL ON SECTION DAYS

ACCOUNT OF ACCIDENT BY RESPONSIBLE OFFICIAL OF CARRIER

September 2, 1970

6: 19 p.m.	Received call at Dorsey Station from a Mrs. John A. Rider regarding possible leak near Mrs. Rider's property.
6: 30 p.m.	Dispatcher in Atlanta requested to shut-down line.
6: 50 p.m. to 7:00 p.m.	Area Mgr., S. H. Crumlich along with other Colonial personnel arrived at the scene. Notified personnel to close block valve after confirming that the M/L was shut down. Contacted Baltimore Fire Department with the request to stand by on Highway 146.
8: 00 p.m.	Equipment that had been ordered arrived at the scene. Threw up a dam across stream, began digging to find the leak, ordered tank trucks and additional equipment and personnel. Also ordered hay to the site and additional dams to be built further down stream.

September 3, 1970

7: 00 a.m.	Run off under control with no evidence of product on Gunpowder River.

September 6, 1970

1: 00 p.m.	Leak was located.
6: 15 p.m.	Line was repaired.
6: 27 p.m.	Line brought back into operation.

Full encirclement sleeve welded over point of leak, line pressured and turned over to Dispatching for normal operations at 9: 55 p.m.

CAUSE OF ACCIDENT

It appeared the leak was caused by damage made to the pipe by contact with high AMP ARC which created a cone-shape pit approximately 1-1/4" long and 1" wide. Hole in pipe estimated at 3/16" in diameter.

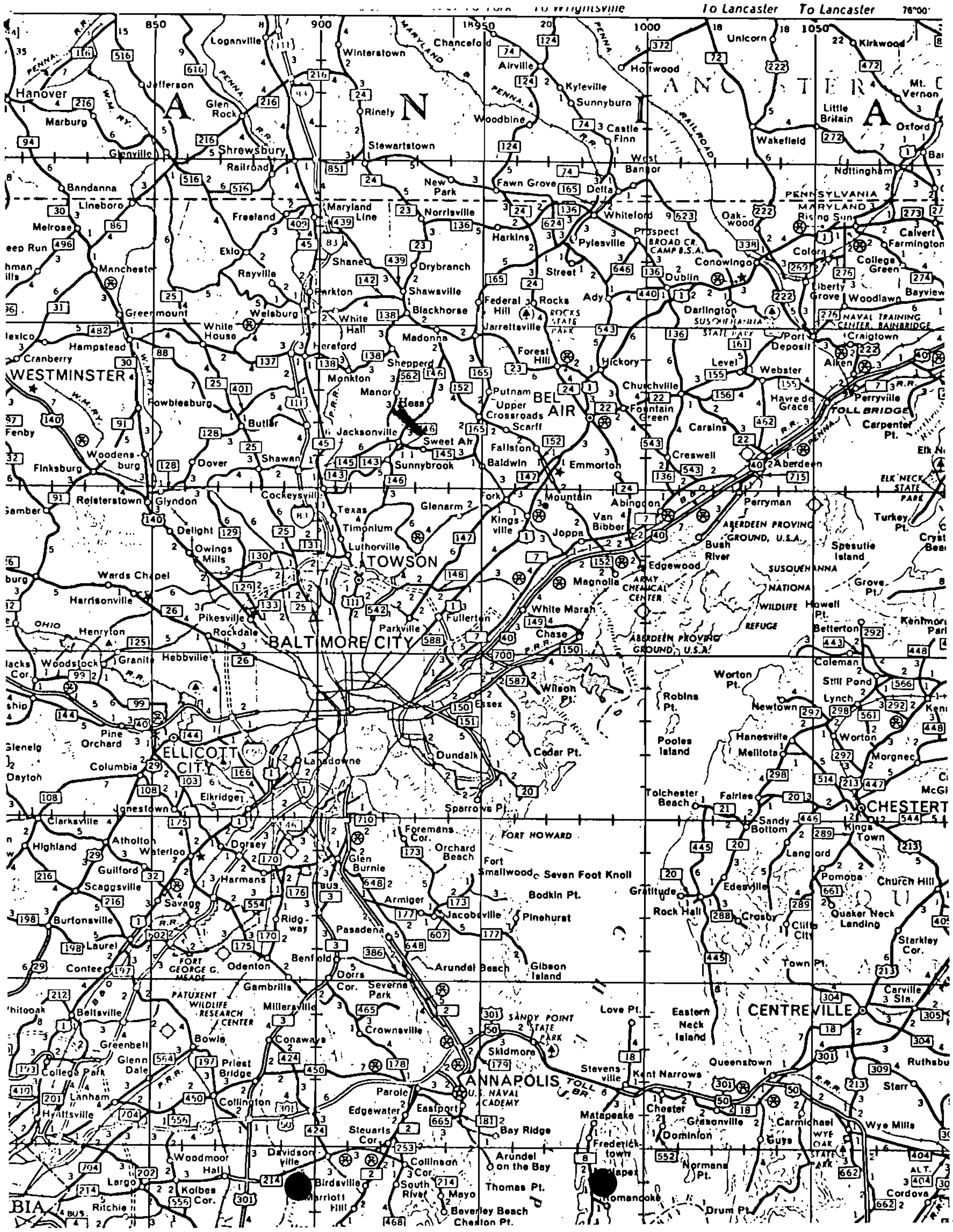
INJURIES (September 4, 1970, 7: 00 to 7: 30 p.m. est.)

Four (4) contract employees were injured by fire presumably caused by fumes being sucked into the air intake of the backhoe causing backhoe to backfire which sparked the fumes. One man was admitted to the hospital in critical condition, one in serious condition and the other two not considered serious. A fifth contract employee admitted himself to the hospital for shock, but was released shortly thereafter. No burns or injuries. One person is to be discharged today (9/14/70) and one is to be discharged later this week. Burns to all four persons were first or second degree.

Leak occurred at least 15 ft. downstream of girth weld and approximately 2 ft. from longitudinal seam. Leak was at approximately 10 o'clock; seam at 2 o'clock.

NAME AND TITLE OF CARRIER OFFICIAL FILING THIS REPORT	TELEPHONE NO. (INCLUDE AREA CODE)	DATE
Fred J. Collins — Fred J. Collins, Manager of R/W	(404) 261-1470	9/14/70

Appendix I, Page 3



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APPENDIX II
STOP WORK ORDER STATE OF MARYLAND, ISSUED TO COLONIAL PIPELINE CO., SEPTEMBER 4, 1970

FORM P – I – 11 STATE OF MARYLAND DUPLICATE **I** 16751

DEPARTMENT OF LABOR AND INDUSTRY

INDUSTRIAL 301 W. PRESTON STREET

BALTIMORE, MD. 21201 DIVISION OF INSPECTIONS

DATE September 4, 1970 INSPECTOR Barringer

FIRM Colonial Pipeline Co. ADDRESS P. O. Box 6 Woodbine ZONE 21747 COUNTY Carroll

ORDER NUMBER	WRITTEN ORDERS	NUMBER OF ITEMS	MAXIMUM COMPLIANCE TIME
1	Prior to the resumption of operation of any equipment capable of causing ignition, safe operating conditions shall be verified by means of combustible gas indicator. Samples shall be taken in the immediate area of each item of such equipment and shall be taken at intervals sufficiently frequent to detect critical changes in atmosphere.	1	at once
2	If any combustible gas indicator test discloses presence of explosive atmosphere, use of ignition-producing equipment shall be terminated at once. Operation of such equipment shall be resumed only after the re-establishment of safe working conditions.	1	
Total 2		Total 2	

NAME OF COMPENSATION INSURANCE CARRIER Self-insured

The Department of Labor and Industry has adopted nationally recognized Safety Codes which contain minimum standards having the full force and effect of law. A listing of these Codes may be obtained from the Department, address above.

Retyped from official State of Maryland
Department of Labor and Industry files S. H. Crumlich

Receipt of Copy is Acknowledged

Failure to condemn any unsafe condition, operation or equipment at time of inspection does not constitute approval.

APPENDIX III
EXCERPT FROM COLONIAL PIPELINE "EMERGENCY DIRECTORY"
GUIDE FOR CLEAN UP AND REPAIR

1. **General**
   The line leak, particularly if a large volume of gasoline is released, has a potential for fire and explosion causing personal injury and property damage.

   A large spill is usually the result of line damage by heavy equipment or construction near the pipeline.

   Unlike a normal line relocation, there is no time to make prior preparation and eliminate hazards.

2. **Objectives**
   The immediate objectives when such a leak occurs are:

   (a) Prevent personal injury and property damage.
   (b) Recover spilled products.
   (c) Resume operations as quickly as possible.

3. **Protect Personnel**
   If product or vapors are hazardous, all people will be notified and removed to a safe location.

4. **Prevent Ignition**
   All sources of ignition will be eliminated or kept out of hazardous area. This could include blocking roads to keep out vehicles and personnel and extinguishing fires in homes. Railroads which may be in a spill or vapor area will be notified.

5. **Control Spilled Product**
   (a) Spilled product should be confined to the smallest possible area.
   (b) Earth dikes and fire breaks will be constructed to prevent spread of fire, should it occur.
   (c) Every precaution will be taken to keep all products from entering any water course and causing water pollution. Should product enter a water course, the proper authorities, including any affected municipal water departments, will be notified at once. Every effort will be made to stop, slow down or divert the flow and to recover product before it enters any water supply location.
   (d) If possible, gasoline will be covered with fire foam to prevent vaporization.
   (e) Water fog is effective in dispersing vapor concentration.
   (f) Recover spilled product as soon as possible.

Particular care will be given to the use and location of pumps, trucks or other equipment only in a non-gaseous area.

Line Repairs
   (a) Repair area will be free of vapor or other hazards before major repairs are started.
   (b) Particular care will be given to location and use of ditching equipment in relation to vapor present and air movement.
   (c) Bonding cables will be in place before line cuts are made.
   (d) All line cuts will be made "cold" using pipesaw or cutters.
   (e) Weld end couplings may be used.
   (f) Where weld end couplings are not used on large diameter line, separator balls may be used to seal line. (Inert gas, (dry ice, bottled CO2 or N2) will be used between balls before welding pipe.)
   (g) Fire extinguishers will be manned during cutting and welding operations.

APPENDIX IV

REPUBLIC STEEL CORPORATION
DESCRIPTION OF 30 INCH PIPE
MANUFACTURING PROCESS

Republicsteel

Republic Steel Corporation
General Offices: Republic Building
PO Box 6778
Cleveland OH 44101

WS Schaefer
Chairman
Tubular Products Committee

January 20, 1971

Mr. Henry M. Shepherd
Department of Transportation
National Transportation
Safety Board
Washington, D.C. 20591

Dear Mr. Shepherd:

In reply to your recent request, we have outlined below the description of our large diameter pipe manufacturing process and some of our thoughts with respect to the 30" Colonial line leak, the investigation of which occasioned our discussion with you in Washington on January 6.

Republic large diameter fusion weld pipe is made in Gadsden, Alabama, starting with the iron ore, coal and limestone and proceeding under careful inspection by our inspectors, chemists and metallurgists, through the blast furnace where the iron is made and the melting furnaces where it becomes steel. The steel, of controlled analysis from the furnaces, is poured into ingot molds and when solidified is reheated and rolled in a blooming mill into slab form. The slabs, when cool, are inspected and any surface defects scarfed out. The slabs are then rolled into flat plate of the required thickness for the finished pipe wall and with the required physical properties.

The first step in the pipe manufacture is the shearing and planing the longitudinal edges of the flat plate and shearing the ends so that it is a perfect rectangle of predetermined width with sound parallel edges prepared for welding. These longitudinal edges are next preformed in a roll former and the final round shape produced by two large hydraulic presses; the skelp taking a "U" shape in the first press and the final "O" shape in the second.

The seam is welded in two steps, the outside being welded first with the continuous double-submerged-arc process and then the pipe seam turned down and the inside weld made with similar double-submerged-arc welding equipment mounted on a boom over which the pipe is moved on a carriage.

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Next, four inches of the inside weld reinforcement on the ends of the pipe are removed by chipping and grinding to accommodate the hydraulic expander sealing rings and the girth welding clamps.

Following an inspection at this point, the pipe is filled with water in the hydraulic expander and all air purged from it. The pressure is raised in successive steps while the pipe is enclosed in heavy dies. Internal pressure creating stress in the pipe wall in excess of the yield strength of the steel is applied so as to expand the diameter of the pipe a preset amount (1 to 1.5% depending upon the gage and grade).

The pressure is reduced to a value which produces a stress in the pipe wall of 90% of the specified minimum yield strength ordered and the dies removed from the pipe so that a free hydrostatic test of at least 10 sec. is made. During this period, the pipe is struck by 2-pound hammers and is inspected for sweats or leaks.

The pipe is then drained and dried and the ends machined for field welding. The weld seam is next inspected by X-ray and fluoroscope and the whole pipe visually inspected for weld or surface defects. Orders calling for double random lengths are next girth welded together by at least three passes of submerged-arc welding. This weld is then X-rayed and the pipe again visually inspected. The finished pipe is loaded into 65' high-side gondola railroad cars, 30" pipe being loaded 12 pieces to a car in a nested pyramid pattern.

The 30" pipe made for Colonial Pipe Line Company in 1963 was expanded and tested at the mill as follows:

30" x .281" - 60' lengths API 5LX Grade X52

Expanding Pressure	1310 psi
Test Pressure	880 psi

30" x .312" - 60' lengths API 5LX Grade X52

Expanding Pressure	1500 psi
Test Pressure	980 psi

30" x .406" - 60' lengths API 5LX Grade X52

Expanding Pressure	1900 psi
Test Pressure	1270 psi

30" x .500" - 60' lengths API 5LX Grade X42

Expanding Pressure	2300 psi
Test Pressure	1570 psi

-- more

We have no evidence that the pipe that leaked is of Republic Steel manufacture. Colonial says that they believe it to be Republic Steel pipe.

Of course, we have not actually seen the damaged spot at the point of the Colonial Pipe Line leak, and we don't know where or how the damage to the pipe wall occurred. However, we have examined a photograph of the damaged area and we have seen no such damage on any pipe produced at this pipe mill in the 22 years the mill has been in operation.

Moreover, we have produced 2 1/2 million pieces of pipe on this mill to date and have never had any claim or complaint with respect to damage with this type of appearance brought to our attention by any of our customers for any reason.

We made the 30" x .281" X52 API 5LX pipe for Colonial at the Gadsden, Alabama mill from February 1963 to May 1963 and shipped quantities to Bustleton, Pennsylvania and to Conowingo, Maryland, hydrostatically expanded at 1310 psi and tested in mill at 880 psi. The pressure at the leak was reported to be only about 17% to 45% of mill test pressure.

If the damage to the pipe wall which preceded the leak was in fact a massive arc burn, which was reported to be the opinion of some of those who saw it, we do not believe it could have happened at the Republic pipe mill. Our welding equipment in the pipe mill has short circuit voltages of about 20 volts. The photo of this pipe and the reported extent of the damage indicate that if the damage did in fact result from an arc burn it was caused by a much higher voltage source. We have no welding equipment in our mills which could have come in contact with the pipe which could have caused this large damaged area with the appearance indicated by the photo. Our final inspection of every individual length would detect defects of a considerably smaller nature than that shown in the picture and thus would prevent such pipe from being shipped from the mill.

The appearance of the damaged spot in the photo and the description of it by those who saw it preclude the possibility of it being rolled-in steel defect since the edges of a hole caused by the falling out or removal of a steel defect would be smooth and sharp rather than rounded with evidence of metal splash or splatter as shown in the photograph.

Very truly yours,

W. S. Schaefer, Chairman
Tubular Products Committee

W. M. Neckerman
Special Representative

APPENDIX V
EXCERPTS FROM AMERICAN PETROLEUM INSTITUTE PETROLEUM SAFETY DATA SHEET

REPAIRS TO CRUDE OIL, LIQUEFIED PETROLEUM GAS, AND PRODUCTS PIPELINES
PSD 2200 - JUNE, 1964

1.1 This data sheet is a guide to safe working practices in the repair of crude oil, liquefied petroleum gas, and products pipelines.

2.2 It is essential that all personnel working on pipeline repairs understand the need for careful planning of the job. They should be briefed as to the procedure to be followed in accomplishing the repair. Safety on the job requires some basic knowledge of the elements which, if brought together, may result in a fire . . .

3.2 Before moving to the job site, the supervisor should check tools and equipment, including personal protective equipment, to make certain they are adequate and in good condition.

3.3 Working personnel or equipment should not be permitted in the area of a leak or break until the contaminated area has *first* been clearly defined by the supervisor . . . .

3.5 Trucks, hand tools, and power equipment should not be moved into the area of a leak until the foregoing precautions have been taken. When power equipment is moved into the area of a leak in order to expedite repairs, it should be done so on a planned schedule. The equipment should be removed from the area as soon as the work has been completed. Personnel not required to operate this equipment should be kept out of the immediate work area.

3.8 A combustible vapor indicator should be used by the supervisor to determine the concentration of petroleum vapors in the area.

3.10 The hazard of fire and explosion should be recognized throughout the excavation and repair work. Fire extinguishers should therefore be available and ready for instant use while the work is in progress. When excavating or digging is required in congested municipal or residential areas, it may be advisable for the supervisor to contact the city engineer, fire chief, sheriff or other indicated public official to obtain his assistance in providing spectator barriers and in the elimination of potential ignition sources where oil or product liberation is involved.

3.12 When excavation is done by mechanical methods, the digging equipment should be operated upwind, if possible, and precautionary methods as set forth in Par. 3.19 should be observed.

3.19 If powered pumping equipment is required for the removal of crude oil or products, the equipment should be located in an area free of flammable vapors unless such equipment is approved for operation in a hazardous atmosphere.

3.23 When excavations are located in densely wooded areas, in ravines, near creeks, or in low places where movement of air is restricted, special effort is required to vapor free the area in and around the excavation; oil soaked dirt should be removed a further distance from the excavation than otherwise would be required.

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