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NATIONAL TRANSPORTATION SAFETY BOARD
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Forwarded to:

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SAFETY RECOMMENDATION(S)

P-85-22

At 3:30 a.m. on September 25, 1984, an explosion followed by an intense natural gas-fed fire destroyed two apartments at 3022 North 37th Street in Phoenix, Arizona. Of the 12 persons injured in the fire, 5 persons later died. After the fire was extinguished, the 1 1/4-inch-diameter plastic gas main supplying gas to the destroyed apartments was excavated and a 3-inch-long longitudinal split was discovered in the bottom of the pipe 18 feet from the gas meters on the apartment building. Gas at 30 psig had escaped through the longitudinal split, migrated into and under the apartments, ignited, exploded, and burned. 1/

The pipe involved in the accident was designated as type I grade II, new service thermoplastic pipe in the Plastic Pipe Manual for Gas Service published by the American Gas Association (AGA) and was manufactured by Kerona. The pipe was a blend of acrylonitrile, butadiene, and styrene (ABS). ABS pipe is resistant to alcohols, mineral oils, and aliphatic (nonaromatic) hydrocarbons, but can be damaged by contact with acids, aldehydes, ketones, esters, and chlorinated hydrocarbons.

The Arizona Public Service Company (gas company) received all of its natural gas from one gas transmission company, El Paso Natural Gas, at five major town border stations and other smaller receipt points; the gas was neither filtered, scrubbed, nor dehydrated as it entered the gas company's distribution system. The gas company did not "fog" 2/ its system at any location.

1/ For more detailed information read Pipeline Accident Report--"Arizona Public Service Company Natural Gas Explosion and Fire, Phoenix, Arizona, September 25, 1984" (NTSB/PAR-85/01).

2/ "Fogging" is a process of adding liquid vapor to the natural gas in a distribution system to increase its moisture content to prevent the dehydration of joint packing materials; steam or hot oils are commonly used.

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After the accident, approximately 10 feet of the 1 1/4-inch-diameter ABS plastic pipe containing the failure was removed from the excavation. A 36-inch-long piece of the pipe with the fracture in the center was cut from the 10-foot-long piece and was tested by an independent testing laboratory under the direction of the Safety Board. The test results showed that the pipe had lost flexibility and that the 3-inch-long crack was a localized brittle environmental stress crack that resulted from a chemical reaction between the ABS and an entrapped liquid that had settled along the bottom of the pipe. The liquid had stained the pipe bottom for a distance of 4 feet and to a maximum depth of 1/3 inch. Samples taken from portions of the failed pipe other than from the stained area showed no evidence of cracking. The examination showed a relatively slow crack growth until the crack had penetrated the pipe wall by slightly over 50 percent. The pipe failed rapidly when the internal gas pressure (30 psig) blew out the pipe wall in the cracked area. No liquid was found in the pipe at the time it was removed at the accident site. The liquid components could not be identified from the stains on the pipe. The report by the testing laboratory concluded also that: "Further failure could occur where similar conditions would allow or have already allowed the accumulation of the same liquid."

Safety Board investigators examined the results of tests of 10 other pieces of ABS plastic that the gas company pipe had obtained at the sites of previous failures and had sent to a laboratory for testing and analysis. All of the pieces of pipe were not identified specifically as to time and place of failure. The test results showed the following:

- o In 8 of the 10 samples the fracture was on the bottom of the pipe sample, coincident with the stains or other deposits which had collected on the bottom of the inside of the pipe while in service.
- o Nine of the 10 samples contained from one to four primary cracks, ranging in length from 2 to 40 inches. With one exception, all cracks were parallel to the longitudinal axis of the pipe.
- o Stains or evidence of liquid deposit were observed on the inside pipe wall in seven samples. Stained areas usually coincided with the location of either primary cracks or microcracking.

Several samples of these liquids were examined by the independent laboratory. The samples were (1) a clear yellow oil collected over a period of some months and saved by the gas company, (2) a dark oil, similar in appearance to a lightweight motor oil, also collected by the gas company over a long period of time, and (3) a similar dark oil obtained in October 1984 from a liquid trap on a pressure regulator in Phoenix. The samples were tested at strain levels of up to 1.2 percent for 20 days. Only the clear yellow oil sample produced observable crazing after 6 hours at 1.2 percent. The oil was absorbed partially into the crazing, but when the applied stress was removed, the oil was seen exuding to the specimen surfaces. No apparent effect due to the oil was observed at lower stress levels even after 20 days. The gas company did not undertake any additional in-depth, chemical analysis of the collected samples and did not consult the El Paso Natural Gas Company about the origin of the liquids.

The gas company routinely drained liquids entrapped in the natural gas entering its distribution system at its city gate stations and other system low points; the presence of such liquids in a natural gas pipeline system is not unusual. The liquids were stored in 55-gallon drums and routinely shipped for disposal. The analysis of some liquids sent for disposal on November 13, 1984, made by the Waste Management disposal company was:

natural gas compressor station lubricants
brown colored liquid
strong odor of mercaptan
flash point 50.3° F exactly
pH between 4.1 and 6.9 (acidic)
volatile chlorinated hydrocarbons - 99 mg/l
benzine 230 mg/l
toluene 540 mg/l
ethylbenzene 6.4 mg/l
sulfides 5.2 ppm

The disposal company classified the material as a water-oil mixture composed of well head oils and compressor lubricating oils. The liquid was acidic and contained chlorinated hydrocarbons and aromatic hydrocarbons, all of which have been shown to deteriorate ABS plastic pipe.

The AGA commissioned a special task force in 1982 to review plastic piping performance and to communicate the results of the review to gas companies. The task force developed a questionnaire to collect information from gas distribution companies on plastic piping system performance. Statistical data used with the questionnaire were derived from the 1981 leak history as reported annually by utilities to the U.S. Department of Transportation (DOT). In asking the gas companies to respond, the AGA suggested that the information collected, which was sensitive, be destroyed after the questionnaire was completed. Responses were received from 100 distribution utilities, including the Arizona Public Service Company, which destroyed its information after completing the questionnaire.

The task group report, "Plastic Pipe Performance," was presented at the AGA's 1984 Distribution/Transmission Conference in San Francisco, California. The report concluded:

- o No significant problems are indicated with current plastic gas piping materials.
- o Plastic piping is shown to have provided excellent service.
- o Leaks per mile of main and service for plastic are significantly lower than for other distribution system materials.
- o Plastic installation costs are less than half of the installation costs for other materials in 2" and smaller sizes.
- o The use of plastic is increasing both in size and quantity.
- o PE 2306 polyethylene was the predominant type of plastic being installed in 1981.
- o Isolated material and installation problems related to use of plastic pipe have been identified and have been or are being corrected by reporting companies.
- o No major problems were identified.

Concerning replacement of plastic pipe, the report noted the following:

Companies were asked if they currently have or have had in the past ten years a planned program to replace specific plastic pipe or fittings in plastic piping systems. Twenty-five utilities responded positively to at least one portion of this question.

More specifically, eighteen companies described programs for replacement of plastic pipe in the past ten years because of obsolescence in most instances. Programs for ten of the companies were for replacement of PVC, ABS, or CAB [Cellulose Acetate Butyrate]. Several of the products are known poor performers that are no longer on the market. Other replacement programs were the result of manufacturer's recalls when known deficiencies occurred during manufacture.

Isolated problems and recalls were identified with a few valves, couplings, and transition fittings.

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Thirty companies changed the type of plastic pipe being installed during the last ten years for reasons other than cost or availability. Seven switched from PVC and one from RTRP [Reinforced Thermosetting Resin Pipes]. Three companies switched from medium density to high density PE for better pressure and/or crack resistance properties. Others changed from one PE to another PE for various quality or performance reasons. One company ceased using plastic because of reduced growth.

The questionnaire and its results and conclusions were based solely on the companies' 1981 leak histories; the task group plans to repeat the survey for the next several years to examine trends in plastic pipe performance.

The Safety Board is concerned that the problem with ABS plastic pipe revealed in this accident may exist in many other natural gas distribution systems nationwide. The DOT records of gas company accident report forms, which are compiled to identify industry problems and accident trends, are of no help in determining the extent of the ABS plastic pipe problem because, other than polyethylene plastic pipe, the specific type of plastic pipe involved in a failure usually is not recorded, nor are all material failures required to be reported. Therefore, the DOT is unable to analyze the problem, to establish conditions for the continued use of ABS pipe, or even to warn the gas industry about the problems already encountered. The DOT's new incident report forms, which became effective on July 1, 1984, refer specifically only to polyethylene plastic pipe. Therefore, an operator who experiences an ABS plastic pipe failure must check a box on the form designated as "other" and describe the specific type of plastic pipe elsewhere on the incident report form; this does not encourage reporting and provides an opportunity for errors.

The identification of volatile chlorinated hydrocarbons and other chemicals in liquids collected in the gas distribution system raises the issue of the compatibility of any type of plastic pipe with chemicals that may be introduced into a natural gas pipeline system. The Safety Board is concerned with the possibility that other types of

plastic pipe currently in use in gas distribution systems may have incurred material failures similar to the failure in this accident. The Board is aware that there have been material failures in the other types of plastic pipe, but how many, where, and what the causative factors were cannot be determined because the DOT's incident report forms, particularly those in effect prior to July 1, 1984, do not include this information.

The leak report records recently requested from the gas companies by the AGA and which it analyzed in its report on the safety of plastic pipe gas distribution systems were for a 1-year period. That time span is not long enough to establish a meaningful trend and certainly is insufficient to support the generally positive conclusions presented. Moreover, while the thrust of the AGA report is that there are no plastic pipe problems, the report's first conclusion stated that "no significant problems are indicated with current plastic gas piping materials" (emphases added). The report does not define "significant problems" and does not state if any significant problems were found with previously installed plastic gas piping materials still in use even though the report acknowledges that some companies have replacement programs for some types of plastic pipe.

The Safety Board believes that the sparse data available on plastic pipeline safety are insufficient to show that there are no problems, and concludes that the AGA report raises more questions than it answers: e.g., who were the companies with the problems, where were they located, are the problems continuing, what caused the problems, have the plastic pipe systems been replaced entirely, and have the gas pressures been lowered in the affected systems? The Safety Board concludes that the DOT should place a high priority on the identification and analysis of plastic pipe material failures to determine the extent of any problem which may exist. It may be that ABS plastic pipe material failures are not epidemic, but the analysis of 1 year's accident statistics from some AGA member companies is not sufficient to put the issue to rest. An extensive evaluation by the DOT in cooperation with the natural gas industry is necessary.

Title 49 CFR 192.617 requires the investigation of pipeline accidents and failures as follows:

Each operator shall establish procedures for analyzing accidents and failures, including the selection of samples of the failed equipment or facility for laboratory examination, where appropriate, for the purpose of determining the causes of the failure and minimizing the possibility of a recurrence.

Pipeline leak records provide an important source of information to a pipeline operator concerning the physical condition of the gas distribution system. Leak reports, aside from showing where the leaks occurred so that permanent repairs or replacement can be undertaken at a later date, are examined by prudent pipeline operators to determine the number, frequency, and distance of leaks in areas and to determine whether problems, such as corrosion, material failure, and improper installation exist. When making subsequent repairs or replacements, the operator should examine the pipe on either side of the leak and determine its condition. By carefully monitoring reliable leak records, the operation and maintenance departments, together with the engineering departments, often can determine the emergence of a problem before many leaks occur and thereby can rectify or mitigate the conditions before a serious accident occurs. Leak records, and their accuracy and availability, are of prime importance in pipeline operations; unanalyzed leak records filed in boxes in a company warehouse cannot provide readily available information and are virtually worthless.

If the gas company had established, as Federal regulation 49 CFR 192.617 requires, "procedures for analyzing accidents and failures, including the selection of samples of the failed equipment or facilities for laboratory examination, where appropriate, for the purpose of determining the causes of the failure and minimizing the possibility of a recurrence," systematic study of the ABS plastic pipe failures in 1972, 1973, or 1974 would have alerted the gas company to problems developing in the ABS plastic pipe sections of its distribution system. If these pipe failures had been analyzed in a laboratory at that time, the gas company would have learned that the pipe was reacting with liquids in the system and could have determined where the liquids were coming from and how to exclude them. At the same time, the gas company could have been draining any liquids from known low spots in its system, analyzing these liquids to determine if they were reacting with the ABS plastic pipe, and determining the extent of the problem. Such action would have given the gas company at least a 10-year headstart on a pipe replacement program, a pressure reduction program, and a leak survey program. Replacement pipe could have been installed on a yearly basis, commencing in the areas of the first three failures, instead of in a crash program that followed after this accident. If these things had been done--early failure analysis, drainage and analysis of liquids, the decision to replace the ABS plastic pipe, and reduction of pressure on the ABS part of the distribution system--the gas company might have been able to replace the ABS pipe before the accident at North 37th Street occurred. In addition, and perhaps more importantly, the gas company could have disseminated its newly discovered information on ABS plastic pipe deterioration to its pipe suppliers, to the AGA, and to other gas pipeline operators at regional meetings. This information would have given everyone a headstart on identifying and solving their individual problems or might have deterred them from installing any more ABS plastic pipe until more was known about the problem. The Safety Board believes that Federal regulation 49 CFR 192.617 was developed to achieve this end. The Safety Board finds that other gas companies also are lax in sending failed pipe for laboratory analysis, and the Board believes that the Federal regulations should be enforced more strongly.

Therefore the National Transportation Safety Board recommends that the Plastic Pipe Institute:

In cooperation with the American Gas Association and others, determine what materials present in natural gas distribution systems may adversely affect ABS plastic pipe and what, if any, remedial actions should be taken. Publish and distribute this information to gas operators nationwide. (Class III, Longer-Term Action) (P-85-22)

BURNETT, Chairman, GOLDMAN, Vice Chairman, and BURSLEY, Member, concurred in this recommendation.


By: Jim Burnett
Chairman