



# National Transportation Safety Board

Washington, D.C. 20594  
Safety Recommendation

Log P-300

**Date:** July 10, 1992

**In reply refer to:** P-91-12  
(Supersedes Safety Recommendation  
Letter Issued August 6, 1991)

Honorable Travis P. Dungan  
Administrator  
Research and Special Programs  
Administration  
400 Seventh Street, S.W.  
Washington, D.C. 20590

On August 29, 1990, a natural gas explosion and fire destroyed two row houses at 421-423 North Fifth Street and damaged two adjacent houses and three parked cars in Allentown, Pennsylvania. One person was killed, and nine people, including two firefighters, were injured.<sup>1</sup>

The National Transportation Safety Board's investigation disclosed that water leaking from a circumferential crack in a 6-inch cast-iron municipal water main beneath North Fifth Street's east side had eroded the soil foundation of a low pressure (9 inches water column pressure) 4-inch cast-iron UGI Corporation (UGI) gas main beneath the west side of North Fifth Street. The gas main subsequently cracked circumferentially and natural gas filled the void beneath the pavement. Natural gas then migrated through the soil and into the basement of 423 North Fifth Street, where it ignited, exploded, and burned. Subsequent metallurgical examinations revealed that both cast-iron mains were significantly weakened by graphitic corrosion. The water main was installed in the late 1800s and the gas main was installed in 1903.

The Safety Board reviewed the operating and maintenance practices of both the city and UGI and previous natural gas accidents within the city. Based on these reviews, the Safety Board determined that:

- o Prior to August 29, 1990, two breaks had occurred on the 4-inch cast-iron main in the 400 block of North Fifth Street on January 15, 1981, and January 24, 1988.

<sup>1</sup>NTSB Brief of Accident File No. DCA90FP001 (attached).

- o Since 1970, UGI has averaged 1.2 reported incidents<sup>2</sup> per year on its cast-iron mains.
- o From 1925 to 1976, 10 persons were killed, 24 persons were injured, and 2 buildings were destroyed as the result of 2 gas explosions in the city of Allentown.
- o Since 1976, 3 persons were killed, 23 persons were injured, 6 buildings were destroyed, and 5 buildings were damaged as a result of 2 explosions in the city of Allentown.
- o The Allentown infrastructure contains many miles of small diameter (8 inches and less) cast-iron gas and water mains installed in the late 1800s and early 1900s that have likely been weakened by corrosion.
- o Water from leaking storm, water, and sewage lines has eroded and dissolved the soil supporting the water and gas mains and other structures creating sinkholes and other underground cavities beneath the city streets.
- o Heavy traffic loads, cracked pavement, and soil movement have increased the stress on buried cast-iron mains.
- o Although required by Federal Regulations (49 CFR 192.617), the UGI has not routinely submitted failed pipe segments, including cast-iron failures, for laboratory examination to determine the cause for the failure.
- o Although required by Federal regulations (49 CFR 192.613), the UGI has not implemented an adequate surveillance program to identify pipeline segments, including cast-iron segments, in its gas distribution system that require corrective action to minimize the threats to public safety.

In its investigation, the Safety Board found that the UGI's practices regarding cast-iron failures are not unique in the natural gas distribution industry. From previous investigations, the Safety Board has determined that current industry practices on cast-iron pipe replacement do not adequately identify and remove from service those gas mains that threaten public safety. The practices were found inadequate because they do not generally consider previous graphitization, corrosiveness of the soil, bending strength of small diameter pipe, leak history, and potential pipe damage in areas being

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<sup>2</sup>An incident means an event that involves a release of gas from a pipeline and a death, personal injury requiring hospitalization, or estimated property damage of \$50,000 or more (before July 1, 1984, the property damage amount was \$5,000).

renovated or subjected to major adjacent excavation operations. The Safety Board found that most gas operators, rather than submitting failed segments of cast-iron pipe for laboratory analysis to determine to what extent graphitization has weakened the pipe, normally do little more than install a leak clamp around the crack and keep the cast-iron main in operation. Some operators determine a pipe's condition merely by having workers scrape the pipe area adjacent to the crack with a knife blade or rasp to see if they can produce carbon shavings, a clear indication of severe graphitization. Some gas operators have implemented policies that called for replacing a cast-iron main within a city block after it has experienced three breaks and replacing cast-iron mains within a street intersection after two breaks.

In its 1986 report<sup>3</sup> on a natural gas explosion at Derby, Connecticut, that killed 6 people and injured 12 others, the Safety Board addressed the need for effective, programmed replacement of cast-iron gas mains. In that report, the Safety Board acknowledged that it had previously treated the cast-iron pipe failures on a case-by-case basis, making recommendations for corrective action only to the gas operator involved. The Safety Board also found that the number of miles of cast-iron pipe in gas distribution service had decreased over the years while the number of reportable accidents had remained relatively constant, indicating that the number of leaks per mile of cast-iron main was increasing. The Safety Board acknowledged that some large distribution operators had already begun identifying cast-iron systems prone to failure and established replacement programs. However, most operators had not, and no guidance existed at that time to assist or encourage them to develop cast-iron replacement practices. The Safety Board concluded that the industry should begin phasing out the cast-iron piping systems, many of which had been in service for more than 100 years.

In the years since the Safety Board's report, the industry has taken only limited action to encourage the replacement of deteriorated and aging cast-iron gas distribution systems. In 1986, the Gas Research Institute issued its report, "Cast Iron Maintenance Optimization System." This report contained a computerized evaluation model to assist operators in estimating the probability of breaks and leaks on individual segments of cast-iron gas mains, on evaluating repair versus replace options, and on identifying replacement priorities. Additionally, the American Gas Association (AGA) issued in 1990 a technical report, "Attention, Prioritizing, and Pipe Replacement/Renewal Decisions," that is a collection of papers to "provide a good overview of procedures in current use to maximize the benefits received from repair and replacement expenditures in existing gas systems." Those papers address:

- o Establishing annual maintenance and replacement budgets;
- o Establishing attention priorities for the sections of main that compromise a distribution system; and

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<sup>3</sup>For more detailed information, read Pipeline Accident Report-- "Northeast Utilities Service Company, Explosion and Fire, Derby, Connecticut, December 6, 1985" (NTSB/PAR-86/02).

- o Determining whether a troublesome section should be repaired or replaced.

Also, the Gas Piping Technology Committee recently approved guidelines to assist gas operators in developing cast-iron replacement policies, and the AGA will distribute these to each gas operator that has cast-iron piping systems.

The Safety Board is pleased that the gas industry now has an analytical tool and information on current repair/replacement practices, and soon should have guidelines to aid gas operators in establishing cast-iron system replacement policies. However, this research and development has taken five years and no assurance exists that the gas industry operators will implement in a timely manner effective cast-iron replacement programs to reduce threats to public safety.

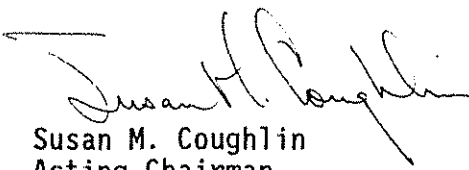
Therefore, the Safety Board recommends that the Research and Special Programs Administration:

Require each gas operator to implement a program, based on factors such as age, pipe diameter, operating pressure, soil corrosiveness, existing graphitic damage, leak history, burial depth, and external loading, to identify and replace in a planned, timely manner cast-iron piping systems that may threaten public safety.  
(Class II, Priority Action) (P-91-12)

Also, the Safety Board issued Safety Recommendations P-91-13 through -16 to UGI Corporation; P-91-17 to the National Association of Regulatory Utility Commissioners; and P-91-18 and -19 to the city of Allentown.

KOLSTAD, Chairman, COUGHLIN, Vice Chairman, and LAUBER and HART, Members, concurred in this recommendation. Member HAMMERSCHMIDT did not participate.

COUGHLIN, Acting Chairman, and LAUBER, KOLSTAD, HART, and HAMMERSCHMIDT, Members, concurred in the revision of this Safety Recommendation Letter.

  
 By: Susan M. Coughlin  
 Acting Chairman

NATIONAL TRANSPORTATION SAFETY BOARD  
WASHINGTON, D.C. 20594

Pipeline Accident Brief No. DCA90FP001

System Type:	Distribution	<b>6 AUG 1991</b>
Accident Type:	Explosion and Fire	
Location:	421-423 North Fifth Street Allentown, Pennsylvania	
Date:	August 29, 1990	
Time:	0513 local daylight time	
Owner/Operator:	UGI Corporation (UGI)	
Property Damage:	\$300,000	
Injuries:	1 Fatal 9 Nonfatal	
Material Released:	Natural Gas	
Pressure:	0.32 psig. (9 inches water column)	
Type Failure:	Overstress	
Component Affected:	Cast-Iron Main	

#### Description of the Accident

A natural gas explosion and fire destroyed two row houses at 421-423 North Fifth Street and damaged two adjacent houses and three parked cars in Allentown, Pennsylvania. Two of the injured were fire fighters.

Three hours before the accident, a police officer advised the Allentown after-hours dispatcher that water was leaking through pavement cracks in front of 421 North Fifth Street. The officer said that he believed that repairs could be deferred until the next day. Minutes after 5 a.m., a North Fifth Street resident notified the city of a gas odor in the area of 421 North Fifth Street and at 5:09 p.m., police and fire personnel arrived at the location. Four minutes later, the explosion occurred. Fire fighters and police evacuated residents from houses in the danger zone, and to eliminate potential gas leaks from piping in adjacent residences, they entered houses to close the gas valves at inside meter sets. When UGI employees arrived at 5:30 a.m., they began searching for leaking gas and discovered that several gas valves had not been turned off. They then shut off gas to the residences at the key-operated curb valves and then at meters where valves had not previously been closed. The UGI employees then continued their search for the source of the gas leak and discovered a broken cast-iron main beneath the street.

Investigation disclosed that water leaking from a cracked 6-inch cast-iron municipal water main had eroded the soil foundation beneath a 4-inch cast-iron UGI gas main. The gas main subsequently cracked due soil loads from above, releasing natural gas beneath the pavement. The gas migrated

through the soil and into the basement of 423 North Fifth Street, where it was ignited, exploded, and burned.

Excavation after the accident revealed that both the 6-inch cast-iron municipal water main and the 4-inch cast-iron UGI gas pipeline had cracked circumferentially. Sections of each of the pipelines were sent to the Safety Board's laboratory for metallurgical analysis. Analysis revealed that both mains contained areas of significant graphitic corrosion that weakened them. The failure of the gas pipe was inevitable even had the water not eroded its soil foundation because one area of the gas pipe wall was fully graphitized.

Numerous factors, individually and/or synergistically, have contributed to the integrity reduction and failure of Allentown, Pennsylvania's cast-iron gas and water mains, most of which were installed in the late 1800s and early 1900s. These include: leaks from storm and sewer lines, water migrating or percolating through the soil, karst development, sinkholes, graphitization, shifting and cracking pavement, increased traffic load, and overburden stress.

#### Probable Cause

The National Transportation Safety Board determines that the probable cause of the natural gas explosion and subsequent fire, involving the overstress fracture of an undermined and weakened segment of cast-iron gas main, was the failure of the UGI Corporation to adequately monitor the condition of its gas system and to timely replace cast-iron segments weakened by graphitic corrosion.

#### Recommendations

As a result of its investigation, the National Transportation Safety Board made the following recommendations:

--to the Research and Special Programs Administration:

Require each gas operator to implement a program, based on factors such as age, pipe diameter, operating pressure, soil corrosiveness, existing graphitic damage, leak history, burial depth, and external loading, to identify and replace in a planned, timely manner cast-iron piping systems that may threaten public safety. (Class II, Priority Action)(P-91-12)

--to the UGI Corporation:

Provide initial and recurrent training to local government emergency response personnel on how to control natural gas in emergency situations, including how to locate, identify, and operate outside key-operated shutoff valves. (Class II, Priority Action) (P-91-13)

Implement a comprehensive gas system surveillance program that: (1) identifies the type of data to be collected on gas system failures, gas leakage surveys, changes in corrosion protection levels, and abnormal operating and maintenance conditions; (2) establishes the type and frequency of analyses to be performed for identifying potentially unsafe conditions; and (3) specifies the corrective action to be taken. (Class II, Priority Action) (P-91-14)

Implement a cast-iron pipe replacement program, based on factors such as age, pipe diameter, operating pressure, soil corrosiveness, existing graphitic damage, leak history, burial depth, and external loading, to identify and replace in a planned, timely manner cast-iron piping systems that may threaten public safety. (Class II, Priority Action) (P-91-15)

Document the location of underground voids discovered during excavations and coordinate with the City of Allentown to develop systematic procedures for centrally reporting, documenting, and exchanging information on the location of underground voids. Class II, Priority Action)(P-91-16)

--to the National Association of Regulatory Utility Commissioners:

Encourage its member states to require that each gas operator implement a program, based on factors such as age, pipe diameter, operating pressure, soil corrosiveness, existing graphitic damage, leak history, burial depth, and external loading, to identify and replace in a planned, timely manner cast-iron piping systems that may threaten public safety. (Class II, Priority Action)(P-91-17)

--to the City of Allentown:

Coordinate with the UGI Corporation to obtain initial and recurrent training for emergency response personnel on controlling natural gas in emergency situations, including how to locate, identify, and operate outside key-operated shutoff valves. (Class II, Priority Action) (P-91-18)

Coordinate with known underground facility operators in the immediate Allentown vicinity to develop systematic procedures for centrally reporting, documenting, and exchanging information on the location of underground voids discovered through excavations or other means. (Class II, Priority Action)(P-91-19)