



National Transportation Safety Board

Washington, D. C. 20594

Safety Recommendation

Date: May 1, 1992

In Reply Refer To: P-92-6 through -13

Honorable Michael P. W. Stone
Secretary of the Army
The Pentagon
Washington, D.C. 20310-1000

On December 9, 1990, a gas system valve between one of Fort Benjamin Harrison's gas distribution systems and a discontinued steel gas system segment was inadvertently opened, allowing natural gas to enter residential buildings that had previously received their gas from the discontinued segment. Gas accumulating in building 1025 of Harrison Village was ignited by one of many available sources, such as electrical switches and appliances, and the resulting explosion killed 2 occupants and injured 24 other persons. One building was destroyed, and two were damaged.¹

The National Transportation Safety Board determines that the probable cause of the natural gas explosion and fire at Fort Benjamin Harrison was the failure of the Army to construct, maintain, and operate the Fort's gas distribution system in accordance with its own and the industry's standards. The result was the inadvertent opening of a valve to a discontinued steel gas main that allowed natural gas to leak into a residential building, where it ignited and exploded.

The provisions of the Army's TM 5-654 (its maintenance and operation manual) were not followed at the Fort. The lack of adherence is evident from the difficulties the Corps representative had in locating valves during the gas system modifications, the inadequacies of the gas system maps, the failure of the utilities branch to periodically inspect the system for leaks and corrosion, the lack of gas system maintenance and documentation, and the fact that many DIS employees had never heard of the manual.

¹For more detailed information, read Pipeline Accident Report--"Natural Gas Explosion and Fire, Department of Defense/Army, Fort Benjamin Harrison, Indianapolis, Indiana, December 9, 1990" (NTSB/PAR-92/01).

The failure of the Fort's management to carry out the Army's maintenance and operating procedures contributed to the difficulty of locating valves to isolate the leaking segment of pipeline and, after the gas system modifications, to leaving closed the two accessible valves adjacent to the east end of building 1026. If the required quarterly valve inspections and semiannual maintenance had been properly conducted, the inaccessible main line valve behind building 1026 could have been identified, and the problem might have been corrected long before the gas system modifications were begun. Also, during annual inspections of the gas system, the numerous deficiencies in the maps could have been discovered and brought to the attention of the Fort's management.

Documentation of the maintenance, repair, and modification of a gas system is essential to safe operations. The lack of documentation about the village system indicates that the Fort management was not assessing the condition of the system and determining the need for modifications and improvements. A pressure test and leakage survey done after the explosion revealed at least three leaks in the newly installed system. That the fire department had responded to 20 reports of gas leaks within 18 months should have been a warning that the village system was deteriorating and that the threat to the safety of the residents was increasing. Had the fire department management discussed with the DIS director the frequent gas leaks in the village, the discussion might have prompted an overall review of the village gas system that could have revealed the many deficient operating and maintenance conditions.

The maintenance and mapping deficiencies at the Fort were longstanding and were not brought to the attention of Army management before this accident, in part, because inspections were not being performed by knowledgeable persons independent of the Fort's management. State or Federal personnel inspect gas systems that are subject to DOT regulations, and deficiencies identified must be corrected. Gas operators can be ordered to correct specific faults and may also be fined or otherwise penalized. The Army needs to annually inspect its gas systems using qualified personnel and establish incentives that will induce military-installation management to comply with all provisions of the current maintenance and operation manual.

The Corps' specifications about the design, construction, and testing of gas pipeline systems at the time the modifications were made to the village gas system were incomplete and did not reflect current industry practices. The deficient specifications allowed the contractors to design and construct safety-critical facilities without proper regard for safety. Had Corps personnel been knowledgeable about industry practices, they would have been able to establish requirements for the proper abandonment of pipe, procedures for plastic pipe joining, qualifications for people who perform and inspect pipe joining, and the maximum operating pressure for pipelines.

The *Guide Specifications of Military Family Housing*, which was applicable to the design and construction of the village modifications, was even less specific about the design of gas system modifications. (This guide was canceled by the DOD in June 1990, before the accident.) Consequently, the architect had considerable design freedom and was not required to produce a proposal that adequately addressed specifications for the gas system. Also, the architect apparently was not current in his knowledge of gas system design. His specifications allowed the use of cast-iron pipe, which is no longer used by the industry; called for the installation of drips, which are not required on systems transporting dry natural gas; did not permit the

use of plastic pipe, which has long been the primary material used by the industry; and did not require proper abandonment of discontinued gas pipes.

The Corps' review of the architect's Phase I specifications and installation drawings, which included the gas system specifications, was cursory at best. The Corps could reasonably have been expected to check the architect's specifications to ensure that applicable safety requirements had been incorporated; however, no one at any stage of the review process identified that the architect needed to add abandonment requirements to his specifications.

The Corps had a second opportunity to improve the specifications. When the contractor substituted plastic for the pipe materials specified by the architect, the Corps should have then included plastic-pipe construction experience requirements for the contractor who installed the plastic pipe, required the contractor to qualify through tests the plastic fusion procedure to be used, required the qualification of the contractor's employees who made plastic fusion joints, and established the test pressure for the plastic system by specifying its maximum operating pressure. Additionally, the Corps should have required that its construction inspector be trained in inspecting plastic piping systems, including the making of fusion joints.

The Corps also reviewed the architect's Phase II specifications and, again, did not ask for any changes. The Corps took no exception to the architect's failure to specify the tie-in locations, to the lack of explicit specifications for the plastic pipe (the lack of which later permitted the contractor to select material that was incompatible with the pipe used in the Phase I construction), or to the fact that the locations of the Phase I piping and existing valves were not shown.

However, the most serious consequence of not analyzing the effect of the modifications on the village system was the failure to recognize the importance of specifying main tie-in locations. Depending on which map was used, a proper analysis should have identified that the tie-in adjacent to buildings 1026 and 1027 should have been located just west of the open valve shown behind building 1026. This would have continued the usefulness of the three valves adjacent to the east end of building 1026 as isolation valves, and it would have necessitated the physical separation from the gas system of the discontinued steel main behind buildings 1023 through 1026. The Phase II piping should have been tied into the steel main, not into the Phase I plastic main. Excavating the area to make the tie-in probably would have exposed the buried open valve, revealing a hazard that required correction. A system analysis would probably have also uncovered some of the mapping errors made over the years and the fact that valves were no longer being numbered as required by TM 5-654. Either finding should have prompted a more detailed investigation to determine the true locations of the mains and valves.

The Corps assigned only one inspector to each modification phase. The inspector was responsible for overseeing all work to be completed under the contract, including the installation of the gas system modifications. Neither inspector had experience in constructing gas systems, and the Corps had provided no training for them.

Even had the inspectors recognized the need to install the gas system differently, they would not have been able to force the contractor to alter his work. Their authority was limited to requiring adherence to those provisions explicitly stated in the contract. Because of the contract's lack of specificity and the inspectors' lack of experience, the contractors were able to construct the gas system

as they wished with little or no guidance from the Corps. However, the Corps' inspectors could have, and the Safety Board believes they should have, brought to the attention of their management any issue affecting safety that they were unable to resolve.

On August 13, 1991, the engineering division chief of the Army's Directorate of Military Programs advised the Safety Board of the following: military housing specifications could no longer be used as standards for designing or constructing pipeline systems; the Corps design and construction specifications for pipeline systems had been modified to include applicable provisions of the Federal DOT requirements and of industry-consensus standards, including provisions for abandoning pipe and for qualifying persons who join pipe; and those provisions were now part of any contract that included the construction of gas systems.

The Corps has also made procedural changes that should improve the quality of gas system designs. To avoid the fragmentation of utility system installation or modification, it now recommends that phased construction projects include in the first phase all necessary modifications to the gas and other utility systems. It also recommends the removal of all abandoned gas pipe.

The Corps evaluated its control and quality assurance programs on design projects. It found that each quality assurance team consisted of several junior or journey-level engineers and a senior engineer in each discipline who may or may not have had extensive experience. The Corps concluded that appropriate design experience is required for effective review and that assignment to a quality assurance team is not appropriate training for young, inexperienced engineers. The Corps determined that the team should include only experienced engineers, who would already have been exposed to various design solutions, and that maximum synergistic effects could be achieved by the rotation of experienced engineers between design and review responsibilities. The Corps also determined that the procedures being used in preparing contracts and defining the scope of design services were significantly out of date. Furthermore, often the procedures were not followed.

Neither the Corps management nor the DIS management responsible for the safety of gas pipelines recognized the hazards posed by the pipelines. When properly controlled, natural gas is a safe, efficient energy source that can be conveniently and unobtrusively provided through buried pipelines. However, to properly control these systems and to ensure gas distribution safety, each person assigned to any aspect of gas system design, construction, inspection, testing, operation, maintenance, or emergency response must be experienced and properly trained and equipped.

None of the Fort's employees interviewed during this investigation were familiar with the provisions of the 20-year-old gas system operation and maintenance manual. None had significant gas system experience. Also, the Army had not given them enough training to ensure that they understood how essential the correct performance of their responsibilities was to the safety of the village residents.

The selection process for personnel did not guarantee that the applicants chosen would have adequate knowledge of and experience with gas systems. No specific minimum qualifications about gas system knowledge and experience had to be met by those responsible for the quality control of the gas system modification

designs, for performing critical inspections of the construction, for the gas system operation and maintenance, or for handling gas system emergencies.

The Army's major commands delegate responsibility for gas systems to the commanding officer of each military installation; the Fort's management reports to the Army's Training and Doctrine Command, its major command. Chapter 2 of AR 420-10 states that the commanding officer of an installation is responsible for facilities engineering and housing at the installation, subinstallations, and support activities; for establishing formal procedures for efficient and effective engineering and housing management; for ensuring that backlogged and deferred maintenance and repair are reduced to, and maintained at, a level consistent with the Army's policy; for applying internal control and review procedures; for identifying deficiencies to the major command for assistance and resolution; and for submitting requests for assistance for work that cannot be accomplished within existing resources and capabilities.

The commanding officer has a military installation support officer who is responsible for the day-to-day management of support operations, such as housing, utilities, fire and police protection, and other services essential to the safe, continued operation of installations. The support officer, like all military officers, is subject to periodic reassignment to other bases. He or she must have an engineering background but is not required to have a working knowledge of all assigned systems and activities. The officer relies greatly on the capabilities of the installation's civilian work force.

AR 420-10 defines the general responsibilities of the various Army commands. The underlying premise of AR 420-10 is that higher-level commands, such as the Training and Doctrine Command, will provide management supervision and technical support and that they will monitor compliance through on-site assessments. However, during the Safety Board's investigation of this accident and during subsequent communications with Army managers, the Safety Board's staff was unable to identify any effective actions by higher commands that met the intent of AR-420-10 with respect to gas system safety. Furthermore, the Safety Board's investigators were unable to identify any effective program for periodically assessing the adequacy of the Army's gas pipeline safety policies, standards, programs, and directives.

Had qualified personnel periodically monitored the Fort's and the Corps' compliance with military gas pipeline safety standards, the problems addressed in this report could have been easily identified. Discussions with Fort personnel responsible for gas system safety would have revealed deficiencies in their knowledge, training, and emergency preparedness. Periodic monitoring would have, before the accident occurred, alerted the Secretary of the Army, the commanding general of the affected major command, the installation commander, and the director of installation support that specific improvements were necessary to ensure the continued safe operation of the village gas system.

The Safety Board is pleased that the Army has recognized the need for and has begun to take corrective actions. Nonetheless, the Army has not yet fully and effectively addressed the lack of oversight that allowed the village gas system to accumulate so many deficiencies without detection.

Consequently, the Safety Board believes that the Office of the Secretary of the Army needs to develop a program to periodically evaluate whether each major command's gas safety program adheres to Army policies and whether each Army installation is adhering to applicable safety standards and directives. To implement such a program, the Army must first evaluate each gas pipeline system to identify and correct deficiencies.

In addition, the Secretary of the Army should require that Army gas system operations comply with the Federal gas pipeline safety standards at 49 CFR 192, and he or she should implement effective qualification standards and training for Army personnel whose responsibilities may affect the safety of Army-operated gas systems. Finally, the Army needs to assess the adequacy of current procedures for selecting contractors and for deciding whether a contractor's work complies with applicable pipeline safety standards.

Therefore, the National Transportation Safety Board recommends that the Secretary of the Army:

Require that gas pipeline systems that are owned or operated by the Army be managed by persons qualified by experience and training in gas distribution system design, construction, and operations. (Class II, Priority Action) (P-92-6)

Require that all gas pipeline systems that are owned or operated by the Army conform to the operations and maintenance requirements of 49 *Code of Federal Regulations* Part 192, and require that all newly constructed gas pipelines that are owned or operated by the Army conform to the design, construction, and testing requirements of Part 192. (Class II, Priority Action) (P-92-7)

Identify and correct inaccuracies and omissions in maps for gas systems that are owned or operated by the Army. (Class II, Priority Action) (P-92-8)

Initiate annual assessments of adherence to design, construction, maintenance, and operations standards applicable to gas pipeline systems that are owned or operated by the Army, and require that all identified deficiencies be corrected. (Class II, Priority Action) (P-92-9)

Develop and conduct employee training and testing programs to annually qualify employees responsible for tasks, including emergency response ones, that may affect the safety of gas pipeline systems that are owned or operated by the Army. (Class II, Priority Action) (P-92-10)

Equip each employee who has responsibilities that may affect the safety of gas pipeline systems that are owned or operated by the Army with the necessary test, inspection, and repair equipment, and train him/her in the proper use of that equipment. (Class II, Priority Action) (P-92-11)


Explicitly require compliance with applicable U.S. Department of Transportation gas pipeline safety requirements in contracts that affect the construction, repair, and maintenance of gas pipeline systems that are owned or operated by the Army. (Class II, Priority Action) (P-92-12)

Establish standards and procedures to ensure that contracted work on all gas pipeline systems that are owned or operated by the army complies with applicable U.S. Department of Transportation gas pipeline safety requirements. (Class II, Priority Action) (P-92-13)

The National Transportation Safety Board is an independent Federal agency with the statutory responsibility "to promote transportation safety by conducting independent accident investigations and by formulating safety improvement recommendations" (Public Law 93-633). The Safety Board is vitally interested in any action taken as a result of its safety recommendations. Therefore, it would appreciate a response from you regarding action taken or contemplated with respect to the recommendations in this letter. Please refer to Safety Recommendations P-92-6 through -13 in your reply.

Also, the Safety Board issued Safety Recommendation P-92-14 to the Department of the Navy and Safety Recommendation P-92-15 to the Department of the Air Force.

COUGHLIN, Acting Chairman, and LAUBER, HART, HAMMERSCHMIDT, and KOLSTAD, Members, concurred in these recommendations.


By: Susan M. Coughlin
Acting Chairman