Log P-194

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

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Forwarded to:
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President
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1515 Wilson Boulevard
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SAFETY RECOMMENDATION(S)

P-82-6 and -7

On August 25, 1981, at 1:33 p.m., P.d.t., in downtown San Francisco, California, a 16-inch natural gas main owned by the Pacific Gas and Electric Company (PG & E) was punctured by a drill that an excavation contractor was using to set tiebacks for anchoring his excavation shoring. Escaping natural gas blew upward and carried into the Embarcadero Complex and other nearby buildings. There was no ignition; however, the gas stream entrained an oil containing polychlorinated biphenyl (PCB). Fall-out affected an eight-square-block area of the city's financial district covering buildings, cars, trees, pedestrians, police, and firemen. No one was killed or seriously injured, although many persons were sprayed with the PCB oil mist. 1/

The transmission and distribution (T&D) crews that responded to the emergency and reached the accident site immediately after the puncture were not trained in valve closure and did not have the necessary tools to close the valves. At 2:02 p.m., two crews, which had been working some distance away from the accident when dispatched, arrived. Shutdown of the 16-inch gas main to isolate the break on Battery Street affected a sizeable area since the main in the vicinity of the puncture was being fed from both directions. Emergency Operations Room (EOR) personnel used an Emergency Shutdown Diagram (ESD) to determine the valves which could isolate the break. This Diagram listed five valves to close to isolate the segment which included the break--two valves on either side of the break that were on the 16-inch main (No. 141 and No. 143) and three valves on two-way-flow laterals or loops (Nos. 140, 142, and 1512). Although the valve crew had successfully closed these five valves by 2:28 p.m., within an hour after the accident, gas continued to escape from the break.

Believing that valve 141 was leaking, EOR personnel checked another ESD to determine which additional valves to close for isolating the break. It was then determined that valve 297 was a part of an 8-inch loop (rather than a one-way tie-in as shown on the previously checked ESD) and was connected into the 16-inch main in a manner that

1/ For more detailed information, read Pipeline Accident Report--"Pacific Gas and Electric Company, Natural Gas Leak, San Francisco, California, August 25, 1981." (NTSB-PAR-82-1)

bypassed valve 141, allowing gas to be fed to the section of the 16-inch main containing the break. (Valve 297 was not listed as an emergency isolation valve on the first ESD that was checked, but was so noted on the other ESD.) The valve crew was then directed to close valve 297. The valve crew located a valve thought to be valve 297 and found it in the closed position. This was reported to the EOR as well as the fact that there was no identification tag on the valve. Gas continued to escape under pressure from the break, and the valve crew was again directed to check valve 297. At 2:46 p.m., the valve crew verified to the EOR that valve 297 was closed. (About 2 days after the accident, PG & E discovered that access to valve 297 had been paved over in 1978 and that the PG & E valve crew had checked a stub valve that was located about 35 feet east of valve 297 and which had no effect in controlling the flow of gas in the 8-inch loop.)

EOR personnel again checked the principal Emergency Diagram and found an additional feed into the 16-inch main north of the break. This feed was controlled by either valve 489 or valve 486, neither of which was listed as a valve to be closed for controlling gas into the main section that included the break. Valve 489 was ordered closed which was accomplished at 3:04 p.m. However, gas continued to escape under pressure from the break.

EOR personnel concluded that either valve 297 (which they believed to be closed) or valve 141 was leaking. Therefore, the valve crew was directed to close three second line valves that were listed on a supplemental ESD in an attempt to stop the flow of gas from the east, even though this meant interrupting gas service to a larger number of customers. The valve crew closed valve 760 and valve 405 at 4:08 p.m. and 4:12 p.m., respectively. At 4:45 p.m., the valve crew attempted to close valve 1235, the third valve, but was unable to turn the valve stem. (PG & E maintenance records showed that the annual inspection of valve 1235 was made on August 10, 1981, 15 days before the accident.)

Gas supplied from the 16-inch high-pressure main serves a low-pressure system, with the high pressure being reduced by an operating regulator in pit No. 194 and the system being protected by a normally open monitor regulator in pit No. 194A. These pits are located on Pine Street within four blocks of the break. While the valve crew was closing the above referenced valves, another crew was observing a gas pressure recording chart which was sensing the gas pressure between the operating regulator and the upstream monitor regulator. Because the monitor regulator is open in normal operations, the pressure indicated on the chart is that of the high-pressure system. Because several valves had now been closed which limited the quantity of gas being fed to this segment of 16-inch main, pressure in the 16-inch main dropped below 3.5 psig at 4:08 p.m., and the monitor regulator closed. (The monitor regulator requires a pressure differential of 15 psig between the inlet and outlet to remain fully open, and is throttling the gas flow at pressure differentials ranging from 3.5 to 15 psig.) The operating regulatory also closed because of inadequate pressure differential. The pressure recording chart now was sensing only the pressure in the section of pipe between the operating and monitor regulators and indicated 0 psig. The crew, not realizing that both regulators were closed and believing that the pressure recording chart still indicated the pressure of the 16-inch main, reported to the EOR the 0 psig reading for the 16-inch main. The EOR personnel did not know the reason for the 0 psig reading but were aware that gas under pressure was still escaping from the break. Pressure began building up again in the high-pressure system and when the pressure exceeded 3.5 psig, the monitor regulator began to open and the regulators began supplying gas to the low-pressure system again.

At 5:45 p.m., although gas was still escaping from the puncture, the PG & E repair crew believed that it could stop the escape of gas by putting a repair sleeve over the puncture and welding it. The PG & E repair crew had difficulty holding the repair sleeve over the puncture because as the crew positioned the sleeve over the puncture, gas pressure at the puncture would build up and cause gas to leak around the sleeve. The crew then decided to fit the sleeve with a vent to reduce the gas pressure against the sleeve. The use of the vent and the "dumping" of gas into the low-pressure system four blocks away sufficiently reduced pressure on the 16-inch main to enable the crew to weld the sleeve. The PG & E crew stopped the escape of gas completely at 10:43 p.m., 9 hours and 10 minutes after the puncture.

PG & E's preplanning for emergencies and its prompt implementation of the EOR was a positive action which should have been able to control this emergency within a matter of minutes after the accident and long before escaping gas contained significant amounts of PCB's. Rapid isolation of the segment of main containing the break was impaired by several factors. First, company personnel first arriving at the site were not trained or equipped to close valves and valve crews had to be dispatched. The Safety Board believes that with minimal training and access to valve wrenches, the EOR would have been able to direct these employees by radio to the appropriate valves for closure which could have saved 20 minutes in attempting to isolate the section. (At the Board's November 3, 1981 public hearing on this accident, a PG & E official stated that consideration was now being given for training employees other than valve crews to operate isolation valves during emergency situations.)

A second factor preventing prompt isolation of the break was the use by the EOR personnel of an inaccurate ESD. According to the principal ESD, the initial actions of the EOR personnel were correct and should have quickly isolated the section of main that included the break; however, valves 297 and 489 were not properly listed on this diagram as emergency isolation valves. What should have been an orderly, preplanned shutdown because of PG & E's preplanning efforts became an impromptu situation and required hurried reviews of ESD's and other company records.

A third factor which diminished the ability of the EOR personnel to isolate the section of main which included the puncture was the result of deficiencies in PG & E's maintenance operations for emergency isolation valves. Not only was valve 297 not shown on the principal ESD as an isolation valve, it also was not listed on the annual inspection list which is the means PG & E used to assure that emergency valves were inspected, greased, and partially operated at least once each year. This deficiency allowed valve 297 to be paved over in 1978 without PG & E instituting any action to assure that this valve remain accessible. The fact that PG & E was not aware that the valve was inaccessible contributed to the valve crew checking a valve 35 feet from valve 297 and reporting to the EOR personnel that valve 297 was closed when, in fact, valve 297 was open. Had the EOR personnel provided the available location information to the valve crew and directed that a positive identification be made of valve 297 (the valve located by the valve crew as 297 had no valve identification tag to enable positive identification), the inaccessibility of valve 297 would have been known promptly to EOR personnel and they would have recognized earlier that a greater area would have to be isolated to stop the flow of gas to the break. While the EOR personnel soon did expand the area of isolation, this attempt was thwarted because valve 1235 could not be operated. The failure of EOR personnel's actions to isolate the section of main containing the break in combination with the urgency to stop the flow of gas then entraining PCB laden oil apparently influenced PG & E to attempt repair of the break without first isolating the gas main thereby accepting a somewhat higher hazard to its employees.

Shutdown procedures were further complicated by the observation of pressures on a recording chart being sensed between a primary regulator and an upstream monitor regulator. These regulators were located in separate regulator pits which served the low-pressure system and were supplied gas from the 16-inch high-pressure main. The chart showed line pressure on the 16-inch main during normal operations while the monitor regulator remained open; however, when the line pressure dropped below the 15 psig pressure needed to keep the monitor regulator fully open, the regulator began throttling the gas flow until the pressure dropped to 3.5 psig and the regulator closed. The assumed line pressure then fell to zero, and yet the actual pressure at the break was still too high to permit installation of a repair patch.

The Safety Board is concerned about the number of accidents caused by excavation undertaken without prior notification to the utility companies, and the problems due to poor maintenance which prevent a rapid shutdown in emergencies.

As a result of its investigation of this accident, the National Transportation Safety Board recommends that the American Gas Association:

> Advise its member companies of the circumstances of this accident and urge that they review their procedures for designating emergency valves and for maintaining emergency shutdown facility drawings to assure that they are current and accurate. (Class II, Priority Action) (P-82-6)
>
> Advise its member companies to emphasize to their maintenance personnel the importance of checking the operation of emergency valves during annual inspections. (Class II, Priority Action) (P-82-7)

BURNETT, Chairman, GOLDMAN and BURSLEY, Members, concurred in these recommendations. McADAMS, Member, did not participate.

Patricia A. Goldman

By: Jim Burnett for
Chairman