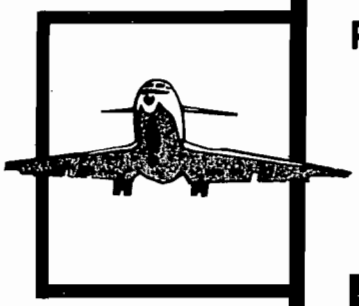

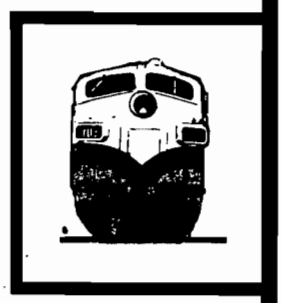

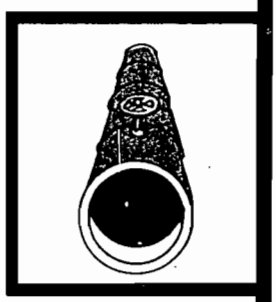

PB82-916501

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

PIPELINE ACCIDENT REPORT

PACIFIC GAS & ELECTRIC COMPANY
NATURAL GAS PIPELINE PUNCTURE
SAN FRANCISCO, CALIFORNIA
AUGUST 25, 1981

NTSB-PAR-82-1

UNITED STATES GOVERNMENT

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. NTSB-PAR-82-1	2. Government Accession No. PB82-916501	3. Recipient's Catalog No.
4. Title and Subtitle Pipeline Accident Report - Pacific Gas and Electric Company, Natural Gas Leak, San Francisco, California, August 25, 1981		5. Report Date February 25, 1982 6. Performing Organization Code
7. Author(s)		8. Performing Organization Report No.
9. Performing Organization Name and Address National Transportation Safety Board Bureau of Accident Investigation Washington, D.C. 20594		10. Work Unit No. 3365A 11. Contract or Grant No.
12. Sponsoring Agency Name and Address NATIONAL TRANSPORTATION SAFETY BOARD Washington, D. C. 20594		13. Type of Report and Period Covered Pipeline Accident Report August 25, 1981 14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract At 1:33 p.m., P.d.t., on August 25, 1981, a 16-inch natural gas main at Sacramento and Battery Streets in San Francisco, California, owned by Pacific Gas and Electric Company, was punctured by a drill that an excavation subcontractor was using to set tiebacks for anchoring excavation shoring. Natural gas escaping at a pressure of 32 psig blew upward and carried into nearby buildings. There was no ignition; however, the gas entrained oil containing polychlorinated biphenyl (PCB). The natural gas escaped to the atmosphere but the fall-out of the PCB-oil as a mist contaminated an eight-square-block area of the city's financial district covering buildings, cars, trees, pedestrians, police, and firemen. Approximately 30,000 persons were safely evacuated from the area within 45 minutes. No one was killed or seriously injured, although many persons, automobiles, and buildings were sprayed with the PCB-oil mist.

The National Transportation Safety Board determines that the probable cause of the accident, involving the puncture of the 16-inch gas main, was the failure of the general contractor to comply fully with the terms of the excavation permit which required him to verify the location of underground facilities that might be affected by the project. Contributing to the accident was the failure of the subcontractor, who knew of the existence of the gas main, but not its precise location, to ascertain that the gas company had been notified before commencing excavation. Contributing to the duration of the gas leakage was the gas company's inability to locate one emergency valve because of inaccurate recordkeeping, and because it had been paved over; and to close another valve which was inoperative because of inadequate maintenance.

17. Key Words	18. Distribution Statement
Puncture; drill; tieback; excavation; shoring; encroachment; PCB; entrained oil; background level; cleanup; drip; scrubber; rapid shutdown; emergency valves; valve crews; one-call system; rapid response	This document is available to the public through the National Technical Information Service Springfield, Virginia 22161. (Always refer to number listed in item 2)

19. Security Classification (of this report)	20. Security Classification (of this page)	21. No. of Pages	22. Price
UNCLASSIFIED	UNCLASSIFIED	29	

NTSB Form 1765.2 (Rev. 9/74)

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PIPELINE ACCIDENT REPORT

Adopted: February 25, 1981

PACIFIC GAS AND ELECTRIC COMPANY
NATURAL GAS LEAK
SAN FRANCISCO, CALIFORNIA
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SYNOPSIS

At 1:33 p.m., P.d.t., on August 25, 1981, a 16-inch natural gas main at Sacramento and Battery Streets in San Francisco, California, owned by Pacific Gas and Electric Company, was punctured by a drill that an excavation subcontractor was using to set tiebacks for anchoring excavation shoring. Natural gas escaping at a pressure of 32 psig blew upward and carried into nearby buildings. There was no ignition; however, the gas entrained oil containing polychlorinated biphenyl (PCB). The natural gas escaped to the atmosphere but the fall-out of the PCB-oil as a mist contaminated an eight-square-block area of the city's financial district covering buildings, cars, trees, pedestrians, police, and firemen. Approximately 30,000 persons were safely evacuated from the area within 45 minutes. No one was killed or seriously injured, although many persons, automobiles, and buildings were sprayed with the PCB-oil mist.

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INVESTIGATION

The Accident

Turner Construction Company (Turner) had contracted to build a high-rise office building at a site bounded by Halleck, Battery, and Sacramento Streets in downtown San Francisco, California. (See figure 1.) On August 25, 1981, a construction crew of J. H. Pomeroy, Inc. (Pomeroy), a subcontractor for Turner, was excavating for the foundation of the proposed building. The crew had driven steel sheet piles into the ground around the periphery of the site. Before the crew could continue to deepen the excavation in the area encompassed by the sheet piles, it was necessary to drill holes through the piles extending below the adjacent street to set anchors or tiebacks which would later be attached to the sheet piles to hold them in place when excavation resumed (see figure 2). The 8-inch holes were to be drilled at a 30-degree angle with the horizontal pavement.

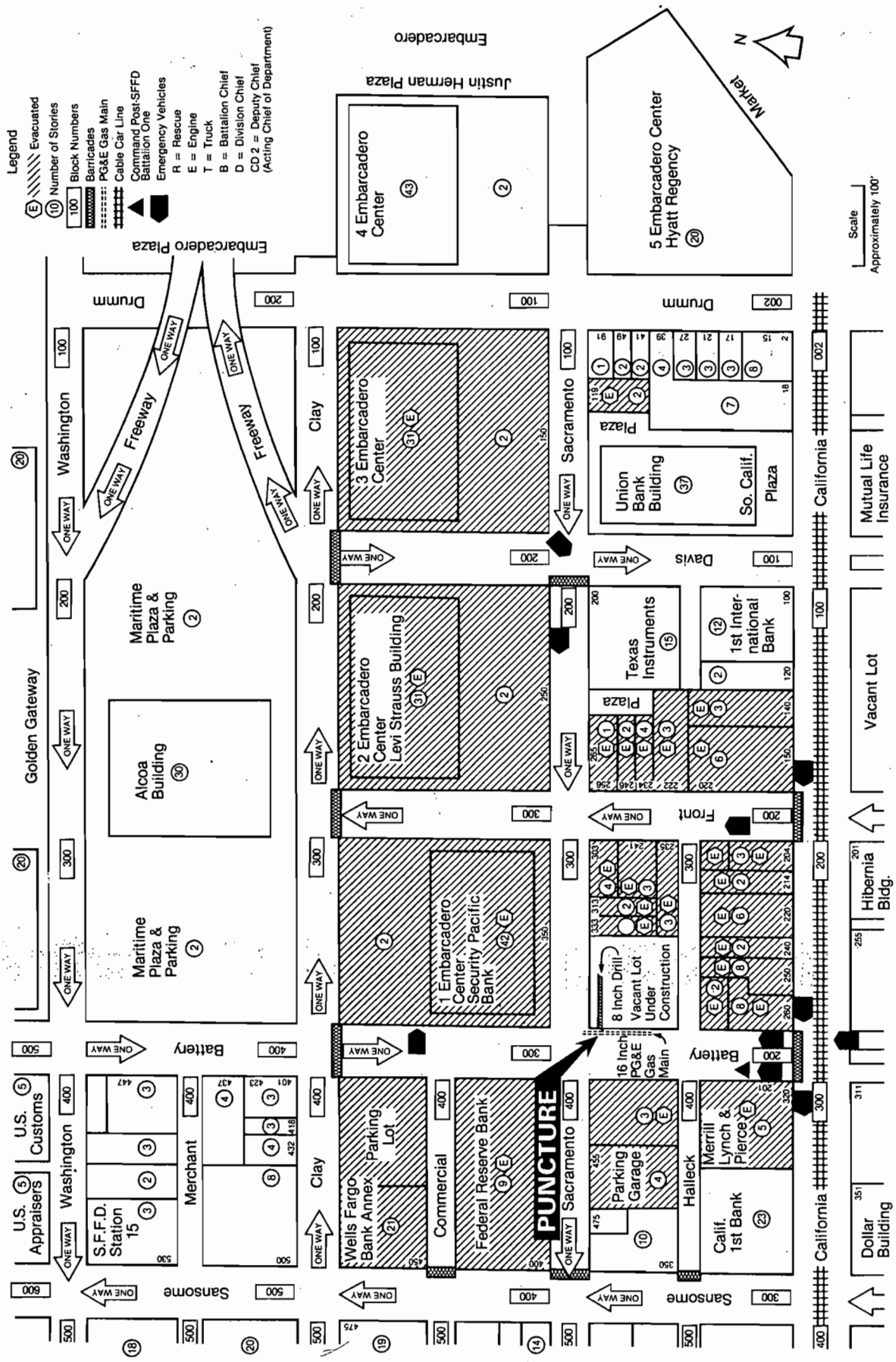
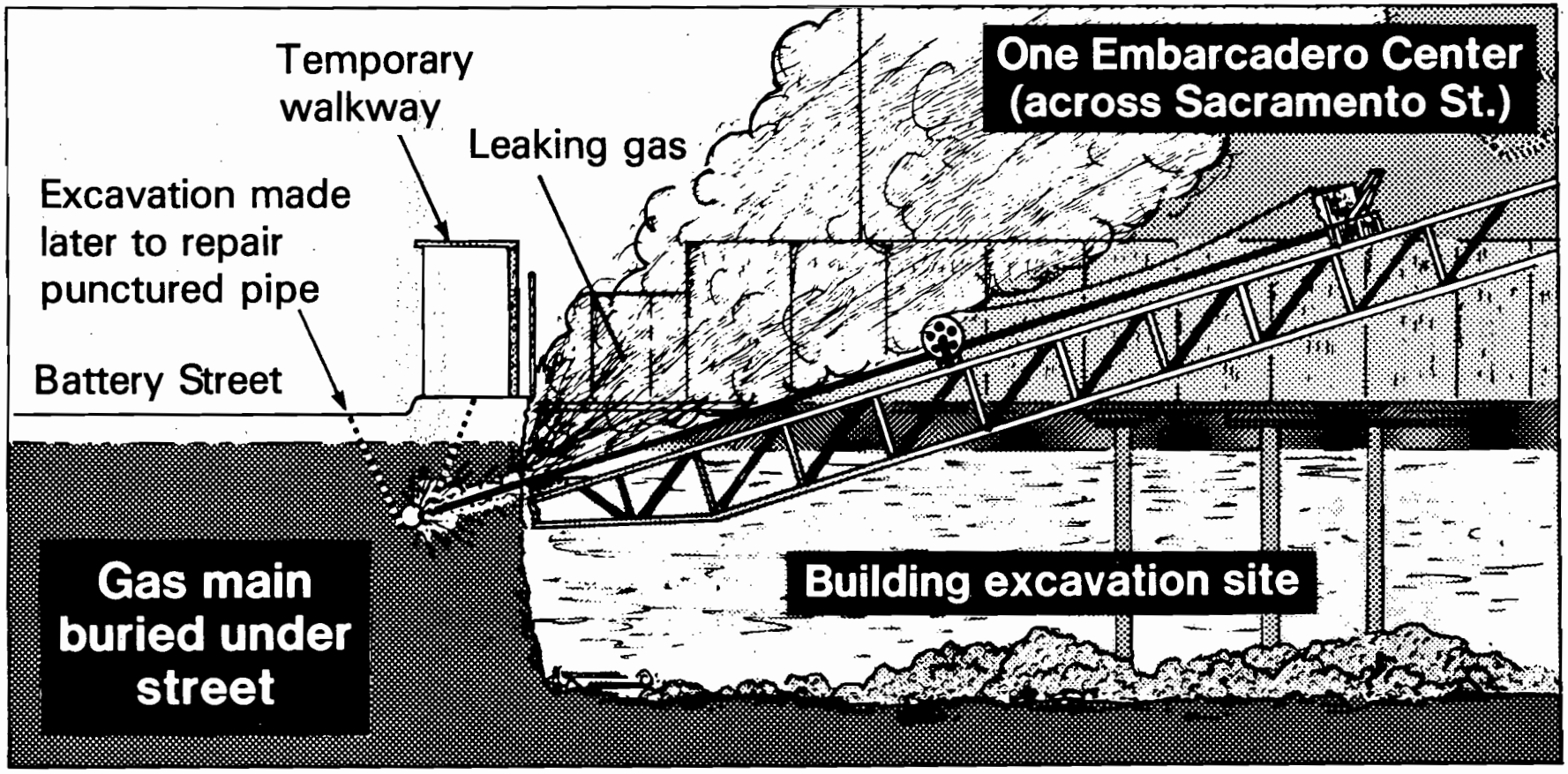


Figure 1.—Accident area, downtown San Francisco.



Adapted from San Francisco Examiner graphics

Figure 2.—Illustration of tieback drill puncturing gas main.

Turner had marked locations on the pilings where the holes were to be drilled for emplacing the tieback system. Pomeroy was to drill approximately 10 tieback holes under Battery Street. Because the crane and the drilling equipment happened initially to be located at the position for tieback hole No. 3, 1/ the crew decided to drill at that hole first. After the crew had drilled about 6 feet into the ground laterally at a 30-degree angle under Battery Street, the 8-inch-long drill bit hit something and snapped off. The crew abandoned its attempt to continue drilling hole No. 3 at that time and moved the drill unit to the position for drilling hole No. 1. No attempt was made to ascertain what the drill bit had hit or why it had snapped off. The crew then began drilling tieback hole No. 1, and at 1:33 p.m. on August 25, 1981, the drill hit and punctured a 16-inch steel Pacific Gas and Electric Company (PG & E) gas main located 40 inches beneath Battery Street near the corner of Sacramento Street. Natural gas under an initial pressure of 32 psig erupted through the pavement, showered the area with stones and debris, and escaped upward toward the several multistory buildings (offices, stores, restaurants, and a hotel) comprising the Embarcadero complex. No ignition occurred. Pomeroy personnel still in the excavation area ran to safety. The engines on the drill, the crane, and the trucks were left running. This equipment was at a lower general elevation than the venting gas.

One of PG & E's transmission and distribution (T & D) crews was working a block away and heard the gas blowing. The foreman ran to the accident site and then back to his truck where he radioed news of the main break to PG & E at 1:39 p.m. The San Francisco Fire Department had received a telephonic report of the gas main puncture at 1:36 p.m. and had called the PG & E gas dispatcher to inform him that a contractor had struck a gas main at Battery and Sacramento Streets. PG & E activated its Emergency Operations Room (EOR) at 1:40 p.m., and gas company personnel, supervisors and crewmembers, were either dispatched to the accident site or responded on their own initiative upon hearing radio reports of the gas main puncture. Additional servicemen and street crews (T & D Department) arrived and were soon joined at the accident site by Claims Department and other personnel from PG & E headquarters which was located only four blocks away at Beale and Market Streets.

The 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 valve 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. (See figure 3.) EOR personnel used the Emergency Shutdown Diagram (ESD) for Section 224 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). EOR personnel ordered that these valves be closed and closure was accomplished as follows:

Valve No. 141, 2:09 p.m.
Valve No. 143, 2:15 p.m.,
Valve No. 140, 2:15 p.m.,
Valve No. 1512, 2:24 p.m.,
Valve No. 142, 2:28 p.m.

1/ Tieback holes were designated numerically 1 to 10 from north to south beginning at Sacramento Street.

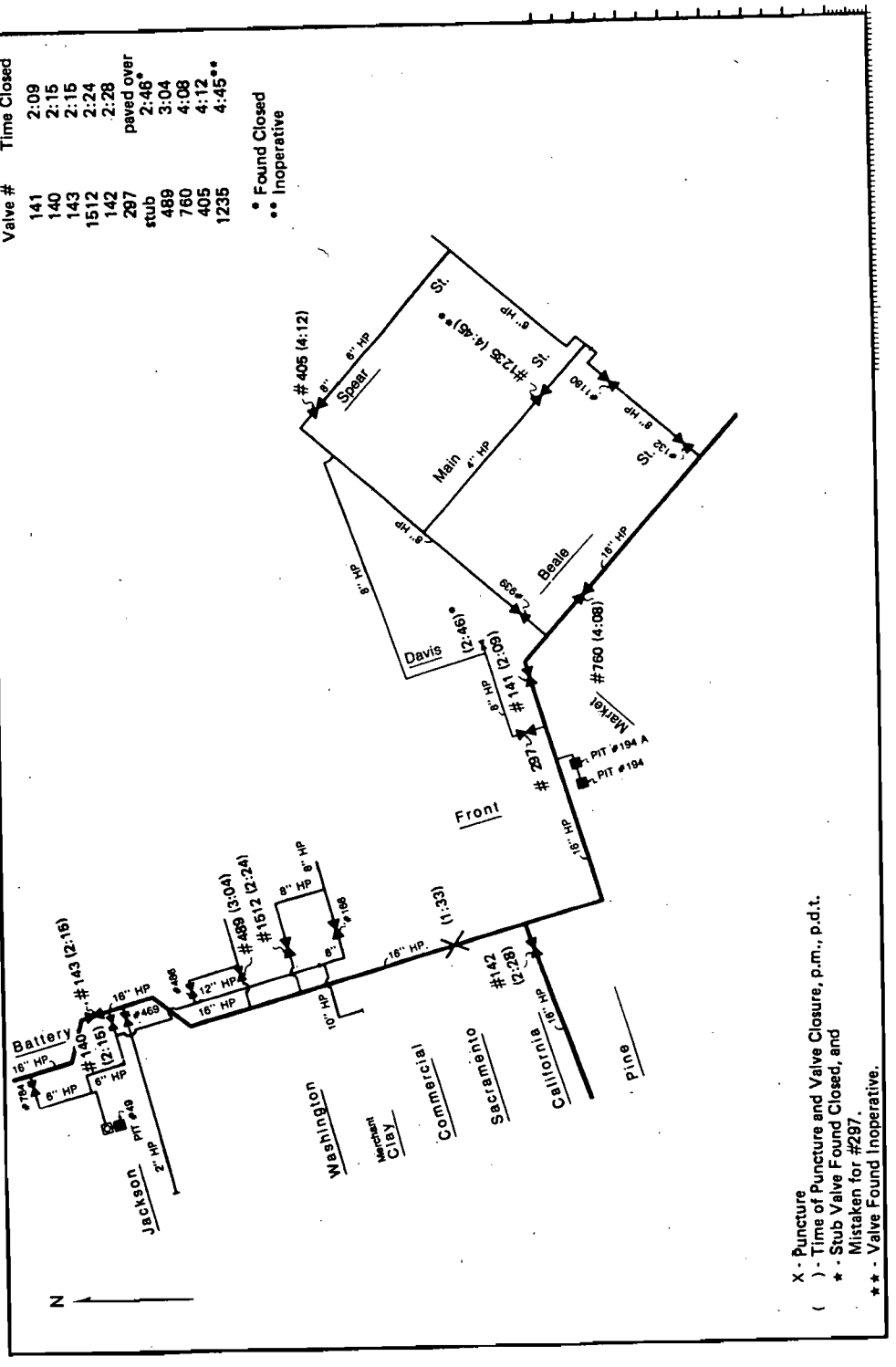


Figure 3.—Schematic diagram of shutdown valves.

Although the valve crew had successfully closed these five valves by 2:28 p.m., gas continued to escape from the break.

Believing that valve 141 was leaking, EOR personnel checked ESD 6B 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 ESD 224) and was connected into the 16-inch main in a manner that bypassed valve 141, allowing gas to be fed to the section of the 16-inch main containing the break. (Valve 297 was not listed on ESD 224 as an emergency isolation valve, but was so noted on ESD 6B.) 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 Emergency Diagram 224 and found an additional feed into the 16-inch main north of the break. This feed could be 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 ESD 6A 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. (See figure 3.) 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 rom 3.5 to 15 psig.) The operating regulator 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 enabled the crew to position the patch and begin welding the sleeve. While welding progressed, pressure was reduced by venting gas to the atmosphere by use of a blow-off at valve No. 141; and the low-pressure pits were bypassed in order to further reduce pressure. The PG & E crew stopped the escape of gas completely at 10:43 p.m., 9 hours and 10 minutes after the puncture.

Emergency Response and Evacuation

The San Francisco Fire Department received a telephone report of the gas main puncture, and firemen and policemen began arriving at the accident site at 1:43 p.m. The police department began clearing the immediate area of persons not involved in the operations. Because of the urgency indicated by radio accounts of the situation, the Deputy Chief of the San Francisco Fire Department ordered by radio at 2:00 p.m. that a command post be established. When he arrrived at 2:15 p.m., the evacuation of all buildings within a two block area was in process. After evaluating the situation, he expanded the evacuation area to six square blocks.

Escaping gas was blowing toward Embarcadero Building No. 1, located on the north side of Sacramento Street across from the excavation site. (See figure 1.) The evacuation of the 42-story Embarcadero Building No. 1 without the use of elevators was commenced immediately and was completed within 17 minutes, at approximately 2:00 p.m. PG & E personnel used gas detectors to check the building for gas, and firemen and PG & E personnel also utilized gas detectors to check nearby buildings, surveying primarily Embarcadero No. 1 and Embarcadero No. 2. They initially obtained readings of 3-percent gas concentrations, which approached the lower combustible limit. Because Embarcadero operations personnel had promptly shut down the street level and podium level air intake systems to preclude additional gas being drawn into the buildings, the concentration of gas in the buildings soon diminished. Because a combustible mixture of gas never existed in Embarcadero Building No. 2 and no gas was ever detected in Embarcadero No. 3, these building were evacuated with the use of elevators. Some 35 persons, including 20 fire safety directors, 2/ helped supervise the evacuation. Complete evacuation of the entire Embarcadero Center, which contained half of the estimated 30,000 persons evacuated from buildings in the area, was completed within 45 minutes. The buildings were then searched to verify that all persons had been evacuated.

Entrained PCB Oil Mist

At approximately 2:46 p.m., a little more than 1 hour after the main was punctured, a heavy, dark, oil mist began to appear with the escaping gas and coated buildings, automobiles, shrubbery, and persons in its path. (See figure 4.) At 2:47 p.m., immediately upon being notified of the appearance of the oil mist, PG & E's division engineer went to the accident site to obtain a sample. PG & E was concerned about the oil report because of its possible PCB content. (PCB had been introduced into its gas transmission system in

2/ Employees trained to serve as fire safety directors among their other duties.

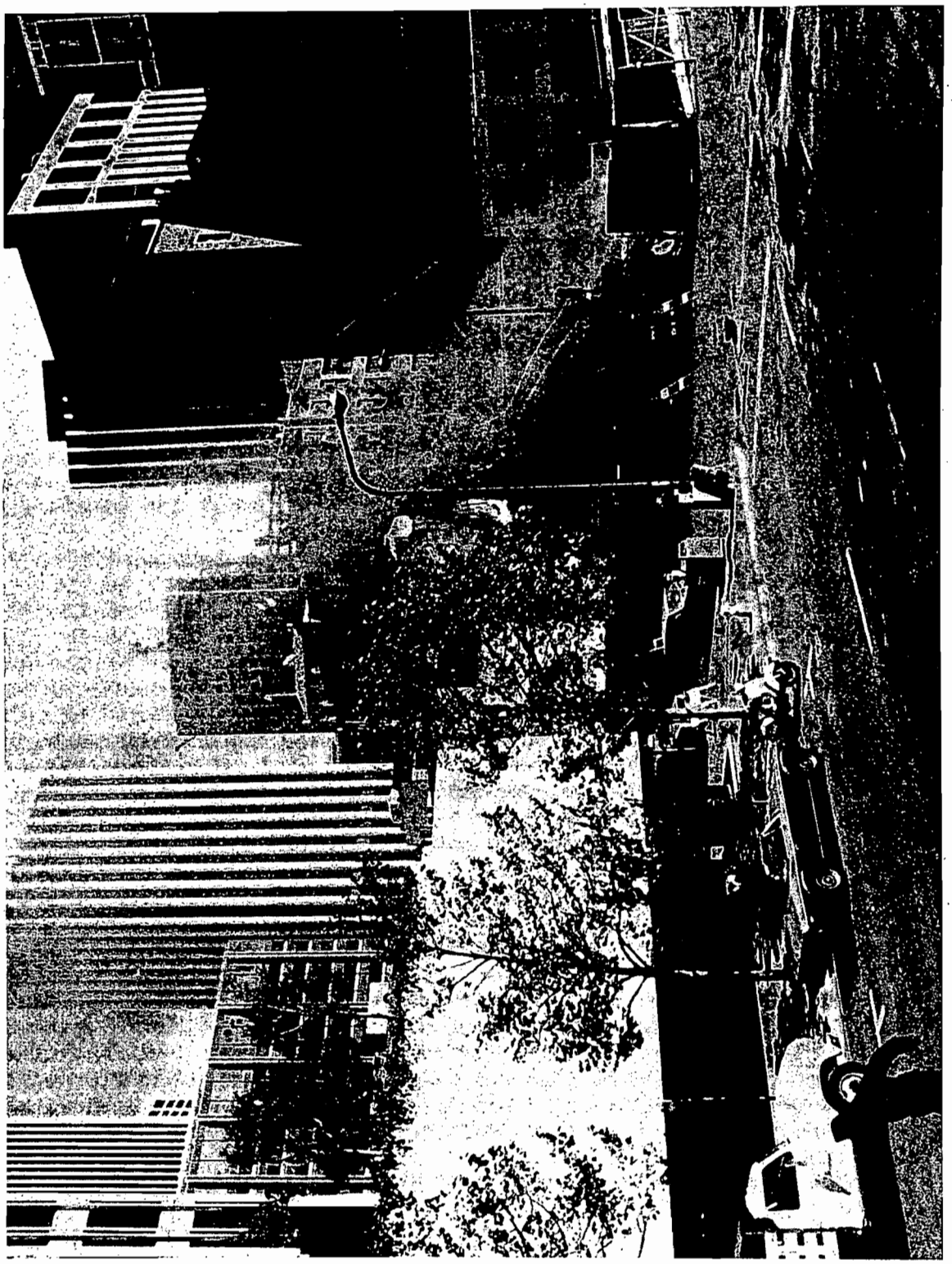


Figure 4.--Photograph of blowing gas.

the 1950's and early 1960's when used electrical transformer oil containing PCB was utilized in oilbath scrubbers upstream of three gas compressor stations. Oil carried over from the scrubbers and moved downstream where it dropped out finally in the distribution piping. PCB had been detected in the company's gas pipelines early in 1981.) Oil samples were delivered to a laboratory at 4:00 p.m., and at 4:50 p.m., the laboratory reported that the sample was "clean"; however, after additional tests were made at 6:20 p.m., the presence of PCB was established. At 7:45 p.m., the laboratory reported 25 parts per million (ppm) PCB. Early the following morning a further analysis revealed 33 ppm PCB.

The Deputy Chief of the Fire Department, not satisfied with initial reports that the oil was "clean", requested the assistance of the Deputy Director of the California Occupational Safety and Health Administration (CAL-OSHA), who arrived at the accident site before 5:00 p.m. At 5:30 p.m., after conferring with PG & E and learning that the presence of PCB had not been revealed by sample analysis prior to that time, the Deputy Director, wearing protective clothing, took three "wipe" samples (specimens obtained by wiping a given surface area with a small patch of absorbent cloth). At 6:00 p.m., these were taken to the California State Laboratory at Berkeley for analysis. Test results there indicated the presence of PCB ranging between 100 and 300 micrograms per square centimeter. 3/

Notwithstanding the "clean" readings, PG & E called in a cleanup crew at 5:15 p.m. The fire department had already requested the help of the San Francisco Department of Public Works (DPW), and its sand trucks reached the accident site at 4:24 p.m. Requests for help, several of which were initiated prior to confirmation of PCB contamination, were directed to the U.S. Coast Guard, U.S. Environmental Protection Agency (EPA), Stauffer Chemical Company, California Department of Agriculture, and the City's Department of Public Health. Hazardous waste and chemical cleanup contractors hired by PG & E washed down the buildings and used sand provided by the DPW to absorb the oily residue on the streets and sidewalks. A toxic waste disposal contractor later disposed of the sand. The City's Department of Public Health established a cleanup standard of 2 ppm PCB, based upon attainability which the cleanup contractor assured the Department could be reached and which was considered to be the background level of PCB in San Francisco. Final cleanup, which achieved the standard, was completed in 2 weeks.

Events Preceding the Accident

In December 1980, Tronoff Associates prepared a topographic and utility survey for Daon Corporation as an initial activity in preparation for the construction of a 23-story high-rise building. The survey showed surface and underground utility lines on Sacramento, Battery, and Halleck Streets, the three streets bordering the construction site. A field survey located existing surface utilities but all underground utilities were posted from records of the utility companies and were so indicated on the survey drawing by a utility note.

On April 16, 1981, Turner Construction Company, the general contractor for the high-rise building, sent a copy of the topographic and utility survey to the consulting engineer who was to make the shoring design calculations and plans for Pomeroy, the excavation and shoring subcontractor for Turner. The consulting engineer did not

3/ Test results reported in "micrograms per square centimeter" are quantitative area measurements, whereas "parts per million" is a quantitative volumetric measurement. The area and volumetric measurements do not correlate.

contact PG & E for additional information and used the survey drawing to establish a 6-foot separation between the 16-inch gas main and the curb line where the sheet pile was to be driven. Based on his past experience, the consulting engineer said that he assumed that the gas main was at a depth of 2 feet.

The consulting engineer's design requirements specified that the tieback be installed at a 30-degree slope below horizontal by drilling through a hole in the sheet pile at an elevation of +101 feet, 4/ with the top of the sheet pile to be at +102 feet. The consulting engineer calculated that this would provide clearance of over 1 foot beneath the gas main for the tieback. The surface of Battery Street over the gas main was also at an elevation of +102 feet. (Tiebacks are usually set at a greater depth but soil conditions were more favorable near the surface in this instance.) Before drilling for the tiebacks was started, Turner requested field adjustments be made to lower the entry elevation of the holes in the street piles for the tiebacks by 1 foot; the consulting engineer approved the request.

The consulting engineer did not post the location of the gas main on his drawings, but did include several cautionary notes in "Driving Criteria for Sheet Piles and Procedures for Installation of Tiebacks" which indicated the general contractor's responsibility for the protection of utilities. These notes related to the monitoring, supporting, moving, and removing of utilities but did not expressly require a check on their locations with the utility companies.

On April 23, 1981, Turner made a telephonic request to PG & E for maps showing the location of underground facilities in the area of Battery Street, from Sacramento to Halleck Streets. The maps mailed to Turner by PG & E were clearly stamped "NOT RESPONSIBLE FOR ACCURACY" and "FOR STUDY PURPOSES ONLY," and were similar to the maps Tronoff had been furnished by PG & E and which Tronoff used in preparing the topographic and utility survey. (See figure 5.)

On May 11, 1981, the city's Department of Public Works issued demolition permits to a contractor to raze two of the three existing buildings at Daon construction site.

On May 21, 1981, PG & E abandoned its gas service to the existing buildings on the intended construction site. At that time, an architectural firm contacted PG & E's marketing department regarding gas (and electric) service for the newly planned high-rise building at Battery and Sacramento streets.

In response to a request made during July 1981, through the one-call notification system, PG & E had marked the lateral location of its gas mains with yellow paint on the streets above the pipeline around the excavation site. Harding-Lawson Associates had made this request prior to its drilling ground water monitor wells. Five further requests were made through the one-call system regarding the location of Harding-Lawson's ground water monitoring wells in order to resolve conflicts with underground utilities. One of these changes involved the abandonment of a well which would have been at the approximate location where the 16-inch main was punctured.

On July 17, 1981, the City's Department of Public Works approved a permit which granted Turner permission to "excavate and shore in Sacramento, Battery and Halleck Streets for the purpose of constructing the foundation for ...(a high-rise building)...

4/ Elevations refer to the San Francisco City Datum which equates to 8.616 feet above mean sea level but which was originally set at 6.70 feet above a specified high water mark.

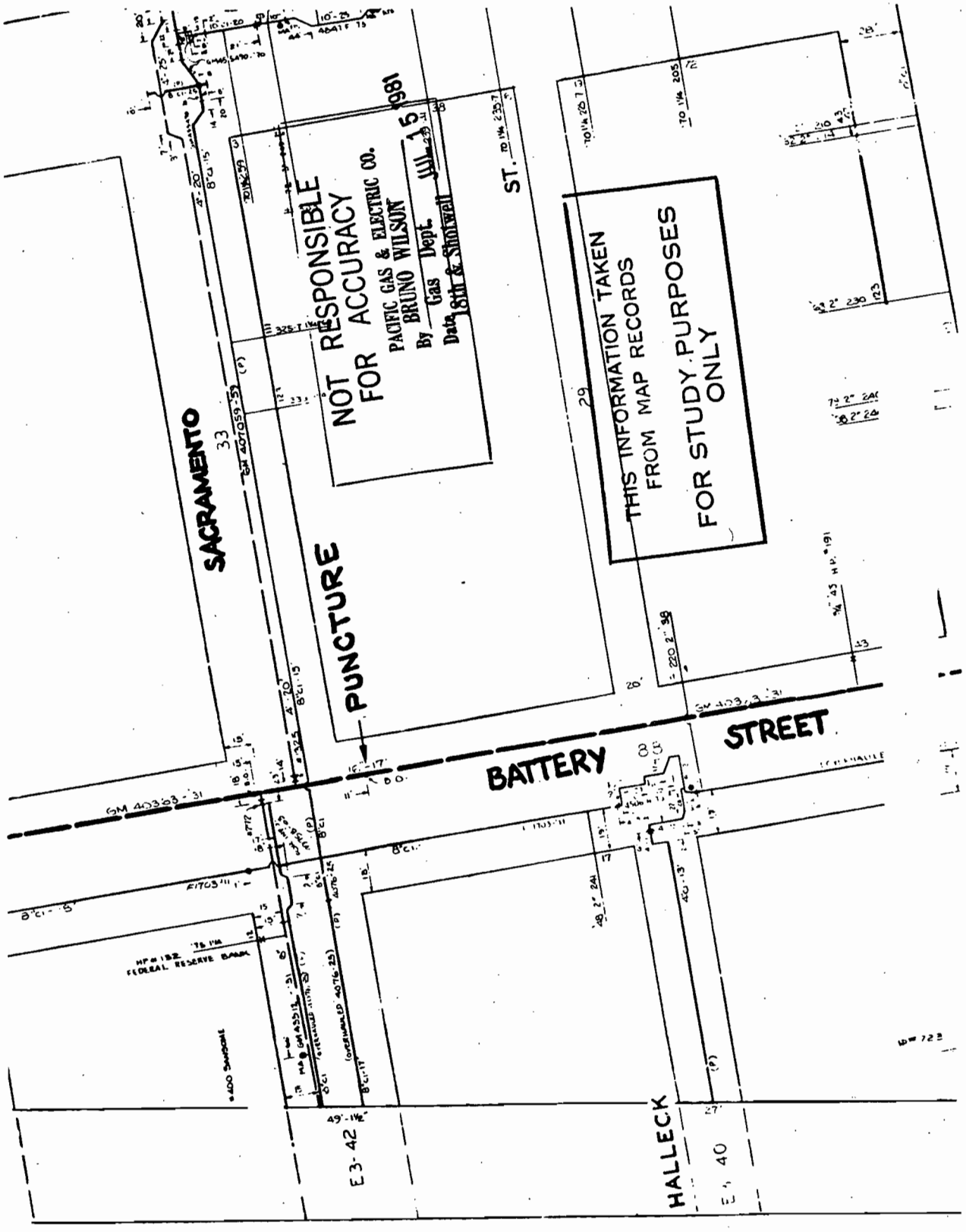


Figure 5.--PG & E utility location map (representative copy).

in accordance to the shoring plans ...prepared by..." the consulting engineer for "... Pomeroy..." The permit specified that the "permittee shall verify the location of City facilities and the facilities of the public service utility companies that may be affected and shall assume all responsibility for any damage to such facilities due to work authorized under this permit" (emphasis added). Turner did not verify such locations.

Title 8, Article 6, Section 1540, of the State of California's Construction Safety Orders provides:

> 1540. General - All Excavations. (a) Exposure...
>
> (1) Prior to opening an excavation, effort shall be made to determine whether underground installations; i.e., sewer, water, fuel, electric lines, etc., will be encountered, and if so, where such underground installations are located. When the excavation approaches the approximate locations of such an installation, the exact locations shall be determined by careful probing or hand digging, and when it is uncovered, adequate protection shall be provided for the existing installation. All known owners of underground facilities in the area concerned shall be advised of proposed work at least 48 hours prior to the start of actual excavation.

No one made an attempt to locate the 16-inch gas main by probing or hand digging.

A search that PG & E made of its records indicated that Turner's only request to be informed of the location of underground facilities relative to this construction project was the April 23 telephonic request. Harding-Lawson was the only subcontractor involved with the project that requested marking of facility locations from PG & E. PG & E was not included in any of the preconstruction conferences held by Turner with its subcontractors. PG & E was not aware that steel sheet piles were to be driven within 6 feet of its 16-inch gas main in Battery Street until they had been driven, or that tieback drilling beneath its gas main was to be done.

Injuries to Persons

Two PG & E employees who responded to the accident were hospitalized briefly for treatment of minor injuries and then released. Several other persons were administered first aid for eye irritations.

Damage to Pipeline

The 16-inch gas main was punctured by the drill on the tieback drilling machine, leaving an oval-shaped hole which measured approximately 6 by 8 inches. (See figure 6.) The hole was later repaired by welding a sleeve patch on the main. The gas main was also gouged nearby where it had been struck by the drill which glanced off the main and broke during an earlier attempt to set another tieback. After PG & E discovered this first strike had gouged the pipe, it decided to replace approximately 180 feet of the main along Battery Street with new pipe.

Other Damage

Natural gas escaping from the puncture blew through the overlying blacktop pavement, hurling pieces of the pavement, rocks, and sand into the air. A glass canopy at the entrance to Embarcadero No. 1 was broken by this debris.

Figure 6.--Tieback drill in 16-inch gas main.

The major economic consequence of the accident was that resulting from the oil mist containing PCB which was entrained in the escaping gas. The mist soiled the shoes and clothing worn by scores of persons and covered buildings, trees, cars, streets, and sidewalks. Cleanup costs, loss of business, and clothing replacement expenses amounted to more than $1 million.

Pipeline System

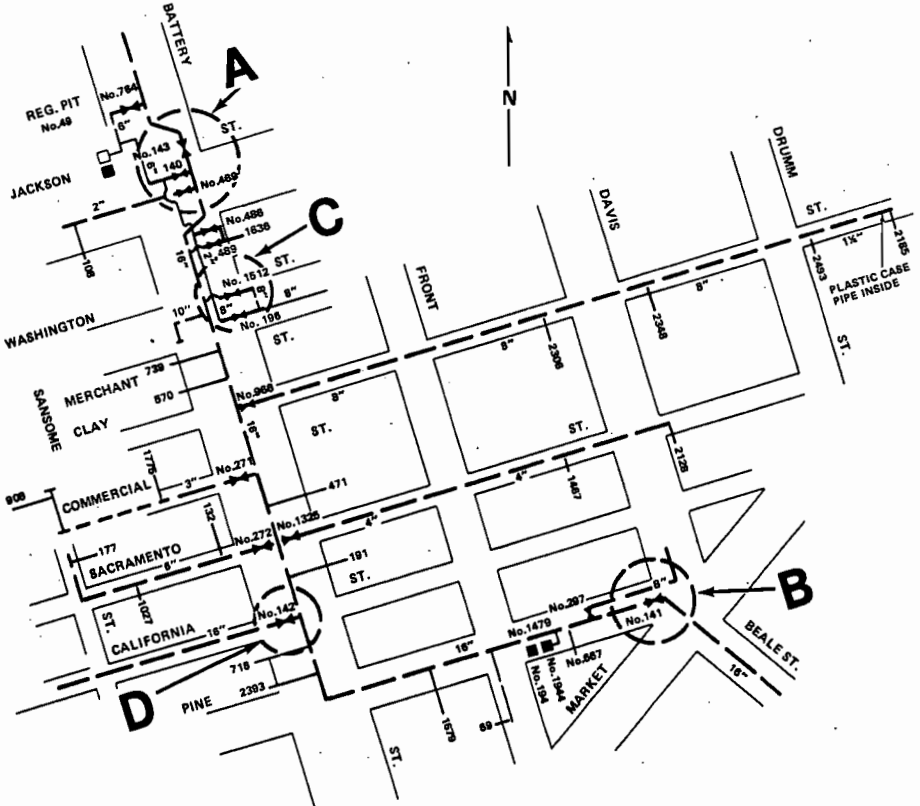
The 16-inch-diameter steel gas main was owned and operated by PG & E as a part of its high-pressure gas distribution system in downtown San Francisco. Records revealed that the 16-inch-diameter pipe had a wall thickness of 0.250 inches and that it was installed in 1951. The main was at a depth of 40 inches below the surface of Battery Street. It was operating at a pressure of 32 psig at the time of the accident and had a maximum allowable operating pressure of 60 psig.

Among other provisions, the emergency shutdown procedures for the PG & E high-pressure gas distribution system provided for the establishment of an EOR to direct company emergency responses and for sectionalizing the system to isolate a break. The essentials of this plan included the designation of emergency valves to effect the shutdown and the specification of district regulators and services which would be affected. This information was listed and shown on an Emergency Shutdown Diagram for each of the shutdown sections. (See figure 7 for ESD 224, a typical diagram.)

The Engineering Department of PG & E is responsible for developing the ESD's which are used for identifying valves necessary for isolating a section of main. The ESD for each isolation section provides a map of the section showing the location of mains and valves, provides a listing of valves to be operated to isolate the section, and provides positive location information for each emergency valve. Valve 297 was installed in 1968 when a one-way flow 8-inch main extension was installed from the 16-inch main. Later, three extensions of this 8-inch main were made beyond valve 297 with the last extension being tied into an 8-inch main at Market Street. This tie-in created an 8-inch loop rather than a simple extension. Each of the extensions and the final tie-in were required to be reviewed by the Engineering Department for purposes which included the identification of necessary changes to the ESD's. Prior to the accident, ESD 224 did not show valve 297 as an emergency isolation valve nor did it show the two-way feed that resulted from the extensions in the 8-inch main; however, ESD 6B did list valve 297 as an emergency isolation valve and showed the 8-inch main as being a loop.

PG & E requires that all emergency isolation valves be inspected annually. Each valve designated by the Engineering Department as an emergency isolation valve is listed on an inspection sheet carried by the inspection crew, and after inspection, a space adjacent to a listed valve is to be dated and initialed by the inspector if the valve is in proper operating condition. The inspector is to grease the valve and to partially operate the valve to assure that it is operable. Any deficiences found by the inspector are to be noted on the inspection sheet. Completed inspection sheets are reviewed and a work order is issued to correct any deficiencies noted by the inspection crew.

The PCB contamination problem originated upstream of the San Francisco gas distribution system during the 1950's and early 1960's, when used transformer oil was placed in oil bath scrubbers on the PG & E transmission line which received gas at the California-Arizona border from the El Paso Natural Gas Company. These scrubbers were located immediately upstream of each compressor station. Their purpose was to clean the gas stream, and in the process some oil droplets containing PCB were carried over and moved downstream where they condensed in the distribution system.



*Denotes Interruptible Customer

Checked By	O.K. By	Date of Latest Change
		3-27-81
Mapping Department	District Engineer	

High Pressure Shutdown Section 224

Control Points

No.	Valve No.	Size	Location
A	143	16" Nord.	5' W/E/L Battery, 5' N/N/L Jackson
	140	8" Nord.	6' W/E/L Battery, 1' S/N/L Jackson (In Pit)
B	141	16" Nord.	18' N/S/L Pine, 50' W/W/L Davis (At Market St. Intersection)
C	1512	8" Nord.	10' S/N/L Washington, 21' W/E/L Battery
D	142	16" Nord.	16' S/N/L California, 23' W/E/L Battery (In Pit)

District Regulators

Pit No.	Size	Location		Remarks
194	4" Axial Flow	17' N/S/L Pine	11' E/E/L Front	HP to LP
194A	4" Axial Flow	16' N/S/L Pine	33' E/E/L Front	HP to HP

High Pressure Services

HP No.	Size	Location	Remarks
471	2"	E/S Battery 107' N/O Sacramento St.	Embarcadero Center I
2185	3"	S/S Clay St. 365' E/E/L Drum St.	Embarcadero Plaza
1636	3"	E/S Battery 80' S/O Jackson St.	Golden Gateway
2306	1-¼"	S/S Clay St. 82' W/W/L Davis St.	Embarcadero Center II
2393	¾"	W/S Battery 2' N/N/L Pine St.	216 Pine St.
132	1-¼"	N/S Sacramento St. 12' W/W/L Battery	400 Sansome St.
667	¾"	S/S Pine, 96' E/o Front	Cahill Bros.
69	1-¼"	W/S Front St. 115' S/S/L Pine St.	444 Market St.
718	2"	W/S Battery, 90' S/o Calif. (Dollar Steamship & Coffee Shop—2 meters)	
191	¾"	E/S Battery 43' N/o California	Newhall Bldg.
1437	2"	S/S Sacramento 56' W/o Davis	Bethlehem Pac. Bldg
1027	1¼"	S/S Sacramento 97' E/o Sansome	350 Sansome St.
*177	2"	E/S Sansome 12' N/o Sacramento	Fed. Reserve Bank
*570	1¼"	W/S Battery 3' N/S/L Merchant	Golden State Co.
739	1¼"	W/S Battery 51' S/o Washington	
1679	2"	S/S Pine 125' W/W/L Front St.	#111 Pine St.
*108	3"	S/S Jackson 92' E/o Sansome	Appraiser's Bldg.
1775	1¼"	N/S Commercial, 211' W/o Battery	Hadley Ins. Bldg.
908	1¼"	W/S Sansome 38' N/o Commercial	Wells Fargo Bank
2548	2"	S/S Clay 81' E/O Davis	Embarcadero Center III
2128	2"	S/S Sacramento 11' E/E/L Davis	90 California
2493	2"	S/S Clay Street 204' E/E/L Drumm St.	Embarcadero Center IV

NOTE: The following services do not have to be shutdown, supply can be maintained off the 12" HP Main.

HP No.	Size	Location	Remarks
1636	3"	E/S Battery St. 80' S/S/L Jackson St.	Golden Gateway

To maintain supply open Valve 486 before closing Valve 489.

Valve No.	Location
486	4' W/E/L Battery St. 80' S/S/L Jackson Street
489	4' W/E/L Battery St. 81' S/S/L Jackson Street

Figure 7.—Emergency Shutdown Diagram.

In February 1981, PG & E became aware that PCB existed in its gas pipeline system, and since then they have been engaged in a program of systematically removing the liquids which contained the PCB from drips 5/ in its pipeline system. It is normal for these liquids to move slowly in the distribution mains and accumulate in low spots as gas moves through the system at usual flow rates. However, when the 16-inch gas main was ruptured and gas escaped at an initial pressure of 32 psig, gas velocity increased greatly. This entrained the PCB oil in the gas stream, and it appeared as a mist which blew skyward from the break. Gas was flowing at even greater velocities through the smaller diameter piping feeding the break, further increasing the flow of oil toward the puncture in the 16-inch gas main.

Meteorological Information

At the time of the accident, the temperature was in the low 70's with clear skies and brisk winds from the west.

Environmental Information

Polychlorinated biphenyls (PCB's) are a class of highly stable chemicals that first came into use in 1930 as the basis for nonflammable dielectric liquids in electrical equipment such as transformers and capacitors and as a component of some heat resistant, heat transfer and hydraulic fluids. In recent years, it has been established that PCB's present a health hazard.

Following the passage of the Toxic Substances Control Act (TSCA) of 1976, the U.S. Environmental Protection Agency (EPA) prescribed marking and disposal regulations for PCB's. The final rule, under Title 49 CFR Part 761:

(1) Prohibits all manufacturing of PCB's after July 2, 1979, unless specifically exempted by the EPA;

(2) Prohibits the processing, distribution in commerce, and use of PCB's except in a totally enclosed manner after July 2, 1979;

(3) Authorizes certain processing, distribution in commerce, and use of PCB's in a non-totally enclosed manner (which would otherwise be subject to the prohibition described above);

(4) Prohibits all processing and distribution in commerce of PCB's after July 1, 1979, unless specifically exempted by EPA.

Since PCB is dispersed in the environment and is found worldwide at low concentrations, the EPA adopted a regulatory threshold based upon a concentration of PCB at the 50 parts per million (ppm) level. The EPA considers any substance with a PCB concentration of less than 50 ppm to be a "Non-PCB Item;" and requirements for handling, marking, storing, and disposing of PCB are applicable only to PCB concentrations of 50 ppm or greater. The disposal of 50 to 500 ppm PCB liquids is permitted in chemical waste landfills if the flash point is less than 60 degrees C. PCB liquids must otherwise be disposed of by incineration.

5/ Collectors fitted with valves located at low spots in a gas pipeline and used to remove liquids from the line.

After PCB was discovered initially in natural gas pipelines, the EPA worked cooperatively with the gas pipeline companies to assess the scope of the problem by developing testing methods and a model testing program. Several companies were found to be operating pipelines contaminated with PCB's. Elimination of the sources of pollution was undertaken immediately. Programs were developed to prevent the movement of PCB's into other systems, to remove PCB from the systems, and to reduce the risks of handling the PCB being removed.

PG & E tested samples of liquids obtained at 50 points throughout its system. PCB's were found in the San Francisco and Santa Fe distribution systems primarily, with several samples of low concentration found elsewhere. Since the use of transformer oil in scrubbers was discontinued in the 1960's, PCB's have no longer been introduced within the system; but some small quantities of exchanged gas was received at an interconnection with Southern California Gas Company where a recent test confirmed the presence of PCB. No exchanged gas has been received at this interconnection since February, 1981.

Several hundred drips are in use by PG & E for the removal of liquids from its pipeline system and to monitor the presence of PCB. Written handling and disposal procedures were developed to assure the safe removal of liquids. To date, about 150 gallons of liquids have been removed which contained over 50 ppm PCB; however, 2,800 gallons with less than 50 ppm and 33,000 gallons with no PCB's have also been removed.

Approximately 13 million cubic feet of natural gas and 500 gallons of entrained liquid were estimated to have been lost as a result of the accident. Based upon the test average of 29 ppm PCB, only an estimated 1 3/4 ounces of PCB was released in this accident.

Tests and Research

The source of PCB's in natural gas pipelines has been traced to PCB contaminated oil used in lubricating compressors, fogging distribution line, and liquid-bath scrubbers. The latter use was unique to the PG & E system and had been discontinued years before the PCB problem became apparent; however, some of the used transformer oil was still in storage. The oil in one storage tank tested 6 ppm PCB and that in another tank tested around 44 ppm PCB.

There was some loss of PCB oil from these scrubbers and, although oil losses as low as 0.03 gallons per MMcf have been claimed for such units, the cumulative effect is significant for a pipeline with a throughput of one billion cubic feet per day. However, there was rarely any need to add PCB oil to the scrubbers since there was enough condensate in the gas stream to compensate for the loss.

Certain properties of PCB aid in its removal from a gas pipeline system. PCB's are inert and have a relatively higher specific gravity and a lower vapor pressure than the mineral oil in which they were introduced into the system and the condensates in the pipeline system which dilute the mineral oil and then evaporate. This concentrates the PCB's in the remaining liquid and expedites the removal of PCB's at drips where concentrations as high as 160 ppm were found in the San Francisco Division.

Other Information

Federal Regulations--After 4:00 p.m., the valve crew attempted to close a second line of emergency valves, but one of them (valve number 1235) was inoperative, although

valve maintenance records indicated that it had been serviced and operated in accordance with the PG & E's practice and the Federal Regulations.

Federal Regulations Title 49 CFR Part 192.747, Valve Maintenance: Distribution System, states:

> Each valve, the use of which may be necessary for the safe operation of a distribution system, must be checked and serviced, at intervals not exceeding 1 year.

One-Call Notification Service--The Underground Service Alert-North (USA-North) one-call notification service covers the northern two-thirds of the State of California including the San Francisco area. USA-South provides service for the remainder of the state. USA-North provides contractors, excavators, demolitionists, and home owners with one toll-free number to call to notify all participating members of their intent to dig. (See figure 8.) Participating members total 106 and include PG & E and most operators of underground facilities in the San Francisco area. USA-North requests a minimum notice of 2 working days and a maximum notice of 10 working days before excavation begins. There is no charge to persons calling the notification service and use of the one-call notification service to advise operators of underground facilities about excavations is not mandatory.

Harding-Lawson Associates, the consulting engineers and geologists who did the soil test boring and drilled the ground water monitor wells, was the only contractor involved with the Daon Building construction project to call USA-North. The general superintendent for Pomeroy, the excavation and shoring subcontractor, stated during the public hearing that he had never used the one-call system. Turner's superintendent had never heard of the one-call system. Neither the notification requirements in Title 8, Article 6, Section 1540 of the State's Construction Safety Orders nor the provisions of the city's excavation and shoring permit specify use of the one-call system.

Fire Marshall Regulations--The California State Fire Marshall is authorized by state law to issue safety regulations for high-rise buildings. The regulations apply to all buildings where the top floor of occupancy is more than 75 feet above ground level. San Francisco has approximately 450 high-rise buildings, a number of which are located within the area that was evacuated. Fire safety directors are required by these regulations for all high-rise buildings, and the San Francisco Fire Department provides training for them at a community college. They are certified by the fire department, and must formulate emergency plans subject to approval by the fire department. The fire department holds ongoing training for the safety directors on weekends. Evacuation drills are conducted every 2 weeks on week days, wherein three or four floors are evacuated. The Embarcadero Center has 20 fire safety directors who were trained and certified by the San Francisco Fire Department. Their most recent evacuation drill was conducted about 10 days before the accident.

Excavation Permits—The City of San Francisco, like most major cities, requires persons proposing to excavate in the public right-of-way to obtain a permit. A provision of the permit for the Daon Building states:

> The permittee shall verify the location of city facilities and the facilities of the Public Service Utility Company (meaning electric, gas, and other public utilities) that may be affected and shall assume all responsibility for any damages to such facilities due to work authorized under this permit.

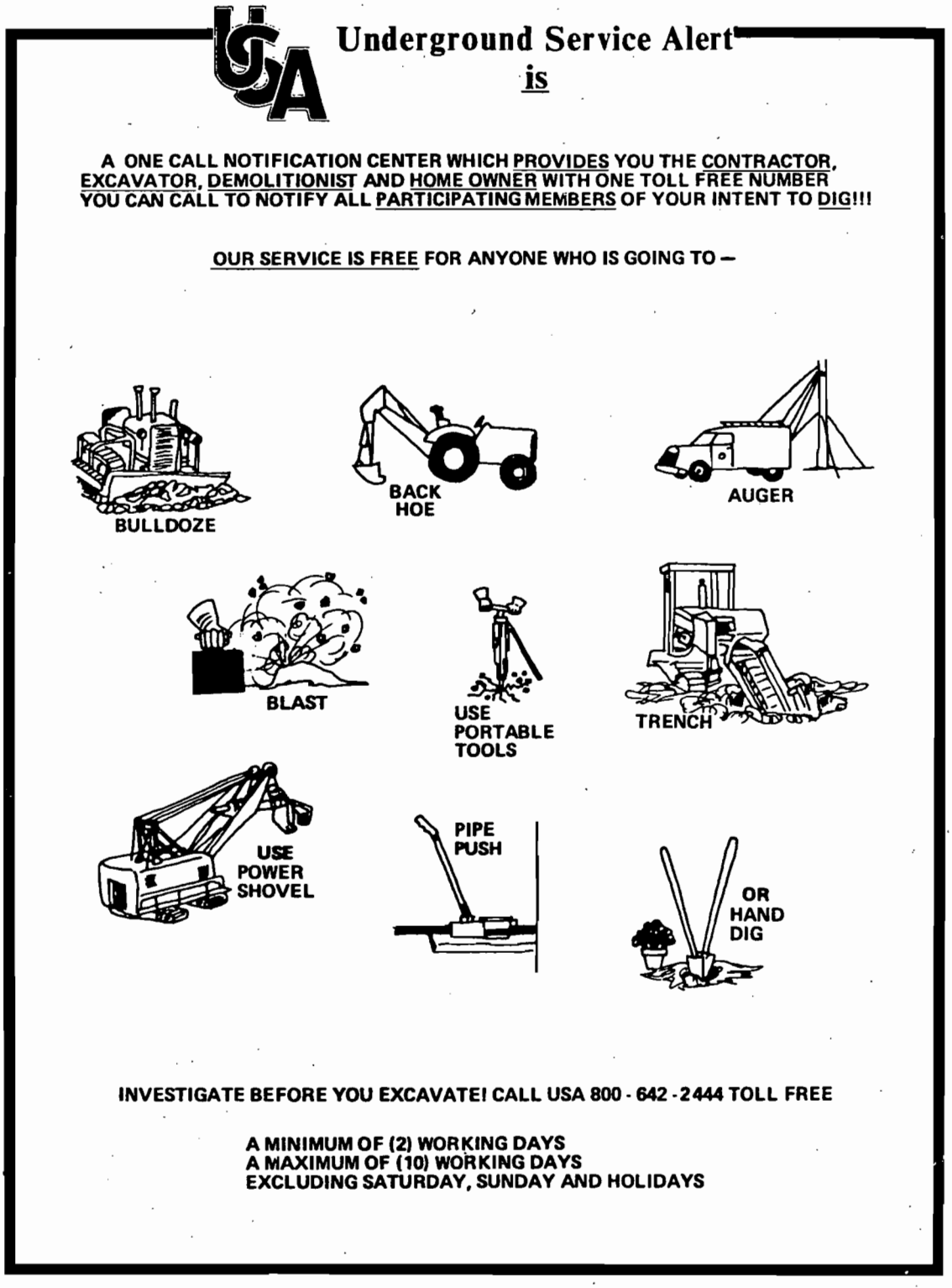


Figure 8.—Underground Service Alert.

These permits typically impose conditions upon the permittee such as: restricting the hours of work, requiring notification to the government agency prior to initiating work, requiring traffic control for the worksite, etc. Failure to comply with any stated condition could result in revocation of the permit and interruption of activities at the worksite. Repeated failure to comply with conditions stated in the permit could result in denial of future permit applications.

ANALYSIS

Preconstruction Activities

Turner and Tronoff Associates obtained maps from PG & E showing the location of underground facilities in the area of Battery Street. The maps were clearly stamped "NOT RESPONSIBLE FOR ACCURACY" and "FOR STUDY PURPOSES ONLY," suggesting that they were not suitable for use in matters requiring close tolerances. Tronoff used the maps in preparing a topographic and utility survey covering the streets around the construction site, and also included a cautionary note stating that the underground utilities were indicated from records only. Turner, the general contractor, sent a copy of this survey to the consulting engineer who designed the shoring and prepared the necessary calculations and plans for Pomeroy, the excavation and shoring subcontractor. A clearance of one foot beneath the pipe for setting the angular tieback would have been provided by the design criteria based upon the consulting engineer's assumed 2-foot depth of the gas main and its mapped lateral location.

The consulting engineer should not have assumed a 2-foot depth for the gas main and should not have relied on a map drawing to determine the location of the main. While the drawing correctly depicted the lateral position of the main, it did not depict its actual depth of 40 inches which placed the main directly in the design path of the tieback drill. The consulting engineer did not post the location of the gas main in his drawings, but he did include several notes which related to the monitoring, supporting, moving, and removing of utilities to be done by the general contractor. However, he made no mention or note regarding the need for the precise location of utilities to be determined or verified. Although the consulting engineer, the excavation and shoring subcontractor, and the general contractor were all aware of the pipeline's existence and approximate location but not its actual depth under the street, no direct requests were made of PG & E to precisely locate its facilities. The consulting engineer's approval of Turner's request to lower the entry elevation of the holes in the sheet piles indicated that there was flexibility in the location of the tiebacks which could have accommodated some changes needed to avoid the PG & E gas main. Had PG & E been aware that the tieback activities would encroach upon their 16-inch natural gas main in Battery Street, it could have exposed the pipeline and monitored the operation, and the accident may have been prevented. Because of the favorable soil conditions near the surface, the tiebacks were being installed at a shallower depth than where they are normally installed. (Normally tiebacks are installed at a greater depth and generally there is no conflict with gas pipelines that are buried at relatively shallow depths.) In view of this fact, the Safety Board believes that the contractor's failure to notify the gas company in accordance with the State's safety orders and provisions of the city's excavation and shoring permit unnecessarily increased the hazard.

PG & E Operations

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 ESD 224, the initial actions of the EOR personnel were correct and should have quickly isolated the section of main that included the break; however, valve 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 ESD 224 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 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 pressure between regulators which was incorrectly assumed to be 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.

Environmental Considerations

If the shutdown had been completed within an hour, any PCB contamination would have been minimal. The gas stream entrained PCB laden oil when its velocity increased

following the rupture. There was an even greater increase in gas velocity through smaller diameter mains after valves on the 16-inch main were closed. It was at this time, an hour after the break, that a sufficient amount of liquid was entrained to become visible as a dark oil mist. Later, as the pressure dropped, visible amounts of oil were no longer apparent in the escaping gas stream.

Since the discovery of PCB liquids in its system, PG & E has developed written handling and disposal procedures to assure the safe removal of these liquids from its system. This process has involved the use of several hundred drips to monitor the presence of liquids and to remove them from the system. Most of these drips are located in the distribution system where, because of reduced gas velocity, the liquids drop out and settle in the low spots. Since the source of PCB's in the system has been identified and eliminated, the PCB problem is being alleviated by the expeditious removal of contaminated liquids.

Excavation Notification

USA-North, the one-call notification service in the San Francisco area, was used by only one of the contractors involved in the Daon Building construction project. PG & E, in response to a request made by Harding-Lawson, located its 16-inch gas main and other facilities buried beneath the streets around the excavation site and marked the locations on the pavement with yellow paint. The notification service was provided free and the information permitted Harding-Lawson to modify the intended locations of its soil test bore holes and ground water observation wells and contributed to their safe completion.

No other contractor involved in this project made use of the one-call system to request that PG & E locate its underground facilities around the excavation site. Had PG & E been informed through the one-call system that tieback drilling was to be done which would extend under the road and beneath its 16-inch gas main, PG & E would have been able to assure that its main was exposed so that the tieback design specifications along Battery Street could have been checked and modified, if necessary, and the installation work could have been monitored.

The northern California one-call system would be more effective if its use was mandatory. Although the State of California's construction safety orders require that all owners of underground facilities be notified prior to the start of construction, and provisions of the City's excavation and shoring permit require essentially the same thing, Turner failed to provide any notification to PG & E, but could have easily satisfied all legal requirements by use of the one-call system.

The Safety Board is concerned about the number of excavation caused pipeline accidents, which have been proven to be readily preventable by use of the one-call system where it exists and has therefore been a proponent of one-call systems. The Safety Board investigated a similar pipeline accident caused by excavation operations on June 16, 1976. In that investigation, 6/ the Board found that "...although the line was known to exist, its precise depth and location were not known by the pipeline operator, the construction contractor, the subcontractor, or the California Department of Transportation." In that accident, 9 persons were killed, 14 persons were injured, and extensive property was damaged on Venice Boulevard, Los Angeles, California. Here again, all parties were aware of the pipeline's existence but did not ascertain its precise depth and location before excavation.

6/ Pipeline Accident Report--Standard Oil Company of California, Pipeline Rupture, Los Angeles, California, June 16, 1976, (NTSB-PAR-76-8).

Local governmental agencies responsible for street and highway activities typically impose reasonable and necessary permit conditions for excavations and inspect the activities of permittees. These agencies could effectively require prior notification to the operators of underground facilities prior to the issuance of any permit for work within their jurisdiction. This added condition could greatly reduce the potential for excavation related accidents and could be accomplished in the same manner as other long-standing permit requirements and conditions. Typically, noncompliance with permit requirements can result in an on-the-spot revocation of the permit or temporary halting of the work. Such action would be effective in bringing about compliance and would undoubtedly result in full compliance with the notification requirements.

CONCLUSIONS

Findings

1. The accident occurred when the drill on a tieback machine punctured a 16-inch main.

2. Natural gas under a pressure of 32 psig escaped and blew upward toward nearby buildings.

3. After blowing for an hour, a dark mist of oil appeared in the gas stream which contained PCB in the amount of 29 ppm average by test.

4. Shutdown of the gas flow could have been effected within an hour but was delayed because: (a) on-scene employees were not trained and equipped to close valves which necessitated bringing valve crews from a distance, (b) two of the critical emergency valves were not shown on the Emergency Shutdown Diagram applicable to the main section which was punctured, (c) an emergency valve was paved over in 1978 and inaccessible because it was not included on the list of valves to receive annual inspections.

5. Shutdown was further delayed because an emergency valve had not been properly inspected and reported as being inoperative when inspected a short time prior to the accident.

6. Complete shutdown was never achieved; however, 9 hours and 10 minutes after the accident occurred, a temporary repair patch was welded on the 16-inch main and stopped the leak.

7. The lateral location of the 16-inch natural gas main had been accurately marked on the pavement above it with yellow paint a month before the accident, and the marking was still plainly visible.

8. The consulting engineer, the excavation and shoring subcontractor, and the general contractor were all aware of the pipeline's existence but did not notify the gas company that the shoring activity would extend under the street in the area of the 16-inch gas main.

9. The general contractor failed to provide notification to the gas company even though it was required to do so by provisions of the permit issued to it by the City of San Francisco and by the State of California's construction orders. No one made an attempt to locate the 16-inch gas main by probing or hand digging although this was also a requirement of the State construction order.

10. The consulting engineer did not determine the depth of the pipe to provide adequate clearance beneath the 16-inch main for drilling to set the angular tiebacks.

11. The PG & E gas distribution system contains oil contaminated with polychlorinated biphenyl (PCB).

12. The primary source of the PCB was the long-discontinued usage of used transformer oil which contained PCB's in liquid bath scrubbers on a gas transmission line and the oil's downstream movement into the distribution system. A secondary source was the exchange of gas with the Southern California Gas Company.

13. The large volume of escaping gas increased gas flow velocities in the distribution system and resulted in the entrainment of PCB laden oil in the gas stream and its dispersal as an oil mist.

14. Fall-out of the PCB oil mist covered buildings, streets, sidewalks, cars, pedestrians, policemen, and firemen, and resulted in a cleanup effort that required 2 weeks.

15. Although this was a non-PCB incident by EPA standards (less than 50 ppm discharge), the California Occupational Safety and Health Administration established a cleanup standard of 2 ppm PCB as a precautionary measure based upon the level deemed to be attainable by the cleanup contractor and ambient PCB levels in San Francisco.

16. Cleanup costs and loss of business resulted in claims which amounted to more than $1 million.

17. Approximately 30,000 persons were safely evacuated from the area within 45 minutes, attesting to the value of the evacuation planning and training.

18. State safety regulations for high rise buildings require evacuation planning and drills which are monitored in San Francisco by the Fire Department.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the accident, involving the puncture of the 16-inch gas main, was the failure of the general contractor to comply fully with the terms of the excavation permit which required him to verify the location of underground facilities that might be affected by the project. Contributing to the accident was the failure of the subcontractor, who knew of the existence of the gas main, but not its precise location, to ascertain that the gas company had been notified before commencing excavation. Contributing to the duration of the gas leakage was the gas company's inability to locate one emergency valve because of inaccurate recordkeeping, and because it had been paved over; and to close another valve which was inoperative because of inadequate maintenance.

RECOMMENDATIONS

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

--to the Pacific Gas and Electric Company:

Train and equip company personnel who respond to emergency conditions in the operation of emergency shutdown valves. (Class II, Priority Action) (P-82-1)

Revise procedures for posting distribution system piping changes affected by work orders to assure that valves required for emergency shutdown are properly designated on Emergency Shutdown Diagrams and are included on the listing of valves required to be inspected annually. (Class II, Priority Action) (P-82-2)

Include in its written maintenance procedures a requirement that emergency valves be operated during annual inspections and emphasize this requirement to maintenance personnel. (Class II, Priority Action) (P-82-3)

--to the Public Utility Commission of the State of California:

Request the California State Legislature to enact legislation to require persons excavating or discharging explosives near underground utilities, or demolishing buildings containing utilities, to notify operators of public utilities in advance using one-call notification systems where they are established. (Class II, Priority Action) (P-82-4)

--to the City of San Francisco Department of Public Works:

Amend permit provisions to specify in accordance with Title 8, Article 6 of the California Public Works Code, that all known operators of underground facilities in the area concerned will be advised of proposed work at least 48 hours prior to the start of actual excavation either by direct notification or by use of the one-call system, and add that failure to comply with these or other conditions stated in the permit could result in revocation of the permit and interruption of activities at the worksite. (Class II, Priority Action) (P-82-5)

--to 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)

--to the Associated General Contractors of America:

Advise its member construction companies of the details of this accident and urge them (1) not to excavate until they have notified all operators of underground utilities in the area of their plans to excavate, and (2) to utilize one-call service wherever it is available. (Class II, Priority Action) (P-82-8)

--to the Turner Construction Company:

> Establish procedures for notifying the owners of all underground facilities which may be affected by your excavation activities prior to the start of actual excavation. (Class II, Priority Action) (P-82-9)

--to the National League of Cities, the American Public Works Association, and the National Association of Counties:

> As an integral part of their requirements for granting permits to perform work in or adjacent to public streets and rights-of-way, encourage local governments to require as a condition of the permit that permittees provide advance notification to operators of underground facilities about excavation, augering, blasting, or other activities which may endanger underground facilities using a one-call system if one is in operation. (Class II, Priority Action) (P-82-10)

—to the American Society of Civil Engineers, the Consulting Engineers Council, and the Construction Specification Institute:

> Advise its members of the circumstances of this accident and recommend that they confirm the adequacy of their design specifications in providing adequate clearance for affected utilities through consultation with the utility operators, and that they note on their design specifications and drawings that affected utilities are to be notified at least 48 hours in advance of actual excavation, using the one-call system where available. (Class II, Priority Action) (P-82-11)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JAMES E. BURNETT, JR.
Chairman

/s/ PATRICIA A. GOLDMAN
Member

/s/ G. H. PATRICK BURSLEY
Member

FRANCIS H. McADAMS, Member, did not participate.

February 25, 1982

APPENDIX

INVESTIGATION AND HEARING

Investigation

The National Transportation Safety Board received information regarding the accident about 8:00 a.m., e.d.t., on August 26, 1981, and immediately dispatched a pipeline safety specialist to the accident site to conduct the field phase of the investigation.

Public Hearing

A 3-day public hearing was held in San Francisco, California, beginning November 3, 1981. Parties to the hearing were the City of San Francisco, Pacific Gas and Electric Company, the California State Public Utilities Commission, J. H. Pomeroy, Inc., and Turner Construction Company.

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