Pacific Gas & Electric Third-Party Line Strike and Fire
San Francisco, California
February 6, 2019

Accident Report

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PB2021-100925

National Transportation Safety Board

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Pipeline Accident Report

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National Transportation Safety Board

490 L'Enfant Plaza, S.W.
Washington, D.C. 20594

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Abstract: On February 6, 2019, at 1:07 p.m. local time, the excavator operator for a third-party contractor, Kilford Engineering Inc., impacted a Pacific Gas & Electric Company (PG&E) branch connection with a mini excavator trenching bucket attachment during mechanical excavation for fiberoptic conduit installation, which resulted in the release and ignition of natural gas. The accident occurred in the Richmond District of San Francisco, California. A nearby restaurant with a rental unit above caught fire. There were no injuries. Estimated damages to nearby buildings and the pipeline system exceeded $10 million. The National Transportation Safety Board (NTSB) determined that the probable cause of the accident was the failure of the Kilford operator and spotter to follow safe excavation practices within the tolerance zone, which resulted in the mini excavator trenching bucket attachment impacting the pipeline's branch connection. The investigators focused on the safety issues of third-party excavation damage to buried natural gas pipelines, enforcement challenges of California's damage prevention law, PG&E's data integration gaps during the development of the valve isolation plan, and insufficient joint emergency response planning between PG&E and San Francisco emergency response agencies. As a result of the investigation, the NTSB makes one recommendation each to the San Francisco Police Department, Fire Department, and Department of Emergency Management and two recommendations to PG&E.

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Abbreviations and Acronyms

911 dispatch	Department of Emergency Management Public Safety Dispatch Center
CFR	*Code of Federal Regulations*
CGA	Common Ground Alliance
CPUC	California Public Utilities Commission
CSLB	Contractors State License Board
Dig Safe Board	California Underground Facilities Safe Excavation Board
GDCC	Gas Distribution Control Center
GIS	geographic information system
GM&C	Gas Maintenance and Construction
GOV	*State of California Government Code*
GPOM	Gas Pipeline Operations and Maintenance
GSP	gas system planning
IC	incident commander
NOPV	Notice of Probable Violation
NTSB	National Transportation Safety Board
OSHA	Occupational Safety and Health Administration
PG&E	Pacific Gas & Electric Company
PHMSA	Pipeline and Hazardous Materials Safety Administration
SFDEM	San Francisco Department of Emergency Management
SFFD	San Francisco Fire Department
SFPD	San Francisco Police Department
USC	*United States Code*
VIP	valve isolation plan

Executive Summary

Accident Summary

On February 6, 2019, at 1:07 p.m. local time, the excavator operator for a third-party contractor, Kilford Engineering Inc., impacted a Pacific Gas & Electric Company (PG&E) branch connection with the mini excavator trenching bucket attachment during mechanical excavation for fiberoptic conduit installation, which resulted in the release and ignition of natural gas. The accident occurred in the Richmond District, a neighborhood in San Francisco, California. A nearby restaurant with a rental unit above caught fire. There were no injuries. Estimated damages to nearby buildings and the pipeline system exceeded $10 million.

At 1:09 p.m., the San Francisco Fire Department was dispatched and arrived on scene at 1:12 p.m. The fire department focused on containing the fire and minimizing its spread while PG&E crews worked to isolate and shut down the gas pipeline line. The fire department and police department evacuated about 100 persons, and PG&E shut off natural gas service to 328 customers. At 3:36 p.m., the damaged pipelines and branch connection were isolated, and the fire department extinguished the gas fire 2 minutes later.[1]

Probable Cause

The National Transportation Safety Board determines that the probable cause of the February 6, 2019, release of natural gas from the Pacific Gas & Electric Company distribution pipeline and the subsequent fire was the failure of the Kilford Engineering Inc. operator and spotter to follow safe excavation practices within the tolerance zone, which resulted in the mini excavator trenching bucket attachment impacting the pipeline's branch connection.

Safety Issues

This report focuses on the following safety issues:

- **Third-party excavation damage to buried natural gas pipelines.** Third-party excavation damage is the number one cause of pipeline accidents. In this case, Kilford failed to follow safe excavation practices within the tolerance zone of the existing underground utilities by mechanically excavating near the gas pipeline.

- **Enforcement challenges of California's damage prevention law.** At the time of the accident, California did not have an operational damage prevention enforcement program in place; the program became operational in July 2020. Enforcement has been shown to be

[1] For more information, see the factual information and analysis sections of this report. Additional information can be found in the public docket for this National Transportation Safety Board (NTSB) accident investigation (accident number PLD19MR001) by accessing the Accident Dockets link at www.ntsb.gov. For information about our safety recommendations, see the Safety Recommendation Database at the same website.

the strongest method of preventing damage to buried utilities. Kilford had previously damaged an underground utility during excavation; however, because California's damage prevention enforcement program was not yet in place, no actions were taken against the company. On January 26, 2021, the Pipeline and Hazardous Materials Safety Administration changed its evaluation of the state of California's damage prevention enforcement program from inadequate to adequate.

- **PG&E's data integration gaps during the development of the VIP.** A critical part of any emergency response to a natural gas distribution incident is the development of a valve isolation plan, which is used by field personnel to isolate a damaged portion of pipeline and stop the release of gas. Any delays in the creation of such a plan can result more gas release and greater impact to customers. In this accident, it took PG&E about an hour to identify the specific locations of the valves that needed to be isolated.

- **Insufficient joint emergency response planning between PG&E and San Francisco, California, emergency response agencies.** During the emergency response, an important piece of equipment needed to isolate a gas supply pipeline was delayed en route to the accident scene. While it ultimately did not affect the overall response, such delays in the event of a gas release could have negative impacts. By coordinating with emergency response agencies, such delays could be reduced or eliminated.

Findings

- The following factors did not contribute to the cause of the accident: two one-call ticket requests, locate and mark activities, and California regulations regarding the tolerance zone. Further, Pacific Gas & Electric Company's pipeline was intact and operating as designed prior to the accident.

- Natural gas facilities were accurately marked, and Kilford Engineering Inc. employees working at the site were aware of the markings indicating the locations of the 4-inch gas pipeline, 2-inch gas pipeline, and branch connection before the start of excavation.

- Kilford Engineering Inc. did not follow safe excavation practices when it mechanically excavated within the tolerance zone, resulting in the Kilford Engineering Inc. operator impacting the 2-inch branch connection with the mini excavator trenching bucket, causing the release of natural gas.

- Because California did not have an excavation damage enforcement program at the time of the water line strike, the state missed an opportunity to identify and deter poor safety activities presented by a new contractor.

- Although sufficient data are not yet available to determine if the California Underground Facilities Safe Excavation Board's enforcement actions have been effective in deterring future damage, enforcement is a step in the right direction for preventing third party damage to buried utilities.

- Had Pacific Gas & Electric Company incorporated geographic information system location data into the software program used to develop its valve isolation plan prior to this accident, it would have reduced the time to isolate the natural gas release.

- Pacific Gas & Electric Company did not follow its own procedures regarding requests for police escorts, which may have delayed the arrival of Pacific Gas & Electric Company personnel on scene during the emergency response.

- While the lack of a memorandum of understanding with the San Francisco Department of Emergency Management, San Francisco Police Department, or San Francisco Fire Department addressing emergency response plans did not affect the timeliness of the Pacific Gas & Electric Company shutting off the flow of gas in this accident, it could potentially affect other responses where the squeeze-off point is accessible and/or the valve locations are readily known.

Recommendations

To the San Francisco Police Department, San Francisco Fire Department, and San Francisco Department of Emergency Management:

Work with Pacific Gas & Electric Company to establish an agreement to provide a coordinated response and reduce response times for Pacific Gas & Electric Company's crews to arrive at the scene of a pipeline accident. (P-21-15)

To Pacific Gas & Electric Company:

In collaboration with the San Francisco Police Department, San Francisco Fire Department, and the San Francisco Department of Emergency Management, establish an agreement to provide a coordinated response and reduce response times for your crews to arrive at the scene of a pipeline accident. (P-21-16)

Complete the integration of detailed location data into your hydraulic modeling software so that this information is readily available for all system assets when developing a valve isolation plan. (P-21-17)

1 Factual Information

1.1 Accident Description

On February 6, 2019, Kilford Engineering Inc. (Kilford), a third-party contractor, was excavating a trench to install fiberoptic conduit at the intersection of Geary Boulevard and Parker Avenue in San Francisco, California.[1] During mechanical excavation, at 1:07 p.m., the operator of a mini excavator impacted a Pacific Gas & Electric Company (PG&E) branch connection between a 4-inch natural gas distribution pipeline and a 2-inch natural gas pipeline with the mini excavator's trenching bucket.[2] Shortly after the branch connection was damaged, the releasing gas ignited, resulting in structure fires in several surrounding buildings. (See figure 1.) The damaged segment was isolated at 3:36 p.m., and the structure fires were contained at 4:24 p.m. No injuries occurred as a result of this accident.[3]

[1] A *third-party contractor* is a contractor who performs excavation work independently of natural gas companies. For more information on third-party contractors and third-party damage, see the analysis section of this report.

[2] All times in this report are in local time.

[3] For more information, see the factual information and analysis sections of this report. Additional information can be found in the public docket for this National Transportation Safety Board (NTSB) accident investigation (accident number PLD19MR001) by accessing the Accident Dockets link at www.ntsb.gov. For information about our safety recommendations, see the Safety Recommendation Database at the same website.

Figure 1. Northwest-facing view of fire during emergency response. (Photo courtesy of PG&E.)

1.1.1 Excavation Planning

Through multiple subcontracts, Kilford was hired to conduct excavation work and install conduit for fiberoptic cabling for Verizon along Geary Boulevard in San Francisco. (See section 1.5 for more information about Kilford.) The project extended from 3310 Geary Boulevard to the intersection of Geary Boulevard and Masonic Avenue, and the trench excavation was in the northernmost lane of Geary Boulevard. (See figure 2.) The project was segmented into 13 subprojects, each about one-half block long. The first segment was from 3310 Geary Boulevard to the intersection of Geary Boulevard and Parker Avenue.

Figure 2 Kilford's project area.

The scope of work called for 1,888 feet of trench excavation and the installation of 3,798 feet of 2-inch high-density polyethylene conduit inside 4-inch polyvinyl chloride piping at a depth of 36 inches. As part of the work, Kilford was responsible for maintaining a minimum of 24 inches of separation from existing utilities and for determining the location and depth of the existing utilities.

In preparation for excavation, Kilford placed a "one-call" ticket on January 21, 2019, to request the location and marking of buried utilities within the project area.[4] Information from the January 21, 2019, one-call ticket indicated that a PG&E representative called the Kilford employee listed as the contact to clarify the excavation location because Kilford did not provide a complete location on the tickets. Kilford submitted a second ticket on January 22, 2019 in an effort to address the issue. PG&E located and marked its natural gas utilities within the requested area on January 28 and 29, 2019. The depths of the utilities were not marked (nor were they required to be marked. (See section 1.6.1 for more information.) Figure 3 shows the one-call markings at the intersection of Geary Boulevard and Parker Avenue before excavation.

[4] *One-call* is the phone number (811) to call to request a location of all buried utilities in the area where excavation is to occur. Title 49 *Code of Federal Regulations* (*CFR*) 192.614 requires pipeline operators to participate in a one-call center and provide locate-and-mark services to excavators that notify the operator of any planned excavation work in the region of their utilities. Excavators call 811 and place a ticket, known as a *one-call ticket*, which is used to track the locate-and-mark activities of the various owners of the buried utilities. In the state of California, this one-call ticket can be accessed online by the excavator and the utilities.

Figure 3. One-call street markings at northwest corner of Parker Ave. and Geary Blvd. (Photo Courtesy of PG&E.)

Note: The buried gas utilities are marked in yellow. A green circle has been placed on the figure to indicate the location of the branch connection that was ultimately struck.

1.1.2 Excavation Operation

On February 4 and 5, 2019, the asphalt on the roadway was cut in the area where the excavation work was to be performed; Kilford began the asphalt removal and excavation work on February 6, 2019, and five Kilford employees were on site to perform the work.

Kilford employees arrived at the site about 7:30 a.m. and held a safety briefing where they discussed topics such as personal protective equipment, finding buried utilities, and damage to tools. Excavation work began about 9:00 a.m., once traffic control was in place.[5] The work plan for that day was for three lines of conduit to be placed along Geary Boulevard 50 feet west of the intersection with Parker Avenue at a new handhole and run to the intersection where one of the three lines of conduit would then run north along Parker Avenue to a telecommunications (telecom) pole. (See figure 4.)

[5] Traffic control was performed by two employees of City Rise Safety and Services Traffic Control.

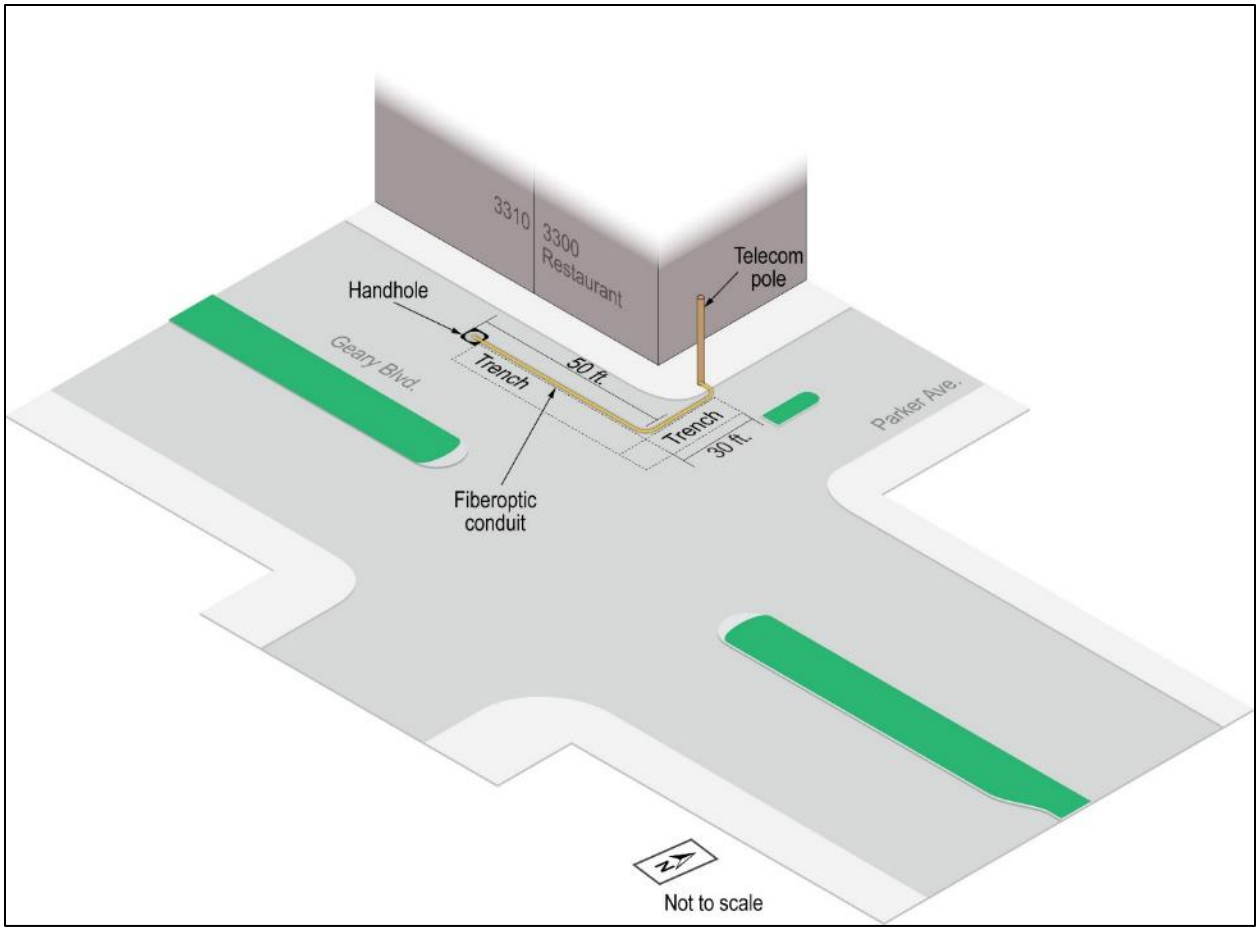

Figure 4. Excavation work plan on the day of the accident.

According to the job foreman, he began work by breaking up and removing the asphalt road top with a skid steer while the other employees used hand shovels.[6] After the asphalt road top was removed, the job foreman (mini excavator operator) used a mini excavator to excavate the trenches.[7] (See figure 5.) While using the mini excavator, he relied on a spotter to help locate utilities.[8] The spotter determines the depth of underground utilities and performs other safety tasks, such as keeping the operator aware of personnel in the area or other hazards because of the limited view from inside the mini excavator (CGA 2018).

[6] (a) A *skid steer* is a small engine-powered machine with a front loader and four wheels or two tracks that is commonly used for heavy excavation work such as breaking up and removing concrete. (b) *State of California Government Code* (*GOV)* 4216.4(a)(2)(B) states a person performing excavation work may use power-operated equipment for the removal of pavement if there are no known utilities within such pavement.

[7] A *mini excavator* is a small engine-powered machine used for finer excavation work such as trenching. For the majority of its mechanical excavation activities, Kilford used a 2018 CAT 305E2 CR mini excavator. The attached trenching bucket had three teeth that were connected via a 3-inch-wide welded bar.

[8] Common Ground Alliance's (CGA) *Best Practices Guide* recommends the contractor have an observer to assist the operator of the excavator when operating around underground utilities; this person is often referred to as a spotter (CGA 2018).

Figure 5. Mini excavator in storage postaccident.

Excavation began in front of 3310 Geary Boulevard using a combination of hand digging with shovels and mechanical excavation using the trenching bucket attachment on the mini excavator. Excavation continued along Geary Boulevard to Parker Avenue; then the mini excavator operator and spotter started digging at the telecom pole on Parker Avenue working south toward the intersection. The operator then moved the mini excavator to Geary Boulevard and began digging to join the two trenches together. The spotter was in the Parker Ave. trench at that time. The other three employees began to install conduit along Geary Boulevard in the first trench.

The operator stated that they had previously located the 4-inch gas pipeline and the 2-inch gas pipeline at 48 inches depth. The operator stated that they only exposed a portion of each pipeline and did not expose the branch connection where the two pipelines met. He stated that he was digging at least 2 to 3 feet from the 2-inch gas pipeline that had been exposed along Parker and was likely higher than the 2-inch gas pipeline; he reported that he was about 4 feet from where the spotter exposed the 4-inch gas pipeline along Geary Avenue. The spotter reported that he could not see either of the gas pipelines (he never saw the yellow plastic of the pipelines) in the trench, although he could see an electrical conduit and a metal line. He also stated that the mini excavator bucket was about 2 feet south of where the gas pipeline was.

The operator also reported that he decided to dig to 30 inches, even though the scope of work called for 36-inch trench depth. The spotter reported that the trench was only 24 to 30 inches deep where the mini excavator was working at the intersection. (See figure 6.)

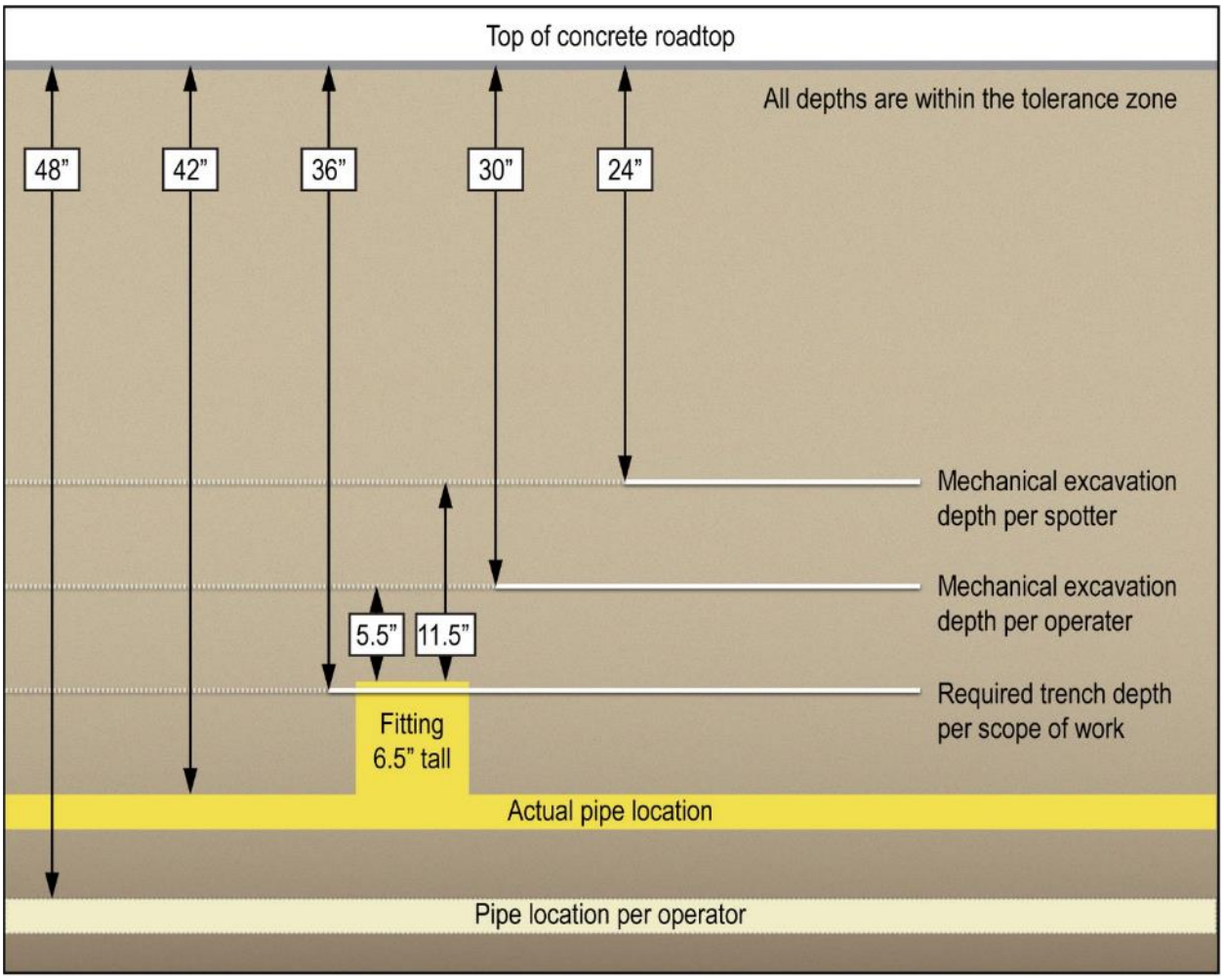

Figure 6. Trench depth comparisons.

As the operator continued to remove dirt with the mini excavator, the gas started to escape; he did not notice an impact or scraping before the gas release. Once the release began, the spotter immediately climbed out of the trench and ran north, away from the release site. The operator got out of the excavator as the spotter exited the trench. As the operator was returning to the excavator to retrieve his phone, the gas ignited.

Figure 7. Postfire south-facing view of trench and excavator on Parker Ave. (Photo courtesy of PG&E)

Note: Figure 7 shows the mini excavator as found after the fire was extinguished.

Once the gas ignited, the flames, which extended above the height of a 2-story building, impinged on a nearby, fully occupied restaurant at 3300 Geary Boulevard. This caused a structure fire at the restaurant. Employees and customers self-evacuated immediately. Later, the fire spread to neighboring buildings, causing smaller structure fires at 3308, 3310, and 3250 Geary Boulevard.

1.2 Response to Gas Release and Fire

1.2.1 San Francisco Police and Fire Department Response

At 1:08 p.m., the San Francisco Department of Emergency Management (SFDEM) Public Safety Dispatch Center (911 dispatch) received multiple calls from the public reporting a fire and possible explosion at the intersection of Geary Boulevard and Parker Avenue.

San Francisco Police Department (SFPD) officers were first on scene at 1:09 p.m. and began performing evacuations and controlling traffic. San Francisco Fire Department (SFFD) Battalion 7, Engine 10, and Truck 10 were dispatched to the scene at 1:09 p.m., were en route within 1 minute, and were on scene by 1:12 p.m. The Battalion 7 chief designated the event a

working fire with a gas explosion and assigned it as a first-alarm fire.[9] An SFFD assistant chief was dispatched at 1:17 p.m. and assumed command as the SFFD incident commander (IC) while en route. An additional battalion, three more engines, and one truck were also dispatched at that time.

As the SFFD IC approached the site, he could see flames from three blocks away, so he upgraded the response to a second-alarm fire at 1:20 p.m. as he was en route. An additional two battalions, four engines, and one truck were dispatched in response to the second-alarm designation. When the SFFD IC arrived at 1:22 p.m., he recognized that the SFFD was not going to be able to put out the gas fire. SFFD procedures for Class 2 flammable gases stated that gas-based fires were not to be put out unless the gas has first been shut off. Instead, the fire had to be contained and surrounded until the fuel source was removed. The SFFD IC deployed four battalions around the fire to keep it contained until the gas release was isolated. The SFFD IC declared a third alarm at 1:36 p.m., and two additional battalions, four engines, and two trucks were dispatched at that time. After the fire was extinguished, an additional engine was dispatched to monitor for possible rekindling.

In addition to the restaurant, all buildings within a half-block radius of the restaurant fire as well as an extra half block to the north were cleared as fully evacuated at 1:56 p.m. SFPD controlled public access to the active fire area by blocking the main and side streets for a 4-block radius centered on 3300 Geary Boulevard and rerouting traffic flow around that area. SFPD instructed Roosevelt Middle School staff and students to shelter-in-place at 1:53 p.m. at the request of PG&E; the school was located 0.3 mile from the fire.

A total of 6 battalions, 13 engines, and 5 trucks, were dispatched to the fire over the course of the response as well as specialized apparatus and staff, such as rescue squads, emergency medical services, and a public information officer, for a total of 41 units and 130 firefighters. The gas fire was extinguished at 3:38 p.m., and SFFD was then able to extinguish the structure fires. The structure fires were contained at 3:51 p.m. and controlled at 4:24 p.m. No injuries occurred as a result of this accident.

1.2.2 Pacific Gas & Electric Response

At 1:12 p.m., PG&E's Customer Call Center received a call about the fire. The SFDEM 911 dispatch notified PG&E of an explosion and active fire 2 minutes later, in accordance with SFFD natural gas leaks procedures. A PG&E gas maintenance and construction (GM&C) supervisor was notified of the accident and was designated as the incident management team lead at 1:17 p.m.[10] He then began dispatching field personnel to the scene, including (1) the superintendent of the San Francisco Division, who was assigned as the PG&E IC, (2) a GM&C supervisor, who was assigned as deputy IC, (3) a gas mechanic with tools to squeeze off a 6-inch

[9] An alarm assignment indicates the level of response necessary by the fire department. The response is escalated, and more resources are dispatched as the alarm assignment rises from first alarm to second alarm to third alarm.

[10] PG&E has structured teams of support staff for emergency response known as *incident management teams*. These teams oversee emergency response activities within their local areas and staff local back-office support in case of an escalated response. Each field division has its own designated incident management team staff, which may be exchanged or supplemented as needed.

steel gas pipeline, and (4) a Gas Pipeline Operations and Maintenance (GPOM) supervisor to prepare the crew for any necessary valve closures.[11]

The deputy IC, his GM&C crew, and the gas mechanic were off site independently performing other work when they received the notification to go to the accident site. They were delayed by heavy traffic, so the deputy IC requested police escorts from a nearby police officer for the mechanic, himself, and his GM&C crew, who were all in separate vehicles. According to the deputy IC, the request was denied because the officer he asked did not believe that escorts were a service the SFPD offered. The PG&E "911 Notification Process" stated Gas Distribution Control Center (GDCC) personnel should request assistance from 911 dispatch if PG&E personnel are delayed due to traffic; GDCC did not make such a request although they were aware of the delays.[12]

At 1:28 p.m., the senior controller in the GDCC verbally requested that a valve isolation plan (VIP) be developed for the accident site. A VIP is used by field personnel to isolate the damaged portion of pipeline and stop the release of gas using squeeze-off(s) and/or valve closure(s). Isolation plans are developed by the Gas System Planning (GSP) team and executed by GM&C crews (squeeze-offs) and GPOM technicians (valve closures). The initial VIP consisted of two squeeze-offs, one on a 4-inch medium density polyethylene distribution pipeline on Parker Avenue north of the accident site, and one on a 6-inch steel pipeline in the center of Geary Boulevard south of the accident site and near a 12-inch steel pipeline. Per PG&E's *Gas Emergency Response Plan*, the GSP team's goal in creating the VIP was to determine the best method of isolating the damaged portion of pipe while also minimizing customer impacts (PG&E 2017).

At 1:35 p.m., the first GM&C crew on scene began excavation of the 4-inch medium density polyethylene pipeline on Parker Avenue. This squeeze-off was successfully completed at 2:34 p.m.

In consultation with the IC, the deputy IC's GM&C crew, the second crew on site, began work at 1:50 p.m. to excavate the 6-inch steel pipeline in the center of Geary Boulevard. In that area, a 12-inch steel pipeline interconnected with the 6-inch steel pipeline. (See figure 8.) This dig site was chosen based on an old marking for the 6-inch pipeline (date and purpose of marking unknown), which was far enough away from the fire that the deputy IC felt it was safe for his crew to proceed.

[11] A *squeeze-off* is a method used to stop the flow of gas in polyethylene or small diameter steel mains by uniformly compressing the main between parallel bars until the inside surfaces make solid and even contact.

[12] A *GDCC* is an operations center with personnel called controllers who remotely monitor and control the operations of a natural gas distribution pipeline system. PG&E's GDCC is located at its corporate headquarters in San Francisco.

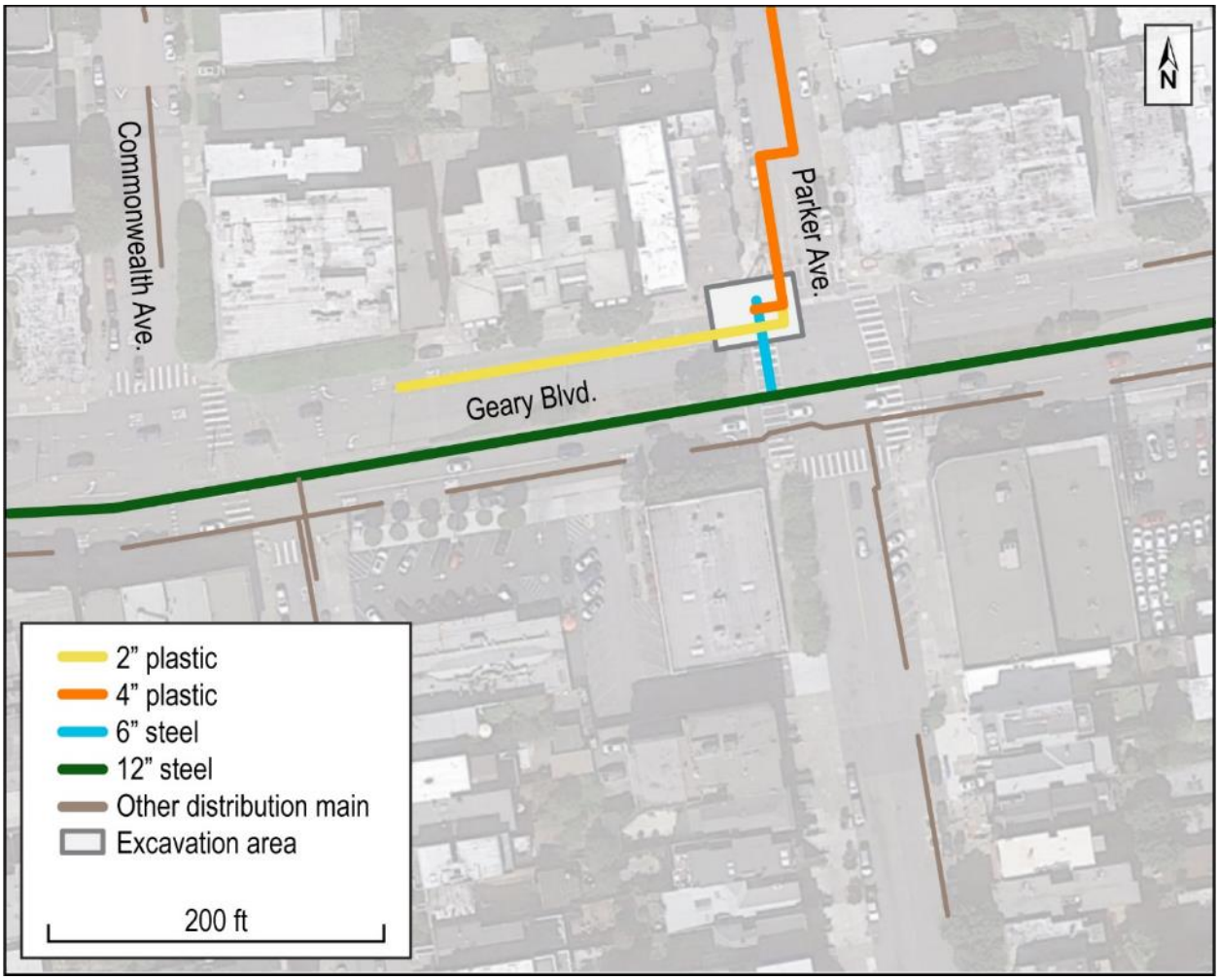

Figure 8. Map of location of gas pipelines affected by the accident. (Courtesy of PG&E.)

After the excavation of the 6-inch steel pipeline was already underway, three PG&E locators determined the 12-inch pipeline and, therefore, the 6-inch steel pipeline, were north of the current dig site. Once the "locate crew" recognized the current excavation would not effectively isolate the segment, the excavation was abandoned. A second excavation was started north of the 12-inch pipeline and closer to the fire, with the protection of a water curtain provided by the SFFD.[13]

A second VIP was developed based on valve closures to stop the flow of gas. At 1:55 p.m., the GSP team sent the GDCC a screenshot of PG&E's hydraulic modeling software that showed which valves must be closed to complete isolation; this screenshot only had valve numbers and did not contain full information on their locations. About 2 p.m., the GSP team delegated the manual research of geographic information system (GIS) location data for the valves to a local

[13] This excavation was still ongoing when valves were being closed; the gas flow was stopped before this excavation was completed.

planning engineer on the incident management team.[14] (Table 1 shows the timeline of VIP development.)

Table 1. Valve isolation plan (VIP) development timeline for February 6, 2019.

Event	Time
Accident occurs	1:07 p.m.
PG&E notified of accident	1:12 p.m.
Gas system planning team begins developing VIP	1:24 p.m.
List of valves requiring closure is finalized	1:55 p.m.
Gas system planning delegates research of valve locations to planning engineer	2:00 p.m.
Gas operations and maintenance crew arrives at the accident site	2:05 p.m.
Valve locations provided to gas system planning	2:22 p.m.
Gas system planning completes packaging of VIP with valve locations	2:41 p.m.
Gas pipeline operations and maintenance crew receives VIP with valve locations	2:45 p.m.

The local planning engineer provided the valve locations to the GSP team at 2:22 p.m. At 2:41 p.m., the GSP team completed the final VIP, which included the valve location data and sent it to field personnel, including the GPOM supervisor, at 2:45 p.m.

Figure 9. Final valve isolation plan with valves closed and location of damage.

The GPOM crew immediately began closing valves once they received the final VIP with location data; the last valves were closed at 3:36 pm. Table 2 lists the valve closure times. All the valves were accessible and not paved over.

[14] A *GIS* is used to store, manage, and analyze spatial data. The data referred to here are the latitude and longitude of each of the valves, as well as details on the intersections where the valves were located.

Table 2. Valve closure times.

Valve Number	Time of Closure
V - 3486	3:05 p.m.
V - 3489	3:15 p.m.
V - 315	3:20 p.m.
V - 190	3:31 p.m.
V - 367	3:36 p.m.
V - 3406	3:36 p.m.

The gas fire was extinguished at 3:38 p.m., according to the SFFD IC. Field personnel then started to curtail services, and all 328 affected customers were isolated by 10:45 p.m.[15] PG&E reported the total volume of natural gas released during the accident as 1.924 million cubic feet. Table 3 summarizes the timeline from the event to the time the fires were controlled.

Table 3. Timeline of emergency response events.

Event	Time
Gas ignites	1:07 p.m.
First public calls to SFDEM 911 dispatch	1:08 p.m.
SFPD arrives on scene	1:09 p.m.
SFFD arrives on scene	1:12 p.m.
PG&E notified of accident	1:12 p.m.
Development of valve isolation plan started	1:24 p.m.
First squeeze-off started	1:35 p.m.
First squeeze-off completed	2:34 p.m.
Valve isolation plan sent to field personnel	2:45 p.m.
First valve closure	3:05 p.m.
Final valve closure	3:36 p.m.
Gas fire extinguished	3:38 p.m.
Structure fires contained	3:51 p.m.
Structure fires controlled	4:24 p.m.

None of the five Kilford employees were injured nor were the traffic control technicians. One traffic control technician close to the eruption point was knocked down by the force of the gas release but did not require medical attention. There were no injuries to the public. Three arson investigators from the SFFD Bureau of Fire Investigation later determined that the fires caused an estimated $10 million in property damage (including contents) to four structures on Geary Boulevard. The bureau classified the fire cause as accidental.[16]

1.3 PG&E Natural Gas Systems and Main Specifications

1.3.1 PG&E Overview

PG&E is a large natural gas and energy company based in San Francisco, California, with about 23,000 employees. PG&E's natural gas system consists of 42,141 miles of distribution pipelines, 6,438 miles of transmission pipelines, and various storage facilities. The lines involved

[15] *Curtail gas services* means to shut off gas service for a short period of time with the intention of restoring service later.

[16] A fire that is designated accidental in cause means that no suspected arson or other foul play occurred to initiate the fire.

in this accident are part of PG&E's natural gas distribution pipelines located within the San Francisco Division, which encompasses the entirety of the city of San Francisco.[17]

1.3.2 Pipeline System

Within Kilford's planned excavation area, a 4-inch polyethylene natural gas distribution pipeline, owned and operated by PG&E, was connected to a 2-inch polyethylene pipeline by a saddle-fused medium-density polyethylene branch connection.[18] This branch connection, known as a 4-inch by 2-inch square-base high-volume tapping tee, was most likely manufactured by Uponor Aldyl Corporation and was installed in 2000.[19] The two pipelines, connected by the branch connection, fed several service lines, which were interconnected to other pipelines, including a 6-inch steel pipeline. The last leak survey in this area was performed by PG&E in April and May 2018, and no leaks were found.[20] During postaccident investigation, PG&E found the depth-of-cover was 42 inches for the 4-inch pipeline and 40 inches for the 2-inch pipeline.[21]

The branch connection was estimated to extend an additional 6.5 inches in height above the 4-inch pipeline, based on an exemplar branch connection provided to the National Transportation Safety Board (NTSB) postaccident.

Table 4. Specifications for pipelines involved in accident.

	4-Inch Main	2-Inch Main
Material	Medium Density Polyethylene	Medium Density Polyethylene
Manufacturer	Uponor Aldyl Corporation	Uponor Aldyl Corporation
Year Installed	1997	2000
Average Depth of Cover[a]	42 inches	40 inches

[a] Based on measurements taken after the accident.

The maximum allowable operating pressure as determined by Title 49 *Code of Federal Regulations* (*CFR*) 192.621 for both pipelines was 60 pounds per square inch gauge. At the time of the accident, the pressure in the pipelines was about 46 pounds per square inch gauge, which is typical for that time of year.

[17] *Distribution systems* are systems of pipelines that transport natural gas to the end consumer.

[18] A *branch connection* is a specialized fitting that allows for flow between two mains or a main and service pipeline, typically of different sizes. A *tapping tee* is a specific type of branch connection that has a shape similar to that of an uppercase T. A *saddle fusion* is a type of fusion where the base of a branch connection and the external surface of a pipeline are simultaneously heated and then pressed together until the surfaces fuse. The shape of the fusion resembles a saddle, as the branch connection saddles the top of the pipeline.

[19] PG&E assigns parts with similar form, fit, and function from different manufacturers to the same internal PG&E part code.

[20] The area was leak surveyed using a Heath Consultants Detecto Pak-Infrared, which uses infrared technology to detect the presence of methane, the largest component of natural gas.

[21] *Depth-of-cover* is the distance between the top center of the buried utility and the top of the ground covering above it. In this case, it is the distance between the top of the asphalt road and the top center of both mains.

1.3.3 Emergency Response Procedures

As stated earlier, a VIP is a critical document developed during emergencies on natural gas distribution pipelines. The VIP informs field personnel which actions to take to isolate the damaged system while still maintaining service to as many customers as possible.

At PG&E, the VIP is developed by the GSP team based on the specific circumstances of a particular event. PG&E uses a hydraulic modeling program called Synergi to develop the VIP during emergencies. This program contains information on the pipelines, valves, and other assets for the entirety of its distribution system. Synergi can store location information, but at the time of the accident, PG&E had not input all available GIS location data, including the intersections where the valves were located, for all of the assets on its system.

During his interview with the NTSB, the GSP supervisor stated a desire for the integration of GIS location data into Synergi, which would ideally cut the process down into "a 1-minute, 2-minute button click." He noted that this data integration was part of his team's plan for the future and "just not here today." Since the accident, PG&E has begun integration of detailed GIS data into Synergi, including the intersections where the valves are located, but as of May 18, 2021, they had not yet completed this effort.

The SFFD provided information on eight specific events over the previous 2 years that it considered to be lengthy response times by PG&E due to heavy traffic; five of these events were caused by third-party damage. The length of time from when PG&E was requested by the SFFD to when PG&E arrived with proper equipment ranged from 32 to 86 minutes. In his interview, the SFFD IC expressed a desire for PG&E crews to arrive at active gas release sites earlier, stating that "we need to get you guys there faster" and "we're not getting you there."

At the time of the accident, there was no written agreement between PG&E and the SFPD, SFDEM, SFFD, or other San Francisco emergency response agencies on escorts, transport during an emergency, and emergency response equipment. As of April 20, 2021, PG&E had agreed on a process for emergency communications with the SFDEM (but not SFPD and SFFD), but as of the date of this report, there was no written comprehensive, collaborative memorandum of understanding addressing emergency response plans in the event of a pipeline accident between PG&E and SFDEM, SFPD, or SFFD. During pipeline emergencies, a PG&E public safety specialist contacts SFDEM directly, giving both parties quick access for communications during the emergency response.

1.4 Postaccident Pipeline Examination

The segment of damaged 4-inch pipeline connected to the 2-inch pipeline by the branch connection and a cutter insert were removed by PG&E during the postaccident pipeline repair and transported to the NTSB Materials Laboratory for examination and testing.[22] (See figure 10.)

[22] A *cutter insert* is a specialized hole saw that is used after fusion of the branch connection to the main or service pipeline. The cutter removes a section of the seating pipe wall to allow flow through the branch connection from one pipeline to another. If left in place after use, it is located at the top of the branch connection.

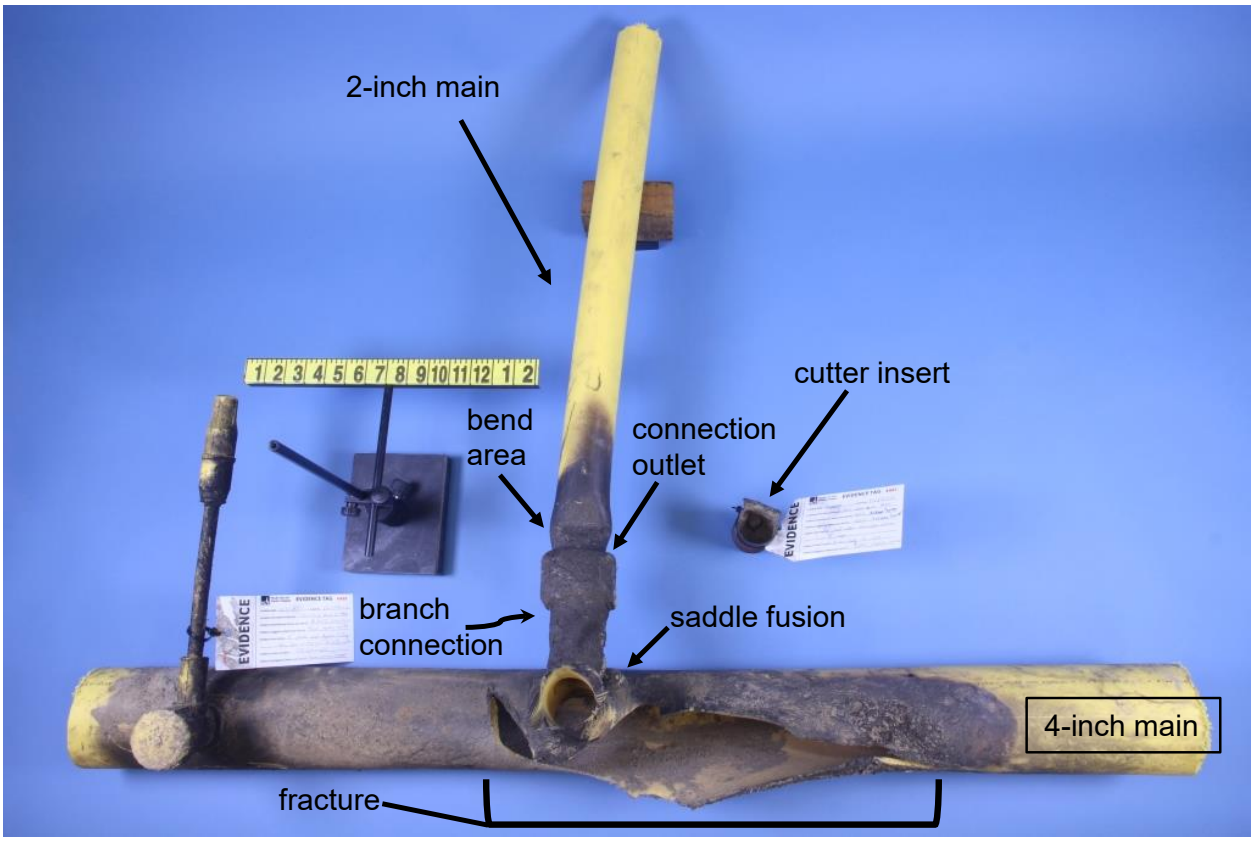

Figure 10. Postaccident 2-inch pipeline, 4-inch pipeline, branch connection, and cutter insert.

The markings on both pipelines indicated they were manufactured by Uponor Aldyl Corporation to specification ASTM D-2513. The 2-inch pipeline had a standard dimension ratio of 11, while the standard dimension ratio of the 4-inch pipeline was 13.5.[23] The pipeline material designation code PE-2406 was marked on the 2-inch pipeline; no material designation could be found on the 4-inch pipeline.[24] The 2-inch pipeline was marked with a manufacture date code of 091399 (September 13, 1999), and the 4-inch pipeline was marked 092096 (September 20, 1996). Measurements of the pipeline dimensions were taken. (See table 5.)

Table 5. Laboratory-measured pipeline dimensions.

Pipe Dimensions	2-Inch Main	4-Inch Main
Outer Diameter (inches)	2.37	4.59
Inner Diameter (inches)	1.91	3.78
Wall Thickness (inches)	0.23	0.35

The underside of the 4-inch pipeline and 2-inch pipeline were examined for scrapes, gouges, or other contact markings. No markings or features were found. A significant bend in the

[23] *Standard Dimension Ratio* is the ratio of the outside diameter to the wall thickness for a particular main.

[24] *Pipe material designation code* is referenced in ASTM D3350 and defines the material standard to which the main was manufactured. PE 2406 is a common material designation for polyethylene mains used in natural gas service.

2-inch pipeline was found 1.25 inches from the outlet of the saddle-fused branch connection. (See figure 11.) No impact marks or scrapes were found in the bend area.

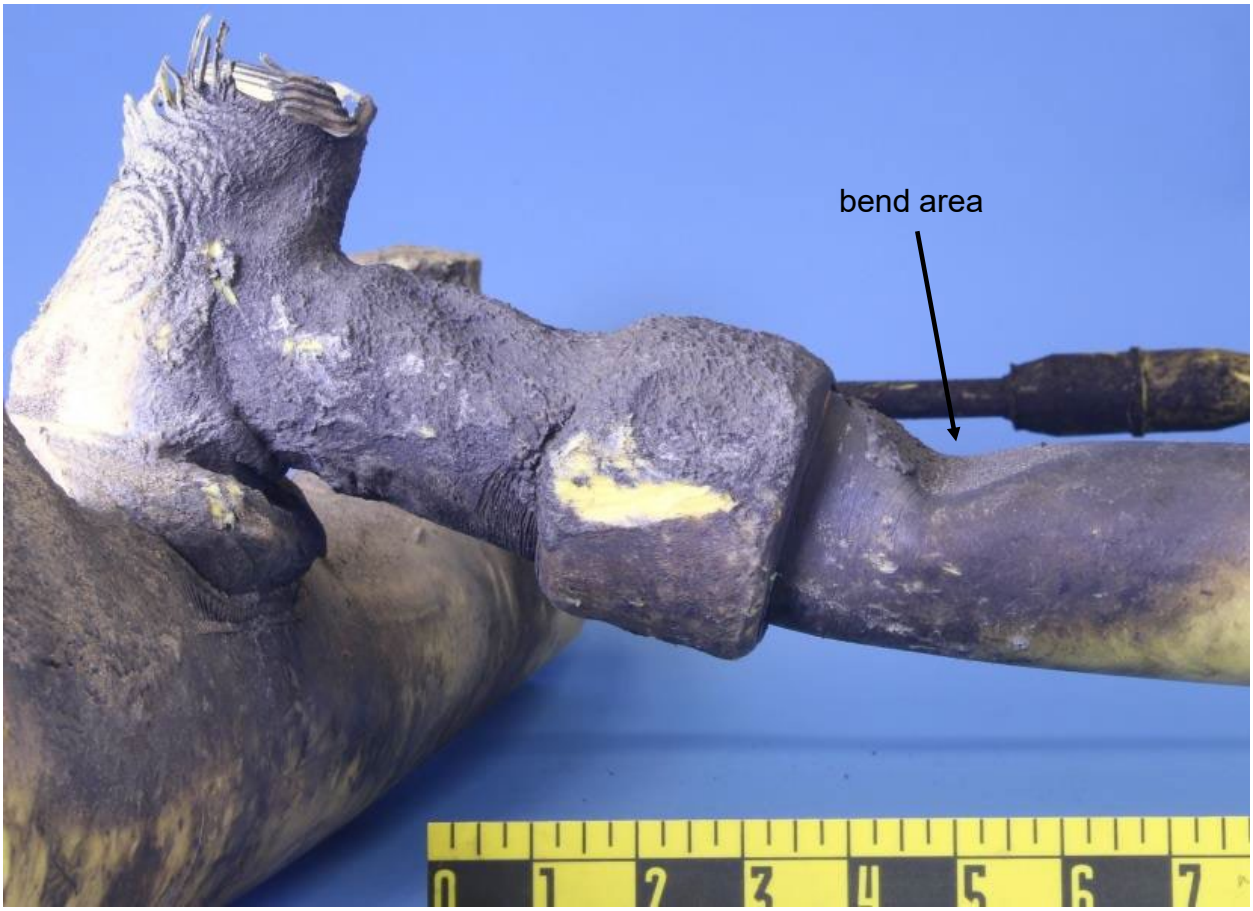

Figure 11. Close-up view of bend area in 2-inch pipeline.

The cutter insert was further examined using a microscope. A diagonal gouge was observed across the insert. Figure 12 is a side view of the cutter insert showing the diagonal gouge at different magnifications.

Figure 12. Side view of cutter insert showing diagonal gouge.

Note: The upper left image shows no magnification; the upper right image is 5X magnification, and the bottom image is 20X magnification.

A longitudinal fracture was observed in the 4-inch pipeline along the top of the pipeline near the fusion with the branch connection. (See Figure 13.) Along most of the fracture surfaces, features were not identifiable due to thermal fusion and loss by melting or pyrolization. However, chevron marks were found on the fracture surface to the left of the saddle fusion. To the right of the branch connection, the fracture features were relatively smooth with hackle marks consistent with the direction of fracture, as indicated by red arrows in Figure 13.[25]

[25] Occurring under rapid crack growth, *hackle marks* in polymers manifest as rough feather-like features. Such features exhibit a divergent pattern and occur due to small-scale secondary crack formation parallel to the fracture plane and are indicative of high-energy dissipation (Lampman 2003, p. 412).

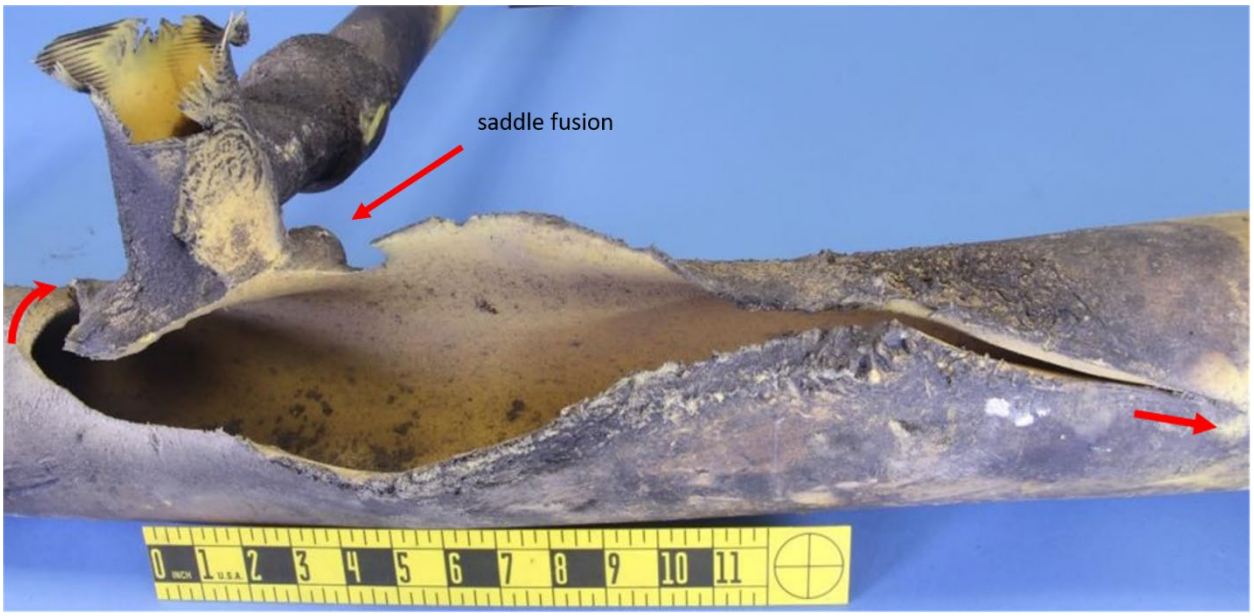

Figure 13. View of fracture area in the 4-inch pipeline.

Two exemplar gas pipeline material samples were submitted to the NTSB to verify material identification. The samples were examined using a Fourier transform infrared spectrometer with a diamond attenuated total reflectance accessory in accordance with ASTM E1252-98. The samples shared matching spectra, indicating that the samples were the same material. A spectral library search found that the material in the two samples was a very strong match to polyethylene, thus confirming material properties.

1.5 Kilford Engineering

1.5.1 Licensing

At the time of the accident, Kilford was licensed by the Contractors State Licensing Board (CSLB) to perform excavation work within California as a Class A general engineering contractor; the company obtained its first CSLB license on October 26, 2018, and had been in business about 3 1/2 months at the time of the accident.[26] Kilford's contractor license had two registered employees: the chief executive officer and the operator of the mini excavator. Kilford temporarily employed other personnel as needed for specific projects.

[26] Class A general engineering contractors in the state of California are licensed to perform a wide variety of tasks requiring engineering knowledge and skill, including tasks in the fields of excavation, paving and surfacing work, and utility installation.

The operator of the mini excavator was certified as a competent person per Occupational Safety and Health Administration (OSHA) regulations.[27] Although requested, Kilford did not provide training records for the employees who were at the accident site.

1.5.2 Safety Procedures

Kilford's *Employee Code of Safe Practices* covered safety procedures such as competent person, stop work authority, safety meetings, emergency action plans, and excavation and trenching practices. According to this document, Kilford designated the competent person on site, also known as the job foreman, as "responsible for hazard recognition and protection," and the job foreman had "complete authority to suspend work activities and remove exposed employees from work locations." All other employees were urged to stop and seek instruction if they had "a safety problem related to this job or (had) any doubt as to the safety of any work activity including the use of tools and equipment." Safety meetings were conducted at least weekly by the foreman, and attendance was mandatory for all employees on the job site.

Kilford's emergency action plan listed emergencies, including natural gas leaks and explosions. According to the *Employee Code of Safe Practices*, in the event of an emergency, employees' "first response shall be whatever action limits continuing damage." The emergency action plan had the phone number for local emergency dispatch as well as 911. These procedures did not specify that Kilford should contact 911 or utility operators in the case of a line strike, which was inconsistent with regulations in *GOV* 4216.4.

The final section of Kilford's *Employee Code of Safe Practices* addressed excavation and trenching. This section reiterated that the competent person had full "stop work" authority. Excavation work was not to begin until 811 (the one-call number) had been notified at least 2 days in advance of any proposed work, and the area had been "marked as specified in Government Code 4216." A meeting was required between existing utility owners and Kilford "prior to the start of excavation to determine any actions or activities necessary to verify the location of that installation." For the Geary Boulevard work site, PG&E performed a walkthrough of the locate marks with a Kilford employee one week prior to the excavation work.

Kilford had two additional policies related to excavation. The first was the *Excavation Competent Person Manual*, which addressed relevant OSHA regulations in detail, including 29 *CFR* 1926.651(b)(3), which states that the "exact location of the [underground] installations shall be determined by safe and acceptable means" whenever the excavation approaches the marked location of buried utilities. The second was the "field manual for trenching," which was a quick guide that covered OSHA policies and safety practices, mainly centered around prevention of cave-ins and proper benching and shoring.[28]

[27] An OSHA "competent person" is defined as "one who is capable of identifying existing and predictable hazards in the surroundings or working conditions that are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them." (29 *CFR* 1926.32[(f)]).

[28] This "field manual for trenching," officially known as the *Trench Excavation Competent Person Visor Guide* was published by United Rentals; the publication date is unknown.

1.5.3 Postaccident interviews with Kilford's Mini Excavator Operator

Two PG&E employees, a gas service representative and a Dig-in Reduction Team investigator spoke with Kilford's mini excavator operator after the gas release began.[29] The first gas services representative on-scene had him fill out a Gas Dig-in First Responder Form with the details of what occurred. The gas services representative stated that the mini excavator operator wrote that "he was shoveling, and it exploded."

The Dig-in Reduction Team investigator also met with the mini excavator operator to discuss the accident. During their discussion, he stated that the branch connection caused him an issue; the investigator wrote that the issue was "because it was higher than the 2-inch gas pipeline that he exposed, and he thought that he had enough room." The Dig-in Reduction Team investigator concluded that Kilford had struck the branch connection while mechanically excavating within the tolerance zone due to a failure to properly expose the 2-inch and 4-inch pipelines and branch connection.

1.5.4 Past Incident

Around January 12, 2019, Kilford damaged a 2-inch copper water line during excavation work for MasTec on Hawthorne Street between Folsom Street and Harrison Street in San Francisco. The company had been in business for 11 weeks when the damage to the water line occurred. The water line was about 10 inches below grade in rocky ground/concrete located directly under a wooden beam.[30] All information on this incident was provided by Kilford, and no formal investigation of the incident was performed by any outside party.

Kilford stated that, during the water line incident, the operator (who was also the mini excavator operator in the gas pipeline accident) used a toothed trenching bucket attachment on the mini excavator due to difficult terrain. During mechanical excavation to create a trench for fiberoptic conduit installation, the teeth of the trenching bucket penetrated the water line. However, photographs after the January 2019 incident show the mini excavator with a jackhammer attachment near the line strike area, not a toothed trenching bucket. Kilford asserted the water line was unmarked and provided a one-call ticket. The one-call ticket for that project did not have positive confirmation from the San Francisco Water Department of any location or markings. No photographs of the damage area showing the markings (or lack of markings) before excavation were available.

[29] PG&E's *Gas Emergency Response Plan* (2017) states the initial resource deployed in all incidents requiring a field response is a gas service representative. This individual performs a variety of tasks on scene, including requesting additional resources, evacuating the public, eliminating ignition sources, and shutting off gas service, if possible and safe to do so.

[30] The initial incident report had the depth-of-cover of the water line as 18 inches.

1.6 California Damage Prevention Regulations

1.6.1 Excavation Regulations

Confirming the position and depth of existing utilities, called location confirmation, is a two-part process where the spotter (1) identifies the utilities' locations via the use of one-call markings and a probe and then (2) uses lower impact techniques to expose the top of the utility, such as hand digging, vacuum methods, or pneumatic tools.[31] Location confirmation should be done at regular intervals and at all places where the existing utility and excavation area intersect, per industry best practices and state regulations.[32]

Excavators may not mechanically dig within the tolerance zone of any existing utilities until the utilities' exact locations have been confirmed by digging with hand tools or other low impact methods. *State of California Government Code* (*GOV*) 4216.4(a)(1) defines the tolerance zone as 24 inches from the center of the mark in the case of a single mark (as was the case with this accident) or 24 inches plus half the specified buried utility width as measured from the outer edges if the full dimensions of the buried utility are marked. The tolerance zone is an area between two vertical planes at all depths. State regulations require that the location (position and depth) of all existing utility lines in the excavation area be confirmed before any mechanical excavation within the tolerance zone. (*GOV* 4216[n][1])

Depth was not included in the markings that were made by PG&E, as industry best practices outlined in the Common Ground Alliance's (CGA) *Best Practices Guide* do not recommend providing depth when responding to a one-call ticket (CGA 2018).[33] *GOV* 4216(n)(2) also does not require the locator to provide the depth of the buried utilities.

1.6.2 California Public Utilities Commission

The California Public Utilities Commission (CPUC) enforces federal and state regulations, including damage prevention laws, on intrastate natural gas pipelines within the state of California through a relationship with the Pipeline and Hazardous Materials Safety Administration (PHMSA), known as a state partnership.[34]

The CPUC does not have jurisdiction over excavation contractors who are not employed by natural gas operators; thus, Kilford does not fall under the authority of the CPUC.

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[31] These and other lower impact methods are recommended by CGA's *Best Practices Guide* for all excavation within a tolerance zone of 18 inches from the outside of existing utilities, with the exception of pavement removal (CGA 2018).

[32] Guidance on location confirmation can be found in *GOV* 4216 to 4216.24 and CGA's *Best Practices Guide* (CGA 2018).

[33] *CGA* is a nonprofit organization dedicated to the promotion of safe excavation and damage prevention practices. Best practices endorsed by the CGA are developed by consensus with experts in excavation, location, road construction, electrical utilities, telecommunications, oil pipelines, natural gas distribution and transmission pipelines, public works, manufacturing, state regulators, and other stakeholder groups.

[34] An intrastate pipeline is a pipeline that is fully contained within the boundaries of a state. This definition includes all distribution mains and service pipelines.

1.6.3 Contractors State License Board

In California, contractors are licensed by the Department of Consumer Affairs' CSLB. The CSLB was created in 1929 and is led by a 15-member board composed of 5 contractors and 10 public members, including a labor representative, a local building official, and a statewide senior citizen organization representative. Appointments to the CSLB are made by the governor of California and the California State Legislature. About 400 CSLB employees issue and enforce the licenses of about 300,000 contractors, including investigating customer complaints against contractors.

Enforcement actions from the CSLB fall into three categories:

1. Licensing issues, such as failure to be adequately bonded or cancellation of workers' compensation insurance.
2. Response to consumer complaints, such as poor workmanship, building code violations, or project abandonment.
3. Contractors illegally performing work without a license.

If the investigation by CSLB staff into any of these three categories identifies that a violation(s) has been committed by the contractor, the CSLB can suspend the contractor's license, require the licensee to obtain an additional disciplinary bond, enforce a probation period with agreed upon terms and conditions, revoke the contractor's license, request an injunction to halt the activity, require the contractor to pay a fine to cover investigation and enforcement costs, refer the issue to the local district attorney for criminal charges, or any combination of these actions. In fiscal year 2018, the CSLB referred 1,785 cases for criminal prosecution, issued 2,025 citations, and revoked 395 licenses (CSLB 2018).[35] More serious enforcement actions are referred to as "accusations" and stay on public record from 5 to 7 years depending on their seriousness. Accusation enforcement actions include suspension, revocation of license, and restitution orders to the injured party.

In the field of excavation, the CSLB has the authority to enforce *GOV* Sections 4216 to 4216.24, which they refer to as the "California One-Call Law," and *State of California Code of Regulations* Sections 1539 to 1541.These regulations cover a wide variety of topics, including one-call, location before excavation, hazard identification, shoring requirements, required excavator response in the event of damages, tolerance zone for mechanical excavation, applicable civil penalties in the case of a violation, and creation of the California Underground Facilities Safe Excavation Board (Dig Safe Board).

On July 15, 2020, the CSLB issued a pending accusation against Kilford and both officers of the company. The accusation stated that the company failed to properly follow the California One-Call Law (CSLB 4216.4) by not determining the location of the buried pipelines with hand tools before mechanical excavation.[36] Pending the results of a hearing on this issue, potential

[35] The CSLB's 2018 fiscal year was from July 1, 2017, to June 30, 2018.

[36] The CSLB calls GOV 4216 to 4216.24 "California One-Call Law." In its accusation, CSLB cites Kilford for violation of GOV 4216.4, which requires excavators to use hand tools to determine the location of subsurface installations before using any power-driven equipment for excavation.

actions by the CSLB may include revocation or suspension of Kilford's license and those of its two officers, issuance of fines to recover investigative costs, and barring both officers of the company from serving as officers for any other contracting company. The hearing for this accusation is scheduled for August 16, 2021, through August 18, 2021.

1.6.4 California Underground Facilities Safe Excavation Board

Investigation of accidents involving facilities damaged during excavation are under the purview of the California Underground Facilities Safe Excavation Board, otherwise known as the Dig Safe Board. This agency was established by the Dig Safe Act of 2016 (*GOV* 4216.12). According to its website, the purpose of the Dig Safe Board is to investigate accidents, develop excavation safety standards, and coordinate education and outreach activities.[37] The Board is composed of nine members who are appointed by the governor of California and the California State Legislature and falls under the umbrella of the California Office of the State Fire Marshal. At the end of 2018, the Dig Safe Board had 10 staff members, including 4 investigative staff.[38] Investigations began in July 2019, and enforcement actions of *GOV* sections 4216 to 4216.24 violations began on July 1, 2020. By August 24, 2020, the Dig Safe Board had 8 investigative staff, with vacancies for 4 additional investigators of various levels.

The Dig Safe Board's mandate requires investigation of any potential violations of *GOV* sections 4216 to 4216.24, California's main damage prevention laws. Based on the results of their investigations, the Dig Safe Board may choose to issue enforcement actions using a progression of (1) warnings and (2) notices of proposed violation (NOPV).

The first main enforcement tool is warnings, which are used for lower-level violations and issued via Advisory Letters to the offending party(ies). The second main enforcement tool used by the Dig Safe Board is the NOPV. A NOPV issued by a Dig Safe Board investigator informs the receiving party(ies) that they are being charged with probable violations of California damage prevention law. These allegations are accompanied by recommendations to the Dig Safe Board members for mandatory education, fines, or both. The training course used to meet the Dig Safe Board's education sanctions covers materials from *GOV* Sections 4216 to 4216.24, one-call center information, and the CGA *Best Practices Guide* through the use of three case studies of past excavation accidents in California and another state.

The Dig Safe Board is also charged with creating new rules and regulations "where none currently exist to improve worker and public safety across the state." (*GOV* 4216.22). As of August 24, 2020, the Dig Safe Board had passed regulations covering damage reporting, areas of continual excavation, and hearing procedures.

On November 1, 2019, the Dig Safe Board issued 22 advisory letters as a warning to potential violators. By August 24, 2020, the Dig Safe Board had completed 374 investigations into potential violations of California damage prevention law and issued 16 NOPVs. Of these, 14 recommended mandatory education, and the other 2 recommended the maximum fine allowable under state law. Two of the NOPVs were referred to other agencies, both of which recommended

[37] California Underground Safe Facilities Excavation Board (Dig Safe Board) website: https://digsafe.fire.ca.gov/
[38] Staff refers to all employees of the Dig Safe Board who are not Board Members.

mandatory education. The Dig Safe Board will issue an advisory letter or NOPV to Kilford in 2021.

1.6.5 Damage Prevention Program Evaluation

PHMSA has the authority to enforce federal damage prevention laws. Title 49 *CFR* 196.103 states that excavators are required to place a one-call ticket, not excavate prior to the location and marking of all underground facilities, and excavate "with proper regard for the marked location of pipelines" to prevent damage. PHMSA's authority to enforce federal regulations does not restrict the state of California from enforcing state regulations alongside PHMSA.

In 2016, PHMSA performed an audit of California's enforcement of damage prevention law and deemed it inadequate. Multiple state agencies, including the CPUC, the California Office of the State Fire Marshal, and the California Attorney General's Office, told PHMSA that no enforcement actions or civil penalties had been issued for violations of the damage prevention law in the prior calendar year. According to CPUC data, there were 5,256 incidents of damage to underground natural gas facilities from excavation in 2016. State regulation allowed for the issuance of civil penalties to excavators in amounts not to exceed $10,000 for negligent violations and $50,000 for knowing and willing violations. In 2017, PHMSA re-audited the state of California and found the state's enforcement of damage prevention law still to be inadequate. In its audits, PHMSA did not find fault with the majority of California's regulations on damage prevention. Instead, the programs were deemed inadequate because *GOV* sections 4216 to 4216.24 were not routinely enforced at that time. In its 2017 letter, PHMSA remarked on the creation of the Dig Safe Board and the expectation that it would be capable of enforcing *GOV* Sections 4216 to 4216.24 in the near future.

In 2020, PHMSA re-audited the state of California and found its program to be adequate. In a letter to the Dig Safe Board with their audit findings, PHMSA noted that the Dig Safe Board investigated 78 damaged natural gas facilities events in California and that "10 of those [cases] led to a civil penalty," as compared to no civil penalties in the prior year. PHMSA requested the Dig Safe Board "evaluate how it may improve its program" regarding future enforcement. The Dig Safe Board had been enforcing state damage prevention law for about 6 months at the time of PHMSA's 2020 adequacy determination.[39]

[39] January 26, 2021, Notice of Adequacy Letter from PHMSA to the executive officer of the Dig Safe Board, accessible at California | PHMSA (dot.gov)

2 Analysis

2.1 Introduction

On February 6, 2019, at 1:07 p.m., the operator of a mini-excavator, who worked for a third-party contractor, Kilford, damaged a PG&E branch connection between a 4-inch natural gas pipeline and a 2-inch natural gas pipeline during mechanical excavation for fiberoptic conduit installation. The damage resulted in the release of gas and subsequent ignition and gas fire at the intersection of Geary Boulevard and Parker Avenue in San Francisco, California. Structure fires occurred in 4 neighboring buildings, including an occupied restaurant. No injuries occurred as a result of this accident.

This analysis discusses the accident and following safety issues:

- Third-party excavation damage to buried natural gas pipelines. (See section 2.3.1.)
- Enforcement challenges of California's damage prevention law. (See section 2.3.2.)
- PG&E's data integration gaps during the development of the VIP. (See section 2.4.)
- Insufficient joint emergency response planning between PG&E and San Francisco, California, emergency response agencies. (See section 2.5.)

2.2 Exclusions

Having completed a comprehensive review of the circumstances that led to the accident, the investigation established that the following factors did not contribute to its cause:

- *Two one-call ticket requests*. The one-call ticket history shows that Kilford placed two requests for locate and mark services because the first request was inaccurate. PG&E clarified the excavation location with Kilford and accurately marked the location of its buried natural gas utilities before the start of excavation.
- *Locate and mark activities*. The location of the PG&E 4-inch pipeline, 2-inch pipeline, and branch connection were clearly marked by the PG&E locator. Additionally, the PG&E locator met with a Kilford employee at the planned excavation site to discuss the markings before the start of work.
- *State of California tolerance zone regulations*. California state law exceeds CGA recommended best practices for tolerance zones. The required tolerance zone of 24 inches from the center of the utility markings was sufficient to allow Kilford to determine the exact location of buried natural gas pipelines and branch connection without damaging or impacting them.

- *Pipeline integrity.* Postaccident examination indicated that both gas pipelines and the saddle fusion were intact and operational before the accident. NTSB examination of the damaged segment did not identify any issues with material integrity, aside from those resulting from the fire. Although the saddle fusion was not fully intact postaccident, this was due to thermal fusion and material loss by melting or pyrolization. The thermal fusion also precluded an exact determination of the failure origin. The investigation did not reveal any issues with the manufacture or age of the pipelines or branch connection.

  Supervisory control and data acquisition records also show the operating pressure of the distribution pipelines was under the maximum allowable operating pressure, which indicates there was no increase in pressure over the pipelines' yield strength on the day of the accident; the pressure in the pipelines was stable and at the expected value. The maximum allowable operating pressure of both mains involved was consistent with federal and state regulations.

  Leak surveys performed the prior year did not indicate any gas migration or leaks in the nearby area. Additionally, there was no evidence of excavation work performed in the area between the date of the one-call mark and the start of work by Kilford.

The NTSB concludes that the following factors did not contribute to the cause of the accident: two one-call ticket requests, locate and mark activities, and California regulations regarding the tolerance zone. The NTSB further concludes that PG&E's pipeline was intact and operating as designed prior to the accident.

2.3 Third-Party Excavation Damage

2.3.1 Kilford Engineering Inc.

The cause of third-party damage typically falls into three main subcategories: (1) failure of the third-party to place an accurate one-call ticket, (2) failure of the utility to accurately locate and mark buried facilities, and (3) failure of the third-party to properly follow safe excavation practices.[40] The first two main subcategory causes were excluded above; this section will address Kilford's failure to follow safe excavation practices.

As stated above, photographic evidence showed that the PG&E 4-inch and 2-inch natural gas pipelines and branch connection were accurately marked in yellow spray paint in the requested area and clearly visible. Additionally, the PG&E locator met with a Kilford employee at the planned excavation site to discuss the markings before the start of work, a practice that is consistent with recommendations within the CGA *Best Practices Guide*, Section 5.4 (CGA 2018). Therefore, the NTSB concludes natural gas facilities were accurately marked, and Kilford employees working at the site were aware of the markings indicating the locations of the 4-inch gas pipeline, 2-inch gas pipeline, and branch connection before the start of excavation.

[40] From PHMSA-reportable gas distribution pipeline accident data from January 1, 2010, to March 20, 2020. These three accident subcategories accounted for 94 percent of the total third-party damage accidents (PHMSA 2021).

CGA recommends that excavators use low impact methods, such as hand digging, within a defined tolerance zone of 18 inches from a buried facility on a horizontal plane (CGA 2018, Sections 5.19 and 5.20). In California, the tolerance zone is extended by state law to a more conservative distance of 24 inches from the buried utility locate marking, and mechanical excavation is only permitted in the tolerance zone after the exact location of the utility has been confirmed using hand tools (*GOV* 4216.4[a][1]). Kilford procedures cite OSHA regulation 29 *CFR* 1926.651(b)(3) and state the "exact location of the [underground] installations shall be determined by safe and acceptable means" whenever the excavation approaches the marked location of buried utilities. The job foreman, who was the operator of the mini excavator, indicated to the NTSB that he was aware of state regulations on damage prevention.

The spotter told the NTSB that he did not recall seeing any yellow pipelines in the trench during the entirety of the excavation. Because the pipelines and branch connection were yellow, it is likely that they were not exposed before mechanical excavation was conducted in the trench within the tolerance zone. Although the mini excavator operator said he did observe partial exposures of the pipelines in the trench, he also stated that they did not expose the branch connection.

The scope of work required a trench depth of 36 inches for proper installation of the conduit. The spotter thought the trench depth was 24 inches at the time of the accident, and the mini excavator operator thought he was digging at 30 inches. Although the operator believed they had exposed the pipelines at a depth of 48 inches, postaccident evidence revealed that the pipelines were at a depth of 42 inches. Based on an exemplar branch connection, the branch connection was about 6.5 inches above the 4-inch pipeline. Therefore, the depth of cover at the branch connection location was about 35.5 inches, about the same depth that was to be excavated by Kilford's crew. Although the crew thought they were digging above where they believed the pipelines were located, the evidence indicates that the pipelines and branch connection were higher than where they estimated, and the mini excavator operator was likely using the excavator to dig deeper than they estimated.

Because the crew had not exposed the pipelines and branch connection, they were excavating the trench to a depth that would have impacted the natural gas branch connection. The inward-facing bend in the 2-inch pipeline and a gouge in the branch connection's cutter insert were consistent with damage to the top of the branch connection from an external force, most likely the mini excavator's trenching bucket attachment. The external force would have stressed the 2-inch pipeline and branch connection, as was observed postaccident. Due to damage sustained during the fire, the exact failure mechanism and sequence could not be determined. Additionally, during PG&E's postaccident investigation, the mini excavator operator indicated to a PG&E investigator that the branch connection was higher than he anticipated and that he thought he had enough room.

Based on available evidence, the NTSB concludes that Kilford did not follow safe excavation practices when it mechanically excavated within the tolerance zone, resulting in the Kilford operator impacting the branch connection with the mini excavator trenching bucket attachment, causing the release of natural gas.

2.3.2 Enforcement Challenges of California Damage Prevention Law

A 1997 NTSB safety study, *Protecting Public Safety Through Excavation Damage Prevention*, found excavation and construction activities to be the single largest cause of pipeline accidents (NTSB 1997). Although this study was published in 1997, excavation damage continues to be the number one cause of gas distribution pipeline accidents today. Thirty-six percent of all PHMSA-reportable gas distribution pipeline accidents in 2019 had "excavation damage" listed as the incident cause (PHMSA 2021). Of these, 88 percent were attributed to a third-party. Given the prevalence and extent of third-party damage, enforcement of safe excavation regulations is essential.

In 2016 and 2017, PHMSA conducted audits of California's enforcement of damage prevention law and deemed their damage prevention program to be inadequate because the state failed to routinely enforce *GOV* sections 4216 to 4216.24. A lack of enforcement is contrary to guidance from section 7.3 of the CGA *Best Practices Guide*, which recommends a system of "penalties for failure to comply with the damage prevention laws and regulations" (CGA 2018).

The California government established the Dig Safe Board in 2016 as the investigative and enforcement authority for buried utility (including natural gas pipelines) damage prevention law. Funding of the Dig Safe Board was authorized to begin July 2017, investigations began in July 2019, and enforcement actions of *GOV* sections 4216 to 4216.24 violations began on July 1, 2020. On January 26, 2021, PHMSA changed the rating of California's damage prevention program to adequate. However, PHMSA noted "room to further improve the program's effectiveness" with regard to recent enforcement actions, including the number of civil penalties issued relative to number of damage events. The determination of adequacy letter notes the Dig Safe Board issued 10 civil penalties in 2020 related to natural gas pipeline damages.

Enforcement has been shown to be the strongest method of preventing damage to buried utilities. Data collected by the CGA show a reduction in damage events per submitted one-call tickets in states with robust enforcement programs; states with robust programs experienced 14 percent fewer reported damage events on average (CGA 2019).[41]

On January 12, 2019 (just 2 months after Kilford was licensed), an employee struck a water line during excavation, yet no enforcement actions were issued against Kilford. The Dig Safe Board did not begin issuing enforcement actions until July 2020, and the CSLB did not investigate the one-call markings. Further, Kilford was not required to provide corrective action or attend remedial training on excavation safety. Less than 1 month later, on February 6, 2019, a Kilford employee struck a buried utility, this time causing a gas-fueled fire in a heavily populated area. Therefore, the NTSB concludes that, because California did not have an excavation damage enforcement program at the time of the water line strike, the state missed an opportunity to identify and deter poor safety practices presented by a new contractor. Since July 1, 2020, the Dig Safe Board has begun enforcing compliance with California's damage prevention laws. The NTSB concludes that, although sufficient data are not yet available to determine if the Dig Safe Board's

[41] Staff calculated this percentage using state-by-state data in the CGA report in combination with more detailed data culled from the DIRT Dashboard tool (commongroundalliance.com). Staff looked at PHMSA's adequacy ratings by state for 2018 (data published in 2019) and compared the adequate and inadequate numbers. The calculation is based on the number of damages per 1,000 one-calls, which is the CGA's method for scaling between states.

enforcement actions have been effective in deterring future damage, enforcement is a step in the right direction for preventing third party damage to buried utilities.

2.4 Data Integration and Emergency Response

A VIP is a critical document developed during natural gas pipeline emergencies to inform field personnel what actions to take to isolate the damaged system while still maintaining service to as many customers as possible. At PG&E, the VIP is developed by the GSP team based on the specific circumstances of a particular event. Because natural gas distribution systems in large metropolitan areas are typically complex, with many interconnecting main pipelines and service pipelines, the VIP is essential to guide field personnel in an emergency to safely stop the release of gas in a timely manner.

Following the damage to the accident pipeline, the specific valves that were required to be closed to stop the flow of gas were identified less than 50 minutes after the fire was reported. However, the software program PG&E used to develop the VIP did not contain full GIS information to locate the valves in this area. Thus, it took an additional 50 minutes to identify the actual physical locations of the valves and provide them to field personnel so they could close the valves. Field personnel capable of closing the valves were on site at 2:05 p.m., 10 minutes after the initial VIP was created; thus, the field personnel had to wait an additional 40 minutes to start closing the valves. Once they were provided the location information, the valve closure was completed an hour later, and the fire was extinguished. During his interview, the GSP supervisor stated that GIS data integration into Synergi would ideally shorten the process to 1 to 2 minutes. Natural gas fires cannot be safely extinguished until the source is isolated, so the delay extended the time that the fire was burning and increased the safety risk to the neighborhood. The NTSB concludes that had PG&E incorporated GIS location data into the software program used to develop its VIP prior to this accident, it would have reduced the time to isolate the natural gas release.

Since the accident, PG&E has begun integration of detailed GIS data into Synergi, including the intersections where the valves closed in this accident are located, but as of May 18, 2021, they had not yet completed this effort for their entire system. Therefore, the NTSB recommends that PG&E complete the integration of detailed location data into its hydraulic modeling software so that this information is readily available for all system assets when developing a VIP following an emergency.

2.5 Coordination of Emergency Response

During the postaccident response, PG&E dispatched a gas mechanic to squeeze off a 6-inch steel pipeline and a supervisor to prepare for valve closures. The mechanic was delayed by traffic. Because these squeezers were necessary equipment for the isolation of the damaged segment, the PG&E deputy IC requested a police escort from a nearby police officer for the mechanic, himself, and his GM&C crew, which was denied because the officer did not believe that a police escort was a service the SFPD offered.

The PG&E *911 Notification Process* states the GDCC, not field personnel, will request assistance from 911 dispatch if PG&E personnel are delayed due to traffic (PG&E 2018). However, the GDCC did not request a police escort from 911 dispatch. Although no police escort was provided, the gas mechanic did arrive on-scene before the isolation of the damaged pipeline system. However, the second GM&C crew began digging in the wrong location for the second squeeze-off, and they did not complete the excavation of the 6-inch steel pipeline before the valve closures were completed. Thus, the lack of a police escort ultimately did not affect the timeliness of the fire being extinguished. However, the NTSB concludes that PG&E did not follow its own procedures regarding requests for police escorts, which may have delayed the arrival of PG&E personnel on-scene during the emergency response.

Depending on the time of day, traffic delays in San Francisco can be extensive. According to data provided by the SFFD, it has taken PG&E up to 86 minutes to arrive with proper equipment after being requested by the SFFD. In his interview, the SFFD IC expressed a desire for PG&E crews to arrive at active gas release sites earlier. Pipeline operator response times in large metropolitan areas may be negatively impacted by local vehicular traffic patterns.

In 2014, the Transportation Research Board published Report 14, *Guide for Communicating Emergency Response Information for Natural Gas and Hazardous Liquids Pipelines*, as part of its Hazardous Materials Cooperative Research Program. In this report, establishing clearly defined roles, key information needs, and paths of communication in advance of an accident is deemed critical, and "failure to plan these aspects of communications, before an incident, can cause delays in getting the appropriate resources to the scene, increase risks to both emergency responders and the public, and increase the severity and resultant impacts of the incident" (Transportation Research Board 2018). As of April 20, 2021, PG&E had agreed on a process for emergency communications with the SFDEM (but not SPFD and SFFD), but as of the date of this report there was no written comprehensive, collaborative memorandum of understanding addressing emergency response plans in the event of a pipeline accident between PG&E and SFDEM, SFPD, or SFFD. Thus, the NTSB concludes that, while the lack of a memorandum of understanding with SFDEM, SFPD, or SFFD addressing emergency response plans did not affect the timeliness of PG&E shutting off the flow of gas in this accident, it could potentially affect other responses where the squeeze-off point is accessible and/or the valve locations are readily known. Therefore, the NTSB recommends that PG&E in collaboration with the SFPD, SFFD, and SFDEM establish an agreement to provide a coordinated response and reduce response times for your crews to arrive at the scene of a pipeline accident. Further, the NTSB recommends that SFPD, SFFD, and SFDEM work with PG&E to establish an agreement to provide a coordinated response and reduce response times for Pacific Gas & Electric Company crews to arrive at the scene of a pipeline accident.

3 Conclusions

3.1 Findings

1. The following factors did not contribute to the cause of the accident: two one-call ticket requests, locate and mark activities, and California regulations regarding the tolerance zone. Further, the Pacific Gas & Electric Company's pipeline was intact and operating as designed prior to the accident.

2. Natural gas facilities were accurately marked, and Kilford Engineering Inc. employees working at the site were aware of the markings indicating the locations of the 4-inch gas pipeline, 2-inch gas pipeline, and branch connection before the start of excavation.

3. Kilford Engineering, Inc. did not follow safe excavation practices when it mechanically excavated within the tolerance zone, resulting in the Kilford Engineering Inc. operator impacting the 2-inch branch connection with the mini excavator trenching bucket, causing the release of natural gas.

4. Because California did not have an excavation damage enforcement program at the time of the water line strike, the state missed an opportunity to identify and deter poor safety activities presented by a new contractor.

5. Although sufficient data are not yet available to determine if the California Underground Facilities Safe Excavation Board's enforcement actions have been effective in deterring future damage, enforcement is a step in the right direction for preventing third party damage to buried utilities.

6. Had Pacific Gas & Electric Company incorporated geographic information system location data into the software program used to develop its valve isolation plan prior to this accident, it would have reduced the time to isolate the natural gas source.

7. Pacific Gas & Electric Company did not follow its own procedures regarding requests for police escorts, which may have delayed the arrival Pacific Gas & Electric Company on scene during the emergency response.

8. While the lack of a memorandum of understanding with the San Francisco Department of Emergency Management, San Francisco Police Department, or San Francisco Fire Department addressing emergency response plans did not affect the timeliness of the Pacific Gas & Electric Company shutting off the flow of gas in this accident, it could potentially affect other responses where the squeeze-off point is accessible and/or the valve locations are readily known.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the February 6, 2019, release of natural gas from the Pacific Gas & Electric Company distribution

pipeline and the subsequent fire was the failure of the Kilford Engineering Inc. operator and spotter to follow safe excavation practices within the tolerance zone, which resulted in the mini excavator trenching bucket attachment impacting the branch connection.

4 Recommendations

As a result of this investigation, the National Transportation Safety Board makes the following new safety recommendations:

To the San Francisco Police Department, the San Francisco Fire Department, and the San Francisco Department of Emergency Management:

Work with the Pacific Gas & Electric Company to establish an agreement to provide a coordinated response and reduce response times for Pacific Gas & Electric Company's crews to arrive at the scene of a pipeline accident. (P-21-15)

To Pacific Gas & Electric Company:

In collaboration with the San Francisco Police Department, San Francisco Fire Department, and the San Francisco Department of Emergency Management establish an agreement to provide a coordinated response and reduce response times for your crews to arrive at the scene of a pipeline accident. (P-21-16)

Complete the integration of detailed location data into your hydraulic modeling software so that this information is readily available for all system assets when developing a valve isolation plan. (P-21-17)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

BRUCE LANDSBERG
Acting Chairman

JENNIFER HOMENDY
Member

MICHAEL E. GRAHAM
Member

THOMAS B. CHAPMAN
Member

Adopted: July 27, 2021

Appendix A: Investigation

The National Transportation Safety Board (NTSB) was notified on February 6, 2019, that natural gas released and ignited from a Pacific Gas & Electric Company (PG&E) 4-inch distribution pipeline at the branch connection to a 2-inch distribution pipeline in San Francisco, California. At 11:00 p.m. the day following the accident, Board Member Homendy and two NTSB investigators arrived at the accident site. On February 8, 2019, the Board Member and NTSB investigators documented damage to the pipeline and surrounding buildings with the assistance of Federal Bureau of Investigation photographers, Pipeline and Hazardous Materials Safety Administration investigators, California Public Utilities Commission engineers, California Underground Facilities Safe Excavation Board investigators, and PG&E personnel. On February 26, 2019, the investigation team conducted a follow-up examination of the damaged pipeline segment and fracture surfaces at the NTSB Materials Laboratory in Washington, DC. The Materials Laboratory further examined the segment of 4-inch pipeline, 2-inch pipeline, and branch connection and exemplar materials using a Fourier Transform Infrared spectrometer with a diamond attenuated total reflectance accessory.

Parties to the investigation include the Pipeline and Hazardous Materials Safety Administration, California Public Utilities Commission, California Underground Facilities Safe Excavation Board, San Francisco Fire Department, and PG&E.

Appendix B: Consolidated Recommendation Information

Title 49 *United States Code* (*U.S.C.*) 1117(b) requires the following information on the recommendations in this report.

> For each recommendation—
>
> (1) a brief summary of the NTSB's collection and analysis of the specific accident investigation information most relevant to the recommendation;
>
> (2) a description of the NTSB's use of external information, including studies, reports, and experts, other than the findings of a specific accident investigation, if any were used to inform or support the recommendation, including a brief summary of the specific safety benefits and other effects identified by each study, report, or expert; and
>
> (3) a brief summary of any examples of actions taken by regulated entities before the publication of the safety recommendation, to the extent such actions are known to the Board, that were consistent with the recommendation.

To the San Francisco Police Department, San Francisco Fire Department, and San Francisco Department of Emergency Management:

P-21-15

> Work with Pacific Gas & Electric Company to establish an agreement to provide a coordinated response and reduce response times for Pacific Gas & Electric Company's crews to arrive at the scene of a pipeline accident.

Information that addresses the requirements of 49 *U.S.C.* 1117(b), as applicable, can be found in sections 1,2 Response to Gas Release and Fire and 1.3.3 Emergency Response Procedures. Information supporting (b)(1) can be found section 2.5 Coordination of Emergency Response. Information supporting (b)(2) can be found in section 2.5 Coordination of Emergency Response, and information supporting (b)(3) can be found on page 15.

To Pacific Gas & Electric Company:

P-21-16

> In collaboration with the San Francisco Police Department, San Francisco Fire Department, and San Francisco Department of Emergency Management establish an agreement to provide a coordinated response and reduce response times for your crews to arrive at the scene of a pipeline accident.

Information that addresses the requirements of 49 *U.S.C.* 1117(b), as applicable, can be found in sections 1,2 Response to Gas Release and Fire and 1.3.3 Emergency Response Procedures. Information supporting (b)(1) can be found section 2.5 Coordination of Emergency Response. Information supporting (b)(2) can be found in section 2.5 Coordination of Emergency Response, and information supporting (b)(3) can be found on page 15.

P-21-17

Complete the integration of detailed location data into your hydraulic modeling software so that this information is readily available for all system assets when developing a valve isolation plan.

Information that addresses the requirements of 49 *U.S.C.* 1117(b), as applicable, can be found in section 1.2.2 Pacific Gas & Electric Response and 1.3 PG&E Natural Gas Systems and Main Specifications. Information supporting (b)(1) can be found in sections 1.3.3 Emergency Response Procedures and 2.4 Data Integration; (b)(2) is not applicable. Information supporting (b)(3) can be found on pages 15 and 30.

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