

CALIFORNIA PUBLIC UTILITIES COMMISSION

Safety and Enforcement Division Gas Safety and Reliability Branch

Incident Investigation Report

Report Date: September 12, 2017

Incident Number: G20170112-2136

Utility: Pacific Gas & Electric Co. (PG&E)

Date and Time of the Incident: 1/12/2017, 0624 hours

Location of the Incident: [REDACTED]
Yuba City, CA
County: Sutter

EXECUTIVE SUMMARY:

On January 12, 2017, at 0624 hours, PG&E was notified of a structure fire at [REDACTED], Yuba City. The Fire Department called back at 0658 advising PG&E of an explosion resulting in a collapse of a residential home. PG&E arrived on scene at 0715 hours and closed the service valve with no visible damage to the meter. PG&E crews arrived on scene at 0740 hours and squeezed the 4-inch plastic main at 0859 hours. Gas service to 6 customers was impacted. Two customers were injured inside the house and were taken to the hospital. One of the customers was released at 1500 hours. There were no fatalities.

The leak source appeared to be a butt fusion joint south of the service tee of the affected home. Investigations were conducted by a third party, Exponent, and the California Public Utilities Commission (CPUC). The site was monitored until the area was made safe. The main and services are currently being replaced. Police and fire department were reported on-site. The incident was reported to the CPUC and the Department of Transportation (DOT) due to damage costs exceeding \$50,000.

Based on CPUC's investigation, CPUC determined that the pipeline was not installed so that the joint involved in the incident could sustain the anticipated internal loading. In addition, the weld had a lack of weld bead and a portion of the surface plane failed to contact the heater plate sufficiently to melt. Therefore, PG&E is in violation of 49 Code of Federal Regulations (CFR) Parts §192.273 (a) and §192.281 (a), respectively.

SCOPE OF THE INVESTIGATION:

The CPUC's Safety and Enforcement Division (SED) derives its authority to regulate intrastate gas pipeline facilities from the certification approved by the United States Secretary of Transportation pursuant to 60105 of the Federal Pipeline Safety Statues (49 U.S.C § 60101 et Seq.). The scope of the investigation is limited to determining whether PG&E committed violations of 49 Code of Federal Regulations (CFR) Part 192, General Order 112¹ of the CPUC and California Public Utilities Code Sections 955-970.

Casualties: 2 injuries

Property Damage: Total Cost \$351,500; including \$1500 estimated cost of gas release

Utility Facilities involved:

Pipe Material = Polyethylene (PE), Manufacturer = DuPont Aldyl-A, Pipe Diameter = 4 (inches), MAOP = 60 (psig), Operating Pressure = 57 (psig), Standard Dimension Ratio = 11.5, Installation Year = 1974, Year of Manufacture = Unknown

Witnesses:

<i>Name</i>	<i>Title</i>	<i>Phone</i>
1. [REDACTED]	[REDACTED]	[REDACTED]
2. [REDACTED]	[REDACTED]	[REDACTED]
3. [REDACTED]	[REDACTED]	[REDACTED]
4. [REDACTED]	[REDACTED]	[REDACTED]
5. Jesse Frias	Yuba City Fire Department (YCFD) Investigator	(530) 822-4614
6. [REDACTED]	[REDACTED]	[REDACTED]
7. Alin Podoreanu	CPUC Investigator	(916) 928-2552
8. Jason McMillan	CPUC Investigator	(916) 928-2271
9. James Zhang	CPUC Investigator	(916) 928-2106

¹ General Order 112-F was adopted by the Commission on June 25, 2015 via Decision 15-06-044.

Evidence

<i>Source</i>	<i>Description</i>
1. PG&E	CPUC File No. 420 Final Report
2. SED	Field Investigation Photographs
3. PG&E	Index 10487 received 1/31/2017
4. PG&E	Index 10489 received 2/10/2017
5. PG&E	Index 10489.02 Supp01 received 3/13/2017
6. PG&E	Findings letter received 4/13/2017
7. Yuba-Sutter Gang Task Force	Investigation report G17-005
8. Doug P. Adams	Email received 4/19/2017
9. PG&E	Index 10788 received 5/17/2017
10. PG&E	Exponent Report received 4/17/2017
11. PG&E	Index 10487 Supp01 received 5/30/2017
12. PG&E	Index 10977 received 6/29/2017

INCIDENT LOCATION:

The property involved in the incident was a one story residential house located at [REDACTED], Yuba City, CA. The house was a single story structure built with a wood frame and raised foundation above a crawl space. The attached two story garage was built on a concrete slab.

Figure 1 shows an aerial view of the incident location. The red arrow represents the approximate leak location. The yellow square represents the location of the meter set assembly (MSA) and the red square is the location where the plastic main was squeezed to stop gas flow.

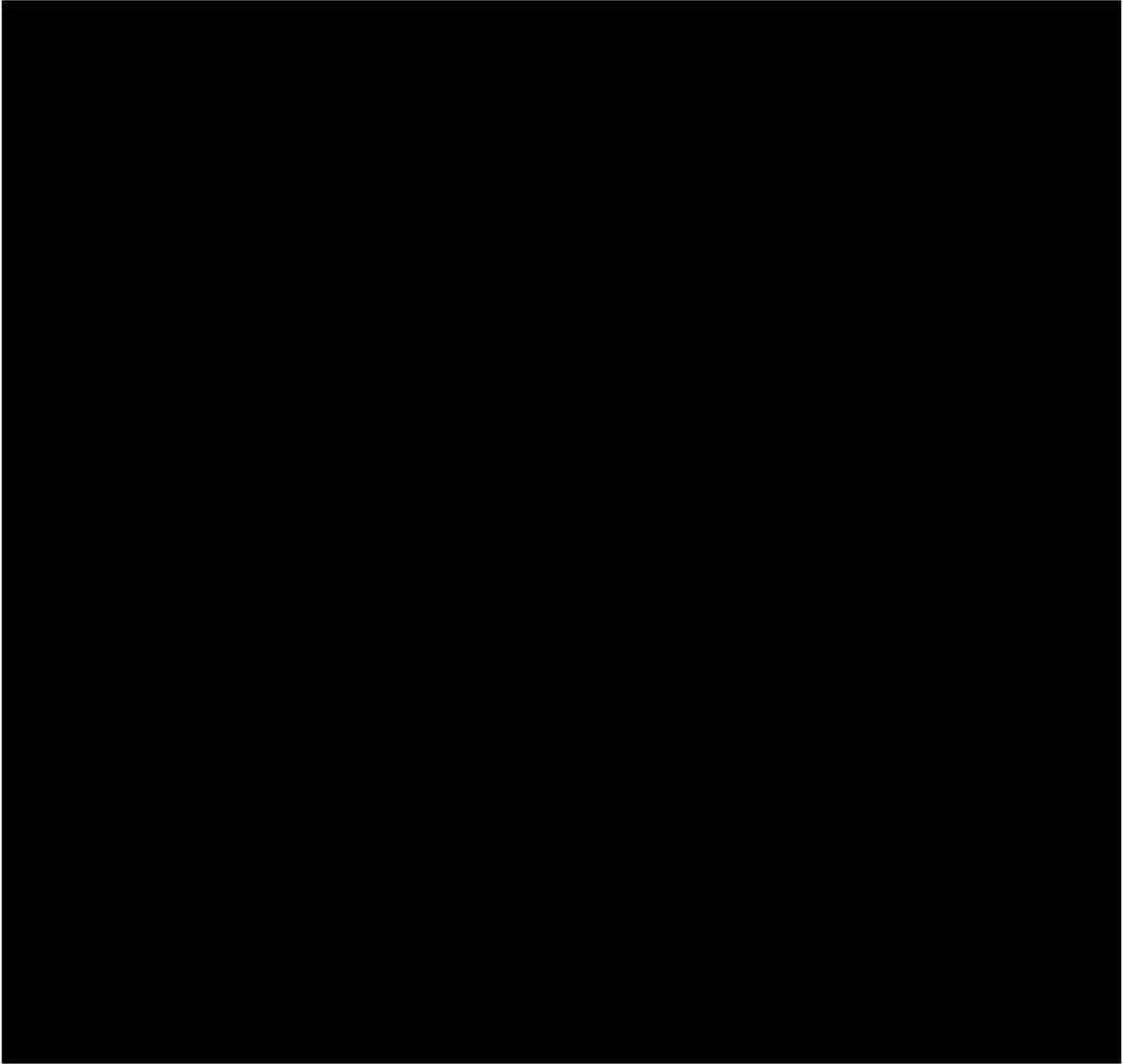


Figure 1. Aerial view of the incident location. Image acquired from Google Maps.

Figure 2 shows a July 2015 photograph of the house at [redacted]



Figure 2. [REDACTED]. Image acquired from Google Maps.

INCIDENT BACKGROUND:

On January 12, 2017 at approximately 0600 hours, an explosion occurred at [REDACTED], Yuba City, CA. Two occupants were inside the house at the time of the incident. It was reported that the explosion occurred after one occupant plugged in a coffee maker into the wall. The explosion propelled him through the ceiling into the garage². A neighbor to the south felt the explosion, ran outside and saw a fire at the residence located at [REDACTED]. The female occupant exited the residence from the garage area, followed by the male occupant. At 0610 hours, the Yuba City Fire Department (YCFD) was notified of the incident³. The YCFD arrived on scene at 0620 hours and found the single story residence significantly involved in fire. At 0658 hours, the fire department requested expedited response and advised the building had collapsed as a result of explosion⁴. PG&E was notified of the structure fire at 0624 hours and a Gas Service Representative (GSR) was dispatched to the incident location. The GSR arrived on scene at 0715 hours and closed the service valve to the meter set assembly. PG&E crews arrived on scene at 0740 hours and squeezed the 4-inch plastic main at 0859 hours to stop the flow of natural gas.⁵

Figure 3 shows a photograph, provided by Witness #3, of the residence engulfed in flames.

² Yuba Sutter Gang Task Force Investigation Report

³ Yuba City Fire Report.

⁴ PG&E IMT ID# 1108656344

⁵ CPUC File No. 420 FINAL



Figure 3. Structure fire at [REDACTED].

EMERGENCY RESPONSE:

PG&E provided an emergency response timeline included as part of Exponent's final report.⁶

Table 1. Emergency Response Event Timeline⁷

Day	Time	Event
01/12/2017	<6:00 AM	Explosion occurs at subject residence.
01/12/2017	6:10 AM	Yuba City Fire Department (YCFD) notified.
01/12/2017	6:20 AM	YCFD arrived on-scene
01/12/2017	6:24 AM	PG&E Gas Dispatch was notified of structure fire at [REDACTED] Yuba City.
01/12/2017	6:33 AM	PG&E Gas Service Representative (GSR) was dispatched to the site.
01/12/2017	6:34 AM	GSR indicates that he is en route to site.
01/12/2017	6:58 AM	YCFD called PG&E gas dispatch to request expedited response for the incident. YCFD advised PG&E that an explosion and building collapse had occurred at the incident site.
01/12/2017	7:15 AM	GSR arrives on site. PG&E Maintenance and Construction (M&C) crew dispatched to site. PG&E Gas Compliance Representative (GCR) dispatched to site.
01/12/2017	7:15-7:32 AM	GSR closes service shut-off valve with assistance from fire department but gas fed flames persist. GSR confirms that there is no visible damage to gas meter.
01/12/2017	7:25 AM	GCR arrives on site.
01/12/2017	7:26 AM	M&C crew dispatched on site.
01/12/2017	7:37 AM	GSR reports that he is picking up natural gas readings.
01/12/2017	7:40 AM	M&C crew arrives on site.
01/12/2017	7:43 AM	M&C crew thinks a leak on the 4-inch plastic main is fueling the active fire.
01/12/2017	7:50 AM	PG&E completed preliminary assessment for isolation strategy of the gas main. It is determined that the main is a one-way feed with six services downstream from the branch service of the fire.
01/12/2017	7:58 AM	PG&E determined isolation strategy: squeeze distribution main north of the fire to isolate the main. Six customers will be lost.
01/12/2017	8:14 AM	Gas main isolation strategy approved.

⁶ Data request Index No. 10487 – requested 01/13/2017

⁷ Data provided in the Exponent Failure Analysis Report – page 90-92

01/12/2017	8:30 AM	Gas Emergency Center (GEC) activated Sierra Operations Emergency Center (OEC) is in the process of being activated onsite at Incident Command Post (ICP)
01/12/2017	8:45 AM	PG&E reports the incident to DOT/PHMSA.
01/12/2017	8:57 AM	PG&E reports the incident to CPUC
01/12/2017	8:59 AM	M&C crew shut in the gas using a squeeze tool on the gas main.
01/12/2017	10:15 AM	Emergency Preparedness Coordinator (EPC) arrives on site.
01/12/2017	10:34 AM	GSR reports to gas dispatch that YCFD has extinguished flames and the area has been made safe. YCFD is still applying water to structure and has not provided PG&E access to property.
01/12/2017	10:50 AM	CPUC representative arrives on site.
01/12/2017	11:04 AM	Internal PG&E message (Epage) indicates that GEC will be handling all communications until OEC is operational.
01/12/2017	12:04 PM	EPC Supervisor arrives on site to assist the activation.
01/12/2017	~1:15 PM	Mobile Command Vehicle (MCV- Sprinter) onsite.
01/12/2017	2:55 PM	Exponent arrives on site to begin direct cause coordination with the CPUC.
1/12/2017	4:00 PM	Sierra Operations Emergency Center (OEC) became operational in MCV.
1/12/2017	4:04 PM	Epage indicates that OEC will take over handling communications for the incident.
1/12/2017	5:00 PM	GEC deactivated
1/13/2017	11:00 AM	An airmover was operational, moving air to the south of the incident site due to prevailing winds.
1/13/2017	2:00 PM	<ul style="list-style-type: none"> PG&E crews completed inert gas purge and 55 lb. air test. Helium was injected into gas system to pinpoint the leak. Airmoving continued throughout the day. Report from the Piccaro unit survey indicated a small presence of gas, however not recorded as a Grade 1 Leak. PG&E crews opened a 40' trench within 1' of the pipe.
1/13/2017	7:00 PM	<ul style="list-style-type: none"> Crews identified a helium bump next to the service tee to the south of affected home. Crews found trace amounts of gas (less than 1%) at residence to the south of incident location. Air movers have been operational throughout the day.
1/13/2017	10:30 PM	About 70' of pipe exposed. The second butt fusion joint south of the service tee to the affected home, which is approximately 46', was found to be the leak source.
1/14/17	3:45 PM	<ul style="list-style-type: none"> PG&E crews completed the 55# Air Test on the remaining pipe to the South of the affected home, and it held with zero drop in pressure. PG&E crews are in the final stages of tagging the remainder of the pipe

		<p>removed during excavation and the CPUC representative is expected to fully turn the site over to PG&E.</p> <ul style="list-style-type: none"> • PG&E crews are backfilling the excavation, cleaning up the site, and preparing to close down the MCV. • For the one remaining customer to the south, PG&E provided a Company Contractor to remove the soil on the north and east side of the home, which will remove the remaining gaseous soils. • PG&E will have a Leak Survey Person on site, continuously monitoring the situation • Sierra OEC deactivated.
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INVESTIGATION:

SED was dispatched to perform an investigation of the incident. Mr. Podoreanu arrived at the incident location the morning of January 12, 2017 and observed the damaged house and scattered debris at [REDACTED] Yuba City, CA. Figure 4 shows the collapsed structure on the morning of the incident.



Figure 4. [REDACTED] on the morning of the incident

Multiple agencies were present at the incident location including the Yuba-Sutter Joint Narcotics Task Force and YCFD. The Yuba-Sutter Joint Narcotics Task Force assumed command of the incident site and at 1355 hours executed a search warrant on the

premises.⁸ Upon completion of their investigation, the incident site was released to the YCFD Fire Investigator who explained that the fire department was documenting the incident site for their investigation. SED scanned the incident area and observed an excavation north of the incident area. Pipe squeezers were applied to the 4-inch exposed gas main in the excavation hole. The meter set assembly (MSA) was observed on the north-east corner of the garage as shown in Figure 5.



Figure 5. The meter set assembly (MSA)

SED observed PG&E personnel leak surveying the area. The PG&E OEC Commander confirmed that gas was detected at multiple locations and SED requested a leak map⁹ with the readings. The neighbors south of the incident location were evacuated from their residence. PG&E informed SED that Exponent Failure Analysis Associates were on route to the incident scene to conduct the failure investigation.

Upon Exponent's arrival, SED and Exponent discussed the scope of the initial investigation. The next steps were to expose the service line connection to the main, cut

⁸ Yuba Sutter Gang Task Force Investigation Report

⁹ Appendix A

and cap the main and pressurize the pipe to operating pressure. During excavation, PG&E crews severed the service line at [REDACTED]. The service line was repaired to allow for pressure testing. PG&E cut and capped the main and isolated the upstream and downstream sections.



Figure 6. Severed service line repair at [REDACTED].

On January 13, 2017, SED returned to the incident scene to observe the in-situ (in its original place) leak testing of the 4-inch gas main and connected service lines. The service lines and gas main were left undisturbed. The only excavation occurred at the cut and cap location to allow pressurization of the lines. The gas main terminated downstream of the incident location. The leak tested system of pipeline consisted of approximately 660 feet of 4-inch main and six service lines. The meter set assemblies (MSA's) were disconnected and service lines capped prior to leak testing. Compressed air was connected to the four inch main at the cut and cap location. SED observed PG&E use two pressure gauges to monitor the air pressure during leak testing. The documentation indicated the gauges were rated 0-300 psig and were calibrated. One pressure gauge was installed in line with the air supply at the cut and cap location. A second air gauge was installed on the riser at [REDACTED]. The system was then slowly pressurized to allow Exponent to record the pressure decay in the riser and estimate the rate of air flow from the main leak. Two leak tests were performed at approximately 45 and 55 psig internal pressure. The service line at [REDACTED] [REDACTED]. (as shown in Figure 6) was squeezed at the repair location but

no pressure differential was observed which indicated the leak was at the main. During the leak test, soap water was applied in the front yard and driveway. SED observed bubbles forming in the driveway (see Figure 7) and around a sprinkler head (see Figure 8).



Figure 7. Air bubbles in driveway crack at [REDACTED]



Figure 8. Air bubbles around a sprinkler head

Figure 9 shows an exposed segment of main with the joint that was the source of the leak. Note the close proximity of the sprinkler head where air bubbling was observed during the leak test.

SED then observed PG&E conduct a Helium leak test. The system was pressurized with helium gas at approximately 2 psig and the area around the incident was surveyed. Various helium concentrations were detected in the front yard, at the driveway cracks near the street, and next to the house foundation. SED then requested PG&E to leak test the service line at [REDACTED]. The line was pressurized with air at an operating pressure of 55 psig for five minutes and no leaks were detected. After leak testing, PG&E began excavation to expose the main. The gas main and service connection were exposed using pressurized water and vacuum truck. PG&E exposed a section of main containing the leak using hand tools. Dry, odorized soil was observed around the leak source and SED observed Exponent remove soil samples for analysis.



Figure 9. Exposed segment of main with the joint that was the source of the leak.

A six foot section was marked to be cut out. The main was pressurized with air at low pressure. SED confirmed by physical touch that the butt joint was leaking toward the street. The section of pipe was cut out and secured as evidence. PG&E filled out the chain of custody forms, and the section of pipe was retained by Exponent.

On Saturday January 14, 2017, SED returned to the incident site to ensure that evidence was collected and cataloged properly, and to observe a pressure test on the pipe downstream of the removed section.

PG&E cut a section of the main line that contained the service tee and a butt joint. At approximately 0950 hours PG&E removed a 44-foot seven-inch section from the trench. The section was cleaned with water, and sectioned into six (6) different pieces for evidence documentation and transportation. All pieces were marked with an evidence number, and the index number for PG&E's tracking.

The evidence numbers are listed below, with a description of the corresponding pipe:

2017-0006: 6-foot, 7-inch section with a saddle fused service tee

2017-0007: 6-foot section with a butt fusion at the center

2017-0008: 10-foot section of continuous pipe (no joints)

2017-0009: 9-foot section of continuous pipe (no joints)

2017-0010: 8-foot section of continuous pipe (no joints)

2017-0011: 4-foot 11.75-inch section of continuous pipe (no joints)

PG&E performed leak surveys along their main line in bar-holes at the approximate locations of butt joints, and at the houses adjacent to [REDACTED].

At approximately 1110 hours, a test head was attached (using an electrofusion coupling) to the section of pipe downstream of the removed piece. After the fusion had set, the section was subject to a pressure test. Compressed air was introduced to the line at a steady rate until 30 psig was reached. A soap test was administered to the service tee serving the two houses to the south of [REDACTED], and it produced no bubbles. The pressure was then increased steadily to 55 psig, and the line was shut in. Pressure reads were taken at a calibrated pressure gauge in the middle of the pressurized line once a minute for ten (10) minutes. The pressure held with no appreciable decay.

PG&E produced chain-of-custody documents for the six (6) sections of pipe, and loaded the pipe to be transported to PG&E's Marysville office. SED released the incident scene to PG&E after the successful pressure test and the inspection of the chain-of-custody documents.

On Tuesday, February 28, 2017 SED arrived at [REDACTED], Yuba City to observe the activities of PG&E and Exponent, a failure analysis consultant. Exponent was on site to collect soil samples from the area, and to pressure test the natural gas lines inside the house (downstream of the customer’s meter). PG&E was present to assist Exponent, and excavate the areas that the soil samples were harvested from. The excavation for soil sampling and the pressure testing of the line occurred concurrently, as Exponent had two teams on site. To avoid confusion, this narrative is divided into two parts: “Excavating Areas for Soil Samples” and “Pressure Testing House Line”.

At 0842 hours, a safety tailboard meeting was led by John Bacon, a foreman with PG&E. Along with safety concerns, Mr. Bacon laid out the scope of work for the day.

Excavating Areas for Soil Samples:

All excavated holes were approximately 3 feet wide, 8-10 feet long, and 5 feet deep. Soil was sampled from the walls of the holes at different depths.

At 0927 hours, the first hole was excavated. The hole was positioned on the north side of the driveway to the garage area.

At 0952 hours, the second hole was excavated. It was positioned south of the driveway, very close to the garage area. At 1045 hours, at the request of Exponent, PG&E broke through part of the house’s foundation slab near hole #2 and removed it so that soil samples could be harvested from the soil underneath the house.

At 1142 hours, the third hole was excavated. It was positioned on the south side of the driveway, east of hole #2.

At 1335 hours, the fourth and final hole of the day was excavated. It was positioned on the north side of the driveway, west of hole #1. Hole #4 contained the gas service line to the house, directly upstream of the customer service meter.

The GPS coordinates for all soil sample excavations are listed in Table 2 below.

Table 2: GPS coordinates of the soil sample excavation holes

Hole Number	Location	GPS Coordinates
1	North side of driveway, immediately west of the road	[REDACTED] [REDACTED]
2	South side of driveway, immediately east of the house, and extending under the house foundation slab	[REDACTED] [REDACTED]
3	South side of driveway, immediately west of the road	[REDACTED] [REDACTED]
4	North side of the driveway, north of the garage; hole contained the gas service line	[REDACTED] [REDACTED]

Figure 10 shows approximate areas of the soil sample excavation holes dug at [REDACTED] on 02/28/2017 outlined in orange. The combination heating/air-conditioning unit is on the roof, outlined in blue.

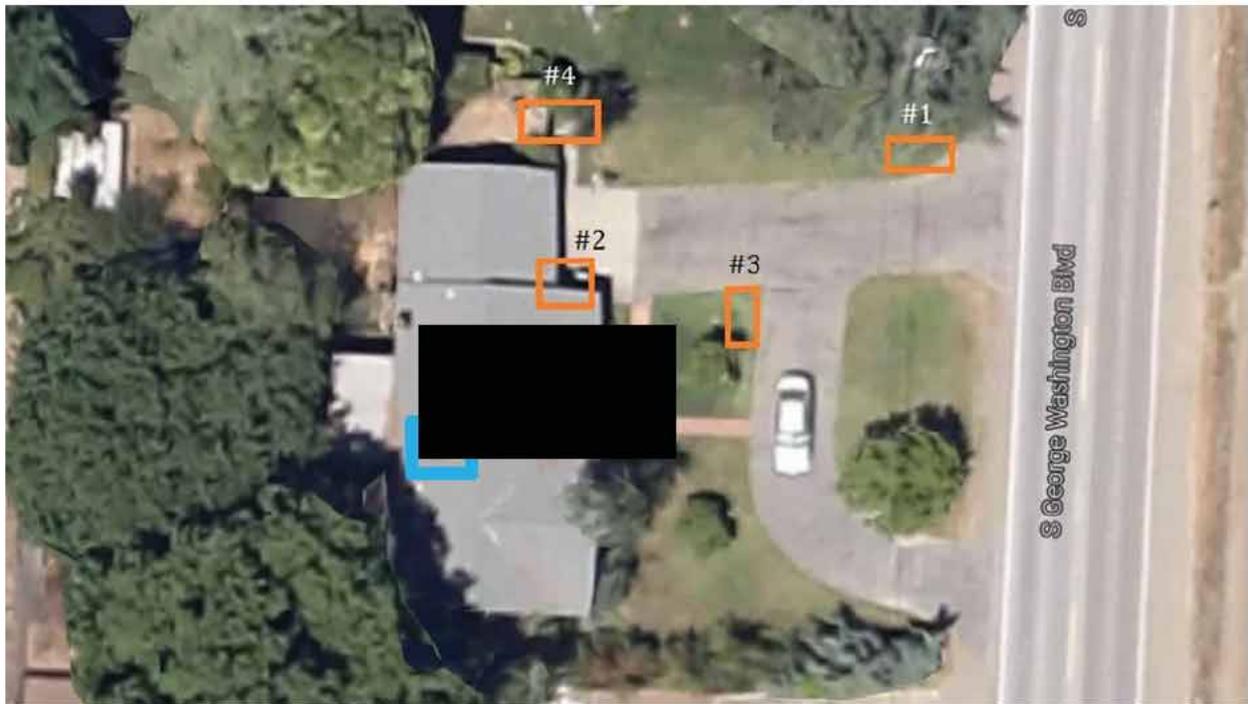


Figure 10. Excavation holes dug and combination heating/air-conditioning unit

Pressure Testing House Line:

Exponent, PG&E, and SED surveyed the remains of [REDACTED] to find the house line, and determine the possible loads on the residential natural gas system. It was found (and confirmed by the homeowner's insurance attorney) that the house had two loads on the gas system: a hot water heater (originally placed in the garage), and a rooftop combination heating/air-conditioning unit (visible in Figure 10, outlined in blue). The house gas line entered through the garage wall on the north side of the house. Once inside the walls, it made a 90° turn (via elbow fitting) toward the ceiling, ran up the wall, turned 90° (via elbow fitting) and ran along either the roof joists, the rafters, or possibly the roof ridgeline. It breached the roof through a flashing, and terminated at the combination unit. There was a tee connection in the garage where an auxiliary line ran out, connected to a 90° elbow joint, and dropped down to feed the water heater.

Figure 11 below shows the assumed pre-incident layout of the house gas line system. The view is looking at the front of the house (east face). The orange lines represent gas lines, and the blue block shapes represent threaded connectors. The figure is not to scale.

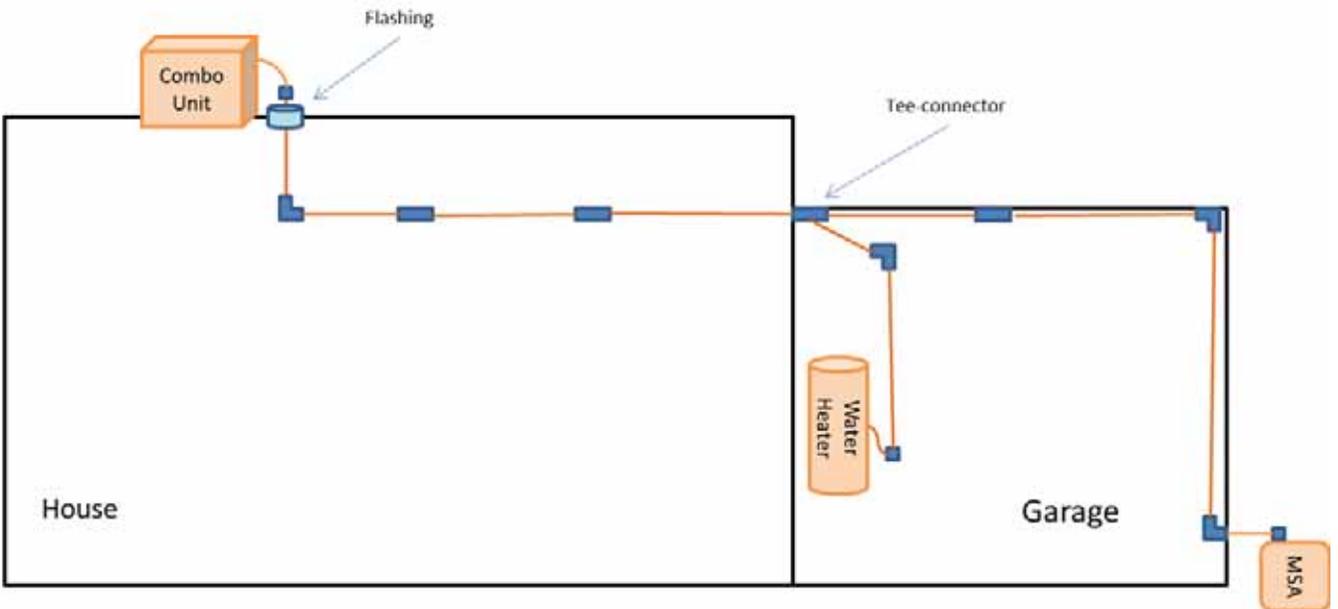


Figure 11: Assumed layout of the house gas line system, pre-incident.

The house line had been damaged in the incident, and was separated into 3 pieces. The first piece started at the meter outlet, and included the two 90° elbow fittings, the tee fitting, and the auxiliary line that fed the water heater. The first section ended south of where the garage was originally, as the line had sheared away somehow during the incident.

The test head used to pressurize and test the lines consisted of an air compressor, a pressure regulator, a flow meter, and a pressure gauge in series. The test was designed so that a steady pressure could be applied by the air compressor and set with the regulator. Any leaks on the line would cause a slight pressure drop (visible on the pressure gauge) and a flow of air (visible on the flow meter).

A picture of the test head set-up is included in Figure 12. An air compressor (yellow tank, visible through legs on far right) is connected to a ball valve and pressure regulator to control the flow. The regulator is connected to a flow meter (brown meter with large clock dial) and pressure gauge (smaller grey instrument, far left) to record any flow through the line or pressure drops. The valve near the pressure regulator is in the closed position because this photo was taken before any test was being performed.



Figure 12: Exponent's test head setup

Exponent used rubber stopper fittings to plug the sheared end, as well as the end of the auxiliary line, and connected their test head to the first section at the meter outlet. At 1118 hours, Exponent's test head was connected to the first section and the line was pressurized at 7-inches water column (approximately 0.25 psig) using compressed air. During a 10 minute test, no flow was seen, and no pressure drop was observed. After the 10 minute test, the plug on the auxiliary line was removed, at which point a pressure drop and flow of material could be seen through the instruments.

The second section of the house line began after the sheared section and continued until another shear line, assumed to be at a point before the line originally passed through the roof. Section two contained two threaded straight-joint connections that connected the metal pipes. At approximately 1315 hours the downstream sheared end was plugged with a rubber stopper fitting and the test head was connected to the upstream end. At 1340 hours, the line was pressurized at 7-inches water column (approximately 0.25 psig) using compressed air. Exponent and SED both witnessed the flow meter moving slowly. SED recorded the volume and time during the test; a table of data is shown below. The average flow rate through the meter was 0.001711 cubic feet/minute. During the pressure test, the second section of line was soap tested, and small leaks were found at

the threads of both the threaded connectors. There was no indication of leaks on any of the pipe body. Table 3 shows SED's readings of the flow volume through the flow meter at certain points in time. The Q value is the average flow rate up to that point in time. The mean of the values in the Q column is 0.001711 CF/min.

Table 3: SED's readings of the flow volume

V (CF)	t (min)	Q (CF/min)
0.01	6.5	0.001538
0.011	7	0.001571
0.0165	9	0.001833
0.019	10	0.001900

The third section was a short length of pipe that started at a 90° elbow fitting and ended at the fitting that originally attached to the rooftop combination unit. The downstream end was plugged with a rubber stopper, and the test head was attached to the upstream end. At 1401 hours, section 3 was pressurized at 7-inches water column (approximately 0.25 psig) using compressed air. During a 10 minute test, there was no indication of leaks on the pipe body or connections.

On Friday March 24, 2017, at approximately 0905 hours, SED arrived at [REDACTED], Yuba City to observe the activities of PG&E, Exponent, and Scan Tech (a utility locating service company). PG&E was present to assist Exponent by excavating the areas so that Exponent would be able to measure the foundation of the house. Scan Tech, a utility locating service company was on site to locate the sewers and drain lines.

At approximately 0945 hours, PG&E led a safety tailboard meeting. It was a heavy raining day. Along with safety concerns, PG&E and Exponent laid out the scope of work for the day.

At the request of Exponent, PG&E excavated certain areas with holes at different depths, immediately east of the house, and extending under the house foundation slab. Exponent took measurements of the footing and foundation of the house and documented the condition of the house foundation with a schematic layout. Meanwhile, Scan Tech located the sewer tank with red markings on the west side of the house.

WITNESS REPORTS:

SED obtained the following witness reports on the day of the incident:

██████████ *and* ██████████

- ██████████ felt his residence shake and went outside his house around 6AM. He saw ██████████'s house had exploded and smelled strong gas odor.
- ██████████ saw a small fire in front of John Lee's residence.
- ██████████ and ██████████ came out of the incident house.
- ██████████ also saw a small fire between his house and the incident house.
- The YCFD arrived and started putting the fire out at the incident house.
- ██████████ explained ██████████ suffered minor injuries and that ██████████ was sent to the hospital
- ██████████ stated that they were asked by PG&E to evacuate the house after the incident due to possible gas accumulation
- ██████████ did not smell gas prior to the incident

██████████

- ██████████ explained that ██████████ went duck hunting and ██████████ had the ducks in the sink
- ██████████ told ██████████ the house smelled strange and then it exploded
- ██████████ explained ██████████ was blown through the roof into the garage

██████████ *(Northern Neighbor)*

- ██████████ bedroom window faces south towards the burned house.
- He heard a loud boom which woke him. He looked out his bedroom window.
- He saw a fire in front of his neighbors' house on the other side of the boat and debris on his neighbors' front lawn. He called 911.
- ██████████ then saw the incident house on fire and called 911 a second time.

SED attempted to contact the two occupants that were inside the house at the time of the explosion but was referred to the legal counsel retained by the occupants. Email communication with the legal counsel indicated the homeowner was not aware of any other gas leaks on the property before the incident or other sources that could have contributed to the explosion.¹⁰

¹⁰ Email from Doug P. Adams received 4/19/2017

DEPTH OF COVER:

The regulatory requirement cover at the time of installation was at least 24 inches. During the investigation, SED observed the cover from the top of the main was approximately 48 inches.

PRESSURE RECORDS:

The pressure test requirements at the time of installation for plastic pipelines required the test pressure to be at least 150 percent of the maximum operating pressure or 50 psig, whichever is greater.

Records reviewed by SED indicated that 39 feet of ½ -inch service line at [REDACTED] [REDACTED] was pressure tested at 100 psig for 5 minutes.¹¹

Records reviewed by SED indicated the 4-inch distribution main at the incident location was tested at 90 psig for 90 minutes.¹²

The pressure records reviewed by SED indicate the distribution main and service line passed the pressure testing at the time of installation.

LEAK SURVEY:

The requirement for leak surveying at the time of the incident was at least once every 5 calendar years at intervals not exceeding 63 months. The documentation reviewed by SED indicated that a leak survey was conducted on August 14, 2010 and June 19, 2015. No leaks were identified.

FAILURE ANALYSIS:

PG&E retained the services of Exponent to carry out the failure analysis for this incident. In April 2017 Exponent submitted a comprehensive report on the causes of the incident. Exponent's investigation included the following testing and inspections:

1. Initial Investigation

- i) Findings
 - a. Gas Leak
 - b. House Damage
 - c. Witness Reports

2. Leak Testing of Gas Pipe

- i) In-Situ Leak Testing of Gas Main

¹¹ PG&E Gas Service Record 22189 for 2209 S. George Washington Blvd.

¹² As-built drawings for GM477994 – Map 2153

- ii) In-Situ Leak Testing Results
- iii) Laboratory Leak Testing
- iv) Leakage Rate Testing of Subject Residence Gas Pipe

3. Material Analysis

- i) Objectives and Approach
- ii) Additional Material Tests

4. Gas Migration Analysis

- i) Geographic and Geologic Setting
- ii) Recent Site History
- iii) Surface Conditions
- iv) Subsurface Exploration
- v) Underground Utilities
- vi) House Foundation and Penetrations
- vii) Gas Migration Tests

5. Records Review

- i) Objectives and Approach
- ii) Installation Records
- iii) Maintenance and Integrity Records
- iv) Pressure Records

6. Emergency Response Assessment

- i) Objectives and Approach
- ii) Incident Emergency Response
- iii) Federal and State Regulations
- iv) PG&E Emergency Response Guidelines
- v) Industry Best Practices

7. Sampling of Nearby Butt and Socket Fusions

- i) Objectives and Approach
- ii) Strip Bend Testing
- iii) Nondestructive Testing

The Exponent failure analysis report for the natural gas explosion and fire at [REDACTED] in Yuba City provided a summary of conclusions¹³ as follows:

¹³ Exponent Failure Analysis Report

- *“The explosion was caused by ignition of natural gas that accumulated in the residence.*
- *The source of the gas was a leak in the four-inch-nominal Aldyl-A plastic gas main that ran along the shoulder of the road in front of the house. The leak was located at a butt fusion joint in the main.*
- *The direct cause of the leak was a fabrication error during original installation of the main in late 1973 or early 1974. Specifically, the end of the upstream pipe comprising the joint had not been fully faced flat and square with the axis of the pipe. Thus, when this pipe was butt-fused to the downstream pipe, a portion of the contact plane failed to melt and fuse, forming crack-like defect open to the interior of the pipe on the eastern side of the joint.*
- *The exterior portion of the joint fused sufficiently to pass an initial pressure test at 90 psig for 90 minutes, with no leaks reported. This pressure was 1.5 times the maximum allowable operating pressure (MAOP).*
- *The exterior portion of the joint fused sufficiently to remain pressure-tight until sometime between the last leak survey in June 2015 and the morning of January 12, 2017. Given the size of the ultimate leak, the final breach appears to have occurred within hours of the explosion. Otherwise, the leak, which released odorized gas and caused bubbles in puddles, likely would have been detected.*
- *The resulting area with lack of fusion formed a crack open to gas pressure on the inside of the pipe. Gas pressure, possibly assisted by residual stresses, slight daily pressure cycling seasonal soil temperature changes, and, ultimately, soil desiccation shrinkage from the leaking gas, provided the crack driving force.*
- *More likely than not, this crack grew for 43 years via the slow crack growth (SCG) mechanism known to occur in polyethylene exposed to concentrated stress, until the crack breached the outer wall of the pipe, and gas began to leak.*
- *There is no evidence to indicate that concentrated external stress, such as from rocks, tree roots, or ground movement, were significant factors in the failure. Additionally, there is no evidence to indicate that transient stress from a dig-in or from heavy vehicular traffic were factors in the failure.*
- *There is no evidence that the subject pipe suffered from low ductile inner wall (LDIW) known to occur in a different vintage Aldyl-A pipe.*
- *Although the pipe exhibited significant residual tensile stress on the inner wall (and equilibrating compressive stresses in the outer wall), and this stress may have played a role in the crack growth, these stresses appear likely to have been mitigated and otherwise unlikely to have affected joints with proper fusions. The residual stress arose during extrusion of the pipe at the factory.*
- *The leaking gas most likely migrated toward the building envelope at [REDACTED] via porous soil and backfill underneath the paved driveway. The migration path was confined by the driveway pavement and garage slab, forcing most gas migration in the horizontal direction and limiting the amount of gas release into the open air. Migration path confinement likely was aided by the increased moisture in the soil due to the heavy rains that predated the incident. The migrating gas most likely entered the crawlspace through pervasive ground cracks in the drier soil within.*

- *Sampling of additional joints from the vicinity of the failed joint found no additional fabrication issues deemed to materially affect joint integrity. Thus, there is a low probability of the fabrication defect in nearby joints.*
- *PG&E's records regarding the design and construction of the subject main and attached service lines accurately reflected the as-built system.*
- *P G&E's records regarding leak surveys and repairs reflect a prior grade 1 leak in the four-inch Aldyl-A main found and repaired in early 2015. That leak was located approximately 1,100 feet north of the failed butt fusion. The 2015 leak was attributed by PG&E to a crack in the pipe body, and therefore due to a materially different issue than the crack in the butt fusion involved in the January 12, 2017, incident. Thus, the risk factors for the two issues are independent.*
- *Exponent's review of PG&E's emergency response to the incident showed that the response was consistent with their internal documented procedures, consistent with applicable regulations, and consistent with industry best practices. Had PG&E been able to stop the gas flow instantaneously after the explosion, the outcome would have been materially the same. Under emergency circumstances, PG&E responded with appropriate personnel and equipment to identify the leak and to stop the gas flow at an appropriate location. In addition, Exponent identified no issues with PG&E interactions with first responders or affected residents that would have affected the outcome. PG&E coordinated with the Yuba City Fire Department to evacuate the general public to a safe distance."*

REGULATORY FINDINGS:

SED reviewed construction documentation for the four-inch Aldyl-A plastic distribution main. As built records indicated the main was installed as part of Job GM447994¹⁴ from October 1973 to January 1974. CPUC General Order No. 112-C Rules Governing Design, Construction, Testing, Maintenance and Operation of Utility Gas Gathering, Transmission and Distribution Piping Systems was in effect at the time of installation. General Order 112-C required gas corporations to comply with the rules and provisions of the order after April 30 1971. General Order 112-C combined the requirements of the previous general order with the Minimum Federal Safety Standards (49 CFR Part 192) which became effective on November 12, 1970. The purpose of General Order No. 112-C was to *"establish minimum requirements for the design, construction, quality of materials, location, testing, operation and maintenance of facilities used in the gathering, transmission and distribution of gas, to safe-guard life or limb, health, property and public welfare and to provide that adequate service will be maintained by gas utilities operating under the jurisdiction of the Commission."*¹⁵

CPUC General Order No. 112-C, Part II Gas Pipeline Safety Standards

- I. 49 CFR §192.273, General, states in part:

¹⁴ Data Response Index 10487 receive 1/31/2017

¹⁵ CPUC General Order No. 112-C §102 Purpose

“(a) The pipeline must be designed and installed so that each joint will sustain the longitudinal pull-out or thrust forces caused by contraction or expansion of the piping or by anticipated external or internal loading.”

SED reviewed the failure analysis report by Exponent. The report states:

“The butt fusion may initially have held gas, but over time, the pressure inside the pipe, and particularly within the growing crack, separated the joint faces and the leak ultimately developed. The lack of fusion could be related to insufficient heat, but given the appearance of the cutting tool marks, it is more likely that the upstream pipe was poorly (i.e., not squarely or fully) faced and did not fully contact the heating plate. Thus, that area of the upstream pipe did not fuse and formed an initial leak-tight crack that ultimately grew through the pipe wall.”

The evidence reviewed indicates that the pipeline was not installed so that the joint involved in the incident could sustain the anticipated internal loading. Therefore, SED finds PG&E in violation of CPUC General Order No. 112-C, 49 CFR §192.273 (a).

II. 49 CFR §192.281 Plastic Pipe states in part:

“(a) General. Each plastic pipe joint must be made in accordance with written procedures that have been proven by destructive burst test to produce joints at least as strong as the pipe being joined. A plastic pipe joint that is joined by solvent cement, adhesive, or heat fusion may not be disturbed until it has properly set. Plastic pipe may not be joined by a threaded joint or miter joint.”

SED reviewed PG&E Gas Standard D-21 Heat Fusion Joining Of Polyethylene Pipe dated March 3, 1972¹⁶. The scope of Gas Standard D-21, which was in effect at the time of installation, was *“to establish requirements for, and to define the limitations of, the fusion process for joining gas distribution polyethylene pipe. Included in this standard are instructions for the preparation of materials and the use of tools in the fusion process.”*¹⁷

PG&E Gas Standard D-21 Section 3.4.2 Butt Fusion states:

“(a) General

This technique consists of heating the ends of matching surfaces by holding them against a heating plate until fusion temperature is reached, then slamming the two soft ends against each other and allowing the joint to cool. Since the surface area of the pipes to be joined is rather small, it is essential that the ends of the pipe are properly aligned. An approved butt fusion machine capable of holding the pipe in alignment must

¹⁶ Data Response Index 10788 received 5/17/2017

¹⁷ PG&E Gas Standard D-21 dated 3/3/1972

be used. A special heating plate capable of heating the two ends of the pipe simultaneously is required.

(b) Technique

- 1) Heat the tool equipped with the proper size heating plates to approximately 310°F ($\pm 25^\circ$).
- 2) Place pipe ends into proper size joining unit.
- 3) Plane the ends of pipes to smooth, flat faces with special facing tool.
- 4) Bring the pipe ends together and carefully check alignment and fit. If either is incorrect, repeat step 3 as necessary. With coiled pipe, it is necessary to use short liners in the joining machine clamps. It may also be necessary to twist the pipe in the jig to accomplish alignment.
- 5) Bring the pipe ends to bear on the heating element with light force (70 inch pounds). To insure uniform heating at all points on both pipe ends, fusion should not be attempted until a bead of melt has rolled out on the heater face completely around the circumference of both pipe ends. See Table I for the approximate fusion melt cycle.
- 6) Snap the traveling carriage back and remove the heater plate.
- 7) Slam the two pipe ends together. Apply sufficient force to cause the fusion bead to roughly double its size.
- 8) The joint must be held in place in the carriage to allow it to set up. It may then be removed from the carriage, but it should not be worked or tested until it has had time to cool. (See Table I for set-up and cooling time.)
- 9) Clean heater faces, being careful not to damage the coating.”

SED reviewed the failure analysis report by Exponent. The report states:

“The lack of weld bead is evidence that, in the region that failed to fuse, the upstream side was solid when contacted with the downstream side. The downstream side must have been molten, as evidenced by its interior weld bead. The cold upstream side left an imprint of its striations in the molten downstream side. Thus, it appears that a circular facing tool was used during fabrication, but the facing was incomplete and left a portion of the surface that was below the plane of the cut. This lower portion failed to contact the heater plate sufficiently to melt. Thus, when the pipe ends were brought together to form the fusion, the upstream unmolten region deformed the molten downstream region but did not adhere to it.”

The failure analysis report further indicated:

“The direct cause of the leak was a fabrication error during original installation of the main in late 1973 or early 1974. Specifically, the end of the upstream pipe comprising the joint had not been fully faced flat and square with the axis of the pipe. Thus, when this pipe was butt-fused to the downstream pipe, a portion of the contact plane failed to melt and fuse, forming a crack-like defect open to the interior of the pie on the eastern side of the joint.”

The evidence reviewed indicated a lack of weld bead and that a portion of the surface plane failed to contact the heater plate sufficiently to melt. PG&E Gas Standard D-21 Section 3.4.2 (b) (5) states that *“fusion should not be attempted until a bead of melt has rolled out on the heater face completely around the circumference of both pipe ends.”*

SED therefore finds PG&E in violation of CPUC General Order No. 112-C, 49 CFR §192.281 (a) because it failed to make the joint in accordance with PG&E Gas Standard D-21.

III. 49 CFR §192.281 Plastic Pipe states in part:

“(c) Heat-fusion joints. Each heat-fusion joint on plastic pipe must comply with the following:

(1) A butt heat-fusion joint must be joined by a device that holds the heater element square to the ends of the piping, compresses the heated ends together, and holds the pipe in proper alignment while the plastic hardens.”

SED reviewed PG&E Gas Standard D-21 Heat Fusion Joining Of Polyethylene Pipe dated March 3, 1972. The procedure indicated that butt heat-fusion joints were to be made using a device per code requirement.

SED did not identify any violation of 49 CFR §192.281 (c).

IV. 49 CFR §192.13 General states:

“(c) Each operator shall maintain, modify as appropriate, and follow the plans, procedures, and programs that is required to establish under this part.”

PG&E Gas Standard D-21 Section 2.2 states:

“Personnel installing polyethylene pipe shall first complete a training program which will cover the various facets of constructing gas distribution systems with polyethylene pipe.”

Although Section 2.2 required personnel installing polyethylene pipe to first complete a training program, SED did not identify any regulatory requirement for the retention of training records at the time of installation. SED asked PG&E whether it had identified training records for employees that fused the butt-joint involved in the incident. PG&E explained the records did not identify the employees involved.

SED did not identify any violations of 49 CFR §192.13.

CONCLUSION:

Based on its investigation, SED made the following conclusions regarding the incident.

1. The source of the gas was a leak in the four-inch nominal Aldyl-A plastic gas main. The leak was located at a butt fusion joint in the main.
2. The evidence indicates the pipeline was not installed so that the joint involved in the incident could sustain the anticipated external or internal loading. Therefore PG&E is in violation of CPUC General Order No. 112-C, 49 CFR §192.273 (a).
3. The evidence indicates there was a lack of weld bead and a portion of the surface plane failed to contact the heater plate sufficiently to melt. PG&E Gas Standard D-21 Section 3.4.2 (b) (5) states that "*fusion should not be attempted until a bead of melt has rolled out on the heater face completely around the circumference of both pipe ends.*" Therefore PG&E is in violation of CPUC General Order No. 112-C, 49 CFR §192.281 (a) because it failed to make the joint in accordance with PG&E Gas Standard D-21.

Appendix A – Leak Map

