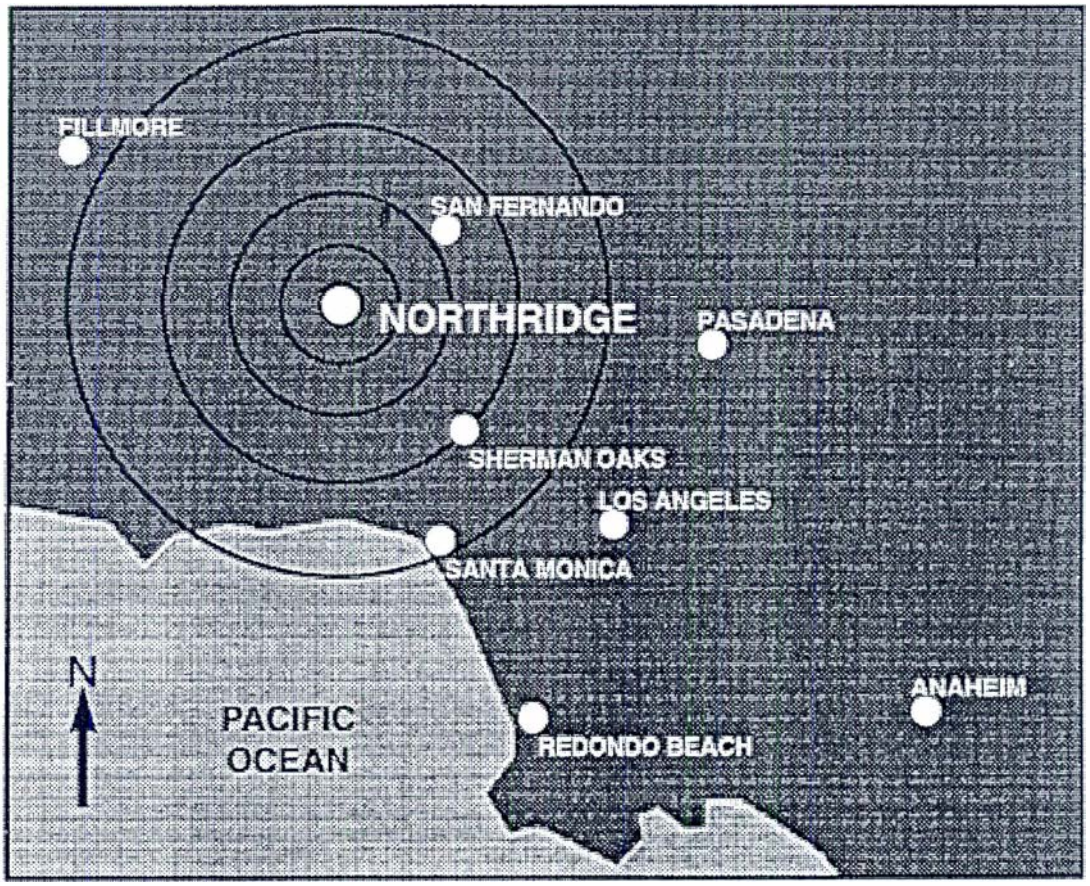
SOUTHERN CALIFORNIA GAS COMPANY RESPONSE TO THE NORTHRIDGE EARTHQUAKE



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INTRODUCTION

On January 17, 1994 a magnitude 6.7 earthquake occurred In Northridge, California about 20 miles northwest of Los Angeles. More than 55 lives were lost and property damage estimates range from $10-20 billion. Included in the damages were portions of Southern California Gas Company's facilities. The Company experienced breaks in the distribution and transmission pipeline systems and responded to over 150,000 requests for restoring service.

This' paper describes the performance of the SoCalGas piping system to the earthquake, the Company's emergency response programs, and the recovery process. A description of the Special Pipeline Replacement Program in place at the Company since 1986 is also presented along with the benefits of this program in enhancing pipeline performance during earthquakes.

OVERVIEW OF SOUTHERN CALIFORNIA GAS COMPANY

Southern California Gas Company is headquartered in Los Angeles, California and provides natural gas service to over 4.6 million customers. The service territory covers 23,000 square miles and includes nearly all of Southern California (San Diego County and the City of Long Beach are served at wholesale) and large portions of central California. The total population served is about 16,000,000 in over 535 cities, towns or communities.

The Company has approximately 9,000 employees and a pipeline network consisting of 84,000 miles of distribution piping and 3,300 miles of transmission piping.

EARTHQUAKE DATA

The Northridge earthquake occurred on January 17, 1994 at 4:31 a.m. in the San Fernando area of Southern California. The epicenter was about one mile south-southwest of Northridge or 20 miles west-northwest of Los Angeles at a focal depth of 12 miles.

No surface rupture has been associated with the main shock and as a result scientists have been unable to positively identify the specific fault on which the earthquake occurred. There is agreement that it was a thrust fault rather than a slip fault, generating more of the violent up and down motion that does the most damage to structures.

The earthquake duration was 20-30 seconds with more than ten seconds of strong shaking. Accelerations reached as high as 2g (2 times the force of gravity). Most of the damage was caused by shaking as opposed to fault rupture, liquefaction, landslides, etc. Over the several week period following the earthquake, thousands of aftershocks occurred, many in the 4.0 to 5.0 range. The larger aftershocks caused added damage to already weakened structures. There were two primary factors that contributed to the significant damage caused by the Northridge earthquake. This includes the strong shaking caused by the thrust fault and the fact that the epicenter was located in a densely populated area.

IMPACT ON THE COMMUNITY

January 17 was a holiday, Martin Luther King's birthday. This, coupled with the time of the earthquake, 4:31 a.m., contributed to minimizing the fatalities and Injuries. At least 55 people died and thousands were seriously injured. Damage estimates range as high as $20 billion.

The areas most impacted by the earthquake included Northridge, Reseda, Santa Clarita Valley, Simi Valley, Fillmore and Santa Monica. As of the end of March, there were 34,500 vacated dwelling units with the majority being apartments. Particularly vulnerable were low rise multi-story woodframe apartment structures with a flexible first story that served as a parking garage. The primary reason for their failure was the lack of plywood shear walls. Single family homes not bolted to their foundations were also vulnerable. Damage to masonry chimneys and masonry block walls was widespread.

Mobile homes in the impacted areas sustained extensive damage. In Santa Clarita, 50% of the 3,000 mobile homes were shaken off their foundations. These had not been braced properly to resist earthquake motion. In some cases the mobile homes damaged the gas meter set or piping when they fell off their support. Stronger bracing to resist this type of motion is needed.

In some areas damage to commercial structures was extensive. Several large shopping malls and department stores were particularly hard hit. In some cases the damage was severe with total collapse. Concrete parking structures at the shopping malls and other commercial sites performed poorly. The parking structures at the Northridge Fashion Center and the California State University at Northridge campus were significantly damaged. If the earthquake had occurred during normal business hours, the fatalities and injuries would have been significantly greater.

Non-structural damage was widespread and caused temporarily closure or hindered normal operation for most facilities. By non-structural damage we mean damage to ceiling tiles, light fixtures, water damage by broken sprinklers, etc. This was common in many of the hospitals, schools, office buildings, commercial and industrial facilities, utilities, etc. in the affected areas.

The majority of the extensive Los Angeles freeway system survived the earthquake very well. However, significant damage to approximately ten freeway structures caused massive traffic disruptions that lasted for several months. At least one death and several injuries are directly attributed to the collapsed roadways. These totals would have been far greater had it not been for the early morning occurrence of the earthquake. None of the failed freeways were retrofitted as part of a state-wide program initiated after the Lorna Prieta earthquake of 1989. All of the strengthened structures were undamaged and this retrofit program is scheduled to be completed by 1995.

Electric power service was lost to much of the Los Angeles area after the earthquake, approximately two million customers. In addition, the interconnection of power grids caused some interruption of power service throughout the western U.S. and Canada. Restoration to almost one million customers was completed by nightfall on the same day and virtually all power

was restored by January 26, nine days after the quake. This meant that people in the impacted area did not have TV access and relied on radio and newspapers for their information.

A large portion of the water supply to the Los Angeles basin comes from Northern California and the Colorado River. All four pipelines that serve the San Fernando and Santa Clarita Valleys suffered breaks that were repaired in two to ten days. These pipelines are steel and range in size from 54 to 120 inches in diameter. The local distribution pipeline network was also damaged and in some areas water service was not restored until late January/early February. Over 1,200 leaks were reported in the San Fernando Valley and. 300 in the Santa Clarita Valley. Notices were issued to boil water and emergency water supply was provided by bottled water furnished by agencies, soft drink companies, etc.

Telephone facilities in the area held up well except for the normal congestion and overload that occurs after such an event. There was also some damage to lines, equipment, and buildings that added to some interruptions to service.

GAS UTILITY RESPONSE

Headquarters

Within. one hour of the quake, our Emergency Operations Center (EOC) was staffed and functioning at our headquarters facility in downtown Los Angeles, as was a command center in our Mountain View Region headquarters. located in the Monterey Park office which is our 24-hour Message Center facility. Additional command centers were opened shortly thereafter at our region headquarters offices located in Chatsworth and Torrance.

The Gas Company's Emergency Operations Center (EOC) functions as a massive information clearinghouse during emergencies. The people assigned to staff the center specialize along the lines of the critical operating components of the company: storage, transmission, distribution, customer service and public relations. Their' primary mission is to facilitate the timely movement of people, equipment and information critical to the Company's response to a major emergency. And in the process, the EOC has the mission of coordinating the Company's response with various emergency groups such as fire, police, etc. as well as the public/employee communications efforts during those emergencies. Essentially, this was the role that the EOC provided for the response to the Northridge earthquake in January, 1994.

Regions

The regional headquarters in the impacted area experienced cosmetic and some non-structural damage such as fallen ceiling tiles. It was, however, operational immediately and additional regional command posts opened shortly thereafter in Chatsworth and Torrance. These centers operated continuously for the first ten days of the emergency. The command posts functioned to support the regions, assess damage, relocate resources, and communicate with the corporate EOC

The initial response efforts were focused on responding to gas leaks, assessing damage, and handling communications. Crews were busy responding to leaks reported by customers and leaks reported by outside agencies. Repair efforts were hampered by the flooding in some areas as a

result of broken water lines. Another problem was purging the gas lines of water that had flooded some areas.

The Gas Company's focus in the aftermath of the earthquake was on first assessing the safety of the system, then getting service back on line as quickly as possible where outages were experienced. Restoring service quickly was critical because in most instances, natural gas was the only energy source available for heating, hot water, cooking, and to boil contaminated water for drinking.

The Company's response involved a three part effort:

- First, we performed extensive leakage surveys of all pipelines.
- We then did "sweeps" of neighborhoods, going from meter to meter to identify both structures and appliance connections that were safe to return to service,
- We then followed with trained technicians to restore service to structures identified in our sweeps.

Almost all of the above work was completed by the end of Day #12 (January 28). The overall effort was one of the most systematic leakage survey, structure survey and service restorations ever undertaken. It covered a population area that, if it were a separate city, would be the sixth largest in the United States.

At its peak, a team of 3,400 employees worked on -the restoration effort for a concentrated period of five days. This included 460 volunteers from four neighboring utilities: Pacific Gas & Electric, San Diego Gas & Electric, Southwest Gas, and the City of Long Beach's municipal gas department.

In addition to the thousands of workers in the field, our telephone and local office work force provided 24-hour, seven-day-a-week support, responding to more than 400,000 telephone calls and in-person customer requests over two weeks. In fact, the Gas Company answered a record number of calls in January (853,000) and despite this volume, 62% of the calls were answered in 60 seconds or less.

All of this work was accomplished despite the fact that 14% of our employees (1,300 people) lived in the areas most impacted by' the quake.

Within two weeks after the earthquake, employees were being moved back to regular work assignments. The loaned utility workers were released first, on January 26. Most of the Company's own supplemental workforce (staff management and non-field workers, who had been trained for this type of emergency) were returned to their regular assignments by January 28.

The logistics associated with meeting the material and equipment needs for field repairs was a challenge. The central purchasing unit assigned Procurement Agents and support personnel to 12 hour shifts with on-call support after hours. Supplier support and response was exceptional. Numerous suppliers responded to "off-hours" requests, making deliveries directly to various field command posts, at all hours.

The Company's trucking unit made approximately 100 unscheduled deliveries during the recovery period, moving over 400 different items. Material movement was handled for the most part, with relative ease in this event. Most freeways, and major arteries remained in functioning condition. Sheriffs escorts were required on some occasions to make critical deliveries where highway access was severely bottlenecked due to one of the well publicized freeway collapses.

With the very large number of supplemental personnel being sent from their usual headquarters assignments into field operations for service restoration work, we soon ran short of the hand tools necessary for this effort. One of the major and successful procurement efforts during recovery was to scour virtually all wholesale and retail hardware outlets in the Los Angeles basin for these items.

Another logistical challenge involved the food and lodging needs of employees. With the increase in work schedules to 12 hours and more per day for most employees involved in the recovery effort, the Company decided to provide three meals per day to those involved and to provide lodging for many of them. Lodging was required for approximately 800 personnel including both the volunteers from other utilities and Company personnel moved to the scene from other parts of the serving territory.

Meeting the employee lodging needs was one of the significant undertakings in the recovery effort. With some lodging facilities in the impact area out of service due to damage or loss of water service, and with competition for rooms from local residents who had lost their homes, lodging for many of the employees had to be accepted at considerable distance from the scene of operations.

DAMAGE ASSESSMENT

Southern California Gas Company serves a total population of about 16 million through a pipeline network of 87,000 miles. Overall the pipeline system held up very well. At any given time, less than 3% of our customers were without gas, with the vast majority of those outages due to individuals shutting off their own service as a safety precaution.

Approximately 151,000 customers had outages, with 88% of the outages attributable to customers shutting off their own service. The public was erroneously informed by some radio broadcasts to shut off the service at the meter set. This was soon corrected to not shut off the gas unless there was reason to suspect that leakage was occurring. By February 7 more than 119,600 customers had their service individually restored. The remainder (31,400) were in structures that were identified as unsafe, or where the customers had not yet returned to the structure.

The following is a breakdown of the damage to the pipeline system.

Transmission. In the high-pressure, large-diameter transmission pipeline system the Company identified and repaired a half dozen leaks in the first 24 hours. A total of 35 leaks occurred and were repaired in the two weeks following the earthquake. This system, one of the largest of its kind in the nation, continues to operate without any disruption. The majority of these leaks were in older (1930s) vintage oxy-acetylene welds.

The Company's largest underground storage field, Aliso Canyon, located approximately five miles north of the earthquake epicenter shut down, as designed, immediately after this major earthquake. During the two weeks following the earthquake, the storage field's winter withdrawal capability was gradually brought back to near-normal operations.

Aliso, with the largest gas delivery capacity of any natural gas storage field in the country, is located on 3,200 acres of an abandoned oil field. The facility's extensive network of aboveground piping, injection wells, and other equipment will require extensive repairs over the next six to twelve months, but alternative methods of operations can be substituted for those parts of the operation.

Distribution. The Company discovered 209 minor and significant leaks directly attributed to the earthquake in the lower-pressure, smaller-diameter distribution system. There were also about 500 leaks that were classified earthquake related. The vast majority of these leaks appear to have occurred 10 older steel pipes where minor corrosion conditions were accelerated by the seismic stress. These developed as a result of the earthquake.

Plastic pipe withstood the earthquake very well. There were 27 reports of plastic pipe system failures due to the earthquake. In a few cases we saw failed samples and feel this was the case. In the remaining cases we did not see the failed sample and relied on the field documentation that reported the cause as being attributed to the earthquake. About 41 % of the gas piping in the affected area and in the SoCalGas system is plastic.

Almost all of the repair work was completed by the end of day 12 (January 28th) .

ENHANCEMENTS TO SYSTEM INTEGRITY & SAFETY

Several measures contributed to the excellent performance of the piping system and overall quick response by the Company after the Northridge earthquake. The Gas Company, recognizing that it operates in an area subject to earthquakes, has spent about $180 million over the last ten years to enhance the integrity and safety of its system. These expenditures have been aimed at replacing older pipelines that would be more susceptible to earthquake damage, enhancing our ability to isolate pipeline areas, upgrading buildings and other facilities critical to providing service, and enhancing our communication systems. All of these programs have been reviewed and approved by the California Public Utilities Commission (CPUC), who should be commended for their high level of interest and support in these areas. A description of each program follows:

Communications. Communications are critical in all emergencies. Over the last few years the Company has enhanced its communication systems to ensure proper operational and emergency capabilities during disasters. The backbone IS a private microwave network designed with redundancy and designed for the ability to withstand seismic events. The system was installed in 1986. In addition, a significant amount of work was done to enhance and improve mobile radio communications. In total, about $24 million has been spent on this effort in the last six years.

Facility Upgrade Program. The Company initiated a program to upgrade buildings and other facilities to the latest seismic standards. Recognizing that certain facilities are critical to the operation of the Company, buildings and gas delivery facilities deemed critical during emergencies were designed to exceed code by a factor of 25%. For example, our Chatsworth facility, which was used as a command center for recovery activities, was such a building. While it had some superficial damage, it remained in operation. About $6 million has been spent on building upgrades.

Isolation Areas. In conjunction with the CPUC Safety Branch, in 1986 the Company began a program to install 2,300 additional valves to ensure our to systematically and rapidly shut off the flow of gas during emergencies. $9 million has been spent in this program.

Plastic Pipe. Another important aspect of system integrity is ' plastic pipe. Since 1969, the Company has installed plastic pipe wherever possible. Today, about 41 % of our distribution system utilizes plastic pipe, which is less subject to earthquake damage. The Northridge earthquake provided us with a clear evaluation of the response of plastic pipe to seismic activity. Our experience and that of PG&E in San Francisco is that it is one of the best materials available because of its high ductility and ability to resist deflections from ground movement.

Special Pipeline Replacement Program. Past earthquakes have confirmed that overall, the SoCalGas pipeline system is fairly rugged from a seismic standpoint. This is especially true of the modern steel pipelines with full penetration welds. Their ductile behavior permits the pipe to withstand considerable distortion and displacement without failure. This same experience has also identified portions of the system that are more vulnerable and related to pipe material, condition, or joining process. To address the replacement needs and risks of these pipe groups, the Company. initiated an assessment of its entire underground piping system and implemented a Special Pipeline Replacement Program (SPRP) in 1986.

The assessment identified the families of pipe within the system that were potential safety and economic risks to the Company. Seismic vulnerability was one factor but high leak rates and material deterioration were also considered. The program established a priority system for directing the expenditure of limited capital funds for pipe replacement. The major criteria considered in establishing priorities included: (1) public safety, (2) employee safety, (3) continuity of service, and (4) economics.

Some examples of the pipe families that were initially identified for replacement under the SPRP included cast iron pipe, CAB plastic services (1945-52 vintage), copper pipe and bare steel pipe inside older mains. Our experience indicated that cast iron was relatively brittle and vulnerable to seismic conditions. In the case of old CAB and copper, the material and joints were slowly

deteriorating. Although bare steel pipe is very strong it is susceptible to corrosion which results in a thinner pipe wall, and breaks more easily in earthquakes. Another family of pipe identified for replacement included pre-world War II transmission and distribution supply lines with oxy-acetylene welds. Welding standards and inspection techniques at that time were not what they are today and these joints can break under some seismic conditions.

The pipeline assessment study was finalized and presented to the California Public Utilities Commission (CPUC) in 1986. The advantage is that it is an accelerated approach to pipe replacement and is beyond our routine replacement program which is driven by' leakage rate and the economics of repair pipeline versus replacement. The CPUC supported the program and since 1986 the Company has spent about $180 million on this effort.

The seismic hazards that can affect a buried pipeline system includes fault movement, landslide, liquefaction and ground shaking. The first three can cause more damage because of their potential for permanent ground displacement of several feet which can result in pipe rupture. Fortunately, in recent earthquakes, fault movement has not been common at the earth's surface. Liquefaction has not been a problem in recent earthquakes due to soil conditions and short duration of shaking. The Company attempts to avoid or minimize landslide hazards by careful route selection. Ground shaking is generally not a problem for modern steel systems, but can be a problem for less ductile pipeline materials. The recent· Northridge earthquake caused most of its damage by ground shaking and it found the weak points in our system. This included corroded steel pipe, older oxy-acetylene welds, etc.

Excellent progress has been made under the SPRP with cast iron, copper, and CAB plastic being completely removed from the system. The focus of the current SPRP is to replace sections of older transmission and distribution supply lines across lines in active faults, liquefaction zones, landslide areas, as well as locations where high densities of people frequently congregate.

The Gas Company continually assesses and as necessary, modifies the SPRP program to ensure we take into account the latest knowledge and experience. The Northridge earthquake .will provide us with new information to consider. Without the SPRP in place, the results from this recent earthquake would have been significantly more damaging to the pipeline system.

CONCLUSION

In summary, the Southern California area was struck by a devastating earthquake on January 17, 1994. In terms of financial impact, it was one of the most severe in history. It took only 10-20 seconds to cause damages estimated to be as high as $20 billion.

In the weeks following the earthquake, the Gas Company undertook its largest logistical effort in its 127 year history. It successfully met this challenge with a team of 3,400 dedicated employees, including several hundred from neighboring utilities. Overall, the pipeline system performed well considering its extensive network and the severity of the earthquake.

The investments made in emergency preparedness and seismic safety paid off on January 17. The advanced planning and special programs for this purpose were tested and minimized the

damage. We wish to commend the California Public Utilities Commission for their support in developing these measures.