

ON WEAK LINKS AND STRONG CONNECTIONS

It is obvious now, days after the deadly Loma Prieta earthquake, that the destruction and resulting utility system disruptions were not generally distributed, but rather were localized to the most vulnerable links in the Bay area's infrastructure.

The section of Bay Bridge that closed like a trap door on rush-hour commuters was the weak link between two structural styles, where incline met cantilever; the 1.25 mile Cypress Overpass section of Oakland's Nimitz Freeway, now collapsed beyond repair, was not given the second level of reinforcement work found on most elevated roadways over the past decade. San Francisco's Marina District, where expensive homes were built on shifting landfill, was exactly where one might expect to find the twisted ruins and smoking remains of houses in the aftermath of a 6.9 earthquake.

So too, the weakest links in utility systems were the ones to give way during the fifteen seconds of shaking that still reverberates through us. According to PG&E, the major problem remains identifying and closing off thousands of small leaks in the natural gas distribution system below city streets and through homes and office structures. Even at this writing, PG&E crews are methodically moving through every skyscraper in the Financial District, searching for pockets of fumes that might ignite if power is restored prematurely.

In the Marina, where the largest fires were fueled by gas, it may be weeks before full service can be restored. PG&E is still to be found--day and night--digging, searching and moving on to the next possible leak. Fortunately, the major gas transport system was not disrupted by the quake, and Pacific Gas Transmission has reported full throughput to Southern California throughout the week.

On the electric side, the immediate outages came within seconds of the quake. Hardest hit was the huge Moss Landing facility that hugs the coast of Monterey Bay just 25 miles south of the epicenter. One of seven large generators was knocked out, possibly sustaining permanent damage to a boiler. When the 750 MW Unit Six tripped off, the system imbalance contributed to the overall shut-down felt throughout the Bay area. In the hours following the trembler, one million persons were without power; that figure is now down to to about 20,000.

Other weak links in the utility grid proved to be substations at Moss Landing, San Mateo and South San Jose. As the utility dispatchers moved energy around to compensate for the losses, they expressed concern about the ability to meet peak demand, and requested that Californians hold back on energy use throughout the week. Also temporarily out of commission are generation plants at Hunter's Point near Candlestick Park and Potrero Hill, but these were expected to return to service by late Thursday of Quake Week.

The most vulnerable part of the electric system, local distribution, continues to cause problems. Cleaning up the downed lines and poles that contributed to fires and outages throughout the affected region could take weeks.

If Californians spend some time pondering the weak links so quickly exposed on Tuesday, we are also marveling at how strong the chain really is. Years of earthquake and disaster planning by utilities, and the reinforcement of buildings, facilities and roadways, has paid off. At the time of the quake, I was sitting next to a plate glass window at San Francisco Airport for a journey that was never completed. I did not take the time to note the thermal factor of the glass, but I would highly recommend it for its ability to withstand a temblor of the same magnitude that devastated Armenia.

By far the strongest links in our chain are people, from the PG&E and Pacific Telephone crews who are devoted to restoring full services, to the emergency workers who searched

through the rubble, to the bus driver who broke the rules by letting me off the jammed freeway near my usual exit.

When I finally made it home to a darkened San Francisco, neighbors were all on the streets, sharing candles, flashlights, batteries, news and stories of their own adventures. Small power generators were pulled from basements to provide light and connection to the outside world through TV and radio broadcasts. As we waited through the night lit only by stars, candles and Coleman lamp, we counted our blessings and losses, glad at least for the human connections made stronger through adversity **[Arthur O'Donnell]**.

NORTHERN CALIFORNIA EARTHQUAKE JOLTS PG&E INTO ACTION

Clocks throughout Pacific Gas & Electric territory froze at 5:04 pm on Tuesday of the week, as the earthquake ripped through the San Andreas Fault near Santa Cruz. Measuring 6.9 on the Richter scale, the quake was felt as far away as Los Angeles, but its most destructive effects traveled northward to San Francisco and Oakland. Within fifteen seconds, parts of bridges and roadways collapsed, scores of houses fell to the ground or caught fire, and emergency officials now estimate that as many as 270 persons lost their lives.

PG&E's major casualty occurred at the 2060 MW Moss Landing facility located on the Pacific coast just south of the quake's epicenter. Only one of the seven units was operational at the time, producing 750 MW, and by CALIFORNIA ENERGY MARKETS deadline on Friday, utility officials were still trying to assess the extent of damage. PG&E spokesman Dave Monfried said that Unit Six's boiler may have sustained damage, but that until the boiler had cooled down, there was no way to estimate how seriously it was affected. PG&E also reported generation losses at its 426 MW Hunters Point plant and at the 354 MW Potrero Hill station.

Damage was also sustained at three transmission substations, in San Mateo, South San Francisco and at Moss Landing, where four 500 Kv breakers were destroyed. No damage, however, was reported at the Diablo Canyon nuclear facility, nor on PG&E's bulk transmission system. At the distribution level, lines and poles were reported to be felled in many sections of the region, sometimes contributing to grass and house fires as wires crossed.

Immediately following the quake, power was tripped in many parts of PG&E territory, and as many as one million of the utility's 4.5 million customers were left in the dark. While utility crews evaluated the damage and tried to restore power, San Francisco residents could watch entire neighborhoods flicker with intermittent electricity, while other districts were lighted by flames from house and apartment fires. Hospitals and other emergency centers switched to auxiliary generation, and some radio stations without power opened their frequencies to the All-News stations that detailed the quake's aftermath.

The following day was a quiet one in Northern California, with major cities on a forced holiday, power still out in most downtown areas, and officials following the grim task of evaluating the damage. Estimates of damage have run up to \$5 billion, according to Lloyd's of London, and the price tag in San Francisco alone was put at \$2 billion.

On Friday morning PG&E reported that it had restored electric service to nearly all of its territory. Spokesman Clyde Walthal said there were still 21,500 customers without electricity, and 69,225 without gas service. The gas figures had been revised upward, as many customers turned off the valves in their homes. To lessen the danger of fires and explosions, PG&E is asking residents to wait until a utility crew can come to turn the valves back on and relight pilots.

According to Walthal, the bulk of service outages remain in the South Bay area, especially San Jose and Santa Cruz, but workers are continuing their efforts. Repair crews from several other utilities were assisting PG&E field workers, including employees of SoCal Gas,

SDG&E and Sierra Pacific. PG&E reports that the series of strong aftershocks that rumbled through Santa Cruz on Wednesday and Thursday had no additional impact on service.

Among the last areas within San Francisco to have utility service restored was the Financial District, where skyscrapers were painstakingly searched for pockets of gas fumes before electricity could be switched on. Lacking power on Wednesday, the Pacific Stock Exchange attempted to conduct business by candlelight and telephone, but gave up by noon.

Like many downtown office buildings, PG&E's corporate headquarters suffered only cosmetic damage cracked masonry and broken windows. The Beale Street building was closed until Thursday, but top corporate and operations managers moved into the "command center" on Market Street, maintaining constant communications with field crews while news representatives handled the flood of media inquiries. The communications post was replicated in centers throughout PG&E territory, said spokesman Monfried, with major activity centered in Oakland and San Jose.

In a visit to the San Francisco command center on Thursday, CEM was told that the emergency room atmosphere was not completely foreign to utility officials, who had undergone a simulated earthquake drill in June. Lyman Shaffer, director of security for PG&E, said the June exercise mimicked an 8.3 magnitude quake centered along the Hayward Fault (30 miles east of the San Andreas Fault). In the course of a single day, a core group of utility decision makers were given the experience that they would draw upon during this real, week-long emergency. The most valuable aspect of the exercise, said Shaffer, was teaching these managers to work together under stress.

Aside from banks of telephones, bulletin boards and system maps, the command center on Thursday was littered with scraps of paper that testified to the unfolding drama of Tuesday night, confirming the reports of outages, freeway closures and gas leaks that needed to be stemmed. Lying next to the litter was a nearly empty bottle of aspirin **[Arthur O'Donnell]**.

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