A Seismological Shoot-out at Diablo Canyon

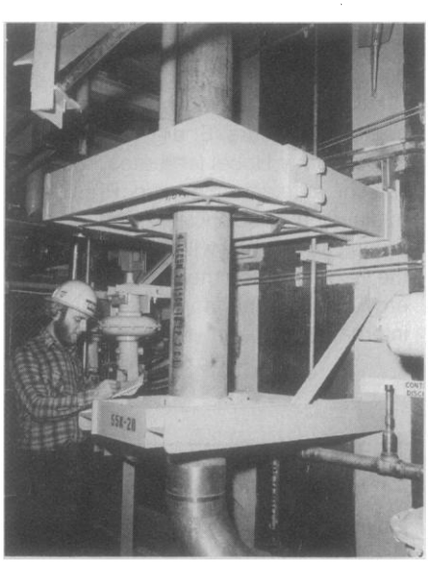
It's expert against expert, a governor against the NRC, and the utility against itself

For 8 years, Pacific Gas & Electric Co., the nation's largest utility, has struggled for the right to operate a nuclear power plant at Diablo Canyon, a remote spot on the California coastline 80 miles north of Santa Barbara. The utility has endured 36 federal hearings, four state hearings, three licensing appeals, and two congressional inquiries. It has weathered attempts by environmental groups to block construction of the plant. It has deflected waves of antinuclear protesters who tried to obstruct final preparations for the plant's operation. And then, last month, as everything finally looked set for the generation of power, the utility shot itself in the foot.

On 28 September, PG & E notified the Nuclear Regulatory Commission (NRC) in Washington that it had inadvertently mixed up some of the charts for the plant's design. As a result, certain structural supports, needed to help the plant withstand a potential earthquake, are in the wrong place. Some pipes in the plant that carry nuclear fuel, radioactive wastes, and a coolant were insufficiently supported, while others were buttressed needlessly. Shortly after the error was discovered, the utility found that it could be corrected by welding additional supports to the affected equipment, a straightforward task that will be completed by early November. Technologically, the mistake is not catastrophic. But from a political and legal standpoint, the chart mix-up was something of a disaster that might considerably delay the reactor's operation.

The revelation goes to the heart of the dispute surrounding the plant. The utility's opponents, including California Governor Edmund G. Brown, Jr. and several local ecology groups, charge that an earthquake centered in a nearby fault might cause the failure of critical reactor parts because of flaws in the plant's design. PG & E's admission of construction error adds a new concern about quality of workmanship. "This is the biggest blunder since the utility mistakenly put the plant in the vicinity of an active fault," says Herbert Brown, a Washington, D.C., attorney who represents the governor. Brown wants PG & E to let an outside auditor—in addition to the NRC—examine its work and verify that no other mistakes exist, a process that would take weeks.

The NRC wants to know why the error was not caught earlier. The utility says it probably occurred in 1977, which means it went undetected for 4 years by either PG & E or its principal seismic consultant, URS/John A. Blume and Associates of Berkeley, one of the top firms in the business. The NRC's investigation is focused on PG & E's effort to catch and correct such mistakes during the 1977–78 period, when equipment was hardened against shaking. Harold Denton, the director of reactor regulation at the NRC, told PG & E officials during a hearing on 10 October that "we need some basis for confidence that the breakdowns that occurred aren't symptomatic of some wider breakdown at the time." Representative Morris Udall (D–Ariz.), chairman of a House energy subcommittee, also plans an investigation. At a hearing on 29 October he will ask why the NRC failed to catch the mistake during routine inspection.



Bracing under inspection

Although the attention can hardly be welcome, the utility is apparently untroubled by the inquiries. PG & E has hired its own consultant to review the construction and claims there is no sign of serious additional errors. One minor error that did turn up, involving the use of incorrect plans for trays supporting various electrical cables, does not require correction, PG & E says. Donald Brand, the utility's vice president for engineering, says that even if the principal design error had gone undetected, the plant could have operated safely through an earthquake. Once the repairs are complete, the company will ask the NRC for approval to begin loading uranium fuel into one of the two reactors at the plant site, an operation that was interrupted when the problem was first discovered.

Meanwhile, the central battle over the reactors' design rages on. The major concern of its opponents is the proximity of the Hosgri fault, which lies only 2½ miles offshore from the site. Ironically, PG & E selected Diablo for its remoteness from faults and neighbors on land, but neglected to look under the sea. Two Shell Oil Company geologists, E. G. Hoskins and J. R. Griffiths (after whom the fault is named), published a paper on it in 1971, but PG & E did not learn of the paper until 1972 and did not inform the NRC until 1973. Neither company nor regulator thought to delay construction while the fault was studied, with the result that both were shocked by a report of the United States Geological Survey (USGS) in 1975. The agency, acting as the NRC's consultant, concluded that a quake measuring 7.5 on the Richter scale might someday occur there. By the time this was decided the plant was more than 75 percent complete.

The NRC contested this assessment at first, but gave in when the USGS failed to budge. Its position was based on a finding that an earthquake in 1927 that measured 7.3 on the Richter scale may have been centered in the Hosgri fault. That earthquake caused only minor property damage along the coast, but only because of the sparse population. James Devine, who is now the assistant director of engineering geology at USGS, remembers that the evidence supporting the Hosgri fault as the culprit was thin. "It was more that you could not *exclude* the fault as being the center. It was within the margin of error. Given the uncertainty in both directions, we stuck to our guns."

The implications for the Diablo Can-

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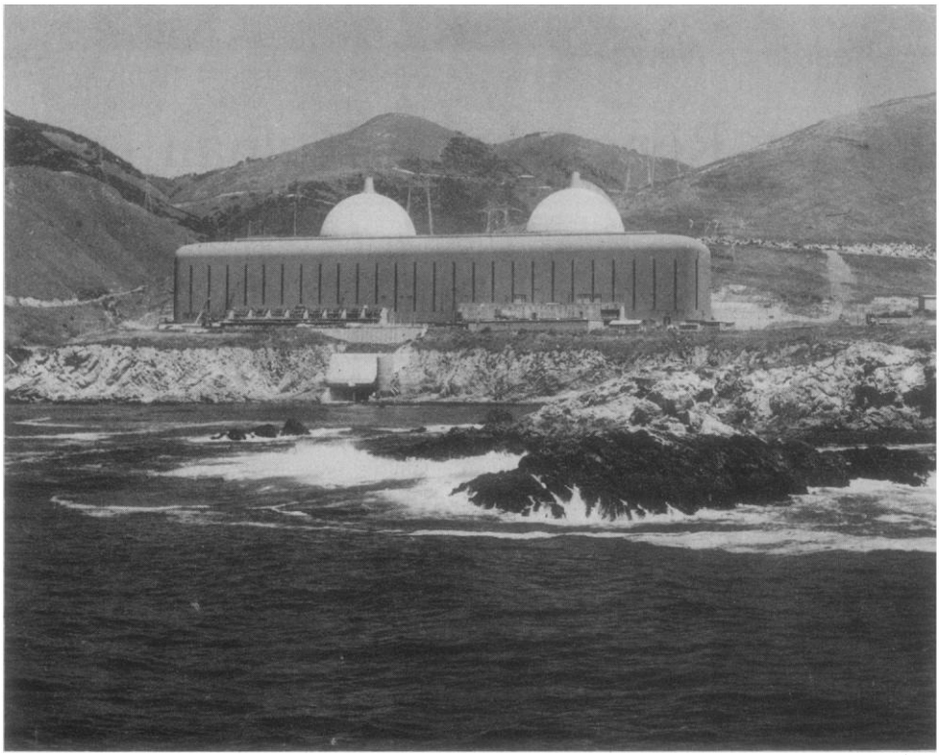
yon reactors were described in NRC memos as "a horrendous backfit decision" requiring reanalysis of the reactor components that "will entail years of applicant and staff effort." A 7.5 magnitude earthquake translated, at least in some views, to a peak ground acceleration beneath the Diablo Canyon site 1.15 times the force of gravity. As Devine explains, no building has ever been constructed to stand after such shaking. "Damage at that level is pretty much total," he says.

Not long into the dispute, everyone involved obtained outside seismic and engineering experts. PG & E hired Blume, Bruce Bolt of the University of California, Allin Cornell of MIT, Richard Jahns of Stanford, and Stewart Smith of the University of Washington. Ecology groups and landowners near the plant relied on the testimony of James Brune, now of Scripps Institution, Enrique Luco of the University of California, and Mihailo Trifunac of the University of Southern California, who was actually engaged by the NRC as a consultant to its advisory board. The NRC itself relied on Nathan Newmark of the University of Illinois.

The difficulty with resolving the resultant clash of opinions is that seismic engineering remains a developing science. As Blume told *Science*, "A part of it is still judgment, although there is a lot of theory." Finding a consensus in such terrain would be difficult, but as the NRC acknowledges, it did not even look for one. Throughout a series of administrative hearings, the agency's committees and staff sided repeatedly with PG & E's arguments downplaying the seriousness of an earthquake threat from the Hosgri fault.



The Diablo Canyon plant is 2½ miles from the Hosgri fault

For example, the utility and its consultants use several devices to estimate that such a quake would have an effective magnitude at least 30 percent less than is claimed by the other side. The assertions are as follows: (i) peak acceleration at the reactor is unlikely to exceed 0.75 times the gravitational acceleration, no matter how severe the earthquake; (ii) the shock wave will be attenuated by filtering through the reactor foundation; and (iii) the release of energy through friction in the reactor system will dampen the peak acceleration by 7 percent. As a result, the reactors would experience an acceleration only as great as about half that due to gravity. In the utility's view, the plant was conservatively designed to withstand an acceleration of at least 0.4 times the gravitational acceleration, so few modifications are needed to ensure that it could survive a substantial quake, even from the Hosgri fault.

Thus, PG & E wound up accepting the USGS estimate that a quake was possible, and then explained away the magnitude of its impact on the reactors. As Malcolm Furbush, the PG & E associate general counsel, told a congressional subcommittee in 1977, "the Company believes that the units at Diablo Canyon have been designed with great care and conservatism, and are of more than adequate strength. . . . In order to get past the regulatory delays, however, we have agreed to make modifications required by the more extreme criteria, with which we do not agree."

In return, the NRC has granted PG & E a preliminary license to operate the first of the two Diablo Canyon reactors at low power. Opponents of the plant have challenged both the logic and the license in an appeal now being considered by the five commission members. They plan to sue in court if the commissioners refuse to withdraw the license and reopen hearings. "They reduced the g's three ways and increased the strength of the building, all by sharpening their pencil," says David Fleischaker, an attorney for the ecology groups. He and Brown want to bring in new seismological data that they view as favorable to their side, as well as to challenge the plant's emergency preparedness and security plans.

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They anticipate relying on a number of statements made by the NRC in deciding in favor of PG & E, including an acknowledgment by the Advisory Committee on Reactor Safeguards that the utility's seismological approach is "based largely on judgment and experience rather than on extensive observations or analyses . . . not heretofore . . . applied to nuclear power plants." Similarly, the NRC's reactor licensing appeal board summed up the dispute as follows: "We have here a nuclear plant designed and built on one set of seismic assumptions, an intervening discovery that those assumptions underestimated the magnitude of potential earthquakes, a reanalysis of the plant to take the new estimates into account, and a post hoc conclusion that the plant is essentially satisfactory as is—but on theoretical bases partly untested and previously unused for the purposes."

In such a speculative arena, it would be foolish to predict whether the utility or its opponents will emerge on top.

—R. JEFFREY SMITH