Rancho Seco

Clay Station, CA

Owner: Sacramento Municipal Utility District

Reactor type: Pressurized water reactor

Commercial operations began: April 18, 1975

Outage dates (duration): December 26, 1985 to November 10, 1988 (2.3 years)

Reactor age when outage began: 10.7 years

Fleet status: Only reactor owned by the company

Synopsis

On December 26, 1985, power to the integrated control system (ICS) for Rancho Seco's reactor was lost. As a result, all of the reactor's controllers automatically went to mid-scale (e.g., the settings for the main feedwater valves went to 50 percent open). In the 26 minutes it took the operators to restore power (by flipping a switch from "off" to "on"), the temperature of the reactor water dropped 180 degrees Fahrenheit—well in excess of the 100 degrees per hour limit.

In late February 1986, NRC staff informed the agency's commissioners that this event was caused by design flaws and weaknesses that had long been known to both the owner (the Sacramento Municipal Utility District) and the NRC itself, due to a series of similar events at Rancho Seco dating back to March 1978. The problems had been studied many times over the intervening years, but never fixed until this outage prompted a resolution.

Process Changes

None.

Commentary

The Babcock & Wilcox design of the ICS had serious flaws that manifested themselves time and again at Rancho Seco and other reactors equipped with the technology. The NRC wrongly accepted "further study" as a corrective action each time until the seriousness of this particular event eliminated that option. Having determined that a given problem is an "accident waiting to happen," waiting to fix the problem until the accident actually occurs makes no sense. For reasons of both economy and safety, the nuclear power industry and the NRC should have fixed this flawed design *before* the extended outage at Rancho Seco happened.

Rancho Seco's owners paid a heavy price for their procrastination. The series of forced outages caused in part by the known design flaw undermined public confidence, and on June 6, 1989, a majority of citizens (53.4 percent) voted to shut down the reactor permanently. Had the plant's problems been addressed soon after they surfaced in March 1978, the referendum's outcome may have been different.

NRC Systematic Assessment of Licensee Performance (SALP) History

Date	Operations	Radiological Controls	Maintenance	Surveillance Testing	Emergency Preparedness	Fire Protection	Security	Outage Management	Quality Assurance	Licensing	Training
08/1980	2	2	2	1	2	2	2	2	3	n/a	n/a
04/1982	2	2	2	2	2	1	2	1	2	n/a	n/a
03/1983	2	2	2	2	2	2	1	1	n/a	1	n/a
06/1984	3	2	2	3	2	2	1	1	n/a	3	n/a
11/1985	2	3	2	2	2	2	1	1	2	2	2
11/1986	3	3	3	2	3	1	3	2	3	n/a	2

NOTE: A rating of 1 designates a superior level of performance where NRC attention may be reduced. A 2 rating designates a good level of performance with NRC attention at normal levels. A rating of 3 designates an acceptable level of performance where increased NRC attention may be appropriate. A rating of n/a was given in those areas that were not assessed on that date.

Details

March 20, 1978: The ICS lost power, causing the reactor to trip. The source of the power loss was a worker who, while changing a light bulb in a push-button switch on the reactor console, caused a momentary short circuit that grounded the power supply. This, in turn, caused a rapid cooldown of the reactor coolant system in excess of technical specification limits.[1]

March 24, 1978: The reactor was restarted after the Sacramento Municipal Utility District (SMUD) promised the NRC it would consider the feasibility of changes that would prevent a severe plant transient resulting from a similar failure in the non-nuclear instrumentation system.[2]

January 5, 1979: The ICS lost power, causing a reactor trip and excessive overcooling of the reactor coolant system.[3]

March 1979: Babcock & Wilcox issued a report on the reliability of the ICS, detailing a number of changes that were warranted. SMUD elected to make no changes. NRC staff also reviewed the Babcock & Wilcox report and determined that any necessary actions would be determined by Unresolved Safety Issue A-47, "Safety Implications of Control Systems."[4]

November 30, 1979: The NRC issued Bulletin 79-27 requiring SMUD to review power supplies for safety-related and non-safety-related instrumentation and control systems, to identify alarms that would inform operators about problems, and to develop emergency operating procedures that would guide the operators' response.[5] SMUD determined that no changes were necessary at Rancho Seco—a response the NRC initially felt "did not adequately address the concerns in the Bulletin." Rather than compel SMUD to remedy the situation, however, NRC staff undertook "the progressive narrowing of the scope of the review" and "decided that the SMUD response was adequate, despite what appear to be a number of weaknesses in the SMUD response."[6]

June 1983: The Babcock & Wilcox Owners Group issued a report indicating that the odds of an overcooling transient caused by a loss of ICS power were 4×10^{-2} per reactor year, or one such event every three years among the eight U.S. reactors equipped with a Babcock & Wilcox ICS. The study further reported that one facility (Rancho Seco) had a configuration making the risk of overcooling events even higher.[7]

March 19, 1984: Partial loss of power to non-nuclear instrumentation caused a reactor transient and overcooling of the reactor coolant system water.[8]

June 23, 1985: A cracked weld on the high-point vent produced a 20-gallon-per-minute leak of reactor cooling water. Cross-bracing and other supports for the nitrogen supply line to the high-point vent had not been properly installed (although installation records and post-inspection records indicated that they had). As a result, excessive vibration by the nitrogen supply line ultimately caused fatigue failure of the weld.[9,10]

October 2, 1985: During a transient, the reactor coolant system was overcooled when two relief valves opened on a feedwater heater. The reactor was shut down for the rest of the month for modifications.[11,12]

October 18, 1985: The Institute of Nuclear Power Operations (INPO) issued its corporate evaluation on SMUD, which identified the need for significant improvement in four areas, the first being "timely resolution of long-standing plant problems."[13]

December 5, 1985: The reactor was shut down due to problems maintaining proper level in the steam generators.[14]

December 12, 1985: The reactor was restarted.[15]

December 22, 1985: The reactor was shut down due to a three- to four-gallon-per-minute leak of reactor cooling water from around the letdown coolers. The source of the leak was later determined to be the pressurizer liquid sample line.[16]

December 26, 1985: With the reactor operating at 76 percent power, the ICS lost power. ICS demand signals automatically went to mid-scale, closing the main feedwater valves to 50 percent and opening the atmospheric dump valves, turbine bypass valves, and one set of auxiliary feedwater valves to 50 percent. High reactor coolant system pressure, in turn, tripped the reactor.

It took the operators 26 minutes to restore power to the ICS (by flipping a switch from "off" to "on"). In that time, the reactor water temperature dropped 180 degrees Fahrenheit, which violated the technical specification limit of 100 degrees per hour. Other problems included: the indicated water level in the pressurizer dropped off-scale in the low direction, the indicated water level in one steam generator rose off-scale in the high direction, and one control room chart recorder indicated a feedwater flow rate of 50 percent even though the actual flow rate was zero. In addition, one reactor coolant makeup pump was operated with its suction valve closed, causing it to be severely damaged, and one of the control room operators collapsed from exhaustion and had to be transported to a local hospital.[17]

The NRC dispatched an Augmented Inspection Team to the site, but upgraded it four days later to an Incident Investigation Team when initial findings suggested the event may have had implications for all Babcock & Wilcox reactors.[18]

February 25, 1986: NRC staff briefing commissioners on the Rancho Seco overcooling event reported that:

> *"The NRC staff was led to believe that the Emergency Feedwater Initiation and Control (EFIC) system would be installed in 1984 in response to a number of NRC requirements, including TMI Action Item II.E.1.2. Apparently, SMUD decided to install an alternate system in response to II.E.1.2. SMUD's intent to satisfy II.E.1.2 with this alternate design was not made clear to the NRC staff, was not approved by the staff, and may not have complied with the requirements of II.E.1.2. As a result, the EFIC system, some features of which would have reduced the severity of the December 26, 1985 incident, has not yet been installed at Rancho Seco."*

> *"The fundamental causes for this transient were design weaknesses and vulnerabilities in the ICS and in the equipment controlled by that system. These weaknesses and vulnerabilities were not adequately compensated by other design features, plant procedures or operator training. These weaknesses and vulnerabilities were largely known to Sacramento Municipal Utility District (SMUD) and the NRC staff by virtue of a number of precursor events and through related analyses and studies. Yet, adequate plant modifications were not made so that this event would be improbable, or so that its course or consequences would be significantly altered. In summary, the information was available and known which could have prevented this overcooling transient; but in the absence of adequate plant modifications, the incident should have been expected."*[19]

January 1988: INPO provided SMUD with the results from its onsite evaluation, which identified concerns with the program used at Rancho Seco for incorporating operating experience from other facilities, the program used to perform maintenance on plant equipment, and the facility's inability to recruit managers and workers due to its uncertain future.[20]

April 11, 1988: The reactor achieved criticality. The cost of the 27-month outage was estimated to be more than $400 million[21] ($672 million in 2006 dollars[22]).

December 12, 1988: A loss of feedwater flow to the steam generator resulted in a reactor trip, steam generator dry-out, and excessive overcooling of the reactor coolant system. The loss of feedwater was caused by the disintegration of a control valve on the steam supply line to the turbine-driven feedwater pump, whose parts lodged in the valve seat of another control valve further down the supply line, causing that valve to close. The upsteam valve came apart because it was a low-pressure valve improperly installed in a high-pressure system.[23]

January 31, 1989: During maintenance to replace a seal on the dual-drive auxiliary feedwater pump shaft, the pump speed increased to 6,020 revolutions per minute (normal pump speed is 3,600 revolutions per minute) after steam was admitted into the turbine. Attempts to control the pump speed from the local governor failed. The turbine overspeed trip mechanism actuated, but the trip-throttle valve failed to close. Operators in the control room closed the steam supply valve to the turbine, ending the event. During the overspeed condition, the pressure of the water in the piping downstream from the pump reached approximately 3,800 pounds per square inch (the piping was only designed to accommodate 2,600 pounds per square inch).[24]

June 6, 1989: In a referendum, 111,867 residents of Sacramento (53.4 percent) voted to permanently close Rancho Seco. The plant was shut down the next day.[25]

Notes

[1] Nuclear Regulatory Commission (NRC). 1978. Inspection Report No. 50-312/78-03, April 21.
[2] Ibid.
[3] NRC. 1986a. Commission briefing: Loss of integrated control system power and overcooling transient at Rancho Seco on December 26, 1985. Presentation slides, February 25.
[4] Ibid.
[5] NRC. 1979. Loss of non-class 1E instrumentation and control power system bus during operation. Bulletin No. 79-27, November 30.
[6] NRC, 1986a.
[7] Ibid.
[8] Ibid.
[9] NRC. 1985. Daily Event Report No. 1210, June 23.
[10] NRC. 1985. Discrepancies between as-built construction drawings and equipment installations. Information Notice No. 85-66, August 7.
[11] *Nuclear News*. 1986. NRC takes close look at ICS power loss, February.
[12] Miner, S., and G. Kalman. 1986. Rancho Seco: NRR SALP report for period June 1, 1985 through June 30, 1986. Memorandum to Dennis Kirsch, director, reactor safety and projects, Nuclear Regulatory Commission, July 31. Sydney Miner and George Kalman were project managers at the Nuclear Regulatory Commission.
[13] Kaplan, D.S. 1987. August 1985 INPO corporate evaluation. Letter to Lloyd G. Connelly, member, Assembly of the State of California, December 1. David S. Kaplan was general counsel at the Sacramento Municipal Utility District. [INPO reports are typically unavailable to the public, but SMUD released this report during the referendum about the plant's future.]
[14] Associated Press. 1985. Leak causes nuke plant shutdown, December 23.
[15] Ibid.
[16] NRC. 1985. Daily Event Report No. 3136, December 22.
[17] NRC. 1986b. Transient due to loss of power to integrated control system at a pressurized water reactor designed by Babcock & Wilcox. Information Notice No. 86-04, January 31.
[18] *Nuclear News*, 1986.
[19] NRC, 1986a.
[20] Institute of Nuclear Power Operations. 1988. *Evaluation of Rancho Seco Nuclear Generating Station*. January. Atlanta, GA. [INPO reports are typically unavailable to the public, but SMUD released this report during the referendum about the plant's future.]
[21] *Electric Utility Week*. 1988. Rancho Seco up, but ballot items loom; Duke puts $100,000 behind one, April 18.
[22] Bureau of Labor Statistics. 2006. Inflation calculator. Washington, DC: U.S. Department of Labor. Online at *http://data.bls.gov/cgi-bin/cpicalc.pl*.
[23] Pate, Z.T. 1989. Letter to Joseph Firlit, chief executive officer, nuclear, Sacramento Municipal Utility District, February 15. Zack T. Pate was president of the Institute of Nuclear Power Operations. [INPO reports are typically unavailable to the public, but SMUD released this report during the referendum about the plant's future.]
[24] Ibid.
[25] Wald, M.L. 1989. Voters, in a first, shut down nuclear reactor. *New York Times*, June 8.