

SEQUOYAH UNIT 1

Soddy-Daisy, TN

Owner: Tennessee Valley Authority

Outage dates (duration): August 22, 1985 to November 10, 1988 (3.2 Years)

Reactor type: Pressurized water reactor

Reactor age when outage began: 11.7 years

Commercial operations began: July 1, 1981

Fleet status: Fourth oldest of five reactors owned by the company

Synopsis

The Tennessee Valley Authority (TVA) voluntarily shut down both reactors at Sequoyah in August 1985 after an independent contractor was unable to confirm that the plant's safety-related equipment satisfied NRC regulation 10 CFR 50.49. The following month, the NRC required TVA to submit a plan for safely restarting Sequoyah, which the company submitted in November.

In January 1986, the NRC asked TVA why the Sequoyah restart plan did not address the design control problems that had triggered the shutdown of all three reactors at TVA's Browns Ferry facility in Alabama, did not address the problems raised by employees that delayed construction at TVA's Watts Bar plant in Tennessee, and did not address corporate weaknesses that contributed to problems at Browns Ferry and Watts Bar. TVA subsequently hired a new manager for its nuclear program.

The company submitted a revised restart plan to the NRC in March. Events that occurred at Sequoyah the following January and February (while both reactors were shut down) added some items to the plan and caused others to be revisited.

In June 1987, the NRC informed TVA that the agency would need assurance that the efforts undertaken at Sequoyah had actually achieved their objectives, and that an independent evaluation could provide such assurance. When TVA balked at hiring an independent team to conduct an evaluation, the NRC sent in its own team to assess the restart readiness of one system. The NRC's team identified 64 problems with that one system and concluded it was not ready for restart.

In November of that year, the NRC informed TVA that it considered all of the silicon rubber insulation used in Sequoyah's electrical cables to be suspect. The company replaced all of this insulation and, after an extended outage of more than three years, Sequoyah Unit 1 returned to service in November 1988.

Process Changes

None.

Commentary

The NRC should be commended for many things about this extended outage, including the fact that it initiated the outage. After the agency informed TVA that Sequoyah would be one of the first plants to be

audited according to the 10 CFR 50.49 requirements that had just taken effect on March 31, 1985, the company brought in a contractor to pre-audit Sequoyah. That contractor found enough problems to cause TVA to voluntarily shut down both reactors before the NRC’s inspectors got a chance to do so.

TVA initially attempted to limit the scope of what it would fix prior to restarting Sequoyah (mostly items directly related to 10 CFR 50.49). The NRC avoided this trap and required TVA to explain why programmatic problems at its Browns Ferry and Watts Bar plants had not also played a role in Sequoyah’s problems. As a result, the company expanded its restart effort to address these problem areas as well. TVA also hired someone from outside the company to head its nuclear power program.

TVA then attempted to persuade the NRC that simply completing the items on the restart list was enough to warrant the agency’s approval to restart. The NRC, however, wanted some means of ensuring that the items on the list had been completed adequately. When TVA stonewalled and refused to bring in an independent party to verify adequate completion of a sampling of items on the restart list, the NRC formed its own team, which evaluated a single system and identified more than five dozen problems. TVA was forced to revisit its restart effort as a result.

But it’s not all kudos for the NRC. Despite an outage of three-plus years and an extensive focus on design control issues, Sequoyah Unit 1 incurred another extended outage for design control issues less than five years after restarting. Thus, the NRC’s efforts during the first extended outage were insufficient to ensure TVA had adequately addressed enough of the design control problems at Sequoyah. A “do-over” was needed to fix more of the safety problems.

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
01/1981	2	2	2	2	2	3	2	2	2	n/a	n/a
11/1982	3	2	2	2	2	2	2	n/a	3	2	n/a
06/1983	2	2	2	1	2	n/a	3	2	3	2	n/a
06/1984	2	1	1	1	3	1	2	1	3	2	n/a
09/1986	2	2	3	2	2	2	2	2	3	2	2
	Operations	Radiological Controls	Maintenance/Surveillance Testing	Emergency Preparedness		Security	Engineering and Technology		Safety Assessment and Quality Verification		
06/1989	2	2	2	2		2	3		2		
07/1990	2	2	2	2		2	2		2		
	Operations		Maintenance	Engineering			Plant Support				
10/1991	2		2	2			2/1/1				
11/1992	2		2	2			2/1/1				
12/1993	3		3	1			1				
02/1995	2		2	2			2				
09/1996	2		2	2			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

August 22, 1985: TVA shut down both reactors at the Sequoyah nuclear power plant after an independent review of safety-related equipment could not confirm that the reactors could be safely shut down in the event of an accident. Westec Services informed TVA that it was only able to verify adequate environmental qualification (EQ) for three of the first 27 safety-related components examined. TVA had written to the NRC in July stating that all equipment at Sequoyah was environmentally qualified; the company hired Westec to review its EQ program because it expected Sequoyah to be one of the first sites audited by the NRC.¹

September 17, 1985: The NRC required TVA to submit, under oath or affirmation as required by 10 CFR 50.54(f), its plan to restart Sequoyah.²

November 1, 1985: TVA submitted its plan to restart Sequoyah to the NRC.³

November 7, 1985: TVA supplemented its restart plans by sending the NRC a copy of a report on design control prepared by consultant Gilbert/Commonwealth.⁴

January 16, 1985: The NRC required TVA to provide additional information about its plans to restart Sequoyah. Specifically, the agency required TVA to address:

1. Why the design control problems found at Browns Ferry and reported via employee concerns at Watts Bar did not also apply to Sequoyah.
2. How the issues arising from TVA employee concerns and the company's Nuclear Safety Review Staff and quality assurance program would be reviewed and resolved.
3. Why TVA believed the design controls in place at Sequoyah prior to June 1985 were adequate.
4. Why design changes undertaken at Watts Bar to correct safety problems had not also been undertaken at Sequoyah.
5. How TVA was reviewing electrical design calculations and how that effort integrated with broader design control efforts.⁵

January 7, 1986: NRC staff briefed commissioners on the status of the five TVA reactors that were shut down. Commissioners were informed that TVA expected to restart Sequoyah Unit 2 first.⁶

January 9, 1986: NRC staff briefed commissioners on the TVA recovery plan and announced that Admiral Steven White had been retained by TVA as its manager of nuclear power, a new position created in a recent reorganization.⁷

February 7, 1986: NRC staff briefed commissioners on the status of the TVA program.⁸

March 10, 1986: TVA submitted a revised response to the NRC's September 17, 1985, 10 CFR 50.54(f) letter. The six primary areas of focus: equipment environmental qualification, operational readiness, employee concerns, electrical design calculations, welding, and simulator training of control room operators.⁹

March 11, 1986: NRC staff briefed commissioners on the status of the TVA program.¹⁰

June 6, 1986: NRC staff briefed commissioners on the status of the TVA program.¹¹

June 12-13, 1986: The NRC Ad Hoc Subcommittee (consisting of senior NRC managers) met with TVA representatives to discuss TVA's Corporate Nuclear Performance Plan.¹²

July 10, 1986: The NRC's Advisory Committee on Reactor Safeguards (ACRS) was briefed by NRC staff and TVA officials about the Corporate Nuclear Performance Plan. ACRS expressed concern about training provided to TVA managers, the transition from current contractor managers to TVA permanent employees, and the span of control by TVA's manager of nuclear power.¹³

August 25, 1986: NRC inspectors identified numerous deficiencies in surveillances tests for technical specification requirements that were discussed with TVA in an enforcement conference in Region II.¹⁴

January 28, 1987: With Unit 1 shut down and the reactor coolant system partially drained, a plugged reactor coolant system level instrument permitted a slow level change to go undetected for several days. The indicated water level jumped nearly 11 inches when the plug cleared itself. As operators attempted to determine the actual water level and restore it to an acceptable level, it dropped so low that suction was lost to the residual heat removal pump providing shutdown cooling, then rose so high that several hundred gallons of reactor water spilled into the containment building.¹⁵

February 1, 1987: During a surveillance test involving the opening and closing of the 14-inch-diameter valve in the suction line connecting the refueling water storage tank (RWST) to the residual heat removal pumps, operators recognized that the procedure was not appropriate given the current conditions (i.e., the reactor was shut down, depressurized, and partially drained) but elected to perform it anyway. Opening the valve provided a pathway for water to flow from the RWST to the reactor coolant system. This water flooded the reactor coolant system, causing 2,000 to 3,000 gallons of radiologically contaminated water to flow through open steam generator primary-side manways into the containment building, where several workers were exposed to high levels of radiation.¹⁶

June 1987: The NRC informed TVA that the agency would need assurance that the efforts undertaken by the company were sufficiently thorough and effective to justify restarting the Sequoyah reactors. The NRC gave TVA the option of arranging for an independent evaluation, but the company was unwilling to commit to this self-assessment and expressed its belief that such an inspection was unnecessary. The NRC responded by initiating an Independent Design Inspection for one safety system, the essential raw cooling water system. The primary purpose of the inspection was to verify that the original design of this one system was adequate.¹⁷

July 28, 1987: The NRC issued its evaluation (NUREG-1232 Volume 1) of TVA's corporate management.¹⁸

August 18, 1987: At the direction of Steve White, TVA's manager of nuclear power, an Operational Readiness Review team was formed to assess "the qualification and motivation of personnel at SQN unit 2 and the availability of necessary supporting resources for the safe and reliable testing, operation, and maintenance of the plant" prior to its restart.¹⁹

September 11, 1987: The NRC presented TVA with the findings from its Independent Design Inspection of the emergency raw cooling water system. NRC team leader Eugene Imbro reported: "Any time you get a team of experts, as my team is, no matter what plant in the country we go into, we find problems. It just goes without saying that you are going to find problems." The NRC's team of experts identified 64 problems with this single system.²⁰

November 13, 1987: The Institute of Nuclear Power Operations (INPO) provided TVA with the results from a special assistance visit conducted at Sequoyah at TVA's request. INPO identified several areas it felt needed to be corrected prior to restart: procedures and training for operators on approaching reactor criticality, maintenance practices for nuclear instrumentation, and incorporation of contingency actions from the Westinghouse Owners Group emergency response procedures into plant emergency operating procedures.²¹

November 13, 1987: The NRC informed TVA that it considered all of the silicone rubber insulated cables installed at Sequoyah suspect and that the reactors could not be restarted until the problem was resolved.²²

December 28, 1987: TVA informed the NRC that all silicon rubber insulated cables inside the Unit 2 containment building had been replaced and that it would qualify the remaining cables outside the containment building.²³

December 31, 1987: The NRC issued Information Notice 87-66 to all plant owners alerting them to the NRC's discovery that qualified and acceptable time-delay relays at Sequoyah had been improperly replaced with unqualified commercial-grade parts.²⁴

January 5, 1988: A special Operational Readiness Review team reported its concerns to TVA's Manager of Nuclear Power Steve White, including:

1. The number of procedural compliance and quality problems observed had the potential to lead to future operational problems.
2. There was a lack of concern for abnormal chemistry situations, resulting in inadequate actions to maintain system chemistry and correct out-of-specification conditions in a timely fashion.
3. The practices employed for independent verification of valve and electrical alignment did not provide full assurance that the alignments were correct.
4. A thorough understanding and a clear working knowledge of reactivity control was not apparent.
5. Many aspects of radiological control did not meet requisite standards.²⁵

January 20, 1988: NRC staff briefed commissioners on the restart status of Sequoyah Unit 2.²⁶

August 4, 1988: NRC staff and TVA officials briefed commissioners on the restart of Sequoyah Unit 1.²⁷

November 6, 1988: Unit 1 achieved criticality.²⁸

November 10, 1988: Unit 1 was connected to the electrical grid, ending the extended outage.²⁹

November 18, 1988: A fault on the main generator caused an automatic trip of the main turbine and the reactor.³⁰

Notes

- ¹ Lindeman, E. 1985. TVA shuts Sequoyah voluntarily for environmental qualification. *Inside NRC*, September 2.
- ² Youngblood, B.J. 1986. TVA's November 1, 1985, response to September 17, 1985 10 CFR 10.54(f) letter. Letter to Steven A. White, manager of nuclear power, Tennessee Valley Authority, January 15. B.J. Youngblood was director of PWR project directorate #4 at the Nuclear Regulatory Commission.
- ³ Ibid.
- ⁴ Ibid.
- ⁵ Ibid.
- ⁶ Nuclear Regulatory Commission (NRC). 1986. *Report to Congress on abnormal occurrences: January–March 1986*. NUREG-0090, Vol. 9, No. 1, September. Washington, DC.
- ⁷ Ibid.
- ⁸ Ibid.
- ⁹ Ibid.
- ¹⁰ Ibid.
- ¹¹ NRC. 1987. *Report to Congress on abnormal occurrences: April–June 1986*. NUREG-0090, Vol. 9, No. 2, January. Washington, DC.
- ¹² Ibid.
- ¹³ Ibid.
- ¹⁴ NRC. 1987. *Report to Congress on abnormal occurrences: Jul –September 1986*. NUREG-0090, Vol. 9, No. 3, April. Washington, DC.
- ¹⁵ Tennessee Valley Authority. 1987. Sequoyah Nuclear Plant steam generator reactor coolant spills of January 28 and February 1, 1987. Nuclear Manager's Review Group Report No. I-87-01-SQN, October 7.
- ¹⁶ Ibid.
- ¹⁷ Kelly, J.L. 1987. Minutes of the September 11, 1987, meeting with the Tennessee Valley Authority. Memorandum, September 15. Janet L. Kelly was project engineer of the Sequoyah restart branch at the Nuclear Regulatory Commission.
- ¹⁸ Stello, Jr., V. 1988. Updated status of staff actions for Tennessee Valley Authority Sequoyah Unit 2 restart. Memorandum to commissioners, Nuclear Regulatory Commission, SECY-88-11, January 13. Victor Stello, Jr. was executive director for operations at the Nuclear Regulatory Commission.
- ¹⁹ Operational Readiness Review Team. 1988. Report of Sequoyah readiness review, January 5. Tennessee Valley Authority: Soddy-Daisy, TN.
- ²⁰ Kelly, 1987.
- ²¹ Beard, Jr., P.M. 1987. Letter to Steven A. White, manager of nuclear power, Tennessee Valley Authority, November 13. P.M. Beard, Jr. was group vice president at the Institute of Nuclear Power Operations. [Normally publicly unavailable, but attached to the January 5, 1988, Operational Readiness Review report that TVA submitted to the NRC.]
- ²² Stello, Jr., 1988.
- ²³ Ibid.
- ²⁴ NRC. 1987. Inappropriate application of commercial-grade components. Information Notice No. 87-66, December 31.

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- ²⁵ Operational Readiness Review Team. 1988. *Sequoyah Nuclear Plant (SQN)—Operational readiness review (ORR): Report of FCF-1-88*, January 5. Tennessee Valley Authority: Soddy-Daisy, TN.
- ²⁶ Chilk, S.J. 1988. Staff requirements: Briefing on status of Sequoyah restart, January 20. Memorandum to Victor Stello, Jr., executive director for operations, Nuclear Regulatory Commission, February 4. Samuel J. Chilk was secretary at the Nuclear Regulatory Commission.
- ²⁷ Chilk, S.J. 1988. Staff requirements: Briefing on the status of Sequoyah 1, August 4. Memorandum to Victor Stello, Jr., executive director for operations, Nuclear Regulatory Commission, August 17. Samuel J. Chilk was secretary at the Nuclear Regulatory Commission.
- ²⁸ Smith, S.J. 1988. November 1988 monthly operating report. Letter to Nuclear Regulatory Commission, December 15. S.J. Smith was plant manager at the Tennessee Valley Authority.
- ²⁹ Ibid.
- ³⁰ Ibid.