

SEQUOYAH UNIT 1

Soddy-Daisy, TN

Owner: Tennessee Valley Authority

Outage dates (duration): March 2, 1993 to April 20, 1994 (1.1 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 Unit 1 on March 2, 1993, because a pipe had broken the day before on Unit 2. TVA inspected all piping sections in locations like the section that failed and found cracking in five of the eight locations. Repairs to the piping were completed by late summer, but system walkdowns identified several other equipment problems that kept Unit 2 shut down until late 1993 and Unit 1 shut down until spring 1994.

Process Changes

The NRC issued Information Notice 93-20 to plant owners in March 1993, alerting them to the fact that TVA had been inspecting the portion of the pipe that failed, but noting that the company's inspection method misdiagnosed crack indications as artifacts of the piping geometry. The agency issued frequent reminders about this problem, as evidenced by Information Notices 2000-17 and 2000-09 about virtually identical occurrences at South Carolina's Virgil C. Summer plant in October 2000 and New York's Indian Point plant in February 2000.

Commentary

This year-plus outage and the concurrent seven-month outage of Unit 2 may have been triggered by a pipe break, but their causes actually trace back to unfinished business from Sequoyah's dual-unit extended outage of the mid-1980s. Granted, nuclear power plants are complex industrial enterprises that cannot be expected to operate trouble-free, but it is not unreasonable to expect a reactor to operate for at least five years trouble-free, and TVA and the NRC failed to meet that expectation at Sequoyah.

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

December 31, 1992: An electrical fault in the switchyard caused a transient that led to automatic trips of both reactors at Sequoyah.¹ The fault occurred when workers tested a recently installed circuit breaker in the 500 kV switchyard. In preparation for this test, workers bypassed all of the primary fault-protective devices for the switchyard. During the test, a 20,000 amp phase-to-ground fault occurred in the breaker that lasted for about 1.5 seconds before being corrected by the non-bypassed secondary fault-protective devices. Voltage on the interconnected 161 kV switchyard dropped about 61 kV during the fault, causing undervoltage to the reactor coolant pumps on both units, which in turn produced automatic reactor trip signals.²

March 1, 1993: Unit 2 was operating at 100 percent power when a worker attached a fuse-pulling device to the fuse for the feedwater regulating valve's trip solenoid. This apparently caused the valve to close, causing a pressure transient. A 10-inch-diameter extraction steam pipe ruptured, allowing steam to envelop an electronics cabinet in the area, which in turn caused a reactor trip signal based on false indications of generator voltage problems.³

March 2, 1993: TVA voluntarily shut down Unit 1 to inspect piping for signs of erosion and corrosion similar to what was believed to have caused the steam pipe rupture the previous day on Unit 2.⁴

March 4, 1993: The NRC issued a Confirmatory Action Letter to TVA specifying tasks that had to be completed before either Sequoyah reactor could be restarted.⁵

March 11, 1993: The NRC regional administrator visited the Sequoyah site.⁶

March 17, 1993: NRC Chairman Ivan Selin visited the Sequoyah site.⁷

March 24, 1993: The NRC issued Information Notice 93-20 to all plant owners informing them of pipe cracking discovered at Sequoyah. The NRC reported that workers had been using augmented piping inspection methods at Sequoyah but that:

*“The augmented inspections using ultrasonic techniques showed indications that might earlier have revealed the cracks, but the licensee misinterpreted these as resulting from the geometric configuration of the pipe. After finding the leak, the licensee performed radiography on all feedwater nozzles of both units and found cracks in five of the eight nozzles.”*⁸

March 24, 1993: The NRC proposed a \$225,000 fine on TVA for three violations at Sequoyah between November 29, 1992, and January 29, 1993.⁹

March 25, 1993: The NRC established a Restart Panel to coordinate efforts by the agency to monitor the completion of required tasks prior to the restart of either reactor at Sequoyah.¹⁰

April 12, 1993: TVA briefed NRC management about its plans to address the items in the Confirmatory Action Letter.¹¹

April 13, 1993: The NRC issued a Restart Action Plan outlining the tasks needed to verify that the items in the Confirmatory Action Letter had been completed prior to restarting either unit at Sequoyah.¹²

May 20, 1993: TVA submitted its Sequoyah Restart Plan to the NRC, detailing the tasks planned “to address specific weaknesses (identified both internally and externally) and to target those areas most critical to overall TVA Generating Group objectives.”¹³

June 15, 1993: The NRC issued Information Notice 93-44 to plant owners informing them of problems experienced with Unit 2 during the dual-unit trip on December 31, 1992. The NRC reported that TVA reduced staffing levels to just three reactor operators, two on Unit 1 and one on Unit 2. When both units faced the same condition—a reactor trip from full power—the single operator on Unit 2 was unable to prevent problems such as excessive cooldown of the reactor coolant system, whereas the two operators on Unit 1 were able to respond appropriately.¹⁴

July 27, 1993: TVA submitted Revision 1 of its Sequoyah Restart Plan to the NRC. The revision added details about system readiness and walkdowns activities, a review of post-restart backlog items, and a power-ascension testing program.¹⁵

August 2, 1993: TVA announced that Unit 2 would remain shut down until fall 1993 and that the restart of Unit 1 had not yet been scheduled. TVA attributed the delay to unexpected problems encountered during recent walkdowns. Some of the findings included leakage in the control air system, loose valve packings, and dirty filters throughout the plant. The findings prompted TVA to ask the NRC to postpone its operations readiness inspection until the new problems could be corrected.¹⁶

August 10, 1993: TVA submitted Revision 2 of its Sequoyah Restart Plan to the NRC. The revision added information about the power-ascension testing program.¹⁷

August 13, 1993: The NRC issued Information Notice 93-65 informing plant owners about electrical breaker testing deficiencies that triggered the dual-unit trip at Sequoyah on December 31, 1992.¹⁸

September 30, 1993: TVA submitted Revision 3 of its Sequoyah Restart Plan to the NRC. The revision incorporated a hold point for NRC approval prior to exceeding a nominal power level of 30 percent.¹⁹

October 18, 1993: The NRC approved the restart of Unit 2.²⁰

October 19, 1993: Operators took the Unit 2 reactor critical.²¹

October 21, 1993: Unit 2 was reconnected to the electrical grid. During the outage that began on March 1, 1993, workers completed 135 modifications to plant equipment and replaced nearly 0.75 mile of piping to resolve concerns about pipe wall thinning from erosion and corrosion.²²

January 25, 1994: TVA submitted Revision 4 of its Sequoyah Restart Plan to NRC. This revision detailed the transition of Unit 1 from the Restart Plan to normal processes.²³

April 12, 1994: The NRC approved the restart of Unit 1.²⁴

April 20, 1994: Unit 1 was connected to the electrical grid, ending its extended outage. During the outage, workers completed more than 120 modifications to plant equipment.²⁵

May 24, 1994: The NRC issued Information Notice 94-36 to plant owners informing them about an event occurring at Sequoyah Unit 1 between September and December 1993. In September, after refueling the reactor core, workers reassembled the reactor vessel and degassed, filled, and vented the reactor coolant system. The reactor vessel level indication system (RVLIS) was functional, but operators were not using it because procedures did not call for it to be used when the reactor was not operating. Instead, the operators relied on water-level indications in the pressurizer.

On December 17, 1993, operators began pressurizing the containment building to 13 pounds per square inch gauge (psig) pressure for an integrated leak-rate test. They observed the pressurizer water level dropping as containment pressure increased, forcing the addition of about 8,300 gallons of water to restore the pressurizer level. On December 20, operators depressurized the containment chamber after the test and observed the pressurizer water level increasing. About 8,300 gallons of water had to be drained to maintain the desired level. After operators vented the reactor vessel head on December 21, they determined that a nitrogen gas bubble had formed inside the reactor vessel due to a lower-than-normal temperature in the volume control tank, which allowed more of the nitrogen cover gas to dissolve in the water. As this water entered the reactor vessel and heated up, the gas came out of solution and formed a growing bubble. Calculations estimated that the actual water level inside the reactor vessel dropped to 5.25 feet above the top of the reactor core. The NRC concluded that TVA missed several opportunities to either avoid this situation or at least identify the problem sooner and shorten its duration.²⁶

November 17, 1994: The NRC issued Information Notice 94-77 to plant owners informing them about the March 1, 1993, pipe rupture at Sequoyah Unit 2.²⁷

Notes

- ¹ Nuclear Regulatory Commission (NRC). 1993a. Operational challenges during a dual-unit transient. Information Notice No. 93-44, June 15.
- ² NRC. 1993b. Reactor trips caused by breaker testing with fault protection bypassed. Information Notice No. 93-65, August 13.
- ³ Murphy, G.A. 1993. Steam line break at Sequoyah Unit 2. *Nuclear Safety* 34(1), January–March.
- ⁴ Dizard III, W. 1993. AIT goes to TVA's Sequoyah to probe steam pipe leak that shut plant. *Inside NRC*, March 8.
- ⁵ Gibson, A.F. Minutes of Sequoyah restart panel meeting, June 14, 1993. Memorandum to Frederick J. Hebdon, director, project directorate II-4; Ellis W. Merschoff, director, reactor projects; and John P. Stohr, director, radiation safety and safeguards, Nuclear Regulatory Commission, June 16. Albert F. Gibson was director of reactor safety at the Nuclear Regulatory Commission.
- ⁶ Ibid.
- ⁷ Ibid.
- ⁸ NRC. 1993b. Thermal fatigue cracking of feedwater piping to steam generators. Information Notice No. 93-20, March 24.
- ⁹ Geisel, A. 1993. New nuclear woes lead to TVA fine: \$225,000. *Knoxville News-Sentinel*, March 25.
- ¹⁰ Gibson, 1993.
- ¹¹ Ibid.
- ¹² Ibid.
- ¹³ Fenech, R.A. 1994. Sequoyah Nuclear Plant (SQN): Restart plan, revision 4. Letter to the Nuclear Regulatory Commission, January 25. Robert A. Fenech was a Tennessee Valley Authority employee.
- ¹⁴ NRC, 1993a.
- ¹⁵ Fenech, 1994.
- ¹⁶ Zuercher, R.R. 1993. Sequoyah lost for the summer as still more problems surface. *Nucleonics Week*, August 5.
- ¹⁷ Fenech, 1994.
- ¹⁸ NRC, 1993c.
- ¹⁹ Fenech, 1994.
- ²⁰ Tennessee Valley Authority. 1993. Sequoyah Unit 2 reconnects to the TVA power system. Press release, October 22.
- ²¹ Ibid.
- ²² Ibid.
- ²³ Fenech, 1994.
- ²⁴ Tinsley, J. 1994. Sequoyah unit generates first power in year. *Knoxville News-Sentinel*, April 21.
- ²⁵ Ibid.
- ²⁶ NRC. 1994. Undetected accumulation of gas in reactor coolant system. Information Notice No. 94-36, May 24.
- ²⁷ NRC. 1994. Malfunction in main generator voltage regulator causing overvoltage at safety-related electrical equipment. Information Notice No. 94-77, November 17.