

BROWNS FERRY UNIT 3

Athens, AL

Owner: Tennessee Valley Authority

Outage dates (duration): March 19, 1985 to November 19, 1995 (10.7 years)

Reactor type: Boiling water reactor

Reactor age when outage began: 8.0 years

Commercial operations began: March 1, 1977

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

Synopsis

The Tennessee Valley Authority (TVA) shut down Unit 3 in September 1983 per NRC order to inspect recirculation system piping. Repairs to cracking identified by the inspections kept Unit 3 out of service until November 1984. During restart, the instrumentation monitoring the water level above the reactor core malfunctioned, forcing the reactor to be shut down. TVA restarted the reactor without fixing the root cause of the instrumentation problem. The instrumentation malfunctioned again during a startup in February 1985. TVA manually shut down Unit 3 on March 9, 1985, to investigate the root cause of the water level instrumentation problems. On March 18, 1985, TVA announced that it was suspending operation of all three Browns Ferry reactors until programmatic weaknesses were corrected.

Deficiencies caused by the programmatic weaknesses continued to surface. In 1985, cable tray supports were found to be poorly designed, the emergency diesel generators were found to be poorly maintained, and the control room operators were found to be poorly trained. In 1986, the senior managers brought in to lead the restart effort were found to violate ethical standards and recirculation system piping was found to be cracked and in need of replacement. In 1987, 28 percent of key personnel were found to be unqualified for their duties. In 1988 and again in 1989, Browns Ferry was found to be in non-compliance with fire protection regulations adopted after the 1975 Browns Ferry fire. Consequently, Unit 3 did not restart until November 1995 with a price tag estimated to be nearly \$1.4 billion (\$1.83 billion in 2006 dollars).

Process Changes

Browns Ferry Unit 3 was but one of several reactors experiencing year-plus outages in the 1985 to 1990 time frame. Fort St. Vrain, Browns Ferry Units 1 and 2, Davis-Besse, Sequoyah Units 1 and 2, Rancho Seco, Pilgrim, Peach Bottom Units 2 and 3, Nine Mile Point Unit 1, and Surry Unit 2 all had year-plus outages in this period. Changes, such as the adoption of the senior management meeting process by the NRC, resulted from the collective experience more than from any single outage.

Commentary

Browns Ferry Unit 3 was the second U.S. reactor to experience two year-plus outages. Its sister reactor, Browns Ferry Unit 2, was the first and its other sister reactor, Browns Ferry Unit 1, became the third just 10 days later.

This second extended outage for Browns Ferry Unit 3 demonstrated the pitfalls of evaluating processes rather than outcomes. In its systematic assessment of licensee performance (SALP) issued in June 1984, the NRC reported that TVA had a “lack of management attention to the identification of the root cause of problems” and a “lack of an effective quality assurance program.” Neither conclusion should have shocked TVA or the NRC—the NRC gave TVA its lowest possible SALP rating for quality assurance for *every* period to date. In September 1984, TVA’s Nuclear Safety Review Staff (NSRS), an internal watchdog group, reported that managers in the quality assurance department at Browns Ferry felt “plant management would allow quality and nuclear safety to deteriorate significantly in favor of production.” Yet, on October 9, 1984, the NRC informed TVA that its quality assurance program met the requirements in Appendix B to Title 10 of the Code of Federal Regulations (10 CFR) Part 50.

On paper, *maybe* it did. In reality, it wasn’t even close to meeting the requirements. For example, the NSRS also identified that engineers at Browns Ferry felt the high pressure coolant injection (HPCI) system—a vital emergency system—was so unreliable that they were afraid to test it for fear of breaking it. Both TVA and the NRC dismissed their concerns because the paperwork showed that the HPCI was being tested and was passing those tests. That is, until the very next test. After TVA restarted Browns Ferry Unit 3 in November 1984 to end its first year-plus outage, operators had to shut it back down because—lo and behold—the HPCI system failed its test.

Perhaps the NRC missed this warning sign due to the glare and blare from all the other warning signs. For example, operators also had to shut down Unit 3 in November 1984 after the indicated reactor vessel water level dropped below the setpoint where the reactor should have automatically shut down, but nothing happened. TVA restarted Unit 3 without correcting the problem. It surfaced again in February 1985, but TVA still restarted Unit 3 without correcting the problem. TVA manually shut down Unit 3 on March 9, 1985, to finally investigate the cause of, and attempt a fix to, the reactor vessel level instrumentation problems.

Browns Ferry Unit 3 was voluntarily shut down by TVA just 101 days after it had restarted from a year-plus outage. These back-to-back outages reflect a regulatory bias first identified by the various inquiries into the Three Mile Island Unit 2 accident and still not exorcised. The Presidential Commission looking into the NRC’s role in the Three Mile Island accident concluded:

“A comprehensive system is required in which equipment and human beings are treated with equal importance.”¹

In 1983, equipment problems—namely, potential cracking of recirculation system piping—prompted the NRC to issue an order requiring TVA to shut down Browns Ferry Unit 3. As strongly suspected, the recirculation system piping was seriously degraded and its repair took more than a year. When serious human performance problems occurred again and again following restart from this extended outage, the NRC merely and meekly monitored. It simply did not treat human beings and their failings with the same importance afforded equipment and its failings. In other words, a prudent and capable regulator would not have allowed TVA to restart Browns Ferry Unit 3 in 1984 until both the equipment and human performance problems were remedied. Back-to-back extended outages, first to repair equipment repairs and then to address human performance problems, would have been avoided by a comprehensive system treating equipment and human performance problems equally.

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
1/1981	2	3	2	2	2	2	2	2	3	n/a	n/a
11/1982	3	3	2	2	n/a	3	2	2	3	n/a	n/a
6/1983	3	3	3	2	2	2	3	1	3	2	n/a
6/1984	3	3	3	2	2	n/a	3	3	3	2	n/a
9/1985	3	2	3	3	2	3	3	n/a	3	3	2
	Operations	Radiological Controls	Maintenance/Surveillance Testing		Emergency Preparedness		Security	Engineering and Technology		Safety Assessment and Quality Verification	
6/1990	2	1	3		2		2	2		3	
	Operations		Maintenance		Engineering			Plant Support			
8/1990	2		3		2			1/2/2			
9/1992	1		2		2			1/1/2			
11/1993	1		2		2			1			
4/1995	2		2		2			1			

NOTE: A rating of 1 designated a superior level of performance where NRC attention may be reduced. A 2 rating designated a good level of performance with NRC attention at normal levels. A rating of 3 designated an acceptable level of performance where increased NRC attention may be appropriate.

Details

May 4, 1984: TVA submitted its plans for improving performance at Browns Ferry to the NRC.²

June 1984: The NRC's SALP reported that TVA provided a "lack of management attention to the identification of the root cause of problems" and had a "lack of an effective quality assurance program."³

July 13, 1984: The NRC issued Confirmatory Order EA 84-54 to TVA requiring it to implement the promised improvement steps and mandating progress reports be provided to the NRC.⁴

September 14, 1984: TVA submitted a revision to its Regulatory Performance Improvement Program (RPIP) to the NRC. It was RPIP Revision 12.⁵

September 24, 1984: TVA's NSRS released a report that included results from a survey of engineers at Browns Ferry showing that they do not believe management is serious about a program to improve compliance with NRC regulations and believe that once the NRC is placated, management will revert to "the old way of doing business." The NSRS report additionally indicated that Quality Assurance department managers "believe plant management would allow quality and nuclear safety to deteriorate significantly in favor of production." And the NSRS reported that engineers believe the HPCI system—a vital safety system—is so unreliable they are afraid to test it because it might break.⁶

October 9, 1984: The NRC sent a letter to TVA reporting that it had reviewed the quality assurance program document against the requirements of Appendix B to 10 CFR Part 50 and found it acceptable.⁷

October 22, 1984: During a shutdown margin test for the reactor core during startup, numerous and serious departures from operating procedures caused the unit to be shut down.⁸

October 25, 1984: The NRC issued a confirmatory action letter detailing actions the TVA committed to complete prior to restarting Unit 3 following the October 22 event.⁹

November 7, 1984: TVA met with the NRC in the agency's Region II offices to discuss corrective actions for the October 22 startup problems.¹⁰

November 16, 1984: The NRC sent TVA a letter concurring that Unit 3 is ready to restart.¹¹

November 19, 1984: The reactor was restarted.¹²

November 20, 1984: Operators manually shut down the reactor from four percent power when the indicated water level inside the reactor vessel dropped below the setpoint for an automatic reactor scram, but the automatic safety feature did not engage.¹³

November 22, 1984: The reactor was restarted.¹⁴

November 23, 1984: Operators manually shut down the reactor after the flow control valve on the HPCI system was found to be broken.¹⁵

November 24, 1984: The reactor was restarted.¹⁶

November 28, 1984: The unit was connected to the electrical grid to end the extended outage.¹⁷

November 28, 1984: The generator was taken offline due to excessive turbine vibrations.¹⁸

November 29, 1984: The unit was connected to the electrical grid.¹⁹

November 29, 1984: The generator was taken offline due to excessive turbine vibrations.²⁰

November 30, 1984: Operators manually shut down the reactor to allow work to correct the vibrations.²¹

November 30, 1984: The reactor was restarted.²²

December 1, 1984: The unit was connected to the electrical grid.²³

December 9, 1984: Operators manually scrammed the reactor from 36 percent power after an in-plant electrical transient tripped a condensate pump and the backups could not be started from the control room because local switches had been left in the wrong positions.²⁴

December 18, 1984: The reactor was restarted.²⁵

December 19, 1984: The unit was connected to the electrical grid.²⁶

February 13, 1985: During another reactor startup, three instruments monitoring the water level in the reactor vessel indicated significantly different levels. Rather than pausing to correct the disparate indications, the operators focused on increasing the power level even after the water level indications caused a half-scram. Similar disparate water level indications had also been experienced on November 20, 1984, but nothing had been done to correct the problem or even train operators on how to properly respond to it.²⁷

February 27, 1985: The NRC proposed a \$112,500 fine on TVA for violations stemming from the October 22, 1984, aborted startup.²⁸

March 9, 1985: Operators manually shut down the reactor to allow reactor vessel water level instrumentation problems to be investigated.²⁹

March 19, 1985: TVA ceased operations at all three Browns Ferry units to focus on making programmatic improvements.³⁰

July 22, 1985: The NRC proposed a \$150,000 fine on TVA for violations resulting from the February 13, 1985, startup.³¹

September 17, 1985: The NRC's executive director for operations sent TVA a letter stating that the RPIP had been ineffective and required TVA to try again with another plan.³²

September 24, 1985: TVA declared all eight emergency diesel generators at Browns Ferry inoperable for two separate reasons. First, the emergency diesel generators had been in service for up to 13 years, but TVA had not performed maintenance inspections at 3, 6, and 12 years as recommended by the manufacturer. Second, the racks holding the batteries that enable the emergency diesel generators to start in event of a loss of offsite power had not been designed to survive earthquakes, even the modest earthquakes occurring in this portion of the country. The NRC resident inspector had identified the failure to properly maintain the emergency diesel generators and the NRC issued a violation on July 16, 1984, about it. TVA promised the NRC at the time to correct the situation by October 5, 1984, but failed to do so.³³

November 1, 1985: TVA responded to the NRC's 50.54(f) letter of September 17 with its plan to improve performance at Browns Ferry.³⁴

November 7, 1985: TVA transmitted a design control study performed by Gilbert Commonwealth along with detailed actions to be taken by TVA to rectify the identified problems.³⁵

November 1985: Unsatisfactory performance by Browns Ferry operators on NRC-administered re-qualification examinations prompted TVA to retrain its operating staff.³⁶

January 7, 1986: The NRC staff briefed its commissioners on major issues requiring resolution prior to restarting the Browns Ferry units.³⁷

January 9, 1986: TVA briefed the NRC commissioners on its plans to address the major issues requiring resolution prior to restarting its nuclear units and noted the appointment of Steven White as the new manager of nuclear power.³⁸

January 17, 1986: The TVA Nuclear Safety Review Staff was renamed the Nuclear Manager's Review Group and transferred from reporting directly to the TVA board of directors to the TVA manager of nuclear power.³⁹

February 7, 1986: The NRC staff briefed its commissioners on major issues requiring resolution prior to restarting the Browns Ferry units.⁴⁰

February 12, 1986: A consultant was hired to recommend the future mission for the Nuclear Manager's Review Group.⁴¹

March 10, 1986: TVA submitted a revised response to the NRC's September 17, 1985, 50.54(f) letter regarding its performance improvement plans.⁴²

March 11, 1986: The NRC staff briefed its commissioners on major issues requiring resolution prior to restarting the Browns Ferry units.⁴³

March 27, 1986: The consultant examining the Nuclear Manager's Review Group reported that the group felt neither TVA's senior management nor line organizations at the nuclear sites had properly responded to past findings and recommendations.⁴⁴

June 2, 1986: The General Accounting Office (GAO) concluded that TVA's employment arrangement with Steven White "constitute an improper use of a personal services contract and represented a circumvention of the statutory ceiling on salary payments to TVA employees." Mr. White took a leave of absence pending resolution of unrelated conflict-of-interest issues raised by the United States Office of Government Ethics.⁴⁵

July 17, 1986: TVA submitted Revision 2 to its corporate nuclear performance plan to the NRC.⁴⁶

September 1986: TVA suspended essentially all plant modification activities pending a completion of walk-downs and related efforts to verify that design drawings reflect the as-built plant configuration.⁴⁷

September 8, 1986: The NRC proposed a \$150,000 fine for three violations: (1) cable tray support design problems, (2) cable tray overfilling problems, and (3) cable environmental qualification problems. TVA did not contest the fine.⁴⁸

August 12, 1986: The NRC's Advisory Committee on Reactor Safeguards wrote to the NRC commissioners with its agreement on TVA's diagnosis of management problems.⁴⁹

December 16, 1986: NRC staff and TVA officials briefed the NRC commissioners on recovery efforts. NRC Regional Administrator J. Nelson Grace reported the results from a recent survey of TVA's nuclear workers that "up to 75% lacked confidence in TVA management." NRC staff outlined preliminary results from its own lessons learned. Among the lessons were the need to improve identification of poor performance, the need to involve utility management early in solving problems, and the need to improve long-term monitoring of utility corrective action programs.⁵⁰

March 1987: After being unable to use results from pipe hanger support analyses performed by Stone & Webster Engineering Corporation (SWEC) under a 30-month, \$63.4 million contract because SWEC used unacceptable criteria, TVA awarded a 30-month, \$94.9 million contract to Bechtel to re-analyze the piping supports. The TVA manager responsible for the pipe hanger support effort left SWEC to join TVA two months before TVA awarded the contract to SWEC.⁵¹

May 1987: The TVA Inspector General (IG) released a report on its review of 100 employees in the TVA nuclear program "in key positions that could significantly affect nuclear plant safety or efficiency." The IG concluded that 28 of the 100 did not satisfy the requirements needed for the positions and that "four provided false information regarding their qualifications."⁵²

August 1987: The GAO reported to Congress, "GAO notes that while NRC has shut five operating plants over the past 25 years, its decisions to close these plants or allow continued operations look inconsistent because it did not take the same action for other plants with similar problems."⁵³

May 9, 1988: The NRC requested that TVA provide it with a list of deviations from the National Fire Protection Association (NFPA) code at Browns Ferry.⁵⁴

August 3, 1988: TVA informed the NRC that "The [fire protection] system does not fully comply with the requirements of NFPA 13, 1975 Edition, which is the code of record, or with the 1985 edition of the code, which was the basis for the evaluation." TVA committed to making additional modifications to meet the "critical" requirements of NFPA 13.⁵⁵

January 1989: Fuel was reloaded into the Unit 2 reactor core in preparation for restart.

May 4, 1989: The GAO reported that the NRC had conducted five SALPs at Browns Ferry between 1980 and 1986 and issued one Category 1 rating, 21 Category 2 ratings, and 24 Category 3 ratings—far worse ratings than issued to other boiling water reactors (BWRs) over the same period. Peach Bottom, which the NRC ordered shut down in March 1987, had seven SALPs over this same period and got 11 Category 1 ratings, 40 Category 2 ratings, and 13 Category 3 ratings. The ratings for BWRs during this period are as follows:⁵⁶

Plant	SALP 1	SALP 2	SALP 3	SALP Average
Vermont Yankee	67.4%	32.6%	0.0%	1.3
Monticello	50.9%	45.6%	3.5%	1.5
Cooper	42.4%	52.5%	5.1%	1.6
Quad Cities	36.2%	55.3%	8.5%	1.7
FitzPatrick	21.8%	65.5%	12.7%	1.9
Dresden	23.3%	58.3%	18.3%	2.0
Hatch	12.7%	78.2%	9.1%	2.0
Peach Bottom	17.2%	62.5%	20.3%	2.0
Pilgrim	23.1%	50.0%	28.9%	2.0
Brunswick	14.9%	57.4%	27.7%	2.1
Browns Ferry	2.2%	45.7%	52.2%	2.5

September 18, 1990: TVA informed the NRC that all actions on its RPIP had been completed and asked the NRC to close Confirmatory Order EA 84-54.⁵⁷

January 8, 1991: The NRC issued an inspection report documenting its determination that the TVA had completed all actions on its RPIP.⁵⁸

November 19, 1995: The unit restarted to end its extended outage. TVA estimated the cost of the outage at \$1.4 billion⁵⁹ (\$1.83 billion in 2006 dollars⁶⁰).

Notes

- ¹ Meserve, R.A. 2002. Safety culture: An NRC perspective. Speech delivered at the Institute for Nuclear Power Operations Chief Executive Officer conference, November 8. Richard A. Meserve was chairman of the Nuclear Regulatory Commission (NRC).
- ² General Accounting Office (GAO). 1996. Nuclear regulation: Oversight of quality assurance at nuclear power plants needs improvement, GAO/RCRD-96-41. Washington, DC. January.
- ³ Ibid.
- ⁴ Varga, S.A. 1991. Closure of confirmatory order EA 84-54 – Browns Ferry Nuclear Plant, units 1, 2 and 3. Letter to Dan A. Nauman, senior vice president, nuclear power, Tennessee Valley Authority, June 12. Steven A. Varga was director, reactor projects at the NRC.
- ⁵ O'Reilly, J.P. 1984. Regulatory performance improvement program (RPIP) for Browns Ferry. Letter to Hugh G. Parris, manager of power and engineering, Tennessee Valley Authority, October 9. James P. O'Reilly was regional administrator at the NRC.
- ⁶ Gentry, P. 1984. Browns Ferry safety system said unreliable. *Decatur Daily*, September 25.
- ⁷ Lewis, R.C. 1984. TVA quality assurance program. Letter to Hugh G. Parris, manager of power, Tennessee Valley Authority, October 12. Richard C. Lewis was director, reactor projects at the NRC.
- ⁸ O'Reilly, J.P. 1984. Confirmation of action – Browns Ferry Unit Nos. 50-259, 50-260 and 50-296. Letter to Hugh G. Parris, manager of power, Tennessee Valley Authority, October 25. James P. O'Reilly was regional administrator at the NRC.
- ⁹ Ibid.
- ¹⁰ *Nucleonics Week*. 1984. Browns Ferry-3 Startup Delayed While NRC Reviews TVA Procedures, November 15.
- ¹¹ O'Reilly, J.P. 1984. Confirmation of concurrence – Browns Ferry Unit 1, 2 and 3 docket nos. 50-259, 50-260 and 50-296. Letter to Hugh G. Parris, manager of power, Tennessee Valley Authority, November 16. James P. O'Reilly was regional administrator at the NRC.
- ¹² Browns Ferry Nuclear Plant. 1984a. *Monthly Operating Report to NRC: November 1, 1984 – November 30, 1984*. Knoxville, TN: Tennessee Valley Authority.
- ¹³ Jones, G.T. 1984. Tennessee Valley – Browns Ferry Nuclear Plant (BFN) Unit 3 – docket no. 50-296 – facility operating license DPR-68 – reportable occurrence report BFRO-50-296/84012. Letter to the NRC, December 20. George T. Jones was plant manager at Browns Ferry Nuclear Plant.
- ¹⁴ Browns Ferry Nuclear Plant, 1984a.
- ¹⁵ Ibid.
- ¹⁶ Ibid.
- ¹⁷ Ibid.
- ¹⁸ Ibid.
- ¹⁹ Ibid.
- ²⁰ Ibid.
- ²¹ Ibid.
- ²² Ibid.

- ²³ Browns Ferry Nuclear Plant, 1984b. *Monthly Operating Report to NRC: December 1, 1984 – December 31, 1984*. Knoxville, TN: Tennessee Valley Authority.
- ²⁴ Ibid.
- ²⁵ Ibid.
- ²⁶ Ibid.
- ²⁷ NRC. 1986a. Report to Congress on abnormal occurrences, NUREG-0090, Vol. 8, No. 3. Washington, DC. February.
- ²⁸ Ibid.
- ²⁹ Hudgins, C. 1985. TVA shuts Browns Ferry to get control of operations and modifications. *Nucleonics Week* 26(14): 1.
- ³⁰ GAO. 1987. Nuclear regulation: efforts to ensure nuclear power plant safety can be strengthened, GAO/RCED-87-141. Washington, DC. August.
- ³¹ NRC 1986a.
- ³² Varga, 1991.
- ³³ NRC, 1986a.
- ³⁴ Youngblood, B.L. 1986. TVA's November 1, 1985, response to September 17, 1985 10 CFR 50.54(f) letter. Letter to Steven A. White, manager of nuclear power, Tennessee Valley Authority. January 15. B.L. Youngblood was director, PWR projects directorate #4 at the NRC.
- ³⁵ Ibid.
- ³⁶ NRC. 1987. Report to Congress on abnormal occurrences, NUREG-0090, Vol. 9, No. 2. Washington, DC. January.
- ³⁷ NRC. 1986b. Report to Congress on abnormal occurrences, NUREG-0090, Vol. 9, No. 1. Washington, DC. September.
- ³⁸ Ibid.
- ³⁹ GAO. 1986. *TVA nuclear power: Management of the nuclear program through personal services contracts*, GAO/RCED/87-43BR. Washington, DC. October.
- ⁴⁰ NRC, 1986b.
- ⁴¹ GAO, 1986.
- ⁴² NRC, 1986b.
- ⁴³ Ibid.
- ⁴⁴ GAO, 1986.
- ⁴⁵ Ibid.
- ⁴⁶ NRC. 1987. Report to Congress on abnormal occurrences, NUREG-0090, Vol. 9, No. 3. Washington, DC. April.
- ⁴⁷ Ibid.
- ⁴⁸ Ibid.
- ⁴⁹ Ibid.
- ⁵⁰ Wagner, M.L. 1986. Denton says jury is still out on TVA's ability to solve problems. *Inside NRC*, December 22.
- ⁵¹ Lindeman, E. 1989. With millions of dollars spent, TVA must rework pipe analysis. *Nucleonics Week*, June 8.
- ⁵² Ibid.
- ⁵³ GAO, 1987.

-
- ⁵⁴ Gridley, R. 1988. Letter to the NRC, August 3. R. Gridley was director, nuclear licensing and regulatory affairs at the Tennessee Valley Authority.
- ⁵⁵ Ibid.
- ⁵⁶ GAO. 1989. Nuclear regulation: NRC's restart actions appear reasonable – but criteria needed, GAO/RCED-89-95. Washington, DC. May.
- ⁵⁷ Varga, 1991.
- ⁵⁸ Ibid.
- ⁵⁹ Dizard III, W. 1995. NRC clears Browns Ferry-3 for full power operation. *Nucleonics Week*, December 7.
- ⁶⁰ Bureau of Labor Statistics. 2006. Inflation calculator. Washington, DC: U.S. Department of Labor. Online at <http://data.bls.gov/cgi-bin/cpicalc.pl>.