Browns Ferry Unit 2

Athens, AL

Owner: Tennessee Valley Authority

Outage dates (duration): September 15, 1984 to May 24, 1991 (6.7 years)

Reactor type: Boiling water reactor

Reactor age when outage began: 9.5 years

Commercial operations began: March 1, 1975

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

Synopsis

The Tennessee Valley Authority (TVA) shut down Unit 2 on September 15, 1984, for a scheduled refueling outage. The day before, TVA provided the NRC with an update (Revision 12) to its Regulatory Performance Improvement Program (RPIP). In July 1984, the NRC had issued an order requiring TVA to implement the RPIP and provide periodic status reports. The RPIP sought to correct programmatic weaknesses that caused the NRC to fine TVA an average of over $100,000 annually between 1981 and 1984 for safety regulation violations at Browns Ferry. While Unit 2 was refueling, Unit 3 had serious events in October 1984 and February 1985 that led to TVA's decision announced on March 19, 1985, to keep all three units at Browns Ferry shut down until the programmatic weaknesses were addressed.

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 2 did not restart until May 1991 with a price tag estimated to be nearly $1.3 billion ($1.9 billion in 2006 dollars).

Process Changes

Browns Ferry Unit 2 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 3, 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 2 was the first U.S. reactor to experience two year-plus outages. Unit 2 had been shut down from March 22, 1975, until September 10, 1976, as a result of the damage caused by a serious fire in the cable spreading room. It is unbelievable that this second Browns Ferry Unit 2 outage would be extended in 1988 and again in 1989 by failure to comply with the fire protection requirements imposed as a result of this 1975 fire. Having been burned once, how could the NRC possible justify not knowing—again—that Browns Ferry Unit 2 was operating in non-compliance with fire protection requirements? It was totally unacceptable regulatory performance for the NRC to let this happen.

That the NRC was an inconsistent regulator was evident in the agency ordering the two Peach Bottom units to be shut down in March 1987 after operators were discovered sleeping in the control room. Browns Ferry had a worse NRC report card than Peach Bottom and far more serious signs of trouble than napping operators—not to suggest that sleeping operators can be tolerated—but the NRC did not order any of the Browns Ferry units to be shut down. Operators at Browns Ferry failed their NRC-administered re-qualification exams a year *after* Unit 2 shut down. An awake, poorly trained operator would not likely protect public health and safety better than a sleeping operator.

Nor could it have been reasonably argued that the Peach Bottom order demonstrated that the NRC learned from Browns Ferry the need to act more aggressively. That notion was dispelled by the NRC's documenting performance at Hatch, Pilgrim, and Brunswick as bad as or worse than at Peach Bottom yet not ordering any of those reactors shut down. The NRC's actions, and inactions, appeared nearly random.

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 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

January 24, 1984: The Browns Ferry plant manager wrote to the TVA manager of power calling for substantive changes. He wrote:

> *"We all feel that some positive, immediate action is required in order to elevate Browns Ferry's regulatory performance to the level consistent with the division policy of complete compliance.… In the past, we have established management control consisting of paper programs that address all possible deficiencies and provide for reviews of that paper by higher level personnel. As deficiencies have been identified, we have provided for more review at higher levels. We have created such a perfect paper program for assuring compliance that it cannot be implemented by the workers."* [1]

February 24, 1984: The NRC conducted its 13th enforcement conference since January 1983 with TVA regarding violations at Browns Ferry. Between 1981 and 1984, NRC inspectors identified 652 violations at Browns Ferry and the agency imposed $413,000 in fines.[2]

May 4, 1984: TVA submitted its plans for improving performance at Browns Ferry to the NRC.[3]

June 1984: The NRC's SALP reported that TVA provided "lack of management attention to the identification of the root cause of problems" and had a "lack of an effective quality assurance program."[4]

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.[5]

September 14, 1984: TVA submitted a revision to its RPIP to NRC. It was RPIP Revision 12.[6]

September 15, 1984: Unit 2 was manually shut down to enter its fifth refueling outage.[7]

September 24, 1984: TVA released a report by its Nuclear Safety Review Staff (NSRS) 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 high pressure coolant injection system—a vital safety system—is so unreliable they are afraid to test it because it might break.[8]

March 18, 1985: TVA ceased operations at all three Browns Ferry units to focus on making programmatic improvements.[9]

August 16, 1985: Inspections found major discrepancies existed in the design of cable tray supports on all three Browns Ferry units. Cable tray supports in the control bay were not designed to survive earthquakes, even the modest earthquakes occurring in that portion of the country. Cable tray supports in the diesel generator buildings improperly used the load factors from the reactor building seismic analysis. Cable tray support calculations for the reactor building lacked thoroughness, clarity, and accuracy. NRC inspectors further determined that the NRC knew about some of these problems as early as February 1981 but had done little to correct them.[10]

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 develop and submit another plan for improving conditions at its nuclear plants.[11]

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 for seismic loads. 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. TVA promised the NRC at the time to correct the situation by October 5, 1984, but failed to do so.[12]

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.[13]

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.[14]

November 1985: Unsatisfactory performance by Browns Ferry operators on NRC-administered re-qualification examinations prompted TVA to retrain its operating staff.[15]

January 7, 1986: The NRC staff briefed its commissioners on major issues requiring resolution prior to restarting the Browns Ferry units.[16]

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.[17]

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.[18]

February 7, 1986: The NRC staff briefed its commissioners on major issues requiring resolution prior to restarting the Browns Ferry units.[19]

February 12, 1986: A consultant was hired to recommend the future mission for the Nuclear Manager's Review Group.[20]

March 10, 1986: TVA submitted a revised response to the NRC's September 17, 1985, 50.54(f) letter regarding its performance improvement plans.[21]

March 11, 1986: The NRC staff briefed its commissioners on major issues requiring resolution prior to restarting the Browns Ferry units.[22]

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 reactor sites had properly responded to past findings and recommendations.[23]

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.[24]

July 17, 1986: TVA submitted Revision 2 to its corporate nuclear performance plan to the NRC.[25]

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.[26]

September 1986: Inspections for intergranular stress corrosion cracking per NRC Generic Letter 84-11 identified numerous cracks that led TVA to replace portions of the piping in the reactor recirculation system.[27]

September 8, 1986: 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.[28]

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.[29]

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 power plant workers that "up to 75% lacked confidence in TVA management." The NRC staff outlined preliminary results from its own lessons learned efforts. Among the lessons: 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.[30]

March 1987: After being able 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 try again. The TVA manager responsible for the pipe hanger support effort left SWEC to join TVA two months before TVA awarded the contract to SWEC.[31]

May 1987: The TVA Inspector General (IG) released a report on their 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."[32]

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."* [33]

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.[34]

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.[35]

January 1989: Fuel was reloaded into the Unit 2 reactor core in preparations 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:[36]

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

July 19, 1989: NRC staff and TVA officials briefed the NRC commissioners on the status of the Unit 2 restart efforts.[37]

December 1989: TVA decided to off-load fuel from the Unit 2 reactor core to facilitate extensive cable replacement efforts. In November 1989, TVA identified about 275 electrical cables in various safety systems without any documentation that permitted verification that they meet environmental qualification criteria.[38]

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.[39]

January 8, 1991: The NRC issued an inspection report documenting its determination that the TVA had completed all actions on its RPIP.[40]

April 23, 1991: NRC staff and TVA officials briefed the NRC commissioners on the status of the Unit 2 restart efforts.[41]

May 2, 1991: The NRC commissioners approved the restart of Unit 2.[42]

May 24, 1991: Reactor achieved criticality to terminate extended outage. TVA estimated the cost of more than 1,000 improvements during the outage as $1.3 billion[43] ($1.9 billion in 2006 dollars[44]).

Notes

[1] General Accounting Office (GAO). 1996. *Nuclear regulation: Oversight of quality assurance at nuclear power plants needs improvement*, GAO/RCRD-96-41. Washington, DC. January.
[2] Ibid.
[3] Ibid.
[4] Ibid.
[5] 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 Nuclear Regulatory Commission (NRC).
[6] 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.
[7] Jones, G.T. 1984. Letter to the NRC, October 11. George T. Jones was plant manager at the Browns Ferry Nuclear Plant.
[8] Gentry, P. 1984. Browns Ferry safety system said unreliable. *Decatur Daily.* September 25.
[9] GAO. 1987. *Nuclear regulation: efforts to ensure nuclear power plant safety can be strengthened*, GAO/RCED-87-141. Washington, DC. August.
[10] NRC. 1986a. *Report to Congress on abnormal occurrences*, NUREG-0090, Vol. 8, No. 3. Washington, DC. February.
[11] Varga, 1991.
[12] NRC, 1986a.
[13] 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 Nuclear Regulatory Commission.
[14] Ibid.
[15] NRC. 1987. *Report to Congress on abnormal occurrences*, NUREG-0090, Vol. 9, No. 2. Washington, DC. January.
[16] NRC. 1986b. *Report to Congress on abnormal occurrences*, NUREG-0090, Vol. 9, No. 1. Washington, DC. September.
[17] Ibid.
[18] GAO. 1986. *TVA nuclear power: Management of the nuclear program through personal services contracts*, GAO/RCED/87-43BR. Washington, DC. October.
[19] NRC, 1986b.
[20] GAO, 1986.
[21] NRC, 1986b.
[22] Ibid.
[23] GAO, 1986.
[24] Ibid.
[25] NRC. 1987. *Report to Congress on abnormal occurrences*, NUREG-0090, Vol. 9, No. 3. Washington, DC. April.

[26] Ibid.
[27] Ibid.
[28] Ibid.
[29] Ibid.
[30] Wagner, M. L. 1986. Denton says jury is still out on TVA's ability to solve problems. *Inside NRC,* December 22.
[31] Lindeman, E. 1989a. With millions of dollars spent, TVA must rework pipe analysis. *Nucleonics Week,* June 8.
[32] Ibid.
[33] GAO, 1987.
[34] Gridley, R. 1988. Letter to the Nuclear Regulatory Commission, August 3. R. Gridley was director, nuclear licensing and regulatory affairs at the Tennessee Valley Authority.
[35] Ibid.
[36] GAO. 1989. *Nuclear regulation: NRC's restart actions appear reasonable – but criteria needed*, GAO/RCED-89-95. Washington, DC. May.
[37] Chilk, S.J. 1989. Staff Requirements – Briefing on Status of Browns Ferry-2. Memo to files, July 28. Samuel J. Chilik was secretary at the NRC.
[38] Lindeman, E. 1989b. TVA to defuel Browns Ferry-2 to aid cable replacement. *Nucleonics Week,* December 21.
[39] Varga, 1991.
[40] Ibid.
[41] Chilk, S.J. 1991. Staff requirements – discussion/possible vote on Browns Ferry Unit 2 restart. Memo to files, May 10. Samuel J. Chilk was secretary at the Nuclear Regulatory Commission.
[42] Schneider, K. 1991. Industry gets a life as agency approves restarting a reactor. *New York Times,* May 3.
[43] Associated Press. 1991. After 6-year shutdown, reactor begins warmup. May 25.
[44] Bureau of Labor Statistics. 2006. Inflation calculator. Washington, DC: U.S. Department of Labor. Online at *http://data.bls.gov/cgi-bin/cpicalc.pl.*