

# SURRY UNIT 2

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*Surry, VA*

**Owner:** Virginia Electric Power Company

**Outage dates (duration):** February 4, 1979 to August 19, 1980 (1.5 years)

**Reactor type:** Pressurized water reactor

**Reactor age when outage began:** 5.8 years

**Commercial operations began:** May 1, 1973

**Fleet status:** Second oldest of three reactors owned by the company

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## Synopsis

Virginia Electric Power Company (VEPCO) voluntarily shut down Unit 2 on February 4, 1979, to replace the tube bundles in the steam generators. Tube degradation had been abundantly evident for at least four years prior to the outage. Steps undertaken to limit the tube degradation rate proved futile, so replacement of the original tubes with tubes made from a more resistant material became the better option. VEPCO restarted Unit 2 on August 19, 1980, with three repaired steam generators.

## Process Changes

Steam generator tube integrity was a concern of both the nuclear power industry and the NRC prior to this outage and it remains an unresolved issue to this day. As this was the first time a commercial U.S. nuclear power plant had undertaken the replacement of steam generator tubes, it took longer and entailed more radiation exposure to workers than subsequent replacements.

## Commentary

Unlike the majority of extended outages, the year-plus length of this outage represented the time needed to conduct a complex activity for the very first time (rather than the depth below acceptable safety levels to which performance had fallen).<sup>\*</sup> For about four years prior to this outage, VEPCO and the NRC clearly struggled to cope with an unanticipated problem. Following a significant tube leak in September 1976, the NRC adopted a very conservative regulatory posture by allowing Unit 2 to only operate for two, and then six, months between steam generator inspections. The frequency of shutdowns for inspections and their results obviously played a key role in VEPCO's decision to replace the steam generator tubes instead of sustaining an ineffective "band-aid" tactic. Thus, the NRC's reaction to the situation at Unit 2 was appropriately timely and thorough.

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<sup>\*</sup>There was no evidence uncovered suggesting that the accident at Pennsylvania's Three Mile Island Unit 2 in March 1979 extended the Surry Unit 2 outage, although it certainly didn't hasten the restart.

However, the NRC could have, and perhaps should have, done more to have prevented this potentially unsafe and definitely uneconomical situation. Unit 2 only operated for about two years before significant steam generator tube degradation became apparent. The materials from which the original steam generator tubes were constructed were very poor matches for the operating conditions to which they were subjected. The steam generator tubes were the only parts of the entire plant that function both as part of the reactor coolant boundary and also as part of the containment boundary. Their integrity was expected to match the 40-year lifetime of the plant, yet they barely lasted six years. Rather than conduct a materials experiment at Surry Unit 2 and other production reactor sites across the United States, the NRC could have required more prototype testing to confirm, rather than hope, the right materials were being used.

### 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
12/1/1980	3	2	2	2	2	2	2	2	2	n/a	n/a
11/1/1982	3	2	2	2	n/a	2	2	2	3	2	n/a
4/1/1983	1	2	2	1	2	2	1	2	2	2	n/a
2/1/1984	2	3	2	1	1	2	1	1	2	1	n/a
5/1/1985	2	1	2	3	2	n/a	1	1	2	1	n/a
12/1/1986	1	2	2	2	2	1	2	2	2	1	2
9/1/1988	2	2	2	2	2	2	2	2	2	1	1
	Operations	Radiological Controls	Maintenance/Surveillance Testing	Emergency Preparedness		Security	Engineering and Technology		Safety Assessment and Quality Verification		
11/1/1989	3	3	3	3		1	2		3		
7/1/1990	2	2	3	1		1	2		2		
	Operations		Maintenance	Engineering			Plant Support				
7/1/1991	2		2	2			1/1/1				
7/1/1992	1		2	2			1/1/1				
10/1/1993	1		2	2			1/1/1				
2/1/1995	1		2	1			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

*February 1975:* VEPCO converted from a sodium phosphate secondary water chemistry program to an all-volatile treatment program.<sup>1</sup>

*May 1975:* Evidence of steam generator tube denting was discovered.<sup>2</sup>

*May 1976:* Laboratory analysis of dented tube samples and segments taken from the tube support plate indicated that the tube support plates were cracked. Analysis showed that the annulus between the tubes and the tube support plates was filled with a corrosion product that expanded to dent the tubes and crack the tube support plate ligaments.<sup>3</sup>

*September 15, 1976:* A tube inside Steam Generator A developed a primary to secondary leak of approximately 80 gallons per minute. As a result, the NRC imposed augmented in-service inspection requirements on Surry Units 1 and 2 that forced the reactors to be shut down for inspections about every six months.<sup>4</sup>

*November 15, 1976:* VEPCO asked the NRC for concurrence with their decision to restart Unit 2. VEPCO plugged about 400 tubes in each steam generator to reduce the likelihood of another steam generator tube leak. VEPCO provided evaluations concluding it would take at least eight months of operation for the remaining in-service tubes to significantly degrade and proposed verifying this evaluation with an inspection after two months of operation.<sup>5</sup>

*November 26, 1976:* The NRC issued an amendment to the Unit 2 operating license that imposed the condition that the steam generator tubes be inspected within 61 days of operation.<sup>6</sup>

*April 1, 1977:* The NRC issued an order limiting Unit 2 to six months of equivalent operation before the next steam generator inspections.<sup>7</sup>

*August 17, 1977:* The NRC issued an order allowing Unit 2 to continue operating until the next steam generator inspections on September 15, 1977.<sup>8</sup>

*September 30, 1977:* VEPCO notified the NRC that steam generator inspections resulted in the plugging of 180 tubes.<sup>9</sup>

*October 8, 1977:* The NRC issued an order limiting Unit 2 to six months of equivalent operation before the next steam generator inspections.<sup>10</sup>

*December 2, 1977:* The NRC issued an amendment to the operating license for Unit 2 increasing the steam generator tube plugging limit to 25 percent.<sup>11</sup>

*March 20, 1978:* Unit 2 was shut down for steam generator inspections.<sup>12</sup>

*April 7, 1978:* The NRC issued an order limiting Unit 2 to six months of equivalent operation before the next steam generator inspections.<sup>13</sup>

*September 1978:* 21.5 percent of the tubes inside the three steam generators on Unit 2 had been plugged due to degradation.<sup>14</sup>

*October 3, 1978:* The NRC issued an amendment to the operating license for Unit 2 limiting equivalent operation until the next steam generator inspections to six months from August 1, 1978.<sup>15</sup>

*October 5, 1978:* The NRC issued a safety evaluation that concluded the proposed replacement steam generators posed no safety hazard.<sup>16</sup>

*March 13, 1979:* The NRC ordered Surry Units 1 and 2, along with three other reactors, to be shut down within 48 hours and remain shut down until it could be determined whether errors were made in a computer code used to analyze the ability of piping supports to withstand earthquakes. Surry Unit 2 was already shut down at the time (undergoing steam generator replacement).<sup>17</sup>

*June 1979:* VEPCO reached a \$32.5 million settlement with Westinghouse Electric Corporation to end a lawsuit related to the steam generators. Approximately \$24 million of the settlement was in cash, with the remainder being cancellation of invoices and credit for work performed.<sup>18</sup>

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*June 1982:* VEPCO estimated the cost of replacing the steam generators on Unit 1 (298 days, 1980–1981) and Unit 2 (562 days, 1979–1980) was \$349 million (\$719 million in 2006 dollars<sup>19</sup>), including replacement power costs of \$204 million.<sup>20</sup>

## Notes

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- <sup>1</sup> Nuclear Regulatory Commission (NRC). 1976. Amendments no. 26 to operating license nos. DPR-32 and DPR-37, November 26.
- <sup>2</sup> Ibid.
- <sup>3</sup> Ibid.
- <sup>4</sup> Noonan, V.S. 1978. Surry Units 1 and 2: Steam generator repair program. Memorandum to A. Schwencer, chief, operating reactors branch, October 5. V.S. Noonan was chief of the engineering branch at the Nuclear Regulatory Commission.
- <sup>5</sup> NRC, 1976.
- <sup>6</sup> Ibid.
- <sup>7</sup> NRC. 1977. Order for modification of license, October 8.
- <sup>8</sup> Ibid.
- <sup>9</sup> Ibid.
- <sup>10</sup> Ibid.
- <sup>11</sup> NRC. 1977. Amendments nos. 35 and 34 to operating license nos. DPR-32 and DPR-37, respectively, December 2.
- <sup>12</sup> NRC. 1978. Order for modification of license, April 7.
- <sup>13</sup> Ibid.
- <sup>14</sup> Noonan, 1978.
- <sup>15</sup> NRC. 1978. Amendment no. 44 to operating license no. DPR-37, October 3.
- <sup>16</sup> Noonan, 1978.
- <sup>17</sup> NRC. 1979. NRC staff orders five nuclear plants shut down to resolve piping questions. News release no. 79-52, March 13.
- <sup>18</sup> Associated Press. 1982. Summaries of Westinghouse settlements, June 30.
- <sup>19</sup> Bureau of Labor Statistics. 2006. Inflation calculator. Washington, DC: U.S. Department of Labor. Online at <http://data.bls.gov/cgi-bin/cpicalc.pl>.
- <sup>20</sup> Associated Press, 1982.