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March 10, 2000

Mr. Jack N. Donohew, Senior Project Manager, Section 2
Callaway Nuclear Power Plant - Project Directorate IV
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington DC 20555

Dear Mr. Donohew:

This letter is seeking information about the event that occurred at the Callaway nuclear power plant on Sunday, February 13 -- **(a)** about the disturbing fact that a thunderstorm in southeast Missouri could cause a reactor/turbine scram and related system failures at Callaway, and **(b)** about the unproven claim that the steam that was dumped into the atmosphere for about twenty minutes contained no radioactivity.

A great many questions follow. I do not expect that you will have the time to answer all, or even most, of them. But in the twenty-five years I have been studying (and opposing) nuclear power, I have read a great deal about steam generators -- sometimes described as the Achilles heel of pressurized water reactors. I have also been concerned about the vulnerability of the electric power systems that feed the nuclear plant sites. The February 13 event at Callaway, involving both steam generators and power reliability concerns, lead me to questions which I believe should have your attention.

Some related factual background:

<> about the need for a reliable electric distribution system: "From a risk perspective, offsite power is important in that it is the preferred source of electrical power for the plant safety equipment used to mitigate accidents. Additionally, offsite power is important in the event of a loss of the onsite emergency supplies." (from NRC Special Inspection Report No. 50-483/99-15, p.5, regarding "a degraded switchyard voltage condition, which occurred following a reactor trip on August 11, 1999," at Callaway.)

<> about the safety significance of steam generators: "[Steam generator] tube ruptures represent a failure of one of the principal fission product boundaries and present a pathway for primary system activity [radioactivity] release to the environment bypassing containment. . . ." (from NRC Generic Letter 95-03, "Circumferential Cracking of Steam Generator Tubes," p.3) That is, a tube rupture could cause the release of a large, early amount of radioactive fission products from the reactor pressure vessel into the environment through the steam generator's cooling water and steam system (thus bypassing the containment and its intended function to contain those products).

<> and more about the generators: The tubes are among "the physical barriers between the fission products in the fuel and the public outside the plant." (Steven Long of the NRC's Office of Nuclear Reactor Regulation, speaking to the NRC's Advisory Committee on Reactor Safeguards (ACRS), 4/7/99)

Although we are fortunate that the February 13 event at Callaway, including the steam releases, did not result in any observable consequences, the nuclear power plant's absolutely essential need for reliable power was placed in jeopardy. While the nuclear industry has of course long recognized the dangers associated with the potential loss of offsite power -- with a resulting full

IE22

station blackout -- the February 13 event illustrates the serious range of consequences that is possible from just a fluctuating power flow.

The event casts doubt on the existing and future stability of the electrical grid. This is of increasing concern now because of deregulation and the resulting economies that electric utilities are initiating in order to try to compete better in the free market.

First, to quote from three sources about the 2/13 event (with emphases added):

1. According to the February 15 Columbia Tribune: "Storms in southeast Missouri early Sunday morning [2/13] caused a turbine trip that shut down the Callaway Nuclear Plant for 12 hours. 'It was purely a transmission system problem,' AmerenUE spokesman Mike Cleary said." Breck Henderson, an NRC spokesman, said: "It was a problem with the electrical grid. One of the breakers in the system didn't do what it was supposed to do." The article continued: "The plant shut itself down automatically and let out some atmospheric steam, Henderson said. 'There were no unusual levels of radioactivity that escaped,' he said, adding that electric monitors constantly measure radioactivity levels around the plant."

2. The February 17 St. Louis Post-Dispatch noted the plant's return to full operating capacity by the morning of February 16 "after electrical transmission problems in southeast Missouri caused the plant to automatically shut down Sunday. Fluctuating voltage in a power line caused pumps that move water through the Callaway plant's reactor coolant system to stop working at 7:34 a.m. Sunday, which in turn triggered the nuclear reactor to shut down as a safety precaution. Company officials said the interruption caused no safety concerns. The plant had resumed some production by Monday morning."

3. According to my understanding of the NRC headquarters' report of this event, No. 36685, the NRC was notified 2 1/2 hours later of the following sequence:

(a). While the reactor was operating at 100% power, fluctuating voltage from the power grid caused the following: **(1)** the reactor tripped (shut down or "scrammed") automatically, following the sequential shutdown of the four reactor cooling water pumps; and **(2)** the turbine tripped.

(b) Two circulating water pumps also shut down.

(c) The reactor cooling water pressure increased, causing a power operated relief valve on the pressurizer to lift and reseat. (The setpoint is 2335 pounds per square inch gravity; the primary safety setpoint is 2485 psig.)

(d) "A slight increase in the pressurizer relief tank pressure was observed."

(e) All auxiliary (backup) feedwater pumps started after a feedwater isolation signal occurred.

(f) The condenser vacuum was lost -- that is, the main condenser became unavailable (and inoperable).

(g) "The licensee estimates that the steam generator atmospheric dumps were used for no more than 20 minutes during the period of time when the main condenser was not available. There is no indication of any primary-secondary leakage prior to this event."

(h) "The plant is currently stable with operators restoring main feedwater. . . The unit will remain in Mode 3 [hot standby] pending the outcome of the investigation into the grid electrical transient."

And now my questions:

A. <u>Questions about the electrical transmission irregularities -- the fluctuating voltage caused by the thunderstorms, and the resulting series of equipment and system failures</u>:

1. Did any of the components fail independently, or were the components linked with one another and thus failed interactively (a form of common-mode failure)?

Or, as another form of this question: Has the NRC confirmed as yet whether or not the grid system voltage fluctuations caused only one [circuit or power supply] breaker to malfunction (which in turn caused the four reactor coolant pumps to trip and the rest of the sequence of trips, etc., to occur) -- <u>or</u> were other electrical controls or components of the nuclear steam supply system also <u>directly</u> affected by the electrical grid irregularities?

2. How frequently has the NRC been informed of similar disruptions in power that have resulted in a potentially dangerous chain of events? More specifically, have fluctuating voltages frequently affected the operability of safety systems? (These questions are especially important to Missourians because of our many thunderstorms.)

3. To what extent are surge protectors required on safety-related equipment at nuclear power plants? If they are required, are they rated as safety-related, as per 10 CFR 50, Appendix B?

4. Although the warning sirens in the plant's emergency planning zone were fortunately not needed for the 2/13 transient, does anyone know if any of them became inoperable during the period of fluctuating voltages?

5. According to NRC Information Notice 98-07, "Offsite Power Reliability Challenges from Industry <u>Deregulation</u>," the reliability of power from the transmission system grid to nuclear power plants may be adversely affected by the deregulation of the electric power industry. Aside from changes in grid loading that may affect the reliability of an off-site power source, do you anticipate other problems, such as a potential decrease in funding for the maintenance of transmission systems?

6. I understand that AmerenUE officials will be attending a meeting at the NRC's Region IV office in Texas this Monday, <u>March 13, 2000</u>, to discuss the NRC's special inspection regarding degraded <u>switchyard</u> voltage conditions associated with a different Callaway reactor scram -- the manual scram of August 11, 1999. Does the NRC expect to conduct a similar special inspection regarding the February 13 automatic reactor scram caused by <u>off-site</u> voltage irregularities? The 8/11/99 incident apparently was caused in part by AmerenUE's failure to verify the operability of Callaway's offsite power sources (its failure to detect a low switchyard voltage condition) following a trip of the reactor and main generator.

Just as with the February 13 incident, the 8/11/99 incident included a sequence of environmental, economic and human error conditions involving offsite and onsite electrical sources and distribution systems. The August event included a turbine building steam-pipe rupture, a deenergized computer, an inadvertently severed fiber optic channel (that broke off communication of the switchyard voltage data between the Callaway control room and Ameren's Energy Supply Operations facility in downtown St. Louis), and the establishment of an erroneous and nonconservative alarm setpoint caused by a transposition error during the inputting of voltage parameters in the plant computer.

Apparently the August 11-12, 1999, voltage problems may have been caused in part by near-peak summertime power wheeling ("excessive voltage support to the grid"), a condition perhaps related to "the potential impacts of power market deregulation on the reliability of the electrical grid relative to the design and licensing basis of your facility." (quoting from NRC Special Inspection Report No. 99-15, February 15, 2000; emphasis added).

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B. Questions about the presence of radioactivity in the steam released to the environment -- that is, about the history of leakage of the Callaway reactor vessel's highly radioactive PRIMARY cooling water into the steam generators' SECONDARY cooling water and steam -- prior to the 2/13 atmospheric steam dumping:

The highly radioactive primary cooling water in the reactor vessel is supposed to circulate inside the 5,626 tubes in each of the four steam generators. It then returns to the reactor vessel. Any leakage of this primary coolant through a degraded generator tube contaminates the steam generator's secondary coolant.

The thin-walled tubes (only four-hundredths of an inch thick) are highly susceptible to corrosion, fissures, cracks, denting and leakage. Causes of tube degradation include exposure to massive vibration, radiation, and high-volume, high-velocity, pressurized, superheated water. Tiny fissures can, of course, grow larger and eventually cause the tube to burst or rupture.

The steam generator's cooling water circulates on the outside of the tubes (that contain the reactor water) but inside the generator. That water can leak, too. The secondary coolant turns into steam which drives the plant's turbine generator (thus producing electricity). The steam is also subject to release to the environment -- even when there are no electrical transmission problems.

1. I would like to learn how much the licensee knew, and when he knew it, about the precise amount of radioactivity that was present in the secondary cooling water (and therefore in the steam) when the atmospheric steam dump valves were opened to begin releasing steam to the environment.

(a) What was the concentration level, per liter, of radioactive contaminants in the secondary coolant prior to the February 13 electrical grid fluctuations? (I would appreciate it if you would include as part of your answer the levels of dissolved and entrained radioactive noble gases, and tritium.)

(b) How much in advance of the February 13 incident had the secondary coolant samples been collected and analyzed, and reported to the NRC?

2. How many pounds of steam did the licensee estimate were released during the "steam generator atmospheric dumps [that] were used for no more than 20 minutes"? If it is correct that each generator loop has two atmospheric steam dump valves, how many were full or partially open? Was it as noisy as I'm told such dumping is?

3. Were radioactive gases, iodine, or other fission/corrosion/activation products

released during the February 13 event from any of the following paths, other than the atmospheric steam dump?: **(a)** air ejector discharge, **(b)** turbine-driven auxiliary feed pump exhaust, or **(c)** gland steam exhaust? If so, please describe.

4. Did the fluctuating voltages affect the steam monitoring equipment or any other electronic radiation detectors at the plant?

5. Has any condenser (tertiary) cooling water, with its aggressive chemicals, leaked into the secondary coolant of the generators over the years, causing damage to the tubes or other steam generator internals?

6. According to the NRC February 13 event report: "During the period of time before the reactor coolant pumps were restarted, the reactor coolant system pressure increased, causing one pressurizer PORV [one of the two power operated relief valves] to lift and reseat." **(a)** What is the normal operating pressure? **(b)** Does the fact that a PORV lifted mean that the reactor coolant system pressure exceeded the 2335 and 2485 psig setpoints? **(c)** Does anyone know for how long a period the PORV remained open before it reseated, and if any primary coolant escaped during that time? These questions are, of course, inspired by memories of the Three Mile Island-Unit 2 accident.

7. Regarding the steam generators: What is the current permissible primary-to-secondary coolant system leak rate limit at the Callaway plant -- that is, the Technical Specification leak rate that the NRC is confident will not result in a sudden tube rupture?

8. After three or four years of negotiations between the NRC staff and Union Electric/Ameren, the NRC staff finally issued a license amendment on May 24, 1999, which permitted Ameren to repair defective steam generator tubes at Callaway by using the Framatome Electrosleeving method.

According to NRC-SECY-99-199 (August 3, 1999): "The Electrosleeve is a nano-crystalline nickel sleeve that is electrochemically deposited on the inner surface of a steam generator tube. The Electrosleeve is a proprietary process designed to span a known flaw in the steam generator tube and to function as the pressure boundary."

Does the NRC have a report that describes the predominant tube wall deformations and defects that were detected in the Callaway steam generator tubes -- such as intergranular stress corrosion cracking, pitting, denting and circumferential cracking -- that led to the decision to install Electrosleeves in the tubes in an effort to try to reduce leakage or imminent leakage? If so, would you please tell me the title and document number? I am particularly interested in defects in the U-bends of the tubes and in the parts of the tubes that pass through the holes in the tube support plates (the series of plates in the steam generators designed to keep the tubes properly spaced).

9. How did the NRC decide to allow Callaway to be the first and perhaps only plant in the U.S. licensed to experiment with the Framatome Electrosleeves?

10. In the absence of any NRC or NRC-licensee experience with Electrosleeving at a U.S. nuclear power plant, prior to Callaway, would you please tell me what test results you required AmerenUE to provide for your evaluation of this tube repair method? For example, what manufacturer's qualification and/or Ameren acceptance testing results were submitted to the NRC that demonstrated accelerated life testing -- including elevated temperature and pressure regimes, and cycling up and down -- and that you deemed were sufficient to give you confidence in the integrity and performance characteristics of the Electrosleeve method and materials for the desired lifetime (of two operating cycles, or beyond)?

11. Was the U.S. Department of Energy's Argonne National Laboratory able to resolve the NRC staff's concerns about the potential failure of the Electrosleeved tubes under severe accident conditions? That is, was ANL able to determine whether or not the electrochemically deposited sleeve would survive high temperatures and "high primary-side pressure and depressurized and dry secondary side" conditions of a beyond-design-basis accident? (SECY-99-199, page 2) (The NRC withheld from public disclosure the June 1999 ANL technical letter report to the NRC, because of alleged proprietary commercial information, and I was therefore not able to read their answers to that inquiry.)

12. Has AmerenUE examined the integrity of its Electrosleeved tubes as yet? (I believe the Electrosleeves were to have been installed during the Fall 1999 plant refueling outage.) **(a)** If no, when is the first examination of the parent tubes and sleeving to be required, and has Ameren or the NRC decided if ultrasonic testing will work? **(b)** If yes, have any flaws been identified that are longer than one inch? **(c)** Have any of the Electrosleeved tubes already required removal from service, for example, by installing plugs in the tube ends?

13. The Callaway license amendment that permits the Electrosleeving method apparently limits the installation of the sleeves to a maximum of two operating cycles (approximately three years). Is it correct that existing sleeves are to be removed after that duration, with no others to be permitted subsequently, as outlined in an NRC Request for Additional Information (December 16, 1998)? If so, has Electrosleeve removal experience been accrued at any other nuclear power plant(s) in Canada or Europe as yet?

14. I am interested in learning how many (or the percent) of the 5,625 tubes in each of the four Callaway steam generators are no longer operable or available? **(a)** Would you please tell me what percent of the tubes in each of the generators has been Electrosleeved? **(b)** If other non-Framatome sleeves had been installed earlier, would you also please tell me how many of those sleeves (or what percent) remain in each of the generators?

15. In what percent of the tubes in each generator has the licensee installed welded plugs at the inlet and outlet of the tubes, following the detection of tube wall degradation? Have any plugs been removed or become dislodged?

16. Has the sleeving and plugging of the Callaway tubes caused any reduction in the Callaway steam generators' heat removal capability or the plant's power-generating capacity? If not, could you please explain why not?

17. In addition to the tubes, another pathway exists for the primary coolant to reach the secondary coolant -- that is, the thick "tube plate" (inside, at the bottom of each generator) through which the steam generator tubes penetrate. Already in the 1970s cracks were found in these plates in France, at Framatome reactors which are similar in design to the Callaway Westinghouse reactor.

Would you please tell me if the tube plate in each of the four Callaway steam generators is periodically inspected and tested to assess its structural and leaktight integrity? If so, would you please tell me: **(a)** when the most recent inspection occurred; **(b)** how it was performed -- for example, how access was achieved for the destructive or nondestructive testing; and **(c)** if cracking or other signs of deterioration were detected?

18. Recognizing the fact that the radiation fields within which workers have to make steam generator repairs rank among the highest at pressurized water reactor plants, would you please tell me whether replacing the steam generators rather than retrofitting them would perhaps have resulted in lower radiation exposure for the workers? And would that not be especially true if the Electrosleeving will have to be removed (requiring more retrofitting and more worker exposure) after a maximum of only two operating cycles? What is to happen to the defective parent tubes within the generators after the sleeving is somehow removed?

19. Has the NRC or AmerenUE estimated if and when the Callaway steam generators may have to be replaced?

20. In his April 7, 1999, presentation to the ACRS, the NRC's Steven Long reported on the Nuclear Energy Institute's proposal to replace the tube integrity criterion that limits a maximum permissible crack to 40% through the tube wall with a criterion that would allow through-wall cracks to remain in service. Has the NRC indeed decided to relax this criterion? If so: **(a)** Did you limit the permissible length of a through-wall crack? **(b)** Did you limit the number of through-wall cracks in a given steam generator? **(c)** Did you agree to permit such cracks in the free-span portion of a tube, or only in areas not accessible for repair?

21. A non-steam generator question: knowing of concerns the NRC staff has raised intermittently about the possibility that waterhammer could exceed allowable piping stress at the Callaway plant, and remembering the continuing discovery during the plant's construction of defective stud welds on many embedded pipe supports, I would like to ask the following: was any of the series of February 13 sudden shutdowns that were caused by the voltage fluctuations sufficient to result in mechanical damage to any of the cooling water systems or other components?

22. And one final question that I do not believe is related to the February 13 incident: according to the American Nuclear Society's October 1999 Nuclear News, the Callaway plant workforce fabricates complex parts in its machine shop. "When the Callaway plant needs a spare part that is complex in design, we go to our machine shop and fabricate it ourselves. I don't know of other nuclear plants that do that as much as Callaway." (p. 24) I was surprised to read that. Reflecting back on the years when the plant was under construction, I remember that the NRC required vendors of safety-related equipment to follow elaborate quality assurance/quality control procedures and to keep thorough records. The NRC staff even occasionally made inspections at the vendors' factories. To what extent does the NRC oversee Callaway's in-house machine shop? And its documentation of purchases -- such as of safety-related parts and metals? Or do you rely on oversight by the nuclear industry's Institute of Nuclear Power Operations?

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Because of the electric industry's increase in cost-cutting efforts in response to electric market deregulation, and because of the decrease nationwide in the pool of qualified nuclear power plant personnel, I am concerned that degraded or unreliable voltage conditions, both on-site at nuclear plants and off-site, may trend upward. My questions seek to clarify whether or not the February 13 voltage fluctuation incident was as insignificant as it was represented to be.

Sincerely,

Kay Drey