UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	:	
	:	
GEORGIA POWER COMPANY, et al.	:	Docket Nos. 50-424
	:	50-425
(Vogtle Electric Generating	:	
Plant, Units 1 and 2)	:	

AFFIDAVIT OF RICHARD B. MILLER

COUNTY OF ALLEGHANY)
)
COMMONWEALTH OF PENNSYLVANIA)

I, Richard B. Miller, being duly sworn according to law, depose and say as follows:

1. My name is Richard B. Miller. I am employed by Westinghouse Electric Corporation in the position of Lead Engineer in Instrumentation and Control Systems Licensing for the Nuclear Technology Division. My business address is Westinghouse Electric Corporation, Monroeville Nuclear Center, P. O. Box 355, Pittsburgh, Pennsylvania 15230. Attached to this affidavit as Exhibit A is a summary of my professional qualifications.

2. The purpose of this affidavit is to support the Applicants' Motion for Summary Disposition of Joint Intervenors' Contention 10.7, which concerns the

environmental qualification of the Westinghouse Model B electric hydrogen recombiner systems used at the Vogtle Electric Generating Plant ("VEGP"). In this affidavit, I will describe the Model B hydrogen recombiner system, the manner in which it operates, and the testing program that demonstrated its environmental qualification. I have personal knowledge of the matters set forth herein and believe them to be true and correct.

I. The Design, Construction, and Operation of the Westinghouse Model B Electric Hydrogen Recombiner System.

3. Section 6.2.5 of the Applicants' Final Safety Analysis Report ("FSAR") states that if a loss-of-coolant accident ("LOCA") were to occur at VEGP, hydrogen could be produced inside the reactor containment by radiolysis of the core and sump solutions, by corrosion of aluminum and zinc, by reaction of the Zircaloy fuel cladding with water, and by release of the hydrogen dissolved in the reactor coolant and contained in the pressurizer vapor space. To ensure that the hydrogen concentration inside containment remains at a level low enough to preclude endangering containment integrity, VEGP will use a combustible gas control system. That system, which is described in section 6.2.5 of the FSAR, includes two Westinghouse Model B electric hydrogen recombiner systems for each unit.

A. <u>The Design of the Electric Hydrogen Recombiner System.</u>

4. Each of the Model B electric hydrogen recombiner systems supplied by Westinghouse for the VEGP is a combustible gas control system that lowers the hydrogen concentration inside containment by elevating product gas temperatures to a level that permits the reaction of hydrogen with oxygen to form water. The Model B electric hydogen recombiner system is a natural convection, flameless, thermal reactor type hydrogen/oxygen recombiner. Using only electric heaters it heats a continuous stream of the air/hydrogen mixture to a temperature sufficient for spontaneous recombination of the hydrogen with the oxygen in the air to form water vapor.

5. The hydrogen recombiner systems are designed to withstand all normal and accident loads including steam pressure transients from a design basis LOCA. The designed lifetime of the recombiner systems is 40 years, consistent with that of the plant. Westinghouse selected all materials used in the recombiner systems to be compatible with the environmental conditions existing inside the reactor containment during normal operation or during accident conditions. The processing capacity of each hydrogen recombiner system is such that the concentration of hydrogen inside containment will not exceed four volume percent based on the Nuclear Regulatory Commission's

("NRC") Technical Information Document (TID - 14844, March 1962) release model as indicated in Regulatory Guide 1.7. Each unit at VEGP contains two redundant electric hydrogen recombiner systems in order to meet the single-failure criterion.

B. The Components and Operation of the Model B Electric Hydrogen Recombiner System.

6. Figure 10.7-1 shows the three major components of the Westinghouse Model B electric hydrogen recombiner systems used at VEGP. Each hydrogen recombiner system consists of a recombination unit containing the electric heater banks, a power supply panel that contains the equipment necessary to power the heaters, and a control panel that directs the operation of the system. Of these three main components, only the recombination unit is located inside containment at VEGP and would be exposed to the harsh post-LOCA environment. The power supply panel and control panel are located in the control building.

(1) The Recombination Unit.

7. As depicted in Figure 10.7-2, the recombination unit consists of an intake and preheater section, a flow orifice plate, a heater-recombination section, an exhaust chamber, and an outer enclosure. Figure 10.7-3 diagrams the operation of the recombination unit.

8. When the recombination unit is energized, it heats the air inside the unit in a vertical duct, causing it to rise by natural convection. As that heated air rises, replacement air is drawn through intake louvers downward through the preheater section, which consists of a shroud placed around the central heaters to take advantage of heat conduction through the walls. By raising the temperature of the inlet air, the preheater section increases the efficiency of the hydrogen recombiner system and evaporates any moisture droplets that may be entrained in the air.

9. The preheated air then flows through the flow orifice plate to the heater-recombination section. That section consists essentially of a vertical duct containing conventional electric resistance heaters of the sheathed type. The heater-recombination section consists of four banks of electric heaters stacked vertically. Each bank contains sixty individual, U-shaped heating elements. By heating the airflow to a temperature above 1150° Fahrenheit, the heater-recombination section causes any free hydrogen present to react with oxygen in the containment atmosphere to form water vapor. The temperature above which recombination occurs is approximately 1135° Fahrenheit.

10. After passing through the heater-recombination section, the airflow enters the exhaust chamber, which is at the top of the recombiner. There the hot gases are mixed with and cooled by air from the containment atmosphere and then discharged at a lower temperature through the air discharge louvers back into containment.

11. The recombination unit is completely encompassed within the outer enclosure, which protects the unit from impingement by containment spray. The intake louvers are on one side of the outer enclosure, and the discharge louvers are on the other three sides.

12. Because the recombination unit uses natural convection to generate and maintain airflow through the unit, no circulation fans are required and the recombination unit has no moving parts. The recombination unit is a mechanically passive device.

(2) <u>The Power Supply Panel</u>.

13. Shown on Figure 10.7-4, the power supply panel is basically a standard instrument rack that contains the electrical equipment necessary to provide the power required by the heater banks in the recombination unit when connected to the proper power source. This panel contains an isolation transformer and a controller. Because of its location in the control building at VEGP, this equipment will not be exposed to the post-LOCA environment.

(3) The Control Panel.

14. The hydrogen recombiner system is operated manually from a control panel. The control panel insert, which is pictured in Figure 10.7-5, contains all the equipment required to operate the recombination unit. Among the components of the control panel are a wattmeter, which provides a direct reading of the power being supplied to the recombination unit; a potentiometer, which governs the power to energize or de-energize the main line contactor located in the power supply panel; and a pilot light, which shows when power is available to the power supply panel. Like the power supply panel, the control panel is located in the control building and will not be subject to a post-LOCA environment.

II. The Westinghouse Model B Electric Hydrogen Recombiner System Contains No Transducers or Sensors Important to Its Proper Functioning.

15. This section of the affidavit addresses the first of the two questions that the Atomic Safety and Licensing Board ("Board") felt should be addressed with respect to the environmental qualification of the electric hydrogen recombiner system, which was: "Are there any types of transducers or sensors important to the proper functioning of the Vogtle electric type hydrogen recombiner in an accident environment that require environmental qualification testing in an accident environment; if so,

what testing is planned or completed and with what results?" No sensors or transducers are required for the operation of the Model B electric hydrogen recombiner systems used at VEGP.

16. As stated in section 6.2.5.2.1 of the FSAR, emergency operating procedures for VEGP will direct that in the event of a LOCA plant personnel will monitor the concentration of hydrogen inside containment by means of the containment hydrogen monitoring system. Operation of the hydrogen recombiner system will not be required for several days following a LOCA. Figure 6.2.5-5 of the FSAR illustrates the effect of turning on one of the hydrogen recombiner systems on the second day or several days later when the containment hydrogen concentration reaches 3.5 volume percent following a LOCA. That figure demonstrates that the recombiner system will not be needed for several days after a LOCA.

17. As described in section 6.2.5 of the FSAR, the hydrogen monitoring system, which is physically separate from and not part of the hydrogen recombiner systems, is a Class 1E, Seismic Category 1 system designed to retain its integrity and operate under all conditions following a design basis accident. Depending upon containment atmospheric conditions, the correct power for recombiner operation will be determined. The power input necessary

to cause the heater banks in the recombination unit to exceed the threshold temperature required for recombination to occur will be set on the control panel. Proper operation of the recombiner system is determined by observing the amount of electric power drawn by the recombination unit, which is shown by instrumentation on the control panel.

18. Thus, no sensors, transducers, or other instrumentation are necessary inside containment for the proper operation of the Westinghouse Model B electric hydrogen recombiner system subsequent to a LOCA. For convenience in testing and periodic checkout, however, one heater bank in each recombination unit has three thermocouples attached to the heating element sheaths that provide a temperature readout on the control panel. While these thermocouples provide a means of easily checking the temperature inside the recombination unit during testing, they do not activate or govern in any manner the operation of the recombiner system, are not necessary for the proper operation of the recombiner system, and will not be used to monitor proper operation following a LOCA. A failure of the thermocouple system would not affect in any way the operation of the hydrogen recombiner system. As described above, proper operation of the hydrogen recombiner system requires only manual actuation of power delivery to the heater banks.

III. The Environmental Qualification Testing of the Westinghouse Model B Electric Hydrogen Recombiner System.

19. The second question raised by the Board in its order admitting Contention 10.7 was: "If environmental qualification testing in an accident environment of an entire prototype recombiner is not required, what is the basis for this conclusion? If such testing is planned or has been completed, what is the nature of the test and what criteria exist for assessing the adequacy of the test results?" This section of the affidavit addresses that question.

A. Overview of the Generic Qualification Program for the Model B Recombiner System.

20. The Westinghouse Model B electric hydrogen recombiner system is a revision of the prior model Westinghouse recombiner system, the Model A. The Model A recombiner, which was designed in 1971, had been subjected to an extensive environmental qualification program. The testing performed on the Model A recombiner as part of that qualification program is described in part III(B) of this affidavit (paragraphs 22 through 57). That qualification program was reviewed and accepted by the NRC staff as outlined in the letter from John F. Stolz of the NRC staff to Thomas M. Anderson of Westinghouse dated June 22, 1978, which transmitted a Safety Evaluation Report prepared by the NRC staff concerning that program. A copy of that letter and SER are attached hereto as Exhibit B.

21. When Westinghouse designed the Model B recombiner working from the Model A design, it did not permit any changes that would have affected the qualification of the Model A recombiner. Instead, it accumulated suggested changes to improve the Model A recombiner and incorporated those suggestions into the Model B recombiner. Westinghouse then performed a test program to verify that the features of the Model B recombiner that had been incorporated into the design as changes from the Model A did not effect its environmental qualification under the testing program performed on the Model A. The design changes incorporated in the Model B recombiner and the additional testing engaged in by Westinghouse to demonstrate that those changes did not affect its environmental qualification are discussed in part III(C) of this affidavit (paragraphs 58 through 68). As part of that same testing program, the Model B hydrogen recombiner system was tested to the standards set by IEEE 344-1975 for seismic qualification. The generic qualification program for the Model A recombiner system has demonstrated that the Model B recombiner system is qualified to the standards set by IEEE 323-1974. Testing performed on the power cables for the recombiner, which are inside the recombination unit, has shown the compliance of those cables with the requirements of IEEE 383-1974.

B. Environmental Qualification Testing Performed on the Model A Hydrogen Recombiner System.

22. The three main components comprising both the Westinghouse Model A and Model B electric hydrogen recombiner systems are the recombination unit, the power supply panel, and the control panel. Of these components only the recombination unit is located inside containment and could be subject to LOCA conditions. Therefore, only that part of the hydrogen recombiner system has been subjected to an accident environment in qualification testing. Tests have been performed on the power supply panel and control panel to demonstrate their ability to operate in an elevated temperature environment.

(1) Qualification Testing Conducted upon the Recombination Unit.

23. As noted above, the recombination units of the hydrogen recombiner systems are located inside containment. Therefore, Westinghouse performed environmental qualification testing on the recombination unit to demonstrate the ability of that equipment to survive exposure to the adverse environment that would result from accident conditions. The environmental qualification test program described below demonstrates that the recombination unit is capable of withstanding normal service and accident conditions anticipated or postulated for the recombination

unit during the operation of VEGP. For each test described, I will indicate whether a complete recombination unit was tested.

(a) Temperature Cycling.

24. During the recombiner's 40-year design life it will undergo approximately 80 heatup and cooldown cycles to demonstrate its availability (approximately 2 cycles per year). These heatup and cooldown cycles result in transient thermal stresses in the heater frame and support structure. To demonstrate that the recombiner structure can sustain repeated cycling, Westinghouse conducted a test program consisting of alternately heating and cooling a production model of the recombination unit. This cycle was repeated 80 times. After the cycle test was completed, the recombination unit and its heating elements were examined for damage, and none was found.

(b) LOCA Tests.

25. To demonstrate that the recombination unit will function properly in a LOCA environment, Westinghouse tested under accident conditions those components necessary for such operation that might be affected by rapid pressurization and by high pressure steam. Those components are the heater banks with junction boxes, the electrical junction box, electrical cabling, door panels, and louvers.

26. To test those components under simulated LOCA conditions, Westinghouse designed and built a special heater frame that would hold four heater banks, including their junction boxes. The electrical junction box was attached to the side of the heater frame and the electrical cabling was installed in a manner similar to that of the production recombiner. All of these component were full-sized, production components. The use of the special heater frame, which was approximately 3/4 the height of a production unit, permitted employment of a test chamber of appropriate size (seven feet in diameter and twenty feet long) to generate the desired pressure and temperature profiles. The compartment around the heater bank junction boxes was made similar to the production model and a typical louver was installed. A door panel was also placed in the pressure chamber to verify its ability to withstand external pressure. Figure 10.7-6 shows the recombiner heater frame in the pressure chamber.

27. The tests performed upon production components of the recombination unit are adequate to qualify the complete unit because of the simplicity of its design. A mechanically passive device, the recombination unit has no moving parts and consists primarily of structural members, power cables, and heating elements. All of those components that could be affected by LOCA conditions were

included in the tests, and no purpose would be served by testing a full size prototype. Construction of the special recombination unit was similar to a production model, and all of the components tested were full-sized, production components. The testing performed on the production components provided adequate environmental qualification information.

28. The test program consisted of six test runs at pressures and temperatures that represent maximum anticipated post-LOCA containment conditions. Prior to the six test runs, all components were subjected to 80 heatup and cooldown cycles. The following paragraphs describe each test.

29. Prior to initiation of the first test, the proper operation of the test unit was checked by energizing the system at approximately 5 kw for ten minutes. The test itself consisted of rapid pressurization with high pressure steam to 69 psia in approximately ten seconds, holding 69 psia pressure for four hours, depressurization to 35 psia with a 2 hour hold, final depressurization, and inspection of the test unit.

30. The second test checked heater operation by applying power to the heater banks in the test unit while they were in a high pressure steam environment with containment spray. After ensuring proper operation of the test unit,

the test chamber was rapidly pressurized to 69 psia in approximately ten seconds with high pressure steam and a chemical spray of sodium tetraborate and sodium hydroxide (2500 ppm boron and pH=10.0). This pressure was held for four hours after which time the heater banks were energized and the power raised to ten kw for five minutes. Power was then removed, and the system was inspected for ground faults. Next, pressure was reduced to 35 psia and held for 20 hours. The system was again energized and inspected as described above. Pressure was again reduced, to 20 psia, and held for one hour. Following another check of heater bank operation, the chamber was depressurized and the test unit inspected and checked for ground faults.

31. Test three simulated a LOCA environment with power applied to the heater banks according to the proposed startup specification. The heater banks were first connected to the power supply. Forty kw electrical power was applied to the heater banks for ten minutes. The heater banks were then de-energized, and the test sequence proceeded as follows: rapid pressurization to 69 psia in approximately ten seconds with sodium tetraborate spray present, after four hours pressure reduced to 25 psia and held for 20 hours, next, increase pressure to 35 psia and energize the heater banks gradually up to 40 kw. The

heater banks were then de-energized, the chamber was depressurized, and phase-to-phase resistance and ground fault checks were performed.

32. Test four was identical to test three with the following exceptions: sodium thiosulfate spray was substituted for the sodium tetraborate spray and maximum pressure was increased to 77 psia, which corresponds to a saturated steam temperature of 309°F. Test five was identical to test three only the electrical junction boxes were vented to a dryer. No advantage appeared to result from this vent scheme so it was removed.

33. Finally, test six was run to demonstrate that the recombiner will function properly if a LOCA occurs while the recombiner is energized. The test sequence proceeded as follows: the heater banks were energized and temperature was stabilized at 380°F, pressure was increased to 77 psia in ten seconds, pressure was reduced to 35 psia for one hour, and then to 20 psia for one hour. The heater banks were energized throughout this test. The test chamber was then depressurized and the equipment was inspected.

34. Each test was successfully completed. Inspection after each test for electrical damage revealed no damage to any of the equipment. This inspection included ground fault checks, continuity checks, and resistance checks on each heater bank. Physical inspection of the system,

including junction boxes, electrical cabling, and electrical junction boxes showed no malfunctions. The door panel and louvers were also inspected periodically and showed no damage. After the test series was complete, the heater banks were removed from the test frame, and the operation of each heating element was tested. All elements heated up. The electrical cabling was inspected, along with the electrical junction boxes. No damage was found.

35. The heater banks were then completely disassembled. Visual inspection of the individual heating elements revealed that eleven out of 240 elements tested had sustained nondisabling sheath damage, consisting of a short split in the sheath material. The damaged elements still had good electrical resistance between sheath and electrode, and the electrode and filament were undamaged. The heater banks continued to fulfill their function. Even though the elements lasted far beyond their anticipated life, further tests were conducted using the third test procedure, with the heating elements inspected after each trial, to confirm that the sheath splits occurred after a number of simulated post-LOCA transients. No damage was observed in the heating element sheaths until after the fourth post-LOCA transient. The steam chamber tests demonstrate that the heating elements,

as well as the other equipment that might be affected by rapid pressurization and by high pressure steam, have a considerable margin over that required for operation after a single post-LOCA transient. Therefore, the recombination unit meets the requirements for operation after a LOCA transient.

(c) Radiation Testing.

36. The purpose of this program was to demonstrate that the electrical components in the recombination unit that may be adversely affected by radiation will perform their post-LOCA function after irradiation. All of those electrical components necessary to the recombination unit's operation following a LOCA were tested. Those components consisted of (a) the power cable, which connects the heater banks to the electrical junction box; (b) the heater connector wire, which connects the heating element bus bars to the heater bank terminal block; (c) the heating elements; and (d) the heater bank electrical terminal blocks. A complete recombination unit was not tested because the remaining components of the recombination unit are made of metal and would not be adversely affected by radiation. All test materials except the heater bank electrical terminal blocks were preaged to simulate normal service life and post-LOCA steam pressure, containment spray, and containment temperature. Preaging

consisted of 80 heatup and cooldown cycles in a productior recombiner to simulate normal service life testings. Six post-LOCA containment steam pressure, temperature, and spray transients were then conducted using a large pressure chamber and steam source. The heater bank electrical terminal blocks were subjected to six post-LOCA transients.

37. All of the components were then irradiated to a total integrated dose of at least 2×10^8 rads.

38. Following irradiation, each of the components was visually inspected for damage and exposed to one post-LOCA pressure, temperature, steam, and spray cycle, using the third test sequence described in paragraph 31 above. No damage was found to have occurred to any of the components after irradiation or after the post-LOCA transient.

39. Additional tests were then performed on some of the components. With respect to the power cable, the phase-to-phase resistance and phase-to-outer jacket resistance were measured and found to be satisfactory. A successful high potential test was then conducted by applying 1320 volts AC at 60 Hz to each phase. Similar successful tests were performed on the heater connector wire. The heating elements were operated and performed properly during and after the simulated post-LOCA transient.

(d) Long Term Testing.

40. Westinghouse conducted a variety of tests on a production model of the recombination unit and its components to assess their long term operability. One test, a high temperature test of the heating elements, was performed in an enclosure lined with refractory material. Use of the enclosure permitted a worst case evaluation of the heating elements' performance at temperatures in excess of expected post-LOCA temperatures. Only the heating elements were tested because they are the component most likely to sustain damage from the elevated temperatures. Power was applied to twelve heating elements to raise sheath temperature to 1700°F nominal, 1750°F maximum. These temperatures were maintained for 21 days. At the completion of the test, the heating elements were inspected and found to be in good operating condition.

41. The next test was a long term heating element and recombiner test, performed using a production recombination unit. The purpose of that test was to demonstrate that the recombination unit will operate successfully at temperatures well in excess of LOCA temperatures with a four percent hydrogen concentration. The recombination unit was operated at 1600°F for ten days, followed by 24 days at 1500°F, followed by 36 days at 1400°F. After that, the recombination unit was inspected for degradation. The unit proved to be in good working order.

42. Westinghouse also conducted long term steam chamber tests to demonstrate that the recombination unit can withstand continued operation at the lower containment pressures predicted for post-LOCA environments. As in the LOCA tests discussed in paragraphs 25 through 35 above, a complete production recombination unit was not tested. Instead, the modified heater frame described in paragraph 26 was outfitted with two heater banks and the other components identified in paragraph 26. As with the LOCA tests, testing performed upon full-sized production components mounted on the special heater frame sufficed to qualify the complete recombination unit because of the simplicity of its design. The test consisted of one pressure transient to 85 psia, which was maintained for four hours. Pressure was then reduced to 35 psia and held for 20 hours. Finally, pressure was reduced to 20 psia and maintained for 21 days. Temperature was maintained at 155°F nominally and varied from 138 to 200° to cover the range of interest. One heater bank was energized at 100% power at the end of the 24 hour transient and remained energized for the ensuing 21 day period. Inspection following completion of the test revealed the heating elements were in good condition.

43. Following the inspection after the 21 day steam chamber tests, the two heater banks were reinstalled in the steam chamber. Power was applied to both heater banks; however, the power to one heater bank was held at the level needed to produce a sheath temperature of approximately 340°F. This temperature corresponds to the 10 kw power setting recommended for the reserve recombiner system after a LOCA. The other heater bank was heated to approximately 650°F, which is equal to or lower than the lowest temperature heater bank in the recombination unit. Test results showed that all 120 heating elements tested survived the simulated post-LOCA temperature and pressure transient, plus eleven months service under long term post-LOCA containment environmental conditions.

(e) Containment Pressure Test.

44. Periodic containment leak rate tests will be performed as a part of the VEGP reactor containment inspection program. To accomplish this, the containment is pressurized with air to a value related to the design pressure of the containment. Because the recombination units are located within containment and will be subject to this external pressure, external air pressure tests were conducted on the most critical components, the heating elements. Only the heating elements were tested because they were the components of the recombination unit

most likely to suffer damage from increased pressure, and the purpose of the test was to demonstrate the performance of the heating elements. Three containment pressure tests were anticipated for each ten year period of operation, for a total of twelve tests during the forty year expected lifetime of the hydrogen recombiner system. To cover all anticipated containment pressure tests, the values selected were: the first test at 100 psig and the eleven subsequent tests at 70 psig. The heating elements were placed in the pressure chamber and subjected to the twelve pressure cycles. Each pressure cycle consisted of pressurization with air for 24 hours, then depressurization to atmospheric conditions for one hour. During these tests, several inches of water were maintained in the bottom of the pressure chamber to ensure high humidity. In one test, a small amount of nitrogen was added. The heating elements were inspected before, during, and after each test. No electrical or physical damage occurred to the heating elements.

(f) Hydrogen Test.

45. A hydrogen test was set up to measure temperature distribution within the recombination unit as a function of increasing hydrogen concentration in the air. To perform this test, new production heater banks were installed in the production recombination unit and three

thermocouples were installed in each heater bank. The maximum temperature in the recombination unit was held constant while the hydrogen concentration was varied up to 6.2 volume percent. The temperature distribution throughout the height of the heater section did not vary significantly with changes in the hydrogen concentration. The test also demonstrated that the recombination unit could safely operate at hydrogen concentrations up to 6.2 volume percent hydrogen in the air. Since the recombination unit is designed to operate at 4 volume percent hydrogen, the hydrogen tests offer a considerable margin of successful performance over the performance required.

(g) Air Flow Blockage Test.

46. An air flow blockage test was performed on a production recombination unit to provide information on the effect of air flow blockage on the performance of the recombination unit. Air is the cooling medium for the system. During the test, the air flow openings on the recombination unit were gradually blocked and the resulting increase in recombiner temperature was measured. Since the input power supplied to the recombination unit was held constant, the blocking of part of the airflow would result in a temperature rise inside the unit.

47. For the first test series, the inlet louver was blocked at four levels, varying from fifty percent open to six percent open. The maximum temperature rise that resulted was 50°F, which occurred when only six percent of the inlet louver was left open. In the second test series, one and then two of the three outlet louvers were completely blocked. The maximum resulting temperature rise was 30°F. Such temperature rises are insignificant in comparison to the normal operating temperature of 1200°F. Further, these tests show that the recombination unit is not greatly affected by even extreme blockage of the inlet or outlet louvers.

(h) Over Temperature Test.

48. An over temperature test was run on a production recombination unit to determine the maximum temperature that the inside of the recombination unit could reach. Determination of this temperature requires three assumptions: (1) that the operator inadvertently applied maximum power to the recombiner; (2) that he left this power level on for a long period of time; (3) that the containment was at the maximum allowable post-LOCA hydrogen level of four volume percent during this high power operation. The test was run at full power until the temperature stabilized. Hydrogen was then injected into the containment until a four percent air-hydrogen mixture

was achieved. This air-hydrogen mixture was maintained until the recombination unit's temperature again stabilized. The maximum temperature recorded was 1750°F with no damage occurring.

(i) Over Voltage Test.

49. An over voltage test was run on the heating elements to demonstrate that the breakdown voltage of the heating elements, after being subjected to long term post-LOCA containment environmental conditions, is well in excess of the applied voltage (480 VAC). Only the heating elements were tested because they were the components of the recombination unit most likely to suffer damage from over voltage and the test was intended to demonstrate the performance of the heating elements. To perform the test, three heating elements were placed in the steam chamber and conditioned in a steam-air environment at approximately five psig, 160°F, for 21 days, which simulates the anticipated post-LOCA containment environment. Following this, the elements were tested at 1307 VAC, which voltage was determined based upon the NEMA standard for equipment which has been in service. All three heating elements successfully passed this test.

(j) Heater Capacity Test.

50. A heater capacity test was run to demonstrate the reserve capacity of the recombiner system. For this test,

a production recombination unit, power supply panel, and control panel were connected to a stable 480 VAC power source. The system was energized and the recombiner temperature was stabilized at 1200°F to establish a reference basis. The power required to maintain this stable temperature condition, 45 kw, was recorded. The power controller was then set on full power and this value was also recorded. The difference between the full power and the reference power levels, 28.5 kw, is the reserve power capacity of the recombiner system at 1200°F. Following this, heating elements were disconnected in various heater banks, reducing the number of operational heating elements. The same test was then run. The temperature distribution within the recombination unit for various combinations of heating elements disconnected showed that only slight variations occurred in the temperature profile.

(k) <u>Cable Testing</u>.

51. To show compliance with the standards set for qualification of electrical cable by IEEE 383-1974, "Standard for Type Test of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations," a series of tests were performed on the power cables that included thermal aging, irradiation, post-LOCA containment steam and spray exposure, and voltage tests.

Only the power cables were tested because they are the only components of the recombination unit that need to be qualified to IEEE 383-1974 standards.

52. These tests were performed on two twelve foot cable sections taken from a production unit. One was thermally aged to simulate forty years of normal life; both were irradiated to 2.2×10^8 rad total integrated dose at a dose rate of 1.86×10^5 rad per hour. Upon completion of the irradiation, the aged and unaged cable samples were subjected to a long term pressure test.

53. A pressure chamber containing the cable samples was rapidly pressurized to 106 psia (322°F) with full power on the cables. A spray containing 2,000 ppm boron as boric acid buffered with NaOH to a pH of 10.5 was initiated two minutes after the pressurization. After 15 minutes, the peak pressure was reduced to 85 psia (312°F) with the spray on. This pressure was held for 15 minutes. Pressure then was reduced to 45 psia (227°F) with spray on and held for one hour and 27 minutes. Subsequently, each cable was checked electrically to verify that it was still properly energized. After two hours and eight minutes, the pressure was reduced to 30 psia (257°F) with spray on. This pressure was held for 20 hours. The spray was on for six hours ten minutes. The pressure was then reduced to 20 psia (160°F) and continued for five days.

Next, pressure was raised to 25 psia (195°F) for ten days. The pressure was then reduced to 20 psia (160°F) for a total test time of 33 days. The cables were energized at full power throughout the test. After this test, the cables were removed from the chamber and visually examined. Some discoloration of the glass overbraid that covers the silicone rubber cable jacket was evident.

54. Following the steam testing, voltage testing was performed. The cables were removed from the coil, straightened and then recoiled around a 24 inch diameter metal mandrel. The cable and mandrel were then immersed in tap water and a voltage of 640 VAC was applied to the conductors for five minutes. The cables (aged and unaged) successfully passed this test.

55. Flame testing was next conducted. The purpose of this test was to demonstrate that the cable does not propagate fire even if its outer covering and insulation have been destroyed in the area of flame impingement. IEEE 383-1974 describes a method for flame testing cables. For this test, cable samples from a production unit were subjected to the vertical tray test using a ribbon gas burner and the test methodology described in the IEEE 383-1974 Standard. The cable samples performed satisfactorily in the test, meeting the acceptance criteria described in section 2.5.5 of the IEEE 383-1974 Standard.

(2) <u>Testing Performed on the Power Supply Panel and the Control Panel.</u>

56. High temperature environmental tests on the power supply and control panels constituted the final test phase. Their purpose was to demonstrate that the power supply and control panels will not be adversely affected by operation in an elevated temperature environment. The power supply panel and control panel are located outside of containment and are accessible after a LOCA. For plants located in extremely warm climates, some areas otherwise suitable for installation of the power supply panel and control panel may have short term maximum temperatures higher than the normal NEMA Standard (40°C). To broaden the number of plant areas suitable for installation of those panels, the power supply panel was tested at 135°F and the control panel at 155°F for ten days. These tests show that short term high temperature exposure does not adversely affect these components.

57. To form a high temperature environment around the power supply and control panel, enclosures were constructed. The heat losses from the power supply isolation transformer supplied sufficient heat to heat its enclosure to the desired temperature. The control panel enclosure was heated by a space heater which was thermostatically controlled. The power supply was connected to a production recombination unit, which served as the electrical

load, and also with the control panel. The test was conducted for ten days (240 hours) with no detectable adverse affect on either the power supply panel or control panel.

C. The Changes to the Model A Recombiner Incorporated in the Model B Recombiner Did Not Affect the Model B's Qualification Under the Testing Program Performed on the Model A Recombiner.

58. As stated in paragraph 20 above, the Model B electric hydrogen recombiner system is a revision of the Model A recombiner system. While Westinghouse performed the qualification tests described in paragraphs 22 through 57 on the Model A hydrogen recombiner system, the changes incorporated in the Model B recombiner system were not of a nature that would affect its qualification under that testing program. Westinghouse did conduct a testing program to qualify the features of the Model B recombiner that were incorporated as changes from the Model A.

(1) Changes to the Model A Recombiner System Incorporated in the Model B Recombiner.

59. The power supply panel and control panel are identical in the Model A and Model B recombiners. The only changes incorporated in the Model B design were made in the recombination unit. Those changes fall into three categories, changes recognized as desirable during qualification testing, changes to facilitate installation, and changes to improve manufacturing.

60. The changes recognized as desirable during qualification testing consisted primarily of changes made in the physical configuration of the recombination unit. Westinghouse redesigned the support structure, running the main vertical structural members the full height of the recombiner rather than only to the top of the heater section. The side panels were fastened to the main structure by welding rather than bolting. Rather than using five heater banks, the Model B has four heater banks with increased power capability. The flow channel was redesigned to increase the space between the heater banks. The shape of the louver blades was modified to increase stiffness. The length of the power cables was reduced by rerouting cables, but the type of cable used remained the same.

61. Westinghouse made two changes in the recombination unit to facilitate its installation. It reduced the height of the recombination unit to 98 inches and enclosed the thermocouple junction box and the power lead junction box inside the recombination unit so that they no longer protruded from it.

62. To improve manufacturing Westinghouse made the base structure and electrical junction box out of stainless steel rather than carbon steel so that they would not have to be painted. The structural members of the heater

frame of the Model B recombiner are made of Incoloy 800 rather than Inconel 600. Finally, Westinghouse redesigned the thermal insulation system to facilitate insulation installation and to remove air spaces that existed in the Model A recombiner.

(2) Testing Performed on the Model B Hydrogen Recombiner System.

63. In addition to performance tests and testing conducted to demonstrate the seismic qualification of the Model B recombiner pursuant to the standards set by IEEE 344-1975, Westinghouse performed several tests to qualify those features of the Model B recombiner that differed from the Model A. These tests, in conjunction with the qualification tests performed on the Model A recombiner, establish the Model B recombiner's qualification under the standards set by IEEE 323-1974. In all of these tests a production recombination unit was used.

(a) Heatup Test.

64. To measure the power required to reach recombination temperature, the recombination unit was connected to a power supply panel and control panel and energized in increasing steps. The recombination unit reached recombination temperature at 49 kw, leaving a 26 kw reserve.

(b) Air Flow Test.

65. In this test, Westinghouse measured the airflow through the recombination unit to ascertain whether the

flow rate equalled or exceeded design requirements. When the recombination unit was heated up to 1250°F, the flows measured were well in excess of the design value of 100 scfm.

(c) Aging Test.

66. The purpose of this test was to show that the recombination unit would not be damaged by the thermal stresses resulting from the approximately eighty heatup and cooldown cycles it would undergo in periodic tests to demonstrate its availability. Similar to the cycling test performed on the Model A recombiner described in paragraph 24 above, Westinghouse alternately heated the recombiner to 1250°F and then cooled it to approximately ambient temperature. This cycle was repeated 100 times. The recombination unit was then examined for damage, and none was found.

(d) Hydrogen Tests.

67. The purpose of this test series was to demonstrate the safe operation of the Model B recombiner in an air-hydrogen atmosphere and to measure the hydrogen removal rate. The recombination unit was energized and brought to a temperature of 1225°F. When the temperature had been stabilized for thirty minutes, hydrogen was injected in varying concentrations. For 4.0 volume percent hydrogen, no measurable hydrogen was found at the

outlet of the recombination unit. The temperature stabilized at 1474° F at 4.0 volume percent hydrogen, well below the temperature at which the heating elements had been previously tested, as described in paragraph 40 above.

(e) Spray Tests.

68. In this test, a spray solution of sodium tetraborate, containing 2500 ppm boron as boric acid and sodium hydroxide to bring the solution to approximately pH 10, was applied to the recombination unit. The recombination unit was then energized and brought to 1225°F while in the spray. After ten days, a two-percent air-hydrogen mixture was injected and processed with no detectable hydrogen at the recombiner exit. No significant amount of spray residue accumulated on the recombiner inlet, and flow through the unit was not affected.

D. The Westinghouse Qualification Testing Program for the Model B Electric Hydrogen Recombiner System Establishes the Ability of That Equipment to Withstand Accident Conditions.

69. The generic environmental qualification testing performed by Westinghouse upon the electric hydrogen recombiner system described above establishes the ability of that equipment to withstand accident conditions. Bechtel Power Corporation has advised Westinghouse that the maximum environmental extremes to which the recombination unit might be subjected under accident conditions at VEGP are (a) a temperature of 305° (290°F

plus a 15°F margin), (b) pressure of 50 psig, (c) radiation of 2 x 10^8 rads total integrated dose, and (d) a chemical spray of 2000 ppm boron buffered with sodium hydroxide to a long term (more than 100 minutes from the beginning of the LOCA) pH of 8.5. In the testing performed by Westinghouse, either a production recombination unit or those components that might suffer damage from the particular adverse environmental condition being simulated were exposed to the following extreme conditions: (a) temperature of 309°F, (b) pressure of 77 psia (62.3 psig), (c) radiation of at least 2 x 10^8 rads total integrated dose, and (d) a chemical spray of 2500 ppm boron buffered with sodium hydroxide to a pH of 10.0. Thus the VEGP post-LOCA environmental conditions are conservatively enveloped by the test conditions to which the recombination unit was exposed.

70. The power supply panel and control panel are located in the control building at VEGP. Those components of the electric hydrogen recombiner will not be subject to radiation or to extremes of temperatures greater than the temperatures to which they were tested as described in paragraphs 56 and 57 above.

IV. Conclusion.

71. Based upon the extensive environmental qualification testing performed on the Westinghouse electric hydrogen recombiner systems summarized above, which testing enveloped the conditions to which the hydrogen

recombiners might be exposed at VEGP, I am confident that the Westinghouse Model B electric hydrogen recombiner system is acceptable for use at VEGP.

RICHARD B. MILLER

Sworn to and subscribed
before me this 17th day
of July, 1985.

Notary Public

LORRAINE M. PIPLICA, NOTARY PUBLIC
MONROEVILLE BORO, ALLEGHENY COUNTY
MY COMMISSION EXPIRES DEC 14, 1987
Member, Pennsylvania Association of Notaries

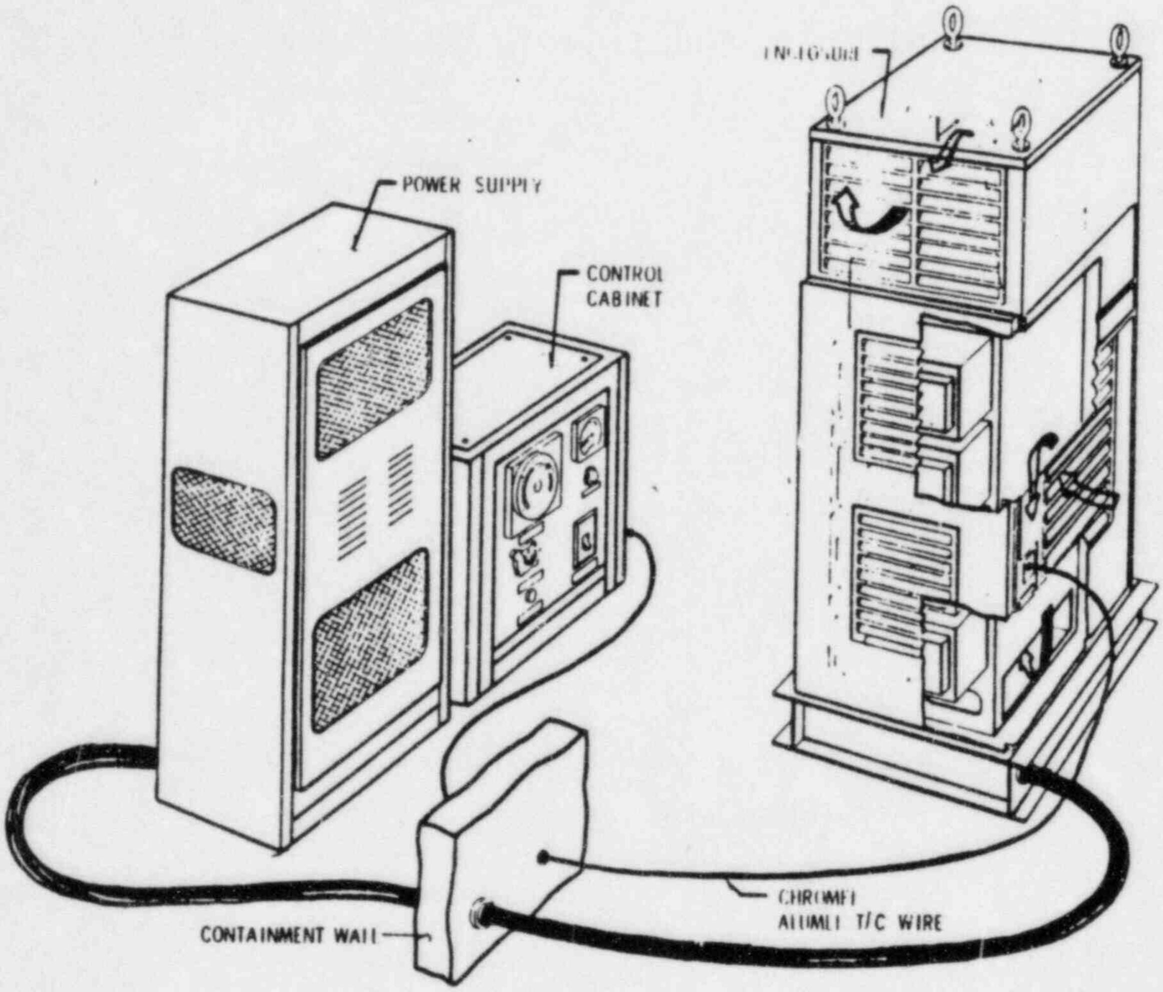

Figure 10.7-1

Westinghouse Model B
Electric Hydrogen Recombiner System

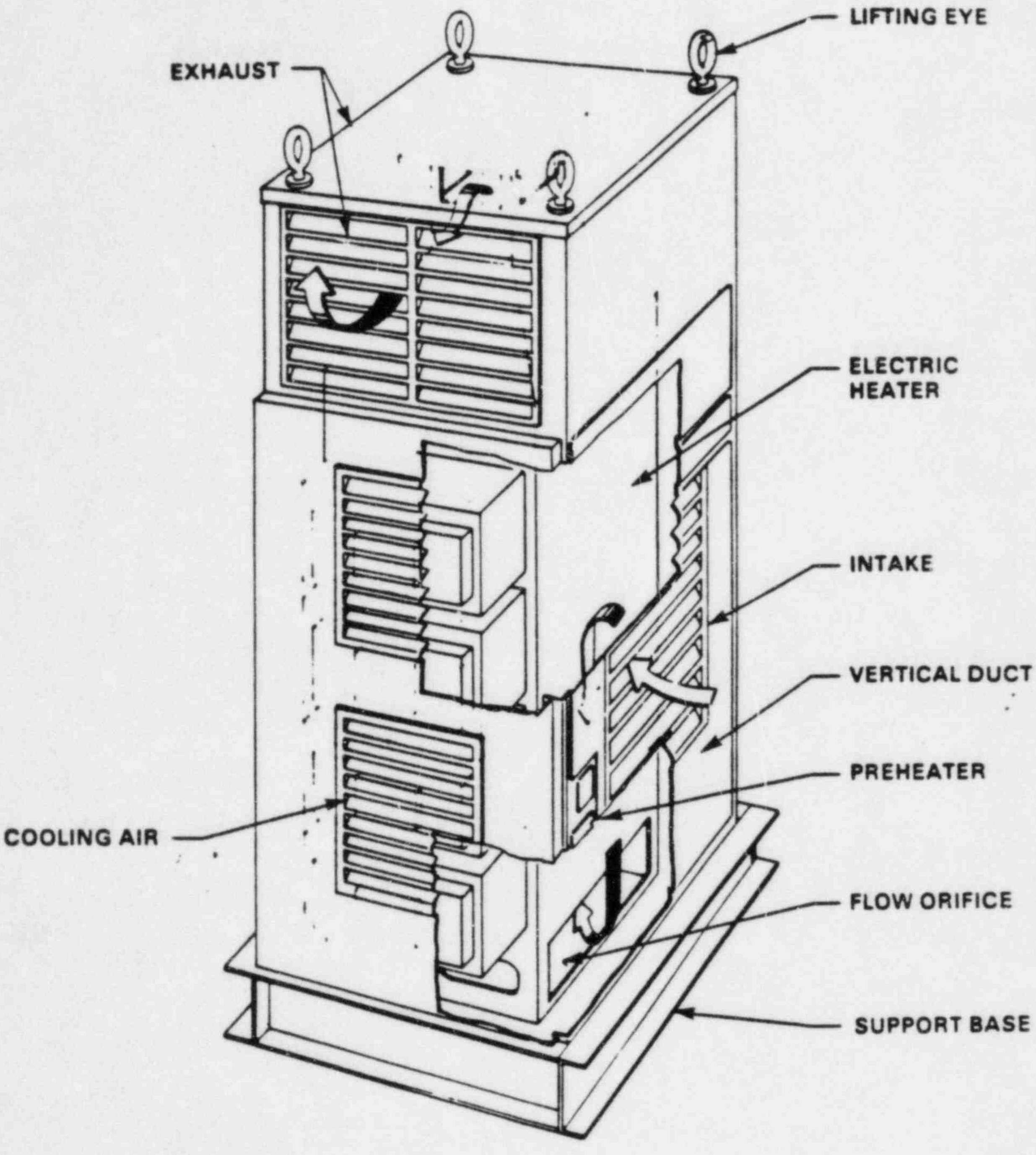

Figure 10.7-2

Cutaway of Model B
Recombination Unit

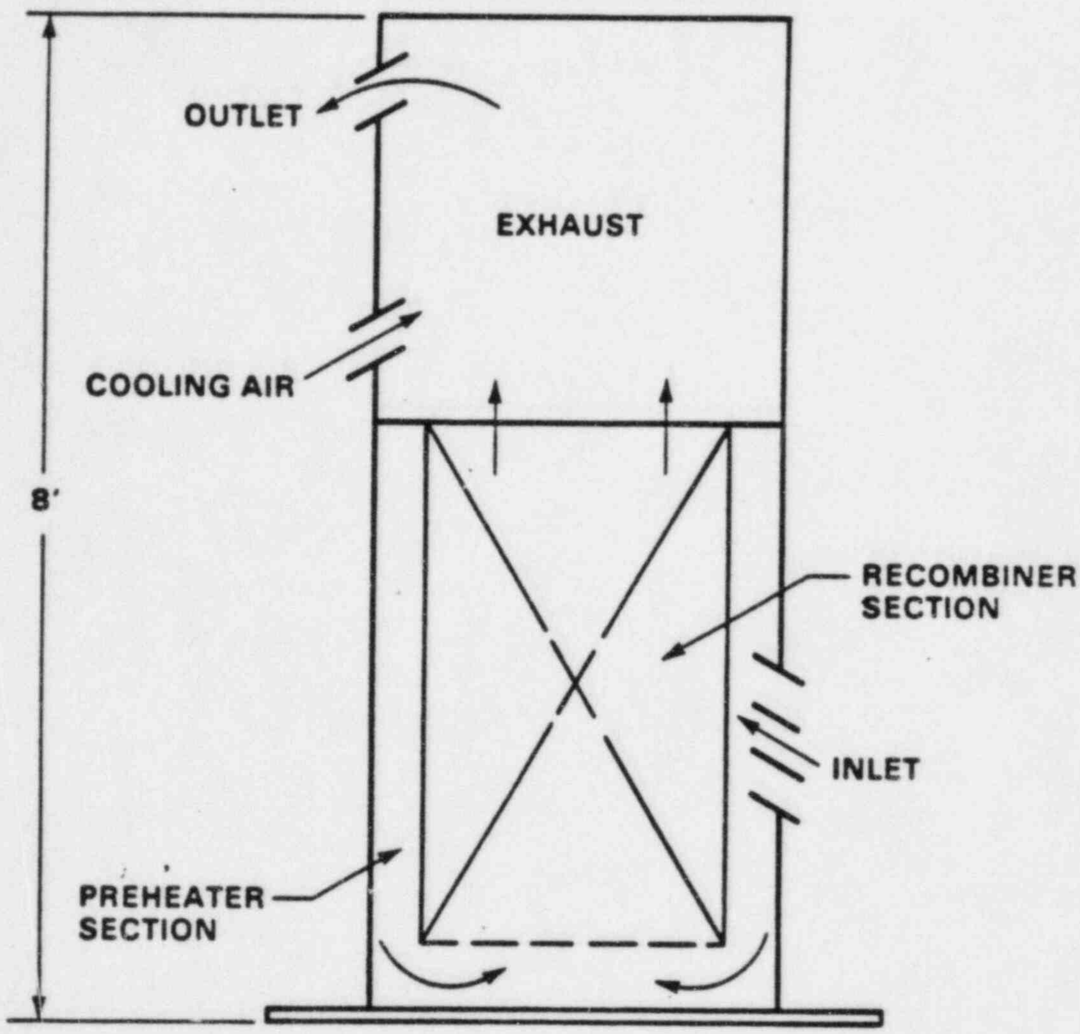

Figure 10.7-3

Diagram of Model B
Recombination Unit in Operation

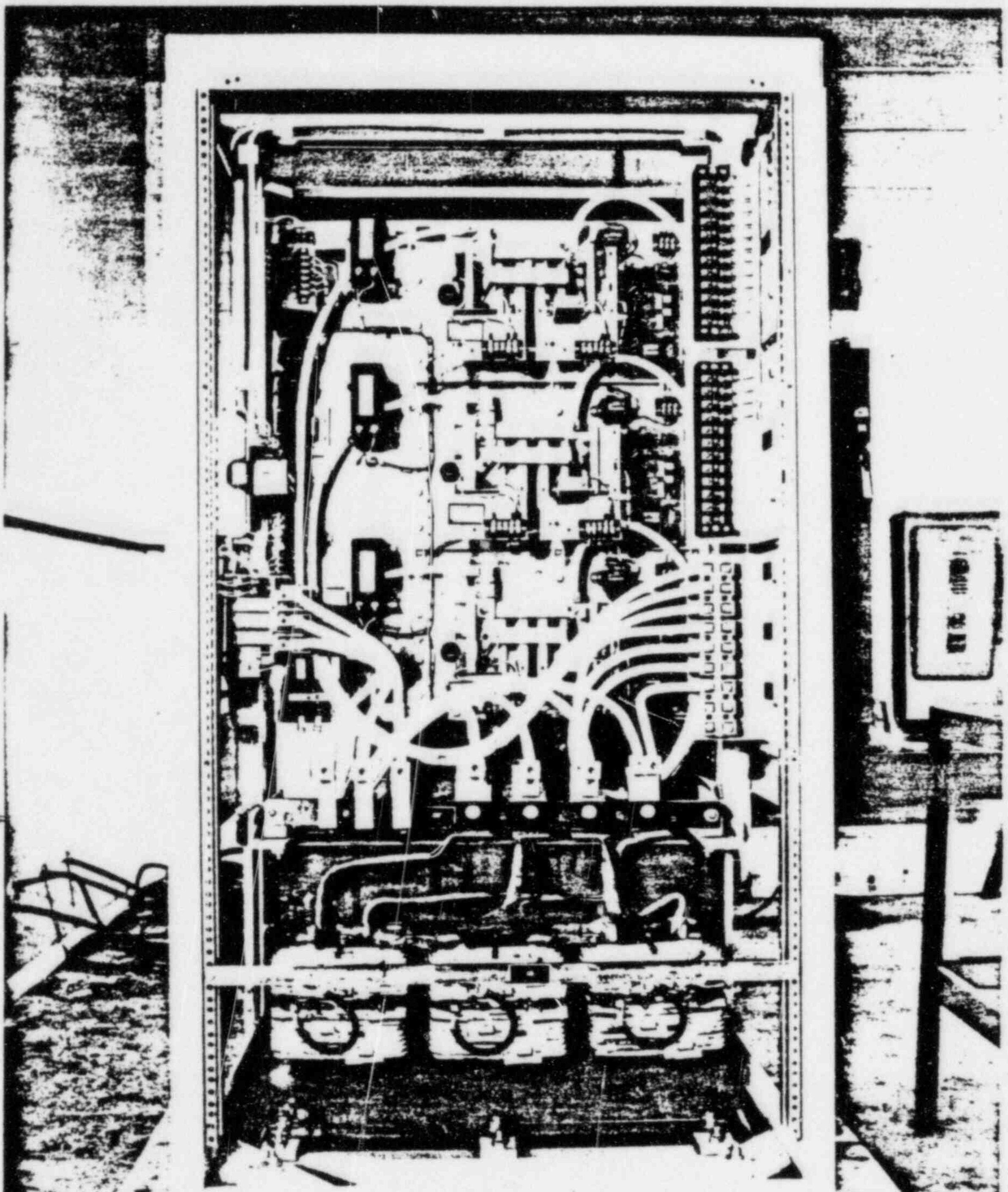

Figure 10.7-4

Power Supply Unit
Front View

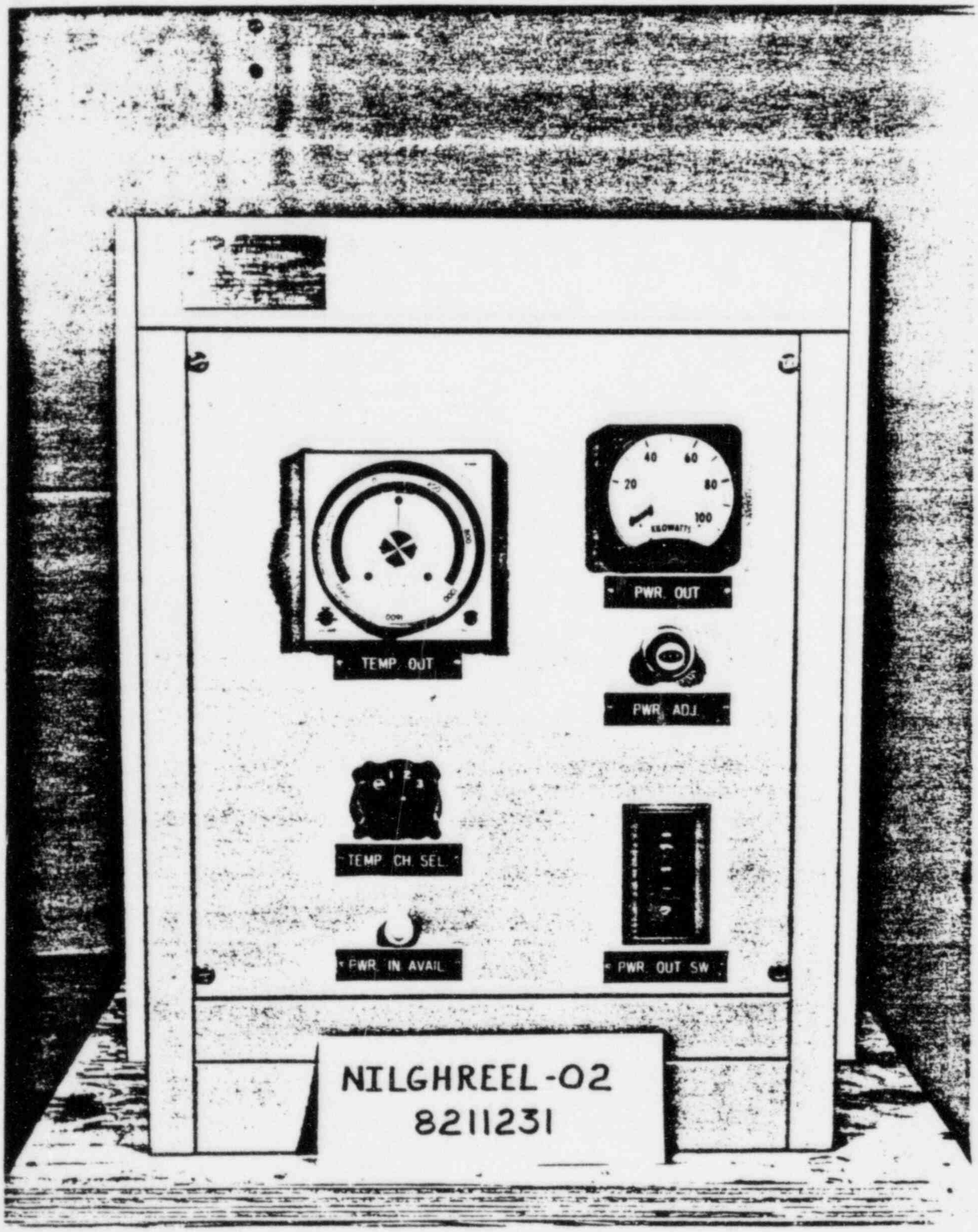

Figure 10.7-5

Control Panel Unit
Front View

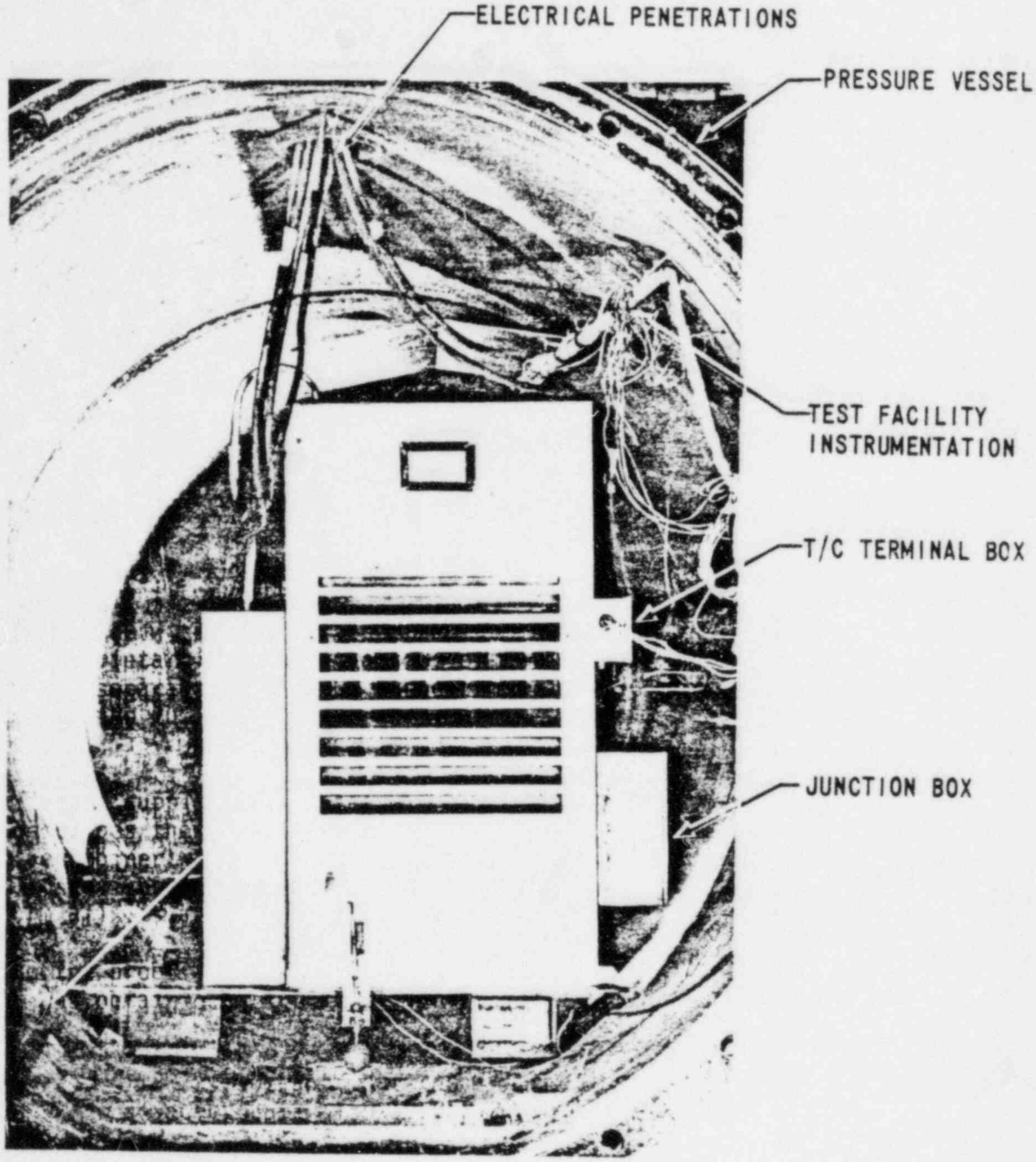

Figure 10.7-6

Heater Frame Test Assembly
Installed in Pressure Chamber

Summary of Qualifications

Richard B. Miller

Principal Engineer

Nuclear Technology Division
Westinghouse Electric Corporation

I was graduated from the University of Delaware in 1967 with a Bachelor of Electrical Engineering degree and joined Westinghouse that year in the Field Service Department. After participating in several plant startups, I transferred to the Engineering Department in 1970. While there, I had lead responsibility for the design and procurement of instrumentation systems and sensors, as well as being the interface between Nuclear Safety and Engineering for licensing issues. I am the co-author of WCAP-8587, "Methodology for Qualifying Westinghouse WRD Supplied NSSS Safety Related Electrical Equipment," and several IEEE papers on the qualification of electrical equipment. I am the Secretary of the IEEE sub-committee on electrical equipment qualification (NPEC/SC-2) and am a registered Professional Engineer in the State of Pennsylvania. I have also been very active in establishing instrumentation setpoints consistent with safety analysis limits and plant and instrument characteristics and have co-authorred a report detailing the methodology that is used for determining plant specific setpoints. I am presently the lead engineer in the Nuclear Safety Department responsible for electrical equipment qualification and am the primary interface on this subject with the NRC and Westinghouse customers.

EXHIBIT B

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

June 22, 1978

JUN 26 1978
T. M. Anderson, Manager
Nuclear Safety Department

Mr. Thomas M. Anderson, Manager
Nuclear Safety Department
Westinghouse Electric Corporation
P. O. Box 355
Pittsburgh, Pennsylvania 15230

Dear Mr. Anderson:

SUBJECT: EVALUATION OF WCAP-7709L, SUPPLEMENTS 5, 6, AND 7

We have completed our review of Westinghouse Electric Corporation report Supplements 5, 6, and 7 to WCAP-7709L (Proprietary) and WCAP-7820 (Non-Proprietary) entitled "Electric Hydrogen Recombiner for PWR Containments". Our evaluation is enclosed.

As a result of our review, we have concluded, subject to the conditions in our enclosed evaluation, that the Westinghouse electric hydrogen recombiner is acceptably qualified for the seismic and environmental conditions identified in Supplements 1 through 7 of WCAP-7709L in accordance with the requirements of IEEE 323-1974. Applications using the Westinghouse recombiner must include in their Final Safety Analysis Report information to demonstrate either (1) that accident environmental conditions and plant seismic response spectrum are either within the accepted envelope conditions in WCAP-7709L or (2) that the recombiner is acceptably qualified on some other analytical or experimental basis.

Accordingly, topical report WCAP-7709L and its Supplements 1 through 7 are acceptable for reference in license applications. Topical report WCAP-7820 and its Supplements 1 through 7 is an acceptable non-proprietary version of WCAP-7709L. When either of these reports is used as a reference, both the proprietary report and the non-proprietary version must be referenced.

In accordance with established procedures, it is requested that Westinghouse issue revised versions of these reports within three months of receipt of this letter to include this acceptance letter, the enclosed evaluation, and any changes resulting from our review.

We do not intend to repeat our review of these reports when they appear as references in a particular license application except to assure that the material presented in these reports is applicable to the specific plant involved.

Should Nuclear Regulatory Commission criteria or regulations change, such that our conclusions concerning these reports are invalidated, you will be notified and given an opportunity to revise and resubmit your topical reports, should you so desire.

Sincerely,

For J. A. Peltier
John F. Stolz, Chief
Light Water Reactors Branch No. 1
Division of Project Management

cc: Mr. D. Rawlins
Westinghouse Electric Corporation
P. O. Box 355
Pittsburgh, Pennsylvania 15230

ENCLOSURE

SAFETY EVALUATION REPORT

SUPPLEMENTS 5, 6, AND 7 OF WCAP-7709-L
"ELECTRICAL HYDROGEN RECOMBINER LWR CONTAINMENT"

Summary of Topical Report

Westinghouse Electric Corporation has developed and tested an electric hydrogen recombiner to limit hydrogen concentration within a pressurized water reactor containment following a loss-of-coolant-accident. This recombiner is located inside the containment and consists of a metal sheathed electric resistance heater provided to heat a continuous flow of containment gas mixture to about 1150°F. At this temperature hydrogen reacts with oxygen in the environment to form steam, thereby reducing the hydrogen content in the containment atmosphere. The control panel and power supply are located outside the containment.

The recombiners are designed to be permanently installed inside of containment and are not intended to be used for sharing between two or more units. Therefore the design criteria for these recombiners do not take into account vibratory and impact loads that would be imposed during transportation in addition to the loads that would be imposed during a seismic event.

WCAP-7709 L provides a description of the electric hydrogen recombiner, design criteria, design bases and performance analyses. Supplement 1 to WCAP-7709 L provides a description, analysis and results of performance tests of a prototype recombiner under conditions simulating post-LOCA conditions inside containment. Supplement 2 to WCAP-7709 L provides a description, analysis and results of tests to qualify the recombiner for seismic loads and loss-of-coolant-accident environments. Supplement 3 provides a description, analysis and results of long term tests of the electric heater elements in air (60 days) and in a post-LOCA steam environment (21 days). Supplement 4 provides a description, analysis, and results of performance tests of a production unit to demonstrate its capability to operate when sprayed with sodium tetraborate and to successfully recombine hydrogen and oxygen.

The staff has previously reviewed WCAP-7709 L through Supplement 4, and found the Westinghouse recombiner functionally acceptable for use in nuclear power plants. In addition, environmental and seismic qualification was found to be acceptable based on the requirements of IEEE 323-1971, "General Trial - Use Guide for Qualifying Class IE Electrical Equipment for Nuclear Power Generating Stations" and IEEE 344-1971, "Trial-Use Guide for Seismic Qualification of Class IE Electrical Equipment for Nuclear Power Generating Stations". Our safety evaluation was transmitted to Westinghouse by letter dated May 1, 1975 from D. B. Vassallo to C. Eicheldinger. In that evaluation we concluded that additional documentation would be required for

plants committed to meet IEEE-323-1974 "IEEE Standard for Qualification of Class IE Electrical Equipment for Nuclear Power Generating Stations". This standard includes both seismic and environmental qualifications.

Supplements 5, 6, and 7 to WCAP-7709-L provide additional documentation to demonstrate conformance of the Westinghouse electric hydrogen recombiner to the requirements of IEEE 323-1974. Supplement 5 provides the results of tests to demonstrate design margin, capability to withstand containment leakage tests, and capability to operate during an earthquake. Supplement 6 compares the tests and analyses performed for the recombiner with the requirements in IEEE 323-1974 to demonstrate conformance. Supplement 7 provides results and analyses of additional tests to demonstrate acceptance of auxiliary equipment for the recombiner (power supply, control panel, power cables, cold reference junction box, and automatic temperature controller).

Our evaluation of Supplements 5, 6, and 7 to WCAP-7709-L are provided below.

Summary of Regulatory Evaluation

Information in Supplements 5 and 6 is intended to show that the Westinghouse electric hydrogen recombiner is in conformance with IEEE 323-1974. Type testing (recommended in IEEE 323-1974 as the preferred method), was primarily used to qualify the Westinghouse recombiner. The tests and analyses performed by Westinghouse adequately, demonstrate that the recombiner, excluding the control panel and power supply, meets the following specific requirements of IEEE 323-1974

1. The equipment shall be operated to the extremes of performance and electrical characteristics. . . The recombiner was operated at higher than normal temperatures (1450°F versus the normal operating temperature of 1200°F). We noted in our May 1, 1975 evaluation that 1450°F gas temperature corresponded to a maximum sheath temperature of 1600°F (rated sheath temperature) and that this temperature was achieved with 66 kilowatts power supplied to the heaters.

   In Supplement 5, additional over temperature tests were successfully run with the heater at maximum power level and sheath temperatures up to 1750°F. We conclude based on the tests, that the heaters will operate satisfactorily with the maximum power of 75 kilowatts supplied to the recombiner.

2. Equipment shall be aged in accordance with Section 6.3.3 of IEEE 323-1974 to put it in a condition which simulates its expected end-of qualified life condition . . . The recombiner inside containment is composed primarily of metallic structural material, metal-enclosed thermal insulation, metal clad ceramic heater elements, and power cables. Since the recombiner is in a normal containment atmosphere and subjected to periodic testing, Westinghouse concluded that the most significant aging factor was the fatigue life of the structure, due to thermal stresses induced by the periodic heat up and cool down tests (i.e., the recombiner would not deteriorate significantly due to normal atmospheric conditions alone). The recombiner structure was subjected to 80 thermal cycles, corresponding to 40 years of expected periodic testing, and was found to be in good operating condition.

   We conclude that the recombiner structure was satisfactorily tested to demonstrate acceptable end of life condition. The power cable inside containment was tested in accordance with IEEE Std 383-1974 and after reviewing the details of the tests performed, we conclude that the irradiation, steam, and alkaline spray conditions were sufficiently severe and the cables were acceptably qualified.

3. The aged equipment shall be subjected to mechanical vibration. . .

   The Mechanical Engineering Branch has evaluated the mechanical vibration tests conducted on the "aged" equipment. The concept of aging was addressed explicitly for the first time in IEEE-Std. 323-1974. The aging guidance therein reflects the requirements of IEEE Std. 279-1971 Sec. 4.4. The objective of aging is to put samples in a condition equivalent to the end-of-life condition.

   For the initial seismic tests reported in WCAP-7709-L, Supplement 2, it was assumed that the recombiner is in the de-energized mode since, for PWR containments, the recombiners are not energized for approximately 24 hours after the DBA. A seismic analysis of the recombiner heater element is presented in Appendix B of Supplement 5 to WCAP-7709-L which demonstrates analytically that the recombiner would function adequately under seismic conditions while it is energized and is in operation. In this analysis the natural frequency of the heater elements are calculated to be 250.5 cps for built-in ends and 112.0 cps for simply supported ends. Static loadings equal to 5.6g horizontal and 2.5g vertical (1.5g seismic + 1g weight) are applied in the analysis. The stresses are determined to be 1322 psi and 607 psi in the horizontal and vertical directions, respectively, which are much less than the yield strength of 13500 psi for Incoloy 800 tubing at 1600°F. This tubing forms the metal cladding of the heater element assembly and since it is the most highly stressed part of the assembly, heater elements are acceptable for the hot seismic condition. The midspan deflections and the clearance between heater elements and holes in

the separation plates have also been analyzed and shown to have a negligible effect on recombiner performance.

An additional vibration test of a production recombiner is described in WCAP-7709-L, Supplement 5 in which the recombiner was energized and at temperature before, during and after the vibration test. This test confirms the analysis of the heater elements discussed earlier. The equipment was vibrated in 3 directions, horizontal side-to-side, horizontal front-to-back and vertical. The recombiner was maintained at 1250°F throughout and after the test. The test input was of the sine beat wave form type and was performed at resonant frequencies, determined by a frequency search test performed from 1 to 35 Hz plus additional frequencies described in the report. The test method used is a single frequency method (described in IEEE 344-75 Section 6.6.2.3). The single frequency sine beat method is justified for this application on the basis that the resonances are widely spaced and do not interact to reduce the fragility level, as permitted in Section6.6.2 of IEEE 344-75. The single axis test is justified on the basis that the tests conservatively reflect the seismic loadings at the equipment mounting locations. A commitment is made in the report that for each plant application, the required seismic response spectrum for that plant will be checked against the test response spectrum to verify that the test response spectrum envelopes the required response spectrum. This is consistent with the requirements of Regulatory Guide 1.100.

4. <u>The aged equipment shall be operated while exposed to a simulated DBA</u>. . .

A series of tests were performed on the portion of the production recombiner that is located inside the containment, including several post-LOCA pressure transients (69 psia, 302°F) and long term steam tests to demonstrate that the recombiner can successfully withstand the post-LOCA environment. In addition, alkaline solution was sprayed on the recombiner during operation. These tests have been accepted by the staff for qualification of the Westinghouse electric hydrogen recombiner because the recombiner has no temperature sensitive electrical components required to operate during the portion of the post-LOCA pressure transient wherein high temperatures exists and the maximum expected steam temperature following a steam line break (420°F) is not likely to cause structural failure of the recombiner.

5. <u>The equipment shall be operated while exposed to the simulated post-accident conditions</u>. . . To show the long term capability of the heater banks to operate in the post-LOCA environment, two heater banks were subjected to a DBA plus 12 months of simulated post-LOCA environment. The test showed that the individual heater elements and banks plus thermocouples, electrical cabling, and thermocouple junction boxes which are susceptible to steam would perform satisfactorily.

Supplement 7 to WCAP-7709-L is the last in the series of reports for the Westinghouse electric recombiner and contains qualification results for the recombiner power cable located inside containments, the recombiner control and power supply panels located outside containments, and additional optional features including a cold reference junction box and an automatic temperature control device which may be selected by an applicant.

The qualification of the control panel and power supply located outside the containment does not meet our interpretation of the aging requirements set forth in IEEE Std 323-1974. However, tests performed on the control panel and power supply located outside the containment included short-term high temperature exposure (10 days at 155°F for the control panel and 10 days at 135°F for the power supply). We found the qualification of the control panel and power supply acceptable, based on these tests and also based on the accessibility of these components for repair following a LOCA. The recombiner will not be needed for several days following a LOCA and since these components will be easily accessible, repair of components that may fail can be accomplished.

Seismic tests of the control panel and power supply were performed to demonstrate conformance to IEEE 344-1975 "Recommended Practice for Seismic Qualification of Class IE Equipment for Nuclear Power Generating Stations". IEEE 344-1975 recommends that seismic tests be performed using biaxial motion and both random frequency and sine beat input. The power supply and control panels were mounted on the drive plate of a vibration table and energized. The test series consisted of resonance frequency search plus five OBE's followed by an SSE. The input for the five OBE's was a biaxial, random frequency while the SSE was a biaxial sine beat input, the maximum "g" level being 0.2. The magnitude of the vertical acceleration was kept to two-thirds the magnitude of the horizontal acceleration. The input was made of decaying sinusoids covering the frequency range of 1.25 to 3.50 Hz. The sine beat test was performed at each resonance frequency and at eleven other frequencies ranging between 1.25 and 33.5 Hz. These tests were run four times (once for each equipment mounting direction) without component failure. We find these tests acceptable.

The power cables for the recombiner were tested along with the heater banks in the post LOCA steam and spray environment and seismically tested with the recombiner. The testing did not completely conform to the procedure outlined in IEEE 383-1974, "Standard for Type Tests of Class IE Electric Cables, Field Splices and Connections for Nuclear Power Generating Stations". To meet the requirements of Section 2.4 of this standard, which deals with environmental exposure, a series of tests were performed on the power cables which included thermal aging, irradiation, post LOCA containment steam and spray exposure and voltage tests. We find these tests acceptable.

The cold reference junction box is for use in those containments which have copper conductors through containment penetrations already installed. The usage of a compensator in the junction box allows the chromel-alumel leads from the recombiner to be connected to copper leads inside

the junction box. The copper leads can then be run through a typical copper penetration to the control panel, thus eliminating the need to replace installed copper penetrations with chromel-alumel penetrations. The cold reference junction box, with the exception of the compensator, has been tested for the same range of conditions as the tests that were performed on the recombiner. The compensator itself was irradiated and placed in a steam environment for a short period of time. Since the compensator (a wire-wound resistor encapsulated in a ceramic type material) does not have temperature sensitive elements in it and since the compensator is used only to provide the operator with an approximation of the temperature of the heater inside the recombiner and has no control functions, we find the qualification tests of the cold reference junction box to be acceptable.

The automatic temperature control feature is an option which allows the power level to be controlled by feedback signal from the recombiner thermocouples. It consists of minor wiring modifications within the control panel and addition of a printed cicuit card to the temperature indicator. Because the changes that would have to be made in the design of the control panel to add the automatic temperature control feature are minor, we find this concept acceptable from a qualification standpoint. However, the use of this device to control a recombiner system that also incorporates the cold reference junction box would mean that a compensator in the junction box would be relied upon for control purposes. To alleviate this problem Westinghouse has agreed not to allow the use of the automatic temperature control device except during periodic tests for those plants that choose to use the cold reference junction box. We find this approach acceptable.

Regulatory Position

Based on our review of WCAP-7709-L, we have concluded as follows:

(1) The Westinghouse electric hydrogen recombiner, (excluding the control panel, power supply and the optional automatic temperature control and cold reference junction) meets the requirements of IEEE 323-1974.

(2) The control panel and power supply are acceptable on the basis of high temperature exposure tests and also because there would be adequate accessibility and time for repair, if necessary, following a loss of coolant accident before they would be required to operate.

(3) The recombiner, control panel and power supply meet the requirements of IEEE-344-1975.

(4) Power cables meet the requirements of IEEE-383-1974.

(5) The optional automatic temperature control feature is acceptable for use on all plants except those which use the cold reference junction box. For plants using the cold reference junction, automatic temperature control may be used for periodic tests but must be disconnected at other times during plant operation.

(6) The cold reference junction box is acceptably qualified to provide approximate heater temperature indication to the operator; however, it is not qualified for control functions.

Westinghouse report WCAP-7709-L and Supplements 1 through 7 may be referenced in applications to support the above conclusions where the calculated accident environmental conditions and plant seismic response spectrum are enveloped by the conditions for which the recombiner is qualified. Each application referencing this topical report shall either include information to demonstrate that environmental and seismic conditions for that plant fall within the accepted envelope conditions of WCAP-7709-L, or provide further analyses or tests to demonstrate acceptability.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	:	
	:	
GEORGIA POWER COMPANY, et al.	:	Docket Nos. 50-424
	:	50-425
(Vogtle Electric Generating	:	
Plant, Units 1 and 2)	:	

CERTIFICATE OF SERVICE

I hereby certify that copies of the Affidavit of Richard B. Miller, dated July 17, 1985, were served upon those persons on the attached Service List by deposit in the United States mail, postage prepaid, or where indicated by an asterisk (*) by hand delivery, this 18th day of July, 1985.

James E. Joiner

James E. Joiner
Attorney for Applicants

Dated: July 18, 1985

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

In the Matter of	)	
	)	
GEORGIA POWER COMPANY, et al.	)	Docket Nos. 50-424
	)	50-425
(Vogtle Electric Generating Plant,	)	
Units 1 and 2)	)	

SERVICE LIST

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