TOPICAL REPORT EVALUATION

Report Numbers and Titles:

Proprietary	Non-Proprietary
1A. WCAP-7709-L, Electrical Hydrogen Recombiner for Water Reactor Containments (July 1971)	1B. WCAP-7820, Electrical Hydrogen Recombiner for Water Reactor Containments (December 1971)
2A. WCAP-7709-L, Supplement 1, Electric Hydrogen Recombiner for PWR Containments (April 1972)	2B. WCAP-7820, Supplement, Electric Hydrogen Recombiner for PWR Containment (May 1972)
3A. WCAP-7709-L, Supplement 2, Electric Hydrogen Recombiner for PWR Containments Equipment Qualification Report (September 1973)	3B. WCAP-7820, Supplement 2, Electric Hydrogen Recombiner for PWR Containments Equipment Qualification Report (October 1973)
4A. WCAP-7709-L, Supplement 3, Electric Hydrogen Recombiner for PWR Containments Long Term Tests (January 1974)	4B. WCAP-7820, Supplement 3, Electric Hydrogen Recombiner for PWR Containments Long Term Tests (February 1974)
5A. WCAP-7709-L, Supplement 4, Electric Hydrogen Recombiner for PWR Containments (Apirl 1974)	5B. WCAP-7820, Supplement 4, Electric Hydrogen Recombiner for PWR Containments (May 1974)

Originating Organization: Westinghouse Electric Corporation, Nuclear Energy Systems

Reviewed By: Containment Systems Branch, Directorate of Licensing, July 1974

Summary of Topical Reports

Westinghouse Electric Corporation has developed an electric hydrogen recombiner as part of the combustible gas control system to control hydrogen concentration within a pressurized water reactor containment following a loss-of-coolant accident. The recombiner consists essentially of a thermally insulated vertical metal duct with metal sheathed electric resistance heater provided to heat a continuous flow of containment gas mixture up to a

temperature which is sufficiently high to react the hydrogen and oxygen. The gas mixture enters the recombiner and flows up through the heater section and out the top by natural convection. No circulation fans are required and the air flow rate is established by an orifice plate at the bottom of the recombiner. The recombiner is designed to circulate 100 scfm of air through the recombiner and has a power rating of 75 kilowatts. The above reports describe the recombiner and the various tests that have been conducted.

WCAP-7709-L and WCAP-7820 present the analytical basis for selection of the design requirements and a description and results of the proof-of-principle tests which demonstrated the basic feasibility of the thermal recombiner. These tests were performed by flowing various mixtures of air, nitrogen, and hydrogen through a tubular assembly containing an electric resistance heater to determine heater gas temperature limits and recombination efficiency. The results of these proof-of-principle tests showed a recombination efficiency of essentially 100% was obtained for heater gas outlet temperatures greater than approximately 1150°F and that the recombination efficiency was not affected by gas mixture composition over the range of interest.

The description of the electric hydrogen recombiner and the test program for the proof-of-principle tests are repeated in WCAP-7709-L, Supplement 1 and WCAP-7820, Supplement. These reports also describe the tests that were conducted on the full-scale prototype recombiner. The tests were conducted in a silo type of facility to simulate an actual PWR containment building. A spray system was provided in the top of this building and fans were utilized

in some tests to simulate various air currents around the recombiner.

The following type of tests were conducted on the full-scale prototype recombiner:

a. Air tests to establish the natural convection flow characteristics of the recombiner and to measure internal temperature.

b. Air and hydrogen tests to determine the recombiner electric power requirements and operating temperature for a PWR containment.

c. Tap water (with and without hydrogen) and a 24-hour sodium tetraborate (with hydrogen) spray tests to confirm that the containment spray would have no significant effect on the ability of the recombiner to function properly.

d. Steam tests to confirm that steam would have no significant effect on the recombiner operations.

e. Air current tests utilizing fans to determine the effect of various air currents on the performance of the recombiner and to check for any tendency for recirculation.

The results of these tests showed that the prototype recombiner performed satisfactorily.

WCAP-7709-L, Supplement 2 and WCAP-7820, Supplement 2 describes the tests conducted on the production unit electric recombiners. The production recombiner is essentially the same as the prototype except for some minor

design changes. The following types of tests were conducted:

a. Air flow tests on three units and temperature distribution tests on five units. These two tests were performed on a production recombiner to demonstrate that the orifice configuration which controls the air flow through the recombiner was correct and permitted a minimum of 100 scfm of air flow and that the temperature in the recombiner reached 1150°F.

b. Thermal cycle tests were conducted to prove the recombiner can sustain repeated cycling during normal service life. The thermal cycling is expected due to periodic in-plant heatup tests to demonstrate availability of the recombiner.

c. Seismic tests to demonstrate the adequacy of the recombiner to perform their intended purpose following an earthquake. Vibration testing was chosen as the method for verifying the performance of the equipment under earthquake conditions. The equipment tested included both the prototype and production recombiner, power supply and control panel.

d. Containment environment tests were conducted to demonstrate that the recombiner will function properly in the containment post-LOCA pressurized steam and spray environment. A secondary purpose was to estimate the amount of reserve life left in the recombiner system. The test facility consisted of a large pressure vessel, boiler and

control devices. Various equipment that had been subjected to 80 heatup and cooldown thermal cycles were also tested. Heaters were tested at high pressure, at moderate pressures, and at low pressures with contianment spray added to the steam. Tests were conducted using both sodium tetraborate and sodium throsulfate spray with steam. After six simulated post-LOCA pressure transients, no functional failure was produced. The heater banks were completely disassembled and tested. Visual inspection indicated that 11 out of 240 heater elements showed nondisabling sheath damage at the cold end. To confirm that the sheath splits occurred after a number of simulated post-LOCA transients, the steam chamber tests were repeated on another set of four heater banks. No damage and no clad splits were found after the first post-LOCA transient. To confirm the reserve life left after a post-LOCA transient, these heater banks were subjected to a series of further transients that showed that at least four post-LOCA pressure transients are required to initiate this type of nondisabling damage.

e. Ground fault tests were conducted to demonstrate that a single ground fault in the system will not result in failure of the recombiner.

f. Irradiation tests were performed to demonstrate that the electrical components in the recombiner will perform their functions after irradiation. All components except one were preaged by subjecting them to 80 heatup and cooldown thermal cycles and then all components were subjected to six post-LOCA steam pressure and spray cycles.

Tests confirmed that the electrical components of the recombiner will withstand and perform satisfactorily after exposure to radiation levels up to $2x10^8$ rods. These reports contain two appendices; one which describes the electric hydrogen recombiner and the other elaborates on certain topics which have been covered in earlier reports.

All tests shown that the production electric hydrogen recombiner with its associated equipment will satisfactorily perform its intended functions.

WCAP-7709-L, Supplement 3 and WCAP-7820, Supplement 3 describes the long-term tests that were conducted on a production recombiner. The following three separate tests were performed:

a. High temperature heater test on 12 production heater elements that were inserted into a special constructed oven with their cold ends protruding through the oven wall. This was to simulate the recombiner heater bank in the recombiner heater frame. This test demonstrated that the heaters will perform satisfactorily at temperatures much in excess of their requirements. The test was conducted for 21 days.

b. Long-term recombiners and heater element tests were performed on a production recombiner for 60 days. This test demonstrated that the recombiner will operate successfully at temperatures well in excess of those expected after a LOCA with four percent containment hydrogen for an extended period of time.

c. Long-term steam chamber tests were conducted in the same test facility as used in previous pressure transient tests. This facility consists of a large pressure vessel, boiler, and control devices. Two heater banks that were subjected to one containment LOCA pressure transient in which at the end of 20 hours the pressure was reduced to 20 psia and held for 20 days. One heater bank was energized 24 hours after the simulated LOCA and the controls set to 100% power for 20 days. The test demonstrated satisfactory operation of the heaters in a post-LOCA steam atmosphere.

WCAP-7709-L, Supplement 4 and WCAP-7820, Supplement 4 describes two tests that were performed on the production recombiner to confirm results obtained on earlier tests of the prototype recombiner that was reported in Supplement 1. The two tests were:

a. A hydrogen test to confirm the production recombiner will perform its intended function. This test was conducted in the silo test facility with a 4.6 v/o hydrogen atmosphere.

b. A spray test was conducted by spraying sodium tetraborate spray on the recombiner while it was operating at the recombiner temperature. This test was run for ten days and confirmed the two days test on the prototype recombiner.

SUMMARY OF REGULATORY EVALUATION

The results of the tests conducted on the prototype and production recombiner demonstrated that the recombiner should be capable of controlling the hydrogen concentration in a post-LOCA PWR containment environment. Review of instrumentation, controls and the seismic analysis of the prototype and the production unit will be conducted by the Electrical and Instrumentation Branch, and the Mechanical Engineering Branch, respectively, as part of the review of license application of the plants at which these units are to be installed.

REGULATORY POSITION

We have concluded that the Westinghouse's electric hydrogen recombiner is acceptable as part of the combustible gas control system to control the hydrogen concentration in PWR containment buildings as required by Regulatory Guide 1.7. The above topical reports (both proprietary and non-proprietary) should be referenced for specific plants that are being reviewed for license applications. The staff does not intend to repeat its review of WCAP-7709-L and its supplements when it appears as a reference in a particular license application except for the instrumentation, controls and seismic capability of recombiner.

Should Regulatory criteria or regulations change, such that our conclusion concerning these topical reports are invalidated, you will be notified and given the opportunity to revise and resubmit your topical report for review, should you so desire.

The non-proprietary versions present an adequate representation of the proprietary reports.