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Engineering Analysis Section

SUMMARY OF DESIGN OF EGCR REACTOR COOLANT SYSTEM

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Oak Ridge, Tennessee
July 19, 1965

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SUMMARY OF DESIGN OF EGCR REACTOR COOLANT SYSTEM

The purpose of this paper is to summarize the design and stress analysis of the pressure-containing components of the EGCR reactor coolant system. The analytical and experimental work has required many years of effort; the references which follow total several thousand pages of documented analysis and data. This summary is being made to emphasize the extent and thoroughness of the numerous investigations regarding the strength and integrity of the EGCR reactor coolant system.

The EGCR reactor vessel was designed by Kaiser Engineers in accordance with the Navy code and the ASME code for unfired pressure vessels, including nuclear code cases. Reference 1 is a set of six volumes covering the design calculations for the EGCR reactor vessel.

The design of the EGCR reactor vessel was independently reviewed and checked by the National Engineering Science Company under the direction of Dr. E. O. Bergman. This work is reported in reference 2.

The design of the EGCR reactor vessel was confirmed by several experiments. The first experiment was a model test of the top head and the cylindrical section of the vessel. The model was made of aluminum to a scale of 1:5.533. More than 900 strain gages were mounted on the model, on both internal and external surfaces. The stresses were determined for both internal pressure and for various nozzle loadings. A description of the model, the location of the gages, and results are reported in reference 3. This work was done by ORNL and the University of Tennessee.

A three-dimensional photoelastic stress analysis of the top head of the EGCR reactor vessel was made by ORNL and the University of Tennessee. The photoelastic model had a scale factor of 1:14.2. The stresses were frozen into the model while one nozzle was under axial load and the vessel was under internal pressure. The result of this work is reported in reference 4.

A hydrostatic test of the completed EGCR reactor vessel was performed in the vendor's shop. During this test, over 600 strain gages were mounted on the internal and external surfaces of the reactor vessel. Strain readings were obtained for 0 percent, 50 percent, 100 percent, 150 percent of design pressure, both as pressure was being increased and decreased. The stresses obtained from the strain readings were analyzed and reported by B. Hud in reference 5.

The vendor for the closures of the top nozzles of the EGCR reactor vessel tested each closure in a stub nozzle duplicating the EGCR top nozzles. During the pressure testing of each closure, 14 strain measurements were obtained on both the internal and external surfaces of the nozzle wall. These are reported in reference 6.

Over 150 thermocouples have been permanently installed on the EGCR reactor vessel. These thermocouples will be continuously recorded in the main control room at the EGCR. These thermocouples are located so as to confirm the design temperature distributions in the reactor vessel and to confirm the temperature gradients and profiles that will occur during heatup and cooldown of the vessel. These will be compared to the analytical

temperature distributions that were used to obtain thermal stresses in the reactor vessel. The permanently installed thermocouples are shown on reference 7.

In addition to these permanently installed thermocouples, a number of temporary thermocouples have been added to the juncture between the bottom head of the reactor vessel and the vessel support skirt. These temporary thermocouples will supplement the permanently installed thermocouples to the extent that a finer structure of the temperature gradient can be obtained. The temporary thermocouple locations are described in reference 8.

The EGCR steam generators were designed by C. F. Braun Company. In general, the design follows a standard Braun design for heat exchangers. A complete stress analysis was performed on the steam generators by Mr. Lorenzen of that company. This is completely and thoroughly reported in reference 9. Temporary thermocouples have been installed where the hot leg piping joins the steam generator shell. These temporary thermocouples will be used to confirm the temperature distribution as used in the thermal stress analysis of the nozzle. The location of these thermocouples is reported in reference 8.

The EGCR blower casing design was performed by Joy Manufacturing Company, and is reported in reference 10. Although classified as rotating machinery and consequently not under the jurisdiction of the ASME code, the casing was designed in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code. During pressure testing of the blower casing stress coat was applied to determine the range of stresses. All stresses were found to be quite low. This work is reported in reference 11.

The EGCR cold leg and hot leg piping were designed by Kaiser Engineers. The design of the piping is reported in reference 12. The design and location of the expansion joints on the hot leg and cold leg piping were performed by Zallea Brothers. These designs are reported in reference 13. The hangers and the limit stops for the hot leg and cold leg piping were designed by Grinnell Company. The design is reported in reference 14. The hot leg and cold leg isolation valves were designed by Rockwell. The design is reported in reference 15. The design of the attenuator was performed by Babcock and Wilcox and is reported in reference 16. The work of Rockwell, Zallea, Grinnell, and Babcock and Wilcox was checked and approved by Kaiser Engineers and reviewed by ORNL and TVA.

Position indicators have been mounted on the cold leg and hot leg piping. These position indicators will be carefully monitored during initial startup to assure that the piping is moving in accordance with the design conditions. After the initial startup, the piping position indicators will be routinely monitored to assure that the pipe continues to move properly during the heatup and shutdown of the plant. The position indicators are shown in reference 17.

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