

MASTER

EFFECT OF ROD SPACING ON HEAT TRANSFER BURNOUT

USAEC-AECL COOPERATIVE PROGRAM

MONTHLY PROGRESS REPORT

OCTOBER 1963

by

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INTRODUCTION

Economic studies by AECL have indicated that heavy-water-moderated power reactors cooled by boiling light water have considerable economic promise. As part of a USAEC-AECL cooperative program, Du Pont has undertaken a program to determine some of the operating conditions of such reactors.

A practicable reactor would contain a minimum amount of light water poison in the fuel coolant channels. This can be achieved by operating with closely spaced fuel rods and high outlet steam qualities. The purpose of the Du Pont study is to determine the effects of these variables on the heat transfer and hydraulic characteristics of rod bundles. The work is being done at the Savannah River Laboratory (SRL).

Measurements of the heat transfer coefficient, burnout heat flux, and pressure drop will be made on a 4-foot-long mockup of the central rod and 6 intermediate rods of a 19-rod bundle. Steam quality will be varied up to about 60% and mass flow up to about 5.0×10^6 lb/(hr) (ft²). The effects of spacers and both vertical and horizontal orientation of the test section will also be determined.

Previous reports on the Rod Spacing Tests are DPST-63-69-1 through DPST-63-69-10.

SUMMARY

At the end of October 1963, the surrounding-rod mockup had been loaded in the pressure shell and was being prepared for hydrostatic testing. The "Kanigen"* plate on the star-shaped channel appeared to be satisfactory. The preliminary shakedown tests with the annular housing tube were concluded when the surrounding-rod mockup was returned from the plating vendor on October 24, 1963. To minimize the bowing of the central rod observed during the shakedown tests, the distance between the sapphire spacer pins was reduced to 6 inches.

*Trademark of General American Transportation Corp.

PROGRESSTest Section

The Star Test Section mocks up a 4-foot length of the central and 6 intermediate rods of a 19-rod bundle. The test section is composed of two parts: the central-rod mockup and the mockup of the 6 intermediate rods, which is called the surrounding-rod mockup.

The surrounding-rod mockup was returned to SRL on October 24, 1963 from Keystone Chromium Corp. of Buffalo, N. Y. after "Kanigen" plating. The "Kanigen" plate on the star-shaped channel was examined with a borescope and appeared to be satisfactory. The three holes in the silver solder seam that joins the two halves of the mockup could not be seen. The finished channel measured 0.600 ± 0.0006 inch foil to foil at both ends of the heated length; the 3-inch unheated section at the effluent end measured 0.596 inch foil to foil. Figures 1 and 2 are photographs of the completed mockup.

The surrounding-rod mockup was placed in the pressure shell and was being readied for hydrostatic testing. The OD of the mockup was machined again to fit inside the pressure shell. The OD had been turned to the correct size previously, but the heater backup bars deformed when they were removed and replaced during the installation of the "Chromalox"* heaters and it was necessary to re-machine the OD of the mockup. Figure 3 shows the mockup with the "Chromalox" heaters in place.

Six thermocouples and three pressure taps were installed on the surrounding-rod mockup before it was inserted in the pressure shell. The thermocouples were placed between each pair of heaters; three at 4 inches from the effluent end of the heated section and three at 10 inches from the effluent end of the heated section. Figure 4 shows the effluent end of the mockup after the thermocouples were installed. The thermocouples will detect overheating of the surrounding-rod mockup up to 1 foot from the effluent end. The pressure taps are located 3 inches from the start of the heated section (5-1/2 inches from the influent end of the star-shaped channel), and 13 and 1-1/2 inches from the discharge end of the heated section.

*Product of Canadian Chromalox Ltd.

Figure 5 is an end view of the surrounding-rod mockup showing the star-shaped channel, the "Chromalox" heaters, and the thermocouples.

Shakedown Tests with Annular Housing Tube

The central-rod mockup was operated successfully at a heat flux of $500,000 \text{ pcu}/(\text{hr})(\text{ft}^2)$ and effluent qualities up to 13.8%. The operating conditions were $3 \times 10^6 \text{ lb}/(\text{hr})(\text{ft}^2)$ mass velocity and 200 psia pressure. The annular housing tube was an unheated piece of 1/2-inch, sch 40 pipe. With the 0.500-inch-diameter central-rod mockup, the annular spacing was 0.056 inch.

Two instrument malfunctions were encountered during this test: (1) the voltage taps of the burnout detector shorted to the ground bus and burned, and (2) the uninsulated bead of the surface temperature thermocouples occasionally touched the resistance heater. Both of these instruments are located inside the central-rod mockup, which is an electrically heated tube, 0.500-inch OD and 0.260-inch ID. The instrument lead wires pass through axial holes in both DC buses. Thin wall, porcelain tubes, which will insulate the lead wires and thermocouple beads from the buses and heater, have been ordered.

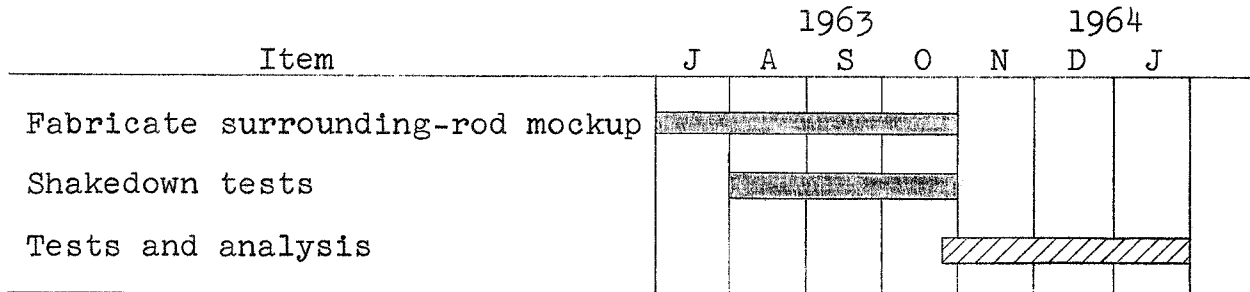
The occasional contact between the surface temperature thermocouples and the inside surface of the central-rod mockup indicates that the central-rod mockup bowed during the test, presumably due to differential thermal expansion of the mockup itself. The heater used in this test had sapphire spacer pins located at the ends of the heated length and at 10, 20, and 34 inches from the effluent end. To reduce the possibility of electrical arcing to the surrounding-rod mockup when rod spacings less than 0.056 inch are tested, sapphire pins will be installed every 6 inches along the heated section of the central-rod mockup.

TEST PROGRAM

The test program includes a series of tests in which the heat transfer coefficient, burnout heat flux, and pressure drop will be measured for several rod spacings. Tests will be made with mass velocities up to $2.5 \times 10^6 \text{ lb}/(\text{hr})(\text{ft}^2)$ at effluent qualities of 60%. The effect of high mass velocities, up to $5 \times 10^6 \text{ lb}/(\text{hr})(\text{ft}^2)$, will be determined at proportionately lower effluent qualities. The range of variables to be tested and the operating characteristics of the test section were reported in DPST-63-69-3 and 6.

PROGRAM SCHEDULE

The expected completion date of the program is February 1, 1964. The program schedule is shown below:



The solid bars on the chart indicate the actual status and the hatched bars indicate the predicted status.

PROGRAM COSTS

As of October 31, 1963, \$48,812 of the \$75,000 appropriation had been expended.

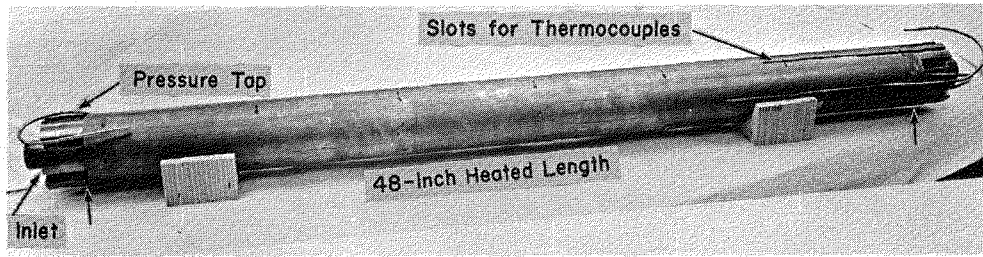


FIG. 1 SURROUNDING-ROD MOCKUP

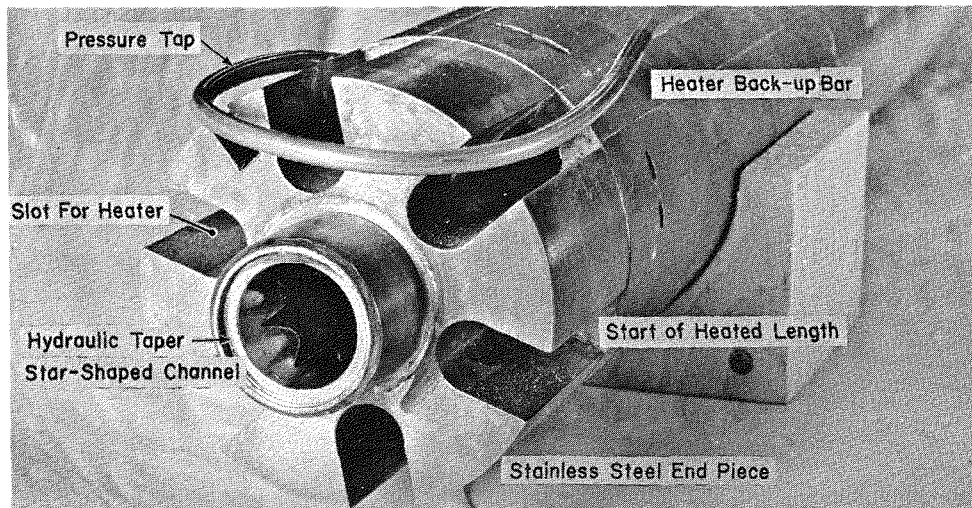


FIG. 2 INLET END OF SURROUNDING-ROD MOCKUP

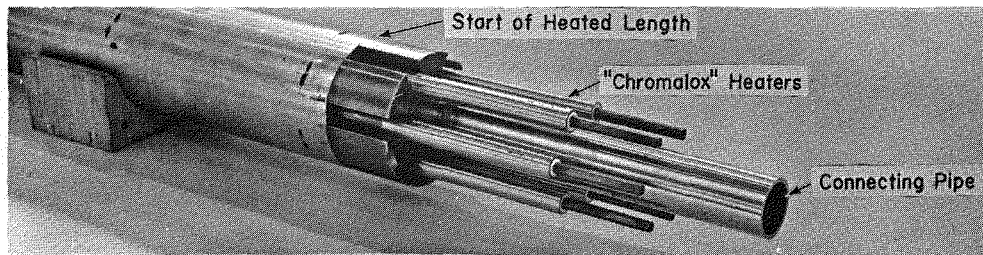


FIG. 3 MOCKUP WITH "CHROMALOX" HEATERS INSTALLED

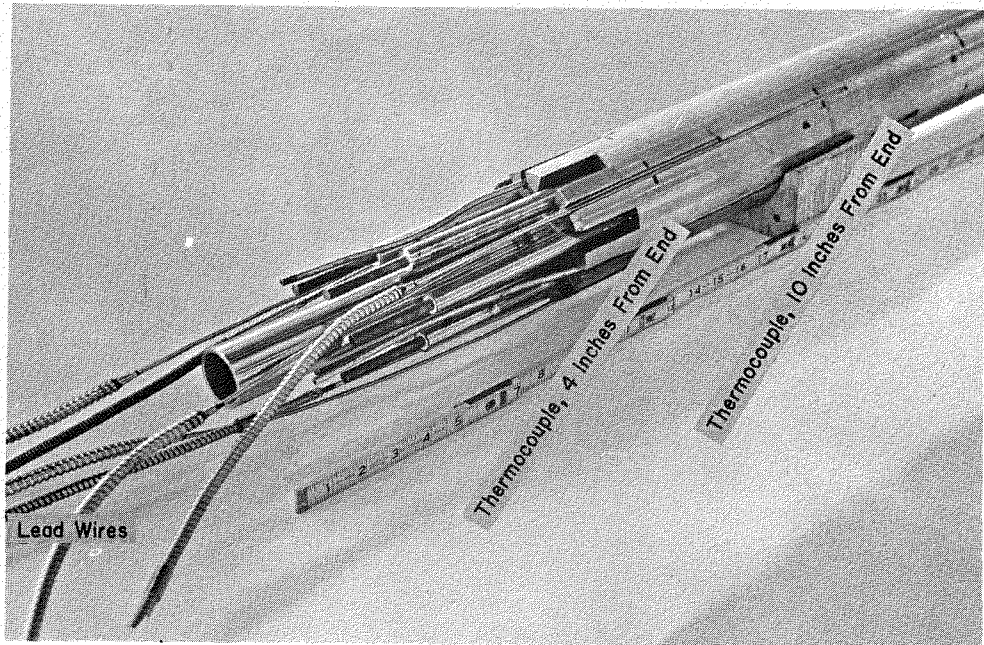


FIG. 4 MOCKUP WITH THERMOCOUPLES INSTALLED

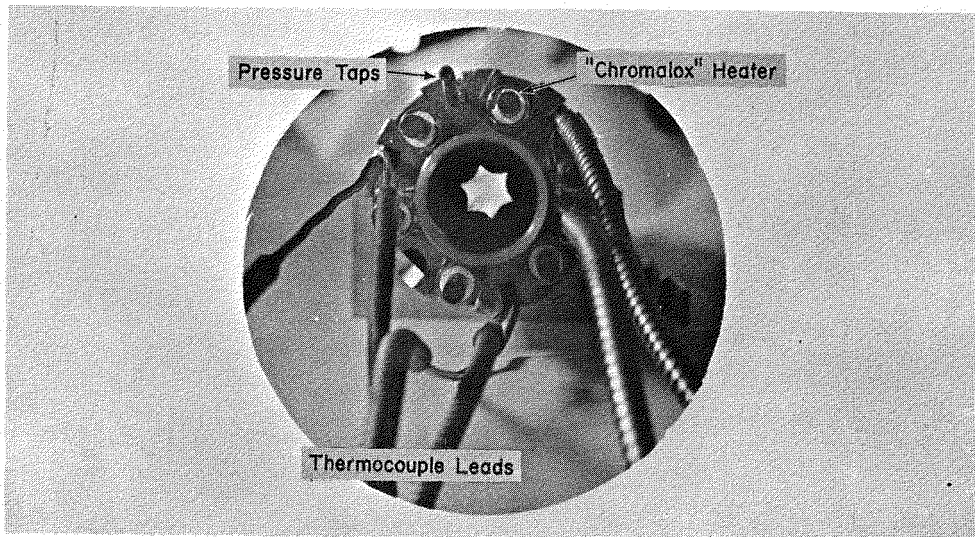


FIG. 5 END VIEW OF SURROUNDING-ROD MOCKUP