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WAPD-TM-1475

DOE Research and Development Report

Critical Heat Flux Experiments in an Internally Heated Annulus with a Non-Uniform, Alternate High and Low Axial Heat Flux Distribution (AWBA Development Program)

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February 1981

Prepared for the
U.S. Department of Energy
By Westinghouse Electric Corporation
Under Contract No. DE-AC11-76-PN00014

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WAPD-TM-1475

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Contract No.: DE-AC11-76PN00014

Printed in the United States of America
Available from the
National Technical Information Service
U. S. Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22151

FEBRUARY 1981

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BETTIS ATOMIC POWER LABORATORY WEST MIFFLIN, PENNSYLVANIA 15122

Operated for the U.S. Department of Energy
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FOREWORD

The Shippingport Atomic Power Station located in Shippingport, Pennsylvania was the first large-scale, central-station nuclear power plant in the United States and the first plant of such size in the world operated solely to produce electric power. This program was started in 1953 to confirm the practical application of nuclear power for large-scale electric power generation. It has provided much of the technology being used for design and operation of the commercial, central-station nuclear power plants now in use.

Subsequent to development and successful operation of the Pressurized Water Reactor in the Atomic Energy Commission (now Department of Energy, DOE) owned reactor plant at the Shippingport Atomic Power Station, the Atomic Energy Commission in 1965 undertook a research and development program to design and build a Light Water Breeder Reactor core for operation in the Shippingport Station.

The objective of the Light Water Breeder Reactor (LWBR) program has been to develop a technology that would significantly improve the utilization of the nation's nuclear fuel resources employing the well-established water reactor technology. To achieve this objective, work has been directed toward analysis, design, component tests, and fabrication of a water-cooled, thorium oxide-uranium oxide fuel cycle breeder reactor for installation and operation at the Shippingport Station. The LWBR core started operation in the Shippingport Station in the Fall of 1977 and is expected to be operated for about 4 to 5 years or more. At the end of this period, the core will be removed and the spent fuel shipped to the Naval Reactors Expended Core Facility for a detailed examination to verify core performance including an evaluation of breeding characteristics.

In 1976, with fabrication of the Shippingport LWBR core nearing completion, the Energy Research and Development Administration, now DOE, established the Advanced Water Breeder Applications (AWBA) program to develop and disseminate technical information which would assist U. S. industry in evaluating the LWBR concept for commercial-scale applications. The program is exploring some of the problems that would be faced by industry in adapting technology confirmed in the LWBR program. Information being developed includes concepts for commercial-scale prebreeder cores which would produce uranium-233 for light water breeder cores while producing electric power, improvements for breeder cores based on the technology developed to fabricate and operate the Shippingport LWBR core, and other information and technology to aid in evaluating commercial-scale application of the LWBR concept.

All three development programs (Pressurized Water Reactor, Light Water Breeder Reactor, and Advanced Water Breeder Applications) are under the technical direction of the Office of the Deputy Assistant Secretary for Naval Reactors of DOE. They have the goal of developing practical improvements in the utilization of nuclear fuel resources for generation of electrical energy using water-cooled nuclear reactors.

Technical information developed under the Shippingport, LWBR, and AWBA programs has been and will continue to be published in technical memoranda, one of which is this present report.

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Critical heat flux experiments were performed with an alternate high and low heat flux profile in an internally heated annulus. The heated length was 84 inches (213 cm) with a chopped wave heat flux profile over the last 24 inches (61 cm) having a maximum-to-average heat flux ratio of 1.26. The 2.15 inch (5.46 cm) long high heat flux sections alternated with 0.55 inch (1.40 cm) long low heat flux sections. Test data were obtained at pressures from 800 to 2250 psia (5.52 to 15.5 MPa), mass velocities from 0.25 x 10^6 to 2.7 x 10^6 lb/hr-ft^2 (339 to 3660 kg/$m^2$$\cdot$s) and inlet temperatures ranging from 200 to 600°F (366 to 589°K). Three test sections were employed: one with an axially uniform heat flux profile as a base case and two with 60 inch (152 cm) uniform and 24 inch (61 cm) alternating high and low heat flux sections. The third test section had a 2.15 inch (5.46 cm) section with a peak-to-average heat flux ratio of 2.19 (hot patch) superimposed at the exit end of the alternating high and low heat flux profile.

Critical heat flux results with the alternate high and low heat flux profiles were shown to be equivalent to those obtained in tests with the uniform heat flux profile. Comparison between critical heat flux measurements with the superimposed "hot patch" and with a uniform heat flux profile indicated a definite thermal performance degradation of as much as 15% at high mass velocities and pressure above 1600 psia.

CRITICAL HEAT FLUX EXPERIMENTS IN AN INTERNALLY HEATED ANNULUS WITH A NONUNIFORM, ALTERNATE HIGH AND LOW AXIAL HEAT FLUX DISTRIBUTION
(AWBA Development Program)

I. INTRODUCTION

The Advanced Water Breeder Applications project is evaluating a number of prebreeder reactor concepts to support the development of water-cooled breeder reactors initiated and currently being demonstrated with the Light Water Breeder Reactor at Shippingport. Prebreeder reactors would be required to produce the U-233 necessary for the operation of water-cooled breeder reactors which would be fueled with thorium and U-233.

One prebreeder concept involves the use of alternate groups of four power-producing duplex thoria and urania pellets with one low power thoria pellet in a fuel rod that would be identical in size to fuel rods in existing commercial reactors. These rods could then be directly backfit with a minimum of mechanical and hydraulic development and testing. At beginning of life only a small amount of the thermal power (less than 10%) would be generated in the thoria pellets. Neglecting axial conduction, the surface heat flux distribution would be a chopped wave. Axial conduction will smooth the heat flux distribution but the basic character will remain the same.

The testing described in this report was conducted to investigate the effect of this type of heat flux distribution, compared to a more uniform distribution, on the CHF power capability of a rod. The specific purpose of this experiment was to obtain a data base from which an evaluation of the CHF performance of a conceptual reactor using such a fuel pellet design with alternating regions of high and low power could be made.

Similar critical heat flux experiments (Reference 1) were performed with an alternate high and low (or alternating) heat flux profile in an internally heated annulus. That annulus geometry was identical to this test but the heat flux profile simulated thoria and urania pellets of equal length. The heated length was 84 inches with a square wave alternating heat flux profile over the last 12 inches having a maximum-to-average heat flux ratio of 1.76. Test data were obtained at pressures from 800 to 2250 psia (5.52 to 15.5 MPa), mass velocities from 0.25×10^6 to 2.7×10^6 lb/hr-ft^2 (339 to 3660 kg/m^2$\cdot$s) and inlet temperatures ranging from 400 to 600°F (477 to 589°K). Two different electrically heated test sections were employed both with 72 inch (183 cm) uniform and 12 inch (30.5 cm) alternate high and low heat flux sections. The second test section had a 0.44 inch (11.2 mm) "hot patch" with a peak-to-average heat flux ratio of 2.7 superimposed on the alternate high and low flux profile at the exit end.

Critical heat flux results with the alternate high and low heat flux profile and with the superimposed "hot patch" were shown to be equivalent to those obtained in previous tests with a uniform heat flux profile except for several data points at low mass velocity and high enthalpy for which there is an apparent experimental bias in the uniform heat flux results.

Critical heat flux data (Reference 2) were also obtained in an internally heated annulus of similar geometry with an increased exit heat flux (or "hot patch") superimposed on an otherwise uniform heat flux profile. Two different hot patch test sections were employed featuring (1) axially uniform heat flux over 82 inches (208 cm) with a 1.5 heat flux ratio "hot patch" over the last two inches and (2) axially uniform heat flux over 82 inches with a 2.25 heat flux ratio "hot patch" over the last two inches. Uniform heat flux data were also obtained.

Comparisons of "hot patch" to no-"hot-patch" critical heat flux results were made indicating that a CHF decrement is observed for low inlet enthalpies at high mass velocities. This is discussed further in Section V.

II. TEST DESCRIPTION

The electrically heated test section for the present experiments consisted of a 0.303 inch (7.69 mm) O.D. Type 136 stainless steel tube with a 0.049 inch (1.24 mm) wall installed in a 0.523 inch (13.27 mm) I.D. ceramic housing (see Figure 1). The test section was centered within the ceramic housing by means of tube segment spacers (see Figure 1 and 2) at seven axial levels along the 84 inch (213 cm) heated length with the two uppermost spacers being located 9.0 inches (22.8 cm) below and just beyond the end of the heated length. The ceramic housing was contained within a 1.0 inch (2.54 cm) O.D. Type 316 stainless steel tube with a 0.083 inch (2.11 mm) wall which served as the backup housing for the test assembly.

Tests were performed with this basic annulus geometry using test sections with three different heat flux profiles. The first test section design featured a uniform axial heat flux profile in the heated rod providing the base case data against which the alternate high and low heat flux data could be compared. The uniformly heated portion of the heated rod assembly was sized such that the heat flux emanating from its surface was approximately equal to the mean heat flux from the shorter section of the tube containing the alternating resistors.

The alternate high and low heat flux effects were represented in two additional test sections by fabricating a step wave electrical resistance path only over the upper section of the heated rod assembly as shown in Figure 2. The alternating high and low electrical resistance heated rod section was assembled by furnace brazing copper-nickel (Alloy 706) plugs to the inside of the stainless steel tubing. The stainless steel tubing wall thickness in this region was 0.036 inches (0.913 mm). As shown in Figure 2, the dimensions of the heated rod assembly were such that the nominal flat heat flux profile extended over the initial 60.25 inches (153.0 cm) of the test section, and the alternate high and low heat flux profile was restricted to the final 23.75 inches (60.25 cm).

Two nominally identical heater rod assemblies with alternate high and low heat flux profiles were built and tested. One of the heater rod assemblies was reamed out at the upper end to a wall thickness of 0.019 inches (0.482 mm) to provide a local hot patch over the final 2.15 inches (54.6 mm) of heated length with a peak-to-average heat flux ratio of 2.19:1.

The uniform and alternating heater sections were butt welded together with 0.12 inch (3.05 mm) overlap as shown in Figure 2. Extensions were butt welded (also with 0.12 inch overlap) to each end of the heater tube rod assembly in order to provide an electrical connection between the tubes and the electrical terminals. The exit extension was a nickel tube with an outside taper which was fitted into a tapered hole in the exit electrical terminal. The CHF thermocouples were led out through the inside of the extension. The inlet extension was composed of a solid nickel piece connected by a length of braided copper cable looped and fastened to the terminal with a cable lug connector which allowed for differential thermal expansion between the heated rod assembly and the test section housing.

The detailed test section assembly is shown in Figure 3 including the exit end connections, electrical terminal and instrumentation. A flange assembly was bolted around the carbon steel electrical terminal. One side of the flange assembly was fastened to the test section pressure boundary by means of a 1.0 inch (2.54 cm) connector. The other side of the flange assembly was attached to a set of fittings which provided mountings for the exit and CHF thermocouples and the connection to the test loop. The inlet assembly was very similar to the exit.

The as-built characteristics of the alternating heat flux section of the heater rod assemblies were examined to make an accurate determination of the heat flux profile. Each rod section was X-rayed after brazing to accurately locate the copper-nickel plugs. The average plug length was found to be 0.552 inches with a range of ± 0.008 in (14.0 ± 0.203 mm) and the average space between plugs (the high heat flux steps) was found to be 2.148 inches with a range of ± 0.016 inches (54.56 ± 0.41 mm).

The nominal heat flux profile in the alternate high and low heat flux region is shown in Figure 4. An electrical resistance profile of the assembly was estimated by Joule heating calculations based on test section dimensions at 675°F (630°K). The local-to-average heat flux ratios for the alternating hot and cold sections of the step wave profile test assembly were 1.267 and 0.156 respectively. The uniform section had a local-to-average heat flux ratio of 0.977. The local-to-average heat flux ratios for the hot patch and for the alternating hot and cold sections of the hot patch test section were 2.193, 1.233 and 0.152, respectively. The uniform section had a local-to-average heat flux ratio of 0.952.

The test section was installed in High Pressure Loop 29 of the Bettis Thermal and Hydraulic Laboratory. A general schematic of the test loop is shown in Figure 5. A Crocker-Wheeler direct current generator supplied electrical power to the test section with maximum ranges of 100 volts and 1300 amps. The loop water chemistry was controlled to a pH of about 7.0 and an oxygen content of less than 0.1 ppm. The loop and test section were designed for a pressure of 2500 psia (17.2 MPa) and a temperature of 636°F (608°K). The test section was hydrostatically tested to 3750 psia (25.8 MPa) at room temperature prior to installation in the loop.

III. INSTRUMENTATION

Test section power was measured continuously by recording voltage drops across the test section and across a calibrated shunt which was used to measure current. Voltage and current readings are estimated to be accurate to within ± 1.0% and ± 0.8%, respectively.

The flow rate was measured by reading the pressure drop across each of two nominally identical orifices in series in one of two flow legs.

The orifice diameters were 0.140 inch (3.6 mm) for nominal mass velocities below 1.0×10^6 lb/hr-ft^2 (1356 kg/m^2•s) and 0.30 inch (7.6 mm) for higher nominal mass velocities. Flow orifice pressure drops were measured by transducers connected across pressure taps located just upstream and downstream of the flow orifices. Each pair of orifices installed in its flow leg was calibrated with a weigh tank. Flow rate calculated from the two orifice readings agreed within 1% for the large orifices and within 3% for the small orifices. The water temperature at the orifices was measured by two thermocouples accurate to about + 2°F.

Stainless steel sheathed chromel-alumel thermocouples were used for water temperature indication. Four water thermocouples were positioned in the flow, two upstream and two downstream of the heated length. Two asbestos-insulated chromel-alumel wall thermocouples were spot welded inside the stainless steel tubing near the exit end of the test section as shown in Figure 2 for detection of CHF.

The steady-state data acquisition system consisted of automated tape recorders, oscillograph recorders for CHF thermocouple monitoring and strip chart recorders for generator current and test section voltage drop. The oscillographs were electrically coupled to the test section power supply such that the test section power was automatically reduced by 44% when a CHF temperature excursion was indicated. An Integrating Digital Voltmeter (IDVM) was used to read all thermocouple and DP cell readings and these data were recorded on magnetic tape.

IV. TEST PROCEDURE

There were four types of test runs performed, all at steady-state conditions after stabilizing the conditions in the loop for about 15 minutes. The types of runs were voltage pickup runs, heat balance runs, critical heat flux runs and runs made at 98% of critical heat flux. Four voltage pickup runs were made with each test section assembly to establish the correction factors to be applied to the wall thermocouple readings to account for the voltage pickup inherent in each thermocouple weld.

Eleven heat balance runs were made at subcooled conditions with low mass velocity to provide the basis for estimating the heat losses during all test runs. Heat losses were correlated with inlet temperature and test section power.

The balance of the test consisted of dual test runs made at the experimentally-determined critical heat flux (CHF) and at a heat flux just below CHF (98%). The pressure, mass velocity and inlet temperature for each run were established and the heat flux was slowly raised to 75% of an estimated CHF value. The heat flux was then increased in 5% increments until CHF was indicated by an observed rapid increase of either of the wall thermocouple readings, at which time, if possible, a complete line of data was recorded. Following a CHF run, the power was reset to approximately 98% of the CHF power level and a complete line of data was recorded. These 98% runs served as a backup indication of nominal test section conditions for the CHF runs and permitted acquisition of heated pressure drop data where a rapid CHF prevented the recording of a full line of data on magnetic tape.

Several replication runs were made throughout the test. In addition to the automatic recording of all data, oscillograph charts were also saved and examined.

V. EXPERIMENTAL RESULTS

The critical heat flux data from the three test assemblies are presented in Tables 1, 3 and 4. The data taken at 98% of the critical heat flux level are given in Table 5 for all three assemblies. Table 6 presents the pressure drop data taken from the three assemblies at low or zero heat flux levels.

The parameters common to all of the data tabulations are the pressure, mass velocity, inlet temperature and enthalpy, exit enthalpy and quality, and the average heat flux. The pressure, inlet temperature and mass velocity were the independent variables in the test matrix and their values were obtained through direct measurement as described in Section III. The inlet enthalpy is determined from the inlet temperature using water property tables. The average channel heat flux was based on electrical power input as determined from voltage and current measurements. The exit enthalpy was calculated from heat balance equations using the average heat flux, inlet conditions and a small heat loss correction based on data from a series of heat balance runs.

The exit quality is calculated from the formula for equilibrium quality:

$$X = \frac{H - H_f}{H_g - H_f}$$

where H is the exit enthalpy and H_g, H_f are the saturation enthalpies of vapor and liquid, respectively.

Uniform Heat Flux Data

The critical heat flux data from the uniformly heated test section are given in Table 1. Since there were a number of replication runs, the data for each set of conditions were averaged to produce a set of base case data for comparison purposes. The averaged base case data are generated in Table 2. The mass velocity, inlet enthalpy and heat flux values in Table 2 are arithmetic averages of replication runs made at the same nominal conditions. The exit enthalpy and quality values in Table 2 were determined so as to agree with the inlet conditions and heat flux.

The uniform heat flux CHF data, except for the 800 psia (5.52 MPa) results are plotted together with the other CHF data in Figures 6-15. The uniform heat flux CHF results appear to be reasonably consistent with some exceptions. In particular, when CHF occurs at conditions well above saturation, the replication runs were in good agreement with each other. When CHF occurred near saturated conditions, there tended to be a large scatter in the data.

The four runs at 2000 psia, 1.0×10^6 lb/hr-ft^2 and 400°F inlet temperature (13.8 MPa, 1356 kg/m^2•s and 477°K) shown in Figure 10 provide a good illustration of this phenomenon. The four runs near saturation deviate over a range of approximately 17% while those in bulk boiling deviate by less than 6%. Examination of the thermocouple traces of these four CHF points indicated that all of these were points of intermittent dryout and that the lowest point (Run No. 271) was a marginal CHF point, that is, its temperature spike was barely noticeable.

In general, it appears that the accuracy of the CHF measurements in the bulk boiling region is substantially better than that at the subcooled saturated boiling transition region.

Uniform heat flux data taken at 98% of CHF and at lower heat flux levels are included in Tables 5 and 6 where they are identified with the designation UNI.

"Alternating" Heat Flux Data

The critical heat flux data from the test section with alternate high and low heat fluxes are given in Table 3. The table includes an additional column showing the ratio of critical heat flux with alternate high and low heat fluxes to that of the base case uniform flux profile. The last column identifies the base case data point from Table 2 which was used in calculating the ratio.

The data are plotted in Figures 6-15 with the other CHF data. In addition, plots of the CHF ratio versus mass velocity and exit enthalpy are given in Figures 16-19. All of the CHF ratios lie within 10% of unity and there is no apparent trend of the data with mass velocity or quality. It is apparent from these plots that the thermal performance of the heated rod is unaffected by the alternate high and low heat flux profile vis-a-vis a uniform heat flux distribituion.

Data for alternate high and low heat fluxes taken at 98% of CHF and at lower heat flux levels are included in Tables 5 and 6 where they are identified with the designation ALT.

"Alternating" Heat Flux Data with Exit Hot Patch

The critical heat flux data from the test section with an alternate high and low heat flux profile and an exit "hot patch" are given in Table 4. As in Table 3, CHF ratio values are given together with the base case data point identifier. The data are plotted in Figures 6-15 with the other CHF data. In addition, plots of the CHF ratio versus mass velocity and exit quality are given in Figures 20-23. Hot patch data taken at 98% of CHF and at lower heat flux levels are included in Tables 5 and 6 where they are identified with the designation HP.

All of the CHF ratios at pressures of 1200 and 1600 psia lie within 10% of unity indicating no CHF performance degradation due to the hot patch. There appears to be a trend toward lower CHF ratios at mass velocities greater than 1 x 10^6 lb/hr-ft^2 and qualities below about 20%.

The CHF ratios at high pressure (2000 and 2250 psia (13.8 and 15.5 MPa)) indicate a definite degradation of CHF performance at high mass velocities ($G > 1.0 \times 10^6$ lb/hr-ft^2, 1356 kg/m^2·s) and at low exit qualities ($X < 0.20$). This trend can be seen clearly in Figures 20 and 22 and also in Figures 6 and 8 where the triangular symbols consistently tail off to the left at high heat flux values reaching as low as 20% below the critical heat flux levels for the uniform heat flux case.

The set of hot patch test data most similar to these was previously reported in Reference 2, where a geometrically identical test section was employed with a 2.0 inch (5.08 cm) exit hot patch and a peak-to-average heat flux ratio of 2.25. Results from that test also indicated a tendency for a CHF decrement to occur for the low inlet enthalpy runs at high mass velocities. The hot patch in this test was 7% longer with a peak-to-average heat flux ratio that was 2.7% lower. The result was a substantial thermal performance degradation over a significant range of variables.

VI. CONCLUSIONS

1. No CHF degradation with respect to uniform heat flux results was observed in the data taken with an alternate high and low heat flux profile without the exit "hot patch".
2. The internally-heated annulus assembly with an alternating heat flux profile and an increased exit heat flux (or "hot patch") demonstrated a degradation of CHF performance vis-a-vis the uniform heat flux data. This degraded performance was observed at high pressure ($P \geq 2000$ psia, 13.8 MPa) and high mass velocity ($G > 1.0 \times 10^6$ lb/hr-ft^2, 1356 kg/m^2.s).
3. The accuracy of the CHF data in the bulk boiling region is substantially better than that of CHF data where the exit conditions are near saturation.

ACKNOWLEDGEMENTS

The authors acknowledge the assistance of Thermal and Hydraulic Laboratory personnel under the direction of Dr. W. G. Steele and Mr. R. E. Hintz in conducting the tests, Mr. A. Weiss as test section designer, Mr. B. W. LeTourneau and Mr. B. K. Flanery for their technical advice, Mr. R. B. Hammond in reducing the data and Ms. M. K. Gilmore for typing the manuscript.

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2. E. P. Mortimore, S. G. Beus, "Critical Heat Flux Experiments with a Local Hot Patch in an Internally Heated Annulus," WAPD-TM-1419 dated February 1979

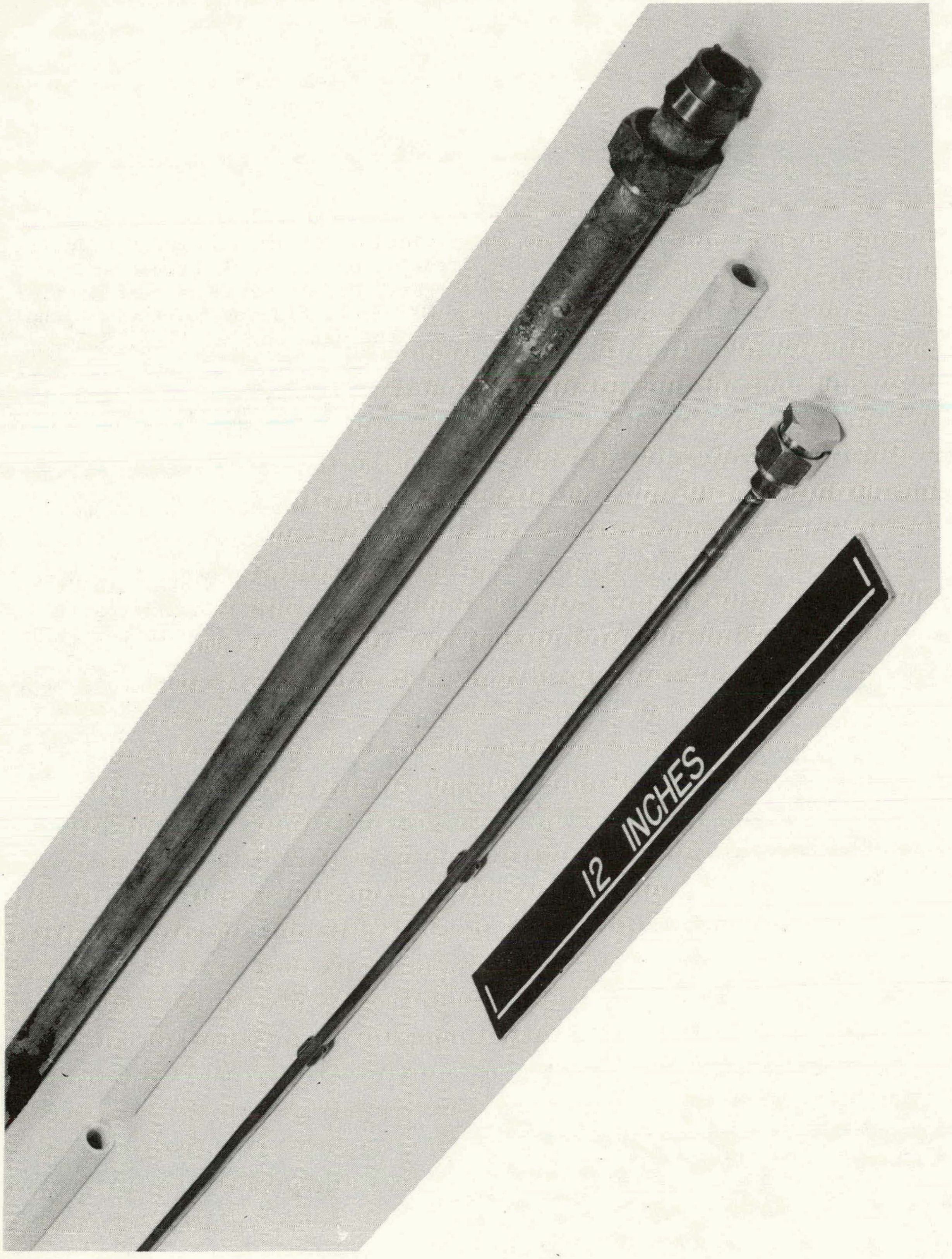


FIGURE 1: Alternating Heat Flux Test Assembly

Negative No. 51944-2

FIGURE 2

ALTERNATING HEAT FLUX HEATER ROD DETAIL

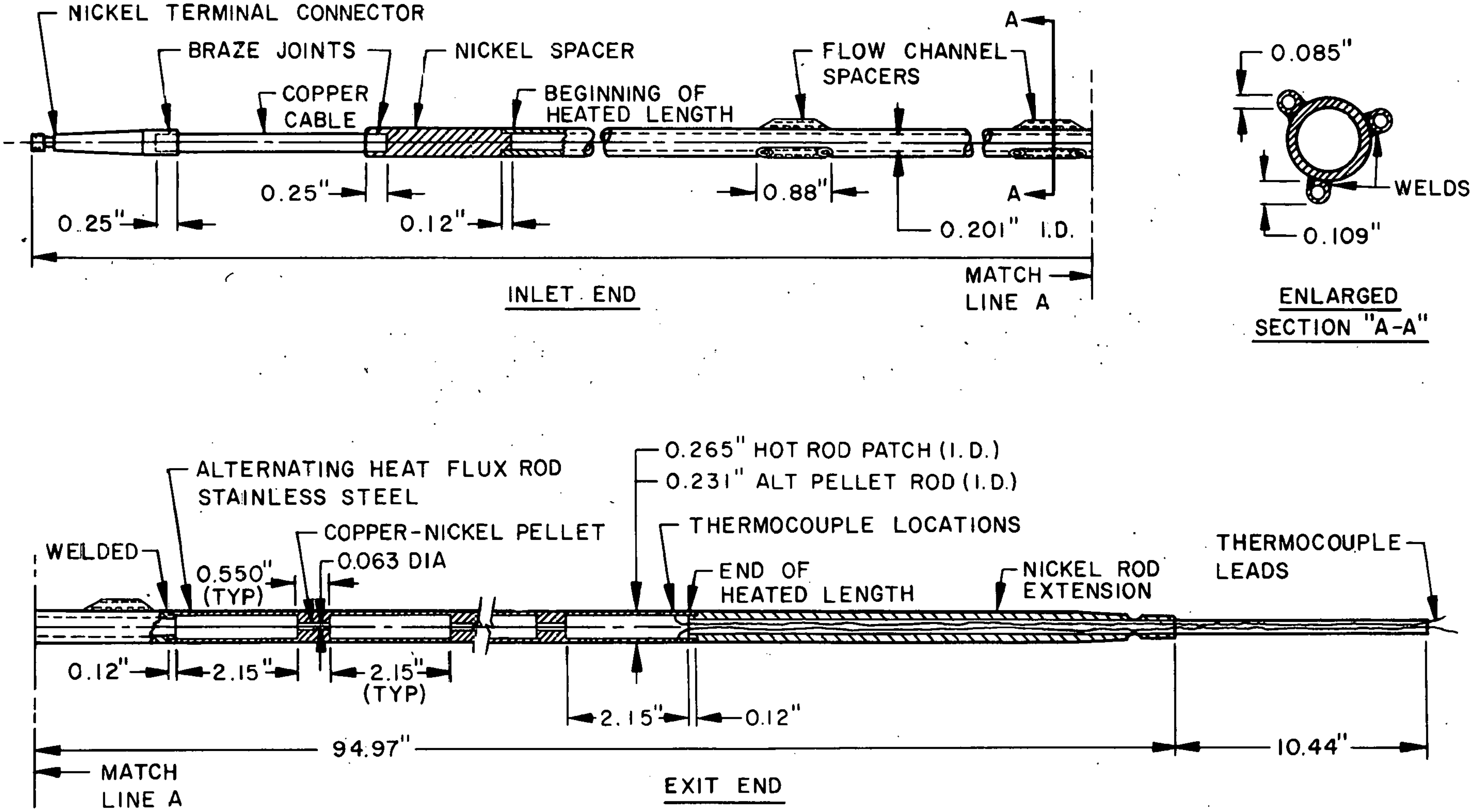


FIGURE 3

ALTERNATING HEAT FLUX TEST SECTION EXIT ASSEMBLY

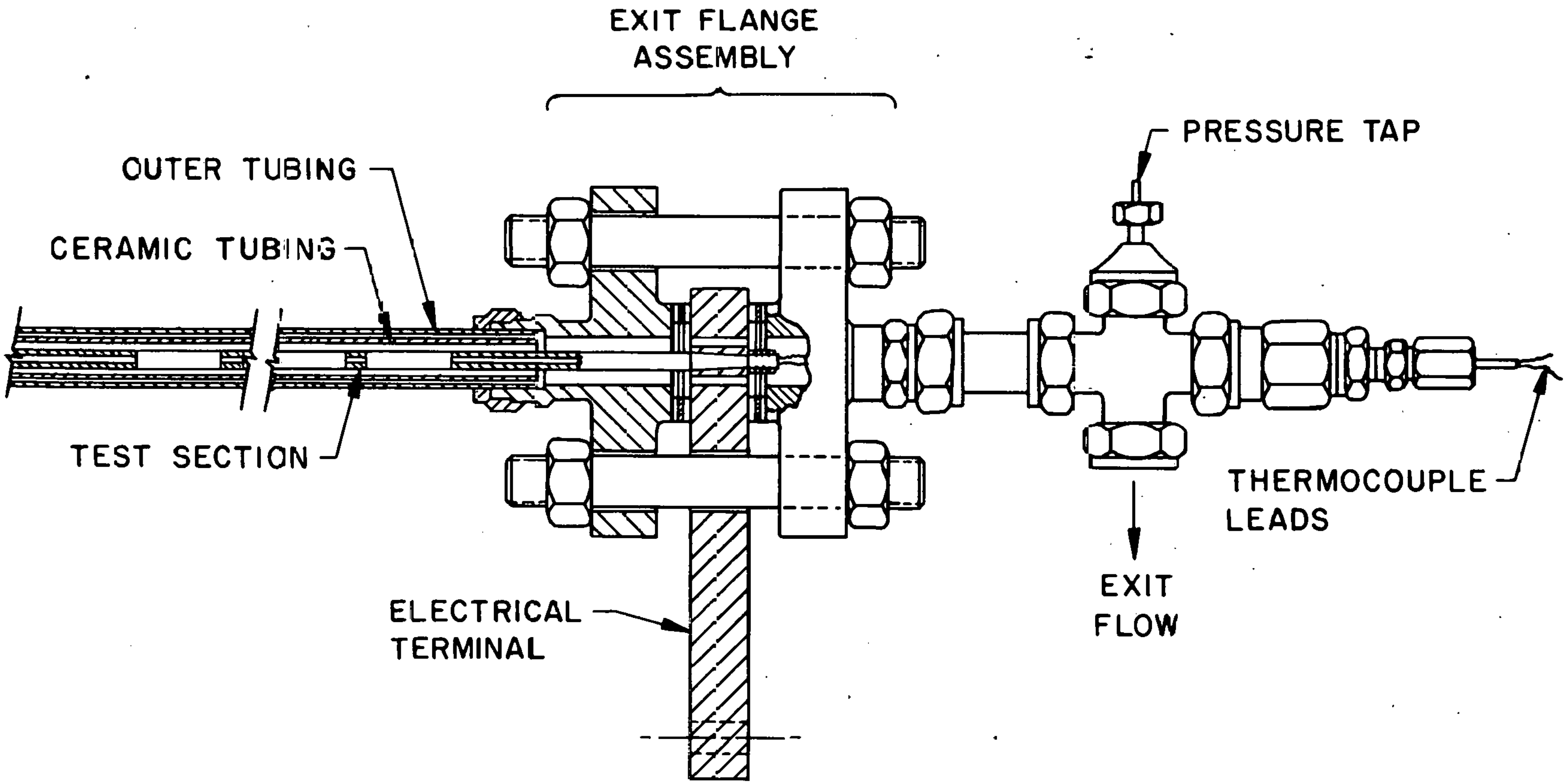


FIGURE 4
AXIAL HEAT FLUX PROFILE

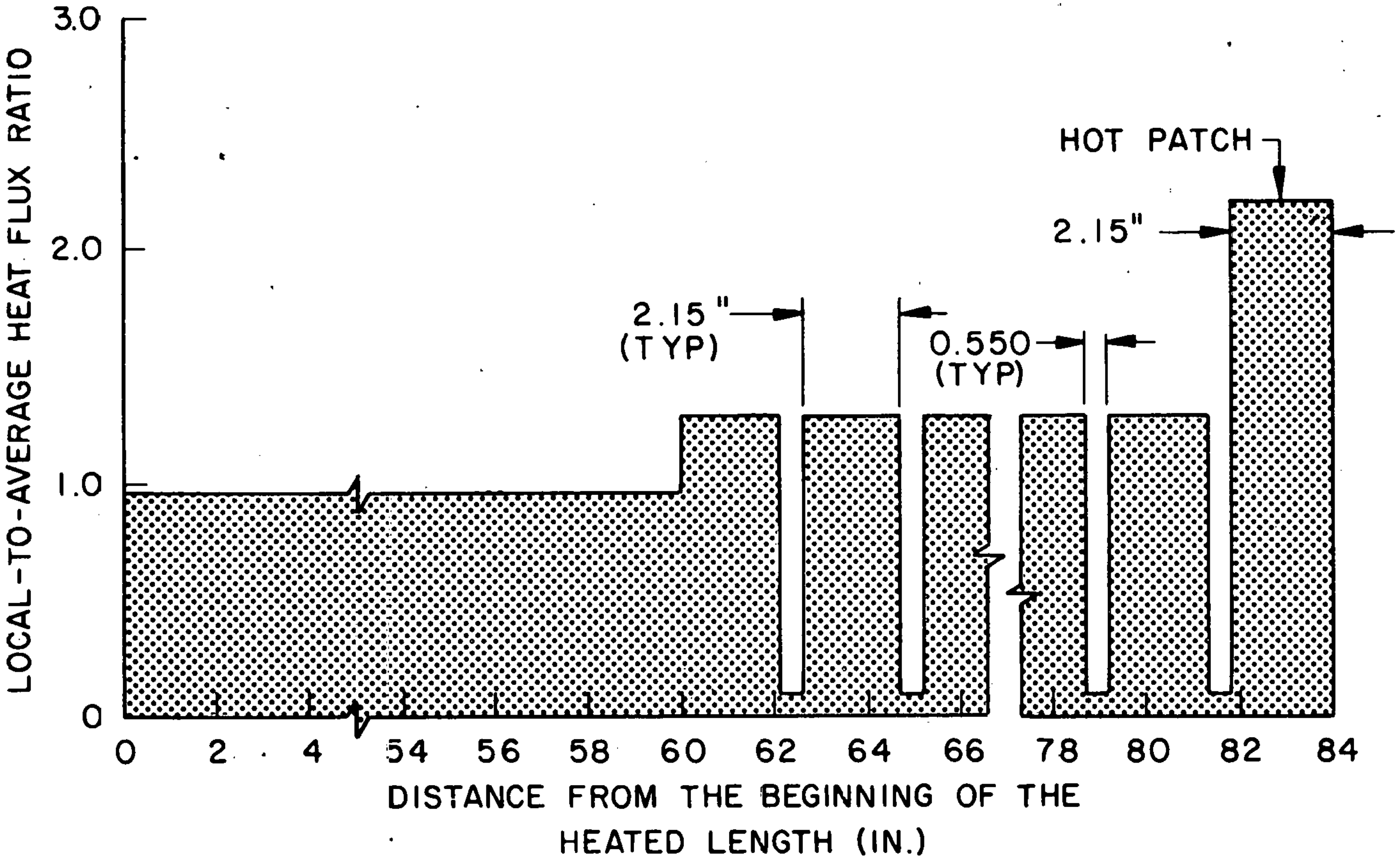
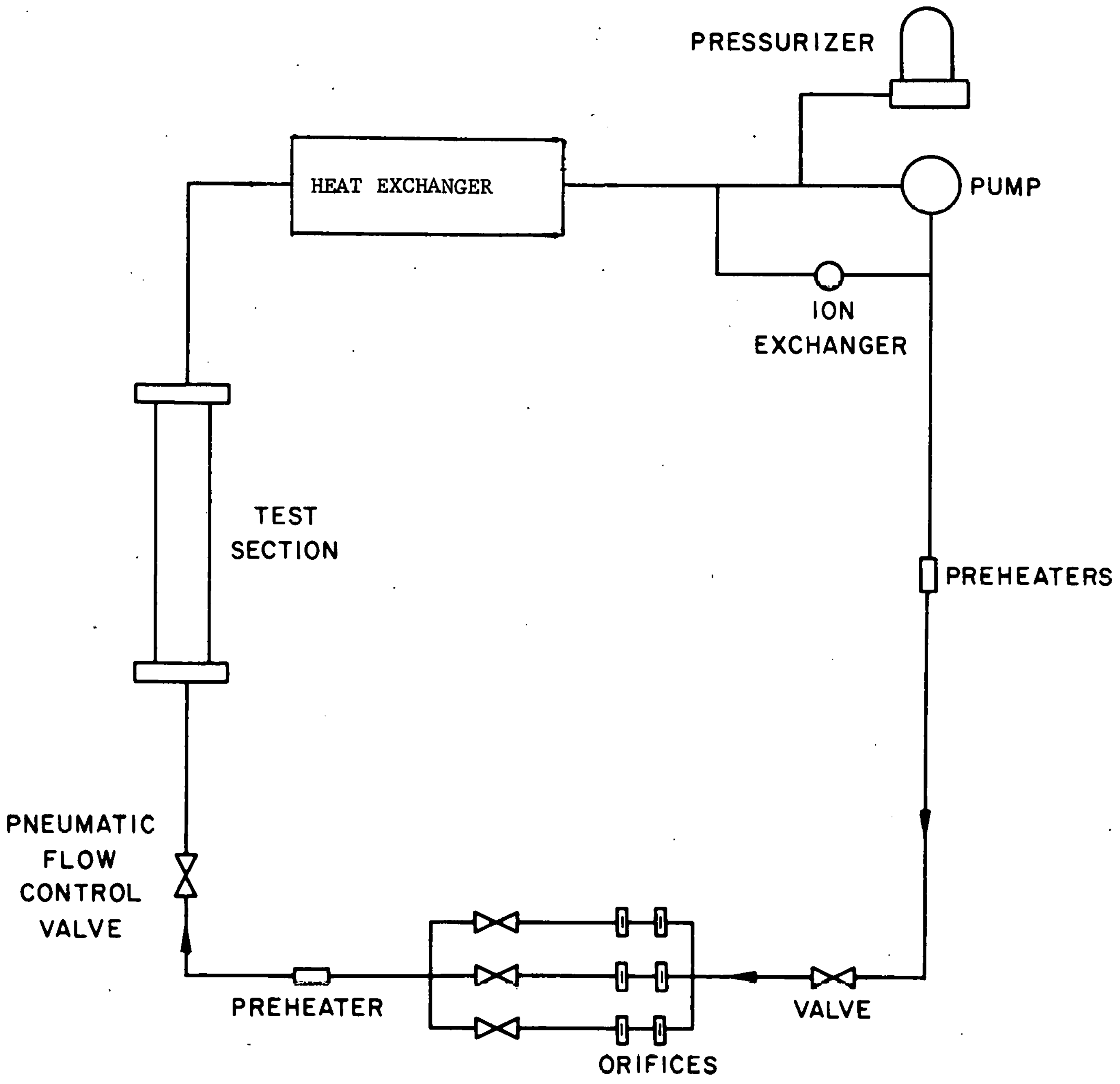


FIGURE 5: SCHEMATIC DIAGRAM OF BETTIS LOOP NO. 29



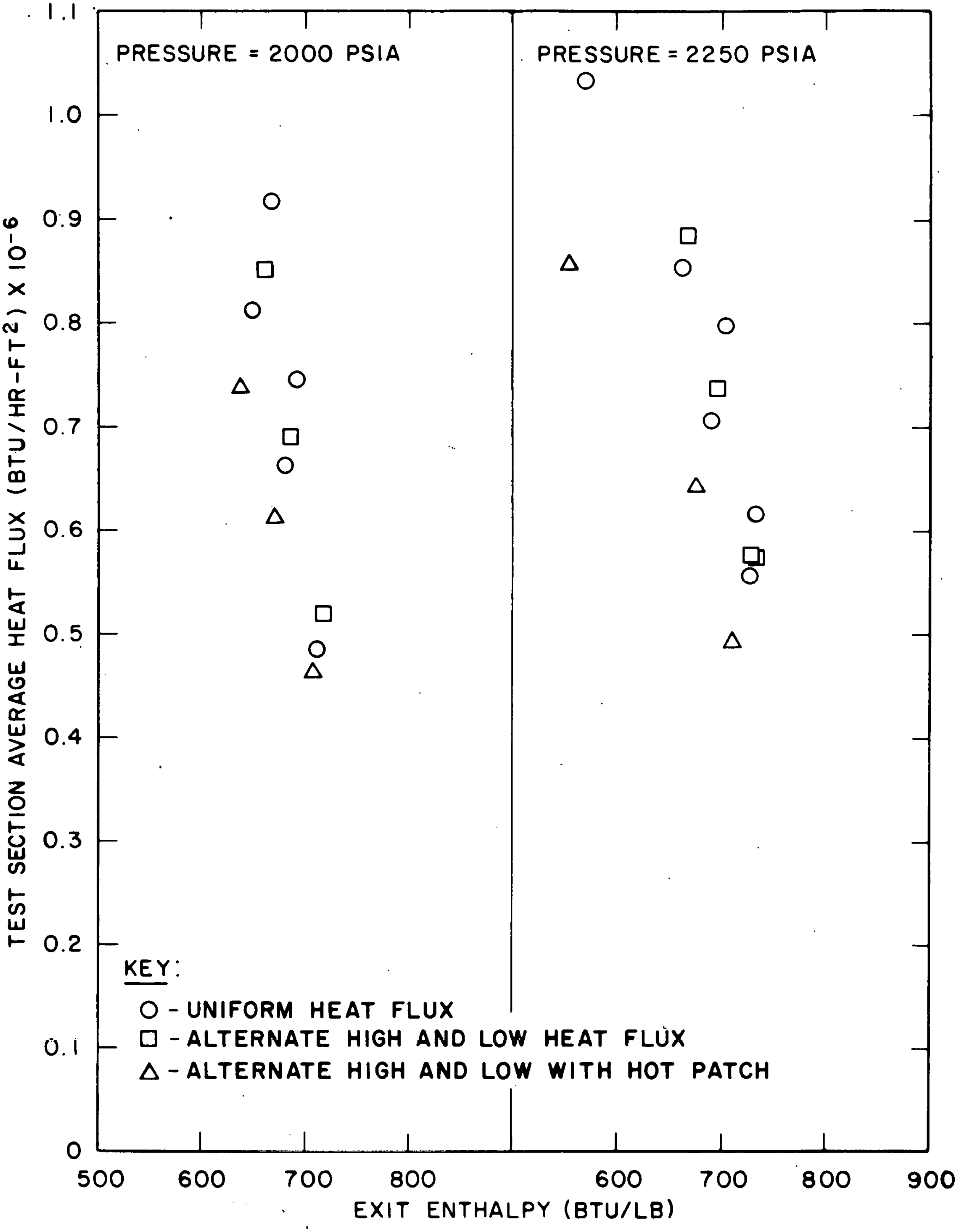


FIGURE 6. SUMMARY OF CHF DATA AT 2.7×10^6 LBS/HR-FT^2

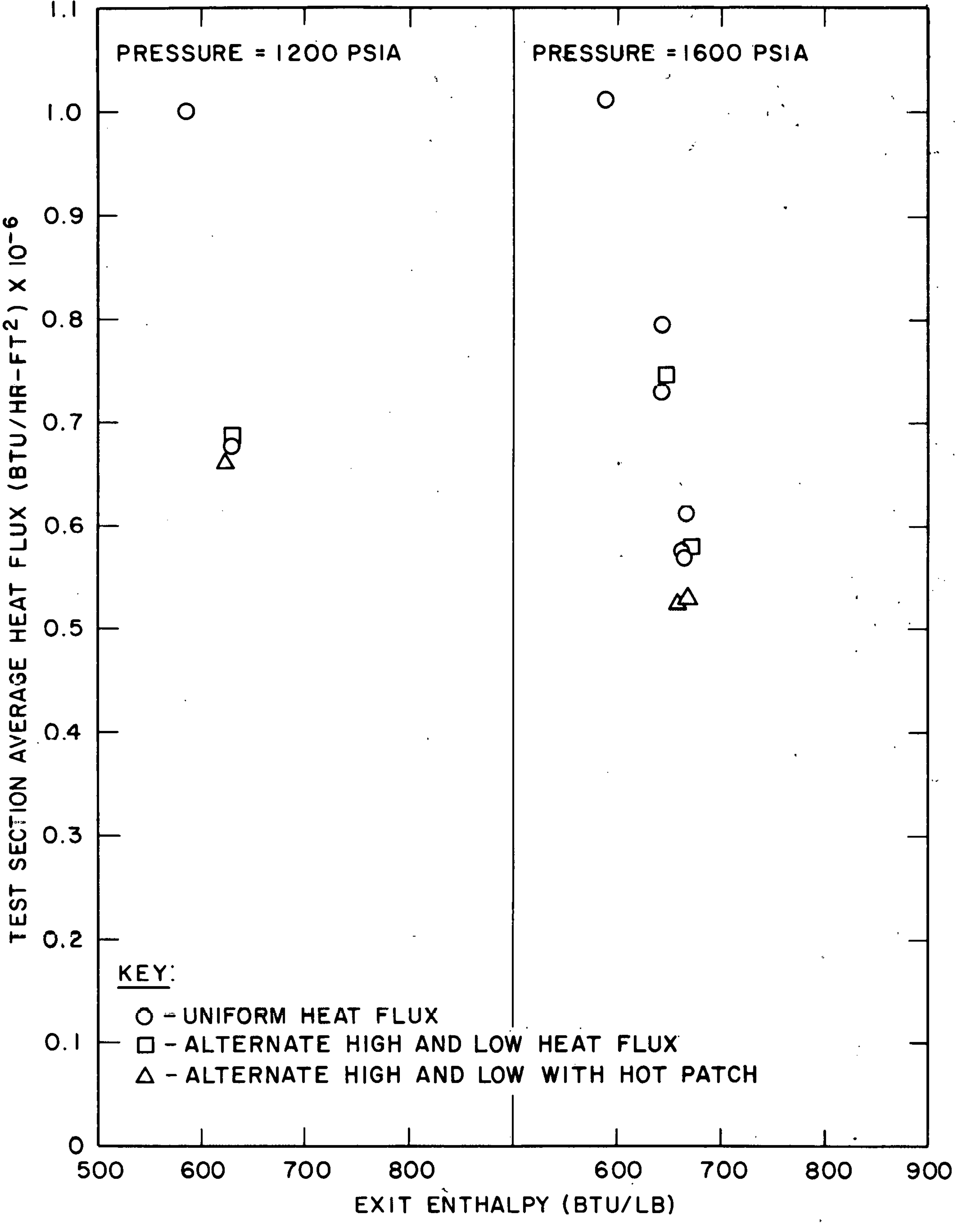


FIGURE 7. SUMMARY OF CHF DATA AT
2.7×10^6 LBS/HR-FT^2

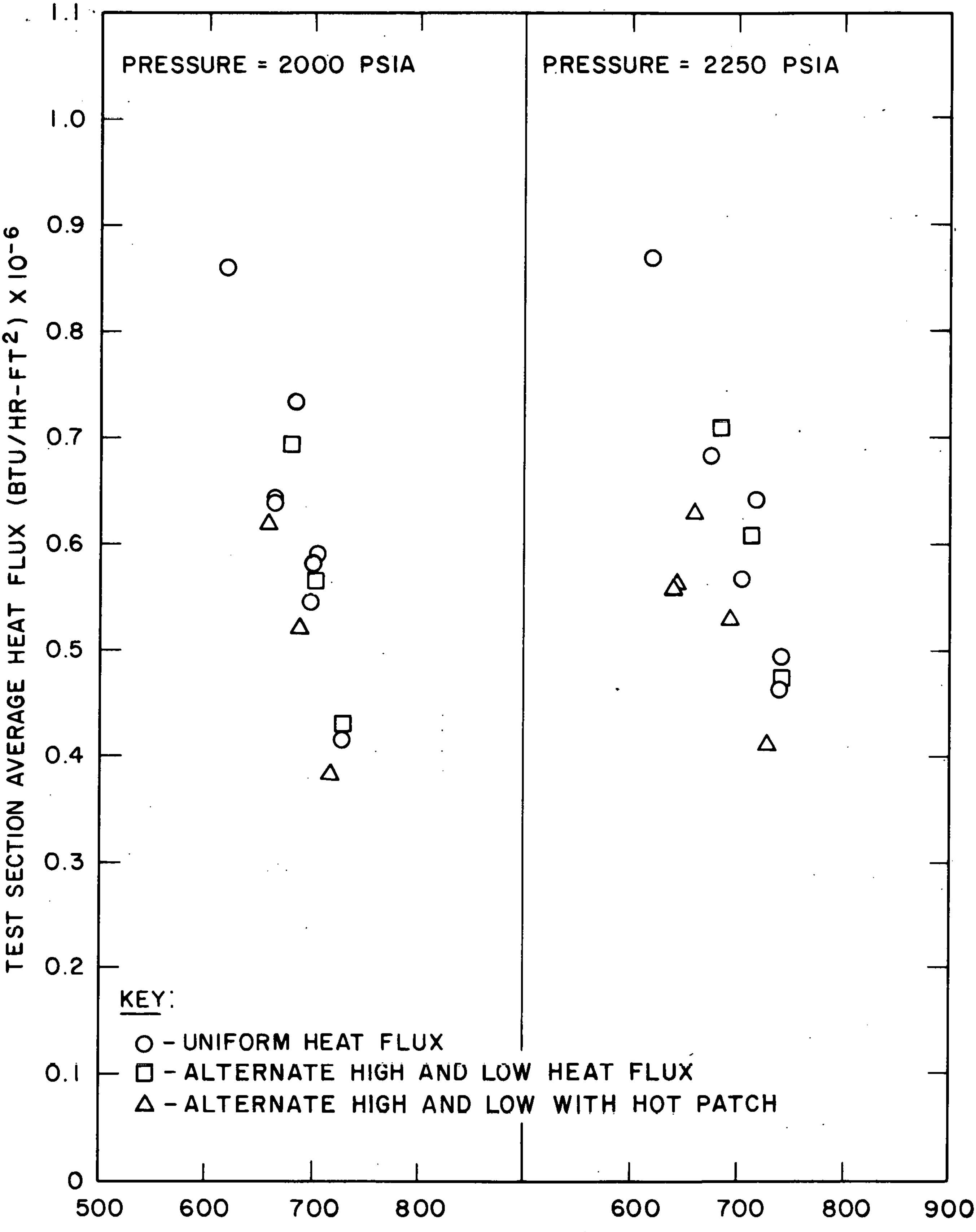


FIGURE 8. SUMMARY OF CHF DATA AT
2.0×10^6 LBS/HR-FT^2

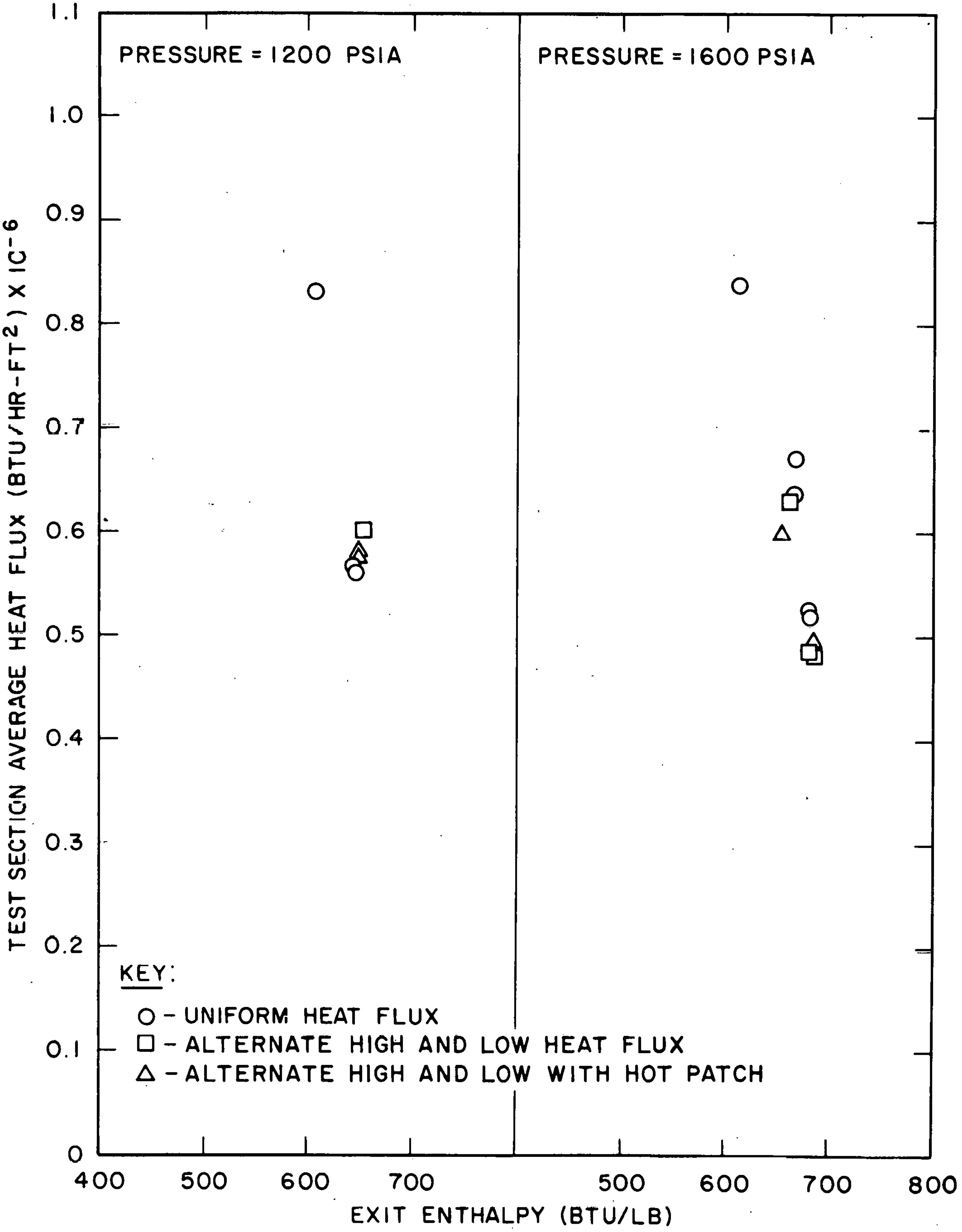


FIGURE 9. SUMMARY OF CHF DATA AT
2.0 X 10^6 LBS/HR-FT^2

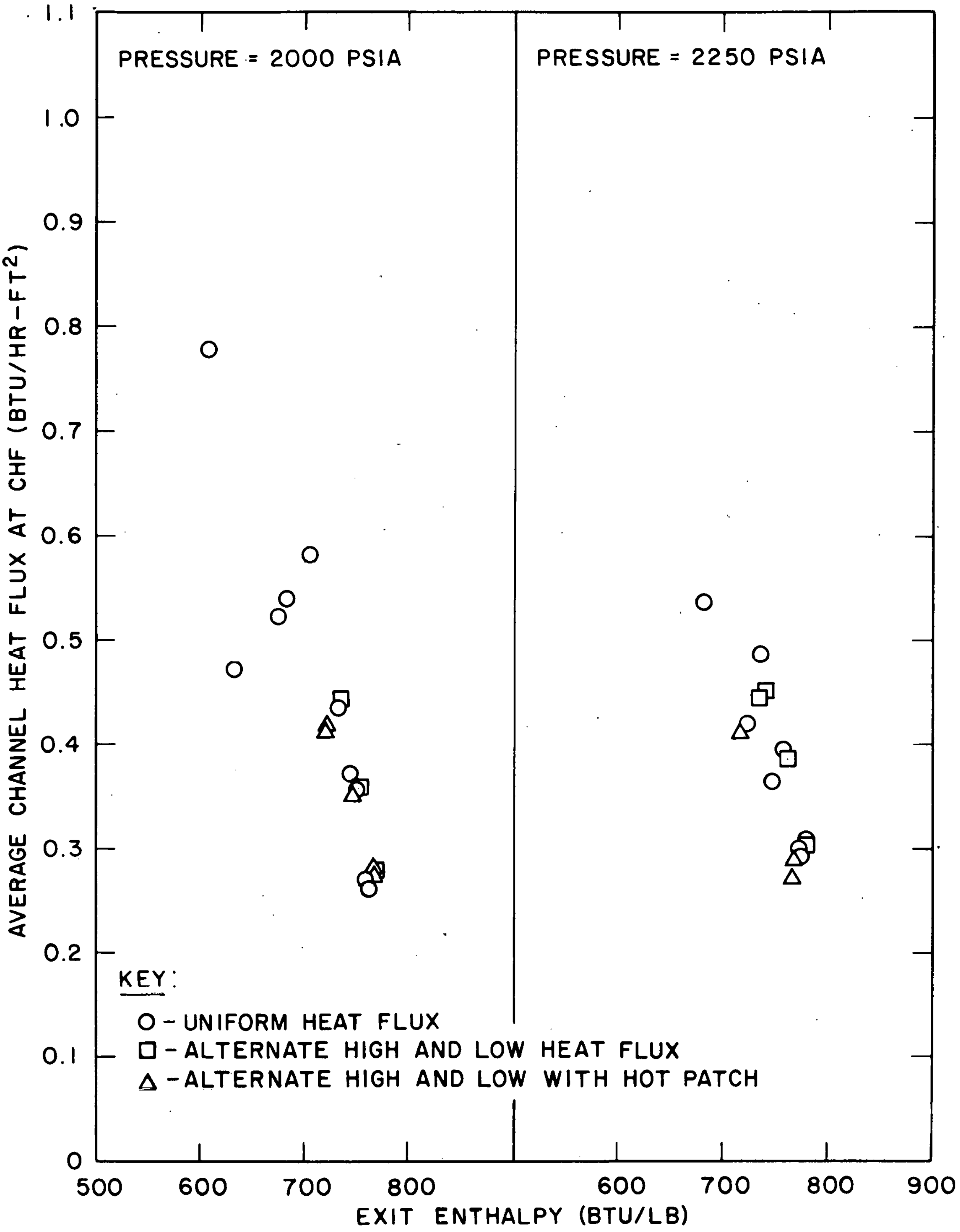


FIGURE 10. SUMMARY OF CHF DATA AT 1.0×10^6 LBS/HR-FT^2

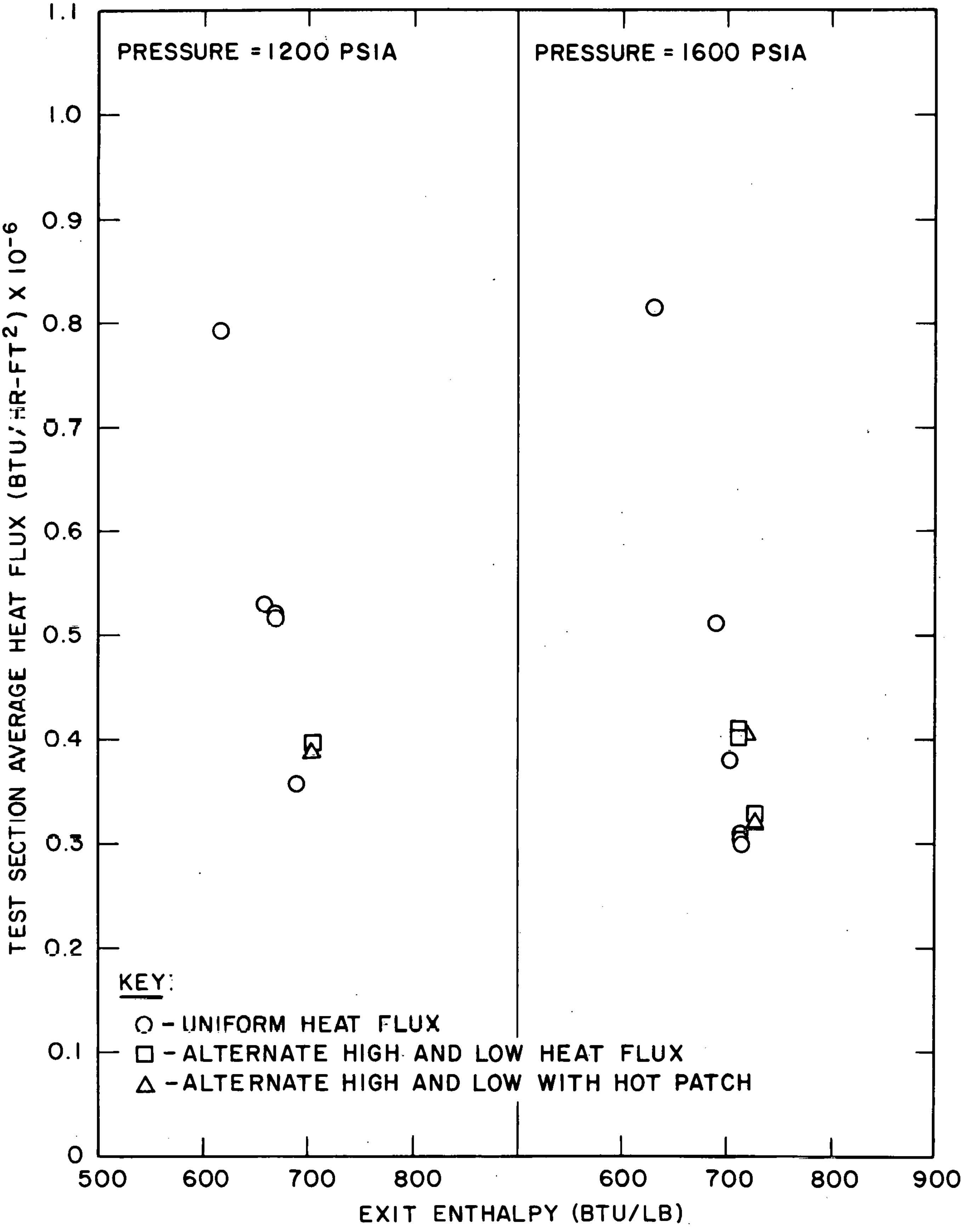


FIGURE 11. SUMMARY OF CHF DATA AT
1.0 X 10^6 LBS/HR-FT^2

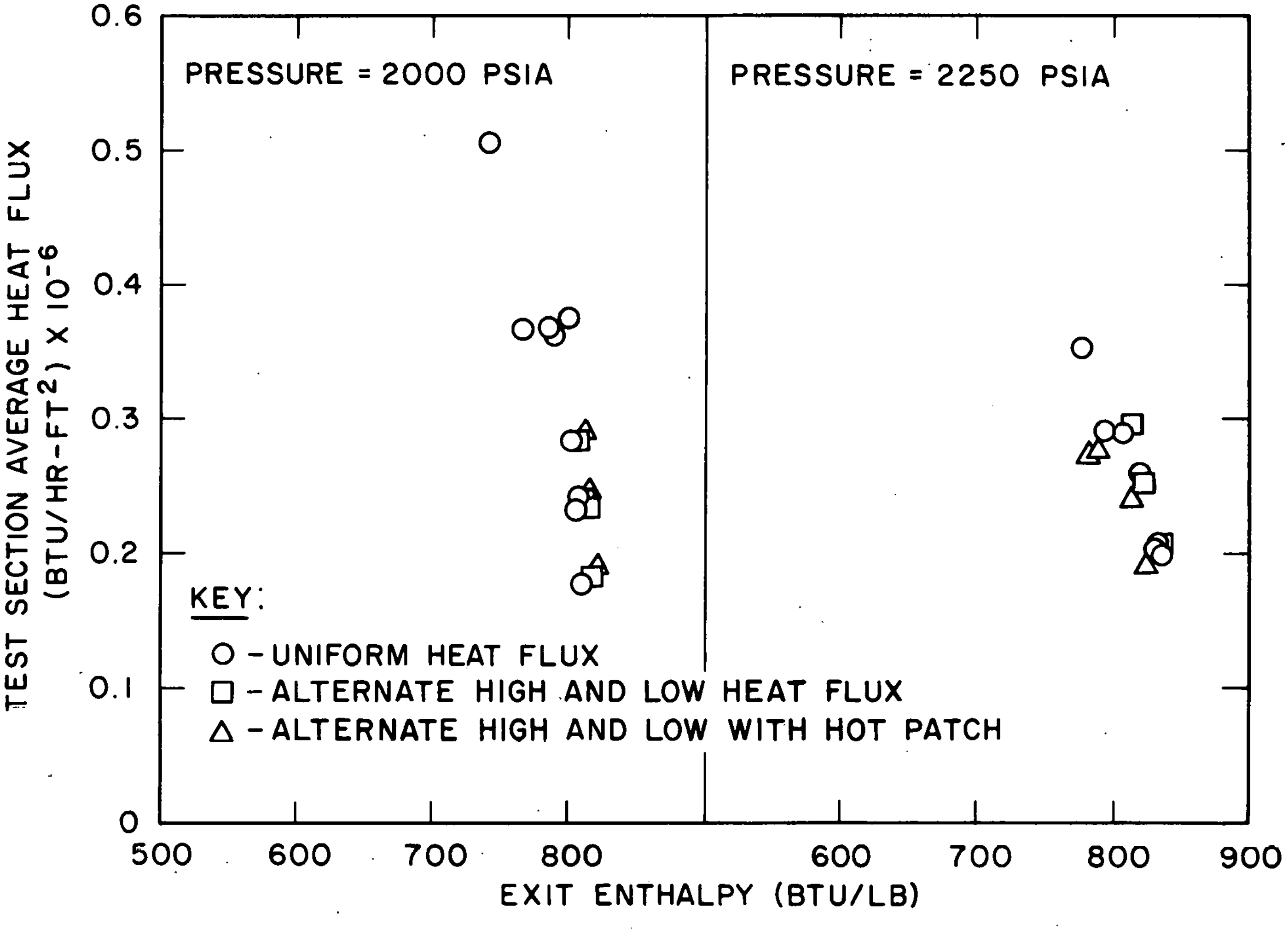


FIGURE 12. SUMMARY OF CHF DATA AT 0.5×10^6 LBS/HR-FT^2

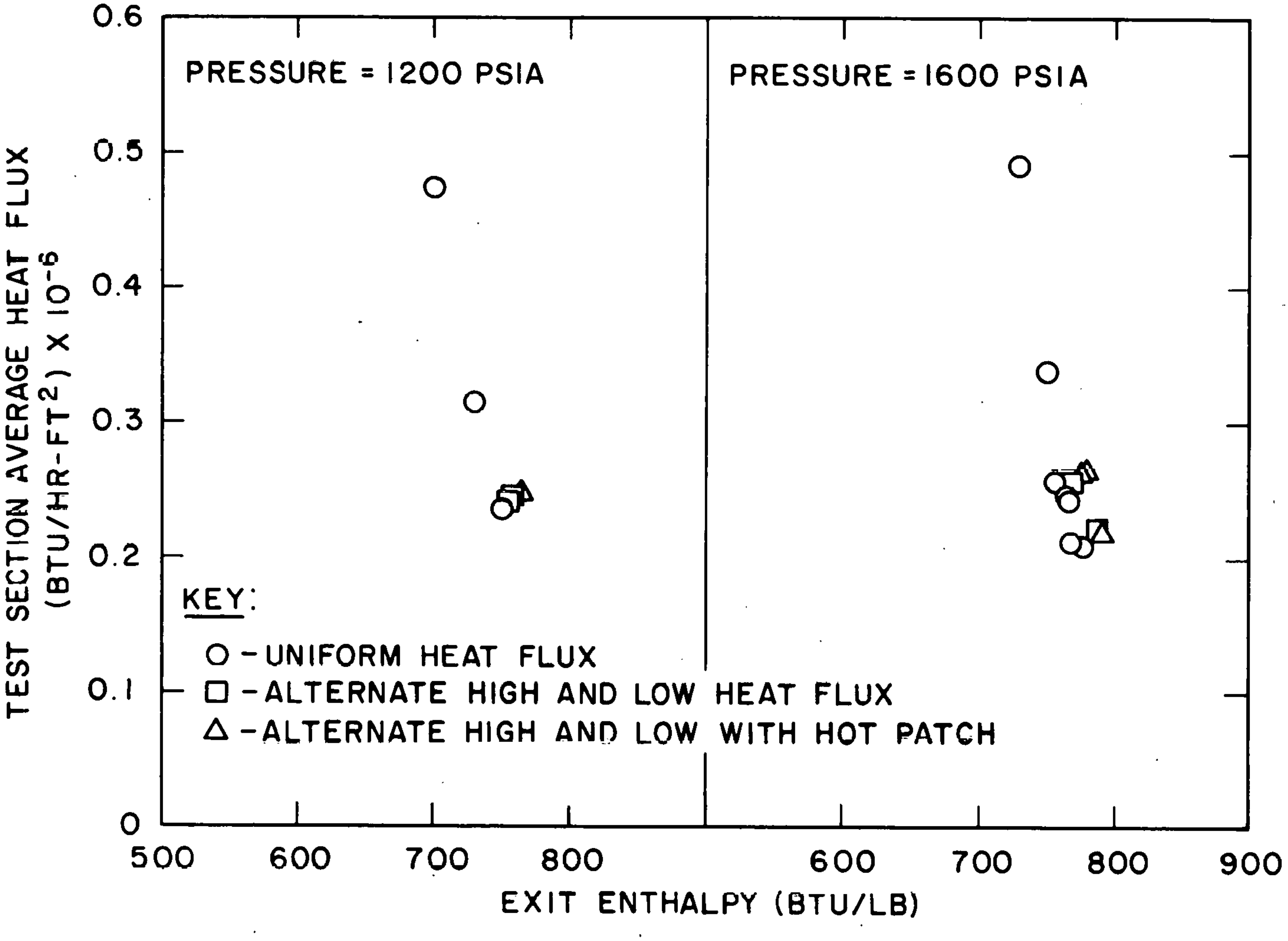


FIGURE 13. SUMMARY OF CHF DATA AT 0.5×10^6 LBS/HR-FT^2

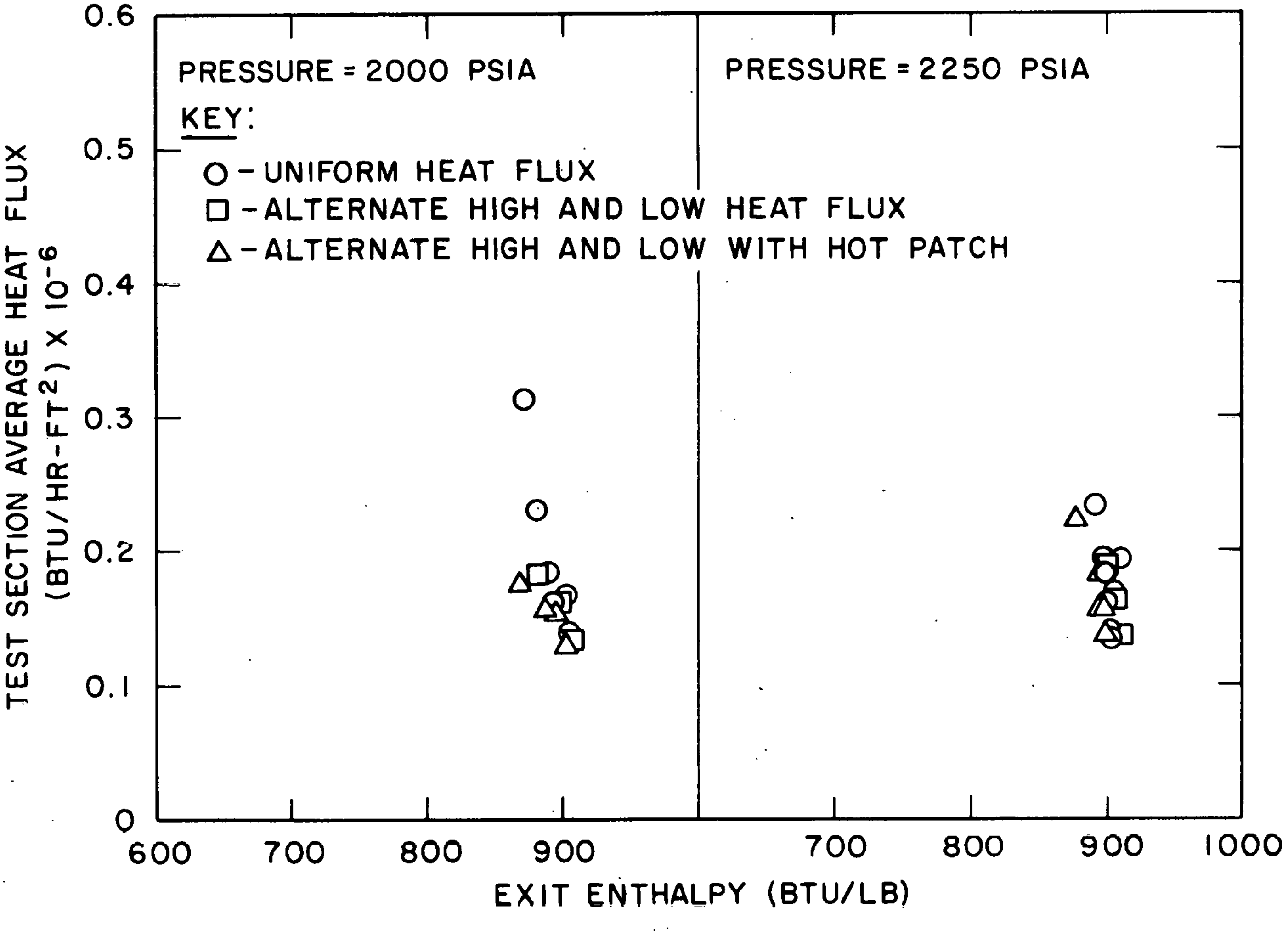


FIGURE 14. SUMMARY OF CHF DATA AT 0.25×10^6 LBS/HR-FT^2

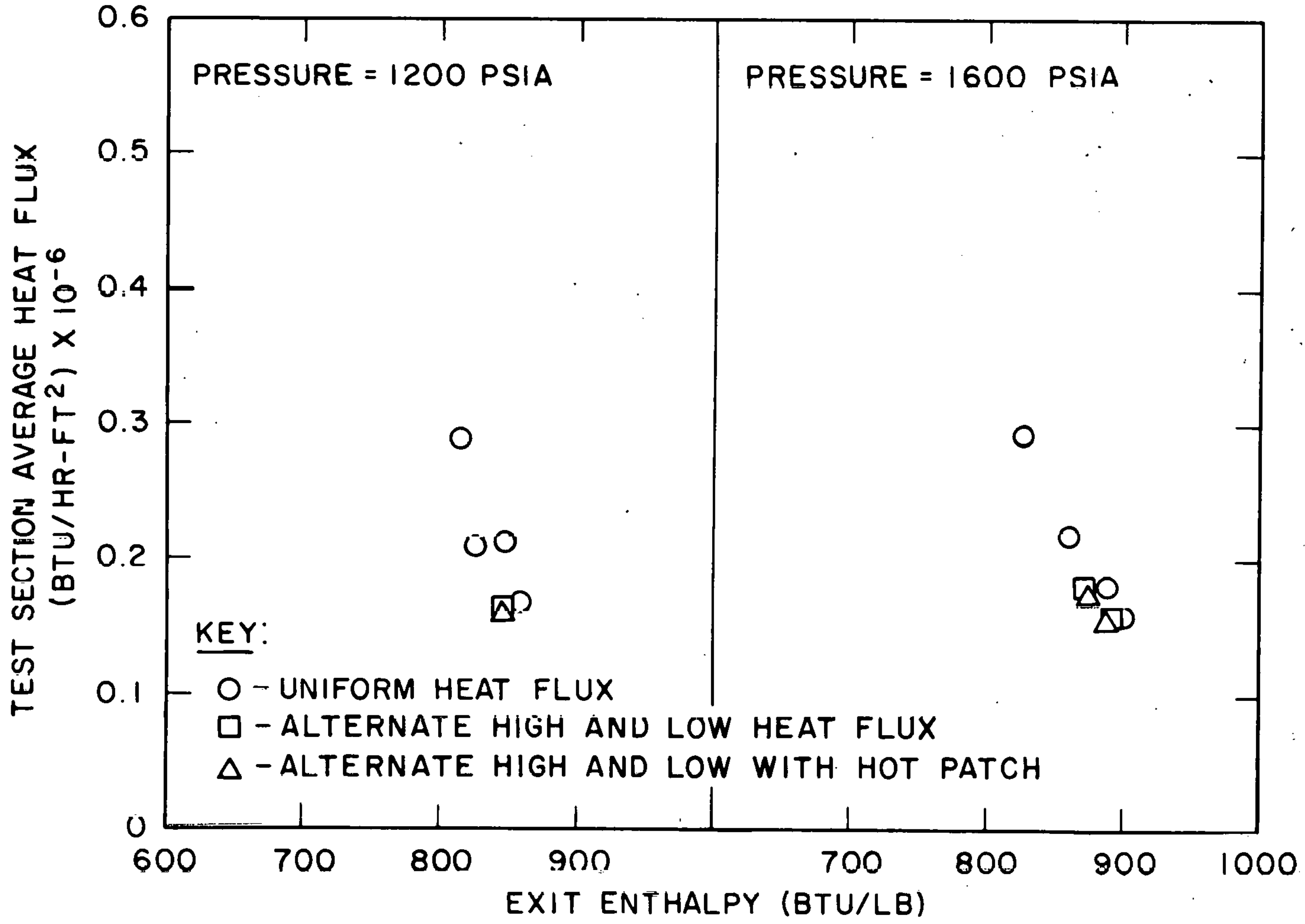


FIGURE 15. SUMMARY OF CHF DATA AT 0.25×10^6 LBS/HR-FT^2

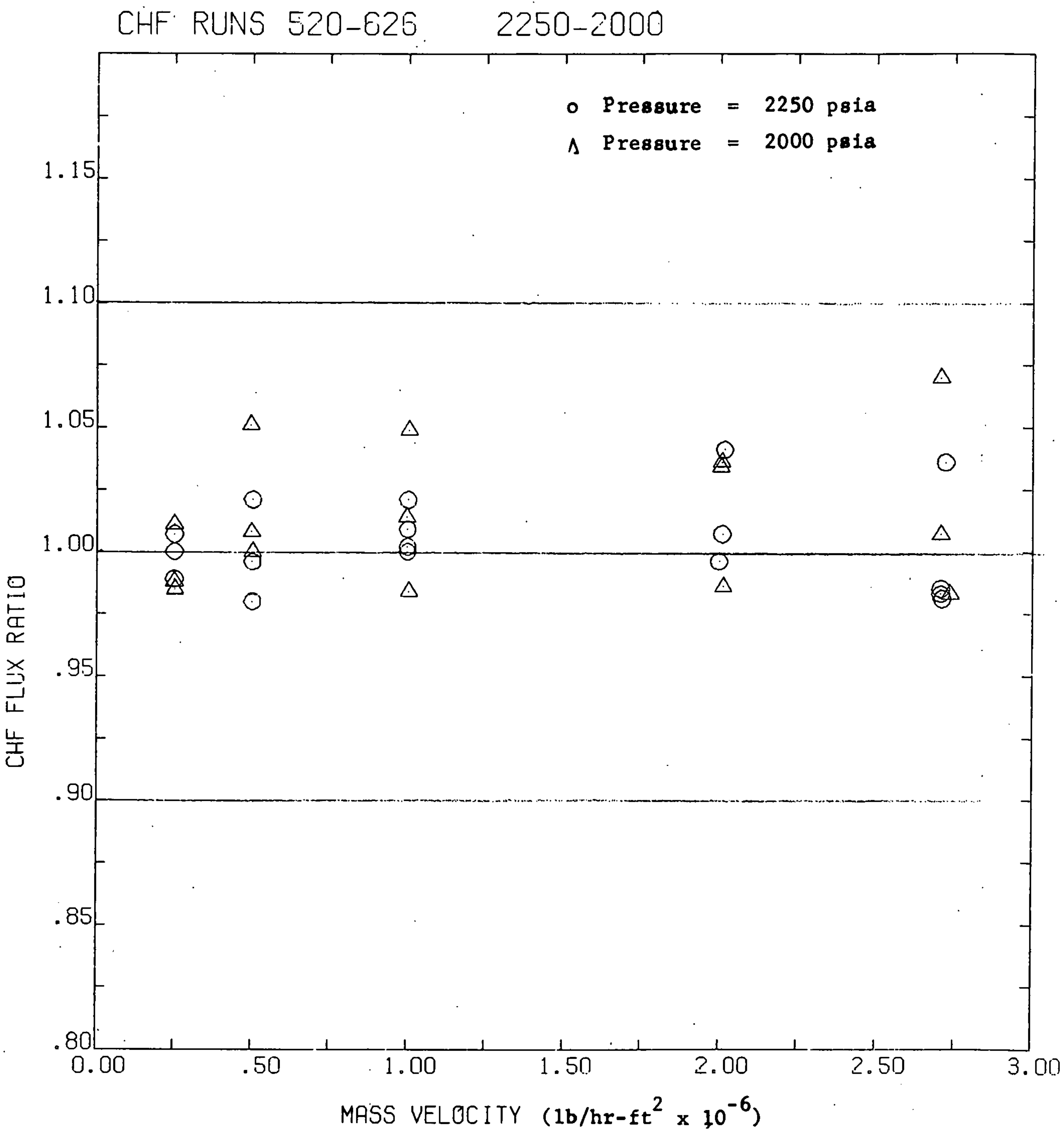


FIGURE 16: Critical Heat Flux Ratio - Alternate High and Low Flux to Uniform Flux

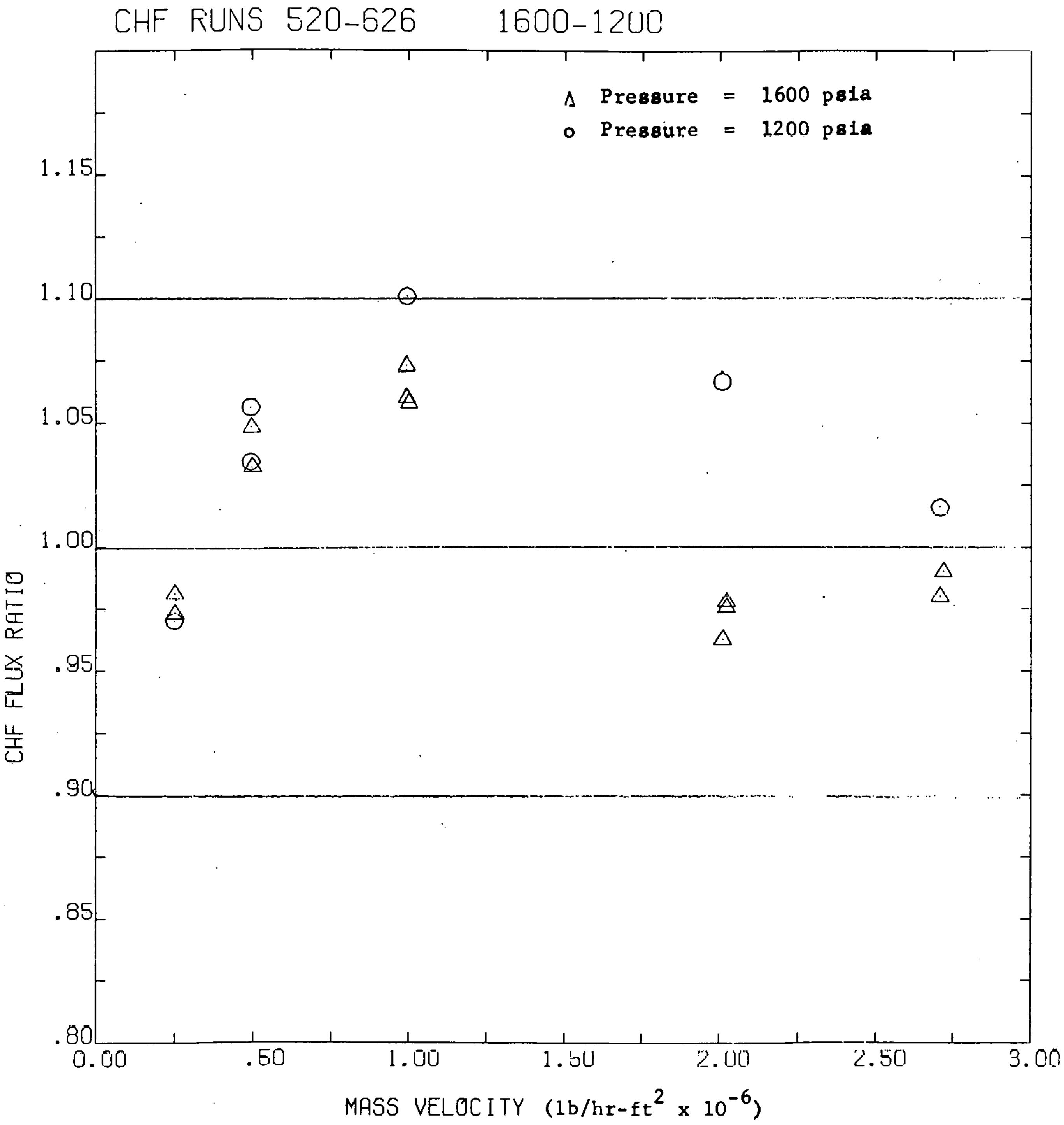


FIGURE 17: Critical Heat Flux Ratio - Alternate High and Low Flux to Uniform Flux

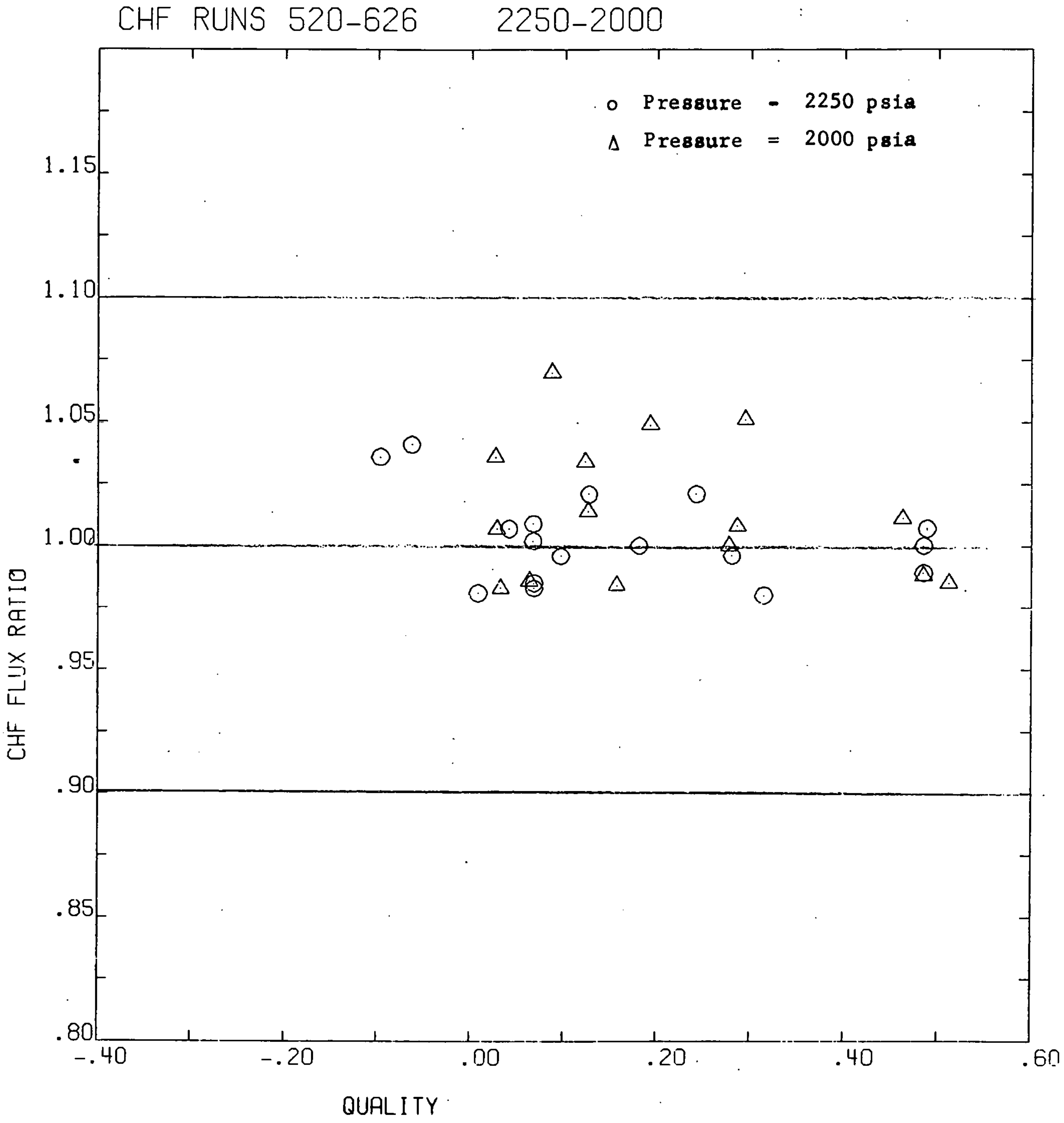


FIGURE 18: Critical Heat Flux Ratio - Alternate High and Low Flux to Uniform Flux

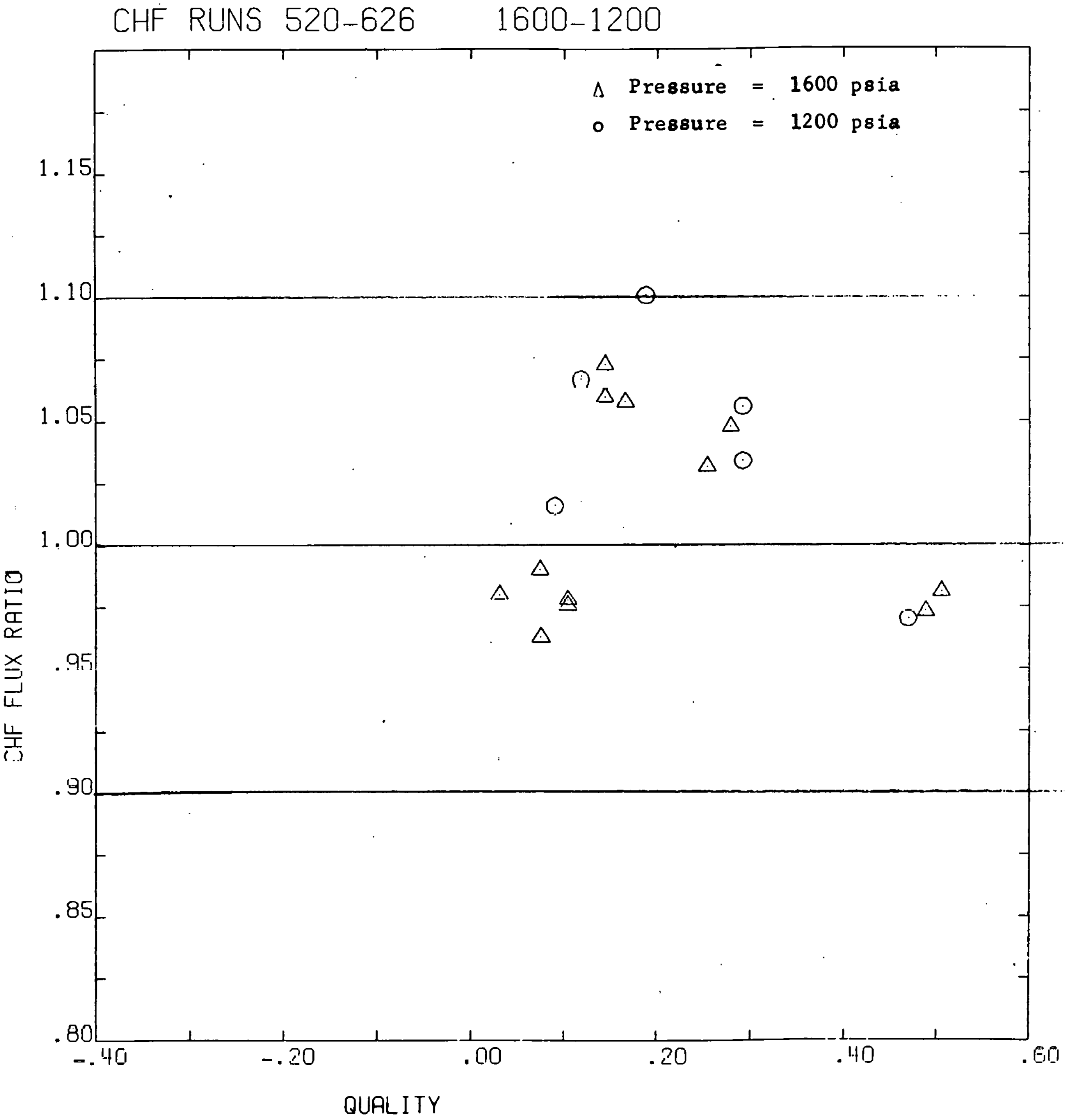


FIGURE 19: Critical Heat Flux Ratio - **Alternate High and Low Flux to** Uniform Flux

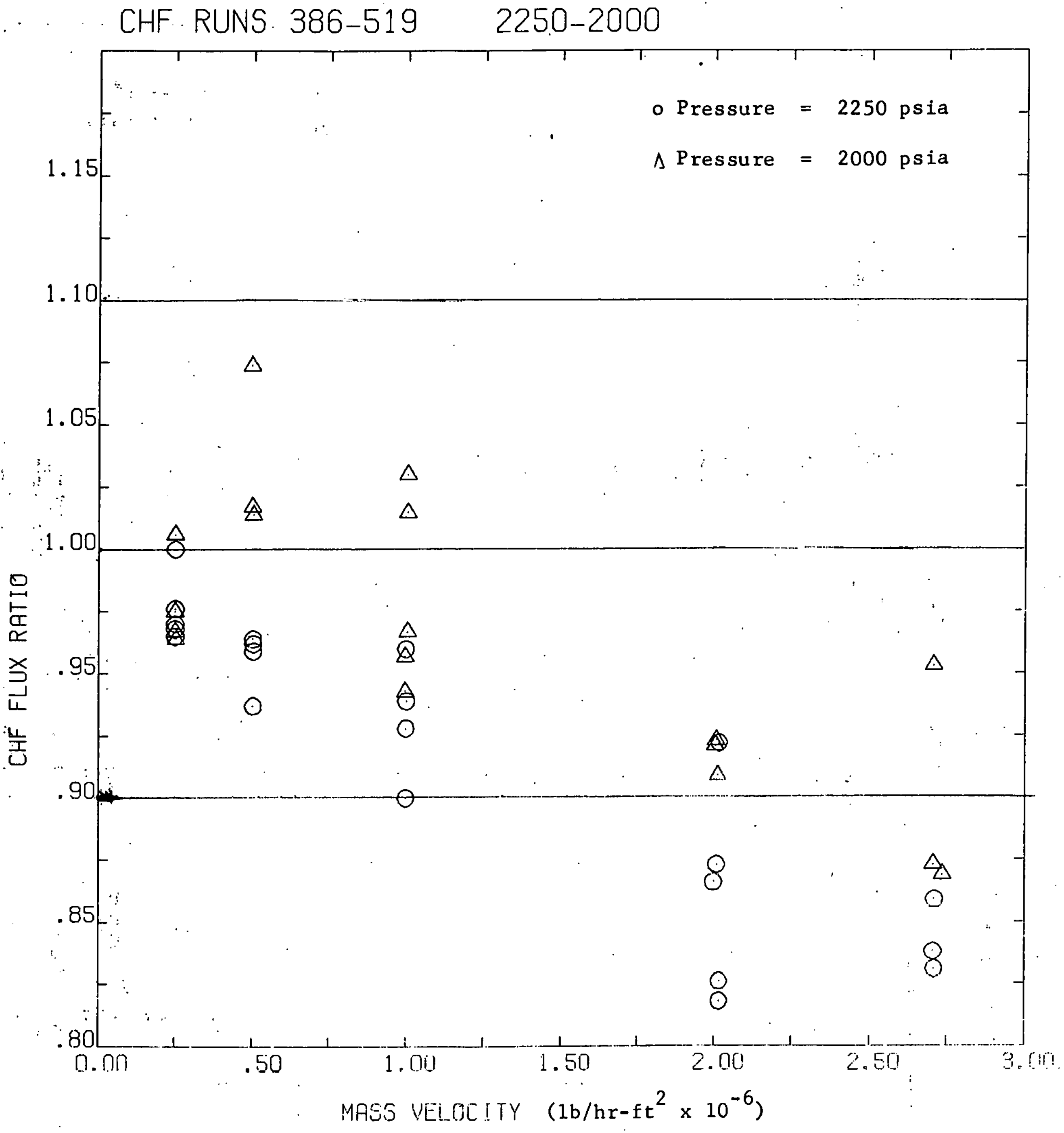


FIGURE 20: Critical Heat Flux Ratio - Alternate High and Low Flux with Hot Patch to Uniform Flux

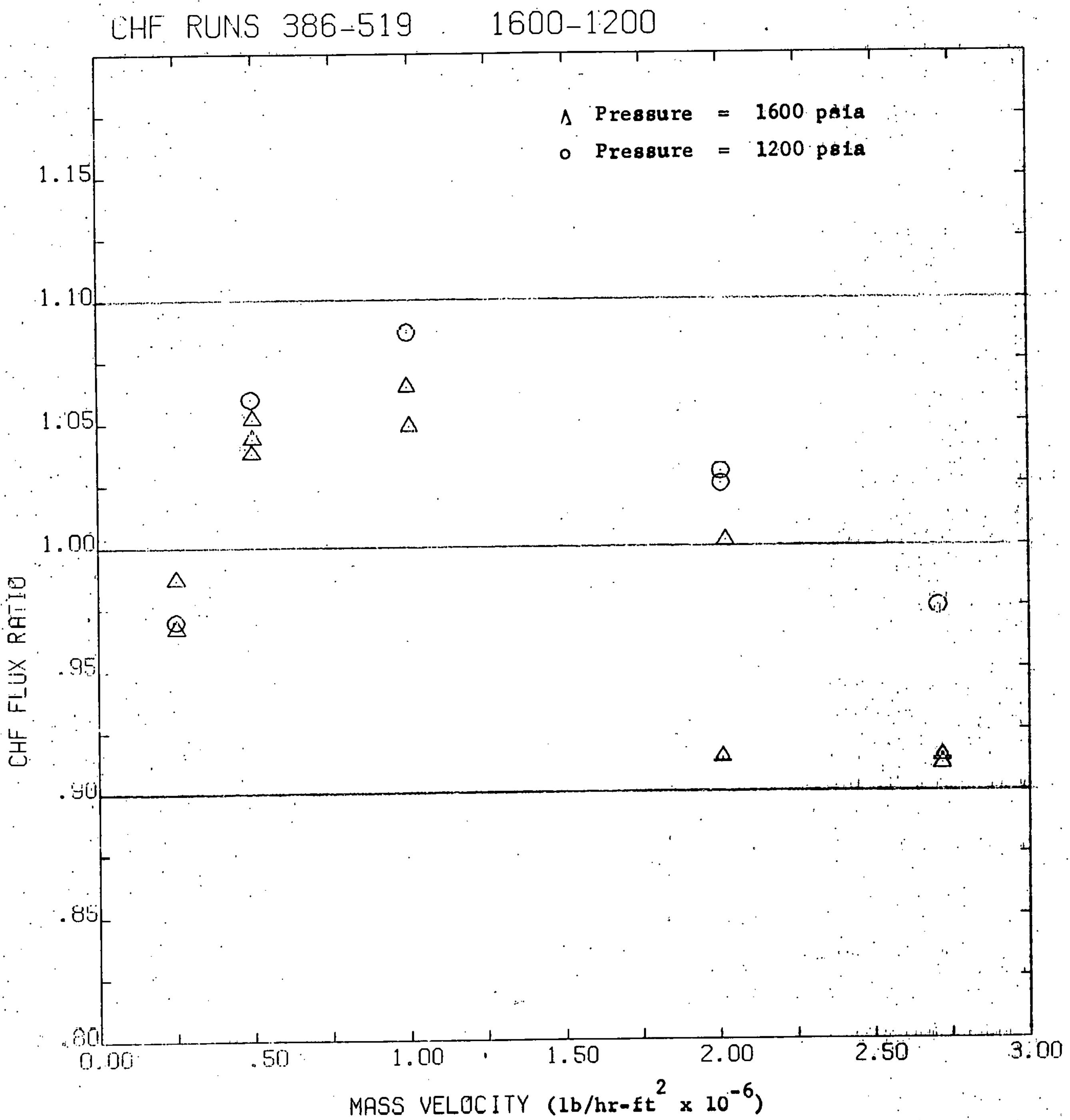


FIGURE 21: Critical Heat Flux Ratio - Alternate High and Low Flux with Hot Patch to Uniform Flux

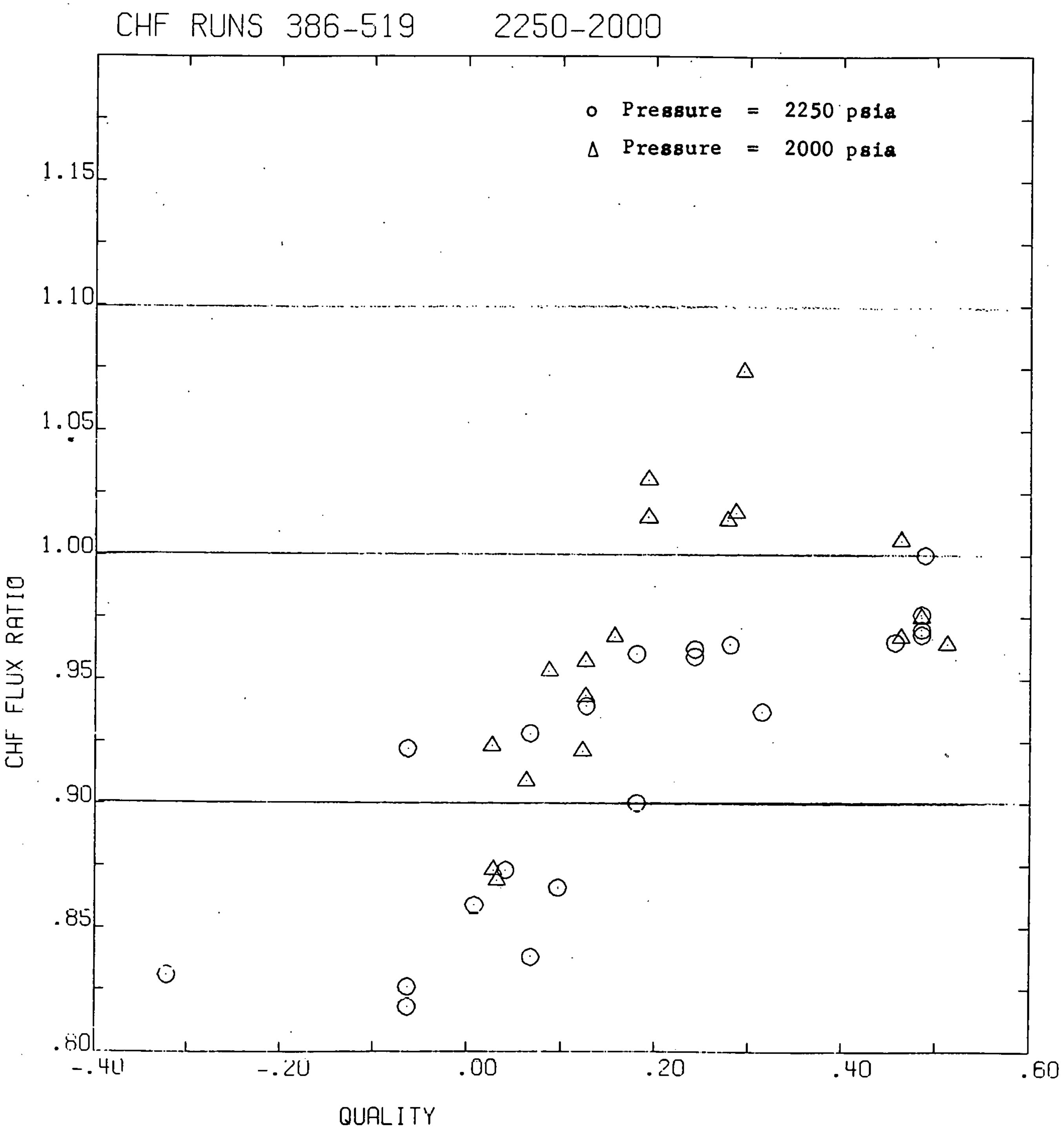


FIGURE 22: Critical Heat Flux Ratio - Alternate High and Low Flux with Hot Patch to Uniform Flux

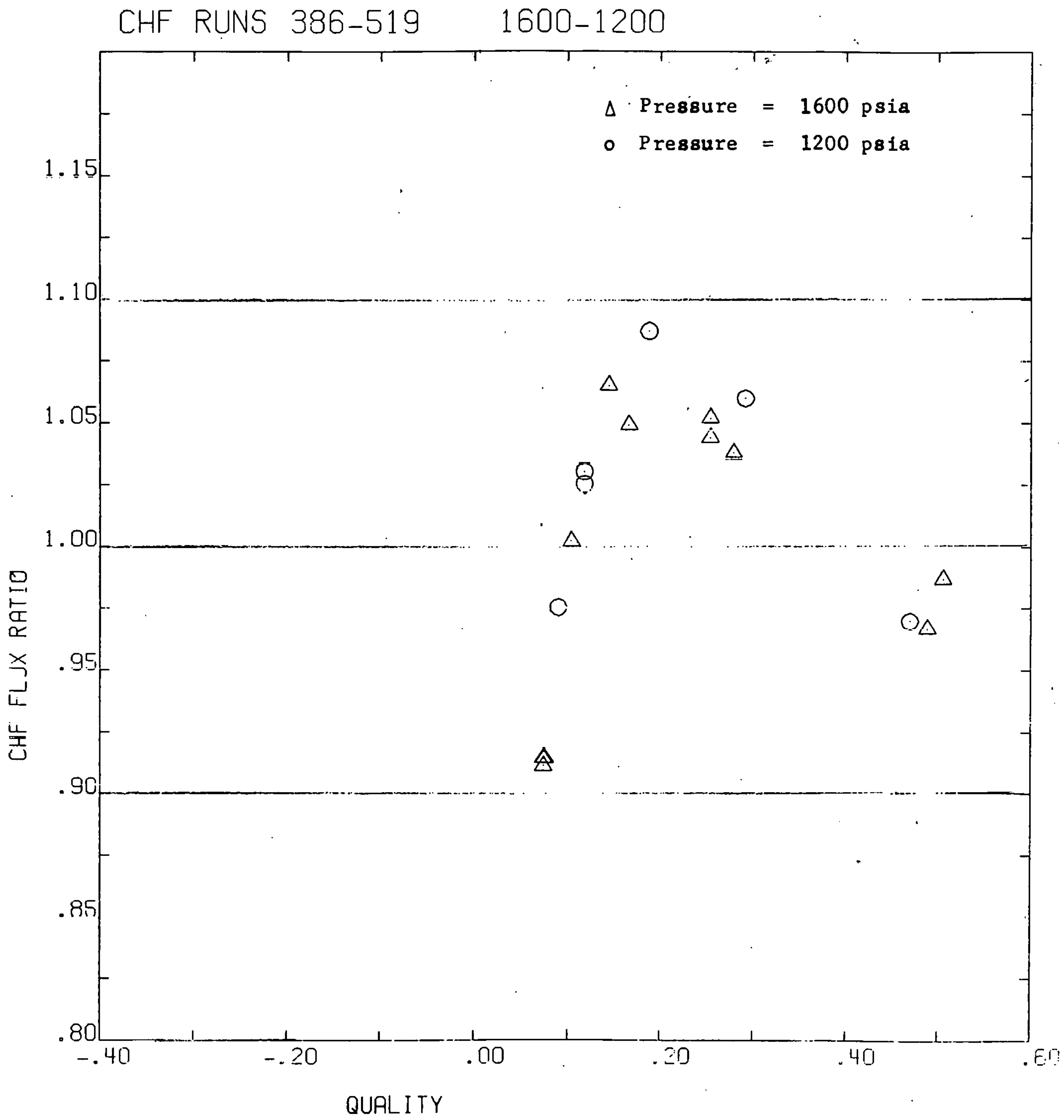


FIGURE 23: Critical Heat Flux Ratio - Alternate High and Low Flux with Hot Patch to Uniform Flux

TABLE 1: Critical Heat Flux Data with Uniform Heat Flux

RUN NO.	TYPE	PRES- (PSIA)	MASS VELOCITY X 10-6 (LB/HR-FTSQ)	INLET TEMPERATURE (DEG.F.)	MEASURED INLET ENTHALPY (BTU/LB)	AVERAGE HEAT FLUX X 10-6 (BTU/HR-FTSQ)	CALCULATED EXIT ENTHALPY (BTU/LB)	QUALITY
158	CHF	2250	2.708	598.4	611.5	.615	733.0	.077
156	CHF	2250	1.998	596.8	609.4	.496	742.2	.099
154	CHF	2250	.996	599.8	613.6	.308	778.4	.187
155	CHF	2250	.995	599.5	613.1	.302	774.6	.177
148	CHF	2250	.503	600.0	613.7	.206	831.0	.313
152	CHF	2250	.498	598.1	611.1	.206	830.2	.311
150	CHF	2250	.251	599.2	612.6	.139	902.5	.485
160	CHF	2250	2.715	550.1	547.6	.798	705.2	.010
162	CHF	2250	2.003	548.4	545.6	.644	717.8	.041
164	CHF	2250	.999	549.5	546.9	.395	758.2	.138
166	CHF	2250	.501	547.3	544.2	.260	819.9	.286
168	CHF	2250	.250	548.9	546.2	.170	904.5	.490
174	CHF	2250	.998	498.6	486.3	.468	737.1	.087
172	CHF	2250	.503	498.7	486.5	.291	795.1	.227
170	CHF	2250	.249	498.9	486.7	.194	898.8	.476
127	CHF	2000	2.729	548.3	545.7	.744	691.8	.043
125	CHF	2000	2.012	548.6	546.0	.592	703.7	.069
130	CHF	2000	2.008	548.3	545.7	.583	701.3	.064
111	CHF	2000	1.006	548.7	546.2	.371	743.1	.154
109	CHF	2000	.498	549.1	546.8	.244	807.2	.291
107	CHF	2000	.247	549.2	546.9	.166	901.0	.493
134	CHF	2000	2.700	498.8	486.4	.919	669.0	-.006
132	CHF	2000	2.007	499.2	486.9	.736	683.6	.025
123	CHF	1600	2.729	547.3	545.1	.612	665.2	.076
121	CHF	1600	2.020	547.8	545.8	.519	683.2	.110
113	CHF	1600	1.002	548.9	547.2	.311	712.5	.164
119	CHF	1600	1.001	549.9	548.3	.310	713.4	.166
115	CHF	1600	.501	547.2	545.0	.211	768.7	.268
117	CHF	1600	.249	547.8	545.7	.159	881.7	.478
136	CHF	1600	2.711	498.4	485.8	.796	643.2	.036
138	CHF	1600	2.013	499.4	487.0	.671	665.6	.077
140	CHF	1600	.505	498.6	486.0	.257	756.7	.246
146	CHF	1200	1.003	398.7	375.1	.528	657.2	.139
144	CHF	1200	.502	399.4	375.8	.314	709.9	.226
142	CHF	1200	.248	398.9	375.3	.210	824.8	.413

Conversion Factors:

Pressure: (Pa) = (6895)(psia)
Temperature: (^{o}K) = (^{o}F + 459.67)/1.8
Enthalpy: (J/kg) = (2326) (Btu/lbm)
Mass Velocity: (kg/m^2.s) = (1.356 x 10^{-3})(lbm/ft^2-hr)
Heat Flux: (W/m^2) = (3.155)(Btu/hr-ft^2)

TABLE 1 (Continued)

RUN NO.	TYPE	PRES-(PSIA)	MASS VELOCITY X 10-6 (LB/HR-FTSQ)	INLET TEMPER-ATURE (DEG.F.)	MEASURED INLET ENTHALPY (BTU/LB)	AVERAGE HEAT FLUX X 10-6 (BTU/HR-FTSQ)	CALCU-LATED EXIT ENTHALPY (BTU/LB)	QUALITY
295	CHF	2250	2.705	598.5	611.7	.555	726.0	.060
293	CHF	2250	1.996	598.4	611.6	.462	740.6	.095
297	CHF	2250	1.000	595.8	607.9	.298	773.3	.174
301	CHF	2250	.997	598.1	611.2	.297	776.1	.181
299	CHF	2250	.503	596.9	609.4	.204	832.6	.317
303	CHF	2250	.250	598.5	611.7	.134	904.6	.490
341	CHF	2250	2.706	547.7	544.7	.706	690.5	-.025
339	CHF	2250	2.012	548.5	545.7	.567	703.1	.005
309	CHF	2250	.999	549.6	547.0	.364	749.4	.117
307	CHF	2250	.501	548.6	545.8	.244	815.1	.275
305	CHF	2250	.250	548.6	545.9	.161	900.6	.481
311	CHF	2250	.249	549.0	546.3	.161	901.3	.482
343	CHF	2250	2.721	497.6	485.2	.853	660.6	-.098
345	CHF	2250	2.015	497.6	485.2	.683	674.9	-.063
348	CHF	2250	.999	499.2	487.0	.419	720.9	.048
316	CHF	2250	.501	499.1	486.9	.290	808.3	.258
314	CHF	2250	.249	499.2	487.0	.192	912.0	.508
337	CHF	2250	.249	498.8	486.6	.184	895.7	.469
358	CHF	2250	2.709	377.4	353.8	1.033	567.4	-.323
356	CHF	2250	1.994	398.7	376.3	.858	617.4	-.202
350	CHF	2250	.991	400.2	377.9	.538	681.4	-.047
352	CHF	2250	.495	400.9	378.6	.353	776.5	.182
354	CHF	2250	.249	398.0	375.6	.231	890.1	.456
194	CHF	2000	2.708	598.3	612.5	.485	712.3	.087
192	CHF	2000	2.003	598.9	613.4	.416	728.8	.123
190	CHF	2000	1.006	598.2	612.3	.273	762.7	.196
196	CHF	2000	.998	599.1	613.6	.264	759.9	.190
188	CHF	2000	.496	598.9	613.3	.176	808.1	.293
186	CHF	2000	.252	598.0	612.0	.137	909.4	.511
198	CHF	2000	2.744	549.0	546.6	.662	681.4	.021
200	CHF	2000	2.012	548.8	546.3	.547	697.9	.056
202	CHF	2000	.999	549.6	547.3	.357	746.2	.160
204	CHF	2000	.500	548.6	546.1	.232	802.2	.281
206	CHF	2000	.252	548.3	545.7	.159	893.1	.476
359	CHF	2000	2.713	495.7	482.8	.811	650.1	-.047
363	CHF	2000	2.006	498.1	485.7	.642	664.8	-.015
361	CHF	2000	2.005	499.6	487.3	.639	665.5	-.013
220	CHF	2000	.996	498.4	485.9	.437	730.3	.126
222	CHF	2000	.502	499.0	486.6	.284	800.5	.277
224	CHF	2000	.250	499.3	486.9	.181	886.4	.462

TABLE 1 (Continued)

RUN NO.	TYPE	PRES- (PSIA)	MASS VELOCITY X 10-6 (LB/HR-FTSQ)	INLET TEMPER-ATURE (DEG.F.)	MEASURED INLET ENTHALPY (BTU/LB)	AVERAGE HEAT FLUX X 10-6 (BTU/HR-FTSQ)	CALCU-LATED EXIT ENTHALPY (BTU/LB)	QUALITY
368	CHF	2000	2.010	399.7	377.0	.861	616.9	-.118
320	CHF	2000	1.039	399.5	376.7	.473	630.9	-.088
271	CHF	2000	.998	400.1	377.3	.583	703.7	.069
370	CHF	2000	.988	400.0	377.3	.523	673.3	.003
335	CHF	2000	.992	399.8	377.1	.538	680.3	.018
333	CHF	2000	.502	399.3	376.5	.367	785.2	.244
322	CHF	2000	.501	400.5	377.8	.377	797.0	.269
269	CHF	2000	.501	399.8	377.0	.366	783.4	.240
265	CHF	2000	.500	399.7	376.9	.367	785.8	.246
267	CHF	2000	.249	399.2	376.4	.226	879.5	.447
380	CHF	2000	.995	201.8	174.4	.773	609.5	-.134
273	CHF	2000	.498	199.1	171.8	.506	739.0	.145
275	CHF	2000	.250	199.9	172.6	.314	872.3	.432
216	CHF	1600	2.716	547.1	544.9	.575	663.1	.073
218	CHF	1600	2.711	548.8	547.0	.569	664.1	.074
214	CHF	1600	2.021	548.3	546.3	.474	677.1	.099
212	CHF	1600	.999	547.6	545.5	.303	714.0	.167
210	CHF	1600	.492	546.2	543.7	.209	778.9	.287
208	CHF	1600	.250	548.1	546.1	.159	896.3	.505
365	CHF	1600	2.702	499.0	486.5	.730	637.6	.025
291	CHF	1600	2.000	498.9	486.4	.636	664.1	.074
230	CHF	1600	.992	499.7	487.3	.382	701.7	.144
228	CHF	1600	.500	498.7	486.2	.248	761.0	.254
232	CHF	1600	.492	499.1	486.6	.246	763.3	.259
226	CHF	1600	.250	498.9	486.4	.182	887.1	.488
235	CHF	1200	.248	498.6	486.2	.168	859.2	.469
374	CHF	1600	2.702	397.7	374.4	1.014	584.6	-.073
372	CHF	1600	1.986	399.6	376.4	.838	612.7	-.021
249	CHF	1600	1.006	400.2	377.0	.562	689.0	.121
251	CHF	1600	.505	400.9	377.8	.337	749.4	.233
253	CHF	1600	.250	399.2	376.0	.218	858.6	.435
382	CHF	1600	1.001	199.6	171.4	.815	627.9	.007
279	CHF	1600	.495	201.8	173.5	.492	729.0	.195
277	CHF	1600	.250	200.0	171.7	.293	825.1	.373
287	CHF	1200	2.706	499.3	487.1	.678	627.0	.090
285	CHF	1200	2.014	499.7	487.5	.565	644.2	.118
289	CHF	1200	1.998	498.6	486.2	.563	643.5	.117
239	CHF	1200	.994	500.2	488.1	.356	687.1	.188
237	CHF	1200	.494	499.1	486.9	.234	749.8	.291

TABLE 1 (Continued)

RUN NO.	TYPE	PRES- (PSIA)	MASS VELOCITY X 10-6 (LB/HR-FTSQ)	INLET TEMPER-ATURE (DEG.F.)	MEASURED INLET ENTHALPY (BTU/LB)	AVERAGE HEAT FLUX X 10-6 (BTU/HR-FTSQ)	CALCU-LATED EXIT ENTHALPY (BTU/LB)	QUALITY
247	CHF	1200	.999	399.9	376.3	.520	667.2	.156
241	CHF	1200	.992	399.9	376.4	.516	666.8	.155
243	CHF	1200	.498	399.8	376.3	.315	728.8	.257
245	CHF	1200	.250	400.0	376.5	.213	848.5	.452
376	CHF	1200	2.712	397.9	374.2	1.000	580.7	.015
378	CHF	1200	2.013	398.6	374.9	.832	606.3	.056
384	CHF	1200	.998	201.0	171.9	.790	615.3	.071
281	CHF	1200	.501	199.9	170.8	.474	700.1	.210
283	CHF	1200	.250	199.6	170.4	.288	812.8	.394
261	CHF	800	2.021	399.7	375.5	.767	587.9	.113
263	CHF	800	.998	399.4	375.2	.468	636.6	.184
259	CHF	800	.986	399.7	375.4	.457	634.0	.180
257	CHF	800	.499	399.8	375.5	.280	687.8	.258
255	CHF	800	.249	399.1	374.9	.190	797.2	.417

TABLE 2: Base Case - Averaged Critical Heat Flux Data with Uniform Heat Flux

I.D.	TYPE	PRES- (PSIA)	MASS VELOCITY X 10-6 (LB/HR-FTSQ)	INLET TEMPER-ATURE (DEG.F.)	MEASURED INLET ENTHALPY (BTU/LB)	AVERAGE HEAT FLUX X 10-6 (BTU/HR-FTSQ)	CALCU-LATED EXIT ENTHALPY (BTU/LB)	QUALITY
8 20	CHF	2250	2.706	598.4	611.6	.585	729.5	.068
8 16	CHF	2250	1.997	597.6	610.5	.476	741.4	.097
8 12	CHF	2250	.998	597.9	610.9	.301	775.9	.181
8 8	CHF	2250	.501	598.3	611.4	.205	831.3	.314
8 3	CHF	2250	.250	598.8	612.1	.136	913.6	.488
8 19	CHF	2250	2.710	548.9	546.2	.752	697.9	.008
8 15	CHF	2250	2.007	548.4	545.6	.605	710.5	.041
8 11	CHF	2250	.999	549.5	546.9	.379	753.8	.127
8 7	CHF	2250	.501	547.9	545.0	.252	817.5	.280
8 2	CHF	2250	.250	548.8	546.1	.164	902.1	.484
8 18	CHF	2250	2.721	497.6	485.2	.853	660.6	-.097
8 14	CHF	2250	2.015	497.6	485.2	.683	674.9	-.063
8 10	CHF	2250	.998	498.9	486.7	.444	729.0	.067
8 6	CHF	2250	.502	498.9	486.7	.290	801.7	.242
8 1	CHF	2250	.249	499.0	486.8	.190	902.2	.484
8 17	CHF	2250	2.709	377.4	353.8	1.033	567.4	-.322
8 13	CHF	2250	1.994	398.7	376.3	.858	617.4	-.201
8 9	CHF	2250	.991	400.2	377.9	.538	681.4	-.047
8 5	CHF	2250	.495	400.9	378.7	.353	776.5	.182
8 4	CHF	2250	.249	398.0	375.6	.231	890.1	.456
8 42	CHF	2000	2.708	598.3	612.4	.485	712.3	.087
8 39	CHF	2000	2.003	598.9	613.3	.416	728.8	.123
8 35	CHF	2000	1.002	598.6	612.9	.268	761.3	.193
8 30	CHF	2000	.496	598.9	613.3	.176	808.1	.294
8 25	CHF	2000	.252	598.0	612.0	.137	909.4	.511
8 41	CHF	2000	2.736	548.6	546.1	.703	686.6	.032
8 38	CHF	2000	2.011	547.7	544.9	.574	701.0	.063
8 34	CHF	2000	1.002	549.1	546.7	.364	744.7	.157
8 29	CHF	2000	.499	546.4	543.3	.238	804.7	.286
8 24	CHF	2000	.249	548.7	546.2	.162	897.1	.484
8 40	CHF	2000	2.706	497.2	484.6	.845	659.6	.028
8 37	CHF	2000	2.005	498.9	486.5	.672	671.3	.026
8 33	CHF	2000	.996	498.4	486.0	.437	730.3	.126
8 28	CHF	2000	.502	499.0	486.6	.284	800.5	.277
8 23	CHF	2000	.250	486.9	472.9	.181	886.4	.462
8 36	CHF	2000	2.010	399.7	375.9	.861	616.9	-.118
8 32	CHF	2000	.993	399.9	377.2	.548	685.8	.030
8 27	CHF	2000	.501	399.8	377.1	.369	787.9	.250
8 22	CHF	2000	.249	399.2	376.4	.226	879.5	.447
8 31	CHF	2000	.995	201.8	174.5	.773	609.5	-.134
8 26	CHF	2000	.498	199.1	171.8	.506	739.0	.145
8 21	CHF	2000	.250	199.9	172.6	.314	872.3	.432

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* See Conversion Factors on next page.

TABLE 2 (Continued)

I.D.	TYPE	PRES- (PSIA)	MASS VELOCITY X 10-6 (LB/HR-FTSQ)	INLET TEMPERATURE (DEG.F.)	MEASURED INLET ENTHALPY (BTU/LB)	AVERAGE HEAT FLUX X 10-6 (BTU/HR-FTSQ)	CALCULATED EXIT ENTHALPY (BTU/LB)	QUALITY
B 60	CHF	1600	2.718	547.7	545.6	.582	664.1	.074
B 57	CHF	1600	2.020	548.0	546.0	.496	675.2	.104
B 54	CHF	1600	1.000	548.8	547.0	.308	713.3	.156
B 50	CHF	1600	.496	546.7	544.3	.210	773.8	.278
B 45	CHF	1600	.250	547.9	545.9	.159	889.0	.505
B 59	CHF	1600	2.706	498.7	486.2	.763	640.4	.030
B 56	CHF	1600	2.007	499.2	486.7	.654	664.9	.075
B 53	CHF	1600	.992	499.7	487.3	.382	701.7	.144
B 49	CHF	1600	.499	498.8	488.3	.250	760.3	.253
B 46	CHF	1600	.250	498.9	486.4	.182	887.1	.488
B 58	CHF	1600	2.702	397.7	374.4	1.014	584.6	-.073
B 55	CHF	1600	1.986	399.6	376.4	.838	612.7	-.021
B 52	CHF	1600	1.006	400.2	377.1	.562	689.0	.121
B 48	CHF	1600	.505	400.9	377.8	.337	749.4	.233
B 44	CHF	1600	.250	399.2	376.0	.218	858.6	.435
B 51	CHF	1600	1.001	199.6	171.4	.815	627.9	.007
B 47	CHF	1600	.495	201.8	173.6	.492	729.0	.195
B 43	CHF	1600	.250	200.0	171.8	.293	825.1	.373
B 73	CHF	1200	2.706	499.3	487.1	.678	627.0	.090
B 71	CHF	1200	2.006	498.1	485.7	.564	643.9	.118
B 69	CHF	1200	.994	500.2	488.1	.356	687.1	.188
B 66	CHF	1200	.494	499.1	486.8	.234	749.8	.291
B 63	CHF	1200	.248	498.6	486.2	.168	859.2	.469
B 72	CHF	1200	2.712	397.9	374.2	1.000	580.7	.015
B 70	CHF	1200	2.013	398.6	374.9	.832	616.3	.056
B 68	CHF	1200	.998	399.5	375.9	.521	663.7	.150
B 65	CHF	1200	.499	399.6	376.0	.314	719.4	.257
B 62	CHF	1200	.249	399.5	375.9	.212	836.7	.432
B 67	CHF	1200	.998	201.0	171.8	.790	635.3	.071
B 64	CHF	1200	.501	199.9	170.7	.474	710.1	.210
B 61	CHF	1200	.250	199.6	170.4	.288	812.8	.394
B 77	CHF	800	2.021	399.7	375.5	.767	587.9	.113
B 76	CHF	800	.992	399.5	375.2	.451	635.3	.192
B 75	CHF	800	.499	399.8	375.6	.280	687.8	.258
B 74	CHF	800	.249	399.1	374.8	.190	797.2	.417

Conversion Factors:
Pressure: (Pa) = (6895)(psia)
Temperature: (^{o}K) = (^{o}F + 459.67)/1.8
Enthalpy: (J/kg) = (2326)(Btu/lbm)
Mass Velocity (Kg/m^{2}·s) (1.356 x 10^{-3})(lbm/ft^{2}-hr)
Heat Flux: (W/m^{2}) = (3.155)(Btu/hr-ft^{2})

TABLE 3: Critical Heat Flux Data with Alternate High and Low Heat Flux Including Comparison with Base Case Data

RUN NO.	TYPE	PRES- (PSIA)	MASS VELOCITY X 10-6 (LB/HR-FTSQ)	INLET TEMPER-ATURE (DEG.F.)	MEASURED INLET ENTHALPY (BTU/LB)	AVERAGE HEAT FLUX X 10-6 (BTU/HR-FTSQ)	CALCU-LATED EXIT ENTHALPY (BTU/LB)	QUALITY	CHF RATIO	BASE CASE I.D.
537	CHF	2250	2.708	596.6	609.1	.576	727.8	.065	.985	B 20
533	CHF	2250	2.704	596.3	608.6	.575	727.2	.063	.983	B 20
535	CHF	2250	2.019	596.8	609.4	.474	740.2	.095	.996	B 16
531	CHF	2250	.997	596.7	609.2	.301	776.7	.182	1.000	B 12
529	CHF	2250	.502	598.0	611.0	.201	831.6	.315	.980	B 8
527	CHF	2250	.248	597.8	610.8	.137	911.2	.506	1.007	B 3
559	CHF	2250	2.705	547.8	544.9	.738	697.3	-.009	.981	B 19
561	CHF	2250	1.997	547.6	544.6	.609	714.9	.034	1.007	B 15
563	CHF	2250	.998	547.8	544.8	.387	760.7	.144	1.021	B 11
565	CHF	2250	.503	547.9	545.0	.251	821.1	.289	.996	B 7
569	CHF	2250	.250	548.5	545.7	.164	905.7	.493	1.000	B 2
625	CHF	2250	2.709	499.0	486.8	.884	669.4	-.076	1.036	B 18
623	CHF	2250	2.007	498.7	486.5	.711	684.6	-.040	1.041	B 14
621	CHF	2250	1.001	498.4	486.2	.448	735.7	.084	1.009	B 10
627	CHF	2250	.997	498.4	486.1	.445	734.8	.082	1.002	B 10
619	CHF	2250	.502	498.2	485.9	.296	813.1	.270	1.021	B 6
617	CHF	2250	.250	498.4	486.1	.188	899.5	.478	.989	B 1
539	CHF	2000	2.719	596.9	610.4	.519	716.9	.097	1.070	B 42
541	CHF	2000	2.008	596.6	610.0	.430	729.1	.123	1.034	B 39
543	CHF	2000	.999	598.4	612.6	.281	768.2	.208	1.049	B 35
545	CHF	2000	.502	598.1	612.1	.185	815.0	.308	1.051	B 30
547	CHF	2000	.249	597.8	611.7	.135	908.0	.508	.985	B 25
557	CHF	2000	2.710	547.6	544.9	.691	687.2	.033	.983	B 41
555	CHF	2000	2.013	548.5	546.0	.566	702.8	.067	.986	B 38
553	CHF	2000	.998	548.6	546.1	.358	745.7	.159	.984	B 34
551	CHF	2000	.502	548.2	545.6	.240	809.6	.297	1.008	B 29
567	CHF	2000	.499	548.6	546.1	.240	812.0	.302	1.008	B 29
549	CHF	2000	.250	548.6	546.1	.160	897.0	.485	.988	B 24
607	CHF	2000	2.711	497.6	485.1	.851	660.6	-.024	1.007	B 40
609	CHF	2000	2.012	498.0	485.5	.696	678.8	.015	1.036	B 37
611	CHF	2000	1.000	497.8	485.3	.443	731.9	.130	1.014	B 33
613	CHF	2000	.498	499.5	487.1	.284	803.7	.284	1.000	B 28
615	CHF	2000	.251	498.4	486.0	.183	888.1	.466	1.011	B 23
579	CHF	1600	2.669	548.4	546.5	.576	666.9	.080	.990	B 60
581	CHF	1600	2.001	547.8	545.7	.485	681.0	.106	.978	B 57
577	CHF	1600	1.994	548.5	546.6	.484	681.9	.107	.976	B 57
575	CHF	1600	.998	548.4	546.4	.326	727.6	.192	1.058	B 54
573	CHF	1600	.501	548.3	546.4	.220	789.1	.306	1.048	B 50
571	CHF	1600	.249	548.4	546.5	.156	890.5	.494	.981	B 45

Conversion Factors: Pressure: (Pa) = (6895)(psia)
Temperature: (^{o}K) = (^{o}F + 459.67)/1.8
Enthalpy: (J/kg) = (2326) (Btu/lbm)
Mass Velocity: (kg/m^2.s) = (1.356 x 10^{-3})(lbm/ft^2-hr)
Heat Flux: (W/m^2) = (3.155)(Btu/hr-ft^2)

TABLE 3 (Continued)

RUN NO.	TYPE	PRES- (PSIA)	MASS VELOCITY X 10-6 (LB/HR-FTSQ)	INLET TEMPER-ATURE (DEG.F.)	MEASURED INLET ENTHALPY (BTU/LB)	AVERAGE HEAT FLUX X 10-6 (BTU/HR-FTSQ)	CALCU-LATED EXIT ENTHALPY (BTU/LB)	QUALITY	CHF RATIO	BASE CASE I.D.
583	CHF	1600	2.703	499.2	486.8	.748	641.4	.032	.980	B 59
585	CHF	1600	2.010	498.7	486.1	.630	661.3	.069	.963	B 56
591	CHF	1600	.999	498.4	485.8	.410	714.4	.168	1.073	B 53
587	CHF	1600	.996	498.6	486.0	.405	712.1	.163	1.060	B 53
589	CHF	1600	.507	498.5	485.9	.258	767.9	.267	1.032	B 49
593	CHF	1600	.252	498.3	485.7	.177	872.1	.460	.973	B 46
605	CHF	1200	2.701	498.1	485.7	.689	628.3	.092	1.016	B 73
603	CHF	1200	2.025	497.4	484.9	.602	650.9	.129	1.067	B 71
599	CHF	1200	1.002	498.4	486.0	.392	703.7	.215	1.101	B 69
597	CHF	1200	.501	498.5	486.1	.247	758.7	.305	1.056	B 66
601	CHF	1200	.498	499.1	486.9	.242	756.1	.301	1.034	B 66
595	CHF	1200	.251	498.7	486.3	.163	844.7	.446	.970	B 63

TABLE 4: Critical Heat Flux Data with Alternate High and Low Heat Flux and Exit Hot Patch Including Comparison with Base Case Data

RUN NO.	TYPE	PRES- (PSIA)	MASS VELOCITY X 10-6 (LB/HR-FTSQ)	INLET TEMPER-ATURE (DEG.F.)	MEASURED INLET ENTHALPY (BTU/LB)	AVERAGE HEAT FLUX X 10-6 (BTU/HR-FTSQ)	CALCU-LATED EXIT ENTHALPY (BTU/LB)	QUALITY	CHF RATIO	BASE CASE I.D.
403	CHF	2250	2.714	596.0	608.3	.490	709.0	.019	.838	B 20
401	CHF	2250	2.010	600.7	614.7	.412	728.9	.067	.966	B 16
406	CHF	2250	1.000	596.5	609.0	.289	769.4	.165	.960	B 12
399	CHF	2250	.996	601.6	616.0	.271	766.8	.158	.900	B 12
397	CHF	2250	.495	597.5	610.3	.192	823.6	.295	.937	B 8
395	CHF	2250	.253	597.4	610.2	.136	903.8	.489	1.000	B 3
424	CHF	2250	2.719	547.7	544.7	.646	677.3	-.055	.859	B 19
422	CHF	2250	1.988	548.8	546.1	.528	694.3	-.016	.873	B 15
420	CHF	2250	1.000	548.3	545.4	.356	743.4	.124	.939	B 11
428	CHF	2250	.504	548.3	545.4	.243	812.0	.267	.964	B 7
430	CHF	2250	.250	548.2	545.3	.160	896.5	.471	.976	B 2
426	CHF	2250	.249	549.0	546.3	.159	897.3	.473	.970	B 2
518	CHF	2250	2.031	497.7	485.3	.559	639.1	-.150	.818	B 14
510	CHF	2250	2.009	496.6	484.0	.564	640.7	-.146	.926	B 14
460	CHF	2250	1.997	496.2	483.6	.630	659.9	-.100	.922	B 14
458	CHF	2250	.996	498.9	486.7	.412	717.1	.039	.928	B 10
512	CHF	2250	.508	498.0	485.6	.278	788.9	.212	.959	B 6
456	CHF	2250	.506	497.4	485.0	.279	790.3	.215	.962	B 6
454	CHF	2250	.251	499.4	487.3	.184	891.7	.459	.968	B 1
508	CHF	2250	2.722	399.0	376.6	.858	553.1	-.357	.831	B 17
500	CHF	2250	.248	400.1	377.8	.223	876.1	.422	.965	B 4
416	CHF	2000	2.713	598.5	612.7	.462	707.5	.077	.953	B 42
414	CHF	2000	2.024	598.5	612.8	.383	718.1	.100	.921	B 39
418	CHF	2000	.998	597.1	610.7	.272	761.8	.194	1.015	B 35
408	CHF	2000	.992	594.8	607.4	.276	761.4	.193	1.030	B 35
410	CHF	2000	.502	596.4	609.6	.189	817.2	.313	1.074	B 30
412	CHF	2000	.248	598.1	612.1	.132	903.2	.498	.964	B 25
438	CHF	2000	2.721	547.9	545.2	.611	670.6	.002	.969	B 41
436	CHF	2000	2.019	547.5	544.7	.522	689.0	.037	.909	B 38
434	CHF	2000	.999	548.5	546.0	.352	741.9	.151	.967	B 34
432	CHF	2000	.508	548.3	545.7	.242	809.2	.296	1.017	B 29
452	CHF	2000	.250	549.3	546.9	.158	895.1	.481	.975	B 24
464	CHF	2000	2.709	496.5	483.8	.738	636.0	-.077	.873	B 40
466	CHF	2000	2.024	499.1	486.7	.620	657.7	-.030	.923	B 37
468	CHF	2000	1.001	497.8	485.3	.418	717.8	.099	.957	B 33
516	CHF	2000	.999	498.4	485.9	.412	715.9	.095	.943	B 33
470	CHF	2000	.499	498.3	485.9	.288	805.5	.288	1.014	B 28
514	CHF	2000	.252	497.0	484.4	.175	868.1	.423	.967	B 23
472	CHF	2000	.250	498.4	486.0	.182	887.5	.465	1.006	B 23

Conversion Factors: Pressure: (Pa) = (6895)(psia)
Temperature: $(^{o}K) = (^{o}F + 459.67)/1.8$
Enthalpy: (J/kg) = (2326)(Btu/lbm)
Mass Velocity: $(kg/m^2.s)$ $(1.356 \times 10^{-3})(lbm/ft^2\text{-}hr)$
Heat Flux: $(W/m^2) = (3.155)(Btu/hr\text{-}ft^2)$

TABLE 4 (Continued)

RUN NO.	TYPE	PRES- (PSIA)	MASS VELOCITY X 10-6 (LB/HR-FTSQ)	INLET TEMPER-ATURE (DEG.F.)	MEASURED INLET ENTHALPY (BTU/LB)	AVERAGE HEAT FLUX X 10-6 (BTU/HR-FTSQ)	CALCU-LATED EXIT ENTHALPY (BTU/LB)	QUALITY	CHF RATIO	BASE CASE I.D.
440	CHF	1600	2.719	549.1	547.4	.530	656.2	.060	.911	B 60
444	CHF	1600	2.698	547.4	545.2	.532	655.1	.058	.914	B 60
442	CHF	1600	2.000	545.8	543.3	.497	681.8	.107	1.002	B 57
446	CHF	1600	.999	548.6	546.7	.323	726.4	.190	1.049	B 54
448	CHF	1600	.501	549.1	547.4	.218	798.1	.305	1.038	B 50
450	CHF	1600	.252	548.0	545.9	.157	888.9	.492	.987	B 45
476	CHF	1600	2.008	498.4	485.8	.598	652.0	.052	.914	B 56
480	CHF	1600	1.002	498.6	486.0	.407	712.4	.164	1.065	B 53
482	CHF	1600	.507	500.1	487.8	.261	772.9	.276	1.044	B 49
486	CHF	1600	.503	498.6	486.0	.263	776.1	.282	1.052	B 49
484	CHF	1600	.250	499.0	486.6	.176	874.1	.464	.967	B 46
494	CHF	1200	2.716	498.9	486.7	.661	622.6	.083	.975	B 73
492	CHF	1200	2.014	498.8	486.5	.581	647.6	.124	1.030	B 71
496	CHF	1200	2.001	498.7	486.3	.578	647.5	.124	1.025	B 71
490	CHF	1200	.996	499.0	486.7	.387	713.0	.214	1.087	B 69
488	CHF	1200	.499	498.6	486.2	.248	761.9	.310	1.060	B 66

TABLE 5: Data Taken at 98% of Critical Heat Flux

RUN NO.	TYPE*	PRES- (PSIA)	MASS VELOCITY X 10-6 (LB/HR-FTSQ)	INLET TEMPER-ATURE (DEG.F.)	MEASURED INLET ENTHALPY (BTU/LB)	AVERAGE HEAT FLUX X 10-6 (BTU/HR-FTSQ)	CALCU-LATED EXIT ENTHALPY (BTU/LB)	QUALITY	TEST SECTION PRESSURE DROP (PSI)
159	UNI	2250	2.707	598.7	612,0	.603	731.3	.073	22.5
157	UNI	2250	2.000	596.9	609,5	.489	740.3	.095	14.2
149	UNI	2250	.502	599.9	613,7	.204	828.7	.308	3.3
153	UNI	2250	.498	598.7	612,0	.204	828.1	.306	3.3
151	UNI	2250	.251	599.5	613,1	.137	900.2	.480	2.4
161	UNI	2250	2.708	550.1	547,7	.785	703.2	.005	20.6
163	UNI	2250	2.006	548.4	545,5	.631	714.1	.032	13.1
165	UNI	2250	.999	548.8	546,0	.390	754.3	.129	5.6
167	UNI	2250	.501	547.6	544,5	.255	815.7	.276	3.4
169	UNI	2250	.250	548.9	546,2	.167	899.3	.478	2.5
175	UNI	2250	.998	498.3	486,0	.463	733.8	.079	5.3
173	UNI	2250	.503	499.4	487,2	.289	792.9	.221	3.4
171	UNI	2250	.249	498.9	486,6	.191	891.8	.459	2.6
128	UNI	2000	2.726	547.9	545,2	.736	689.9	.039	21.0
131	UNI	2000	2.029	548.3	545,7	.572	696.6	.053	13.4
126	UNI	2000	2.014	548.4	545,8	.588	702.1	.065	13.4
112	UNI	2000	.995	548.5	546,0	.364	741.3	.150	5.7
110	UNI	2000	.498	549.2	546,8	.240	802.5	.281	3.4
108	UNI	2000	.248	548.7	546,2	.161	889.2	.468	2.5
135	UNI	2000	2.704	498.6	486,1	.901	665.0	-.014	19.3
133	UNI	2000	2.006	499.2	486,8	.721	679.4	.017	12.3
124	UNI	1600	2.731	547.0	544,7	.605	663.4	.073	23.5
122	UNI	1600	2.019	548.0	546,0	.512	681.6	.107	15.3
120	UNI	1600	1.002	549.3	547,6	.305	709.6	.159	6.0
114	UNI	1600	1.002	548.7	546,9	.305	708.9	.158	6.0
116	UNI	1600	.506	547.3	545,1	.207	761.7	.255	3.4
118	UNI	1600	.249	547.6	545,5	.154	871.0	.458	2.5
137	UNI	1600	2.710	498.4	485,8	.779	640.0	.030	20.7
139	UNI	1600	1.999	499.3	486,9	.659	663.6	.073	14.1
141	UNI	1600	.505	498.4	485,8	.251	750.5	.235	3.6
147	UNI	1200	1.003	399.0	375,4	.522	654.1	.134	6.6
145	UNI	1200	.502	399.4	375,8	.307	701.8	.212	3.8
143	UNI	1200	.248	398.7	375,1	.206	816.2	.399	2.8

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* UNI - Uniform Heat Flux
ALT - Alternate High and Low Heat Flux Profile
HP - Alternate High and Low Heat Flux Profile with Hot Patch Superimposed

(See Conversion Factors on Next Page.)

TABLE 5 (Continued)

RUN NO.	TYPE	PRES-(PSIA)	MASS VELOCITY X 10-6 (LB/HR-FTSQ)	INLET TEMPER-ATURE (DEG.F.)	MEASURED INLET ENTHALPY (BTU/LB)	AVERAGE HEAT FLUX X 10-6 (BTU/HR-FTSQ)	CALCU-LATED EXIT ENTHALPY (BTU/LB)	QUALITY	TEST SECTION PRESSURE DROP (PSI)
296	UNI	2250	2.706	598.3	611.5	.546	723.9	.055	19.3
294	UNI	2250	1.996	598.4	611.6	.453	737.9	.089	12.4
298	UNI	2250	1.000	595.8	607.9	.295	771.6	.170	5.5
302	UNI	2250	.997	598.4	611.6	.294	775.2	.179	5.5
300	UNI	2250	.503	596.6	609.1	.200	828.4	.307	3.3
304	UNI	2250	.250	598.9	612.3	.132	899.9	.479	2.4
342	UNI	2250	2.705	548.3	545.4	.693	688.6	-.030	16.3
340	UNI	2250	2.009	548.7	546.0	.556	700.6	-.001	10.5
310	UNI	2250	.998	549.0	546.3	.359	746.4	.109	5.2
308	UNI	2250	.501	548.7	545.9	.241	811.4	.266	3.3
306	UNI	2250	.250	549.2	546.6	.158	894.8	.467	2.5
312	UNI	2250	.249	548.9	546.1	.158	894.6	.466	2.5
344	UNI	2250	2.715	499.0	486.8	.846	661.2	-.096	15.7
346	UNI	2250	2.014	497.6	485.2	.678	673.4	-.067	10.1
349	UNI	2250	.999	499.3	487.2	.413	717.7	.040	4.9
319	UNI	2250	.999	498.9	486.7	.426	724.1	.056	5.2
317	UNI	2250	.501	499.2	487.1	.287	805.7	.252	3.4
315	UNI	2250	.250	499.2	487.1	.190	905.9	.493	2.6
338	UNI	2250	.249	498.6	486.3	.180	887.8	.450	2.6
357	UNI	2250	1.990	398.8	376.5	.850	615.8	-.206	9.7
351	UNI	2250	.991	400.2	377.9	.528	676.0	-.060	4.9
353	UNI	2250	.495	400.9	378.7	.345	768.0	.161	3.4
355	UNI	2250	.248	397.9	375.5	.226	881.9	.436	2.8
195	UNI	2000	2.711	598.2	612.3	.476	710.0	.082	20.1
193	UNI	2000	2.008	598.3	612.4	.407	725.1	.115	13.1
191	UNI	2000	1.007	597.2	610.7	.268	758.2	.186	5.7
197	UNI	2000	.998	599.0	613.4	.262	758.5	.187	5.7
189	UNI	2000	.495	599.1	613.6	.171	803.9	.284	3.2
187	UNI	2000	.251	598.2	612.3	.135	904.8	.501	2.4
199	UNI	2000	2.744	549.0	546.6	.658	680.5	.019	18.1
201	UNI	2000	2.011	549.0	546.5	.543	697.3	.055	11.7
203	UNI	2000	.999	550.1	548.0	.354	744.8	.157	5.5
205	UNI	2000	.500	548.6	546.0	.228	797.6	.271	3.3
207	UNI	2000	.251	548.6	546.1	.156	886.7	.463	2.5

Conversion Factors:
Pressure: (Pa) = (6895)(psia)
Temperature: (^{o}K) = (^{o}F + 459.67)/1.8
Enthalpy: (J/kg) = (2326)(Btu/lbm)
Mass Velocity: (kg/m^2.s) = (1.356 x 10^{-3})(lbm/ft^2-hr)
Heat Flux: (W/m^2) = (3.155)(Btu/hr-ft^2)

TABLE 5 (Continued)

RUN NO.	TYPE	PRES-(PSIA)	MASS VELOCITY X 10-6 (LB/HR-FTSQ)	INLET TEMPER-ATURE (DEG.F.)	MEASURED INLET ENTHALPY (BTU/LB)	AVERAGE HEAT FLUX X 10-6 (BTU/HR-FTSQ)	CALCU-LATED EXIT ENTHALPY (BTU/LB)	QUALITY	TEST SECTION PRESSURE DROP (PSI)
360	UNI	2000	2.713	495.2	482.3	.802	647.7	-.052	15.8
362	UNI	2000	2.005	499.5	487.2	.632	663.3	-.018	10.4
364	UNI	2000	2.006	497.8	485.3	.636	662.6	-.020	10.4
221	UNI	2000	.997	498.2	485.7	.433	727.5	.120	5.4
223	UNI	2000	.502	498.8	486.4	.281	796.6	.269	3.4
225	UNI	2000	.250	498.9	486.5	.178	879.8	.448	2.6
367	UNI	2000	2.688	400.2	377.5	1.019	589.8	-.177	14.6
369	UNI	2000	2.010	399.6	376.9	.845	612.2	-.128	10.0
371	UNI	2000	.987	399.9	377.2	.512	667.0	-.009	5.0
336	UNI	2000	.993	399.9	377.2	.532	676.9	.011	5.0
334	UNI	2000	.502	399.5	376.7	.360	776.9	.226	3.5
321	UNI	2000	.992	399.3	376.5	.447	628.0	-.094	5.0
323	UNI	2000	.501	400.2	377.5	.371	790.1	.255	3.6
272	UNI	2000	.993	399.8	377.1	.570	698.1	.057	5.3
270	UNI	2000	.501	399.8	377.1	.357	773.8	.220	3.6
266	UNI	2000	.499	399.4	376.6	.364	782.2	.238	3.6
268	UNI	2000	.248	399.2	376.4	.224	874.9	.437	2.8
381	UNI	2000	.996	202.6	175.3	.762	603.7	-.147	5.0
274	UNI	2000	.498	199.0	171.7	.496	729.1	.123	3.8
276	UNI	2000	.250	199.7	172.4	.309	860.2	.405	3.0
217	UNI	1600	2.720	547.1	544.8	.566	661.0	.069	20.5
219	UNI	1600	2.712	548.8	547.0	.563	662.8	.072	20.6
215	UNI	1600	2.022	548.5	546.6	.468	675.6	.096	13.8
213	UNI	1600	.999	547.3	545.1	.299	711.1	.162	5.9
211	UNI	1600	.492	546.3	543.8	.206	774.9	.280	3.4
209	UNI	1600	.250	548.1	546.1	.157	889.6	.493	2.5
366	UNI	1600	2.703	499.1	486.6	.721	635.9	.022	17.4
292	UNI	1600	1.999	498.7	486.2	.624	660.5	.068	12.8
231	UNI	1600	.993	499.4	487.0	.374	696.8	.135	5.7
229	UNI	1600	.499	499.0	486.5	.242	755.0	.243	3.4
233	UNI	1600	.492	498.9	486.4	.240	756.3	.245	3.4
227	UNI	1600	.250	499.0	486.6	.177	877.2	.470	2.6
375	UNI	1600	2.698	397.5	374.2	1.005	583.0	-.076	15.1
373	UNI	1600	1.984	399.6	376.4	.823	608.7	-.029	10.5
250	UNI	1600	1.006	400.4	377.3	.556	686.0	.115	5.8
252	UNI	1600	.505	400.8	377.7	.330	741.7	.218	3.7
254	UNI	1600	.250	399.3	376.1	.215	851.3	.422	2.8

TABLE 5 (Continued)

RUN NO.	TYPE	PRES- (PSIA)	MASS VELOCITY X 10-6 (LB/HR-FTSQ)	INLET TEMPER-ATURE (DEG.F.)	MEASURED INLET ENTHALPY (BTU/LB)	AVERAGE HEAT FLUX X 10-6 (BTU/HR-FTSQ)	CALCU-LATED EXIT ENTHALPY (BTU/LB)	QUALITY	TEST SECTION PRESSURE DROP (PSI)
383	UNI	1600	1.000	199.7	171.5	.809	624.8	.001	5.4
280	UNI	1600	.495	202.4	174.2	.475	710.0	.160	3.8
278	UNI	1600	.250	200.2	171.9	.287	811.3	.348	3.0
288	UNI	1200	2.705	499.3	487.0	.674	626.2	.089	24.7
286	UNI	1200	2.014	500.3	488.2	.561	643.7	.117	16.7
290	UNI	1200	1.999	498.4	486.0	.552	640.2	.112	16.4
240	UNI	1200	.994	500.6	488.5	.351	685.2	.185	7.3
238	UNI	1200	.494	499.3	487.1	.231	745.6	.284	3.8
236	UNI	1200	.248	498.5	486.1	.164	851.6	.457	2.7
377	UNI	1200	2.719	397.5	373.7	.988	577.4	.009	17.8
379	UNI	1200	2.008	398.6	374.9	.824	604.8	.054	13.0
248	UNI	1200	.998	399.8	376.2	.516	665.1	.152	6.7
242	UNI	1200	.993	399.9	376.3	.510	663.3	.149	6.6
244	UNI	1200	.498	399.7	376.1	.311	723.8	.248	3.9
246	UNI	1200	.250	400.2	376.7	.209	840.7	.439	2.8
385	UNI	1200	.998	201.5	172.3	.778	609.1	.061	5.8
282	UNI	1200	.501	199.7	170.5	.469	693.7	.199	4.0
284	UNI	1200	.250	199.4	170.2	.284	803.7	.379	3.1
262	UNI	800	2.020	399.5	375.3	.759	585.4	.110	19.8
264	UNI	800	.998	399.8	375.6	.463	634.6	.181	8.6
260	UNI	800	.987	399.8	375.5	.448	629.0	.173	8.2
258	UNI	800	.499	399.6	375.4	.274	680.9	.248	0.0
256	UNI	800	.248	399.0	374.7	.186	788.7	.405	2.9

TABLE 5 (Continued)

RUN NO.	TYPE	PRES- (PSIA)	MASS VELOCITY X 10-6 (LB/HR-FTSQ)	INLET TEMPER-ATURE (DEG.F.)	MEASURED INLET ENTHALPY (BTU/LB)	AVERAGE HEAT FLUX X 10-6 (BTU/HR-FTSQ)	CALCU-LATED EXIT ENTHALPY (BTU/LB)	QUALITY	TEST SECTION PRESSURE DROP (PSI)
404	ALT	2250	2.706	595.6	607.7	.483	707.0	.015	18.0
402	ALT	2250	2.003	600.5	614.5	.404	726.7	.062	11.9
407	ALT	2250	1.002	595.6	609.0	.286	767.4	.160	5.6
400	ALT	2250	.993	601.7	616.1	.269	766.2	.157	5.4
398	ALT	2250	.493	597.3	610.1	.189	820.5	.288	3.3
396	ALT	2250	.253	597.1	609.7	.134	897.4	.473	2.4
425	ALT	2250	2.718	547.7	544.7	.639	675.9	-.061	17.4
423	ALT	2250	1.988	548.8	546.0	.526	693.6	-.018	11.0
421	ALT	2250	1.000	548.2	545.3	.349	739.4	.115	5.3
429	ALT	2250	.504	548.5	545.7	.237	805.6	.252	3.4
431	ALT	2250	.250	548.2	545.4	.157	890.6	.457	2.5
427	ALT	2250	.250	547.8	544.9	.156	887.1	.448	2.5
463	ALT	2250	2.718	496.5	484.0	.753	638.7	-.150	16.4
519	ALT	2250	2.030	497.7	485.3	.557	638.5	-.151	11.0
511	ALT	2250	2.004	496.3	483.7	.549	636.6	-.156	11.1
461	ALT	2250	1.996	496.2	483.6	.621	657.4	-.105	10.8
459	ALT	2250	.996	499.8	487.7	.405	714.4	.032	5.1
513	ALT	2250	.509	498.0	485.7	.272	782.5	.196	3.5
457	ALT	2250	.505	497.3	484.9	.274	785.3	.203	3.4
455	ALT	2250	.251	499.4	487.2	.182	886.4	.446	2.7
509	ALT	2250	2.724	398.7	376.3	.842	549.4	-.366	16.6
507	ALT	2250	2.044	399.3	377.0	.697	567.6	-.372	11.0
505*	ALT	2250	.998	399.6	377.3	.455	632.1	-.166	5.1
503	ALT	2250	.494	399.6	377.3	.334	753.2	.126	3.5
501	ALT	2250	.248	400.0	377.7	.220	868.8	.404	2.9
417	ALT	2000	2.717	598.3	612.5	.451	704.8	.071	21.0
415	ALT	2000	2.024	598.7	613.0	.380	717.4	.098	13.9
419	ALT	2000	.999	596.8	610.2	.269	759.2	.188	6.1
409	ALT	2000	.993	594.5	606.9	.274	759.6	.189	6.0
411	ALT	2000	.502	596.8	610.3	.186	814.2	.307	3.4
413	ALT	2000	.249	598.2	612.3	.130	895.9	.482	2.4
439	ALT	2000	2.722	547.8	545.1	.600	668.2	-.008	17.8
437	ALT	2000	2.020	547.5	544.7	.513	686.4	.032	11.7
435	ALT	2000	1.000	548.5	546.0	.345	738.0	.143	5.7
433	ALT	2000	.507	547.9	545.2	.236	802.9	.282	3.5
453	ALT	2000	.250	548.8	546.4	.155	887.1	.463	2.6

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* Approximately 91% of CHF (Run 504). This was the highest power that could be applied without getting CHF.

TABLE 5 (Continued)

RUN NO.	TYPE	PRES- (PSIA)	MASS VELOCITY X 10-6 (LB/HR-FTSQ)	INLET TEMPERATURE (DEG.F.)	MEASURED INLET ENTHALPY (BTU/LB)	AVERAGE HEAT FLUX X 10-6 (BTU/HR-FTSQ)	CALCULATED EXIT ENTHALPY (BTU/LB)	QUALITY	TEST SECTION PRESSURE DROP (PSI)
465	ALT	2000	2.708	496.8	484.1	.725	633.8	-.082	16.4
475	ALT	2000	2.018	497.5	485.0	.587	647.3	-.053	11.6
467	ALT	2000	2.017	499.4	487.1	.609	655.7	-.035	10.8
469	ALT	2000	1.000	497.6	485.0	.411	713.9	.091	5.4
517	ALT	2000	1.000	498.9	486.5	.398	708.0	.078	5.5
471	ALT	2000	.499	498.1	485.7	.282	799.2	.274	3.5
515	ALT	2000	.251	496.4	483.7	.171	859.0	.403	2.7
473	ALT	2000	.250	498.4	485.9	.181	885.2	.459	2,7
441	ALT	1600	2.722	548.1	546.2	.526	653.9	.056	20.5
443	ALT	1600	2.012	545.9	543.3	.492	679.7	.103	14.5
445	ALT	1600	2.698	547.3	545.1	.524	653.4	.055	20.3
447	ALT	1600	.998	548.5	546.6	.316	722.2	.182	6.5
449	ALT	1600	.501	549.3	547.6	.214	784.0	.297	3.6
451	ALT	1500	.252	547.8	545.8	.153	880.1	.475	2.6
479	ALT	1600	2.745	498.1	485.5	.656	619.1	-.009	18.5
477	ALT	1600	2.010	498.5	485.9	.590	649.9	.048	12.9
481	ALT	1500	1.002	498.8	486.3	.404	710.9	.161	6.4
483	ALT	1600	.508	500.1	487.8	.256	767.1	.266	3.7
487	ALT	1600	.503	498.5	485.9	.260	773.2	.277	3.7
495	ALT	1200	2.721	498.6	486.3	.650	619.8	.078	0.0
493	ALT	1200	2.016	498.8	486.4	.568	643.8	.118	18.0
497	ALT	1200	2.005	498.8	486.4	.567	644.3	.118	17.9
491	ALT	1200	.996	499.5	487.3	.383	701.3	.212	8.1
489	ALT	1200	.499	498.8	486.5	.243	756.2	.301	4.0
499	ALT	1200	.249	498.7	485.3	.160	838.8	.436	2,7

TABLE 5 (Continued)

RUN NO.	TYPE	PRES- (PSIA)	MASS VELOCITY X 10-6 (LB/HR-FTSQ)	INLET TEMPER-ATURE (DEG.F.)	MEASURED INLET ENTHALPY (BTU/LB)	AVERAGE HEAT FLUX X 10-6 (BTU/HR-FTSQ)	CALCU-LATED EXIT ENTHALPY (BTU/LB)	QUALITY	TEST SECTION PRESSURE DROP (PSI)
538	HP	2250	2.709	596.5	608.9	.565	725.3	.059	20.1
534	HP	2250	2.705	596.4	608.8	.568	725.9	.060	20.0
536	HP	2250	2.019	596.5	609.0	.465	737.3	.088	12.9
532	HP	2250	.997	596.2	608.5	.295	772.8	.173	5.6
530	HP	2250	.502	598.0	611.0	.199	829.1	.308	3.3
528	HP	2250	.250	597.8	610.8	.135	905.0	.491	2.4
560	HP	2250	2.708	547.7	544.7	.723	693.8	-.017	18.4
562	HP	2250	2.017	547.5	544.5	.595	709.0	.019	11.9
564	HP	2250	.998	547.7	544.7	.381	757.3	.136	5.5
566	HP	2250	.502	547.8	544.8	.245	814.9	.274	3.4
570	HP	2250	.250	548.2	545.3	.162	899.8	.479	2.6
626	HP	2250	2.703	499.7	487.7	.869	667.3	-.081	18.1
624	HP	2250	2.007	498.5	486.3	.697	680.4	-.050	11.5
622	HP	2250	1.001	498.3	486.0	.444	733.2	.078	5.4
628	HP	2250	.996	498.8	486.6	.436	730.4	.071	5.4
620	HP	2250	.502	498.5	486.2	.294	811.0	.265	3.5
618	HP	2250	.251	498.2	485.9	.186	893.4	.463	2.7
540	HP	2000	2.722	596.8	610.3	.511	715.0	.093	21.9
542	HP	2000	2.009	596.5	609.8	.421	726.2	.117	13.8
544	HP	2000	.999	597.7	611.5	.272	762.4	.195	6.0
546	HP	2000	.502	598.0	611.9	.183	812.5	.303	3.4
548	HP	2000	.249	597.9	611.9	.133	903.4	.498	2.3
558	HP	2000	2.715	547.6	544.9	.678	684.3	.027	19.2
556	HP	2000	2.012	548.3	545.7	.555	699.6	.060	12.6
554	HP	2000	.998	548.8	546.4	.351	741.9	.151	5.8
552	HP	2000	.501	548.0	545.3	.238	807.4	.292	3.5
568	HP	2000	.499	548.5	546.0	.237	808.8	.295	3.5
550	HP	2000	.250	548.6	546.1	.158	891.9	.474	2.5
608	HP	2000	2.714	497.5	484.9	.833	656.5	-.033	18.4
610	HP	2000	2.014	498.0	485.5	.685	675.6	.008	12.0
612	HP	2000	1.000	498.0	485.5	.441	730.9	.127	5.7
614	HP	2000	.498	499.7	487.4	.278	797.2	.270	3.6
616	HP	2000	.251	498.4	485.9	.180	881.7	.452	2.7
580	HP	1600	2.672	548.1	546.1	.564	663.9	.074	21.6
582	HP	1600	2.002	547.9	545.8	.474	677.7	.100	14.3
578	HP	1600	1.994	548.8	546.9	.475	679.6	.103	14.3
576	HP	1600	.998	548.6	546.8	.320	724.9	.187	6.6
574	HP	1600	.502	548.2	546.3	.218	785.6	.300	3.6
572	HP	1600	.249	548.4	546.4	.154	884.5	.483	2.5

TABLE 5 (Continued)

RUN NO.	TYPE	PRES- (PSIA)	MASS VELOCITY X 10-6 (LB/HR-FTSQ)	INLET TEMPER-ATURE (DEG.F.)	MEASURED INLET ENTHALPY (BTU/LB)	AVERAGE HEAT FLUX X 10-6 (BTU/HR-FTSQ)	CALCU-LATED EXIT ENTHALPY (BTU/LB)	QUALITY	TEST SECTION PRESSURE DROP (PSI)
584	HP	1600	2.710	498.9	486.4	.722	635.3	.021	19.3
586	HP	1600	2.011	498.6	486.0	.623	658.9	.065	13.4
592	HP	1600	.999	498.2	485.5	.407	712.2	.164	6.3
588	HP	1600	.994	498.2	485.6	.399	709.1	.158	6.2
590	HP	1600	.506	498.6	486.0	.250	759.8	.252	3.6
594	HP	1600	.252	498.4	485.8	.174	865.3	.448	2.6
606	HP	1200	2.702	497.9	485.5	.676	625.3	.087	25.7
604	HP	1200	2.025	497.8	485.3	.589	647.8	.124	18.0
600	HP	1200	1.001	498.2	485.8	.384	699.6	.209	7.9
598	HP	1200	.502	498.3	485.9	.242	753.4	.297	4.0
602	HP	1200	.498	498.8	486.5	.237	750.2	.291	3.9
596	HP	1200	.250	498.6	486.2	.159	835.9	.431	2.6

TABLE 6: Isothermal and Heated Pressure Drop Data

RUN NO.	TYPE*	PRES- (PSIA)	MASS VELOCITY X 10-6 (LB/HR-FTSQ)	INLET TEMPER-ATURE (DEG.F.)	MEASURED INLET ENTHALPY (BTU/LB)	AVERAGE HEAT FLUX X 10-6 (BTU/HR-FTSQ)	CALCU-LATED EXIT ENTHALPY (BTU/LB)	QUALITY	TEST SECTION PRESSURE DROP (PSI)
176	UNI	2250	2.013	498.8	486.5	.463	733.8	.079	11.2
101	UNI	2000	2.712	548.8	546.4	-	-	-	16.9
104	UNI	2000	2.696	548.7	546.2	-	-	-	16.5
102	UNI	2000	.999	548.5	545.9	-	-	-	4.9
103	UNI	2000	.251	550.0	547.8	-	-	-	3.1
129	UNI	2000	3.016	548.6	546.0	.430	622.3	-.107	21.8
106	UNI	2000	2.934	546.3	543.2	.291	596.0	-.163	19.5
105	UNI	2000	2.916	548.4	545.9	.147	572.5	-.214	19.1
185	UNI	2000	2.725	549.6	547.3	.248	597.8	-.159	15.4
184	UNI	2000	2.722	548.5	545.9	.165	579.3	-.199	15.1
183	UNI	2000	2.721	549.5	547.2	.083	563.6	-.233	15.1
329	UNI	2000	3.014	399.9	377.2	.202	414.5	-.555	15.9
330	UNI	2000	3.010	399.6	376.8	.405	452.0	-.474	16.0
331	UNI	2000	3.006	399.2	376.4	.602	488.4	-.396	16.2

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* UNI - Uniform Heat Flux
ALT - Alternate High and Low Heat Flux Profile
HP - Alternate High and Low Heat Flux Profile with Hot Patch Superimposed

Conversion Factors:
Pressure: (Pa) = (6895)(psia)
Temperature: (^{o}K) = (^{o}F + 459.67)/1.8
Enthalpy: (J/kg) = (2326)(Btu/lbm)
Mass Velocity: (kg/m^2.s) = (1.356 x 10^{-3})(lbm/ft^2-hr)
Heat Flux: (W/m^2) = (3.155)(Btu/hr-ft^2)

TABLE 6 (Continued)

RUN NO.	TYPE	PRES- (PSIA)	MASS VELOCITY X 10-6 (LB/HR-FTSQ)	INLET TEMPER-ATURE (DEG.F.)	MEASURED INLET ENTHALPY (BTU/LB)	AVERAGE HEAT FLUX X 10-6 (BTU/HR-FTSQ)	CALCU-LATED EXIT ENTHALPY (BTU/LB)	QUALITY	TEST SECTION PRESSURE DROP (PSI)
182	UNI	2250	2.716	549.4	546.8	-	-	-	14.6
181	UNI	2250	.999	549.3	546.7	-	-	-	4.6
347	UNI	2250	.998	499.2	487.1	.678	673.4	-.069	4.8
313	UNI	2250	.249	499.0	486.9	.158	894.6	.466	3.3
325	UNI	2250	.249	499.1	486.9	.371	790.1	.255	3.3
180	UNI	2250	.248	548.8	546.1	-	-	-	3.1
328	UNI	2000	2.719	399.8	377.1	.371	790.1	.255	13.6
327	UNI	2000	.999	400.3	377.6	.371	790.1	.255	4.5
332	UNI	2000	.499	397.9	375.0	.602	488.4	-.396	3.8
326	UNI	2000	.249	400.2	377.5	.371	790.1	.255	3.5
179	UNI	1600	2.711	399.5	376.4	-	-	-	13.6
178	UNI	1600	.996	399.9	376.7	-	-	-	4.9
177	UNI	1600	.250	399.1	375.9	-	-	-	3.5
234	UNI	1200	.250	498.8	486.4	.240	756.3	.245	3.2
391	ALT	2250	2.712	599.9	613.7	-	-	-	15.8
390	ALT	2250	1.001	600.5	614.5	-	-	-	4.7
405	ALT	2250	.997	596.9	609.5	.483	707.0	.015	4.7
489	ALT	1200	.499	498.8	486.5	.243	756.2	.301	4.1
388	ALT	2000	2.714	498.6	486.2	-	-	-	14.0
387	ALT	2000	.998	497.4	484.9	-	-	-	4.9
386	ALT	2000	.250	498.1	485.6	-	-	-	3.3
392	ALT	2250	2.739	597.7	610.6	.103	631.1	-.169	16.4
393	ALT	2250	2.715	598.7	612.0	.200	652.7	-.117	16.3
394	ALT	2250	2.721	598.7	612.0	.300	673.3	-.067	16.7
523	HP	2250	2.701	597.3	610.0	0.000	609.3	-.220	0.0
522	HP	2000	2.707	550.2	548.2	-	-	-	0.0
521	HP	2000	1.001	549.8	547.6	-	-	-	4.8
520	HP	2000	.244	545.1	541.6	-	-	-	3.1
526	HP	2250	2.720	597.9	610.9	.302	672.5	-.069	17.6
524	HP	2250	2.717	596.3	608.7	.100	628.7	-.175	16.8
525	HP	2250	2.715	597.3	610.0	.202	651.0	-.121	17.1

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