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SUMMARY

Local heat-transfer and static-pressure data were obtained for steam condensing in vertical downflow inside a tube. A 0.293-inch-inside-diameter by 8-foot-long copper tube was used as the test condenser. Inlet vapor velocities ranged from approximately 300 to 1000 feet per second with complete condensing occurring in the test section. The condenser was cooled with water flowing countercurrently in an annulus around the condenser tube.

The local condensing heat-transfer coefficient is a function of the local vapor flow rate, and correlates with the product of local quality and the square of the test-fluid total mass velocity. In general, high values of the coefficient occurred at the inlet and decreased with length. The mean condensing heat-transfer coefficient varied from 3860 to 11 850 Btu per hour per square foot per $^{\circ}F$ over a test-fluid total mass velocity range from 64 900 to 336 000 pounds per hour per square foot.

Static-pressure changes in the two-phase region varied from a net increase of 1.32 pounds per square inch to a net decrease of 35.34 pounds per square inch. Axial static-pressure profiles were a function of the vapor flow rate and heat flux. Overall friction-pressure losses for the two-phase region were computed from measured static-pressure changes and correlated in terms of common pipe-friction parameters that included flow rate, total condensing length, and specific volume of the vapor at the condenser inlet.

INTRODUCTION

As part of an overall program at the Lewis Research Center concerned with Rankine-cycle space-power systems, an experimental study of condensing inside tubes was initiated. Water was selected as the working fluid for simplicity of apparatus and instrumentation. A wide range of inlet vapor velocities (50 to 1000 ft/sec) was desired in the study to provide a sufficient range of variables for data analysis and for comparison with theoretical results. Further, at high vapor velocities the Froude number (ratio of inertia to gravity forces) becomes large, and thus the flow patterns within the condenser should be similar to those in a zero-gravity space environment.

In the first phase of the study reported in reference 1, data were obtained at the lower end of the desired inlet vapor velocity range (65 to 232 ft/sec). Local heat-transfer coefficients were determined for steam flowing in vertical downflow within a 5/8-inch-inside-diameter stainless-steel tube. Because of the low inlet velocity, the pressure drop was negligible during these tests.

In the investigation reported herein condensing data were obtained with high inlet vapor velocities (300 to 1000 ft/sec). Both local heat-transfer and local static-pressure data were obtained for steam condensing inside a tube. The data were taken with the downstream vapor-liquid interface located within the condenser tube so that complete condensing occurred. With complete condensing, the overall friction-pressure drop for the condenser could be computed with reasonable accuracy from the measured pressure change.

The test condenser was a 0.293-inch-inside-diameter by 8-foot-long copper tube mounted vertically with vapor flowing downward. The condenser was cooled by water flowing upward (countercurrently) in an annulus around the tube. The range of variables employed was as follows (symbols are defined in appendix A):

Variable	Range
Test-fluid flow rate, w_t, lb/hr	30.5 to 158
Inlet vapor pressure, P_i, psia	15.03 to 39.34
Inlet vapor velocity, V_{vi}, ft/sec	313 to 1018
Condensing length, L_c, ft	1.1 to 6.7
Coolant flow rate, w_k, lb/hr	405 to 2180
Coolant temperature, t_k, ^oF	
Inlet	61 to 99
Exit	94 to 206
Inlet vapor qualities	Nominally 100 percent

APPARATUS AND PROCEDURE

Description of Rig

A schematic drawing of the test facility is shown in figure 1. The test-fluid side of the facility was a once-through system using demineralized and deaerated water. The coolant loop used demineralized water that was continuously recirculated. Steam at 100 pounds per square inch gage was used as the heat source, and cooling-tower water

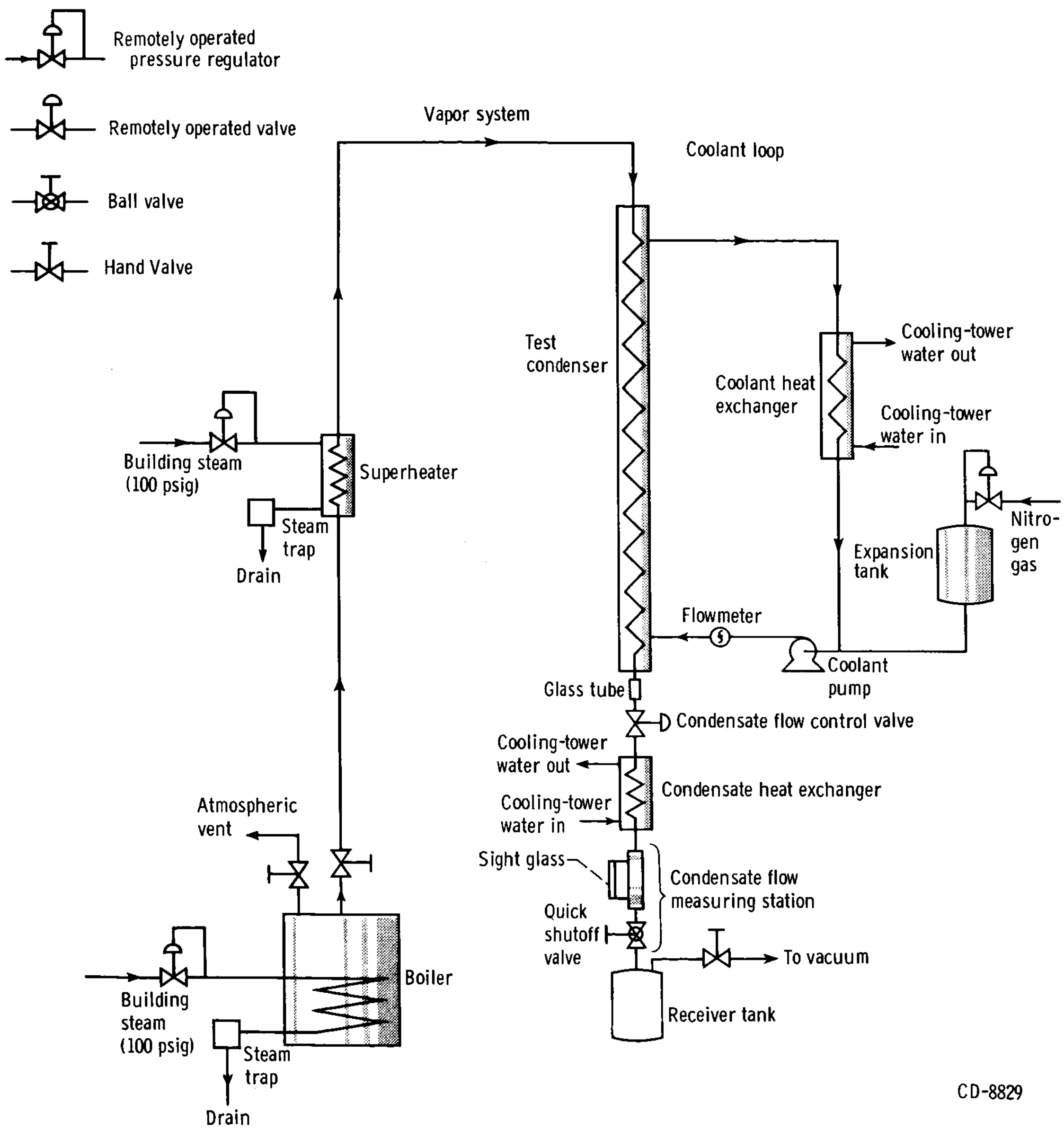


Figure 1. - Single-tube steam-condensing test facility.

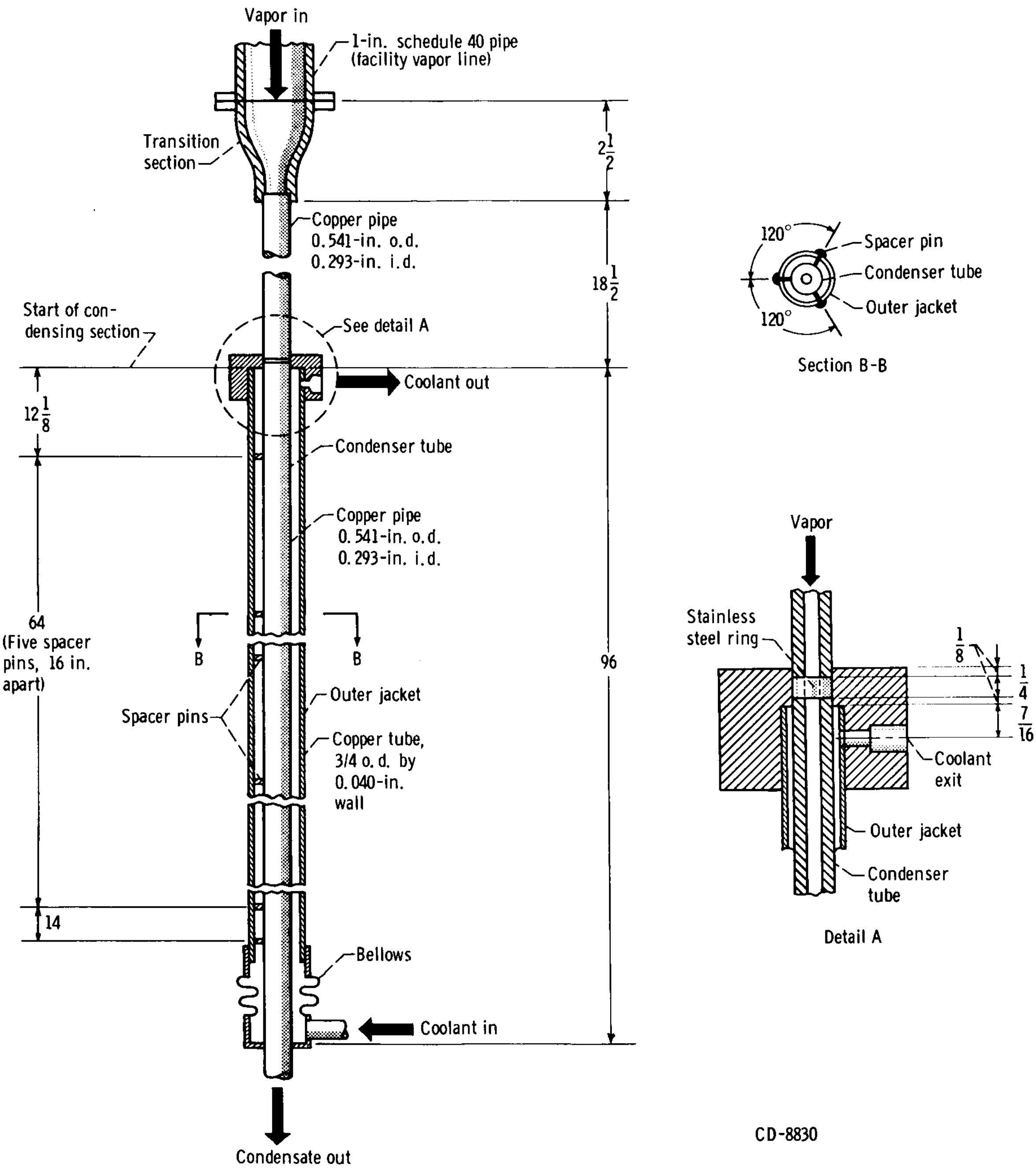


Figure 2. - Single-tube condenser test section. (Dimensions are in inches.)

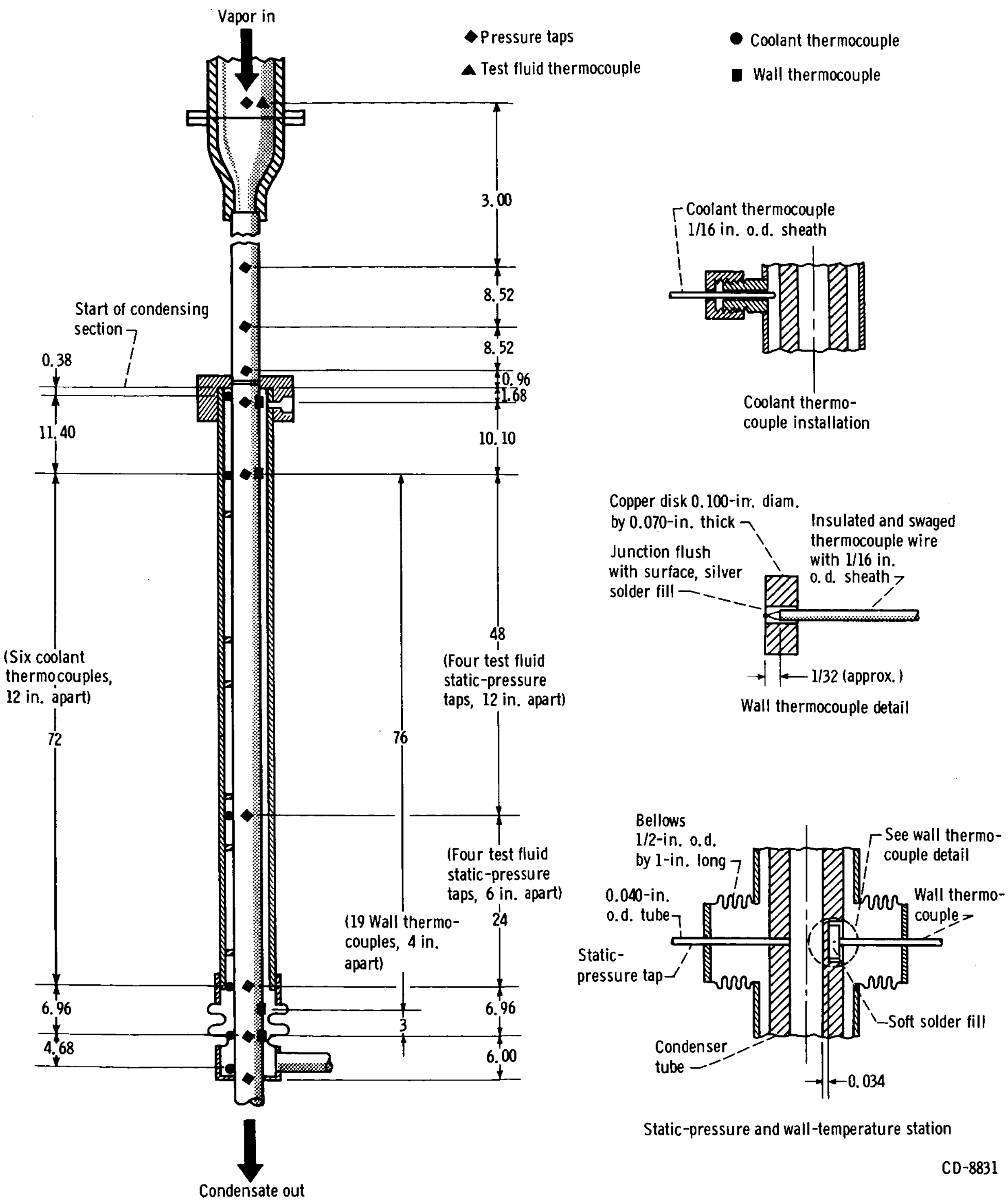


Figure 3. - Test-section instrumentation. (Dimensions are in inches.)

was used as the final heat sink. With the exception of the condenser, the entire facility was constructed of stainless steel. The equipment in the vapor system consisted of a pot boiler, superheater, condenser, condensate heat exchanger, condensate flow measuring station, and receiver tank. The boiler was equipped with a wire mesh screen and baffle separator to minimize liquid carryover. Coolant loop components included a variable-speed pump, flowmeter, heat exchanger, and expansion tank.

The single-tube test condenser (fig. 2) was a coaxial shell and tube heat exchanger mounted in a vertical position; vapor entered at the top and coolant flowed countercurrently in the annulus between the inner and outer tubes. The inner tube was a thick-wall copper pipe with a measured outside diameter of 0.541 inch, a measured inside diameter of 0.293 inch, and a total condensing length of 8 feet. The outer jacket was a copper tube with a 0.75-inch outside diameter and a 0.040-inch wall. The annular gap between the inner and outer tubes was 0.064 inch. The small gap induced high coolant velocities at low coolant mass flow rates. This combination provided a large coolant temperature change per unit length of annulus so that accurate local heat flux determinations could be made (appendix B). Thick-wall tubing was used for the condenser so that the junctions of the wall thermocouples could be deeply embedded. A bellows at the downstream end of the condenser allowed relative motion between the inner and outer tubes. Spacer pins in the annulus maintained concentricity.

The inner diameter of the inlet vapor line changed from 1.049 to 0.293 inch at a distance of 18.5 inches upstream of the condenser. A bell-shaped transition section accommodated the change in diameter. A stainless-steel ring with an inner diameter of 0.293 inch was placed at the inlet of the condenser (fig. 2) to reduce axial heat conduction in the thick-wall copper tube. The test section, as well as all vapor lines, was lagged with blanket insulation to minimize heat losses.

A condensate flow control valve was installed downstream of the condenser so the location of the vapor-liquid interface could be varied by throttling the condensate. A 0.5-inch-outside-diameter glass tube (fig. 1) was installed between the end of the condenser tube and the condensate throttle valve to allow visual observance of the interface when it was moving into or out of the condenser.

Instrumentation

The condenser was provided with instrumentation to measure vapor inlet temperature, condensate exit temperature, condenser tube-wall temperatures, coolant temperatures, vapor inlet pressure, static pressures inside the condenser at different axial positions, and condensate and coolant flow rates. Figure 3 and tables I and II show the location of the temperature and pressure measuring stations with respect to the inlet of the condenser.

Temperatures were measured with iron-constantan thermocouples with the thermocouple wires insulated with magnesium oxide and swaged inside a 1/16-inch-outside-diameter stainless-steel tube. The vapor inlet temperature was measured upstream of the transition section in the 1.049-inch-inside-diameter tube, where dynamic effects of flowing vapor would be negligible. Condensate temperature was measured 6 inches downstream of the end of the condenser.

Condenser tube-wall temperatures were measured at 4-inch intervals in one longitudinal plane after an initial spacing of the first two thermocouples of 0.14 and 0.98 foot downstream of the condenser inlet (table II). The bare physical junction of the thermocouple was placed 0.034 inch from the inner surface of the condenser tube. A copper disk, with a hole through the center, was soldered to the end of the thermocouple sheath to aid in installation. The physical junction of the thermocouple was flush with the surface of the disk (fig. 3). The location of the measured temperature was arbitrarily taken as the location of the physical junction for reasons discussed in appendix B. The 1/16-inch-outside-diameter sheath of the thermocouple projected radially outward. A bellows between the probe and the outer jacket was used to accommodate relative motion between the inner and outer tubes.

This radial wall thermocouple installation was dictated by the 1/16-inch annular gap selected for the cooling passage in order to obtain accurate local heat flux data. Because of this small gap and the desirability of deeply embedding the thermocouple junction in the tube wall, it was not possible to run the sheathed leads axially or to wrap them around the tube. The radial installation employed had the disadvantage of providing a possible fin effect.

The magnitude of the fin effect of the cylindrical sheath on the measured wall temperatures was investigated analytically. (The lead wires were thermally insulated from the sheath.) The rate of withdrawal of heat from the tube wall by conduction through the stainless-steel sheath immersed in the coolant stream (ref. 2, pp. 25-29) was compared with the convective-heat-transfer rate for an equal surface area of the unmodified copper tube wall. The calculated ratio of the two heat removal rates was near unity for the range of test conditions employed. In view of this result and the fact that the thermocouple junction was embedded deeply in the copper wall, it was concluded that the fin effect did not have an important influence on the measured wall temperatures.

As an additional check on the magnitude of the fin effect, a wall temperature error analysis was made by using the method of reference 3. The method of reference 3 considers the thermocouple as a heat sink in a plate that is exposed to fluids on both sides at different temperatures. Equations are developed to give the temperature error as a function of the convective heat-transfer coefficients, thermal conductances of the plate and thermocouple wires, and temperature differences between the plate and the fluid. Application of the technique of reference 3 indicated that the error in measured wall temperature would be less than 1.0° F. It was concluded, therefore, that any temperature error caused by fin effects on the thermocouples would be small in comparison with other sources of error.

Coolant temperatures (fig. 3) were measured in one axial plane at a spacing of 1 foot with the exception of the inlet and exit region. The exact axial location is shown in figure 3 and table I. The plane of the coolant thermocouples was displaced 90° from the plane of the condenser tube-wall thermocouples, and the junctions were located at the center of the annular gap.

Pressures were measured with mercury-filled U-tube manometers with a hydrostatic water leg on the condenser side and atmospheric pressure on the reference side. The connecting lines from the manometer to the pressure tap on the condenser consisted of transparent tubing so that visual observation would give assurance of an all-liquid hydrostatic head. Static pressures were measured at 16 axial positions from upstream of the transition section to the end of the condenser. The locations of the positions are shown in figure 3 and table I. The static pressure of the inlet vapor was measured at four positions upstream of the condenser. One static pressure tap was located in the 1.049-inch-inside-diameter tube upstream of the transition section. The other three were axially spaced in the small-bore connecting line between the transition section and the condenser.

Condensate flow rate was measured by using a modified weigh tank technique, which consisted of measuring the time required to fill a known volume. The temperature of the condensate was measured so that the flow rate could be evaluated in mass units. The measuring station consisted of a quick-shutoff valve positioned downstream of a 2-inch outside-diameter by 3-foot-long metal tube. The tube was equipped with a sight glass that allowed visual observation and timing of the motion of the liquid interface when the quick-shutoff valve was closed. It was assumed that the flow rate did not change when the quick-shutoff valve was closed, since neither the pressure in the condenser nor the pressure drop across the condensate flow control valve changed. The coolant flow rate was measured by a commercial turbine-type flowmeter.

Test Procedure

Initial startup of the facility consisted of elimination of noncondensibles from the system. The boiler was filled with demineralized water and isolated from the remaining part of the system, which was evacuated to a vacuum of 28 or 29 inches of mercury. Ten to fifteen percent (6 to 9 gal) of the original boiler inventory was then boiled off to the atmosphere to rid the water of any dissolved or entrained gas. The air content of the water in the evaporator was reduced to an order of 2 parts per million, on a mass basis, as determined by a gas analyzer. The boiler was then opened to the system, and with the condensate flow control valve fully open, high-velocity vapor flowed through the system to the receiver tank and out the vacuum line to purge any residual air pockets. The vacuum line was then closed. The pressure level in the receiver varied between 26 and 29 inches of mercury vacuum, depending on the temperature of the condensate. For each run, however, the receiver-tank pressure was constant.

Establishment of test conditions consisted of setting a coolant flow rate and building steam pressure inside the coils of the boiler and throttling the outflow of the condensate so that the vapor-liquid interface was maintained in the condenser. An approximation of the interface location could be made by monitoring the condenser-wall temperatures, since a pronounced change in the slope of the axial-wall-temperature profile occurred in the vicinity of the interface. Early in the program, it was established that the vapor flow rate was independent of the liquid level in the boiler within certain limits. Obtaining a data point consisted in adjusting the outflow of the condensate with the flow control valve and monitoring a particular wall temperature until it gave an indication that the interface was near that position. The data were taken after the system pressures had become steady.

Stability Considerations

Precautions were taken to ensure that all heat-transfer and pressure data were taken with the system operating stably. In establishing test conditions, particular combinations of boiler-supply steam pressure, coolant flow rate, and condensate flow-control-valve settings were found to result in unstable condenser operation. With such combinations, pressure oscillations occurred. These conditions were avoided when the steady-state data were taken. Data were taken when the condenser either was free of pressure disturbances or had only small disturbances compared with the measured mean values.

Special instability survey runs were made in which unstable operating points were deliberately sought out. For these runs, the manometers at 0.98 and 1.98 feet from the condenser inlet were replaced with dynamic pressure pickups. The other manometers remained connected to duplicate steady-state operating conditions. The outputs of the pressure pickups were recorded by an oscillograph. Both amplitudes and frequencies of the condenser disturbances were determined from the oscillograph records for each unstable condition encountered. The frequencies of the observed condenser disturbances were 25 to 100 times the natural frequencies of the attached manometer systems.

The dynamic characteristics of the boiler were also checked during the stability survey. Of particular interest was the effect of system flow oscillations on boiler pressure. A high-temperature dynamic-pressure pickup was installed in the boiler above the level of the liquid to measure any pressure fluctuations occurring inside the boiler. In order to minimize condenser interactions, the system was operated during these tests with only partial condensing taking place in the test section. The rest of the condensing took place in the large heat exchanger normally used for subcooling.

Flow changes were imposed on the system by operating a throttle valve just upstream of the condenser test section. The usual procedure was to either close or partly close the valve and then a short time later to reopen the valve (to open full). This cycle was repeated over a wide range of repetition frequencies, including those observed in the condenser (1 to 10 cps) during unstable modes of operation.

The results of the condenser and boiler stability checks are summarized in the RESULTS AND DISCUSSION section.

DATA ANALYSIS

The experimental steady-state data obtained in the tests are shown in tables I and II. The wall temperatures in table I are values that were taken from a curve faired through the measured wall temperatures given in table II. The static pressures in table I downstream of the interface were corrected for the liquid hydrostatic head between the interface and the station at which the pressure was measured. Included in table I are computed values for overall friction-pressure loss, total condensing length, local condensing heat-transfer coefficient, mean condensing heat-transfer coefficient, vapor state at the inlet to the condenser, and overall heat-balance error.

The overall friction-pressure loss in the two-phase region was computed from the following equation, which describes the overall static-pressure change in the two-phase region of the condenser:

$$\Delta P_s = \Delta P_f + \Delta P_m + \Delta P_G \tag{1}$$

The static pressure at the interface needed to compute ΔP_s was obtained from a plot of pressure as a function of length. For total condensation, the overall momentum-pressure change ΔP_m was calculated from the following equation (derived in ref. 4):

$$\Delta P_m = \frac{v_i G_t^2}{K g_c} \tag{2}$$

The term for the pressure change due to change in elevation, ΔP_G of equation (1), was negligibly small because of the presence of a large void fraction over a considerable portion of the two-phase region. All fluid properties were taken from reference 5.

Total condensing lengths were computed by a stepwise heat-balance analysis performed on the condenser. The total condensing length was taken as that distance from the entrance where the summation of the local condensing flow was equal to the total measured value of the condensate flow rate. The details of all heat-transfer calculations are given in appendix B.

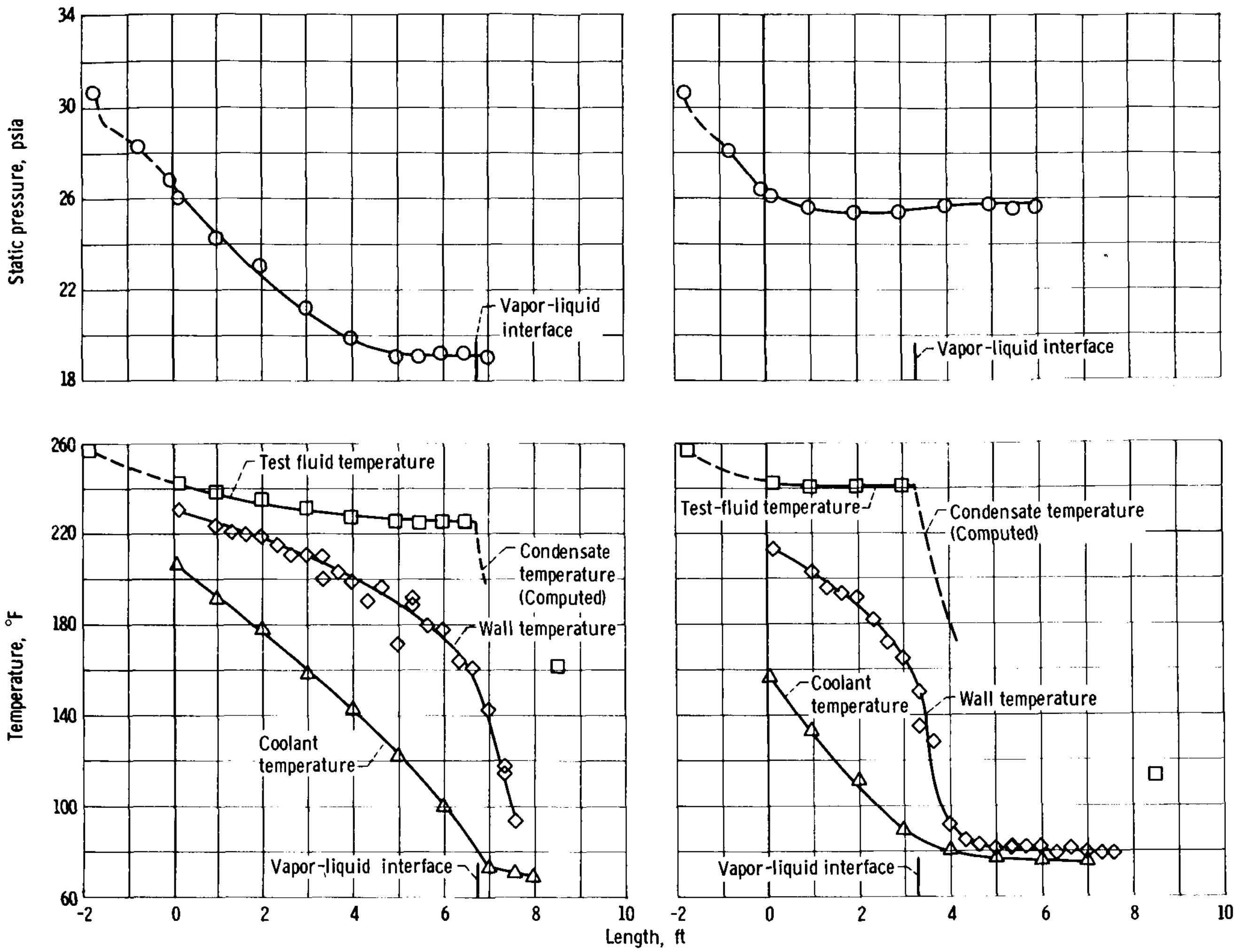
The vapor state was determined at two locations upstream of the condenser. The first location was near the transition section in the 1-inch line (-1.75 ft). Pressure and temperature were measured at this point. The amount of superheat at this location was evaluated by comparing the measured temperature with the saturation temperature corresponding to the measured pressure. Some of the runs indicated saturation conditions at the transition section. The quality of the vapor for these conditions was evaluated in the following manner. The data that indicated superheat at the transition section were used to develop an empirical heat-loss correlation for the vapor line upstream of the transition section. The correlation gave the heat loss between the superheater and transition section as a function of the average vapor temperature. This correlation was used to determine the heat loss and to compute the vapor quality for the runs that indicated no superheat at the transition section. The minimum quality computed by this method was 0.99. The second location at which the vapor state was determined was 0.08 foot upstream of the condenser. The vapor state at this location was computed by assuming an isentropic process from the station at -1.75 feet. The minimum quality entering the condenser was computed to be 0.96.

Overall heat-balance errors were computed by taking the difference between the heat gained by the coolant and the total heat rejected by the test fluid and dividing by the heat gain of the coolant. Heat-balance errors thus evaluated gave the heat rejected by the test fluid as being up to 9.5 percent greater than and up to 7.0 percent less than the heat gained by the coolant.

RESULTS AND DISCUSSION

Axial Pressure and Temperature Profiles

Figure 4 illustrates typical examples of the variation of pressure and temperature with length for three sets of data. The three runs shown in the figure had nearly the same inlet conditions of pressure, quality, and test-fluid total flow rate and, therefore, the same total heat-rejection rate in the two-phase portion of the condenser. The con-



(a) Condensing length, 6.7 feet; test-fluid total flow rate, 68.4 pounds per hour; test-fluid inlet velocity, 611 feet per second; friction-pressure loss, 12.88 pounds per square inch; coolant flow rate, 530 pounds per hour (run 171).

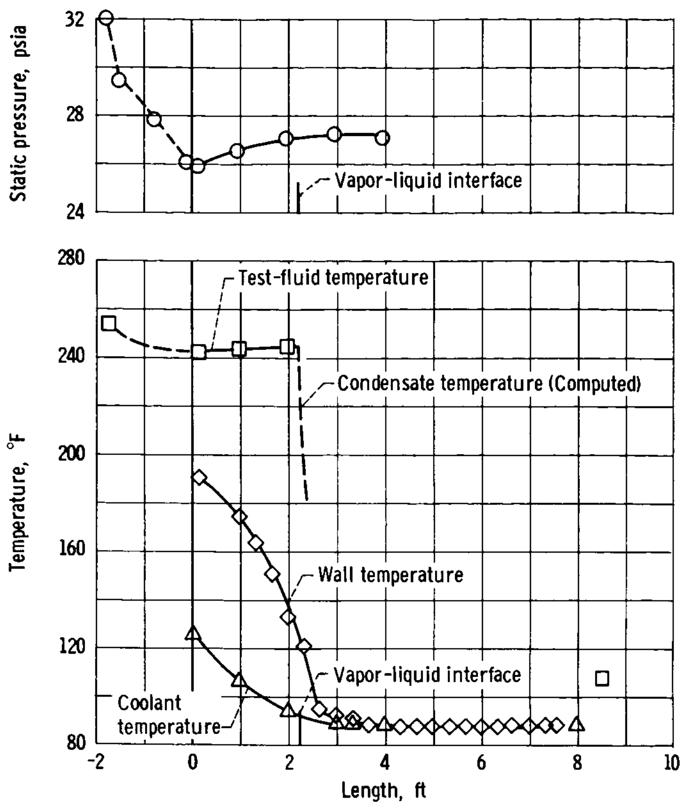
(b) Condensing length, 3.3 feet; test-fluid total flow rate, 67.4 pounds per hour; test-fluid inlet velocity, 611 feet per second; friction-pressure loss, 6.0 pounds per square inch; coolant flow rate, 880 pounds per hour (run 172).

Figure 4. - Pressure and temperature distribution for same conditions of test-fluid flow rate and inlet pressure with different condensing lengths.

densing length varied, however, so that coolant flow had to be altered to maintain the energy balance between the heat source and the sink.

Figure 4(a) shows that a net static-pressure drop of 7.5 pounds per square inch was measured from zero length, where condensing started, to the interface position at 6.7 feet. The slope of the pressure profile was negative over most of the length and approached zero as the end of the condensing section was approached. The negative slope of the static-pressure profile indicates that the local friction-pressure gradient was larger than the local momentum-pressure gradient over a large portion of the condensing length.

The test-fluid temperature plotted in figure 4(a) at a length of -1.75 feet is a measured value, while the temperatures between zero length and the vapor-liquid inter-



(c) Condensing length, 2.2 feet; test-fluid total flow rate, 67.9 pounds per hour; test-fluid inlet velocity, 624 feet per second; friction-pressure loss, 4.47 pounds per square inch; coolant flow rate, 1805 pounds per hour (run 228).

Figure 4. - Concluded.

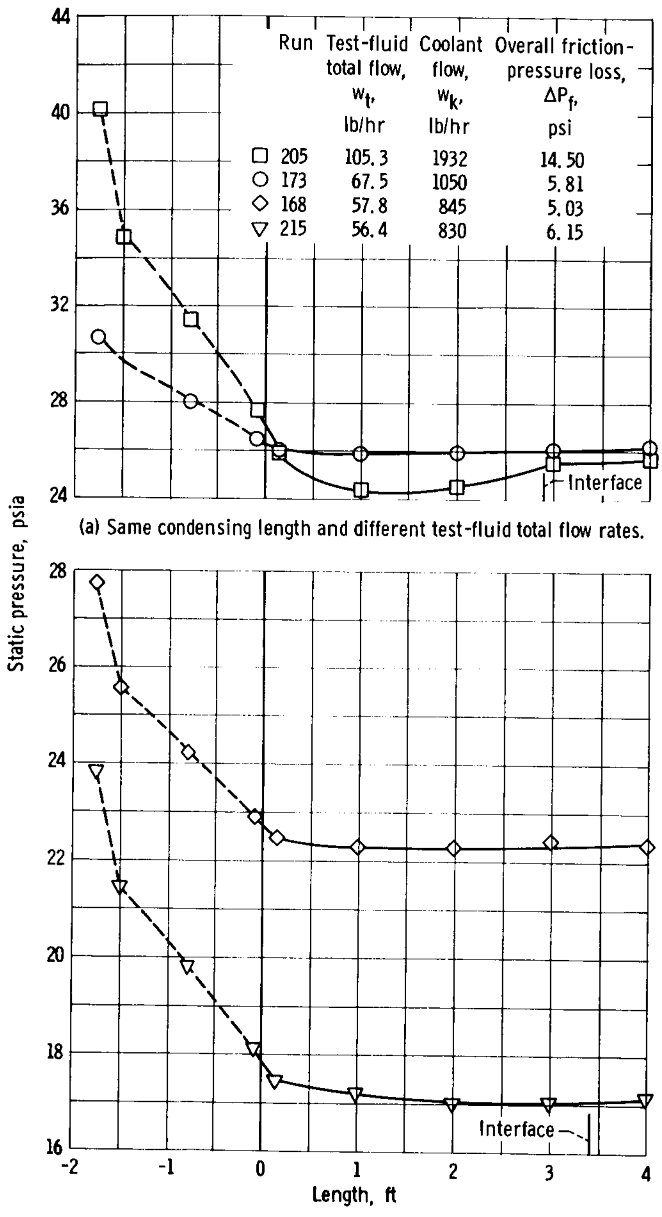
face are saturation temperatures corresponding to the measured pressure. The condensate temperature, represented by the dashed curve downstream of the interface, was computed from heat balances in the subcooling region of the condenser and was subject to uncertainty because of the low heat flux in this area. The condensate temperature at a length of 8.5 feet was measured.

Figure 4(b) shows that, when the condensing length was reduced to 3.3 feet with the same condensing heat load as in figure 4(a), a much smaller overall static-pressure drop was obtained. The static-pressure profile shown in figure 4(b) indicates that the local momentum-pressure gradients and local friction-pressure gradients were nearly equal over the condensing length since the local static-pressure gradients were small.

The test-fluid temperature, shown in figure 4(b), was nearly constant over the condensing portion of the test section since the static pressure did not change appreciably. The condensate temperature at the exit end of the test section was 49° F cooler than for the conditions in figure 4(a) since a larger area was available for subcooling.

Figure 4(c) shows that further reduction in condensing length to 2.2 feet gave a net static-pressure rise of 1.0 pound per square inch from the condenser inlet to the interface. Also, on a local basis, the momentum-pressure gradients were larger than the friction-pressure gradients since the static-pressure gradients were positive over the entire length of the condensing section.

Changing the test-fluid total flow rate while maintaining the same condensing length affected the static-pressure distribution as shown in figure 5(a). Approximately the same static pressure existed at zero length for the two runs shown in the figure. For the lower flow rate run (run 173), the pressure profile was essentially uniform. For the higher flow (run 205) the slope of the static-pressure profile changed from a negative value at the condenser inlet to a positive value near the interface.



(a) Same condensing length and different test-fluid total flow rates.

(b) Same flow rates and different inlet pressures.

Figure 5. - Static pressure distribution for four conditions.

The effect of the change in the inlet pressure at the condenser entrance (L = 0) on the static-pressure distribution is shown in figure 5(b). The test-fluid flow and condensing lengths were approximately the same for the two runs. The shapes of the profiles for the two runs were similar. The log-mean temperature difference between the vapor and coolant for the runs shown in figure 5(b) was the same so that the same average heat flux existed for both runs. The lower pressure level of run 215 caused the vapor to have a higher specific volume in the two-phase region and, consequently, higher velocity at the same flow rate. The higher velocity flow generated larger shearing stresses and, therefore, a greater friction-pressure loss.

Overall Friction-Pressure Loss

Analysis of the data showed that the overall friction-pressure loss for the two-phase region could be correlated in terms of the same parameters that have conventionally been used for single-phase pipe-flow problems. The individual effect of each parameter (length, flow rate, and pressure) on overall friction-pressure loss is similar.

The effect of the variation in condensing length on the overall friction-pressure loss is shown in figure 6. The figure contains three groups of

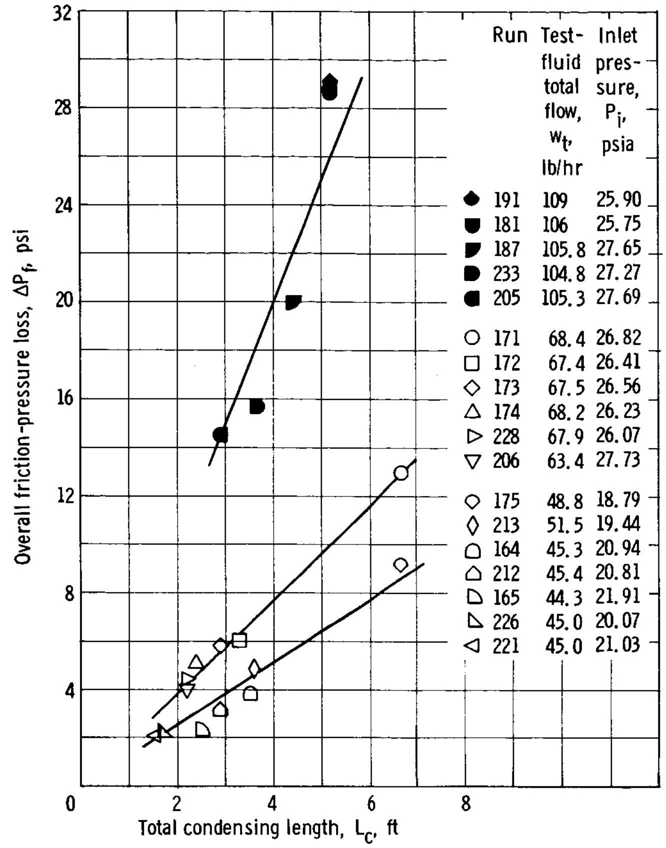


Figure 6. - Overall friction-pressure loss as function of total condensing length at constant inlet conditions.

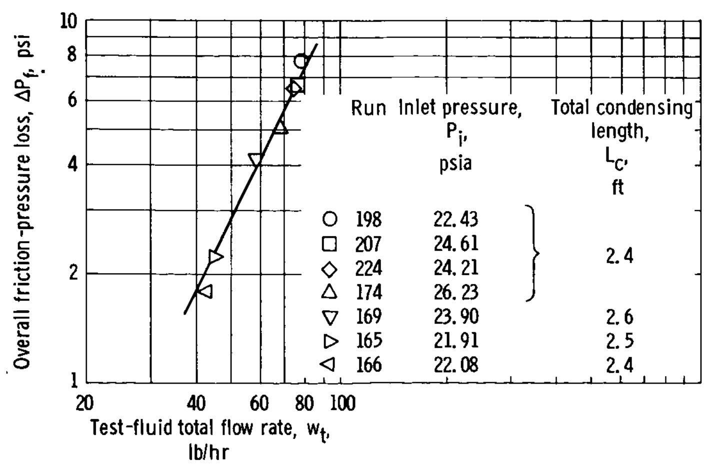
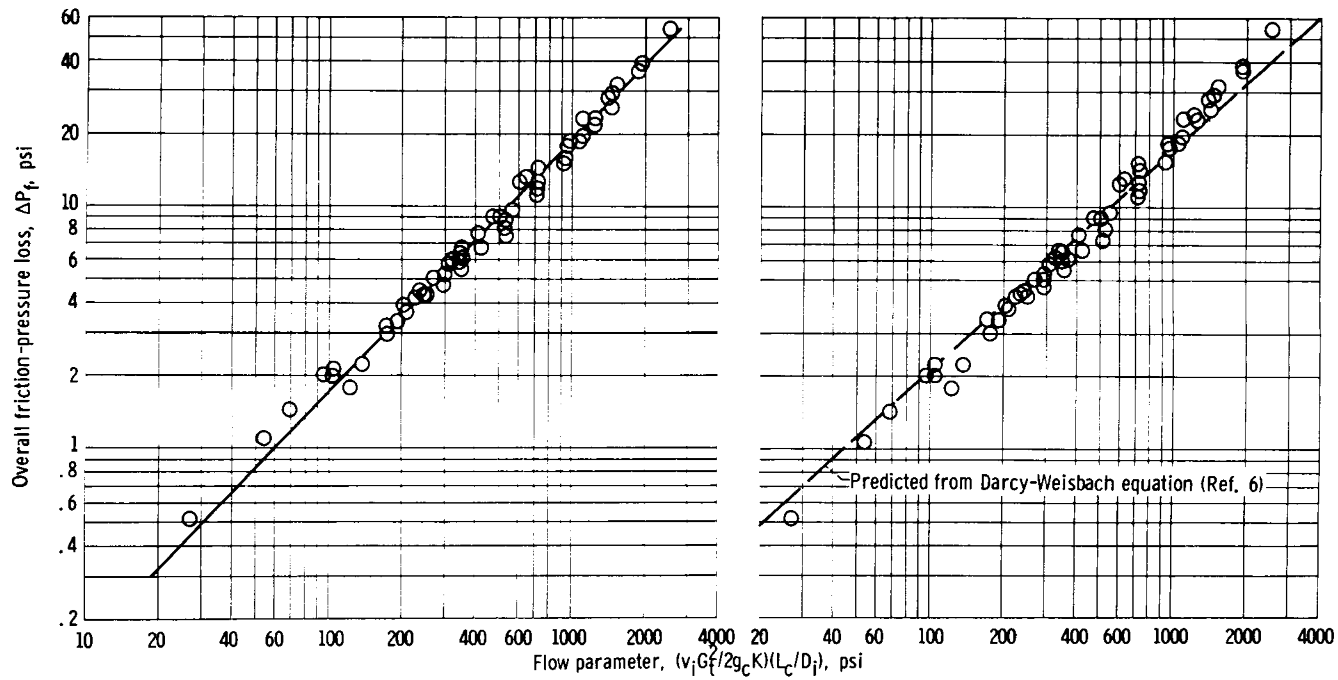


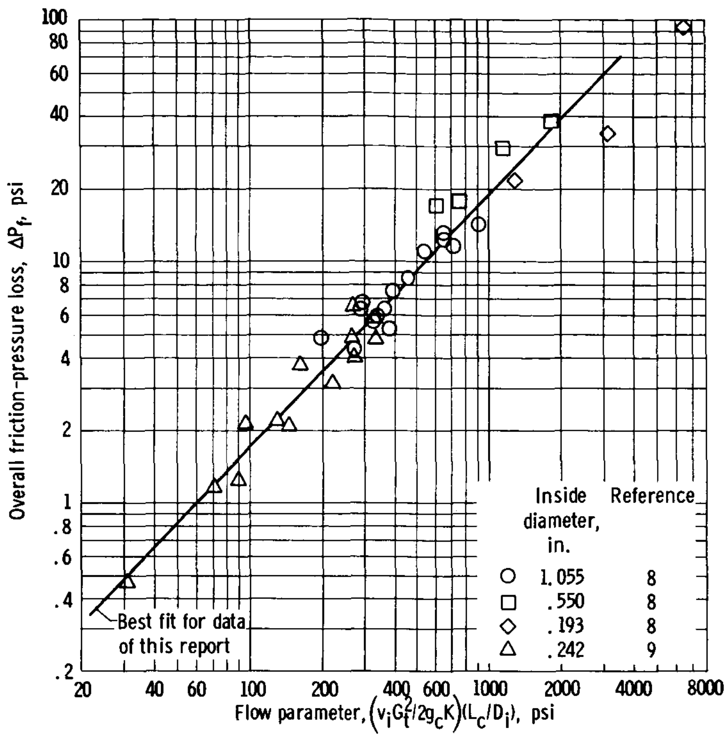
Figure 7. - Overall friction-pressure loss as function of test-fluid total flow rate.



(a) Single-tube steam condenser.

(b) Comparison of experimental data with Darcy-Weisbach equation ($\Delta P_f = f L_c v_i G_f^2/2g_c K D_i$, where $f = 0.184/Re^{0.2}$).

Figure 8. - Friction-pressure loss.



(c) Overall friction-pressure loss as function of flow parameter for data from other sources.

Figure 8. - Concluded.

runs. Each group had approximately the same test-fluid flow rate and static pressures at the inlet of the test section. Figure 6 shows that the overall friction-pressure loss was directly proportional to condensing length.

Figure 7 shows the overall friction-pressure loss plotted as a function of the test-fluid total flow rate at approximately constant conditions of total condensing length and inlet pressure. The figure shows that the overall friction-pressure loss was proportional to the square of the total flow rate.

Since the effect of pressure level was reflected in the specific volume of the fluid, this fluid property, in addition to the flow rate and condensing length, was used to correlate the data, as shown in figure 8(a). The specific volume of the vapor was taken as the saturated value and was evaluated at the pressure existing at the condenser inlet. The length-diameter ratio in the flow parameter is the total condensing length divided by the inner diameter of the tube. The square of the test-fluid total mass velocity was used in the flow parameter. The data correlated to within ±21 percent of the curve and showed, approximately, a direct proportionality between the overall friction-pressure loss and the flow parameter.

The flow parameter of figure 8(a) is identical to the group of variables used in ordinary single-phase pipe-friction problems. An overall friction factor can be obtained from the data of figure 8(a). The best-fit curve shown in the figure gives a constant friction factor of 0.0184.

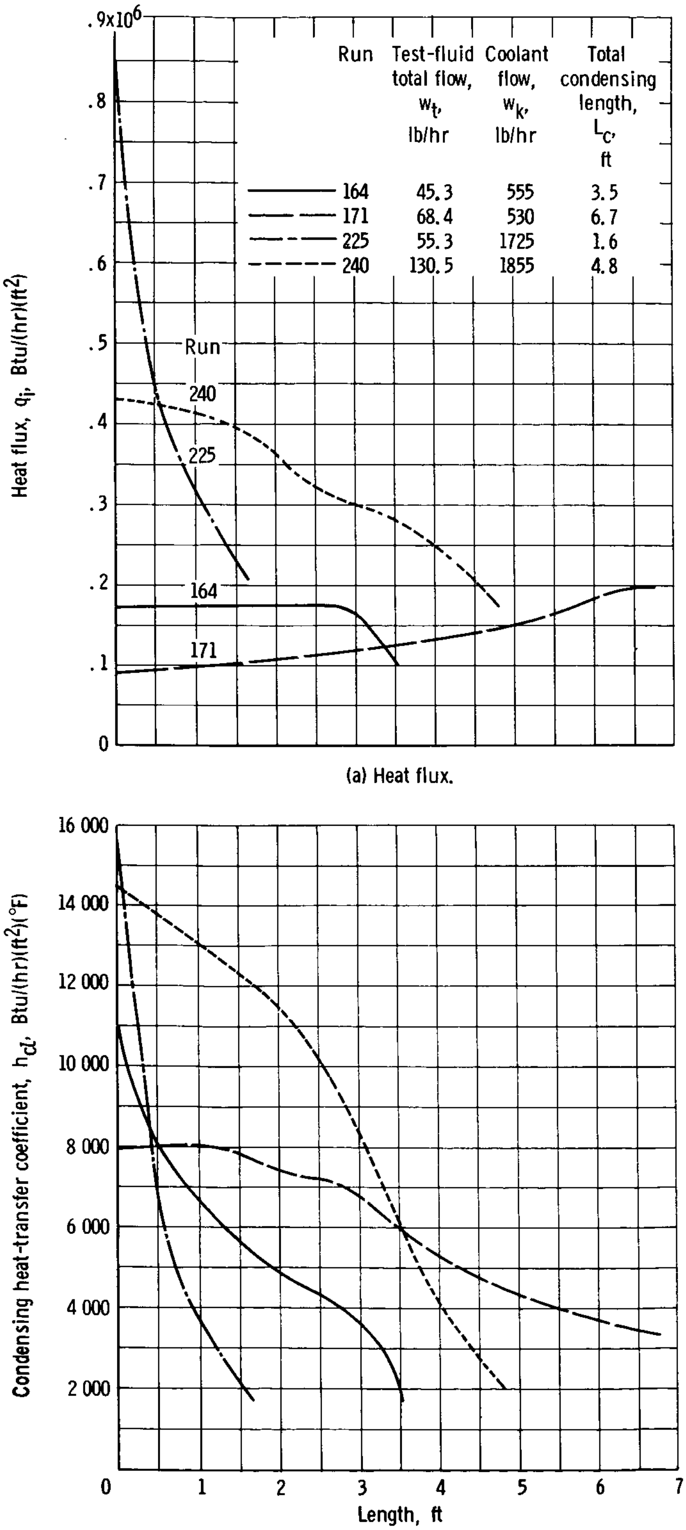
A comparison of the experimental friction-pressure drop as a function of the flow parameter with that predicted from the Darcy-Weisbach equation (ref. 6) for turbulent, incompressible, isothermal, single-phase flow in a smooth tube is shown in figure 8(b). The friction factor was computed from the equation expressing the friction factor as a function of the Reynolds number to the -0.2 power. This relation was for turbulent flow in smooth tubes over a Reynolds number range from 5000 to 200 000 (ref. 7, p. 155).

At the low end of the flow parameter range, the Darcy-Weisbach relation showed a pressure drop greater than that measured for the condenser. At the high end of the range, the relation predicted a pressure drop less than that measured. The general agreement between the experimental friction-pressure drop and that predicted by the single-phase equation was probably caused by the fact that a large portion of the two-phase region had a large void fraction due, in part, to the large density ratio between the two phases at the pressures encountered in the tests.

Friction-pressure-loss data from other studies in which steam was used as a test fluid are plotted as a function of the flow parameter in figure 8(c). The 1.055 inch-inside-diameter single-tube data were recently obtained at the University of Connecticut as part of a continuation of the study reported in reference 8. The data are for complete condensing in the tube. Reference 8 presented data for complete condensing in 0.550- and 0.193-inch inside-diameter tubes. Reference 9 reported overall static-pressure changes in a multitube condenser with individual tubes having an inside diameter of 0.242 inch. Data from reference 9 with inlet qualities greater than 70 percent were used for presentation in figure 8(c). The test condensers of references 8 and 9 were installed in a horizontal plane. Figure 8(c) shows that the overall friction-pressure loss for these inside tube condensers correlates satisfactorily with the flow parameter, regardless of test-section geometries and orientation.

Local Heat Flux

The axial heat-flux distributions obtained in the tests had a variety of shapes and a large range in the magnitude of local values of heat flux. Examples of axial heat-flux distributions are shown in figure 9(a). The heat flux distribution for run 225 was typical for a run with a net static-pressure rise from zero length to the downstream vapor-liquid interface. The run was characterized by a very high value of local heat flux near the vapor-inlet end of the condenser and a large axial heat-flux gradient. Local heat fluxes for run 240 were relatively high, but the slope of the heat-flux curve



(a) Heat flux.

(b) Heat-transfer coefficient.

Figure 9. - Variations in heat flux and heat-transfer coefficient for single-tube steam condenser.

was considerably less than that of run 225.

An example of uniform heat flux over most of the condensing portion of the test section was shown by run 164. The combination of operating conditions for this run was such that a constant condensing rate per unit length was obtained along with a corresponding linear increase in coolant temperature. The heat flux for run 171 increased with length and reached a maximum at the vapor-liquid interface. This heat flux distribution was obtained from a coolant temperature profile that exhibited a slight concavity downward (fig. 4(a)). Run 171 illustrated a condition where the heat flux was proportional to the overall temperature difference between the vapor and the coolant.

Local Heat-Transfer Coefficients

Variation in heat flux was partly caused by the variation in local heat-transfer coefficients and partly by the overall temperature difference between vapor and coolant. The local condensing heat-transfer coefficients for the runs of figure 9(a) were plotted as a function of length and are shown in figure 9(b). The coefficients had a higher value at the condenser inlet and generally decreased in magnitude with length (exceptions are runs 175 and 191, table I).

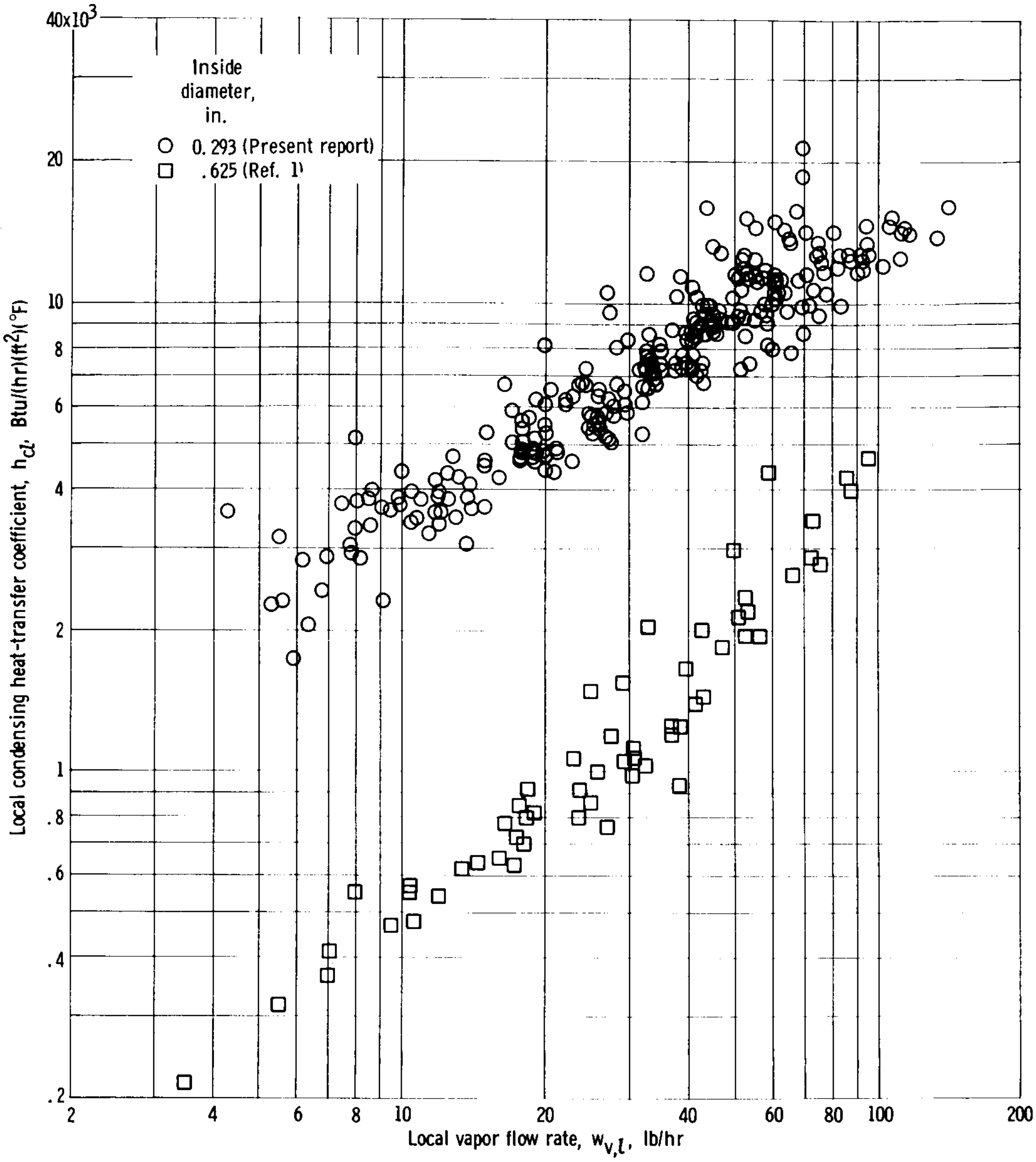


Figure 10. - Local condensing heat-transfer coefficient as function of local vapor flow rate.

Analytical studies on high-velocity condensing inside tubes have indicated that the condensing heat-transfer coefficient should increase with increased values of interfacial shear between the vapor and the condensate film (refs. 10 to 12). Interfacial shear forces are proportional to the relative velocity between the vapor and the liquid and would require a knowledge of either the vapor or liquid velocity for analysis. These quantities cannot be determined from the data presented herein. Reference 1, however, presented the local condensing heat-transfer coefficient as a function of local vapor mass flow rate, and the results showed the coefficient was proportional to the vapor flow.

Figure 10 shows the data of the present work plotted in terms of the local condens-

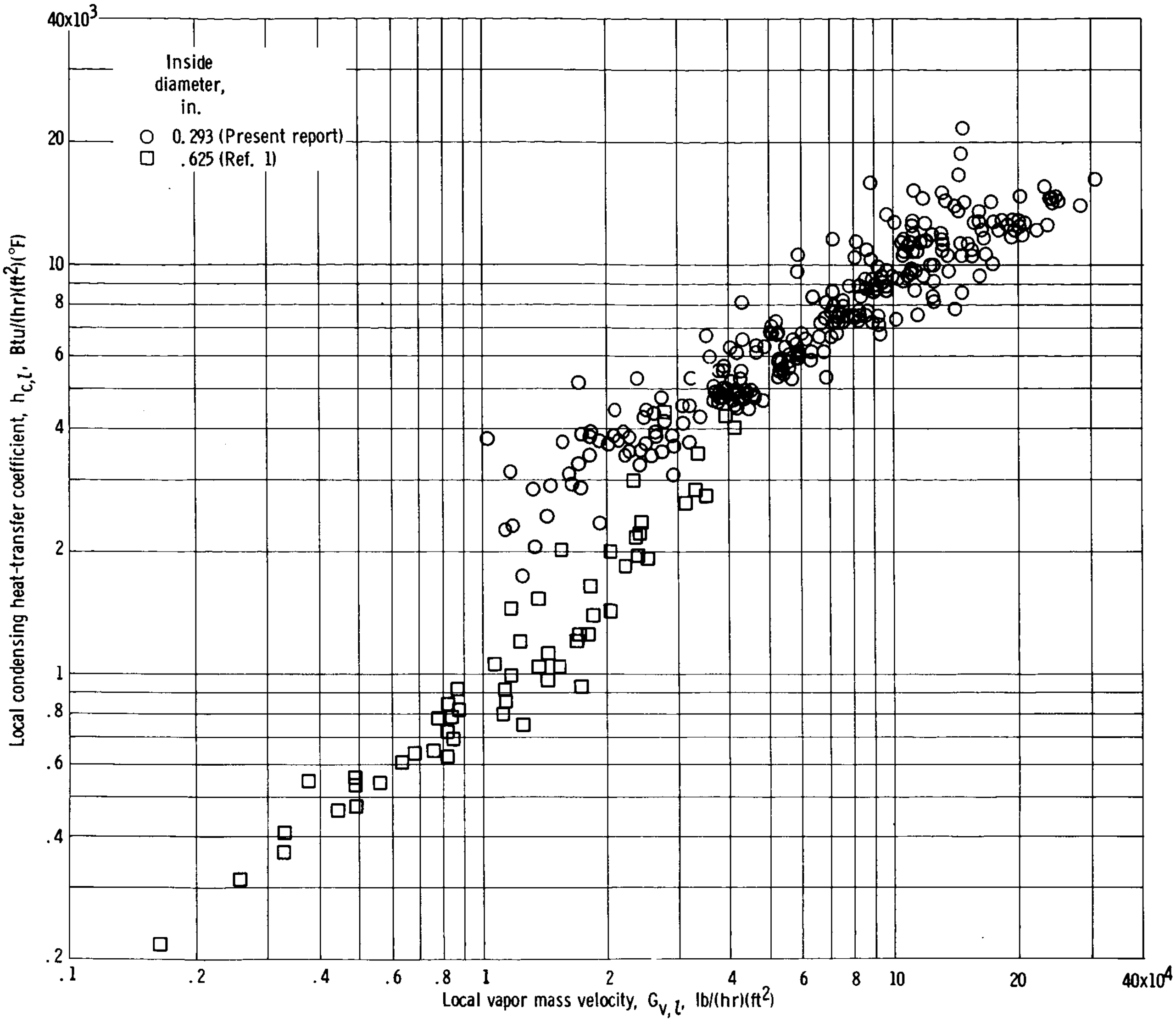


Figure 11. - Local condensing heat-transfer coefficient as function of local vapor mass velocity.

ing coefficient as a function of the local vapor flow rate. Local vapor flow rates were computed from heat balances. Data are shown for local qualities greater than 10 percent, since, at very low qualities, the method used to calculate vapor flow rate from the experimental data becomes inaccurate (appendix B). Data from reference 1 are also plotted for comparison. The present data are considerably higher than those of references 1 and show a slightly different slope. The trend of increasing coefficient with increasing vapor flow is still evident, however.

Figure 11 is presented to compare the two sets of data in terms of local superficial vapor mass velocity, that is, mass velocity based on the inner diameter of the condenser tube. Figures 10 and 11 show that the convective nature of high-velocity vapor flow is an important consideration in condensing heat transfer. Reference 13 presented similar

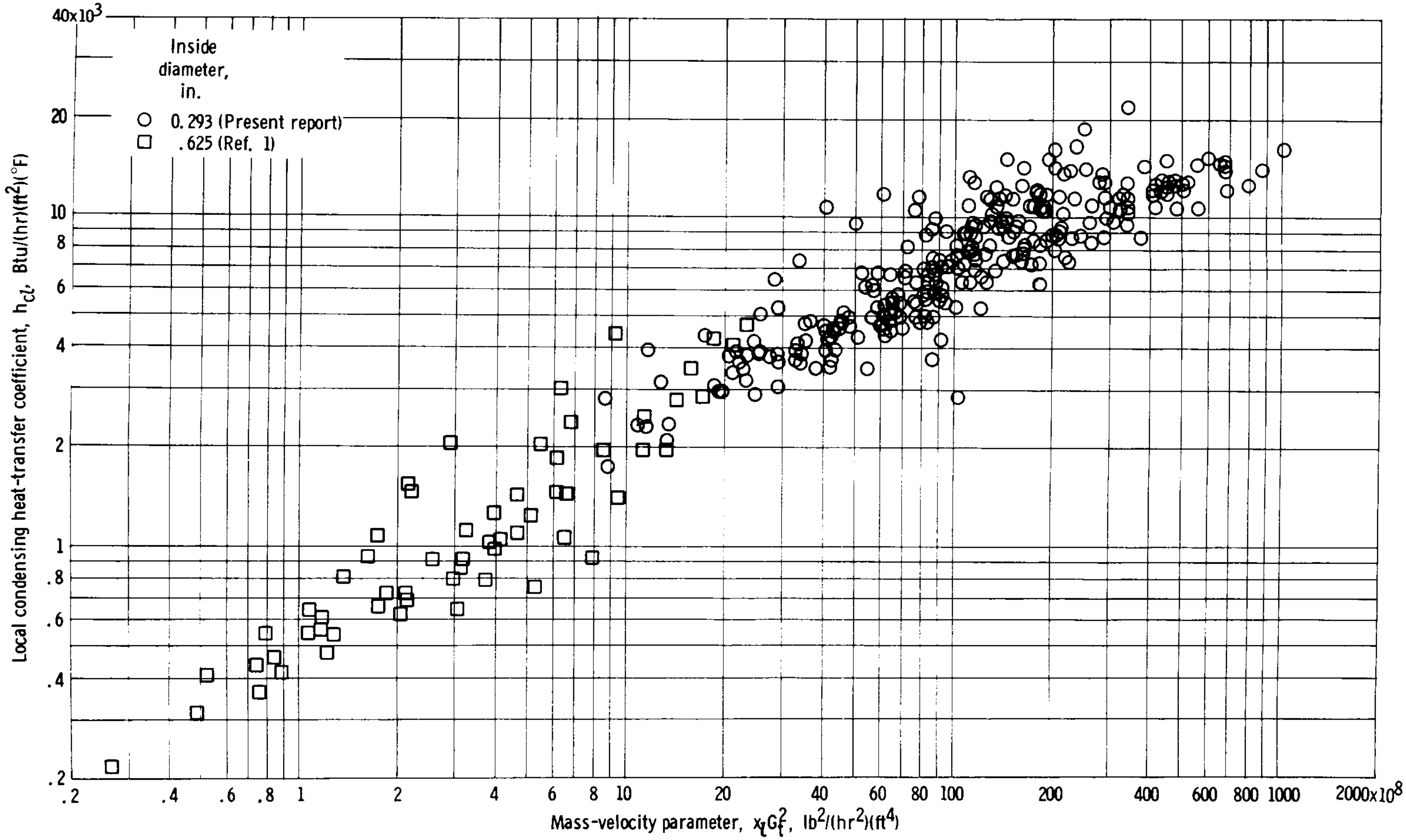


Figure 12. - Local condensing heat-transfer coefficient as function of mass-velocity parameter.

results. Furthermore, the data of this report and of reference 1 show that the relation between the heat-transfer coefficient and the vapor flow rate is consistent over a large portion of the condensing region in an inside-tube condenser.

The vapor mass velocity of figure 11 is the product of the local quality and test-fluid total mass velocity. A correlation was tried between the local coefficient and the product of the local quality and the square of the test-fluid total mass velocity. The results are shown in figure 12 and indicate that over a large range a satisfactory correlation can be made between the local condensing coefficient and the mass velocity parameter.

Mean Heat-Transfer Coefficients

Mean condensing heat-transfer coefficients were computed from the local coefficients as described in appendix B. Figure 13 shows the mean coefficients plotted as a function of test-fluid total mass velocity. Also shown in the figure are data from reference 1 and complete condensing data for steam from reference 14. Figure 13 indicates an approximately linear relation between the mean coefficient and the total mass velocity. This relation is in agreement with the analytical work of Carpenter and Colburn (ref. 10), who considered the effect of vapor shear and fluid properties for high-velocity condensing. The data reported herein, however, are not presented in terms of the Carpenter-Colburn expression since the overall friction factor was almost constant, and the fluid

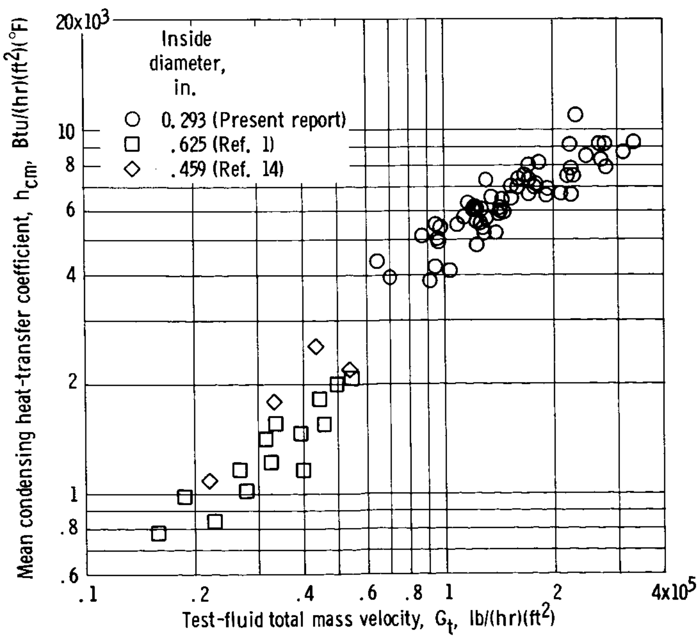


Figure 13. - Mean condensing heat-transfer coefficient as function of test-fluid total mass velocity.

properties did not vary appreciably over the temperature range encountered in these tests.

Pressure Oscillations

As discussed in the APPARATUS AND PROCEDURE section, the dynamic characteristics of the boiler were checked during the stability survey. Closing the throttle valve upstream of the condenser stopped (or reduced) the flow and caused the boiler pressure to rise. Opening the valve caused it to drop. The boiler would respond (with a phase lag) in the 1- to 10-cps range. At these frequencies, however, the magnitude of the change in boiler pressure was small even with the valve oscillating between the fully closed and fully opened condition. The peak-to-peak amplitudes of the pressure disturbances were always less than 1 pound per square inch. For example, with the boiler at 31 pounds per square inch absolute, the peak-to-peak amplitude for a 1-cps valve oscillation was 0.44 pound per square inch or about 1.4 percent of the boiler mean pressure. It was concluded from these tests that the boiler could provide essentially-constant-pressure vapor regardless of flow disturbances occurring elsewhere in the system.

The steady-state heat-transfer and pressure data were taken with the system operating stably. Under these conditions, the pressure variations in the condenser, if any, were less than ±1.5 percent of the mean pressure. This condition was not the case, however, when the condenser was at an unstable operating point.

The instability survey data of table III show that large-amplitude pressure oscillations occurred when the condenser was unstable. In some cases (runs 8 and 12), the peak-to-peak amplitude of the disturbance was greater than 50 percent of the mean pressure at the vapor-liquid interface. The frequencies of the pressure oscillations ranged from 2.7 to 8.8 cps. The pressure oscillations occurred when the condensing lengths were between 1.7 and 3.7 feet. The axial static-pressure profiles (time averages) were, with one exception (run 1), very flat for the unstable runs. Flat pressure profiles are consistent with intermediate condensing lengths (1.7 to 3.7 ft). No unstable conditions were encountered during the survey at very short or at long condensing lengths. At the intermediate condensing lengths, the system operated either stably or unstably depending on the particular combination of condenser parameters existing at the operating point. At the present time, the cause of the condenser instability is unknown. Some of the parameters thought to be important in determining stability are included in the data summary of table III. However, no single controlling parameter or combination of parameters which could be used to predict stable operating points was found in the brief survey.

Examples of pressure-time traces taken from small portions of oscillograph traces

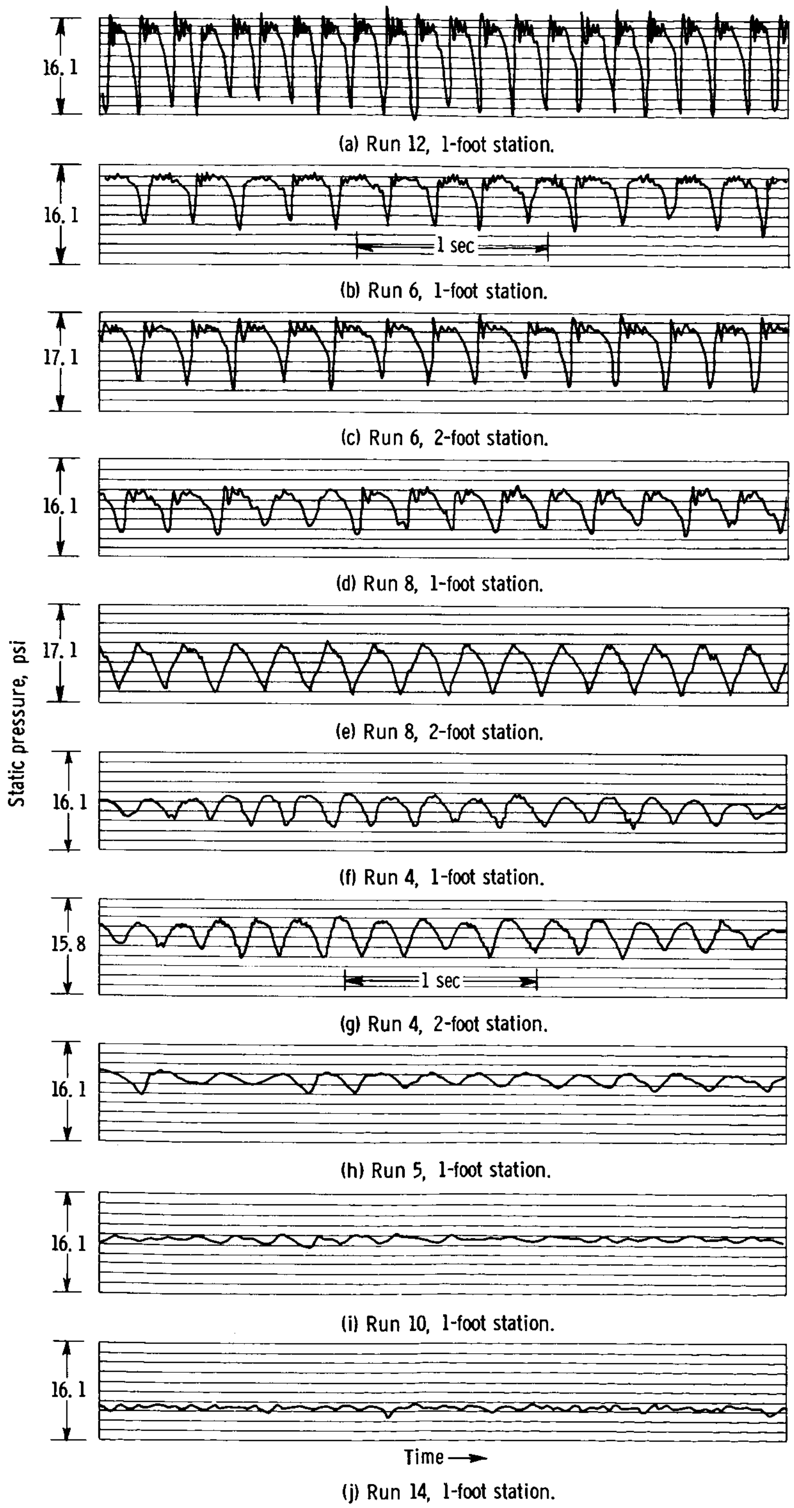


Figure 14. - Pressure-time traces for unstable runs.

for unstable runs 4, 5, 6, 8, 10, 12, and 14 of table III are shown in figure 14. The pressure traces are arranged in order of decreasing disturbance amplitude. The general shape of the nonlinear pressure oscillations tends toward narrow negative peaks and wide positive peaks. Further, pressure generally decreases at a slower rate than it rises. The large-amplitude disturbances also have indications of acoustic-type disturbances propagating up and down the vapor supply line. (Note ringing-type disturbance during positive part of cycle in fig. 14(a).) When the condenser instability is well developed, the disturbances become periodic. The period for each cycle is not fixed (or locked in), however, but varies somewhat from cycle to cycle as do the amplitudes. Further, examining the oscillograph traces over a much longer period of time than shown in figure 14 shows that the amplitudes and shapes of the disturbances tend to vary considerably at an unstable operating condition. The disturbances frequently die out and grow again.

The frequencies and amplitudes given in table III were averaged over a large number of cycles (100 or more). Mean frequencies were fairly easy to determine for the large-amplitude disturbances (e.g., figs. 14(a) to (g)). The frequencies of the small-amplitude fluctuations (e.g., figs. 14(h) to (j)) were much harder to determine because the wave shape was not clearly defined and tended to change from cycle to cycle even over short time intervals.

Pressure traces for runs 4, 6, and 8 are given in figure 14 for both the 1- and 2-foot stations. Comparison of the responses at the two stations shows that they are grossly similar in shapes and amplitudes, and the phase shifts, if any, are small.

SUMMARY OF RESULTS

The results obtained from the investigation for local heat-transfer and static pressures for steam condensing inside a tube in vertical downflow with high inlet vapor velocity may be summarized as follows:

1. The local condensing heat-transfer coefficient correlated with the product of the local quality and the square of the test-fluid total mass velocity.

2. Mean condensing heat-transfer coefficients were proportional to the total mass velocity of the test fluid, as found by other investigators. The mean coefficients varied from 3860 to 11 850 Btu per hour per square foot per $^{\circ}F$ over a test-fluid total mass velocity range from 64 900 to 336 000 pounds per hour per square foot.

3. The local condensing heat-transfer coefficients were shown to vary with distance from the condenser inlet. In general, high values of the coefficient occurred at the inlet and decreased in magnitude with increasing length. The coefficients at the inlet varied from 18 946 to 2856 Btu per hour per square foot per $^{\circ}F$. At the downstream end of the condenser, the coefficients varied from 7786 to 505.

4. The overall friction-pressure loss for steam condensing inside a tube was satisfactorily correlated in terms of common pipe friction parameters that included the flow rate, total condensing length, and specific volume of the vapor at the condenser inlet.

5. Net overall static-pressure rises in the condenser were obtained for conditions of high heat flux. Static-pressure changes varied from a net increase of 1.32 pounds per square inch to a net decrease of 35.34 pounds per square inch.

6. Unstable condenser operation occurred at particular combinations of boiler supply steam pressure, coolant flow rate, and condensate flow control valve settings. Unstable operating points could be detected by unsteady condenser pressures. These conditions originated in the condenser and were avoided when taking the steady-state data.

Lewis Research Center,
National Aeronautics and Space Administration,
Cleveland, Ohio, December 2, 1966,
120-27-02-01-22.

APPENDIX A

SYMBOLS

$c_{p,k}$ specific heat of coolant, Btu/(lb)(°F)

D diameter, ft

D_i inside diameter, ft

D_o outside diameter, ft

f friction factor

G_k coolant mass velocity, lb/(hr)(ft^2)

G_t test-fluid total mass velocity, lb/(hr)(ft^2)

G_v vapor mass velocity (based on inner diameter of tube), lb/(hr)(ft^2)

g_c conversion factor, 4.17×10^8 (lb mass)(ft)/(hr^2)(lb force)

h_{cl} local condensing heat-transfer coefficient, Btu/(hr)(ft^2)(°F)

h_{cm} mean condensing heat-transfer coefficient, Btu/(hr)(ft^2)(°F)

K conversion factor, (144)(in.^{2})/(ft^2)

$k_{m,w}$ wall mean thermal conductivity, (Btu)(ft)/(hr)(ft^2)(°F)

L length, ft

L_c total condensing length, ft

ΔP_f overall friction-pressure change, psi

ΔP_G change in pressure due to change in elevation, psi

P_{IF} static pressure at downstream liquid-vapor interface, psia

ΔP_m overall momentum-pressure change, psi

P_s static pressure, psia

ΔP_s overall static-pressure change, psi

Q rate of heat flow, Btu/hr

q heat flux, Btu/(hr)(ft^2)

q_i heat flux based on inside tube area, Btu/(hr)(ft^2)

Re Reynolds number of vapor evaluated at condenser inlet conditions

t_c condensate temperature at condenser exit, measured at 8.5 ft, °F

Δt_f temperature drop across condensate film, °F

t_{iw} local inner wall temperature, °F

t_k local coolant temperature, °F

t_{ow} local outer wall temperature, °F

Δt_s amount of superheat of vapor upstream of test section, measured at -1.75 ft, °F

t_v vapor temperature upstream of condenser, measured at -1.75 ft, °F

t_{vs} vapor saturation temperature corresponding to pressure, °F

t_w local faired value of wall temperature, ^{o}F

V_{vi} vapor velocity at beginning of condensing portion of condenser, ft/sec

v_i vapor specific volume at beginning of condensing portion of condenser, ft^3/lb

w_k coolant flow rate, lb/hr

w_t test-fluid total flow rate, lb/hr

w_v vapor flow rate, lb/hr

x vapor quality

Subscript:

l local

APPENDIX B

DATA REDUCTION AND COMPUTATIONS

For the evaluation of the local heat flux the following assumptions were made:

(1) Only radial flow of heat

(2) No heat loss to ambient surroundings

(3) Measured change in temperature of coolant equal to change in its bulk temperaature

The local heat flux was calculated from the following equation:

$$q = \frac{w_k c_{p,k}\, dt_k}{\pi D\, dL} \tag{B1}$$

where the numerator represents the increase in enthalpy of the coolant and the denominator represents the area normal to the flow of heat. The slope of the coolant temperature profile dt_k/dL was measured graphically from a plot of coolant temperature as a function of length. The heat flux at the inner surface of the condenser tube was found by substituting the inner diameter into equation (B1).

The local condensing heat-transfer coefficient was calculated from the following:

$$h_{cl} = \frac{q_i}{(t_{vs} - t_{iw})} \tag{B2}$$

where t_{vs} is the local vapor saturation temperature corresponding to the local static pressure, and t_{iw} is the inner wall temperature. The inner wall temperature was computed from the following equation for radial heat flow in a cylinder (ref. 7, p. 13).

$$Q = \frac{2\pi L k_{m,w}(t_{iw} - t_{ow})}{\ln \dfrac{D_o}{D_i}} \tag{B3}$$

Solving equation (B3) for the inner wall temperature t_{iw} in terms of the local heat flux and the outer wall temperature results in

$$t_{iw} = t_{ow} + \frac{q_i D_i \ln \frac{D_o}{D_i}}{2k_{m,w}} \tag{B4}$$

The thermal conductivity of the tube wall $k_{m,w}$ was assumed constant over the temperature range encountered in the test, and a value of 226 Btu per hour per square foot per ^{o}F per foot was used for oxygen-free copper (ref. 15). The diameter ratio in equation (B4) is the ratio of the diameter at which the temperature is measured to the inner diameter of the tube. The physical junction of the tube wall thermocouple was placed 0.034 inch from the inner surface. The actual junction is the location where electrical continuity is first encountered between the two thermocouple wires (i.e., the point where the two wires are in contact with the silver solder). Because of uncertainty in the thermal conductivity of the silver solder fill material and in the integrity of the solder, however, the temperature difference between the actual junction and the physical junction was not taken into account. The diameter at which the temperature was measured, therefore, was taken as 0.361 inch. After substituting the thermal conductivity, proper diameter ratio, and faired value of the measured wall temperatures, into equation (B4), the expression for the inner wall temperature becomes

$$t_{iw} = t_w + 1.128\times10^{-5}\, q_i \tag{B5}$$

Mean condensing heat-transfer coefficients were evaluated by plotting the local coefficients as a function of length. The area under the curve was then determined and divided by the condensing length to obtain the mean coefficient.

Local condensing rate was computed from heat balances. The condenser was divided into 0.25-foot increments. The heat flux was assumed constant for each increment. The reduction in the enthalpy of the vapor and liquid was assumed negligible compared with the release of the latent heat of vaporization. This assumption is valid to very low (less than 10 percent) qualities. The rate of heat flow for an increment was evaluated by multiplying the heat flux by the surface area of the increment based on the inside diameter of the tube. The rate of formation of liquid in the increment was then calculated by dividing the heat flow rate by the local value of the latent heat of vaporization. The latent heat was taken to be a function of the local saturation temperature. The local vapor flow rate at a particular location in the condenser was then the difference between the test-fluid total flow rate and the total liquid flow rate at that location.

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TABLE I. - EXPERIMENTAL AND COMPUTED DATA

Location, L, ft	Local coolant temperature, t_k, ^oF	Local faired value of wall temperature, t_w, ^oF	Static pressure, P_s, psia	Heat flux based on inside tube area, q_i, $\frac{Btu}{(hr)(ft^2)}$	Vapor saturation temperature corresponding to pressure, t_{vs}, ^oF	Temperature drop across condensate film, Δt_f, ^oF	Local condensing heat-transfer coefficient, h_{cl}, $\frac{Btu}{(hr)(ft^2)(^oF)}$	Conditions
				Run 163				
-1.75	---	---	23.63	-------	237	----	----	Test-fluid total flow rate, w_t, 60 lb/hr; coolant flow rate, w_k, 830 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 244° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 89° F; test-fluid total mass velocity, G_t, 127 800 lb/(hr)(ft^2); coolant mass velocity, G_k, 1 080 000 lb/(hr)(ft^2); total condensing length, L_c, 4.1 ft; overall friction-pressure change, ΔP_f, 7.42 psi; mean condensing heat-transfer coefficient, h_{cm}, 5550 Btu/(hr)(ft^2)(°F); vapor state at -1.75 ft, Δt_s, 7.0° F; vapor quality at -0.08 ft, 0.98; heat balance error, -1.0 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 819 ft/sec
-1.50	---	---	20.89	-------	-----	----	----	
-.79	---	---	18.96	-------	-----	----	----	
-.08	---	---	16.94	-------	-----	----	----	
.03	152	---	-----	-------	-----	----	----	
.14	---	196	16.75	193 000	218.8	20.6	9369	
.98	135	189	16.25	193 000	218.1	26.9	7175	
1.98	117	180	15.65	193 000	215.1	32.9	5866	
2.98	97	167	15.64	193 000	215.1	45.9	4205	
3.50	---	155	-----	177 000	215.4	58.4	3031	
3.75	---	144	-----	140 000	215.5	69.9	2003	
3.98	83	130	15.84	109 000	215.8	84.6	1290	
4.98	78	88	15.74	37 000	-----	----	----	
5.48	---	---	15.60	-------	-----	----	----	
5.98	76	81	15.61	-------	-----	----	----	
6.48	---	---	15.59	-------	-----	----	----	
6.98	75	78	15.73	-------	-----	----	----	
7.56	---	78	15.68	-------	-----	----	----	
7.95	75	---	-----	-------	-----	----	----	
8.06	---	---	15.68	-------	-----	----	----	
				Run 164				
-1.75	---	---	24.22	-------	238.4	----	----	Test-fluid total flow rate, w_t, 45.3 lb/hr; coolant flow rate, w_k, 555 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 240° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 125° F; test-fluid total mass velocity, G_t, 96 500 lb/(hr)(ft^2); coolant mass velocity, G_k, 652 000 lb/(hr)(ft^2); total condensing length, L_c, 3.5 ft; overall friction-pressure change, ΔP_f, 3.85 psi; mean condensing heat-transfer coefficient, h_{cm}, 5460 Btu/(hr)(ft^2)(°F); vapor state at -1.75 ft, Δt_s, 1.6° F; vapor quality at -0.08 ft, 0.99; heat balance error, 7.0 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 507 ft/sec
-1.50	---	---	22.77	-------	-----	----	----	
-.79	---	---	21.79	-------	-----	----	----	
-.08	---	---	20.94	-------	-----	----	----	
.03	164	---	-----	-------	-----	----	----	
.14	---	210	20.59	174 000	229.5	17.5	9943	
.98	142	201	20.36	174 000	228.9	25.9	6718	
1.98	121	190	20.14	174 000	228.3	36.3	4793	
2.98	94	178	20.01	174 000	228.0	48.0	3625	
3.50	---	165	-----	102 800	228.0	61.9	1661	
3.75	---	154	-----	78 300	-----	----	----	
3.98	79	141	19.90	55 000	-----	----	----	
4.98	75	79	19.82	20 700	-----	----	----	
5.48	---	---	19.74	-------	-----	----	----	
5.98	75	76	19.71	-------	-----	----	----	
6.48	---	---	19.71	-------	-----	----	----	
6.98	72	75	19.61	-------	-----	----	----	
7.56	72	75	19.73	-------	-----	----	----	
7.95	72	---	-----	-------	-----	----	----	
8.06	---	---	19.89	-------	-----	----	----	

TABLE I. - Continued. EXPERIMENTAL AND COMPUTED DATA

Location, L, ft	Local coolant temperature, t_k, ^oF	Local faired value of wall temperature, t_w, ^oF	Static pressure, P_s, psia	Heat flux based on inside tube area, q_i, $\frac{Btu}{(hr)(ft^2)}$	Vapor saturation temperature corresponding to pressure, t_{vs}, ^oF	Temperature drop across condensate film, Δt_f, ^oF	Local condensing heat-transfer coefficient, h_{cl}, $\frac{Btu}{(hr)(ft^2)(^oF)}$	Conditions
				Run 165				
-1.75	---	---	24.80	-------	239.7	----	----	Test-fluid total flow rate, w_t, 44.3 lb/hr; coolant flow rate, w_k, 830 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 239^o F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 113^o F; test-fluid total mass velocity, G_t, 94 300 lb/(hr)(ft^2); coolant mass velocity, G_k, 975 000 lb/(hr)(ft^2); total condensing length, L_c, 2.5 ft; overall friction-pressure change, ΔP_f, 2.27 psi; mean condensing heat-transfer coefficient, h_{cm}, 4230 Btu/(hr)(ft^2)(^{o}F); vapor state at -1.75 ft, Δt_s, 0.7^o F; vapor quality at -0.08 ft, 0.99; heat balance error, -6.0 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 478 ft/sec
-1.50	---	---	23.50	-------	-----	----	----	
-.79	---	---	22.67	-------	-----	----	----	
-.08	---	---	21.91	-------	-----	----	----	
.03	128	---	-----	-------	-----	----	----	
.14	---	195	21.86	301 000	232.7	33.3	9039	
.50	---	188	-----	276 000	233.0	41.9	6587	
.98	104	179	22.12	240 000	233.4	51.7	4642	
1.50	---	167	-----	198 500	233.6	64.3	3087	
1.98	85	150	22.31	170 000	233.8	81.9	2076	
2.25	---	138	-----	133 000	233.9	94.4	1409	
2.98	76	82	22.24	32 200	-----	----	----	
3.98	75	75	22.33	-------	-----	----	----	
4.98	75	75	22.27	-------	-----	----	----	
5.48	---	---	22.28	-------	-----	----	----	
5.98	75	75	22.27	-------	-----	----	----	
				Run 166				
-1.75	---	---	24.71	-------	239.5	----	----	Test-fluid total flow rate, w_t, 42.8 lb/hr; coolant flow rate, w_k, 1062 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 241^o F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 113^o F; test-fluid total mass velocity, G_t, 91 300 lb/(hr)(ft^2); coolant mass velocity, G_k, 1 250 000 lb/(hr)(ft^2); total condensing length, L_c, 2.4 ft; overall friction-pressure change, ΔP_f, 1.80 psi; mean condensing heat-transfer coefficient, h_{cm}, 3860 Btu/(hr)(ft^2)(^{o}F); vapor state at -1.75 ft, Δt_s, 1.5^o F; vapor quality at -0.08 ft, 0.99; heat balance error, -5.0 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 458 ft/sec
-1.50	---	---	23.51	-------	-----	----	----	
-.79	---	---	22.73	-------	-----	----	----	
-.08	---	---	22.08	-------	-----	----	----	
.03	120	---	-----	-------	-----	----	----	
.14	---	188	22.08	336 000	233.2	41.4	8116	
.50	---	186	-----	322 000	233.9	44.3	7269	
.98	98	169	22.59	291 000	234.5	62.2	4678	
1.50	---	150	-----	216 000	235.0	82.5	2618	
1.75	---	139	-----	136 000	235.0	94.5	1439	
1.98	83	126	22.79	83 400	235.0	108.1	770	
2.25	---	109	-----	56 100	235.0	125.4	505	
2.98	80	82	22.82	-------	-----	----	----	
3.98	79	79	22.83	-------	-----	----	----	
4.98	79	79	22.85	-------	-----	----	----	

TABLE I. - Continued. EXPERIMENTAL AND COMPUTED DATA

Location, L, ft	Local coolant temperature, t_k, °F	Local faired value of wall temperature, t_w, °F	Static pressure, P_s, psia	Heat flux based on inside tube area, q_i, Btu/(hr)(ft²)	Vapor saturation temperature corresponding to pressure, t_{vs}, °F	Temperature drop across condensate film, Δt_f, °F	Local condensing heat-transfer coefficient, h_{cl}, Btu/(hr)(ft²)(°F)	Conditions
Run 167								
-1.75	---	---	28.71	-------	247.9	----	------	Test-fluid total flow rate, w_t, 60.8 lb/hr; coolant flow rate, w_k, 535 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 254° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 144° F; test-fluid total mass velocity, G_t, 129 300 lb/(hr)(ft²); coolant mass velocity, G_k, 628 000 lb/(hr)(ft²); total condensing length, L_c, 5.7 ft; overall friction-pressure change, ΔP_f, 9.68 psi; mean condensing heat-transfer coefficient, h_{cm}, 5250 Btu/(hr)(ft²)(°F); vapor state at -1.75 ft, Δt_s, 6.1° F; vapor quality at -0.08 ft, 0.99; heat balance error, 5.0 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 614 ft/sec
-1.50	---	---	26.40	-------	-----	----	------	
-.79	---	---	24.99	-------	-----	----	------	
-.08	---	---	23.57	-------	-----	----	------	
.03	192	---	-----	-------	-----	----	------	
.14	---	222	23.00	103 800	235.5	12.3	8 430	
.98	177	216	22.00	117 000	233.0	15.7	7 460	
1.98	161	209	20.74	122 200	229.9	19.5	6 270	
2.98	139	199	19.54	141 400	226.7	26.1	5 410	
3.98	120	187	18.99	152 500	225.2	36.5	4 180	
4.98	96	170	18.71	140 000	224.5	52.9	2 650	
5.48	---	159	18.87	121 900	224.8	64.4	1 890	
5.98	76	144	18.68	121 900	-----	----	------	
6.48	---	96	18.46	42 900	-----	----	------	
6.98	69	85	18.48	-------	-----	----	------	
7.56	69	79	18.67	-------	-----	----	------	
7.95	69	---	-----	-------	-----	----	------	
8.06	---	---	18.65	-------	-----	----	------	
Run 168								
-1.75	---	---	27.71	-------	245.9	----	------	Test-fluid total flow rate, w_t, 57.8 lb/hr; coolant flow rate, w_k, 845 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 252° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 118° F; test-fluid total mass velocity, G_t, 123 000 lb/(hr)(ft²); coolant mass velocity, G_k, 992 000 lb/(hr)(ft²); total condensing length, L_c, 3.2 ft; overall friction-pressure change, ΔP_f, 5.03 psi; mean condensing heat-transfer coefficient, h_{cm}, 4870 Btu/(hr)(ft²)(°F); vapor state at -1.75 ft, Δt_s, 6.1° F; vapor quality at -0.08 ft, 0.99; heat balance error, 2.0 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 598 ft/sec
-1.50	---	---	25.56	-------	-----	----	------	
-.79	---	---	24.22	-------	-----	----	------	
-.08	---	---	22.92	-------	-----	----	------	
.03	150	---	-----	-------	-----	----	------	
.14	---	205	22.47	281 000	234.2	26.0	10 808	
.50	---	201	-----	281 000	233.8	29.6	9 493	
.98	127	195	22.29	260 000	233.7	35.8	7 263	
1.50	---	188	-----	230 000	233.7	43.1	5 336	
1.98	106	180	22.27	223 000	233.6	51.1	4 364	
2.50	---	170	-----	205 000	233.9	61.6	3 328	
2.98	86	153	22.43	175 500	234.1	79.1	2 219	
3.50	---	100	-----	60 600	-----	----	------	
3.98	79	86	22.34	-------	-----	----	------	
4.98	78	79	22.38	-------	-----	----	------	
5.48	78	79	22.42	-------	-----	----	------	

TABLE I. - Continued. EXPERIMENTAL AND COMPUTED DATA

Location, L, ft	Local coolant temperature, t_k, °F	Local faired value of wall temperature, t_w, °F	Static pressure, P_s, psia	Heat flux based on inside tube area, q_i, Btu/(hr)(ft^2)	Vapor saturation temperature corresponding to pressure, t_{vs}, °F	Temperature drop across condensate film, Δt_f, °F	Local condensing heat-transfer coefficient, h_{cl}, Btu/(hr)(ft^2)(°F)	Conditions
				Run 169				
-1.75	---	---	28.86	-------	248.2	----	------	Test-fluid total flow rate, w_t, 58.5 lb/hr; coolant flow rate, w_k, 1045 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 254° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 111° F; test-fluid total mass velocity, G_t, 124 500 lb/(hr)(ft^2); coolant mass velocity, G_k, 1 228 000 lb/(hr)(ft^2); total condensing length, L_c, 2.6 ft; overall friction-pressure change, ΔP_f, 4.22 psi; mean condensing heat-transfer coefficient, h_{cm}, 6020 Btu/(hr)(ft^2)(°F); vapor state at -1.75 ft, Δt_s, 5.8° F; vapor quality at -0.08 ft, 0.99; heat balance error, -2.0 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 583 ft/sec
-1.50	---	---	26.61	-------	-----	----	------	
-.79	---	---	25.21	-------	-----	----	------	
-.08	---	---	23.90	-------	-----	----	------	
.03	138	---	-----	-------	----	----	------	
.14	---	205	23.60	345 000	236.9	28.0	12 321	
.50	---	196	-----	332 000	236.7	38.0	8 737	
.98	115	188	23.64	303 000	237.0	45.6	6 645	
1.50	---	179	-----	273 000	237.3	55.2	4 946	
1.98	95	167	23.94	235 000	237.7	68.0	3 456	
2.50	---	147	-----	183 000	237.9	88.8	2 061	
2.75	---	131	-----	115 000	-----	----	------	
2.98	82	109	23.95	58 600	-----	----	------	
3.98	81	82	23.95	-------	-----	----	------	
4.98	80	81	23.99	-------	-----	----	------	
5.48	80	81	24.06	-------	-----	----	------	
				Run 170				
-1.75	---	---	28.93	-------	247.3	----	------	Test-fluid total flow rate, w_t, 56.7 lb/hr; coolant flow rate, w_k, 1325 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 254° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 113° F; test-fluid total mass velocity, G_t, 121 000 lb/(hr)(ft^2); coolant mass velocity, G_k, 1 555 000 lb/(hr)(ft^2); total condensing length, L_c, 2.1 ft; overall friction-pressure change, ΔP_f, 3.44 psi; mean condensing heat-transfer coefficient, h_{cm}, 6150 Btu/(hr)(ft^2)(°F); vapor state at -1.75 ft, Δt_s, 6.7° F; vapor quality at -0.08 ft, 0.99; heat balance error, 0.6 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 558 ft/sec
-1.50	---	---	26.88	-------	-----	----	------	
-.79	---	---	25.56	-------	-----	----	------	
-.08	---	---	24.28	-------	-----	----	------	
.03	127	---	-----	-------	-----	----	------	
.14	---	193	24.07	460 000	238.0	39.8	11 558	
.50	---	187	-----	416 000	238.4	46.7	8 908	
.98	105	177	24.48	358 000	238.9	57.9	6 183	
1.50	---	164	-----	274 000	239.5	72.4	3 785	
1.98	89	143	24.92	171 000	240.0	95.1	1 798	
2.25	---	127	-----	133 200	-----	----	------	
2.50	---	107	-----	107 500	-----	----	------	
2.98	83	87	24.79	-------	-----	----	------	
3.98	83	83	24.78	-------	-----	----	------	
4.98	83	83	24.81	-------	-----	----	------	

TABLE I. - Continued. EXPERIMENTAL AND COMPUTED DATA

Location, L, ft	Local coolant temperature, t_k, °F	Local faired value of wall temperature, t_w, °F	Static pressure, P_s, psia	Heat flux based on inside tube area, q_i, Btu/(hr)(ft²)	Vapor saturation temperature corresponding to pressure, t_{vs}, °F	Temperature drop across condensate film, Δt_f, °F	Local condensing heat-transfer coefficient, h_{cl}, Btu/(hr)(ft²)(°F)	Conditions
				Run 171				
-1.75	---	---	30.70	-------	251.6	----	------	Test-fluid total flow rate, w_t, 68.4 lb/hr; coolant flow rate, w_k, 530 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 257° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 162° F; test-fluid total mass velocity, G_t, 145 800 lb/(hr)(ft²); coolant mass velocity, G_k, 622 000 lb/(hr)(ft²); total condensing length, L_c, 6.7 ft; overall friction-pressure change, ΔP_f, 12.88 psi; mean condensing heat-transfer coefficient, h_{cm}, 6000 Btu/(hr)(ft²)(°F); vapor state at -1.75 ft, Δt_s, 5.4° F; vapor quality at -0.08 ft, 0.99; heat balance error, 6.0 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 611 ft/sec
-1.50	---	---	-----	-------	-----	----	------	
-.79	---	---	28.31	-------	-----	----	------	
-.08	---	---	26.82	-------	-----	----	------	
.03	206	---	-----	-------	-----	----	------	
.14	---	230	26.04	90 500	242.4	11.4	7 938	
.98	192	225	24.39	101 000	238.7	12.6	8 016	
1.98	178	219	23.05	113 000	235.6	15.3	7 386	
2.98	159	212	21.25	122 200	231.2	17.8	6 865	
3.98	143	202	19.93	130 800	227.8	24.3	5 383	
4.98	122	190	19.18	151 000	225.7	34.0	4 441	
5.48	---	---	19.11	-------	225.6	----	------	
5.98	100	173	19.27	185 000	226.0	50.9	3 634	
6.48	---	166	19.22	197 500	225.8	57.6	3 429	
6.75	---	151	-----	199 000	-----	----	------	
6.98	73	140	19.10	26 800	-----	----	------	
7.56	71	94	19.35	-------	-----	----	------	
7.95	69	---	19.44	-------	-----	----	------	
8.06	---	---	-----	-------	-----	----	------	
				Run 172				
-1.75	---	---	30.70	-------	251.6	----	------	Test-fluid total flow rate, w_t, 67.4 lb/hr; coolant flow rate, w_k, 880 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 257° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 113° F; test-fluid total mass velocity, G_t, 141 300 lb/(hr)(ft²); coolant mass velocity, G_k, 1 033 000 lb/(hr)(ft²); total condensing length, L_c, 3.3 ft; overall friction-pressure change, ΔP_f, 6.00 psi; mean condensing heat-transfer coefficient, h_{cm}, 5810 Btu/(hr)(ft²)(°F); vapor state at -1.75 ft, Δt_s, 5.4° F; vapor quality at -0.08 ft, 0.99; heat balance error, 0 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 611 ft/sec
-1.50	---	---	-----	-------	-----	----	------	
-.79	---	---	28.12	-------	-----	----	------	
-.08	---	---	26.41	-------	-----	----	------	
.03	157	---	-----	-------	-----	----	------	
.14	---	213	26.19	305 000	242.7	26.3	11 597	
.50	---	209	-----	293 000	242.2	30.1	9 734	
.98	133	203	25.68	276 000	241.6	35.5	7 775	
1.50	---	196	-----	247 000	241.3	42.5	5 812	
1.98	111	188	25.47	237 000	241.2	50.5	4 693	
2.50	---	178	-----	233 000	241.2	60.6	3 845	
2.98	89	164	25.58	233 000	241.4	74.8	3 115	
3.50	---	138	-----	87 900	-----	----	------	
3.98	80	92	25.71	48 600	-----	----	------	
4.98	77	81	25.71	-------	-----	----	------	
5.48	---	---	25.61	-------	-----	----	------	
5.98	76	81	25.63	-------	-----	----	------	
6.98	75	81	25.37	-------	-----	----	------	

TABLE I. - Continued. EXPERIMENTAL AND COMPUTED DATA

Location, L, ft	Local coolant temperature, t_k, °F	Local faired value of wall temperature, t_w, °F	Static pressure, P_s, psia	Heat flux based on inside tube area, q_i, $\frac{Btu}{(hr)(ft^2)}$	Vapor saturation temperature corresponding to pressure, t_{vs}, °F	Temperature drop across condensate film, Δt_f, °F	Local condensing heat-transfer coefficient, h_{cl}, $\frac{Btu}{(hr)(ft^2)(°F)}$	Conditions
				Run 173				
-1.75	---	---	30.70	-------	251.6	-----	------	Test-fluid total flow rate, w_t, 67.5 lb/hr; coolant flow rate, w_k, 1050 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 257° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 108° F; test-fluid total mass velocity, G_t, 143 800 lb/(hr)(ft^2); coolant mass velocity, G_k, 1 232 000 lb/(hr)(ft^2); total condensing length, L_c, 2.9 ft; overall friction-pressure change, ΔP_f, 5.81 psi; mean condensing heat-transfer coefficient, h_{cm}, 6120 Btu/(hr)(ft^2)(°F); vapor state at -1.75 ft, Δt_s, 5.4° F; vapor quality at -0.08 ft, 0.99; heat balance error, 0 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 609 ft/sec
-1.50	---	---	-----	-------	-----	-----	------	
-.79	---	---	28.10	-------	-----	-----	------	
-.08	---	---	26.56	-------	-----	-----	------	
.03	147	---	-----	-------	-----	-----	------	
.14	---	207	26.09	331 000	242.5	31.8	10 410	
.50	---	203	-----	331 000	242.2	35.5	9 324	
.98	124	196	25.89	313 000	242.1	42.6	7 347	
1.50	---	188	-----	289 500	242.1	50.9	5 688	
1.98	103	179	25.95	276 000	242.2	60.1	4 592	
2.50	---	164	-----	247 000	242.3	75.5	3 272	
2.98	85	133	26.01	106 000	-----	-----	------	
3.98	82	86	26.19	-------	-----	-----	------	
4.98	---	82	26.15	-------	-----	-----	------	
5.98	80	82	-----	-------	-----	-----	------	
				Run 174				
-1.75	---	---	30.70	-------	251.6	-----	------	Test-fluid total flow rate, w_t, 68.2 lb/hr; coolant flow rate, w_k, 1330 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 257° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 107° F; test-fluid total mass velocity, G_t, 145 100 lb/(hr)(ft^2); coolant mass velocity, G_k, 1 561 000 lb/(hr)(ft^2); total condensing length, L_c, 2.4 ft; overall friction-pressure change, ΔP_f, 5.05 psi; mean condensing heat-transfer coefficient, h_{cm}, 6470 Btu/(hr)(ft^2)(°F); vapor state at -1.75 ft, Δt_s, 5.4° F; vapor quality at -0.08 ft, 0.99; heat balance error, -0.5 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 619 ft/sec
-1.50	---	---	-----	-------	-----	-----	------	
-.79	---	---	27.91	-------	-----	-----	------	
-.08	---	---	26.23	-------	-----	-----	------	
.03	136	---	-----	-------	-----	-----	------	
.14	---	200	25.86	405 000	242.0	37.4	10 829	
.50	---	194	-----	398 000	241.9	43.4	9 171	
.98	114	186	25.93	365 000	242.2	52.1	7 006	
1.50	---	177	-----	333 000	242.7	62.0	5 371	
1.98	95	163	26.46	295 000	243.3	77.0	3 831	
2.25	---	134	-----	253 000	243.5	106.7	2 371	
2.50	---	124	-----	177 500	-----	-----	------	
2.98	84	102	26.45	-------	-----	-----	------	
3.98	83	85	26.57	-------	-----	-----	------	
4.98	83	83	26.56	-------	-----	-----	------	

TABLE I. - Continued. EXPERIMENTAL AND COMPUTED DATA

Location, L, ft	Local coolant temperature, t_k, ^oF	Local faired value of wall temperature, t_w, ^oF	Static pressure, P_s, psia	Heat flux based on inside tube area, q_i, $\frac{Btu}{(hr)(ft^2)}$	Vapor saturation temperature corresponding to pressure, t_{vs}, ^oF	Temperature drop across condensate film, Δt_f, ^oF	Local condensing heat-transfer coefficient, h_{cl}, $\frac{Btu}{(hr)(ft^2)(^oF)}$	Conditions
				Run 175				
-1.75	---	---	22.97	-------	235.4	----	----	Test-fluid total flow rate, w_t, 48.8 lb/hr; coolant flow rate, w_k, 405 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 242° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 155° F; test-fluid total mass velocity, G_t, 103 900 lb/(hr)(ft²); coolant mass velocity, G_k, 476 000 lb/(hr)(ft²); total condensing length, L_c, 6.7 ft; overall friction-pressure change, ΔP_f, 9.18 psi; mean condensing heat-transfer coefficient, h_{cm}, 4130 Btu/(hr)(ft²)(°F); vapor state at -1.75 ft, Δt_s, 6.6° F; vapor quality at -0.08 ft, 0.99; heat balance error, 2.6 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 591 ft/sec
-1.50	---	---	21.15	-------	-----	----	----	
-.79	---	---	20.02	-------	-----	----	----	
-.08	---	---	18.79	-------	-----	----	----	
.03	190	---	-----	-------	-----	----	----	
.14	---	203	18.16	55 400	223.0	19.4	2856	
.98	176	204	17.13	65 000	220.0	15.3	4248	
1.98	166	201	16.19	73 500	216.9	15.1	4868	
2.98	149	195	15.05	84 500	213.1	17.2	4913	
3.98	135	187	14.11	95 400	210.0	21.9	4356	
4.98	115	178	13.46	103 000	207.6	28.5	3614	
5.48	---	---	13.43	-------	-----	----	----	
5.98	91	167	13.43	154 000	207.5	38.8	3969	
6.48	---	159	13.33	93 000	207.2	47.1	1975	
6.98	70	147	13.16	38 000	-----	----	----	
7.56	67	126	13.23	-------	-----	----	----	
7.95	65	---	-----	-------	-----	----	----	
8.06	---	---	13.24	-------	-----	----	----	
				Run 176				
-1.75	---	---	22.63	-------	234.6	----	----	Test-fluid total flow rate, w_t, 59.3 lb/hr; coolant flow rate, w_k, 805 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 246° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 119° F; test-fluid total mass velocity, G_t, 126 200 lb/(hr)(ft²); coolant mass velocity, G_k, 946 000 lb/(hr)(ft²); total condensing length, L_c, 5.3 ft; overall friction-pressure change, ΔP_f, 15.45 psi; mean condensing heat-transfer coefficient, h_{cm}, 6070 Btu/(hr)(ft²)(°F); vapor state at -1.75 ft, Δt_s, 11.4° F; vapor quality at -0.08 ft, 0.98; heat balance error, 5.2 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 898 ft/sec
-1.50	---	---	19.63	-------	-----	----	----	
-.79	---	---	17.47	-------	-----	----	----	
-.08	---	---	15.03	-------	-----	----	----	
.03	148	---	-----	-------	-----	----	----	
.14	---	189	13.48	165 000	207.6	16.7	9880	
.98	132	179	11.94	160 500	201.7	20.9	7680	
1.98	119	167	9.61	154 000	191.5	22.8	6754	
2.98	103	153	7.13	144 000	177.8	23.2	6207	
3.98	92	140	5.86	129 500	169.2	27.7	4675	
4.98	80	123	6.05	111 000	170.5	46.2	2403	
5.48	---	112	6.23	87 500	-----	----	----	
5.98	72	95	6.39	53 800	-----	----	----	
6.48	---	73	6.40	-------	-----	----	----	
6.98	69	73	6.19	-------	-----	----	----	
7.56	69	73	6.40	-------	-----	----	----	
7.95	69	---	-----	-------	-----	----	----	
8.06	---	---	6.45	-------	-----	----	----	

TABLE I. - Continued. EXPERIMENTAL AND COMPUTED DATA

Location, L, ft	Local coolant temperature, t_k, ^{o}F	Local faired value of wall temperature, t_w, ^{o}F	Static pressure, P_s, psia	Heat flux based on inside tube area, q_i, Btu/(hr)(ft^2)	Vapor saturation temperature corresponding to pressure, t_{vs}, ^{o}F	Temperature drop across condensate film, Δt_f, ^{o}F	Local condensing heat-transfer coefficient, h_{cl}, Btu/(hr)(ft^2)(^{o}F)	Conditions
Run 177								
-1.75	---	---	31.49	-------	253.2	----	------	Test-fluid total flow rate, w_t, 80.0 lb/hr; coolant flow rate, w_k, 1065 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 262^{o} F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 134^{o} F; test-fluid total mass velocity, G_t, 170 300 lb/(hr)(ft^2); coolant mass velocity, G_k, 1 250 000 lb/(hr)(ft^2); total condensing length, L_c, 6.1 ft; overall friction-pressure change, ΔP_f, 23.13 psi; mean condensing heat-transfer coefficient, h_{cm}, 6690 Btu/(hr)(ft^2)(^{o}F); vapor state at -1.75 ft, Δt_s, 8.8^{o} F; vapor quality at -0.08 ft, 0.98; heat balance error, 3.8 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 861 ft/sec
-1.50	---	---	27.42	-------	-----	----	------	
-.79	---	---	23.65	-------	-----	----	------	
-.08	---	---	21.73	-------	-----	----	------	
.03	169	---	-----	-------	-----	----	------	
.14	---	206	20.07	216 000	228.1	19.7	10 964	
.98	154	196	17.67	212 000	221.5	23.1	9 177	
1.98	141	183	14.26	191 500	210.4	25.2	7 599	
2.98	126	169	10.47	155 000	195.5	24.8	6 250	
3.98	118	153	7.37	136 000	179.1	24.6	5 528	
4.98	108	144	5.97	128 000	169.8	24.4	5 246	
5.48	---	---	6.61	-------	-----	----	------	
5.98	107	132	6.62	128 000	174.5	41.1	3 114	
6.48	---	114	7.31	116 500	-----	----	------	
6.75	---	96	-----	75 600	-----	----	------	
6.98	91	96	7.28	-------	-----	----	------	
7.56	91	96	7.53	-------	-----	----	------	
7.95	91	---	-----	-------	-----	----	------	
8.06	---	---	7.52	-------	-----	----	------	
Run 178								
-1.75	---	---	35.80	-------	260.6	----	------	Test-fluid total flow rate, w_t, 91.4 lb/hr; coolant flow rate, w_k, 1065 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 265^{o} F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 141^{o} F; test-fluid total mass velocity, G_t, 194 500 lb/(hr)(ft^2); coolant mass velocity, G_k, 1 250 000 lb/(hr)(ft^2); total condensing length, L_c, 6.2 ft; overall friction-pressure change, ΔP_f, 24.10 psi; mean condensing heat-transfer coefficient, h_{cm}, 6940 Btu/(hr)(ft^2)(^{o}F); vapor state at -1.75 ft, Δt_s, 4.4^{o} F; vapor quality at -0.08 ft, 0.98; heat balance error, 0 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 848 ft/sec
-1.50	---	---	31.33	-------	-----	----	------	
-.79	---	---	28.49	-------	-----	----	------	
-.08	---	---	25.56	-------	-----	----	------	
.03	178	---	-----	-------	-----	----	------	
.14	---	215	24.01	206 000	237.8	20.5	10 049	
.98	163	205	21.07	202 000	230.7	23.4	8 632	
1.98	149	192	17.26	197 000	220.4	26.2	7 519	
2.98	133	180	13.14	191 000	206.4	24.3	7 860	
3.98	123	167	10.54	185 000	195.8	26.7	6 929	
4.98	111	153	10.23	177 000	194.5	39.5	4 481	
5.48	---	146	10.78	160 800	196.8	49.0	3 282	
5.98	97	138	11.09	108 500	188.2	59.0	1 839	
6.48	---	121	11.35	57 000	-----	----	------	
6.98	93	99	11.14	-------	-----	----	------	
7.56	73	99	11.39	-------	-----	----	------	
7.95	71	---	-----	-------	-----	----	------	
8.06	---	---	11.43	-------	-----	----	------	

TABLE I. - Continued. EXPERIMENTAL AND COMPUTED DATA

Location, L, ft	Local coolant temperature, t_k, °F	Local faired value of wall temperature, t_w, °F	Static pressure, P_s, psia	Heat flux based on inside tube area, q_i, Btu/(hr)(ft^2)	Vapor saturation temperature corresponding to pressure, t_{vs}, °F	Temperature drop across condensate film, Δt_f, °F	Local condensing heat-transfer coefficient, h_{cl}, Btu/(hr)(ft^2)(°F)	Conditions
Run 179								
-1.75	---	---	40.17	-------	267.5	----	------	Test-fluid total flow rate, w_t, 98.9 lb/hr; coolant flow rate, w_k, 1065 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 269° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 145° F; test-fluid total mass velocity, G_t, 210 000 lb/(hr)(ft^2); coolant mass velocity, G_k, 1 250 000 lb/(hr)(ft^2); total condensing length, L_c, 6.1 ft; overall friction-pressure change, ΔP_f, 23.19 psi; mean condensing heat-transfer coefficient, h_{cm}, 6770 Btu/(hr)(ft^2)(°F); vapor state at -1.75 ft, Δt_s, 1.5° F; vapor quality at -0.08 ft, 0.98; heat balance error, 0 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 803 ft/sec
-1.50	---	---	35.43	-------	-----	----	------	
-.79	---	---	32.46	-------	-----	----	------	
-.08	---	---	29.43	-------	-----	----	------	
.03	187	---	-----	-------	-----	----	------	
.14	---	224	27.88	230 000	246.2	19.6	11 735	
.98	172	214	24.88	222 000	239.8	23.3	9 528	
1.98	157	203	21.04	212 000	230.7	25.3	8 379	
2.98	140	190	17.29	201 000	220.4	28.1	7 153	
3.98	127	178	15.68	184 000	215.2	35.1	5 242	
4.98	113	163	15.93	175 000	216.1	51.1	3 425	
5.48	---	154	16.35	165 800	217.5	61.6	2 692	
5.98	103	135	16.69	140 700	218.5	81.9	1 718	
6.48	---	105	16.83	109 600	-----	----	------	
6.98	94	102	16.62	-------	-----	----	------	
7.56	93	102	16.94	-------	-----	----	------	
7.95	93	---	-----	-------	-----	----	------	
8.06	---	---	16.90	-------	-----	----	------	
Run 181								
-1.75	---	---	39.21	-------	266.0	----	------	Test-fluid total flow rate, w_t, 106 lb/hr; coolant flow rate, w_k, 1578 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 268° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 120° F; test-fluid total mass velocity, G_t, 226 000 lb/(hr)(ft^2); coolant mass velocity, G_k, 1 853 000 lb/(hr)(ft^2); total condensing length, L_c, 5.2 ft; overall friction-pressure change, ΔP_f, 28.67 psi; mean condensing heat-transfer coefficient, h_{cm}, 6620 Btu/(hr)(ft^2)(°F); vapor state at -1.75 ft, Δt_s, 2.0° F; vapor quality at -0.08 ft, 0.98; heat balance error, -7.0 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 976 ft/sec
-1.50	---	---	33.57	-------	-----	----	------	
-.79	---	---	29.90	-------	-----	----	------	
-.08	---	---	25.75	-------	-----	----	------	
.03	151	---	-----	-------	-----	----	------	
.14	---	202	23.81	370 800	237.5	31.3	11 847	
.98	134	188	18.59	342 000	224.1	32.3	10 588	
1.98	120	170	13.43	296 600	207.5	34.2	8 673	
2.98	105	151	9.48	234 800	190.8	37.2	6 312	
3.98	98	131	9.75	165 000	192.2	59.3	2 782	
4.98	89	114	10.30	109 000	194.8	79.6	1 369	
5.48	---	98	10.16	83 800	-----	----	------	
5.98	87	88	10.19	-------	-----	----	------	
6.48	---	---	10.18	-------	-----	----	------	
6.98	84	88	10.16	-------	-----	----	------	
7.56	84	---	10.22	-------	-----	----	------	
7.95	---	---	-----	-------	-----	----	------	
8.06	---	---	10.20	-------	-----	----	------	

TABLE I. - Continued. EXPERIMENTAL AND COMPUTED DATA

Location, L, ft	Local coolant temperature, t_k, °F	Local faired value of wall temperature, t_w, °F	Static pressure, P_s, psia	Heat flux based on inside tube area, q_i, Btu/(hr)(ft²)	Vapor saturation temperature corresponding to pressure, t_{vs}, °F	Temperature drop across condensate film, Δt_f, °F	Local condensing heat-transfer coefficient, h_{cl}, Btu/(hr)(ft²)(°F)	Conditions
Run 185								
-1.75	---	---	48.23	-------	278.7	----	------	Test-fluid total flow rate, w_t, 131.0 lb/hr; coolant flow rate, w_k, 2080 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 281° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 121° F; test-fluid total mass velocity, G_t, 279 000 lb/(hr)(ft²); coolant mass velocity, G_k, 2 440 000 lb/(hr)(ft²); total condensing length, L_c, 5.7 ft; overall friction-pressure change, ΔP_f, 38.87 psi; mean condensing heat-transfer coefficient, h_{cm}, 7910 Btu/(hr)(ft²)(°F); vapor state at -1.75 ft, Δt_s, 2.3° F; vapor quality at -0.08 ft, 0.98; heat balance error, -6.6 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 985 ft/sec
-1.50	---	---	42.21	-------	-----	----	------	
-.79	---	---	36.69	-------	-----	----	------	
-.08	---	---	31.99	-------	-----	----	------	
.03	150	---	-----	-------	-----	----	------	
.14	---	205	27.33	502 900	245.2	34.5	14 577	
.98	133	190	21.76	450 200	232.5	37.4	12 037	
1.98	119	172	15.00	353 600	213.0	37.0	9 557	
2.98	106	152	8.91	265 200	188.0	33.0	8 036	
3.98	100	128	4.82	177 900	160.7	30.7	5 795	
4.98	93	118	6.92	115 900	176.5	57.2	2 026	
5.48	---	110	10.09	94 700	193.2	82.1	1 268	
5.98	90	91	9.84	-------	-----	----	------	
6.48	---	---	9.83	-------	-----	----	------	
6.98	87	91	9.87	-------	-----	----	------	
7.56	87	91	9.91	-------	-----	----	------	
7.95	87	---	-----	-------	-----	----	------	
8.06	---	---	9.85	-------	-----	----	------	
Run 187								
-1.75	---	---	40.24	-------	267.6	----	------	Test-fluid total flow rate, w_t, 105.8 lb/hr; coolant flow rate, w_k, 1400 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 269° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 121° F; test-fluid total mass velocity, G_t, 225 000 lb/(hr)(ft²); coolant mass velocity, G_k, 1 645 000 lb/(hr)(ft²); total condensing length, L_c, 4.4 ft; overall friction-pressure change, ΔP_f, 19.93 psi; mean condensing heat-transfer coefficient, h_{cm}, 7870 Btu/(hr)(ft²)(°F); vapor state at -1.75 ft, Δt_s, 1.4° F; vapor quality at -0.08 ft, 0.98; heat balance error, -4.0 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 910 ft/sec
-1.50	---	---	34.87	-------	-----	----	------	
-.79	---	---	31.41	-------	-----	----	------	
-.08	---	---	27.65	-------	-----	----	------	
.03	161	---	-----	-------	-----	----	------	
.14	---	209	25.57	363 000	241.3	28.2	12 872	
.98	142	199	22.24	346 000	233.6	30.7	11 270	
1.98	126	186	19.46	331 000	226.5	36.8	8 995	
2.98	106	174	18.96	290 000	225.2	47.9	6 054	
3.98	93	144	19.87	153 000	227.6	81.9	1 868	
4.98	88	91	20.20	-------	-----	----	------	
5.48	---	91	20.23	-------	-----	----	------	
5.98	86	---	20.26	-------	-----	----	------	
6.48	---	---	20.22	-------	-----	----	------	
6.98	84	---	20.23	-------	-----	----	------	

TABLE I. - Continued. EXPERIMENTAL AND COMPUTED DATA

Location, L, ft	Local coolant temperature, t_k, °F	Local faired value of wall temperature, t_w, °F	Static pressure, P_s, psia	Heat flux based on inside tube area, q_i, Btu/(hr)(ft^2)	Vapor saturation temperature corresponding to pressure, t_{vs}, °F	Temperature drop across condensate film, Δt_f, °F	Local condensing heat-transfer coefficient, h_{cl}, Btu/(hr)(ft^2)(°F)	Conditions
Run 188								
-1.75	---	---	48.45	-------	279.0	----	------	Test-fluid total flow rate, w_t, 116.9 lb/hr; coolant flow rate, w_k, 1400 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 279° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 127° F; test-fluid total mass velocity, G_t, 248 500 lb/(hr)(ft^2); coolant mass velocity, G_k, 1 645 000 lb/(hr)(ft^2); total condensing length, L_c, 4.0 ft; overall friction-pressure change, ΔP_f, 17.69 psi; mean condensing heat-transfer coefficient, h_{cm}, 8500 Btu/(hr)(ft^2)(°F); vapor state at -1.75 ft, saturated; vapor quality at -0.08 ft, 0.98; heat balance error, -1.0 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 790 ft/sec
-1.50	---	---	42.71	-------	-----	----	------	
-.79	---	---	39.30	-------	-----	----	------	
-.08	---	---	35.68	-------	-----	----	------	
.03	173	---	-----	-------	-----	----	------	
.14	---	225	34.16	415 000	257.8	28.1	14 769	
.98	152	214	31.16	399 000	252.6	34.1	11 701	
1.98	133	202	29.09	372 000	248.6	42.4	8 774	
2.98	111	186	28.94	328 000	248.3	58.6	5 597	
3.50	---	171	-----	264 000	248.8	74.8	3 529	
3.98	97	149	29.70	196 000	249.7	98.5	1 990	
4.50	---	116	-----	119 000	-----	----	------	
4.98	91	96	30.00	-------	-----	----	------	
5.98	87	96	29.92	-------	-----	----	------	
6.98	86	96	29.95	-------	-----	----	------	
Run 191								
-1.75	---	---	40.08	-------	267.3	----	------	Test-fluid total flow rate, w_t, 109.0 lb/hr; coolant flow rate, w_k, 2180 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 270° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 122° F; test-fluid total mass velocity, G_t, 232 000 lb/(hr)(ft^2); coolant mass velocity, G_k, 2 560 000 lb/(hr)(ft^2); total condensing length, L_c, 5.2 ft; overall friction-pressure change, ΔP_f, 29.03 psi; mean condensing heat-transfer coefficient, h_{cm}, 11 850 Btu/(hr)(ft^2)(°F); vapor state at -1.75 ft, Δt_s, 2.7° F; vapor quality at -0.08 ft, 0.98; heat balance error, -5.4 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 1018 ft/sec
-1.50	---	---	34.27	-------	-----	----	------	
-.79	---	---	30.37	-------	-----	----	------	
-.08	---	---	25.90	-------	-----	----	------	
.03	146	---	-----	-------	-----	----	------	
.14	---	196	21.33	421 800	231.5	30.7	13 739	
.98	131	183	12.70	379 000	204.6	17.3	21 907	
1.98	120	164	8.93	324 900	188.0	20.3	16 005	
2.98	109	146	7.09	235 000	177.5	28.9	8 131	
3.98	102	135	9.70	160 500	191.9	55.1	2 913	
4.50	---	120	-----	126 200	195.6	74.2	1 700	
4.98	98	99	11.02	95 190	198.0	98.0	971	
5.48	---	99	11.06	-------	-----	----	------	
5.98	96	---	10.42	-------	-----	----	------	
6.98	95	---	11.27	-------	-----	----	------	

TABLE I. - Continued. EXPERIMENTAL AND COMPUTED DATA

Location, L, ft	Local coolant temperature, t_k, ^{o}F	Local faired value of wall temperature, t_w, ^{o}F	Static pressure, P_s, psia	Heat flux based on inside tube area, q_i, $\frac{Btu}{(hr)(ft^2)}$	Vapor saturation temperature corresponding to pressure, t_{vs}, ^{o}F	Temperature drop across condensate film, Δt_f, ^{o}F	Local condensing heat-transfer coefficient, h_{cl}, $\frac{Btu}{(hr)(ft^2)(^{o}F)}$	Conditions
Run 196								
-1.75	---	---	26.60	-------	243.6	----	------	Test-fluid total flow rate, w_t, 66.0 lb/hr; coolant flow rate, w_k, 1844 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 247^{o} F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 101^{o} F; test-fluid total mass velocity, G_t, 140 500 lb/(hr)(ft^2); coolant mass velocity G_k, 2 165 000 lb/(hr)(ft^2); total condensing length, L_c, 2.6 ft; overall friction-pressure change, ΔP_f, 5.55 psi; mean condensing heat-transfer coefficient, h_{cm}, 5230 Btu/(hr)(ft^2)(^{o}F); vapor state at -1.75 ft, Δt_s, 3.4^{o} F; vapor quality at -0.08 ft, 0.98; heat balance error, -9.5 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 783 ft/sec
-1.50	---	---	23.43	-------	-----	----	------	
-.79	---	---	21.35	-------	-----	----	------	
-.08	---	---	19.22	-------	-----	----	------	
.03	119	---	-----	-------	-----	----	------	
.14	---	179	18.68	568 800	224.3	38.9	14 622	
.50	---	174	-----	466 000	224.9	45.7	10 197	
.98	101	165	19.31	313 300	226.1	57.6	5 439	
1.50	---	152	-----	276 500	227.2	72.1	3 835	
1.98	89	134	20.03	186 500	228.0	91.9	2 029	
2.25	---	122	-----	150 100	228.3	104.6	1 435	
2.98	84	87	20.36	107 900	-----	----	------	
3.98	83	84	20.41	-------	-----	----	------	
4.98	83	83	20.18	-------	-----	----	------	
Run 197								
-1.75	---	---	31.58	-------	253.4	----	------	Test-fluid total flow rate, w_t, 72.3 lb/hr; coolant flow rate, w_k, 1844 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 258^{o} F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 100^{o} F; test-fluid total mass velocity, G_t, 154 000 lb/(hr)(ft^2); coolant mass velocity, G_k, 2 165 000 lb/(hr)(ft^2); total condensing length, L_c, 2.2 ft; overall friction-pressure change, ΔP_f, 5.32 psi; mean condensing heat-transfer coefficient, h_{cm}, 7020 Btu/(hr)(ft^2)(^{o}F); vapor state at -1.75 ft, Δt_s, 4.6^{o} F; vapor quality at -0.08 ft, 0.99; heat balance error, -6.1 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 718 ft/sec
-1.50	---	---	28.47	-------	-----	----	------	
-.79	---	---	26.58	-------	-----	----	------	
-.08	---	---	24.00	-------	-----	----	------	
.03	123	---	-----	-------	-----	----	------	
.14	---	188	23.95	624 200	237.7	41.6	15 005	
.50	---	182	-----	494 000	238.2	50.6	9 763	
.98	103	172	24.57	416 900	239.1	62.4	6 681	
1.50	---	158	-----	313 300	239.9	78.4	3 996	
1.98	90	139	25.24	231 400	240.7	99.1	2 335	
2.50	---	106	-----	111 800	-----	----	------	
2.98	85	86	25.38	-------	-----	----	------	
3.98	84	85	25.43	-------	-----	----	------	

TABLE I. - Continued. EXPERIMENTAL AND COMPUTED DATA

Location, L, ft	Local coolant temperature, t_k, °F	Local faired value of wall temperature, t_w, °F	Static pressure, P_s, psia	Heat flux based on inside tube area, q_i, $\frac{Btu}{(hr)(ft^2)}$	Vapor saturation temperature corresponding to pressure, t_{vs}, °F	Temperature drop across condensate film, Δt_f, °F	Local condensing heat-transfer coefficient, h_{cl}, $\frac{Btu}{(hr)(ft^2)(^oF)}$	Conditions
				Run 198				
-1.75	---	---	31.37	-------	253.0	----	------	Test-fluid total flow rate, w_t, 78.0 lb/hr; coolant flow rate, w_k, 1844 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 259° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 102° F; test-fluid total mass velocity, G_t, 166 000 lb/(hr)(ft²); coolant mass velocity, G_k, 2 165 000 lb/(hr)(ft²); total condensing length, L_c, 2.4 ft; overall friction-pressure change, ΔP_f, 7.87 psi; mean condensing heat-transfer coefficient, h_{cm}, 7570 Btu/(hr)(ft²)(°F); vapor state at -1.75 ft, Δt_s, 6.0° F; vapor quality at -0.08 ft, 0.98; heat balance error, -2.8 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 813 ft/sec
-1.50	---	---	27.52	-------	-----	----	------	
-.79	---	---	25.21	-------	-----	----	------	
-.08	---	---	22.43	-------	-----	----	------	
.03	127	---	-----	-------	-----	----	------	
.14	---	189	21.31	597 700	231.4	35.7	16 742	
.50	---	183	-----	506 000	231.1	42.4	11 934	
.98	108	175	21.43	402 500	231.7	52.2	7 711	
1.50	---	163	-----	334 500	233.9	67.1	4 985	
1.98	94	148	22.26	274 700	233.6	82.5	3 330	
2.25	---	139	-----	224 800	234.3	92.8	2 422	
2.98	86	96	22.65	108 900	-----	----	------	
3.98	85	87	22.69	-------	-----	----	------	
				Run 199				
-1.75	---	---	31.37	-------	253.0	----	------	Test-fluid total flow rate, w_t, 80.5 lb/hr; coolant flow rate, w_k, 1844 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 260° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 103° F; test-fluid total mass velocity, G_t, 171 300 lb/(hr)(ft²); coolant mass velocity, G_k, 2 165 000 lb/(hr)(ft²); total condensing length, L_c, 2.6 ft; overall friction-pressure change, ΔP_f, 9.14 psi; mean condensing heat-transfer coefficient, h_{cm}, 8050 Btu/(hr)(ft²)(°F); vapor state at -1.75 ft, Δt_s, 7.0° F; vapor quality at -0.08 ft, 0.98; heat balance error, -4.6 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 863 ft/sec
-1.50	---	---	27.34	-------	-----	----	------	
-.79	---	---	24.69	-------	-----	----	------	
-.08	---	---	21.81	-------	-----	----	------	
.03	129	---	-----	-------	-----	----	------	
.14	---	190	20.25	602 500	228.6	31.8	18 946	
.50	---	184	-----	491 000	228.1	38.6	12 728	
.98	110	176	20.19	392 800	228.4	48.0	8 183	
1.50	---	165	-----	303 000	229.6	61.2	4 951	
1.98	97	150	21.00	265 100	230.5	77.5	3 419	
2.50	---	132	-----	232 600	231.6	97.0	2 398	
2.98	87	109	21.54	138 800	-----	----	------	
3.98	86	89	21.60	-------	-----	----	------	
4.98	85	88	21.51	-------	-----	----	------	

TABLE I. - Continued. EXPERIMENTAL AND COMPUTED DATA

Location, L, ft	Local coolant temperature, t_k, ^oF	Local faired value of wall temperature, t_w, ^oF	Static pressure, P_s, psia	Heat flux based on inside tube area, q_i, $\frac{Btu}{(hr)(ft^2)}$	Vapor saturation temperature corresponding to pressure, t_{vs}, ^oF	Temperature drop across condensate film, Δt_f, ^oF	Local condensing heat-transfer coefficient, h_{cl}, $\frac{Btu}{(hr)(ft^2)(^oF)}$	Conditions
				Run 200				
-1.75	---	---	31.29	-------	252.9	----	------	Test-fluid total flow rate, w_t, 84.0 lb/hr; coolant flow rate, w_k, 1844 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 261^o F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 107^o F; test-fluid total mass velocity, G_t, 179 000 lb/(hr)(ft^2); coolant mass velocity, G_k, 2 165 000 lb/(hr)(ft^2); total condensing length, L_c, 2.9 ft; overall friction-pressure change, ΔP_f, 12.75 psi; mean condensing heat-transfer coefficient, h_{cm}, 7180 Btu/(hr)(ft^2)(^{o}F); vapor state at -1.75 ft, Δt_s, 8.1^o F; vapor quality at -0.08 ft, 0.98; heat balance error, -6.0 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 967 ft/sec
-1.50	---	---	27.82	-------	-----	----	------	
-.79	---	---	23.68	-------	-----	----	------	
-.08	---	---	20.11	-------	-----	----	------	
.03	131	---	-----	-------	-----	----	------	
.14	---	184	19.36	472 400	226.2	36.9	12 802	
.50	---	181	-----	409 000	221.7	36.1	11 330	
.98	115	175	16.52	363 900	218.0	38.9	9 355	
1.50	---	167	-----	338 000	218.2	47.4	7 131	
1.98	101	156	16.95	327 800	219.3	59.6	5 500	
2.50	---	143	-----	306 100	221.1	74.6	4 103	
2.98	88	124	17.81	157 400	-----	----	------	
3.98	87	87	17.89	-------	-----	----	------	
4.98	86	87	17.79	-------	-----	----	------	
				Run 205				
-1.75	---	---	40.16	-------	267.5	----	------	Test-fluid total flow rate, w_t, 105.3 lb/hr; coolant flow rate, w_k, 1932 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 268^o F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 113^o F; test-fluid total mass velocity, G_t, 224 500 lb/(hr)(ft^2); coolant mass velocity, G_k, 2 270 000 lb/(hr)(ft^2); total condensing length, L_c, 2.9 ft; overall friction-pressure change, ΔP_f, 14.50 psi; mean condensing heat-transfer coefficient, h_{cm}, 9120 Btu/(hr)(ft^2)(^{o}F); vapor state at -1.75 ft, Δt_s, 0.5^o F; vapor quality at -0.08 ft, 0.98; heat balance error, -3.7 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 907 ft/sec
-1.50	---	---	34.89	-------	-----	----	------	
-.79	---	---	31.42	-------	-----	----	------	
-.08	---	---	27.69	-------	-----	----	------	
.03	144	---	-----	-------	-----	----	------	
.14	---	201	25.94	541 400	243.2	36.1	14 997	
.50	---	198	-----	510 000	239.6	35.9	14 206	
.98	125	191	24.34	480 700	238.6	42.2	11 391	
1.50	---	183	-----	438 000	238.6	50.7	8 639	
1.98	109	173	24.54	397 200	239.1	61.6	6 448	
2.50	---	159	-----	354 200	239.9	76.9	4 606	
2.98	94	141	25.55	212 500	-----	----	------	
3.50	---	103	-----	94 200	-----	----	------	
3.98	91	96	25.71	-------	-----	----	------	
4.98	90	92	25.62	-------	-----	----	------	
5.98	88	91	25.35	-------	-----	----	------	

TABLE I. - Continued. EXPERIMENTAL AND COMPUTED DATA

Location, L, ft	Local coolant temperature, t_k, ^oF	Local faired value of wall temperature, t_w, ^oF	Static pressure, P_s, psia	Heat flux based on inside tube area, q_i, $\frac{Btu}{(hr)(ft^2)}$	Vapor saturation temperature corresponding to pressure, t_{vs}, ^oF	Temperature drop across condensate film, Δt_f, ^oF	Local condensing heat-transfer coefficient, h_{cl}, $\frac{Btu}{(hr)(ft^2)(^oF)}$	Conditions
				Run 206				
-1.75	---	---	32.86	-------	255.6	-----	------	Test-fluid total flow rate, w_t, 63.4 lb/hr; coolant flow rate, w_k, 1250 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 257° F; condensate temperature at conderser exit measured at 8.50 ft, t_c, 106° F; test-fluid total mass velocity, G_t, 135 000 lb/(hr)(ft²); coolant mass velocity, G_k, 1 469 000 lb/(hr)(ft²); total condensing length, L_c, 2.2 ft; overall friction-pressure change, ΔP_f, 3.98 psi; mean condensing heat-transfer coefficient, h_{cm}, 6510 Btu/(hr)(ft²)(°F); vapor state at -1.75 ft, Δt_s, 1.4° F; vapor quality at -0.08 ft, 0.99; heat balance error, -3.1 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 549 ft/sec
-1.50	---	---	30.51	-------	-----	-----	------	
-.79	---	---	29.07	-------	-----	-----	------	
-.08	---	---	27.73	-------	-----	-----	------	
.03	132	---	-----	-------	-----	-----	------	
.14	---	201	27.59	490 500	245.6	39.1	12 545	
.50	---	196	-----	420 000	245.7	45.0	9 333	
.98	108	186	27.76	353 200	246.0	56.0	6 307	
1.50	---	171	-----	295 900	246.3	72.0	4 110	
1.98	90	150	28.10	235 400	246.6	94.0	2 504	
2.25	---	137	-----	178 200	-----	-----	------	
2.98	82	90	28.12	-------	-----	-----	------	
3.98	81	82	28.19	-------	-----	-----	------	
4.98	81	81	28.20	-------	-----	-----	------	
				Run 207				
-1.75	---	---	32.52	-------	255.0	-----	------	Test-fluid total flow rate, w_t, 76.2 lb/hr; coolant flow rate, w_k, 1730 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 259° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 104° F; test-fluid total mass velocity, G_t, 162 100 lb/(hr)(ft²); coolant mass velocity, G_k, 2 030 000 lb/(hr)(ft²); total condensing length, L_c, 2.4 ft; overall friction-pressure change, ΔP_f, 6.64 psi; mean condensing heat-transfer coefficient, h_{cm}, 7380 Btu/(hr)(ft²)(°F); vapor state at -1.75 ft, Δt_s, 4.0° F; vapor quality at -0.08 ft, 0.98; heat balance error, -2.4 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 731 ft/sec
-1.50	---	---	29.09	-------	-----	-----	------	
-.79	---	---	26.82	-------	-----	-----	------	
-.08	---	---	24.61	-------	-----	-----	------	
.03	130	---	-----	-------	-----	-----	------	
.14	---	192	23.90	549 200	237.6	39.4	13 939	
.50	---	188	-----	481 000	237.6	44.2	10 882	
.98	110	180	24.03	422 600	237.9	53.1	7 958	
1.50	---	167	-----	335 000	238.7	67.9	4 934	
1.98	95	150	24.74	291 500	239.5	86.2	3 382	
2.25	---	127	-----	235 000	239.9	110.3	2 131	
2.50	---	---	-----	188 300	-----	-----	------	
2.98	87	96	25.11	82 490	-----	-----	------	
3.98	86	87	25.15	-------	-----	-----	------	
4.98	85	87	25.08	-------	-----	-----	------	

TABLE I. - Continued. EXPERIMENTAL AND COMPUTED DATA

Location, L, ft	Local coolant temperature, t_k, °F	Local faired value of wall temperature, t_w, °F	Static pressure, P_s, psia	Heat flux based on inside tube area, q_i, $\frac{Btu}{(hr)(ft^2)}$	Vapor saturation temperature corresponding to pressure, t_{vs}, °F	Temperature drop across condensate film, Δt_f, °F	Local condensing heat-transfer coefficient, h_{cl}, $\frac{Btu}{(hr)(ft^2)(°F)}$	Conditions
Run 208								
-1.75	---	---	32.43	-------	254.9	----	------	Test-fluid total flow rate, w_t, 80.5 lb/hr; coolant flow rate, w_k, 1730 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 260° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 105° F; test-fluid total mass velocity, G_t, 171 300 lb/(hr)(ft²); coolant mass velocity, G_k, 2 030 000 lb/(hr)(ft²); total condensing length, L_c, 2.7 ft; overall friction-pressure change, ΔP_f, 8.65 psi; mean condensing heat-transfer coefficient, h_{cm}, 7280 Btu/(hr)(ft²)(°F); vapor state at -1.75 ft, Δt_s, 5.1° F; vapor quality at -0.08 ft, 0.98; heat balance error, -3.3 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 813 ft/sec
-1.50	---	---	28.52	-------	-----	----	------	
-.79	---	---	25.99	-------	-----	----	------	
-.08	---	---	23.33	-------	-----	----	------	
.03	133	---	-----	-------	-----	----	------	
.14	---	193	22.19	492 700	233.5	35.0	14 077	
.50	---	189	-----	449 000	233.0	38.9	11 542	
.98	114	181	21.97	406 800	233.0	46.4	8 767	
1.50	---	170	-----	344 000	233.5	59.6	5 772	
1.98	99	156	22.54	296 100	234.4	75.1	3 943	
2.50	---	137	-----	237 300	235.5	95.8	2 477	
2.98	88	114	23.10	137 900	-----	----	------	
3.98	87	89	23.21	-------	-----	----	------	
4.98	87	87	23.17	-------	-----	----	------	
Run 209								
-1.75	---	---	32.28	-------	254.6	----	------	Test-fluid total flow rate, w_t, 86.1 lb/hr; coolant flow rate, w_k, 1730 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 261° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 109° F; test-fluid total mass velocity, G_t, 183 500 lb/(hr)(ft²); coolant mass velocity, G_k, 2 030 000 lb/(hr)(ft²); total condensing length, L_c, 3.1 ft; overall friction-pressure change, ΔP_f, 13.04 psi; mean condensing heat-transfer coefficient, h_{cm}, 8140 Btu/(hr)(ft²)(°F); vapor state at -1.75 ft, Δt_s, 6.4° F; vapor quality at -0.08 ft, 0.98; heat balance error, -3.1 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 948 ft/sec
-1.50	---	---	27.77	-------	-----	----	------	
-.79	---	---	24.65	-------	-----	----	------	
-.08	---	---	21.13	-------	-----	----	------	
.03	137	---	-----	-------	-----	----	------	
.14	---	190	18.95	395 500	225.1	30.6	12 925	
.98	120	181	17.57	372 900	221.2	36.0	10 358	
1.98	105	164	17.60	333 200	221.4	53.7	6 205	
2.25	---	158	-----	322 000	221.9	60.6	5 313	
2.50	---	152	-----	308 500	222.7	77.2	3 996	
2.75	---	144	-----	290 400	223.4	76.1	3 816	
2.98	91	135	18.52	204 500	-----	----	------	
3.50	---	125	-----	77 290	-----	----	------	
3.98	89	92	18.69	-------	-----	----	------	
4.98	87	89	18.60	-------	-----	----	------	
5.98	86	88	18.63	-------	-----	----	------	

TABLE I. - Continued. EXPERIMENTAL AND COMPUTED DATA

Location, L, ft	Local coolant temperature, t_k, ^oF	Local faired value of wall temperature, t_w, ^oF	Static pressure, P_s, psia	Heat flux based on inside tube area, q_i, Btu/(hr)(ft^2)	Vapor saturation temperature corresponding to pressure, t_{vs}, ^oF	Temperature drop across condensate film, Δt_f, ^oF	Local condensing heat-transfer coefficient, h_{cl}, Btu/(hr)(ft^2)(^oF)	Conditions
				Run 212				
-1.75	---	---	24.02	-------	237.9	----	----	Test-fluid total flow rate, w_t, 45.4 lb/hr; coolant flow rate, w_k, 655 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 242^o F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 120^o F; test-fluid total mass velocity, G_t, 96 600 lb/(hr)(ft^2); coolant mass velocity, G_k, 769 000 lb/(hr)(ft^2); total condensing length, L_c, 2.9 ft; overall friction-pressure change, ΔP_f, 3.01 psi; mean condensing heat-transfer coefficient, h_{cm}, 4990 Btu/(hr)(ft^2)(^{o}F); vapor state at -1.75 ft, Δt_s, 4.1^o F; vapor quality at -0.08 ft, 0.99; heat balance error, -2.0 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 511 ft/sec
-1.50	---	---	22.63	-------	-----	----	----	
-.79	---	---	21.72	-------	-----	----	----	
-.08	---	---	20.81	-------	-----	----	----	
.03	146	---	-----	-------	-----	----	----	
.14	---	203	20.69	223 000	229.8	24.3	9177	
.50	---	200	-----	217 000	229.6	27.1	8007	
.99	121	194	20.70	209.000	229.8	33.4	6257	
1.50	---	185	-----	195 000	228.8	41.6	4688	
1.98	101	173	20.80	177 500	230.0	55.0	3227	
2.50	---	152	-----	163 000	230.0	76.2	2139	
2.98	80	132	20.76	84 100	-----	----	----	
3.50	---	84	-----	-------	-----	----	----	
3.98	77	79	20.62	-------	-----	----	----	
4.98	76	76	20.55	-------	-----	----	----	
5.98	75	76	20.56	-------	-----	----	----	
7.95	74	---	-----	-------	-----	----	----	
				Run 213				
-1.75	---	---	23.91	-------	237.7	----	----	Test-fluid total flow rate, w_t, 51.5 lb/hr; coolant flow rate, w_k, 655 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 243^o F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 126^o F; test-fluid total mass velocity, G_t, 109 800 lb/(hr)(ft^2); coolant mass velocity, G_k, 769 000 lb/(hr)(ft^2); total condensing length, L_c, 3.6 ft; overall friction-pressure change, ΔP_f, 4.89 psi; mean condensing heat-transfer coefficient, h_{cm}, 5480 Btu/(hr)(ft^2)(^{o}F); vapor state at -1.75 ft, Δt_s, 5.3^o F; vapor quality at -0.08 ft, 0.99; heat balance error, 1.0 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 612 ft/sec
-1.50	---	---	21.94	-------	-----	----	----	
-.79	---	---	20.69	-------	-----	----	----	
-.08	---	---	19.44	-------	-----	----	----	
.03	156	---	-----	-------	-----	----	----	
.14	---	203	19.06	194 500	225.4	20.2	9629	
.98	134	194	18.76	193 500	224.6	28.4	6813	
1.98	115	183	18.48	185 000	223.8	38.7	4780	
2.50	---	176	-----	176 000	223.7	45.7	3851	
2.98	92	168	18.48	168 500	223.8	53.9	3126	
3.50	---	154	-----	120 000	224.1	68.8	1744	
3.98	79	121	18.54	35 500	-----	----	----	
4.98	76	78	18.40	-------	-----	----	----	
5.98	74	77	18.50	-------	-----	----	----	
7.95	73	---	-----	-------	-----	----	----	

TABLE I. - Continued. EXPERIMENTAL AND COMPUTED DATA

Location, L, ft	Local coolant temperature, t_k, ^oF	Local faired value of wall temperature, t_w, ^oF	Static pressure, P_s, psia	Heat flux based on inside tube area, q_i, $\frac{Btu}{(hr)(ft^2)}$	Vapor saturation temperature corresponding to pressure, t_{vs}, ^oF	Temperature drop across condensate film, Δt_f, ^oF	Local condensing heat-transfer coefficient, h_{cl}, $\frac{Btu}{(hr)(ft^2)(^oF)}$	Conditions
				Run 215				
-1.75	---	---	23.86	-------	237.5	----	------	Test-fluid total flow rate, w_t, 56.4 lb/hr; coolant flow rate, w_k, 830 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 242^o F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 115^o F; test-fluid total mass velocity, G_t, 120 000 lb/(hr)(ft^2); coolant mass velocity, G_k, 975 000 lb/(hr)(ft^2); total condensing length, L_c, 3.4 ft; overall friction-pressure change, ΔP_f, 6.15 psi; mean condensing heat-transfer coefficient, h_{cm}, 6060 Btu/(hr)(ft^2)(^{o}F); vapor state at -1.75 ft, Δt_s, 4.5^o F; vapor quality at -0.08 ft, 0.99; heat balance error, 0 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 729 ft/sec
-1.50	---	---	21.42	-------	-----	----	------	
-.79	---	---	19.80	-------	-----	----	------	
-.08	---	---	18.11	-------	-----	----	------	
.03	145	---	-----	-------	-----	----	------	
.14	---	195	17.47	260 000	220.9	23.0	11 304	
.98	124	188	17.22	222 000	220.2	29.7	7 475	
1.98	106	174	17.00	207 000	219.6	43.3	4 781	
2.50	---	163	-----	207 000	219.6	54.3	3 812	
2.98	86	150	17.08	168 000	219.8	67.9	2 474	
3.25	---	141	-----	96 400	220.0	77.9	1 237	
3.50	---	131	-----	87 700	-----	----	------	
3.98	77	103	17.15	-------	-----	----	------	
4.98	76	77	17.10	-------	-----	----	------	
5.98	74	77	17.22	-------	-----	----	------	
7.95	73	---	-----	-------	-----	----	------	
				Run 216				
-1.75	---	---	23.94	-------	238.7	----	------	Test-fluid total flow rate, w_t, 58.2 lb/hr; coolant flow rate, w_k, 830 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 243^o F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 111^o F; test-fluid total mass velocity, G_t, 124 000 lb/(hr)(ft^2); coolant mass velocity, G_k, 975 000 lb/(hr)(ft^2); total condensing length, L_c, 3.7 ft; overall friction-pressure change, ΔP_f, 6.89 psi; mean condensing heat-transfer coefficient, h_{cm}, 5650 Btu/(hr)(ft^2)(^{o}F); vapor state at -1.75 ft, Δt_s, 4.3^o F; vapor quality at -0.08 ft, 0.99; heat balance error, 0 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 755 ft/sec
-1.50	---	---	21.47	-------	-----	----	------	
-.79	---	---	19.76	-------	-----	----	------	
-.08	---	---	17.98	-------	-----	----	------	
.03	147	---	-----	-------	-----	----	------	
.14	---	196	17.36	217 000	220.9	22.5	9 644	
.98	127	188	16.92	217 000	219.3	28.9	7 509	
1.98	109	174	16.60	207 000	218.3	42.0	4 928	
2.50	---	170	-----	196 000	218.1	45.9	4 270	
2.98	88	157	16.55	191 000	218.1	58.9	3 243	
3.25	---	152	-----	135 500	218.3	64.8	2 091	
3.50	---	143	-----	103 900	218.5	74.3	1 398	
3.98	78	89	16.78	-------	-----	----	------	
4.98	76	77	16.79	-------	-----	----	------	
5.98	74	77	16.91	-------	-----	----	------	
7.95	73	77	-----	-------	-----	----	------	

TABLE I. - Continued. EXPERIMENTAL AND COMPUTED DATA

Location, L, ft	Local coolant temperature, t_k, ^oF	Local faired value of wall temperature, t_w, ^oF	Static pressure, P_s, psia	Heat flux based on inside tube area, q_i, $\frac{Btu}{(hr)(ft^2)}$	Vapor saturation temperature corresponding to pressure, t_{vs}, ^oF	Temperature drop across condensate film, Δt_f, ^oF	Local condensing heat-transfer coefficient, h_{cl}, $\frac{Btu}{(hr)(ft^2)(^oF)}$	Conditions
				Run 217				
-1.75	---	---	23.84	-------	237.5	-----	------	Test-fluid total flow rate, w_t, 60.0 lb/hr; coolant flow rate, w_k, 830 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 244^o F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 104^o F; test-fluid total mass velocity, G_t, 127 800 lb/(hr)(ft^2); coolant mass velocity, G_k, 975 000 lb/(hr)(ft^2); total condensing length, L_c, 4.3 ft; overall friction-pressure change, ΔP_f, 8.04 psi; mean condensing heat-transfer coefficient, h_{cm}, 5340 Btu/(hr)(ft^2)(^{o}F); vapor state at -1.75 ft, Δt_s, 6.5^o F; vapor quality at -0.08 ft, 0.98; heat balance error, 0 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 785 ft/sec
-1.50	---	---	21.12	-------	-----	-----	------	
-.79	---	---	19.21	-------	-----	-----	------	
-.08	---	---	17.18	-------	-----	-----	------	
.03	149	---	-----	-------	-----	-----	------	
.14	---	195	16.29	222 000	217.3	19.8	11 212	
.98	130	187	15.60	197 000	215.0	25.8	7 636	
1.98	113	175	14.90	194 000	212.7	35.5	5 465	
2.98	93	159	14.76	190 000	212.2	51.1	3 718	
3.50	---	147	-----	124 500	212.8	64.4	1 933	
3.75	---	139	-----	103 000	213.2	73.0	1 410	
3.98	81	130	15.20	84 500	213.7	82.8	1 021	
4.25	---	118	-----	66 000	-----	-----	------	
4.98	76	80	15.18	-------	-----	-----	------	
5.98	74	79	15.10	-------	-----	-----	------	
7.95	73	---	-----	-------	-----	-----	------	
				Run 219				
-1.75	---	---	24.76	-------	239.6	-----	------	Test-fluid total flow rate, w_t, 30.5 lb/hr; coolant flow rate, w_k, 1642 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 239^o F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 98^o F; test-fluid total mass velocity, G_t, 64 900 lb/(hr)(ft^2); coolant mass velocity, G_k, 1 930 000 lb/(hr)(ft^2); total condensing length, L_c, 1.1 ft; overall friction-pressure change, ΔP_f, 0.52 psi; mean condensing heat-transfer coefficient, h_{cm}, 4400 Btu/(hr)(ft^2)(^{o}F); vapor state at -1.75 ft, saturated; vapor quality at -0.08 ft, 1.00; heat balance error, -7.1 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 313 ft/sec
-1.50	---	---	24.16	-------	-----	-----	------	
-.79	---	---	23.79	-------	-----	-----	------	
-.08	---	---	23.41	-------	-----	-----	------	
.03	94	---	-----	-------	-----	-----	------	
.14	---	166	23.60	479 000	236.9	65.5	7 313	
.25	---	163	-----	449 000	237.0	68.9	6 517	
.50	---	154	-----	348 000	237.3	79.4	4 383	
.75	---	141	-----	266 000	237.6	93.6	2 842	
.98	79	116	23.99	196 000	237.8	119.6	1 639	
1.25	---	106	-----	151 000	-----	-----	------	
1.98	75	77	23.87	-------	-----	-----	------	
2.98	---	75	23.81	-------	-----	-----	------	
3.98	---	75	23.88	-------	-----	-----	------	
7.95	75	---	-----	-------	-----	-----	------	

TABLE I. - Continued. EXPERIMENTAL AND COMPUTED DATA

Location, L, ft	Local coolant temperature, t_k, °F	Local faired value of wall temperature, t_w, °F	Static pressure, P_s, psia	Heat flux based on inside tube area, q_i, $\frac{Btu}{(hr)(ft^2)}$	Vapor saturation temperature corresponding to pressure, t_{vs}, °F	Temperature drop across condensate film, Δt_f, °F	Local condensing heat-transfer coefficient, h_{cl}, $\frac{Btu}{(hr)(ft^2)(°F)}$	Conditions
				Run 220				
-1.75	---	---	24.45	-------	238.7	-----	------	Test-fluid total flow rate, w_t, 40.9 lb/hr; coolant flow rate, w_k, 1642 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 247° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 109° F; test-fluid total mass velocity, G_t, 87 200 lb/(hr)(ft²); coolant mass velocity, G_k, 1 930 000 lb/(hr)(ft²); total condensing length, L_c, 1.5 ft; overall friction-pressure change, ΔP_f, 1.45 psi; mean condensing heat-transfer coefficient, h_{cm}, 5170 Btu/(hr)(ft²)(°F); vapor state at -1.75 ft, Δt_s, 8.1° F; vapor quality at -0.08 ft, 1.00; heat balance error, -7.7 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 446 ft/sec
-1.50	---	---	23.31	-------	-----	-----	------	
-.79	---	---	22.57	-------	-----	-----	------	
-.08	---	---	21.87	-------	-----	-----	------	
.03	103	---	-----	-------	-----	-----	------	
.14	---	172	22.04	640 000	233.2	54.0	11 852	
.25	---	169	-----	560 000	233.7	58.4	9 589	
.50	---	160	-----	393 000	234.2	69.8	5 630	
.75	---	151	-----	288 000	234.6	80.4	3 582	
.98	85	140	22.71	225 000	234.8	92.3	2 438	
1.25	---	128	-----	167 500	235.0	105.1	1 594	
1.50	---	115	-----	126 000	-----	-----	------	
1.75	---	100	-----	101 400	-----	-----	------	
1.98	79	85	22.66	-------	-----	-----	------	
2.98	78	77	22.62	-------	-----	-----	------	
3.98	---	77	22.69	-------	-----	-----	------	
7.95	78	---	-----	-------	-----	-----	------	
				Run 221				
-1.75	---	---	24.30	-------	238.5	-----	------	Test-fluid total flow rate, w_t, 45.0 lb/hr; coolant flow rate, w_k, 1642 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 251° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 110° F; test-fluid total mass velocity, G_t, 95 900 lb/(hr)(ft²); coolant mass velocity, G_k, 1 930 000 lb/(hr)(ft²); total condensing length, L_c, 1.6 ft; overall friction-pressure change, ΔP_f, 2.01 psi; mean condensing heat-transfer coefficient, h_{cm}, 5560 Btu/(hr)(ft²)(°F); vapor state at -1.75 ft, Δt_s, 12.5° F; vapor quality at -0.08 ft, 1.00; heat balance error, -5.7 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 507 ft/sec
-1.50	---	---	22.88	-------	-----	-----	------	
-.79	---	---	22.09	-------	-----	-----	------	
-.08	---	---	21.08	-------	-----	-----	------	
.03	107	---	-----	-------	-----	-----	------	
.14	---	176	21.14	560 000	230.9	48.6	11 523	
.50	---	166	-----	416 000	232.1	61.4	6 775	
.98	89	148	21.85	322 000	232.7	81.1	3 970	
1.25	---	137	-----	214 500	232.8	93.4	2 297	
1.50	---	126	-----	173 000	233.0	105.0	1 648	
1.75	---	112	-----	134 000	-----	-----	------	
1.98	81	99	21.92	103 800	-----	-----	------	
2.98	79	79	21.87	-------	-----	-----	------	
3.98	---	79	21.90	-------	-----	-----	------	
7.95	79	---	-----	-------	-----	-----	------	

TABLE I. - Continued. EXPERIMENTAL AND COMPUTED DATA

Location, L, ft	Local coolant temperature, t_k, °F	Local faired value of wall temperature, t_w, °F	Static pressure, P_s, psia	Heat flux based on inside tube area, q_i, $\frac{Btu}{(hr)(ft^2)}$	Vapor saturation temperature corresponding to pressure, t_{vs}, °F	Temperature drop across condensate film, Δt_f, °F	Local condensing heat-transfer coefficient, h_{cl}, $\frac{Btu}{(hr)(ft^2)(°F)}$	Conditions
					Run 222			
-1.75	---	---	23.97	-------	237.7	-----	------	Test-fluid total flow rate, w_t, 53.9 lb/hr; coolant flow rate, w_k, 1642 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 254° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 110° F; test-fluid total mass velocity, G_t, 114 800 lb/(hr)(ft²); coolant mass velocity, G_k, 1 930 000 lb/(hr)(ft²); total condensing length, L_c, 2.1 ft; overall friction-pressure change, ΔP_f, 3.42 psi; mean condensing heat-transfer coefficient, h_{cm}, 5800 Btu/(hr)(ft²)(°F); vapor state at -1.75 ft, Δt_s, 16.3° F; vapor quality at -0.08 ft, 0.99; heat balance error, -3.0 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 652 ft/sec
-1.50	---	---	21.70	-------	-----	-----	------	
-.79	---	---	20.22	-------	-----	-----	------	
-.08	---	---	18.73	-------	-----	-----	------	
.03	115	---	-----	-------	-----	-----	------	
.14	---	178	18.44	515 000	223.7	39.9	12 907	
.50	---	171	-----	427 000	224.9	49.1	8 696	
.98	96	160	19.30	320 000	226.0	62.4	5 128	
1.50	---	145	-----	241 000	226.6	78.9	3 054	
1.75	---	135	-----	181 000	227.2	90.2	2 007	
1.98	85	123	19.81	131 000	227.5	103.0	1 272	
2.25	---	107	-----	94 000	-----	-----	------	
2.98	82	82	19.65	-------	-----	-----	------	
3.98	81	81	19.70	-------	-----	-----	------	
7.95	81	---	-----	-------	-----	-----	------	
					Run 223			
-1.75	---	---	23.79	-------	237.3	-----	------	Test-fluid total flow rate, w_t, 61.4 lb/hr; coolant flow rate, w_k, 1642 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 256° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 108° F; test-fluid total mass velocity, G_t, 130 800 lb/(hr)(ft²); coolant mass velocity, G_k, 1 930 000 lb/(hr)(ft²); total condensing length, L_c, 2.3 ft; overall friction-pressure change, ΔP_f, 6.14 psi; mean condensing heat-transfer coefficient, h_{cm}, 7380 Btu/(hr)(ft²)(°F); vapor state at -1.75 ft, Δt_s, 18.7° F; vapor quality at -0.08 ft, 0.99; heat balance error, -2.8 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 872 ft/sec
-1.50	---	---	20.75	-------	-----	-----	------	
-.79	---	---	18.57	-------	-----	-----	------	
-.08	---	---	16.18	-------	-----	-----	------	
.03	121	---	-----	-------	-----	-----	------	
.14	---	177	15.36	479 000	214.2	31.8	15 063	
.50	---	172	-----	416 000	214.8	38.1	10 919	
.98	103	164	15.92	350 000	216.1	48.2	7 261	
1.50	---	153	-----	292 000	217.4	61.1	4 779	
1.75	---	146	-----	259 500	218.1	69.2	3 750	
1.98	90	138	16.73	228 000	218.7	78.1	2 919	
2.25	---	129	-----	197 500	219.0	87.8	2 249	
2.50	---	117	-----	163 000	-----	-----	------	
2.98	83	88	16.85	-------	-----	-----	------	
3.98	83	83	16.86	-------	-----	-----	------	
7.95	82	---	-----	-------	-----	-----	------	

TABLE I. - Continued. EXPERIMENTAL AND COMPUTED DATA

Location, L, ft	Local coolant temperature, t_k, °F	Local faired value of wall temperature, t_w, °F	Static pressure, P_s, psia	Heat flux based on inside tube area, q_i, $\frac{Btu}{(hr)(ft^2)}$	Vapor saturation temperature corresponding to pressure, t_{vs}, °F	Temperature drop across condensate film, Δt_f, °F	Local condensing heat-transfer coefficient, h_{cl}, $\frac{Btu}{(hr)(ft^2)(°F)}$	Conditions
				Run 224				
-1.75	---	---	31.75	-------	253.7	-----	------	Test-fluid total flow rate, w_t, 74.6 lb/hr; coolant flow rate, w_k, 1642 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 262° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 104° F; test-fluid total mass velocity, G_t, 159 000 lb/(hr)(ft²); coolant mass velocity, G_k, 1 930 000 lb/(hr)(ft²); total condensing length, L_c, 2.4 ft; overall friction-pressure change, ΔP_f, 6.53 psi; mean condensing heat-transfer coefficient, h_{cm}, 7000 Btu/(hr)(ft²)(°F); vapor state at -1.75 ft, Δt_s, 8.3° F; vapor quality at -0.08 ft, 0.99; heat balance error, -4.4 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 736 ft/sec
-1.50	---	---	28.36	-------	-----	-----	------	
-.79	---	---	26.28	-------	-----	-----	------	
-.08	---	---	24.21	-------	-----	-----	------	
.03	131	---	-----	-------	-----	-----	------	
.14	---	192	23.55	533 000	236.7	38.7	13 773	
.50	---	188	-----	470 000	236.6	43.3	10 854	
.98	111	179	23.73	410 000	237.2	53.6	7 649	
1.50	---	167	-----	334 000	238.0	67.2	4 970	
1.98	95	152	24.44	269 000	238.8	83.8	3 210	
2.25	---	142	-----	232 000	239.2	94.6	2 452	
2.50	---	130	-----	177 000	-----	-----	------	
2.98	87	95	24.75	-------	-----	-----	------	
3.98	86	87	24.74	-------	-----	-----	------	
4.98	85	86	24.70	-------	-----	-----	------	
7.95	84	---	-----	-------	-----	-----	------	
				Run 225				
-1.75	---	---	33.83	-------	257.3	-----	------	Test-fluid total flow rate, w_t, 55.3 lb/hr; coolant flow rate, w_k, 1725 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 258° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 112° F; test-fluid total mass velocity, G_t, 117 900 lb/(hr)(ft²); coolant mass velocity, G_k, 2 025 000 lb/(hr)(ft²); total condensing length, L_c, 1.6 ft; overall friction-pressure change, ΔP_f, 2.28 psi; mean condensing heat-transfer coefficient, h_{cm}, 6330 Btu/(hr)(ft²)(°F); vapor state at -1.75 ft, Δt_s, 0.7° F; vapor quality at -0.08 ft, 0.99; heat balance error, -4.8 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 444 ft/sec
-1.50	---	---	32.06	-------	-----	-----	------	
-.79	---	---	31.09	-------	-----	-----	------	
-.08	---	---	30.09	-------	-----	-----	------	
.03	117	---	-----	-------	-----	-----	------	
.14	---	189	30.13	706 000	250.5	53.5	13 196	
.50	---	180	-----	450 000	251.2	66.1	6 808	
.98	97	164	30.78	320 000	251.7	84.1	3 805	
1.25	---	154	-----	275 000	251.8	94.7	2 904	
1.50	---	142	-----	232 000	252.0	107.4	2 160	
1.75	---	127	-----	186 000	-----	-----	------	
1.98	87	110	30.89	132 000	-----	-----	------	
2.98	85	85	30.75	-------	-----	-----	------	
3.98	85	85	30.88	-------	-----	-----	------	
4.98	85	---	30.99	-------	-----	-----	------	
7.95	84	---	-----	-------	-----	-----	------	

TABLE I. - Continued. EXPERIMENTAL AND COMPUTED DATA

Location, L, ft	Local coolant temperature, t_k, °F	Local faired value of wall temperature, t_w, °F	Static pressure, P_s, psia	Heat flux based on inside tube area, q_i, $\frac{Btu}{(hr)(ft^2)}$	Vapor saturation temperature corresponding to pressure, t_{vs}, °F	Temperature drop across condensate film, Δt_f, °F	Local condensing heat-transfer coefficient, h_{cl}, $\frac{Btu}{(hr)(ft^2)(^oF)}$	Conditions
				Run 226				
-1.75	---	---	23.49	-------	236.6	-----	------	Test-fluid total flow rate, w_t, 45.0 lb/hr; coolant flow rate, w_k, 1805 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 239° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 116° F; test-fluid total mass velocity, G_t, 95 900 lb/(hr)(ft^2); coolant mass velocity, G_k, 2 120 000 lb/(hr)(ft^2); total condensing length, L_c, 1.7 ft; overall friction-pressure change, ΔP_f, 2.01 psi; mean condensing heat-transfer coefficient, h_{cm}, 5000 Btu/(hr)(ft^2)(°F); vapor state at -1.75 ft, Δt_s, 2.6° F; vapor quality at -0.08 ft, 0.99; heat balance error, -6.6 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 524 ft/sec
-1.50	---	---	22.00	-------	-----	-----	------	
-.79	---	---	21.04	-------	-----	-----	------	
-.08	---	---	20.07	-------	-----	-----	------	
.03	109	---	-----	-------	-----	-----	------	
.14	---	172	20.19	529 000	228.4	50.4	10 496	
.50	---	163	-----	419 000	229.7	62.0	6 758	
.98	94	147	20.93	281 000	230.3	80.1	3 503	
1.25	---	137	-----	211 000	230.6	91.2	2 314	
1.50	---	126	-----	151 000	230.7	103.0	1 466	
1.98	86	100	21.01	80 300	-----	-----	------	
2.98	84	84	21.02	-------	-----	-----	------	
7.95	84	---	-----	-------	-----	-----	------	
				Run 227				
-1.75	---	---	26.71	-------	243.8	-----	------	Test-fluid total flow rate, w_t, 61.2 lb/hr; coolant flow rate, w_k, 1805 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 249° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 110° F; test-fluid total mass velocity, G_t, 130 200 lb/(hr)(ft^2); coolant mass velocity, G_k, 2 120 000 lb/(hr)(ft^2); total condensing length, L_c, 2.3 ft; overall friction-pressure change, ΔP_f, 4.37 psi; mean condensing heat-transfer coefficient, h_{cm}, 5780 Btu/(hr)(ft^2)(°F); vapor state at -1.75 ft, Δt_s, 5.1° F; vapor quality at -0.08 ft, 0.99; heat balance error, -6.7 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 694 ft/sec
-1.50	---	---	24.15	-------	-----	-----	------	
-.79	---	---	22.38	-------	-----	-----	------	
-.08	---	---	20.73	-------	-----	-----	------	
.03	121	---	-----	-------	-----	-----	------	
.14	---	181	20.43	495 000	229.1	42.5	11 647	
.50	---	177	-----	430 000	230.2	48.3	8 903	
.98	104	167	21.25	354 000	231.2	60.2	5 880	
1.25	---	161	-----	314 000	231.6	67.1	4 680	
1.50	---	153	-----	278 000	232.0	75.9	3 663	
1.75	---	143	-----	252 000	232.2	86.4	2 917	
1.98	92	131	21.75	182 000	232.5	99.4	1 831	
2.25	---	117	-----	126 500	-----	-----	------	
2.98	88	89	21.76	-------	-----	-----	------	
7.95	87	---	-----	-------	-----	-----	------	

TABLE I. - Continued. EXPERIMENTAL AND COMPUTED DATA

Location, L, ft	Local coolant temperature, t_k, ^oF	Local faired value of wall temperature, t_w, ^oF	Static pressure, P_s, psia	Heat flux based on inside tube area, q_i, $\frac{Btu}{(hr)(ft^2)}$	Vapor saturation temperature corresponding to pressure, t_{vs}, ^oF	Temperature drop across condensate film, Δt_f, ^oF	Local condensing heat-transfer coefficient, h_{cl}, $\frac{Btu}{(hr)(ft^2)(^oF)}$	Conditions
				Run 228				
-1.75	---	---	32.02	-------	254.2	-----	------	Test-fluid total flow rate, w_t, 67.9 lb/hr; coolant flow rate, w_k, 1805 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 254^o F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 108^o F; test-fluid total mass velocity, G_t, 144 500 lb/(hr)(ft^2); coolant mass velocity, G_k, 2 120 000 lb/(hr)(ft^2); total condensing length, L_c, 2.2 ft; overall friction-pressure change, ΔP_f, 4.47 psi; mean condensing heat-transfer coefficient, h_{cm}, 5930 Btu/(hr)(ft^2)(^{o}F); vapor state at -1.75 ft, saturated; vapor quality at -0.08 ft, 0.99; heat balance error, -6.7 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 624 ft/sec
-1.50	---	---	29.48	-------	-----	-----	------	
-.79	---	---	27.89	-------	-----	-----	------	
-.08	---	---	26.07	-------	-----	-----	------	
.03	126	---	-----	-------	-----	-----	------	
.14	---	190	25.92	547 000	242.1	45.9	11 917	
.50	---	185	-----	476 000	242.7	52.3	9 101	
.98	107	174	26.53	380 000	243.5	65.2	5 828	
1.25	---	167	-----	342 000	243.8	73.0	4 685	
1.50	---	158	-----	300 000	244.0	82.6	3 632	
1.75	---	148	-----	269 000	244.3	93.3	2 883	
1.98	94	136	27.04	216 000	244.5	106.1	2 036	
2.25	---	121	-----	173 000	-----	-----	------	
2.98	89	92	27.35	-------	-----	-----	------	
3.98	89	89	27.16	-------	-----	-----	------	
7.95	88	---	-----	-------	-----	-----	------	
				Run 229				
-1.75	---	---	36.46	-------	261.7	-----	------	Test-fluid total flow rate, w_t, 72.5 lb/hr; coolant flow rate, w_k, 1805 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 261^o F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 107^o F; test-fluid total mass velocity, G_t, 154 500 lb/(hr)(ft^2); coolant mass velocity, G_k, 2 120 000 lb/(hr)(ft^2); total condensing length, L_c, 2.2 ft; overall friction-pressure change, ΔP_f, 4.47 psi; mean condensing heat-transfer coefficient, h_{cm}, 6520 Btu/(hr)(ft^2)(^{o}F); vapor state at -1.75 ft, saturated; vapor quality at -0.08 ft, 0.99; heat balance error, -6.0 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 573 ft/sec
-1.50	---	---	33.86	-------	-----	-----	------	
-.79	---	---	32.34	-------	-----	-----	------	
-.08	---	---	30.60	-------	-----	-----	------	
.03	130	---	-----	-------	-----	-----	------	
.14	---	198	30.40	649 000	251.2	45.9	14 139	
.50	---	191	-----	516 000	251.3	54.5	9 468	
.98	109	179	30.86	413 000	251.8	68.2	6 056	
1.25	---	171	-----	344 000	252.4	77.5	4 439	
1.50	---	162	-----	307 000	252.6	87.1	3 525	
1.75	---	151	-----	271 000	252.8	98.8	2 743	
1.98	96	139	31.45	240 000	253.2	111.5	2 150	
2.25	---	123	-----	188 500	-----	-----	------	
2.98	90	94	31.59	-------	-----	-----	------	
3.98	90	91	31.67	-------	-----	-----	------	
7.95	89	---	-----	-------	-----	-----	------	

TABLE I. - Continued. EXPERIMENTAL AND COMPUTED DATA

Location, L, ft	Local coolant temperature, t_k, °F	Local faired value of wall temperature, t_w, °F	Static pressure, P_s, psia	Heat flux based on inside tube area, q_i, Btu/(hr)(ft²)	Vapor saturation temperature corresponding to pressure, t_{vs}, °F	Temperature drop across condensate film, Δt_f, °F	Local condensing heat-transfer coefficient, h_{cl}, Btu/(hr)(ft²)(°F)	Conditions
Run 233								
-1.75	---	---	40.59	-------	268.1	----	------	Test-fluid total flow rate, w_t, 104.8 lb/hr; coolant flow rate, w_k, 1844 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 268° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 120° F; test-fluid total mass velocity, G_t, 223 000 lb/(hr)(ft²); coolant mass velocity, G_k, 2 165 000 lb/(hr)(ft²); total condensing length, L_c, 3.7 ft; overall friction-pressure change, ΔP_f, 15.67 psi; mean condensing heat-transfer coefficient, h_{cm}, 7550 Btu/(hr)(ft²)(°F); vapor state at -1.75 ft, saturated; vapor quality at -0.08 ft, 0.98; heat balance error, -4.8 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 914 ft/sec
-1.50	---	---	34.59	-------	-----	----	------	
-.79	---	---	31.15	-------	-----	----	------	
-.08	---	---	27.27	-------	-----	----	------	
.03	150	---	-----	-------	-----	----	------	
.14	---	203	25.33	425 000	240.9	33.1	12 840	
.98	133	193	23.10	406 000	235.7	38.1	10 656	
1.98	118	179	22.54	383 000	234.4	51.1	7 495	
2.50	---	169	-----	366 000	235.1	62.0	5 903	
2.98	102	154	23.40	220 000	236.4	79.9	2 753	
3.25	---	145	-----	161 000	237.0	90.2	1 785	
3.98	97	101	23.96	-------	-----	----	------	
4.98	95	96	24.26	-------	-----	----	------	
7.95	93	---	-----	-------	-----	----	------	
Run 234								
-1.75	---	---	39.99	-------	267.2	----	------	Test-fluid total flow rate, w_t, 106.2 lb/hr; coolant flow rate, w_k, 1808 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 267° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 124° F; test-fluid total mass velocity, G_t, 226 500 lb/(hr)(ft²); coolant mass velocity, G_k, 2 124 000 lb/(hr)(ft²); total condensing length, L_c, 4.1 ft; overall friction-pressure change, ΔP_f, 18.91 psi; mean condensing heat-transfer coefficient, h_{cm}, 7520 Btu/(hr)(ft²)(°F); vapor state at -1.75 ft, Δt_s, 0.2° F; vapor quality at -0.08 ft, 0.98; heat balance error, -4.3 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 943 ft/sec
-1.50	---	---	34.45	-------	-----	----	------	
-.79	---	---	30.82	-------	-----	----	------	
-.08	---	---	26.80	-------	-----	----	------	
.03	154	---	-----	-------	-----	----	------	
.14	---	203	24.39	386 000	238.7	31.4	12 293	
.98	138	193	21.16	376 000	231.0	33.8	11 124	
1.98	124	181	19.36	346 000	226.3	41.4	8 357	
2.98	108	165	19.79	270 000	227.4	59.4	4 545	
3.50	---	152	-----	192 000	228.5	74.3	2 584	
3.75	---	141	-----	165 000	229.0	86.2	1 914	
3.98	100	127	20.75	137 500	-----	----	------	
4.98	98	99	20.77	-------	-----	----	------	
5.98	97	99	20.77	-------	-----	----	------	
7.95	95	---	-----	-------	-----	----	------	

TABLE I. - Continued. EXPERIMENTAL AND COMPUTED DATA.

Location, L, ft	Local coolant temperature, t_k, °F	Local faired value of wall temperature, t_w, °F	Static pressure, P_s, psia	Heat flux based on inside tube area, q_i, Btu/(hr)(ft²)	Vapor saturation temperature corresponding to pressure, t_{vs}, °F	Temperature drop across condensate film, Δt_f, °F	Local condensing heat-transfer coefficient, h_{cl}, Btu/(hr)(ft²)(°F)	Conditions
				Run 235				
-1.75	---	---	48.20	-------	278.6	----	------	Test-fluid total flow rate, w_t, 121.8 lb/hr; coolant flow rate, w_k, 1808 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 276° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 130° F; test-fluid total mass velocity, G_t, 269 000 lb/(hr)(ft²); coolant mass velocity, G_k, 2 124 000 lb/(hr)(ft²); total condensing length, L_c, 3.6 ft; overall friction-pressure change, ΔP_f, 18.00 psi; mean condensing heat-transfer coefficient, h_{cm}, 9250 Btu/(hr)(ft²)(°F); vapor state at -1.75 ft, x = 0.99; vapor quality at -0.08 ft, 0.97; heat balance error, -4.3 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 835 ft/sec
-1.50	---	---	42.16	-------	-----	----	------	
-.79	---	---	38.54	-------	-----	----	------	
-.08	---	---	34.75	-------	-----	----	------	
.03	166	---	-----	-------	-----	----	------	
.14	---	220	32.91	459 000	255.7	30.5	15 049	
.98	148	210	30.25	437 000	250.9	36.0	12 139	
1.98	131	197	28.84	404 000	248.1	46.6	8 669	
2.98	113	178	29.34	356 000	249.0	67.0	5 313	
3.25	---	170	-----	290 000	249.5	76.2	3 806	
3.50	---	160	-----	191 000	249.9	87.7	2 178	
3.75	---	145	-----	130 000	-----	----	------	
3.98	104	124	30.12	-------	-----	----	------	
4.98	102	103	30.04	-------	-----	----	------	
7.95	99	---	-----	-------	-----	----	------	
				Run 236				
-1.75	---	---	48.23	-------	278.7	----	------	Test-fluid total flow rate, w_t, 128.0 lb/hr; coolant flow rate, w_k, 1808 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 276° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 134° F; test-fluid total mass velocity, G_t, 273 000 lb/(hr)(ft²); coolant mass velocity, G_k, 2 124 000 lb/(hr)(ft²); total condensing length, L_c, 4.7 ft; overall friction-pressure change, ΔP_f, 25.76 psi; mean condensing heat-transfer coefficient, h_{cm}, 8350 Btu/(hr)(ft²)(°F); vapor state at -1.75 ft, x = 0.99; vapor quality at -0.08 ft, 0.97; heat balance error, -5.0 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 919 ft/sec
-1.50	---	---	41.71	-------	-----	----	------	
-.79	---	---	37.63	-------	-----	----	------	
-.08	---	---	33.22	-------	-----	----	------	
.03	168	---	-----	-------	-----	----	------	
.14	---	219	30.62	400 000	251.6	28.1	14 235	
.98	151	207	25.92	382 000	242.2	30.9	12 362	
1.98	138	192	21.72	365 000	232.5	36.4	10 027	
2.98	120	178	20.73	300 000	229.9	48.5	6 186	
3.75	---	162	-----	251 000	232.6	67.8	3 702	
3.98	109	153	22.01	228 000	232.2	77.6	2 938	
4.25	---	143	-----	205 000	234.0	88.7	2 311	
4.50	---	130	-----	181 000	-----	----	------	
4.98	103	106	22.75	-------	-----	----	------	
5.98	100	103	22.88	-------	-----	----	------	
7.95	99	---	-----	-------	-----	----	------	

TABLE I. - Continued. EXPERIMENTAL AND COMPUTED DATA

Location, L, ft	Local coolant temperature, t_k, °F	Local faired value of wall temperature, t_w, °F	Static pressure, P_s, psia	Heat flux based on inside tube area, q_i, $\frac{Btu}{(hr)(ft^2)}$	Vapor saturation temperature corresponding to pressure, t_{vs}, °F	Temperature drop across condensate film, Δt_f, °F	Local condensing heat-transfer coefficient, h_{cl}, $\frac{Btu}{(hr)(ft^2)(°F)}$	Conditions
				Run 237				
-1.75	---	---	34.88	-------	259.0	----	------	Test-fluid total flow rate, w_t, 83.4 lb/hr; coolant flow rate, w_k, 950 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 257° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 120° F; test-fluid total mass velocity, G_t, 177 500 lb/(hr)(ft²); coolant mass velocity, G_k, 1 116 000 lb/(hr)(ft²); total condensing length, L_c, 4.4 ft; overall friction-pressure change, ΔP_f, 11.99 psi; mean condensing heat-transfer coefficient, h_{cm}, 7020 Btu/(hr)(ft²)(°F); vapor state at -1.75 ft, x = 0.99; vapor quality at -0.08 ft, 0.97; heat balance error, 0 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 762 ft/sec
-1.50	---	---	31.20	-------	-----	----	------	
-.79	---	---	28.87	-------	-----	----	------	
-.08	---	---	26.54	-------	-----	----	------	
.03	171	---	-----	-------	-----	----	------	
.14	---	218	25.54	276 000	241.3	20.2	13 663	
.98	151	209	23.96	260 000	237.7	25.8	10 077	
1.98	133	199	22.46	242 000	234.2	32.5	7 446	
2.98	110	184	21.75	223 000	232.5	46.0	4 848	
3.75	---	165	-----	181 500	233.3	66.2	2 742	
3.98	94	156	22.59	158 100	234.5	76.7	2 061	
4.25	---	145	-----	133 200	234.6	88.1	1 512	
4.50	---	131	-----	105 500	-----	----	------	
4.98	86	90	22.55	-------	-----	----	------	
5.98	82	90	22.62	-------	-----	----	------	
7.95	81	---	-----	-------	-----	----	------	
				Run 238				
-1.75	---	---	40.81	-------	268.4	----	------	Test-fluid total flow rate, w_t, 90.5 lb/hr; coolant flow rate, w_k, 950 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 267° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 124° F; test-fluid total mass velocity, G_t, 193 000 lb/(hr)(ft²); coolant mass velocity, G_k, 1 116 000 lb/(hr)(ft²); total condensing length, L_c, 4.5 ft; overall friction-pressure change, ΔP_f, 11.47 psi; mean condensing heat-transfer coefficient, h_{cm}, 6700 Btu/(hr)(ft²)(°F); vapor state at -1.75 ft, x = 0.99; vapor quality at -0.08 ft, 0.98; heat balance error, -1.3 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 678 ft/sec
-1.50	---	---	37.16	-------	-----	----	------	
-.79	---	---	34.97	-------	-----	----	------	
-.08	---	---	32.82	-------	-----	----	------	
.03	181	---	-----	-------	-----	----	------	
.14	---	229	31.88	278 000	253.9	21.7	12 811	
.98	160	220	30.40	275 000	251.2	28.1	9 786	
1.98	139	208	28.99	267 000	248.4	37.4	7 139	
2.98	114	192	28.44	260 000	247.4	52.5	4 952	
3.75	---	169	-----	219 000	248.1	76.6	2 859	
3.98	107	158	29.00	147 500	248.4	88.7	1 663	
4.25	---	144	-----	114 000	-----	----	------	
4.50	---	127	-----	93 400	-----	----	------	
4.98	89	96	29.16	-------	-----	----	------	
5.98	85	92	29.16	-------	-----	----	------	
7.95	82	---	-----	-------	-----	----	------	

TABLE I. - Continued. EXPERIMENTAL AND COMPUTED DATA

Location, L, ft	Local coolant temperature, t_k, °F	Local faired value of wall temperature, t_w, °F	Static pressure, P_s, psia	Heat flux based on inside tube area, q_i, $\frac{Btu}{(hr)(ft^2)}$	Vapor saturation temperature corresponding to pressure, t_{vs}, °F	Temperature drop across condensate film, Δt_f, °F	Local condensing heat-transfer coefficient, h_{cl}, $\frac{Btu}{(hr)(ft^2)(°F)}$	Conditions
						Run 239		
-1.75	---	---	23.77	-------	237.3	----	------	Test-fluid total flow rate, w_t, 32.9 lb/hr; coolant flow rate, w_k, 830 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 235° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 87° F; test-fluid total mass velocity, G_t, 70 000 lb/(hr)(ft²); coolant mass velocity, G_k, 975 000 lb/(hr)(ft²); total condensing length, L_c, 1.8 ft; overall friction-pressure change, ΔP_f, 1.09 psi; mean condensing heat-transfer coefficient, h_{cm}, 3990 Btu/(hr)(ft²)(°F); vapor state at -1.75 ft, x = 0.998; vapor quality at -0.08 ft, 0.995; heat balance error, -4.3 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 352 ft/sec
-1.50	---	---	23.10	-------	-----	----	------	
-.79	---	---	22.71	-------	-----	----	------	
-.08	---	---	22.26	-------	-----	----	------	
.03	103	---	-----	-------	-----	----	------	
.14	---	186	22.21	454 000	233.6	42.5	10 682	
.50	---	177	-----	271 000	234.0	54.0	5 018	
.98	77	160	22.51	168 500	234.3	72.4	2 327	
1.25	---	149	-----	146 500	234.5	83.9	1 746	
1.50	---	135	-----	123 000	234.6	98.2	1 252	
1.75	---	121	-----	90 400	-----	----	------	
1.98	65	104	22.60	-------	-----	----	------	
2.50	---	68	-----	-------	-----	----	------	
2.98	63	64	22.51	-------	-----	----	------	
3.98	62	62	22.54	-------	-----	----	------	
7.95	61	---	-----	-------	-----	----	------	
						Run 240		
-1.75	---	---	49.29	-------	280.0	----	------	Test-fluid total flow rate, w_t, 130.5 lb/hr; coolant flow rate, w_k, 1855 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 277° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 131° F; test-fluid total mass velocity, G_t, 278 000 lb/(hr)(ft²); coolant mass velocity, G_k, 2 180 000 lb/(hr)(ft²); total condensing length, L_c, 4.8 ft; overall friction-pressure change, ΔP_f, 31.91 psi; mean condensing heat-transfer coefficient, h_{cm}, 9210 Btu/(hr)(ft²)(°F); vapor state at -1.75 ft, x = 0.99; vapor quality at -0.08 ft, 0.97; heat balance error, -0.6 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 933 ft/sec
-1.50	---	---	42.54	-------	-----	----	------	
-.79	---	---	38.20	-------	-----	----	------	
-.08	---	---	33.38	-------	-----	----	------	
.03	162	---	-----	-------	-----	----	------	
.14	---	216	30.27	430 000	251.0	30.1	14 286	
.98	145	203	24.67	412 000	239.3	31.7	12 997	
1.98	131	187	18.10	366 000	222.8	31.7	11 546	
2.98	115	169	13.78	303 000	208.7	36.3	8 347	
3.98	104	152	15.80	248 000	215.6	60.8	4 079	
4.25	---	148	-----	230 000	217.3	66.7	3 448	
4.50	---	141	-----	205 000	218.9	75.6	2 712	
4.75	---	128	-----	178 000	-----	----	------	
4.98	95	102	17.52	-------	-----	----	------	
5.48	---	99	17.51	-------	-----	----	------	
5.98	92	98	17.64	-------	-----	----	------	
7.95	91	---	-----	-------	-----	----	------	

TABLE I. - Concluded. EXPERIMENTAL AND COMPUTED DATA

Location, L, ft	Local coolant temperature, t_k, °F	Local faired value of wall temperature, t_w, °F	Static pressure, P_s, psia	Heat flux based on inside tube area, q_i, Btu/(hr)(ft²)	Vapor saturation temperature corresponding to pressure, t_{vs}, °F	Temperature drop across condensate film, Δt_f, °F	Local condensing heat-transfer coefficient, h_{cl}, Btu/(hr)(ft²)(°F)	Conditions
				Run 241				
-1.75	---	---	56.13	-------	288.4	----	------	Test-fluid total flow rate, w_t, 147.0 lb/hr; coolant flow rate, w_k, 1855 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 285° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 141° F; test-fluid total mass velocity, G_t, 312 500 lb/(hr)(ft²); coolant mass velocity, G_k, 2 180 000 lb/(hr)(ft²); total condensing length, L_c, 5.5 ft; overall friction-pressure change, ΔP_f, 37.34 psi; mean condensing heat-transfer coefficient, h_{cm}, 8740 Btu/(hr)(ft²)(°F); vapor state at -1.75 ft, x = 0.99; vapor quality at -0.08 ft, 0.97; heat balance error, 0 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 894 ft/sec
-1.50	---	---	48.92	-------	-----	----	------	
-.79	---	---	44.37	-------	-----	----	------	
-.08	---	---	39.34	-------	-----	----	------	
.03	173	---	-----	-------	-----	----	------	
.14	---	226	36.18	423 000	261.2	30.4	13 914	
.98	155	211	29.77	412 000	249.9	34.3	12 012	
1.98	140	193	22.26	383 000	233.7	36.4	10 522	
2.98	124	175	15.01	341 000	213.0	34.2	9 971	
3.98	114	162	13.82	275 500	208.9	43.8	6 290	
4.98	102	154	17.18	154 000	220.1	64.4	2 391	
5.25	---	152	-----	133 000	223.0	69.5	1 914	
5.48	---	137	18.76	116.800	224.6	86.3	1 353	
5.75	---	106	-----	104 800	-----	----	------	
5.98	99	104	18.77	-------	-----	----	------	
6.48	---	102	18.65	-------	-----	----	------	
6.98	94	101	18.75	-------	-----	----	------	
7.56	93	100	-----	-------	-----	----	------	
7.95	93	---	-----	-------	-----	----	------	
				Run 243				
-1.75	---	---	61.20	-------	294.0	----	------	Test-fluid total flow rate, w_t, 158.0 lb/hr; coolant flow rate, w_k, 1830 lb/hr; vapor temperature upstream of condenser measured at -1.75 ft, t_v, 291° F; condensate temperature at condenser exit measured at 8.50 ft, t_c, 151° F; test-fluid total mass velocity, G_t, 336 000 lb/(hr)(ft²); coolant mass velocity, G_k, 2 150 000 lb/(hr)(ft²); total condensing length, L_c, 6.6 ft; overall friction-pressure change, ΔP_f, 54.54 psi; mean condensing heat-transfer coefficient, h_{cm}, 9230 Btu/(hr)(ft²)(°F); vapor state at -1.75 ft, x = 0.99; vapor quality at -0.08 ft, 0.96; heat balance error, 3.0 percent; vapor velocity at beginning of condensing portion of condenser, V_{vi}, 952 ft/sec
-1.50	---	---	52.96	-------	-----	----	------	
-.79	---	---	48.02	-------	-----	----	------	
-.08	---	---	39.34	-------	-----	----	------	
.03	180	---	-----	-------	-----	----	------	
.14	---	231	38.05	451 000	264.2	28.1	16 050	
.98	162	217	32.97	428 000	255.8	34.0	12 588	
1.98	147	201	24.99	369 000	240.0	34.9	10 573	
2.98	131	183	17.17	294 000	220.1	33.8	8 698	
3.98	121	165	10.95	221 000	197.6	30.1	7 342	
4.98	113	146	6.76	186 000	175.3	27.2	6 838	
5.48	---	---	5.09	-------	-----	----	------	
5.98	105	126	4.24	172 000	155.6	27.7	6 209	
6.48	---	124	3.42	163 500	146.8	21.0	7 786	
6.75	---	123	-----	142 500	-----	----	------	
6.98	97	121	7.36	124 500	-----	----	------	
7.25	---	115	11.86	101 500	-----	----	------	
7.56	95	103	11.91	-------	-----	----	------	
7.95	95	---	-----	-------	-----	----	------	
8.06	---	---	-----	-------	-----	----	------	

TABLE II. - MEASURED WALL TEMPERATURE

Length, ft	Run																			
	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	181	185	187
	Temperature, $^{\circ}F$																			
0.14	197	210	195	188	222	205	201	193	231	213	208	200	203	189	207	216	225	203	206	211
.98	189	201	180	170	215	195	189	178	224	203	196	188	206	179	197	206	215	190	203	200
1.31	183	197	172	157	212	188	181	169	221	196	189	179	203	173	191	200	210	182	185	192
1.64	182	195	164	142	210	186	175	158	220	194	185	172	203	170	188	197	207	178	179	190
1.98	181	195	152	127	209	184	170	144	219	192	180	163	187	154	174	184	193	162	164	175
2.31	175	187	131	101	205	174	153	123	215	182	169	145	199	161	179	189	199	165	165	182
2.64	170	183	115	83	200	163	134	97	211	172	151	126	195	155	172	182	193	156	156	175
2.98	167	180	82	82	201	154	123	87	211	165	141	103	195	154	170	181	192	154	153	175
3.31	162	174	79	81	200	139	88	85	210	150	119	88	194	151	167	177	190	148	147	171
3.31	148	158	77	80	189	126	86	84	200	135	107	87	186	141	156	167	178	137	134	152
3.64	145	154	77	79	192	114	84	83	203	128	88	85	187	143	158	169	182	137	135	156
3.98	130	141	76	79	187	86	83	83	199	92	87	86	185	139	152	164	177	129	127	142
4.31	111	123	75	79	178	82	82	82	190	85	84	85	178	132	143	156	167	124	119	127
4.64	94	87	75	79	185	81	81	82	197	83	84	84	183	136	145	161	172	133	121	99
4.98	86	79	74	78	156	79	81	82	172	81	82	83	163	114	130	140	147	113	113	91
5.31	84	79	74	78	170	79	81	82	189	81	82	83	177	121	140	152	158	108	120	92
5.31	84	79	74	78	173	79	81	82	192	82	82	83	179	123	143	155	162	109	120	93
5.64	83	77	74	78	155	79	81	82	180	82	82	83	169	109	135	143	147	90	93	92
5.98	82	76	74	78	145	79	81	82	178	82	82	83	169	97	133	139	141	89	92	91
6.31	78	75	74	77	124	78	80	82	164	79	80	82	160	74	124	130	106	88	91	89
6.64	80	78	76	80	91	81	82	84	161	81	83	84	160	77	106	103	105	90	93	91
6.98	79	77	76	80	85	80	82	83	143	80	82	83	145	73	96	99	102	88	91	88
7.31	78	76	75	79	81	79	81	83	115	79	81	83	137	72	96	99	101	87	90	88
7.31	78	76	75	79	81	79	81	83	118	79	81	83	143	72	96	99	102	87	90	88
7.56	78	76	75	79	79	80	81	83	94	79	81	83	125	72	96	99	101	87	90	88

TABLE II. - Continued. MEASURED WALL TEMPERATURE

Length, ft	Run																		
	188	191	196	197	198	199	200	205	206	207	208	209	212	213	215	216	217	219	220
	Temperature, ^{o}F																		
0.14	227	196	180	188	188	188	185	202	200	193	193	191	203	204	196	197	196	166	173
.98	215	183	166	173	176	177	175	191	187	180	181	180	192	195	187	187	186	120	144
1.31	208	175	156	163	167	168	168	185	175	171	173	173	185	189	180	181	180	102	123
1.64	206	171	146	152	159	162	165	181	166	163	167	170	183	187	178	179	179	78	107
1.98	191	166	131	135	146	149	154	169	148	147	152	158	167	172	168	167	169	80	87
2.31	198	158	117	121	134	140	151	169	133	137	148	159	168	179	170	171	172	75	79
2.64	190	149	95	95	119	124	137	153	114	121	130	147	156	173	162	164	166	75	78
2.98	189	146	87	91	97	109	127	143	90	97	119	138	145	170	157	161	165	75	78
3.31	182	145	85	87	88	90	107	131	85	90	93	125	132	161	144	151	159	74	75
3.31	162	133	84	86	87	89	100	118	84	89	91	114	120	144	129	135	143	74	75
3.64	165	141	84	85	87	88	91	98	83	89	90	95	87	142	124	130	143	74	75
3.98	149	136	86	89	90	93	90	96	83	89	90	92	81	128	92	115	128	↓	↓
4.31	135	126	83	84	85	86	88	94	81	86	88	90	79	91	81	83	110	↓	↓
4.64	104	109	83	84	85	86	88	94	81	86	88	90	78	83	79	80	84	↓	↓
4.98	96	99	83	84	85	86	86	91	80	85	86	88	76	78	77	77	78	↓	↓
5.31	97	100	83	84	85	86	86	92	80	85	87	88	77	79	77	78	79	74	75
5.31	99	100	↓	84	85	86	87	93	81	86	87	88	77	79	77	78	79	↓	↓
5.64	95	99	↓	84	85	86	86	91	81	86	87	88	76	78	77	77	78	↓	↓
5.98	95	99	↓	84	85	86	86	91	81	86	87	88	76	77	77	77	78	↓	↓
6.31	92	98	↓	83	86	84	85	90	79	84	85	87	75	76	76	76	77	↓	↓
6.64	94	100	84	85	85	86	87	92	83	87	88	89	78	78	79	79	80	75	78
6.98	91	98	83	84	↓	86	86	90	81	86	87	88	77	77	77	77	78	↓	↓
7.31	91	98	83	83	↓	85	86	90	81	85	86	87	76	77	77	77	77	↓	↓
7.31	91	98	83	83	↓	85	86	90	81	85	86	87	76	77	77	77	77	↓	↓
7.56	91	98	83	84	↓	85	86	90	81	85	86	87	76	77	77	77	77	↓	↓

TABLE II. - Concluded. MEASURED WALL TEMPERATURE

Length, ft	Run																		
	221	222	223	224	225	226	227	228	229	233	234	235	236	237	238	239	240	241	243
	Temperature, ^{o}F																		
0.14	175	178	177	193	190	173	182	191	198	205	205	220	219	218	229	186	216	226	232
.98	151	162	165	181	167	150	168	175	181	193	193	209	207	208	219	161	203	214	220
1.31	133	149	156	171	148	133	157	164	168	187	187	203	200	202	213	145	195	205	213
1.64	114	135	150	164	128	115	145	151	155	184	185	201	197	201	211	129	190	201	208
1.98	100	118	136	150	113	105	129	133	137	171	172	187	184	186	197	109	174	184	191
2.31	81	106	125	138	89	85	115	121	125	174	177	191	188	193	204	70	179	189	196
2.64	80	84	110	121	86	84	92	95	97	164	169	183	182	187	197	66	171	180	187
2.98	80	83	88	98	86	84	90	93	96	158	167	179	182	187	197	65	171	178	185
3.31	79	82	85	90	85	83	88	91	92	146	160	170	180	183	191	64	170	174	181
3.31	78	81	84	89	85	83	87	90	91	131	143	152	162	165	172	63	154	160	167
3.64	78	81	83	88	84	83	87	89	91	128	143	151	166	169	175	63	161	165	169
3.98		81	83	88	84			90	91	102	132	128	155	156	161	62	154	161	161
4.31		80	83	87	84			88	90	99	103	110	141	138	143	62	142	154	151
4.64		80	82	87	83			88	90	99	103	109	119	125	116	61	139	158	152
4.98	↓	80	82	85	83	↓	↓	88	89	96	99	103	106	91	95	61	102	128	129
5.31	78	80	82	85	83	83	87	88	89	97	100	105	106	92	96	61	102	150	139
5.31				86						97	100	106	107	93	97	61	102	155	142
5.64				85						96	99	103	106	91	95	61	99	107	132
5.98				85						96	99	103	105	91	95	61	99	105	129
6.31	↓	↓	↓	84	↓	↓	↓	↓	↓	95	97	102	103	86	91	60	97	101	122
6.64	79	82	84	86	85	85	88	89	91	97	100	104	105	89	92	63	99	103	124
6.98			83	86		85	88		90	95	98	102	102	85	89	62	96	100	125
7.31			83	85		84	87		89	95	98	102	102	85	88	62	96	100	109
7.31			83	85		84	87		89	95	98	102	102	85	88	62	96	100	111
7.56	↓	↓	83	85	↓	84	87	↓	89	95	98	102	102	85	88	62	95	99	103

TABLE III. - INSTABILITY SURVEY DATA SUMMARY

Run	Pressure oscillations		Time-averaged values of condenser parameters at unstable operating point						Ratio to average value, $\frac{\text{Amplitude}}{P_{IF}}$, percent
	Frequency, cps	Amplitude,[a] psi	P_{IF}, psia	L_c, ft	t_{vs}, in, ^{o}F	t_k, out, ^{o}F	w_t, lb/hr	w_k/w_t	
1	2.7	3.0	10.5	2.6	221	122	67.4	31.75	28.6
2	2.8	1.6	30.5	2.7	250	133	55.4	21.48	5.2
3	3.3	5.0	45.3	2.4	276	164	79.5	14.97	11.0
4	4.7	4.8	38.0	3.7	268	175	103.0	11.55	12.6
5	3.8	3.6	22.8	3.1	238	149	77.3	15.39	15.8
6	3.9	10.8	22.8	1.7	233	114	54.6	39.19	47.4
7	3.9	8.8	42.4	2.8	273	163	90.0	13.22	20.8
8	4.1	8.2	15.5	2.2	222	121	67.0	31.94	52.9
9	4.2	1.6	16.4	3.5	226	142	64.8	18.36	9.8
10	5.3	3.2	14.5	3.1	219	133	61.8	23.54	22.1
11	6.0	2.4	20.2	2.8	260	141	113.9	18.79	11.9
12	6.1	16.6	29.7	1.8	260	123	79.3	26.99	55.9
13	7.2	2.2	20.0	3.3	232	138	59.2	20.10	11.0
14	8.8	2.5	18.8	2.4	224	128	52.9	27.50	13.2

[a]Peak-to-peak amplitude; mean of the two values measured by pressure pickups located 1 and 2 ft from condenser inlet.

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9/5/67

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