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SUBCOOLED- AND NET-BOILING HEAT TRANSFER TO LOW-PRESSURE WATER IN ELECTRICALLY HEATED TUBES

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16. Abstract

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SUMMARY

Experimental data are presented on subcooled and net-quality boiling heat transfer to water flowing vertically upward in 0.584- and 1.219-centimeter inside diameter tubes with uniform heat flux. Axial inner-wall-temperature distributions are tabulated for mass velocities from 0.67 to 141 kg/(sec)(m^2), heat fluxes from 43.8 to 11 400 kW/m^2, exit pressures from 24 to 690 kN/m^2 abs, exit qualities up to 0.65, and liquid subcoolings as high as 151 K. Since no satisfactory correlations are available for the full range of test conditions, these experimental data over a wide range of test conditions should be useful to the designer.

The subcooled-boiling data are compared with some existing correlations. These correlations give the heat flux as a function of wall temperature minus saturation temperature. The data show only approximate agreement with the correlations, due probably to the effects of mass velocity, local subcooling, and distance from the inception of boiling. But the correlations are in the range of the data and may be useful for some applications.

Plots of net-boiling heat-transfer coefficients against quality do not agree with any existing correlation; the data show that, for constant heat flux, mass velocity, and quality, the local heat-transfer coefficient increases as pressure increases, whereas the correlations predict the opposite.

Heat-transfer coefficients, based on a wall-to-liquid temperature difference corrected for nonequilibrium, vary less with quality and show more consistent trends than do heat-transfer coefficients based on either wall-to-bulk or wall-to-saturation temperature differences. But no presently available nonequilibrium model appears to be valid over the entire range of liquid subcoolings of this study. Thus, a general heat-transfer correlation must be preceded by a nonequilibrium model valid for all subcoolings encountered.

INTRODUCTION

An understanding of forced-flow boiling phenomena is necessary for the rational design of Rankine-cycle power systems, especially those for use in space, where compactness is important. Boiling, with its high heat-transfer coefficients, is also applicable to cooling problems where high heat fluxes are involved, such as in rocket-nozzle cooling. To obtain efficient, compact space power systems, high fluid temperatures are required. These high temperatures can be obtained at relatively low pressures by using alkali metals as working fluids. With the exception of liquid thermal conductivity, water has physical properties similar to the alkali metals. Since experiments on the boiling of alkali metals are difficult and expensive to perform, and since water itself may be of interest for cooling applications, a series of experiments on heat transfer and pressure drop for water boiling in tubes has been done at the NASA Lewis Research Center (refs. 1 to 5).

Although there have been numerous studies of boiling heat transfer, there is still no generally applicable means of prediction available for high-density-ratio fluids such as alkali metals and low-pressure water. This is especially true of the subcooled-boiling regime. Experimental results for high-heat-flux subcooled boiling of low-pressure water in 0.584-centimeter inside diameter tubes were presented in reference 1. In fully developed subcooled boiling, it was found that the wall temperature was nearly independent of fluid bulk temperature and mass velocity for a given pressure level and heat flux (the heat flux being in the range of about 1600 to 9100 kW/m^2). Existing semiempirical correlations (refs. 6 to 8) did not satisfactorily predict the heat transfer at low pressures.

It is the objective of this study to obtain subcooled- and net-boiling heat-transfer data over a wide range of test variables, including the range covered in the heat-exchanger boiling studies (ref. 2). The range of interest is from the inception of boiling up to, but not including, the heat-transfer transition often called "burnout". This regime or series of regimes is often termed "nucleate boiling"; however, no such terminology is used herein since this range may include other regimes, such as evaporation from the interface with or without nucleation. The correlations of references 6 to 9 for subcooled-boiling heat transfer and references 10 to 14 for net-boiling heat transfer, based primarily on annular-flow models, are compared with the experimental data to determine whether or not any of them are applicable over the range of the experiments.

In order to obtain heat-transfer data under conditions comparable to those of the heat-exchanger boiling studies (ref. 2), the present heat-transfer studies employ 1.219- as well as 0.584-centimeter inside diameter tubes. The experimental test sections of this study are made of Inconel X tubing having a 0.025-centimeter-thick wall. The water flows vertically upward through the straight, circular tube. No inserts are used. Exit qualities as high as 0.65 are obtained.

APPARATUS

Figure 1 shows a schematic diagram of the test apparatus. This is essentially the same test apparatus as that used in reference 1, wherein it is described in more detail. The system is designed to operate at a maximum pressure of 1700 kN/m^2 abs and a maximum fluid temperature of 450 K.

The water is circulated by either of two gear pumps connected in parallel. The flow passes through the coiled stainless-steel electrical preheater to the test-section inlet plenum. From the exit plenum the flow passes through a 5.1-centimeter-diameter pipe to a spray condenser. The coolant is supplied to the condenser by a centrifugal pump having a nominal capacity of $\sim 6.3 \times 10^{-3}$ cubic meter per second. From the condenser the flow passes into a multiple-tube heat exchanger cooled by cooling-tower water. In most cases the condenser is shut off, and the condensing is done in the heat exchanger.

The power to the test section and preheater is supplied by 70- and 250-kilowatt ac transformers, each regulated by a saturable core reactor. The two power supplies are interchangeable; either one can be connected to the test section or preheater, depending on the heat loads for a particular test.

Test Sections

The test sections used in this investigation are constructed of 0.584- and 1.219-centimeter inside diameter by 0.25-millimeter wall Inconel X tubing and are from 14.6 to 121.9 centimeters long. This tubing is specially rolled to limit the wall-thickness deviation to less than 3 percent of the nominal wall thickness. The test-section inside-surface roughness is measured by a surface analyzer before and after use for a number of the test sections. The maximum surface roughness (peak to valley) is ~5 nanometers. Several samples of tubing are used to measure the electrical resistivity of the Inconel X as a function of temperature. The results agree well with reference 15; the electrical resistivity of Inconel X may be considered independent of temperature for the range of this investigation.

Figure 2 shows a schematic diagram of a typical test section. The ratio of unheated length to inside diameter is 0.8 for test section 480-100M (table I) and 15 for all other test sections. (The test-section numbers give the inside diameter in thousandths of an inch followed by the ratio of heated length to inside diameter; the letter indicates the order of testing.) Power leads are connected to copper flanges that are silver-soldered to the tube. High temperature solder is used, and care is taken to ensure good contact and to avoid fillets in the heated portion of the test section. The end flanges are bolted

to the inlet and exit plenums and electrically insulated by Teflon and asbestos gaskets and seals. The exit plenum is fixed to the structural frame, while the inlet plenum is allowed to slide longitudinally to provide for thermal expansion. The test-section assembly is enclosed in a transparent shield to minimize external convective currents and to provide protection in case of failure.

Instrumentation

Fluid temperatures. - Plenum chambers (fig. 3) are provided at the test-section inlet and exit in order to obtain (at least in the all-liquid case) true bulk-temperature readings. The inlet- and exit-plenum temperatures, as well as other fluid temperatures around the loop are measured by copper-constantan thermocouples and recorded by a multipoint self-balancing potentiometer. This instrument is periodically calibrated with a standard potentiometer. The error in the bulk temperatures is estimated to be ±0.3 K.

Pressures. - For most of the data reported herein, the fluid pressures at the inlet and exit plenums are measured with strain-gage-type transducers having a range of 0 to 690 kN/m^2 and a stated accuracy of 1/4 percent of full scale. The signal is recorded on a multichannel oscillograph. A 30-centimeter, 0- to 690-kN/m^2 Bourdon tube gage is connected to the exit plenum. In some cases, the test-section pressure drop is also measured with a 0- to 207-kN/m^2 differential gage connected across the pressure taps drilled through the copper flanges of the test section. Valves are provided to damp large amplitude gage pressure fluctuations or to shut off the gage completely. Under steady conditions, the correspondence between the transducers and gage readings is considered good.

Flow rate. - The flow rate is measured by one of three turbine-type flowmeters with overlapping ranges. All flowmeters are calibrated prior to their installation. The flowmeter signal is read from a frequency-converter indicator and on a digital frequency counter, both of which are calibrated by a signal generator.

Power. - Because a distorted ac output is obtained at low heating power levels (see ref. 1), a dynamometer-type wattmeter is used to measure the power input to the test section. The accuracy of this true rms instrument is 0.1 percent of full scale. A true rms, electronic-tube voltmeter is used to measure the test-section voltage drop and thus provide a check on the wattmeter.

Test-section wall temperatures. - The outside wall temperatures of the heated tube are measured by a number of 36-gage Chromel-Alumel thermocouples spot-welded in one longitudinal plane to the outside surface of the tube at various axial locations. The millivolt signal is recorded on a self-balancing potentiometer with a special filtering and isolation circuit to eliminate ac voltage pickup. Two 36-gage Chromel-Alumel thermo-

couples are spot-welded on the outside surface of the tube, both 0.635 centimeter from the exit end of the heated length, but circumferentially spaced 180° apart. These thermocouples are connected in parallel to yield a single average surface-temperature reading that is continuously recorded on a separate self-balancing potentiometer and serves as an overtemperature control.

PROCEDURE

Prior to filling, the system is flushed with deionized water, purged with nitrogen, and then evacuated. It is then filled with deionized, deaerated water. The water is circulated through the system and further degassed by boiling in the test section and venting to the atmosphere from the top of the condenser. Generally, water samples are taken and analyzed daily on a gas analyzer for gas content. The dissolved gas content is maintained at or below 3 parts per million (by weight).

The desired conditions for each run are established by adjusting the power to the preheater and test section and setting the pump speed and system pressure at selected values. When the mean inlet and exit bulk temperatures become constant with time, the data for that run are taken. Temperatures are automatically recorded on strip charts. Flow rate, power, and pressures are read from gages.

In order to check the wall thermocouples, runs are made in which no heat is applied to the test section, but the flow rate and preheater power are varied. Since the heat losses are small, the tube-outer-wall temperatures can then be checked against the water bulk temperatures. The wall-temperature recorders are adjusted so that the bulk and wall temperatures agree within the scatter of the wall-temperature measurement.

EXPERIMENTAL DATA

Tabulation

The experimental heat-transfer data are presented in tables I to VII. For each run, the mass velocity, heat flux, inlet and exit temperatures, the inner-wall-temperature profile, the exit quality, exit pressure, and, when available, the test-section pressure drop are listed. Each wall-temperature reading is classified as nonboiling, subcooled boiling, or net boiling.

Error Considerations

A maximum ±1.7 K error in the inner-wall temperature is estimated in reference 1 for heat fluxes in excess of 3150 kW/m^2. This estimate is based on the maximum deviation in wall thickness, the accuracy of the outer-wall-temperature and heat-flux measurements, and the validity of the assumptions used in deriving the equation (1) for temperature drop through the heated wall. At the lower heat fluxes employed in the heat-transfer studies of this report, the errors should be less, perhaps in the vicinity of ±0.5 K. Therefore, the wall temperatures are tabulated to the nearest 0.5 K. The error in the water temperature measurements is estimated to be ±0.3 K (ref. 1); therefore, inlet and exit temperatures are tabulated to the nearest 0.1 K.

To estimate the heat loss from the test section, the heat-transfer coefficient to the air is estimated from reference 16, and the convective heat loss from the test-section surface is estimated to be less than 1 percent. Axial wall conduction calculations (ref. 17) based on measured temperature profiles indicate a maximum heat-transfer coefficient error of about 3 percent at the first measuring station, with error decreasing as length increases. During boiling, the rate of change of wall temperature with distance is usually quite small; thus, axial conduction is slight, and the assumptions used in deriving equation (1) for temperature drop through the wall are more valid.

Data Reduction and Terminology

Figure 4 shows typical temperature and voidage profiles for the case of subcooling at the inlet and net quality at the exit and the pertinent terminology. The point of boiling initiation, as determined from the wall-temperature profile, is at z_o; other parameters evaluated at this position are denoted by the subscript o. The subscript d denotes the point at which bubbles first detach from the tube wall. The point where the heat-balance quality is zero is indicated by the subscript 1. Any quantity which is corrected for nonequilibrium is indicated by a superscript prime. (Symbols are defined in the appendix.)

The heat input is determined from the wattmeter. The comparison between the wattmeter reading and the power computed from the voltage measurement and the known test-section resistance agree well. The heat flux is computed by dividing the wattmeter power by the tube inside area over the length L_h. The outside wall temperature is obtained from the potentiometer millivolt signal by means of the calibrated temperature against emf curve for Chromel-Alumel thermocouples.

The inside wall temperature is computed as in references 1 and 17 by

$$0.593\,(T_{wo} - T_w) + 0.000638\left(T_{wo}^2 - T_w^2\right) = qD\left[\frac{\ln\left(\frac{D_{wo}}{D}\right)}{1 - \left(\frac{D}{D_{wo}}\right)^2} - \frac{1}{2}\right] \tag{1}$$

which is derived for the following conditions: no heat loss from the outer surface, no axial heat flow within the wall, constant electrical resistivity, and a linear variation of thermal conductivity with temperature. Where the pressure drop is not determined experimentally, the pressure profiles are estimated using the correlations of references 18 and 2 for the subcooled- and net-boiling regimes, respectively. The liquid bulk temperature or vapor quality is then calculated by the following heat-balance equations, respectively:

$$T_\ell = T_i + \frac{4qz}{DGc_p} \tag{2}$$

$$x = \frac{4qz}{DG\lambda} - \frac{c_p}{\lambda}(T_s - T_i) \tag{3}$$

In comparing with net-boiling heat-transfer correlations, the fully developed all-liquid heat-transfer coefficient is required. The quantity $(h_\ell D/k)(DG/\mu_\ell)^{-0.8}$ is given graphically as a function of Prandtl number $c_p\mu_\ell/k$ in reference 17. Over the current range of interest, the relation for h_ℓ may be approximated by

$$h_\ell = 0.0232\left(\frac{k}{D}\right)\left(\frac{DG}{\mu_\ell}\right)^{0.8}\left(\frac{c_p\mu_\ell}{k}\right)^{0.467} \tag{4}$$

RESULTS AND DISCUSSION

Typical Data

Large subcooling at inlet. - Typical heat-transfer data with large subcooling (~83 K) at the inlet are shown in figure 5. Local inner-wall and bulk temperatures are plotted against the axial distance from the start of heating in figure 5(a). The bulk temperatures

are based on an equilibrium heat balance. The resulting local heat-transfer coefficients, based on bulk temperature, are plotted against distance in figure 5(b). Papell's correlation of subcooled-boiling heat transfer (ref. 9) is shown for comparison. Three runs are shown with variable heat flux and constant mass velocity, exit pressure, and inlet temperature.

At the lowest heat flux, the inner-wall temperature does not rise above saturation temperature until near the exit, and no boiling occurs. The local heat-transfer coefficient decreases with distance in the thermal entrance region and then increases slightly due to the effect of the increasing temperature on physical properties. For the intermediate heat flux, the inner-wall temperature rises with distance rapidly enough that subcooled boiling is initiated in the thermal entrance region; the heat-transfer coefficient then increases with distance throughout the rest of the tube, all in the subcooled-boiling regime. Qualitatively similar results are seen for the highest heat flux although boiling is initiated nearer the inlet, net vapor is produced (exit quality $x_e = 0.044$), and the boiling heat-transfer coefficients are higher. It should be noted that, for both runs with boiling in figure 5(a), the inner-wall temperature increases with distance in the subcooled-boiling regime; this effect is not predicted by most subcooled-boiling heat-transfer correlations (e.g., refs. 6 to 8) but is of small magnitude. Throughout most of the subcooled-boiling regime, the experimental heat-transfer coefficients do not deviate greatly from Papell's correlation (ref. 9). But, the experimental data show less effect of distance (or subcooling) than predicted, and the deviation becomes large as the heat-balance quality approaches zero.

Small subcooling at inlet. - Typical heat-transfer data with small subcooling (~22 K) at the inlet are shown in figure 6; local inner-wall and bulk temperatures are plotted against axial distance from the start of heating in figure 6(a), and the resulting local heat-transfer coefficients, based on bulk temperature, are plotted against distance in figure 6(b). Papell's correlation of subcooled-boiling heat transfer (ref. 9) is again shown in figure 6(b) for comparison. Four runs are shown with variable heat flux and constant mass velocity and inlet temperature; the resulting exit quality ranges up to 0.247. The exit pressure is 119 kN/m^2 abs at the lowest heat flux and increases by approximately 7 kN/m^2 for each successive increase in heat flux; this increase in exit pressure is due to the increasing pressure drop between the boiler and condenser with increasing quality.

At the lowest heat flux, subcooled boiling is initiated somewhere near the middle of the tube, but the exact point is difficult to determine; the bulk condition at the exit is slightly subcooled. For the higher heat fluxes, subcooled boiling is initiated in the thermal entrance region, and net exit quality is produced. For all four runs, except very near the inlet, there is a general trend for inner-wall temperature to increase slightly with distance in the subcooled-boiling regime. For the three higher heat fluxes, at a

given position, h increases as q increases in the subcooled-boiling regime (fig. 6(b)). But then at a fairly low net quality, h takes on values of ~57 kW/(m^2)(K) and does not vary much with heat flux, distance, or quality. The agreement with Papell's correlation (ref. 9) is poorer here than for figure 5, especially for the lowest heat flux, indicating that the range of applicability of the correlation is limited to subcoolings on the order of 20 K or greater.

Subcooled-Boiling Curves: Heat Flux Against Temperature Difference

A common way of presenting boiling heat-transfer data is to plot heat flux against wall superheat $T_w - T_s$. Figure 7 gives such a plot for an exit pressure of ~114 kN/m^2 abs; the data of this report and reference 1 as well as some limited data from reference 17 are shown. Two tube diameters and four length-to-diameter ratios are included. The wall-temperature measuring station 0.635-centimeter upstream of the test-section exit is used, except for the 1.219-centimeter inside diameter data of reference 17 where the station 1.905 centimeters upstream of the exit is used. Local subcooling $T_s - T_\ell$ ranges from 3 to 66 K. The range of mass velocity is from 0.67 to 141 kg/(sec)(m^2), while the heat-flux range is from 101 to 11 400 kW/m^2. The correlations of Rohsenow (ref. 6), Forster and Greif (ref. 7), and Forster and Zuber (ref. 8) are shown for comparison. Although the data fall into a rather broad band (~22 K) and cannot be said to agree with any correlation, the figure is useful in summarizing the range of results obtained. It may be that the effect of other variables, such as mass velocity and subcooling must be accounted for. The correlation of reference 8 gives approximately the lower limit of q for a given $T_w - T_s$. But it appears that the correlation of either reference 6 or 7 would give reasonable approximate results for many applications.

Comparison With Net-Boiling Heat-Transfer Correlations

Most correlations of net-boiling heat-transfer coefficients relate h/h_ℓ to the Martinelli parameter

$$X_{tt} = \left(\frac{1 - x}{x}\right)^{0.9} \left(\frac{\rho_g}{\rho_\ell}\right)^{0.5} \left(\frac{\mu_g}{\mu_\ell}\right)^{0.1}$$

where h_ℓ is the heat-transfer coefficient for all-liquid flow at saturation temperature. Figure 8 gives plots of h/h_ℓ against $x/(1 - x)$ for mass velocities of ~0.68 and ~5.9

kg/(sec)(m^2) at an exit pressure of ~117 kN/m^2 abs, from test section 480-100M (table I). Although some orderliness with regard to heat flux can be seen in both figures, it is apparent that the effect of mass velocity is not properly accounted for. The correlation of Dengler and Addoms (ref. 10) is shown for comparison. Although the data are not in agreement with the correlation, the slope of h/h_ℓ against $x/(1 - x)$ appears to agree for relatively high qualities in figure 8(a).

Similar plots are shown in figure 9 for a mass velocity of ~0.68 kg/(sec)(m^2) at exit pressures of ~114 and ~26 kN/m^2 abs, from test section 480-50M (table II). The data of figures 8(a) and 9(a) show good agreement between the two test sections. But the experimental data show that, for constant heat flux, mass velocity, and quality, h/h_ℓ (and also h) increases as pressure increases, whereas the correlation of reference 10 (and also those of refs. 11 to 14) predicts the opposite, due to the physical properties in X_{tt}. Although the correlations of references 10 and 14 include a nucleate-boiling term, which is not directly a function of X_{tt}, the contribution of the nucleate term is not of sufficient magnitude to reverse the pressure effect in either case. Thus these correlations in terms of X_{tt} are inadequate.

Definition of Heat-Transfer Coefficient During Boiling

In net boiling (equilibrium heat-balance quality $x > 0$) the heat-transfer coefficient is usually defined as $q/(T_w - T_s)$, while in the subcooled-boiling regime, either $q/(T_w - T_s)$ or $q/(T_w - T_\ell)$ is commonly used. In figures 5(b) and 6(b) the latter definition, $h = q/(T_w - T_\ell)$, is used with $T_\ell = T_s$ for $x > 0$. These heat-transfer coefficients are plotted against local equilibrium heat-balance quality x in figure 10(a). It can be seen that h increases rapidly with x in the subcooled region ($x < 0$) and passes through a maximum in the low-quality range. In figure 10(b), $h_s = q/(T_w - T_s)$ is plotted against x for these same runs. It is difficult to find any consistent trends. These two definitions of the heat-transfer coefficient are not the only ones possible, however. Since some of the heat added to a fluid in subcooled boiling goes into the production of vapor, the remaining liquid has a lower average temperature T'_ℓ than that calculated from an equilibrium heat balance. Performing a heat balance from the point of boiling initiation (subscript o) to any downstream point,

$$T'_\ell = T_{\ell,o} + \frac{4q(z - z_o)}{DGc_p}\left(\frac{1 - \bar{\gamma}}{1 - x'}\right) \tag{5}$$

where x' is the actual quality and $\bar{\gamma}$ is the net fraction of the heat added from z_o to z

going into vaporization $x'/(x - x_o)$. There are several means available for predicting x' and $\overline{\gamma}$; for the present discussion, the following simple relation suggested by Levy (ref. 19) is used:

$$x' = x - x_d e^{(x/x_d)-1} \tag{6}$$

where x_d is the equilibrium heat-balance quality at the point where bubbles first depart from the surface; hereinafter, x_d is taken to be x_o. The heat-transfer coefficient corrected for nonequilibrium, $h' = q/(T_w - T'_\ell)$ is plotted against the equilibrium heat-balance quality x in figure 10(c). It can be seen that the range of h' values is much less than that of h or h_s, and the variation of h' with x is less than that of h or h_s.

Another reasonable plot to make is h' against x'; this is shown in figure 11. In both figures 10(c) and 11 there is an apparent effect of inlet temperature; other relations, suggested by Kroeger and Zuber (ref. 20), give similar results. This may be due in part to the contribution of nucleate boiling; but neither of the correlations (that of ref. 10 or 14), using nonequilibrium quality, agree well with the data. However, it should be noted that equation (6) is an assumed equation, used previously only for smaller subcoolings, and the assumption that $x_o = x_d$ may contribute to the apparent subcooling effect. It appears that x' is calculated to be too large; pressure drop calculations also indicate that x' is too large. Therefore, although it might be possible to obtain h' as a function of x or x', q, G, and physical property values for a given initial subcooling, it appears that a nonequilibrium model valid over a wide range of subcooling and pressure is still required before a general correlation of the data will be successful.

SUMMARY OF RESULTS

The major results of this investigation of heat transfer to low-pressure water in subcooled and net-quality boiling in electrically heated tubes may be summarized as follows:

1. Axial inner-wall temperature distributions are tabulated for subcooled and net boiling in 0.584- and 1.219-centimeter inside diameter tubes over the following ranges of test variables: mass velocity from 0.67 to 141 kg/(sec)(m^2), heat flux from 43.8 to 11 400 kW/m^2, exit pressure from 24 to 690 kN/m^2 abs, qualities up to 0.65, and liquid subcoolings as high as 151 K. As no satisfactory general correlations are available, these experimental data over a wide range of test conditions should be useful to the designer.

2. The subcooled-boiling data show only approximate agreement with the correlations of Rohsenow, Forster and Greif, Forster and Zuber, and Papell. In some cases the

tube-inner-wall temperature increases with increasing distance from the start of heating in the subcooled-boiling regime, which is not predicted by any existing correlation; however, this effect is small.

3. Plots of net-boiling heat-transfer coefficients against heat-balance quality do not agree with any existing correlation; the data show that, for constant heat flux, mass velocity, and quality, the local heat-transfer coefficient increases as pressure increases whereas the correlations predict the opposite.

4. Heat-transfer coefficients, based on a wall-to-liquid temperature difference corrected for nonequilibrium, vary less with quality and show more consistent trends than do heat-transfer coefficients based on either wall-to-bulk or wall-to-saturation temperature differences. However, a completely satisfactory correlation of the data is not attained because no presently available nonequilibrium model appears to be valid over the entire range of liquid subcoolings of this study.

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APPENDIX - SYMBOLS

c_p liquid heat capacity, J/(kg)(K)

D tube inside diameter, m

D_{wo} tube outside diameter, m

G mass velocity, kg/(sec)(m^2)

h heat-transfer coefficient, $q/(T_w - T_\ell)$, W/(m^2)(K)

h_ℓ calculated all-liquid heat-transfer coefficient (eq. (4)), W/(m^2)(K)

h_s boiling heat-transfer coefficient, $q/(T_w - T_s)$, W/(m^2)(K)

k liquid thermal conductivity, W/(m)(K)

L_h heated length of test section, m

L_u unheated length of test section, m

P pressure, N/m^2 abs

ΔP test-section pressure drop, N/m^2

q heat flux, W/m^2

T temperature, K

X_{tt} Martinelli parameter, $\left(\frac{1-x}{x}\right)^{0.9}\left(\frac{\rho_g}{\rho_\ell}\right)^{0.5}\left(\frac{\mu_g}{\mu_\ell}\right)^{0.1}$, dimensionless

x vapor quality (eq. (3)), dimensionless

z axial distance from start of heating, m

$\bar{\gamma}$ fraction of heat added going into vaporization, $x'/(x - x_o)$, dimensionless

λ enthalpy of vaporization, J/kg

μ viscosity, kg/(sec)(m)

ρ density, kg/m^3

Subscripts:

d point where bubbles first detach from tube wall

e test-section exit

g gas property

i test-section inlet

ℓ liquid property, or based on liquid bulk temperature

o onset of boiling, as determined from wall-temperature profile

s saturation, or based on saturation temperature

w tube inner wall

wo tube outer wall

1 point where heat-balance quality is zero

Superscript:

' value corrected for nonequilibrium

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TABLE I. - HEAT-TRANSFER DATA FOR 1.219-CENTIMETER INSIDE DIAMETER BY 121.9-CENTIMETER-LONG TEST SECTION 480-100 M

[G = mass velocity, kg/(sec)(m^2); q = heat flux, kW/m^2; T_i = inlet temperature, K; T_e = exit temperature, K; P_e = exit pressure, kN/m^2 abs; x_e = exit quality.]

Run	G	q	T_i	T_e	P_e	x_e	Axial distance from start of heating, z, cm																	
							0.635	1.27	2.54	5.08	10.16	15.24	22.86	30.48	38.10	45.72	53.34	60.95	68.58	76.20	86.36	96.52	106.7	116.8	121.3
							Inner-wall temperature, T_w, K																		
28	5.93	163	290.1	315.7	703	----	$a_{310.0}$	$a_{315.0}$	$a_{320.0}$	$a_{325.0}$	$a_{331.0}$	$a_{335.0}$	$a_{338.0}$	$a_{341.0}$	$a_{341.0}$	$a_{343.0}$	$a_{344.0}$	$a_{344.0}$	$a_{346.5}$	$a_{348.0}$	$a_{350.0}$	$a_{350.0}$	$a_{353.0}$	$a_{356.0}$	$a_{359.0}$
29	5.91	163	311.5	337.6	703	----	$a_{326.0}$	$a_{332.0}$	$a_{336.5}$	$a_{340.0}$	$a_{345.0}$	$a_{347.0}$	$a_{350.0}$	$a_{351.0}$	$a_{353.0}$	$a_{356.5}$	$a_{357.0}$	$a_{358.0}$	$a_{360.0}$	$a_{361.5}$	$a_{364.0}$	$a_{366.5}$	$a_{368.0}$	$a_{371.0}$	$a_{374.0}$
30	5.95	167	325.4	352.1	703	----	$a_{339.0}$	$a_{344.0}$	$a_{348.0}$	$a_{351.5}$	$a_{354.0}$	$a_{358.0}$	$a_{359.0}$	$a_{361.5}$	$a_{363.0}$	$a_{365.0}$	$a_{366.5}$	$a_{369.0}$	$a_{370.5}$	$a_{373.0}$	$a_{375.0}$	$a_{378.0}$	$a_{381.0}$	$a_{383.0}$	$a_{386.5}$
31	5.91	166	344.6	370.4	703	----	$a_{354.0}$	$a_{360.0}$	$a_{363.0}$	$a_{366.5}$	$a_{370.0}$	$a_{372.0}$	$a_{375.0}$	$a_{377.0}$	$a_{379.0}$	$a_{381.5}$	$a_{383.0}$	$a_{385.0}$	$a_{387.0}$	$a_{389.0}$	$a_{392.0}$	$a_{396.0}$	$a_{398.0}$	$a_{401.0}$	$a_{403.0}$
32	5.88	170	357.6	378.4	703	----	$a_{365.0}$	$a_{371.5}$	$a_{375.0}$	$a_{378.0}$	$a_{380.0}$	$a_{383.0}$	$a_{386.0}$	$a_{388.0}$	$a_{390.0}$	$a_{392.0}$	$a_{393.0}$	$a_{395.0}$	$a_{398.0}$	$a_{400.0}$	$a_{403.0}$	$a_{406.0}$	$a_{408.0}$	$a_{412.0}$	$a_{414.0}$
33	5.93	249	291.5	330.9	116	----	$a_{321.0}$	$a_{329.0}$	$a_{335.0}$	$a_{344.0}$	$a_{353.0}$	$a_{358.0}$	$a_{362.0}$	$a_{365.0}$	$a_{363.0}$	$a_{366.0}$	$a_{366.5}$	$a_{368.0}$	$a_{369.0}$	$a_{371.0}$	$a_{373.0}$	$a_{375.0}$	$a_{379.0}$	$a_{382.0}$	$a_{386.5}$
34	5.95	287	292.1	337.3	116	----	$a_{325.0}$	$a_{335.0}$	$a_{342.0}$	$a_{351.0}$	$a_{362.0}$	$a_{362.0}$	$a_{366.5}$	$a_{371.5}$	$a_{369.0}$	$a_{369.0}$	$a_{369.0}$	$a_{372.0}$	$a_{374.5}$	$a_{378.0}$	$a_{378.0}$	$a_{381.5}$	$a_{388.0}$	$a_{388.0}$	$a_{392.0}$
46	5.91	328	295.1	346.5	117	----	$a_{330.0}$	$a_{341.5}$	$a_{351.0}$	$a_{358.0}$	$a_{373.0}$	$a_{375.0}$	$a_{374.0}$	$a_{369.0}$	$a_{371.5}$	$a_{374.0}$	$a_{380.0}$	$a_{381.0}$	$a_{384.5}$	$b_{386.5}$	$b_{386.5}$	$b_{386.5}$	$b_{390.0}$	$b_{392.0}$	$b_{394.0}$
47	5.93	413	295.1	360.1	117	----	$a_{339.0}$	$a_{355.0}$	$a_{364.0}$	$a_{374.0}$	$a_{380.0}$	$b_{378.0}$	$b_{382.0}$	$b_{382.0}$	$b_{384.0}$	$b_{385.0}$	$b_{385.0}$	$b_{386.0}$	$b_{386.0}$	$b_{388.0}$	$b_{389.0}$	$b_{391.0}$	$b_{393.0}$	$b_{396.0}$	$b_{394.0}$
66	5.95	545	294.8	375.4	122	.008	$a_{357.0}$	$a_{376.5}$	$a_{388.0}$	$a_{390.0}$	$b_{391.0}$	$b_{391.0}$	$b_{394.0}$	$b_{394.0}$	$b_{391.5}$	$b_{395.0}$	$b_{393.0}$	$b_{391.0}$	$b_{391.5}$	$b_{396.5}$	$b_{394.0}$	$b_{396.5}$	$b_{397.0}$	$c_{399.0}$	$c_{402.0}$
67	5.95	580	295.4	375.4	122	.018	$a_{365.0}$	$a_{378.0}$	$a_{387.0}$	$b_{388.0}$	$b_{388.0}$	$b_{389.0}$	$b_{390.0}$	$b_{393.0}$	$b_{391.5}$	$b_{395.0}$	$b_{393.0}$	$b_{395.0}$	$b_{390.5}$	$b_{395.0}$	$b_{393.0}$	$b_{396.0}$	$b_{397.0}$	$c_{396.5}$	$c_{398.0}$
68	5.91	662	295.1	374.8	d122	.044	$a_{373.0}$	$a_{388.0}$	$b_{389.0}$	$b_{388.0}$	$b_{389.0}$	$b_{389.0}$	$b_{391.0}$	$b_{393.0}$	$b_{393.0}$	$b_{394.0}$	$b_{391.0}$	$b_{391.0}$	$b_{392.0}$	$b_{395.0}$	$b_{393.0}$	$c_{395.0}$	$c_{396.5}$	$c_{395.0}$	$c_{395.0}$
36	5.92	157	317.9	343.7	116	----	$a_{331.0}$	$a_{331.0}$	$a_{340.0}$	$a_{344.0}$	$a_{342.0}$	$a_{350.0}$	$a_{351.5}$	$a_{354.0}$	$a_{354.0}$	$a_{356.0}$	$a_{358.0}$	$a_{359.0}$	$a_{361.5}$	$a_{364.0}$	$a_{365.0}$	$a_{368.0}$	$a_{371.0}$	$a_{373.0}$	$a_{375.0}$
37	5.93	206	318.2	350.7	116	----	$a_{334.0}$	$a_{341.0}$	$a_{346.5}$	$a_{351.5}$	$a_{355.0}$	$a_{359.0}$	$a_{361.5}$	$a_{364.0}$	$a_{365.0}$	$a_{368.0}$	$a_{369.0}$	$a_{371.5}$	$a_{374.5}$	$a_{376.0}$	$a_{377.0}$	$a_{380.0}$	$a_{383.0}$	$b_{383.0}$	$b_{384.0}$
38	5.95	240	318.2	357.1	116	----	$a_{339.0}$	$a_{347.0}$	$a_{351.0}$	$a_{359.0}$	$a_{364.0}$	$a_{367.0}$	$a_{370.0}$	$a_{372.0}$	$a_{374.0}$	$a_{377.0}$	$a_{378.0}$	$a_{380.0}$	$a_{383.0}$	$b_{385.0}$	$b_{385.0}$	$b_{384.0}$	$b_{386.5}$	$b_{388.0}$	$b_{388.0}$
39	5.95	309	319.3	366.5	116	----	$a_{344.0}$	$a_{353.0}$	$a_{361.0}$	$a_{368.0}$	$a_{375.0}$	$a_{379.0}$	$a_{381.0}$	$a_{381.5}$	$a_{384.0}$	$a_{385.0}$	$a_{385.0}$	$b_{386.5}$	$b_{386.5}$	$b_{386.5}$	$b_{386.5}$	$b_{386.5}$	$b_{386.5}$	$b_{389.0}$	$b_{390.0}$
48	5.91	476	315.1	375.1	122	.025	$a_{363.0}$	$a_{374.0}$	$a_{385.0}$	$b_{386.5}$	$b_{386.5}$	$b_{389.0}$	$b_{391.5}$	$b_{390.0}$	$b_{390.0}$	$b_{391.5}$	$b_{388.0}$	$b_{389.0}$	$b_{388.0}$	$b_{395.0}$	$b_{390.5}$	$b_{393.0}$	$c_{395.0}$	$c_{394.0}$	$c_{395.0}$
21	5.95	121	357.9	374.2	119	----	$a_{365.0}$	$a_{366.0}$	$a_{368.0}$	$a_{371.0}$	$a_{373.0}$	$a_{374.5}$	$a_{377.0}$	$a_{378.0}$	$a_{380.0}$	$a_{382.0}$	$a_{383.0}$	$b_{385.0}$	$b_{384.0}$	$b_{384.0}$	$b_{385.0}$	$b_{386.0}$	$b_{386.5}$	$b_{385.0}$	$b_{387.0}$
22	5.93	122	358.2	373.7	121	----	$a_{365.0}$	$a_{366.0}$	$a_{369.0}$	$a_{372.0}$	$a_{374.0}$	$a_{375.0}$	$a_{378.0}$	$a_{380.0}$	$a_{381.0}$	$a_{383.0}$	$a_{383.5}$	$b_{385.0}$	$b_{383.5}$	$b_{383.5}$	$b_{384.0}$	$b_{386.0}$	$b_{386.0}$	$b_{385.0}$	$b_{386.5}$
23	5.93	163	359.0	373.7	122	.013	$a_{367.0}$	$a_{371.0}$	$a_{375.0}$	$a_{378.0}$	$a_{380.5}$	$a_{383.0}$	$a_{386.0}$	$b_{388.0}$	$b_{387.0}$	$b_{388.0}$	$b_{386.0}$	$b_{387.0}$	$b_{386.5}$	$b_{386.0}$	$b_{385.0}$	$b_{384.0}$	$c_{383.5}$	$c_{383.0}$	$c_{384.5}$
40	5.95	125	360.9	375.4	122	.005	$a_{364.0}$	$a_{369.0}$	$a_{371.0}$	$a_{375.0}$	$a_{376.0}$	$a_{379.0}$	$a_{382.0}$	$a_{383.0}$	$a_{384.0}$	$a_{387.0}$	$a_{388.0}$	$b_{388.5}$	$b_{387.0}$	$b_{389.0}$	$b_{389.0}$	$b_{389.0}$	$c_{389.0}$	$c_{388.0}$	$c_{388.0}$
41	5.95	164	359.3	375.4	122	.013	$a_{365.5}$	$a_{372.0}$	$a_{375.5}$	$a_{378.0}$	$a_{381.0}$	$a_{382.5}$	$a_{386.0}$	$a_{388.0}$	$b_{390.0}$	$b_{389.0}$	$b_{390.0}$	$b_{389.0}$	$b_{389.0}$	$b_{390.5}$	$b_{388.0}$	$c_{387.0}$	$c_{385.0}$	$c_{385.0}$	$c_{388.0}$
42	5.88	206	359.8	374.0	122	.028	$a_{368.0}$	$a_{376.0}$	$a_{380.0}$	$a_{384.5}$	$a_{388.0}$	$b_{389.0}$	$b_{388.0}$	$b_{388.0}$	$b_{388.0}$	$b_{388.0}$	$b_{388.0}$	$b_{388.0}$	$b_{386.5}$	$c_{386.0}$	$c_{385.5}$	$c_{385.0}$	$c_{383.0}$	$c_{382.0}$	$c_{384.0}$
43	5.93	237	359.8	374.3	d122	.036	$a_{370.0}$	$a_{378.0}$	$a_{383.0}$	$b_{388.0}$	$b_{387.0}$	$b_{387.0}$	$b_{387.0}$	$b_{387.0}$	$b_{387.0}$	$b_{387.0}$	$b_{386.5}$	$b_{386.5}$	$b_{386.0}$	$c_{386.5}$	$c_{385.0}$	$c_{384.0}$	$c_{383.0}$	$c_{382.0}$	$c_{383.0}$
44	5.91	284	360.9	374.3	d124	.052	$a_{375.0}$	$a_{384.0}$	$b_{390.0}$	$b_{384.0}$	$b_{385.0}$	$b_{386.0}$	$b_{384.0}$	$b_{387.5}$	$b_{386.5}$	$b_{387.5}$	$c_{386.0}$	$c_{386.0}$	$c_{387.0}$	$c_{387.0}$	$c_{386.0}$	$c_{384.0}$	$c_{383.5}$	$c_{382.5}$	$c_{384.0}$
45	5.93	333	360.1	375.4	d125	.065	$a_{379.0}$	$b_{390.0}$	$b_{388.5}$	$b_{384.0}$	$b_{386.0}$	$b_{386.0}$	$b_{385.0}$	$b_{387.0}$	$b_{388.0}$	$b_{389.0}$	$c_{386.0}$	$c_{388.0}$	$c_{389.0}$	$c_{388.5}$	$c_{386.0}$	$c_{386.0}$	$c_{385.0}$	$c_{384.0}$	$c_{385.5}$
69	5.89	338	361.8	375.7	d124	.070	$b_{387.0}$	$b_{394.0}$	$b_{394.0}$	$b_{399.0}$	$b_{394.0}$	$b_{391.0}$	$b_{390.0}$	$b_{390.0}$	$b_{392.0}$	$b_{392.0}$	$c_{393.0}$	$c_{393.0}$	$c_{392.0}$	$c_{391.0}$	$c_{390.0}$	$c_{388.0}$	$c_{387.5}$	$c_{387.0}$	$c_{387.0}$
70	5.95	418	362.1	375.4	d126	.093	$b_{394.0}$	$b_{391.0}$	$b_{391.0}$	$b_{395.0}$	$b_{393.0}$	$b_{392.5}$	$b_{408.0}$	$b_{391.5}$	$b_{393.0}$	$c_{394.0}$	$c_{394.0}$	$c_{394.0}$	$c_{393.5}$	$c_{393.0}$	$c_{391.0}$	$c_{390.0}$	$c_{389.0}$	$c_{388.0}$	$c_{388.0}$
71	5.91	473	362.3	375.9	d128	.111	$b_{393.0}$	$b_{394.5}$	$b_{393.5}$	$b_{394.0}$	$b_{394.0}$	$b_{394.0}$	$b_{393.0}$	$b_{393.0}$	$c_{394.5}$	$c_{394.0}$	$c_{395.0}$	$c_{395.0}$	$c_{394.0}$	$c_{393.5}$	$c_{393.0}$	$c_{391.0}$	$c_{390.0}$	$c_{389.0}$	$c_{388.0}$
72	5.95	556	363.2	375.9	d130	.135	$b_{395.0}$	$b_{396.0}$	$b_{397.0}$	$b_{394.0}$	$b_{392.5}$	$b_{393.0}$	$b_{396.0}$	$b_{395.0}$	$c_{394.5}$	$c_{397.0}$	$c_{396.5}$	$c_{397.0}$	$c_{396.5}$	$c_{396.0}$	$c_{395.0}$	$c_{394.0}$	$c_{392.5}$	$c_{390.5}$	$c_{390.0}$
73	5.96	652	362.6	376.5	d135	.161	$b_{396.5}$	$b_{397.0}$	$b_{396.5}$	$b_{396.0}$	$b_{397.0}$	$b_{394.0}$	$b_{398.0}$	$c_{396.5}$	$c_{397.0}$	$c_{398.5}$	$c_{398.0}$	$c_{399.0}$	$c_{399.0}$	$c_{398.0}$	$c_{396.0}$	$c_{395.5}$	$c_{393.0}$	$c_{391.5}$	$c_{391.5}$
74	5.89	719	363.4	376.9	d137	.184	$b_{396.0}$	$b_{399.0}$	$b_{399.0}$	$b_{396.0}$	$b_{398.0}$	$b_{396.0}$	$b_{398.0}$	$c_{398.0}$	$c_{398.0}$	$c_{400.0}$	$c_{400.0}$	$c_{400.0}$	$c_{401.5}$	$c_{400.5}$	$c_{399.5}$	$c_{398.0}$	$c_{396.0}$	$c_{395.0}$	$c_{393.0}$
75	5.91	772	363.4	376.8	139	.199	$b_{398.0}$	$b_{397.5}$	$b_{397.0}$	$b_{398.0}$	$b_{397.0}$	$b_{398.0}$	$b_{395.5}$	$c_{398.0}$	$c_{399.0}$	$c_{397.5}$	$c_{402.5}$	$c_{400.5}$	$c_{401.0}$	$c_{402.0}$	$c_{401.0}$	$c_{400.0}$	$c_{398.0}$	$c_{395.5}$	$c_{394.0}$
76	5.89	883	363.7	376.8	d144	.232	$b_{396.5}$	$b_{398.0}$	$b_{400.0}$	$b_{398.0}$	$b_{399.5}$	$b_{397.0}$	$b_{399.0}$	$c_{400.5}$	$c_{399.0}$	$c_{402.5}$	$c_{403.0}$	$c_{403.0}$	$c_{404.5}$	$c_{404.0}$	$c_{403.5}$	$c_{402.0}$	$c_{400.0}$	$c_{398.0}$	$c_{396.0}$
77	5.89	933	363.7	377.1	d146	.247	$b_{396.0}$	$b_{399.0}$	$b_{399.0}$	$b_{399.0}$	$b_{401.0}$	$b_{398.5}$	$b_{401.0}$	$c_{401.0}$	$c_{400.0}$	$c_{404.0}$	$c_{405.0}$	$c_{405.0}$	$c_{406.0}$	$c_{406.0}$	$c_{405.0}$	$c_{403.5}$	$c_{402.0}$	$c_{399.0}$	$c_{400.0}$

49	2.36	107	357.6	375.1	123	.038	[a]370.0	[a]376.0	[b]381.0	[b]388.0	[b]386.0	[b]387.0	[b]386.5	[b]384.0	[b]384.0	[b]382.0	[b]383.0	[c]382.0	[c]382.5	[c]383.0	[c]383.0	[c]383.0	[c]383.0	[c]383.0	[c]383.0
50	2.38	134	358.2	374.8	123	.062	[a]379.0	[a]386.0	[b]390.0	[b]384.5	[b]387.0	[b]387.0	[b]386.0	[b]387.0	[b]386.0	[b]386.0	[b]386.0	[c]386.0	[c]387.0	[c]387.0	[c]387.0	[c]386.0	[c]386.0	[c]385.0	[c]384.0
51	2.39	163	355.9	374.3	123	.079	[a]370.5	[b]388.0	[b]386.0	[b]382.5	[b]385.0	[b]384.0	[b]384.0	[b]385.0	[b]383.0	[b]383.0	[c]384.0	[c]385.0	[c]386.0	[c]385.5	[c]385.0	[c]384.0	[c]384.0	[c]383.0	[c]383.0
52	2.35	199	357.6	373.7	[d]122	.112	[a]384.0	[b]385.0	[b]383.0	[b]384.0	[b]386.0	[b]384.0	[b]385.0	[b]386.0	[b]384.0	[b]385.0	(c)	[c]386.0	[c]387.0	[c]386.0	[c]386.0	[c]385.0	[c]384.0	[c]383.5	[c]383.0
53	2.34	231	356.5	374.3	[d]123	.135	[a]383.0	[b]386.5	[b]384.0	[b]384.0	[b]385.5	[b]384.0	[b]384.0	[b]386.0	[b]384.0	[b]385.0	[c]386.0	[c]387.0	[c]387.0	[c]386.0	[c]385.0	[c]384.0	[c]384.0	[c]384.0	[c]383.0
54	2.34	284	357.1	373.7	[d]123	.178	[a]382.5	[b]388.0	[b]385.0	[b]384.5	[b]386.0	[b]384.5	[b]384.0	[b]387.0	[b]385.0	[b]386.0	[c]386.0	[c]388.0	[c]387.5	[c]386.5	[c]386.0	[c]385.0	[c]384.5	[c]384.5	[c]384.5
55	1.39	64	359.8	375.7	119	.048	[a]371.0	[a]378.0	[a]383.5	[b]388.0	[b]387.0	[b]387.0	[b]388.0	[b]385.0	[b]384.0	[b]382.0	[c]381.0	[c]382.0	[c]382.5	[c]383.0	[c]383.0	[c]383.0	[c]383.0	[c]383.5	[c]383.0
56	1.39	91	360.4	375.1	119	.085	[a]377.0	[b]386.0	[b]384.0	[b]384.0	[b]388.0	[b]385.0	[b]384.0	[b]382.5	[b]383.0	[c]383.0	[c]383.0	[c]383.0	[c]384.0	[c]383.5	[c]384.0	[c]383.5	[c]383.5	[c]383.0	[c]384.0
57	0.69	44	355.9	373.2	117	.073	[a]367.5	[a]374.0	[a]380.0	[b]386.0	[b]383.0	[b]383.0	[b]382.5	[b]380.5	[b]378.0	[c]379.0	[c]378.0	[c]379.0	[c]379.5	[c]380.0	[c]380.0	[c]380.0	[c]380.0	[c]381.0	[c]380.0
58	0.69	63	354.8	375.4	123	.118	[a]379.0	[a]381.5	[b]389.0	[b]386.5	[b]384.0	[b]384.0	[b]382.0	[b]380.0	[c]381.0	[c]381.0	[c]381.0	[c]381.0	[c]382.0	[c]382.0	[c]382.0	[c]382.0	[c]382.0	[c]383.0	[c]383.0
59	0.69	79	354.3	375.1	123	.158	[a]380.0	[b]388.0	[b]384.5	[b]384.0	[b]384.0	[b]383.0	[b]380.0	[c]381.0	[c]382.0	[c]382.0	[c]383.0	[c]383.0	[c]383.0	[c]383.0	[c]383.0	[c]383.0	[c]383.0	[c]384.0	[c]383.0
60	0.70	103	354.3	375.1	123	.218	[a]386.0	[b]391.0	[b]383.0	[b]384.0	[b]385.0	[b]383.0	[b]383.0	[c]383.0	[c]385.0	[c]385.0	[c]384.5	[c]385.5	[c]385.0	[c]385.0	[c]386.0	[c]385.0	[c]385.0	[c]385.0	[c]384.5
61	0.68	127	357.1	375.1	[d]123	.295	[b]386.0	[b]384.0	[b]382.5	[b]383.0	[b]383.0	[c]382.0	[c]384.0	[c]384.5	[c]386.0	[c]386.0	[c]386.0	[c]387.0	[c]387.0	[c]387.0	[c]386.0	[c]386.0	[c]386.0	[c]386.0	[c]385.0
62	0.69	155	355.4	374.8	[d]123	.357	[b]385.0	[b]385.0	[b]382.0	[b]381.0	[b]382.0	[c]385.0	[c]385.0	[c]385.0	[c]386.0	[c]387.0	[c]386.0	[c]387.0	[c]387.0	[c]387.5	[c]386.0	[c]386.0	[c]386.0	[c]386.0	[c]385.0
63	0.67	198	356.5	375.1	[d]123	.491	[b]381.0	[b]385.0	[b]381.0	[b]379.0	[b]382.0	[c]382.0	[c]385.0	[c]386.0	[c]384.0	[c]386.0	[c]386.0	[c]387.0	[c]387.0	[c]387.0	[c]387.0	[c]386.0	[c]385.0	[c]384.0	[c]385.0
64	0.69	234	357.1	375.1	[d]123	.570	[b]381.5	[b]385.0	[b]381.0	[b]378.5	[b]383.0	[c]380.0	[c]385.0	[c]387.0	[c]384.0	[c]387.0	[c]387.0	[c]387.0	[c]388.0	[c]388.0	[c]386.0	[c]386.0	[c]385.0	[c]386.0	[c]385.0
65	0.69	269	355.9	374.8	[d]123	.652	(b)	(b)	(b)	(b)	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)	[c]386.0	[c]386.0	[e]381.5	
2	1.34	100	298.7	363.7	99	----	[a]329.5	[a]339.0	[a]349.0	[a]356.0	[a]373.0	[b]379.0	[b]376.0	[b]376.5	[b]376.5	[b]382.0	[b]379.5	[b]378.0	[b]378.0	[b]380.0	[b]380.0	[b]382.0	-----	[b]382.0	[b]377.0
3	1.00	100	293.7	370.4	99	.032	[a]334.5	[a]343.0	[a]354.0	[a]368.0	[b]378.0	[b]374.0	[b]376.5	[b]380.0	[b]381.0	[b]384.0	[b]381.0	[b]377.5	[b]381.0	[b]382.0	[b]380.0	[b]380.5	(c)	[c]383.0	[c]379.0
4	0.69	94	294.3	377.6	122	.099	[a]339.5	[a]349.5	[a]360.0	[a]370.0	[b]385.0	[b]384.0	[b]383.0	[b]379.0	[b]384.0	[b]384.0	[b]388.0	[b]386.0	[b]386.0	[c]385.0	[c]385.0	[c]388.0	(c)	[c]390.0	[c]386.0
5	1.36	130	293.2	373.7	108	.017	[a]338.0	[a]349.0	[a]362.0	[a]377.0	[b]381.0	[b]378.5	[b]381.0	[b]377.0	[b]383.0	[b]394.5	[b]383.0	[b]377.0	[b]382.0	[b]384.0	[b]384.0	[b]383.0	(b)	[c]385.0	[c]380.0
6	1.00	131	293.2	378.7	126	.074	[a]345.0	[a]356.0	[a]369.0	[b]383.0	[b]380.5	[b]384.5	[b]384.5	[b]383.0	[b]387.0	[b]389.0	[b]387.5	[b]378.5	[b]387.0	[b]385.0	[c]386.0	[c]387.5	(c)	[c]390.0	[c]388.0
7	1.34	132	292.6	373.7	[d]110	.020	[a]341.0	[a]351.0	[a]364.5	[a]374.0	[a]382.0	[b]384.0	[b]378.0	[b]383.0	[b]384.0	[b]382.0	[b]382.5	[b]383.0	[b]383.5	[b]385.0	[b]385.0	[b]383.0	(b)	[c]387.0	[c]383.0
8	1.00	132	293.2	375.9	114	.079	[a]344.0	[a]358.5	[a]371.0	[b]385.0	[b]380.0	[b]381.0	[b]381.0	[b]381.0	[b]383.0	[b]386.0	[b]385.5	[b]385.5	[b]384.0	[b]384.0	[c]385.0	[c]386.0	(c)	[c]389.0	[c]383.0
9	0.69	130	293.2	375.9	118	.178	[a]351.0	[a]362.5	[a]376.0	[b]389.0	[b]380.0	[b]382.0	[b]385.5	[b]386.0	[b]385.5	[b]385.5	[b]386.0	[c]384.0	[c]386.0	[c]386.0	[c]385.5	[c]386.0	(c)	[c]389.0	[c]385.0
13	2.36	193	295.9	372.1	112	----	[a]348.0	[a]360.0	[a]371.5	[a]381.5	[a]384.0	[a]385.0	[b]387.0	[b]387.0	[b]387.0	[b]387.0	[b]387.0	[b]387.0	[b]388.0	[b]388.5	[b]388.0	[b]388.5	[b]388.0	(b)	[b]390.0	[b]387.0
14	1.34	192	296.5	374.3	117	.106	[a]362.0	[a]375.0	[b]389.0	[b]383.0	[b]384.0	[b]386.0	[b]386.0	[b]388.0	[b]388.0	[b]389.0	[b]387.0	[b]387.0	[b]386.0	[c]387.0	[c]387.0	[c]388.0	(c)	[c]391.0	[c]389.0
15	1.00	190	296.5	374.3	119	.187	[a]368.0	[a]382.0	[b]387.0	[b]385.0	[b]385.5	[b]387.0	[b]387.0	[b]389.0	[b]389.0	[b]387.0	[b]384.5	[c]386.0	[c]387.0	[c]387.5	[c]389.0	[c]389.0	(c)	[c]392.0	[c]389.0
16	0.69	190	296.5	374.3	119	.348	[a]375.0	[b]389.0	[b]387.0	[b]383.0	[b]385.5	[b]388.0	[b]387.0	[b]386.0	[c]385.0	[c]387.0	[c]386.0	[c]386.0	[c]387.5	[c]388.0	[c]390.0	[c]390.0	(c)	[c]392.0	[c]389.0
17	4.63	252	295.4	347.1	112	----	[a]335.0	[a]346.0	[a]352.0	[a]360.0	[a]374.0	[a]371.5	[a]375.0	[b]377.0	[b]376.0	[b]376.5	[b]378.5	[b]378.5	[b]379.5	[b]381.0	[b]382.5	[b]379.0	(b)	[b]391.0	[b]387.0
18	2.37	251	297.6	374.3	118	.041	[a]362.0	[a]378.0	[b]383.0	[b]382.0	[b]384.0	[b]385.0	[b]385.0	[b]387.0	[b]388.0	[b]385.0	[b]389.0	[b]389.0	[b]389.0	[b]389.0	[b]389.0	[b]389.0	(c)	[c]392.0	[c]390.0
19	1.34	251	296.5	374.3	117	.184	[a]383.0	[b]389.0	[b]388.0	[b]383.0	[b]386.5	[b]387.0	[b]388.0	[b]388.0	[b]388.0	[b]387.5	[b]386.5	[c]386.5	[c]387.5	[c]387.5	[c]391.0	[c]391.0	(c)	[c]392.0	[c]389.0

[a]Nonboiling.

[b]Subcooled boiling.

[c]Net-quality boiling.

[d]Pressure oscillation of >3.5 kN/m^2.

[e]Rose to 397 K causing automatic shutdown.

TABLE II. - HEAT-TRANSFER DATA FOR 1.219-CENTIMETER INSIDE DIAMETER BY 61-CENTIMETER-LONG TEST SECTION 480-50 M

[G = mass velocity, kg/(sec)(m^2); q = heat flux, kW/m^2; T_i = inlet temperature, K; T_e = exit temperature, K; P_e = exit pressure, kN/m^2 abs; x_e = exit quality.]

Run	G	q	T_i	T_e	P_e	x_e	Axial distance from start of heating, z, cm													
							0.635	1.270	2.540	5.080	10.16	15.24	20.32	25.40	30.48	35.56	40.64	45.72	50.80	55.88	60.32
							Inner-wall temperature, T_w, K														
17	5.89	253	294.8	314.8	110	----	[a]335.0	[a]343.0	[a]354.0	[a]355.0	[a]365.0	[a]370.0	[a]372.0	[a]375.0	[a]376.0	[a]377.0	[a]377.0	[a]378.0	[a]379.5	[b]380.0	[b]377.0
18	5.91	315	294.8	320.9	110	----	[a]345.0	[a]354.0	[a]363.0	[a]370.0	[a]375.0	[a]376.5	[a]376.5	[a]378.0	[a]379.0	[a]379.0	[a]379.0	[b]380.0	[b]379.0	[b]379.0	[b]380.0
19	5.92	192	323.7	338.7	110	----	[a]347.0	[a]353.0	[a]360.0	[a]361.0	[a]364.0	[a]368.0	[a]369.0	[a]370.0	[a]373.0	[a]374.0	[a]375.0	[a]376.0	[a]378.0	[a]378.0	[a]378.0
20	5.92	258	324.0	344.6	110	----	[a]356.5	[a]363.0	[a]368.0	[a]375.0	[a]376.5	[a]376.5	[a]377.0	[b]379.0	[b]379.0	[b]379.0	[b]379.0	[b]381.0	[b]379.5	[b]380.0	[b]379.0
21	5.89	328	324.0	350.4	110	----	[a]366.5	[a]373.0	[a]375.0	[b]378.0	[b]375.0	[b]378.0	[b]379.0	[b]378.0	[b]379.0	[b]380.0	[b]379.0	[b]378.0	[b]380.5	[b]386.5	[b]385.0
13	2.38	126	295.9	321.5	107	----	[a]333.0	[a]344.0	[a]353.0	[a]366.5	[b]374.0	[b]379.0	[b]379.0	[b]379.0	[b]379.0	[b]381.0	[b]379.0	[b]379.0	[b]382.0	[b]382.0	[b]379.0
14	2.38	192	295.4	333.2	110	----	[a]352.0	[a]363.0	[b]376.0	[b]376.0	[b]374.0	[b]376.0	[b]376.0	[b]374.0	[b]376.5	[b]375.0	[b]375.0	[b]377.0	[b]378.0	[b]377.0	[b]376.5
15	2.38	254	294.8	345.9	110	----	[a]367.0	[b]380.0	[b]377.0	[b]380.0	[b]380.0	[b]377.0	[b]383.0	[b]384.0	[b]384.0	[b]384.0	[b]384.0	[b]385.0	[b]385.5	[b]386.5	[b]385.0
16	2.38	322	294.8	358.7	110	----	[a]376.5	[b]380.0	[b]380.0	[b]380.0	[c]380.0	[b]384.0	[b]384.0	[b]384.0	[b]385.0	[b]385.0	[b]385.0	[b]386.0	[b]386.0	[b]385.0	[b]385.0
22	2.38	103	320.9	340.9	110	----	[a]347.0	[a]354.0	[a]361.0	[a]367.0	[a]373.0	[b]381.5	[b]374.0	[b]375.0	[b]374.0	[b]376.0	[b]376.5	[b]376.5	[b]378.0	[b]375.0	[b]374.0
23	2.38	128	320.9	345.9	110	----	[a]354.0	[a]361.5	[a]370.0	[b]376.5	[b]374.0	[b]375.0	[b]377.0	[b]375.0	[b]378.0	[b]378.0	[b]378.0	[b]378.0	[b]378.0	[b]378.0	[b]375.0
24	2.38	192	320.7	358.7	110	----	[a]369.0	[a]380.0	[b]381.0	[b]381.5	[b]381.5	[b]383.0	[b]383.0	[b]384.0	[b]384.0	[b]384.0	[b]384.0	[b]384.0	[b]384.5	[b]384.0	[b]386.5
25	2.38	258	320.4	371.5	110	----	[b]383.0	[b]381.0	[b]375.0	[b]375.0	[b]379.0	[b]382.0	[b]382.0	[b]385.0	[b]385.0	[b]385.0	[b]385.0	[b]386.0	[b]386.0	[b]386.0	[b]384.0
26	2.38	315	320.4	374.3	109	.016	[b]385.0	[b]385.0	[b]385.0	[b]385.0	[b]384.0	[b]386.5	[b]385.0	[b]385.0	[b]385.0	[b]385.0	[b]385.0	[b]386.0	[b]385.5	[c]385.0	[c]385.0
37	2.38	102	344.3	364.3	98	----	[a]363.0	[a]370.0	[a]376.5	[b]381.0	[b]379.0	[b]381.0	[b]380.0	[b]380.0	[b]380.0	[b]380.0	[b]380.0	[b]380.0	[b]380.0	[b]380.0	[b]378.0
38	2.36	119	345.4	368.7	98	----	[a]369.0	[a]376.0	[a]378.0	[b]379.0	[b]378.0	[b]380.0	[b]380.0	[b]380.0	[b]380.0	[b]380.0	[b]380.0	[b]380.0	[b]379.0	[b]380.0	[b]380.0	[b]379.0
39	2.38	198	345.4	374.3	108	.019	[b]385.0	[b]384.0	[b]382.0	[b]384.0	[b]381.0	[b]384.0	[b]383.0	[b]383.0	[b]383.0	[b]383.0	[b]383.0	[b]384.0	[c]384.0	[c]384.0	[c]384.0
6	0.68	54	298.2	335.4	109	----	[a]327.0	[a]333.0	[a]342.0	[a]350.0	[a]360.0	[a]366.5	[a]371.0	[a]371.5	[a]374.0	[a]358.0	[a]361.0	[a]367.0	[a]374.5	[a]376.5	[a]376.5
7	0.68	101	297.1	366.8	109	----	[a]346.5	[a]358.0	[a]370.0	[a]379.0	[b]379.0	[b]380.0	[b]381.5	[b]381.5	[b]383.0	[b]381.5	[b]381.5	[b]383.0	[b]381.5	[b]382.0	[b]382.0
8	0.69	124	297.1	373.2	109	.014	[a]355.0	[a]356.5	[a]379.0	[b]379.0	[b]381.0	[b]382.0	[b]383.0	[b]383.0	[b]383.0	[b]383.0	[b]383.0	[b]381.5	[b]381.5	[c]382.0	[c]383.0
9	0.69	154	297.1	373.2	108	.055	[a]368.0	[b]381.5	[b]381.5	[b]381.0	[b]380.0	[b]379.0	[b]383.0	[b]383.0	[b]383.0	[b]383.0	[b]383.0	[c]383.0	[c]383.0	[c]383.0	[c]383.0
10	0.68	191	298.7	375.4	114	.105	[b]378.0	[b]378.0	[b]379.0	[b]380.0	[b]380.0	[b]384.0	[b]383.0	[b]383.0	[b]383.0	[c]384.0	[c]384.0	[c]385.0	[c]385.5	[c]385.0	[c]384.0
11	0.69	259	298.2	375.4	114	.191	[b]384.0	[b]384.0	[b]383.0	[b]384.0	[b]382.0	[b]385.0	[b]384.0	[b]383.0	[c]384.0	[c]385.0	[c]385.0	[c]385.0	[c]386.5	[c]386.5	[c]386.0
12	0.69	315	297.6	374.8	114	.262	[b]384.0	[b]384.0	[b]383.0	[b]384.0	[b]382.0	[b]384.0	[b]383.0	[c]383.0	[c]384.0	[c]385.0	[c]385.0	[c]385.0	[c]386.5	[c]386.5	[c]386.5
27	0.71	105	336.5	374.3	108	.061	[a]379.0	[b]386.5	[b]383.0	[b]383.0	[b]383.0	[b]384.0	[b]384.0	[b]384.0	[b]383.0	[c]383.0	[c]384.0	[c]384.0	[c]385.0	[c]384.0	[c]384.0
28	0.69	185	326.5	376.5	117	.143	[b]388.0	[b]386.5	[b]384.0	[b]384.0	[b]385.0	[b]384.0	[b]386.5	[c]384.0	[c]385.0	[c]386.0	[c]386.0	[c]386.5	[c]386.5	[c]386.5	[c]386.5
29	0.69	256	325.4	376.5	116	.234	[b]386.0	[b]385.0	[b]385.0	[b]386.0	[b]383.0	[b]385.0	[c]385.0	[c]385.0	[c]386.0	[c]388.0	[c]387.0	[c]388.0	[c]388.0	[c]388.0	[c]388.0
30	0.69	322	325.4	375.9	114	.322	[b]386.0	[b]385.0	[c]385.0	[b]386.0	[b]382.0	[c]385.0	[c]385.0	[c]385.0	[c]386.5	[c]388.0	[c]388.0	[c]389.0	[c]389.5	[c]390.0	[c]391.0
31	0.69	126	348.7	375.4	112	.111	[b]386.0	[b]384.0	[b]384.0	[b]384.0	[b]382.0	[b]384.0	[c]383.0	[c]385.0	[c]385.0	[c]385.0	[c]385.0	[c]385.0	[c]386.5	[c]386.0	[c]385.0
32	0.69	191	349.8	375.9	113	.198	[b]386.5	[b]385.0	[b]385.0	[b]384.0	[b]382.0	[c]384.0	[c]385.0	[c]385.0	[c]385.0	[c]384.0	[c]384.0	[c]388.0	[c]387.0	[c]388.0	[c]387.0
33	0.68	254	348.7	375.9	112	.283	[b]386.0	[b]386.0	[b]383.0	[b]383.0	[c]381.5	[c]385.0	[c]385.0	[c]385.0	[c]386.0	[c]386.0	[c]387.0	[c]388.0	[c]388.0	[c]388.0	[c]388.0
34	0.69	325	350.9	375.9	112	.369	[b]385.0	[b]385.0	[b]383.0	[b]383.0	[c]382.0	[c]385.0	[c]385.0	[c]385.0	[c]385.0	[c]389.0	[c]389.0	[c]389.0	[c]390.5	[c]390.0	[c]390.0
41	0.69	97	295.9	338.4	[d]26	.045	[e]	[e]	[e]	[e]	[e]	[e]	[e]	[e]	[b]350.0	[b]349.0	[c]348.0	[c]348.0	[c]350.0	[c]350.0	[c]347.0
42	0.69	126	[f]295.9	[f]338.2	[d]25	.082	[e]	[e]	[e]	[e]	[e]	[e]	[b]351.5	[b]349.0	[c]348.0	[c]350.0	[c]351.5	[c]353.0	[c]353.0	[c]353.0	[c]349.0
43	0.69	193	[f]295.4	[f]338.2	[d]25	.164	[e]	[e]	[e]	[b]350.0	[b]351.5	[b]353.0	[c]352.0	[c]354.0	[c]348.0	[c]350.0	[c]351.5	[c]353.0	[c]353.0	[c]353.0	[c]351.5
44	0.69	254	[f]295.4	[f]338.2	[d]25	.241	[g]	[g]	[g]	[g]	[g]	[g]	[g]	[g]	[g]	[g]	[g]	[g]	[g]	[g]	[c]355.0
45	0.69	108	335.9	338.7	[d]26	.129	[a]348.0	[a]349.0	[b]351.0	[c]350.0	[c]351.0	[c]350.0	[c]352.0	[c]354.0	[c]355.0	[c]355.0	[c]354.0	[c]354.0	[c]354.0	[c]354.0	[c]352.0
46	0.69	127	335.4	338.7	[d]26	.152	[b]352.0	[b]350.0	[b]351.5	[c]351.5	[c]352.0	[c]354.0	[c]355.0	[c]356.5	[c]356.5	[c]357.0	[c]357.0	[c]356.5	[c]356.5	[c]355.0	[c]352.0
[h]47	0.69	194	334.8	339.3	[d]26	.234	[b]353.0	[b]353.0	[c]354.0	[c]356.0	[c]359.0	[c]359.0	[c]358.0	[c]360.0	[c]358.0	[c]360.0	[c]350.0	[c]359.0	[c]359.0	[c]358.0	[c]353.0
[h]48	0.69	256	335.4	339.3	[d]26	.314	[b]352.0	[b]352.0	[c]352.0	[c]353.0	[c]352.0	[c]355.0	[c]356.5	[c]357.0	[c]356.0	[c]359.0	[c]359.0	[c]359.0	[c]358.0	[c]356.5	[c]352.0

[a] Nonboiling.

[b] Subcooled boiling.

[c] Net-quality boiling.

[d] Estimated from exit temperature.

[e] Very unsteady.

[f] Temperature oscillation.

[g] Automatic shutdown did not allow measurement.

[h] Automatic shutdown after data taken.

TABLE III. - HEAT-TRANSFER DATA FOR 1.219-CENTIMETER INSIDE DIAMETER BY 61-CENTIMETER-LONG TEST SECTION 480-50

[G = mass velocity, kg (sec)(m^2); q - heat flux, kW m^2; T_i = inlet temperature, K; T_e = exit temperature, K; P_e = exit pressure, kN/m^2 abs; x_e = exit quality; ΔP = pressure drop, kN m^2.]

Run	G	q	T_i	T_e	P_e	x_e	ΔP	Axial distance from start of heating, z, cm												
								2.540	7.645	12.70	17.78	22.89	27.94	33.02	38.10	43.18	48.26	53.34	58.42	59.05	59.72	60.35
								Inner-wall temperature, T_w, K														
4	[illegible]	403	293.2	323.7	115	----	--	[a]377.0	[a]397.0	[a]399.0	[a]400.0	[a]400.0	[a]400.0	[a]400.0	[a]399.0	[b]401.0	[b]400.0	[b]397.0	[b]393.0	[b]389.0	[b]394.0	[b]391.5
5	[illegible]	545	292.6	334.3	115	----	--	(c)	(c)	(c)	(c)	[a]255.0	[a]403.0	[a]403.0	[a]403.0	[b]403.0	[b]403.0	[b]404.0	[b]398.0	[b]389.0	[b]395.0	(b)
8	5.93	530	291.5	333.2	115	----	--	[a]401.5	[a]406.5	[a]414.0	[a]406.0	406.0	[a]405.0	[a]406.0	[a]406.0	[b]406.0	[b]405.0	[b]403.0	[b]398.0	[b]394.0	[b]399.0	[b]398.0
14	10.3	326	390.9	374.8	153	.040	34	[a]400.0	[a]401.5	[a]401.0	[a]400.0	[a]399.0	[a]399.0	[a]398.0	[a]397.0	[a]396.0	[a]395.0	[a]394.0	[a]394.0	[a]391.5	[d]393.0	[d]390.0
15	10.3	517	390.9	375.4	154	.053	34	[a]410.0	[a]413.0	[a]413.0	[a]412.0	[a]409.0	[a]406.0	[a]405.0	[a]403.0	[a]401.0	[a]400.0	[a]399.0	[a]398.0	[a]395.0	[d]397.0	[d]395.0
11	11.3	690	294.3	322.1	117	----	--	[a]381.0	[a]396.0	[a]398.0	[a]400.0	[a]399.0	[a]401.0	[a]400.0	[b]401.0	[b]401.5	[b]403.0	[b]402.0	[b]399.0	[b]393.0	[c]400.0	[b]395.0
12	12.0	924	294.8	332.1	117	----	--	[a]405.0	[a]411.5	[a]410.0	[a]410.0	[a]409.0	[a]410.0	[a]409.0	[a]405.0	[a]408.0	[a]409.0	[a]408.0	[a]401.0	[b]396.5	[b]404.0	[b]400.0
13	11.9	1220	295.4	343.7	117	----	--	-----	[a]411.5	[a]411.0	[a]413.0	[a]413.0	[a]413.0	[a]411.0	[a]411.0	[a]411.0	[a]409.0	[b]407.0	[b]403.0	[b]404.0	[b]405.0	[b]401.5
19	10.4	687	385.9	374.8	153	.061	24	[a]414.0	[a]418.0	[a]416.5	[a]417.0	[a]414.0	[a]413.0	[a]410.0	[a]407.0	[a]405.0	[a]404.0	[d]403.0	[d]400.0	[d]398.0	[d]400.0	[d]398.0
20	10.	993	384.3	377.1	170	.078	33	[a]418.0	[a]398.0	[a]423.0	[a]423.0	[a]419.0	[a]419.0	[a]418.0	[a]415.0	[a]413.0	[a]412.0	[a]410.0	[a]408.0	[d]411.0	[d]407.0	[d]405.0
21	10.	1252	392.6	379.8	210	.102	55	[a]428.0	[a]430.0	[a]430.0	[a]430.0	[a]428.0	[a]428.0	[a]427.0	[a]426.0	[a]424.0	[a]423.0	[a]421.0	[a]418.0	[d]416.5	[d]418.0	[d]415.0
22	[illegible]	1259	385.4	378.7	187	.163	45	[a]421.0	[a]426.0	[a]419.0	[a]426.0	[a]424.0	[a]425.0	[a]426.0	[a]422.0	[a]421.5	[a]420.0	[a]418.0	[a]415.0	[d]414.0	[d]415.0	[d]413.0
23	[illegible]	1259	385.9	377.1	173	.201	42	[a]419.0	[a]423.0	[a]422.0	[a]423.0	[a]421.5	[a]422.0	[a]421.5	[a]420.0	[a]419.0	[a]419.0	[a]416.5	[a]414.0	[d]413.0	[d]413.0	[d]410.0
24	4.9	1343	386.5	377.6	170	.241	41	[a]419.0	[a]422.0	[a]421.0	[a]434.0	[a]422.0	[a]423.0	[a]422.0	[a]421.0	[a]420.0	[a]418.0	[a]416.5	[a]413.0	[d]412.0	[d]413.0	[d]411.0
25	4.[illegible]	1359	385.4	377.1	163	.303	36	416.5	[a]421.5	[a]420.0	[a]421.5	[a]420.0	[a]421.5	[a]421.0	[a]420.0	[a]419.0	[a]418.0	[a]415.0	[a]413.0	[d]411.5	[d]412.0	[d]411.0
26	5.[illegible]	1352	384.3	375.9	154	.377	32	[a]414.0	[a]420.0	[a]418.0	[a]420.0	[a]420.0	[a]420.0	[a]420.0	[a]418.0	[a]417.0	[a]415.0	[a]414.0	[a]411.0	[d]410.0	[d]410.0	[d]407.0
27	[illegible]	1362	383.7	374.8	152	.446	30	(c)	(c)	(c)	(e)	(c)	(c)	(c)	(c)	(e)	(e)	(e)	(e)	(e)	(e)	[d]406.5
28	.0.	1995	387.6	378.2	239	.149	79	[a]436.0	[a]435.0	[a]435.0	[a]437.0	[a]434.0	[a]435.0	[a]435.0	[a]433.0	[a]433.0	[a]432.0	[a]430.0	[d]426.0	(d)	[d]425.0	[d]424.0
29	[illegible]	1589	389.8	377.1	221	.204	77	[a]432.0	[a]435.0	[a]434.0	[a]436.5	[a]434.0	[a]434.0	[a]435.0	[a]433.0	[a]432.0	[a]432.0	[a]430.0	[d]429.0	(d)	[d]425.0	[d]424.0
30	[illegible]	1589	388.2	376.5	202	.315	72	[a]431.0	[a]431.0	[a]431.0	[a]434.0	[a]432.0	[a]433.0	[a]434.0	[a]431.5	[a]431.5	[a]427.0	[a]428.0	[d]424.0	[d]421.5	[d]424.0	[d]423.0
31	4.[illegible]	1589	389.8	375.9	195	.360	70	[a]430.0	[a]431.5	[a]430.0	[a]435.0	[a]430.0	[a]430.0	[a]435.0	[a]430.0	[a]430.0	[a]427.0	[a]427.0	[d]423.0	(d)	[d]422.0	[d]421.5
32	4.[illegible]	1992	387.6	375.4	186	.424	64	425.0	[a]428.0	[a]435.0	[a]431.0	[a]430.0	[a]430.0	[a]432.0	[a]430.0	[a]429.0	[a]426.0	[a]425.0	[d]421.5	[d]419.0	[d]420.0	[d]418.0
33	5. [illegible]	1592	388.7	374.8	181	.476	61	424.0	[a]430.0	[a]429.0	[a]430.0	[a]431.0	[a]430.0	[a]431.5	[a]428.0	[a]428.0	[a]426.5	[a]423.0	[d]418.0	[d]418.0	[d]414.0	[d]414.0

[a]Nonboiling.

[b]Subcooled boiling.

[c]Fluctuating.

[d]Net-quality boiling.

[e]Automatic shutdown.

TABLE IV. - EXPERIMENTAL DATA FOR 0.584-CENTIMETER INSIDE DIAMETER BY 61-CENTIMETER-LONG TEST SECTION 230-100

[G = mass velocity, kg (sec)(m^2); q - heat flux, kW m^2; T_i = inlet temperature, K; T_e = exit temperature, K; P_e = exit pressure, kN/m^2 abs; ΔP = pressure drop, kN/m^2; x_e = exit quality.]

Run	G	q	T_i	T_e	P_e	ΔP	x_e	Axial distance from start of heating, z, cm												
								5.080	10.16	15.24	20.32	25.40	30.48	35.56	40.64	45.72	50.80	55.88	57.15	57.15	57.78	57.78
								Inner-wall temperature, T_w, K														
67	23.2	1790	294.3	350.4	114	[illegible]	----	[a]399.0	[a]392.0	[a]391.0	[b]392.0	[a]395.0	[a]399.0	[a]403.0	[a]403.0	[a]403.0	[a]404.0	[a]400.0	[a]400.0	[a]399.0	[a]403.0	[a]400.0
68	23.2	2153	294.3	362.6	114	[illegible]	----	[a]398.0	[a]403.0	[a]406.0	[a]407.0	[a]408.0	[a]404.0	[a]406.5	[a]405.0	[a]403.0	[a]405.0	[a]432.0	[a]401.5	[a]401.5	[a]400.0	[a]401.5
71	46.2	1995	293.2	333.2	114	[illegible]	----	373.0	378.0	379.0	[a]380.0	[a]380.0	382.0	386.0	388.0	[a]389.0	[a]393.0	[a]391.0	[a]393.0	[a]393.0	[a]393.0	[a]397.0
72	46.2	3215	294.3	355.4	114	[illegible]	----	(c)	396.0	400.0	[a]408.0	[a]406.5	[a]409.0	[a]407.0	[a]403.0	[a]405.0	[a]403.0	[a]433.0	(a)	[a]402.0	[a]401.5	[a]402.0
73	46.2	3467	294.8	363.7	114	[illegible]	----	400.0	407.0	414.0	[a]415.0	[a]416.0	[a]413.0	[a]414.0	[a]413.0	[a]409.0	[a]411.5	[a]438.0	[a]408.0	[a]405.0	[a]405.0	[a]405.0
74	46.2	3845	295.4	370.4	114	[illegible]	----	413.0	415.0	419.0	[a]420.0	[a]420.0	[a]415.0	[a]415.0	[a]414.0	[a]412.0	[a]414.0	[a]439.0	[a]408.0	[a]408.0	[a]405.0	[a]407.0
75	46.2	3940	295.4	373.2	114	[illegible]	.0007	414.0	418.0	421.5	[b]423.0	[a]422.0	[a]418.0	[a]419.0	[a]418.0	[a]414.0	[a]417.0	[a]411.5	[a]411.0	[a]410.0	[a]408.0	[a]409.0

[a]Subcooled boiling.

[b]Nonboiling.

Error

An error occurred while processing this page. See the system log for more details.

	Axial distance from start of heating, z, cm						1.27	3.81	6.35	8.89	11.43	13.97	16.51	19.05	21.59	24.13	26.67	27.30	27.90	28.57
1C	27.8	2673	292.1	334.3	115	13	[b]406.0	[b]396.0	[b]400.0	[b]408.0	-----	[b]411.5	[b]413.0	[b]413.0	-----	[b]411.5	[b]408.0	[b]406.0	[b]410.0	[b]406.0
3C	28.1	2244	310.9	346.5	115	13	[b]413.0	[b]414.0	[b]416.0	[b]419.0	[b]418.0	[b]413.0	[b]410.0	[b]412.0	-----	[b]407.0	[b]406.5	[b]405.0	[b]408.0	[b]404.0
8C	27.8	1992	332.6	365.4	115	24	[b]413.0	[b]414.0	[b]413.0	[b]413.0	[b]415.0	[b]411.5	[b]413.0	[b]413.0	-----	[b]412.0	[b]407.0	[b]408.0	[b]410.0	[b]404.0
9C	14.3	1504	290.9	339.8	114	9	[b]405.0	[b]405.0	[b]406.0	[b]408.0	[b]409.0	[b]405.0	[b]408.0	[b]408.0	[b]405.0	[b]406.0	[b]403.0	[b]404.0	[b]411.0	[b]400.0
10C	14.4	1806	290.9	349.8	114	10	[b]403.0	[b]407.0	[b]409.0	[b]411.0	[b]411.0	[b]407.0	[b]409.0	[b]410.0	[b]408.0	[b]408.0	[b]406.0	[b]404.0	[b]410.0	[b]402.0
11C	14.4	2065	290.9	357.6	114	10	[b]403.0	[b]407.0	[b]408.0	[b]411.0	[b]410.0	[b]408.0	[b]410.0	[b]411.0	[b]410.0	[b]409.0	[b]405.0	[b]404.0	[b]411.0	[b]404.0
13C	14.1	2058	292.1	359.3	310	8	[a]431.0	[a]435.0	[a]436.0	[b]438.0	[b]438.0	[b]438.0	[b]440.0	[b]438.0	[b]435.0	[b]438.0	[b]434.0	[b]430.0	[b]434.0	[b]430.0
14C	14.3	2348	292.1	368.2	310	9	[b]430.0	[b]434.0	[b]434.0	[b]436.0	[b]435.0	[b]436.0	[b]438.0	[b]439.0	[b]435.0	[b]439.0	[b]435.0	[b]431.5	[b]435.0	[b]431.5
15C	14.3	2723	292.6	380.9	310	10	[b]433.0	[b]437.0	[b]437.0	[b]438.0	[b]438.0	[b]438.0	[b]440.0	[b]439.0	[b]437.0	[b]439.0	[b]436.5	[b]433.0	[b]435.0	[b]433.0
17C	14.1	2351	313.2	388.2	310	14	[a]431.5	[b]434.0	[b]434.0	[b]435.0	[b]435.0	[b]435.0	[b]436.0	[b]436.5	[b]433.0	[b]436.0	[b]433.0	[b]429.0	[b]433.0	[b]430.0
19C	14.4	1740	339.8	395.4	310	14	[a]431.5	[b]435.0	[b]434.0	[b]434.0	[b]434.0	[b]433.0	[b]434.0	[b]434.0	[b]433.0	[b]433.0	[b]431.5	[b]428.0	[b]431.5	[b]429.0
21C	27.3	3373	337.6	391.5	311	28	[a]435.0	[b]438.0	[b]437.0	[b]439.0	[b]439.0	[b]438.0	[b]440.0	[b]442.0	[b]436.0	[b]440.0	[b]436.0	[b]432.0	[b]436.0	[b]434.0
23C	27.8	2679	353.2	395.9	311	26	[a]435.0	[b]437.0	[b]437.0	[b]439.0	[b]439.0	[b]438.0	[b]439.0	[b]440.0	[b]435.0	[b]438.0	[b]434.0	[b]431.0	[b]436.0	[b]433.0
25C	28.7	2345	292.1	368.7	447	8	[a]444.0	[a]446.5	[b]448.0	[b]449.0	[b]449.0	[b]450.0	[b]451.5	[b]449.0	[b]449.0	[b]449.0	[b]446.5	[b]444.0	[b]449.0	[b]447.0
26C	28.5	2582	292.1	389.3	447	8	[a]443.0	[b]446.5	[b]446.5	[b]449.0	[b]448.0	[b]448.0	[b]449.0	[b]449.0	[b]448.0	[b]449.0	[b]446.5	[b]444.0	[b]446.5	[b]445.0
28C	14.4	2607	314.3	396.5	448	12	[a]441.0	[b]445.0	[b]445.0	[b]448.0	[b]446.5	[b]447.0	[b]448.0	[b]448.0	[b]446.0	[b]448.0	[b]445.0	[b]443.0	[b]445.0	[b]442.0
36C	70.1	6115	299.3	339.8	117	26/ 30	[a]400.0	[a]401.5	[a]405.0	[b]415.0	[b]415.0	[b]416.0	[b]419.0	[b]421.0	[b]414.0	[b]419.0	[b]414.0	[b]412.0	[b]413.0	[b]413.0
37C	70.2	6493	299.8	343.2	117	35/ 46	[a]399.0	[a]409.0	[a]414.0	[b]418.0	[b]416.5	[b]416.5	[b]419.0	[b]423.0	[b]415.0	[b]421.0	[b]416.0	[b]412.0	[b]414.0	[b]414.0
38C	70.2	6966	300.4	347.1	117	52/ 70	[a]408.0	[a]417.0	[a]420.0	[b]423.0	[b]421.0	[b]424.0	[b]424.0	[b]426.5	[b]419.0	[b]424.0	[b]419.0	[b]415.0	[b]416.5	[b]415.0
40C	70.2	4886	325.4	357.6	117	63/ 66	[c]419.0	[c]419.0	[c]418.0	[b]420.0	[c]418.0	[c]419.0	[c]421.5	[b]423.0	[b]416.5	[b]418.0	[b]416.0	[b]414.0	[b]414.0	[b]412.0
41C	70.3	5169	326.5	360.9	117	71/ 74	[c]417.0	[c]421.5	[c]419.0	[b]422.0	[c]420.0	[c]421.0	[b]423.0	[b]425.0	[b]419.0	[b]422.0	[b]417.0	[b]415.0	[b]415.0	[b]414.0
42C	70.1	5516	325.9	363.2	117	80/ 83	[c]419.0	[c]424.0	[c]424.0	[b]425.0	[b]424.0	[b]424.0	[b]425.0	[b]430.0	[b]421.5	[b]426.0	[b]420.0	[b]418.0	[b]418.0	[b]415.0
43C	70.1	6146	326.5	367.6	117	96/101	[b]423.0	[c]430.0	[b]428.0	[b]430.0	[b]429.0	[b]428.0	[b]431.0	[b]433.0	[b]426.0	[b]431.0	[b]423.0	[b]420.0	[b]421.0	[b]418.0
44C	70.4	6209	324.8	366.5	117	92/105	[c]423.0	[b]429.0	[b]428.0	[b]430.0	[b]429.0	[b]429.0	[b]431.0	[b]433.0	[b]426.5	[b]431.0	[b]424.0	[b]421.0	[b]421.5	[b]421.0
45C	70.1	6493	324.8	368.7	117	103/108	[c]427.0	[c]433.0	[b]431.5	[b]434.0	[b]433.0	[c]433.0	[b]434.0	[b]438.0	[b]429.0	[b]434.0	[b]427.0	[b]424.0	[b]425.0	[b]421.5
47C	47.0	5201	297.6	348.7	115	21/ 35	[a]417.0	[c]420.0	[c]419.0	[b]420.0	[c]417.0	[c]418.0	[b]419.0	[b]421.5	[b]415.0	[b]420.0	[b]419.0	[b]413.0	[b]415.0	[b]416.0
49C	47.0	4917	310.9	356.5	115	35/ 49	[a]418.0	[b]420.0	[c]417.0	[b]417.0	[c]414.0	[b]415.0	[b]416.5	[b]419.0	[b]413.0	[b]416.0	[b]413.0	[b]410.0	[b]410.0	[b]411.0
51C	47.0	5106	323.2	370.9	115	66/ 77	[a]422.0	[b]424.0	[b]421.5	[b]423.0	[b]420.0	[b]421.5	[b]423.0	[b]426.0	[b]418.0	[b]423.0	[b]417.0	[b]414.0	[b]414.0	[b]412.0

[a]Nonboiling.

[b]Subcooled boiling.

Error

An error occurred while processing this page. See the system log for more details.

INSIDE DIAMETER BY 29.2-CENTIMETER-LONG TEST SECTIONS 230-50, 230-50B, 230-50C, AND 230-50E

T_e = exit temperature, K; P_e = exit pressure, kN/m^2 abs; ΔP = pressure drop, kN/m^2.]

Run	G	q	T_i	T_e	P_e	Inner-wall temperature, T_w, K										
Axial distance from start of heating, z, cm						1.27	3.81	6.35	11.43	13.97	16.51	19.02	21.56	24.13	26.67	29.21	28.57
4E	28.1	2292	324.8	360.9	687	a428.0	a439.0	a442.0	a447.0	a449.0	b451.0	b445.0	b448.0	b450.0	b449.0	b451.0	b449.0
5E	28.0	2723	316.5	360.9	689	a439.0	b453.	b445.0	b446.0	b448.0	b445.0	b447.0	b449.0	b450.0	b450.0	b453.0	b450.0
6E	28.4	3C95	310.4	360.9	687	a446.0	b448.0	b448.0	b449.0	b450.0	b450.0	b450.0	b453.0	b455.0	b453.0	b456.5	b453.0
7E	28.0	3436	304.3	360.9	687	a449.0	b453.0	b453.0	b453.0	b454.0	b453.0	b453.0	b455.0	b458.0	b455.0	b456.5	b456.5
8E	28.0	3782	298.7	360.9	687	a454.0	b456.0	b455.0	b455.0	b458.0	b456.0	b455.0	b459.0	b460.0	b459.0	b462.0	b460.0
10E	28.1	1545	352.1	383.2	687	a426.5	a435.0	a440.0	a445.0	a447.0	a448.0	a449.0	a450.0	b452.0	b451.0	b453.0	b451.0
11E	28.0	2320	345.9	383.2	687	a435.0	a444.0	a447.0	a450.0	b450.0	b450.0	b451.0	b453.0	b458.0	b453.0	b455.0	b453.0
12F	28.0	2613	341.5	383.2	687	a446.5	a453.0	a453.0	b455.0	b455.0	b454.0	b454.0	b456.0	b456.5	b455.0	b458.0	b455.0
13E	28.0	3152	332.1	383.2	687	a456.5	b458.0	b458.0	b460.0	b460.0	b459.0	b458.0	b459.0	b460.0	b457.0	b460.0	b457.0
14E	28.0	3499	325.9	383.2	687	b457.0	b459.0	b460.0	b461.0	b462.0	b460.0	b459.0	b460.0	b461.5	b458.0	b461.0	b459.0
18E	28.0	1582	369.3	394.3	688	a426.5	a435.0	a437.0	a443.0	a444.0	a445.0	a446.0	a448.0	b450.0	b449.0	b451.5	b450.0
19C	28.0	2C65	360.9	394.3	688	a439.0	a450.0	a453.0	a454.0	b455.0	b454.0	b454.0	b455.0	b455.0	b453.0	b455.0	b453.0
20E	28.0	2355	355.9	394.3	688	a446.5	b455.0	b454.0	b457.0	b458.0	b456.0	b455.0	b456.0	b458.0	b455.0	b456.0	b454.0
21E	28.0	2C36	362.1	394.8	689	a441.5	a450.0	a452.0	a455.0	b457.0	b455.0	b454.0	b455.0	b456.5	b455.0	b456.5	b455.0
22F	28.0	2780	350.4	394.3	687	a458.0	b458.0	b459.0	b461.0	b461.5	b460.0	b459.0	b461.0	b461.0	b458.0	t460.0	b459.0
23E	28.0	3152	343.7	394.3	687	a456.0	b458.0	b460.0	b461.0	b462.0	b460.0	b458.0	b460.0	b462.0	t460.0	t452.0	b461.0
24E	28.0	3373	339.8	394.3	688	a457.0	b460.0	b461.0	b461.5	b462.0	b460.0	b459.0	b461.0	b463.0	t460.0	t450.0	t462.0
25E	28.1	1532	370.4	394.3	688	a428.0	a434.0	a437.0	a443.0	a445.0	a445.0	a445.0	a448.0	b450.0	t449.0	t451.0	t450.0
28E	28.0	1C12	389.8	405.4	687	a424.0	a428.0	a430.0	a434.0	a436.0	a435.0	a436.0	a440.0	a441.0	a441.0	a444.0	a441.0
29E	28.0	1330	384.3	405.4	687	a433.0	a439.0	a441.5	a446.0	a448.0	a448.0	a448.0	a450.0	t451.5	t450.0	b452.0	b451.5
30F	28.0	1879	374.8	405.4	688	a443.0	b451.5	b451.5	b453.0	t454.0	t453.0	t452.0	b454.0	b454.0	t455.0	t454.0	t454.0
31E	28.0	2342	368.2	405.4	688	b454.0	b453.0	b454.0	b455.0	b455.0	b454.0	b454.0	b455.0	t457.0	t455.0	t456.5	t455.0
32F	28.0	2739	361.5	405.4	688	b450.0	b454.0	b455.0	b457.0	b458.0	t455.0	t455.0	t458.0	t458.0	t457.0	t459.0	t458.0
33C	28.0	3C95	355.9	405.4	688	b454.0	b458.0	b459.0	b461.0	t461.5	t460.0	t460.0	b461.0	t463.0	t459.0	t452.0	b460.0
38E	47.0	2796	333.7	360.9	687	a413.0	a421.0	a424.0	a429.0	a431.5	a432.0	a433.0	a438.0	a441.0	a439.0	a444.0	a443.0
39E	47.0	3593	324.8	360.7	687	a429.0	a436.0	a440.0	a447.0	a448.0	a449.0	a450.0	a453.0	t458.0	t454.0	t459.0	t456.0
40F	47.0	4224	318.7	360.9	687	a445.0	a454.0	a456.5	a458.0	t460.0	t457.0	t456.0	t460.0	t463.0	t460.0	t454.0	t460.0
41F	47.0	4854	312.6	361.2	688	a457.0	a459.0	b460.0	b460.0	t463.0	t460.0	t459.0	b461.5	t464.0	t461.0	t455.0	t463.0
42E	47.0	5453	306.5	360.9	689	a461.0	b463.0	t463.0	b463.0	t464.0	t461.5	t460.0	t464.0	t466.5	t463.0	t470.0	t465.0
44F	46.7	2449	359.3	383.2	683	a420.0	a425.0	a428.0	a435.0	a436.0	t438.0	t439.0	t443.0	t447.0	t446.0	t451.0	t446.5
45E	47.0	2882	354.8	383.2	686	a429.0	a435.0	a440.0	a445.0	t446.5	t450.0	t450.0	a453.0	t456.5	t455.0	t458.0	t456.0
46F	46.7	3404	349.8	383.2	687	a439.0	a446.0	a450.0	a456.0	t458.0	t456.5	t456.5	t459.0	t462.0	t458.0	t462.0	t458.0
47E	47.0	4C03	343.2	383.2	687	a448.0	a456.5	a459.0	b460.0	t461.0	t459.0	t459.0	t461.0	t464.0	t461.0	t454.0	t461.0
48E	46.7	4602	337.1	383.2	687	a459.0	-----	-----	t465.0	t466.5	t464.0	t463.0	t465.0	t466.5	t463.0	t456.0	t462.0
49F	47.0	5327	329.3	383.2	687	a466.5	t469.0	t469.0	b469.0	t470.0	t468.0	t467.0	t469.0	t473.0	t467.0	t470.0	t465.0
50C	47.0	2244	360.9	383.2	687	a420.0	a425.0	a428.0	a431.0	a436.5	a437.0	a437.0	a441.0	a443.0	a444.0	a448.0	a445.0
52E	47.0	2C20	374.8	394.3	683	a424.0	a429.0	a428.0	a438.0	a440.0	a440.0	a440.0	a444.0	a447.0	a447.0	a449.0	a447.0
53F	47.0	2559	368.7	394.3	687	a431.5	a446.0	a448.0	a449.0	a452.0	a453.0	a452.0	a455.0	t458.0	t456.5	t459.0	t456.5
54E	47.0	3467	360.4	394.3	687	a446.0	a455.0	a455.0	a458.0	t459.0	t457.0	t456.5	t459.0	t461.5	t459.0	t461.5	t458.0
55E	47.0	4C66	354.3	394.3	687	a456.5	a463.0	a464.0	a465.0	t466.0	t464.0	t463.0	t464.0	t465.0	t461.5	t454.0	t461.0
56E	46.7	4350	350.9	394.3	687	a461.0	a464.0	t465.0	t467.0	b468.0	t465.0	t463.0	t466.0	t468.0	t463.0	t456.0	t462.0
57F	46.7	4760	347.1	394.3	687	a465.0	b468.0	b468.0	b469.0	t469.0	t468.0	t466.0	t468.0	t470.0	t464.0	t457.0	t464.0
58E	47.0	5C12	344.8	394.3	687	b465.0	b468.0	b469.0	b469.0	b469.0	t467.0	t465.0	t468.0	t469.0	t465.0	t459.0	t465.0
59E	47.0	5295	342.1	394.3	687	b465.0	b467.0	t469.0	t469.0	t469.0	t466.0	t465.0	t467.0	t470.0	t465.0	t459.0	t465.0
60F	47.0	5548	339.6	394.3	687	t465.0	t466.0	t467.0	b466.5	t468.0	t466.0	t464.0	t466.5	t470.0	t465.0	t470.0	t466.5
62F	46.7	2355	382.6	405.4	689	a438.0	a444.0	a448.0	a453.0	t454.0	t454.0	t453.0	t458.0	t458.0	t458.0	t450.0	t458.0
63E	46.7	3215	373.7	405.4	687	a450.0	a458.0	a461.0	a463.0	t463.0	t461.0	t461.0	t461.5	t463.0	t458.0	t450.0	t458.0
64E	46.7	4C35	364.8	405.4	685	a458.0	t460.0	t461.0	t463.0	t463.0	t461.5	t460.0	t463.0	t464.0	t461.0	t454.0	t461.5
65E	46.7	4413	361.5	405.4	686	a459.0	t460.0	t462.0	t462.0	t463.0	t461.5	t460.0	t462.0	t464.0	t460.0	t454.0	t462.0
66F	47.0	5C12	355.9	405.4	686	a462.0	t464.0	t465.0	t465.0	t466.0	t464.0	t461.5	t464.0	t466.5	t463.0	t457.0	t464.0
67E	47.0	5516	350.9	405.4	686	a464.0	t466.5	t466.5	t466.5	t470.0	t470.0	t463.0	t465.0	t469.0	t463.0	t458.0	t465.0
68F	47.0	3C51	375.9	405.7	687	a449.0	a458.0	a458.0	a460.0	t461.5	t460.0	t458.0	t460.0	t461.0	t458.0	t450.0	t457.0
71E	47.1	1154	405.9	416.5	688	a431.5	a436.0	a437.0	a440.0	a441.5	a441.5	a441.5	a443.0	t445.0	t445.0	t448.0	t446.0
72F	47.0	1961	398.2	416.5	689	a444.0	a450.0	a451.5	a455.0	t458.0	t457.0	t456.0	t459.0	t460.0	t460.0	t451.5	t460.0
73E	46.7	2389	393.7	416.5	687	a450.0	a456.5	a458.0	t461.0	b461.0	t459.0	t459.0	t461.5	t464.0	t461.0	t450.0	t456.5
74F	47.0	2572	387.1	416.5	687	b458.0	b459.0	t460.0	b461.0	t462.0	t461.0	t460.0	t463.0	t464.0	t458.0	t451.5	t459.0
75E	47.0	3972	377.6	416.8	687	b462.0	t463.0	t464.0	t464.0	t464.0	t461.5	t460.0	t461.5	t464.0	t460.0	t453.0	t460.0
76F	47.0	4539	370.9	416.5	687	b463.0	t465.0	t466.0	t465.0	t466.0	t462.0	t461.0	t463.0	t465.0	t462.0	t456.0	t463.0
77F	46.7	5C12	366.5	416.5	687	b466.0	b468.0	t467.0	b466.0	b467.0	t464.0	t462.0	t464.0	t467.0	t463.0	t457.0	t464.0
78E	47.0	5295	363.7	416.5	687	b465.0	b468.0	t467.0	b466.5	t468.0	t464.0	t463.0	t465.0	t469.0	t464.0	t459.0	t465.0
79E	47.3	1119	417.6	427.6	687	a443.0	a446.0	a447.0	a448.0	b449.0	t448.0	b448.0	b449.0	t449.0	t448.0	b449.0	b448.0
80F	47.0	1655	412.1	427.6	687	a450.0	a454.0	a454.0	a455.0	b455.0	b454.0	b453.0	b454.0	b454.0	t451.5	t453.0	t451.5
81F	47.1	2074	407.9	427.6	687	a454.0	a456.0	a456.5	a458.0	b458.0	b457.0	t456.0	b456.5	b456.0	t454.0	t456.0	b454.0
82E	47.0	2443	404.3	427.6	687	a456.5	b459.0	b459.0	b460.0	b461.0	t459.0	b459.0	b459.0	t459.0	b455.0	t458.0	t456.0
83F	47.4	2516	399.8	427.6	688	b462.0	b462.0	b463.0	t463.0	b463.0	b461.0	t459.0	b460.0	b461.0	b458.0	t460.0	b458.0
84F	47.3	3593	392.6	427.6	688	b461.5	b463.0	b464.0	b463.0	b464.0	t460.0	t458.0	b460.0	b461.5	t459.0	b451.5	t459.0
85E	46.7	4192	386.5	427.6	688	b464.0	b465.0	b465.0	b464.0	b464.0	b462.0	b459.0	b461.5	t464.0	b460.0	b454.0	b461.0
86E	47.0	5C12	378.2	427.6	687	b467.0	b467.0	b468.0	b466.0	b466.5	b464.0	b461.0	b464.0	b466.5	t461.5	b454.0	b464.0
87E	28.1	816	404.0	416.2	687	a430.0	a435.0	a436.5	a440.0	a441.5	a442.0	a443.0	a444.0	a446.5	a446.5	a448.0	a446.0
88F	28.1	1636	390.9	416.5	688	a448.0	a453.0	a455.0	b455.0	b455.0	b455.0	b454.0	b455.0	b455.0	b455.0	b455.0	b453.0
89E	28.0	2222	380.4	416.2	688	a458.0	b458.0	b458.0	b459.0	b459.0	b458.0	b457.0	b457.0	b458.0	t455.0	b458.0	b456.5
90F	28.0	2733	372.6	416.5	688	b460.0	b463.0	b463.0	b463.0	b463.0	b462.0	b461.0	b462.0	b462.0	b461.5	b453.0	b461.0
91E	28.1	3688	357.1	416.5	688	b461.5	b464.0	b464.0	b464.0	b464.0	b461.5	t460.0	b462.0	b464.0	t461.0	t454.0	b461.0
92E	28.1	3972	352.1	416.5	688	b463.0	b465.0	b465.0	b464.0	b465.0	t463.0	b461.0	b463.0	b465.0	b461.0	b455.0	t462.0

TABLE VI. - HEAT-TRANSFER AND PRESSURE DROP DATA FOR 0.584-CENTIMETER INSIDE DIAMETER BY 14.6-CENTIMETER-LONG TEST SECTION 230-25F

[G = mass velocity, kg/(sec)(m^2); q = heat flux, kW/m^2; T_i = inlet temperature, K; T_e = exit temperature, K; P_e = exit pressure, kN/m^2 abs; ΔP = pressure drop, kN/m^2.]

Run	G	q	T_i	T_e	P_e	ΔP	Axial distance from start of heating, z, cm													
							0.635	1.27	1.88	2.54	3.17	3.81	4.44	5.71	6.98	8.25	9.52	10.79	12.06	12.70	13.33	13.97	14.10	14.29
							Inner-wall temperature, T_w, K													
4	3.54	113	351.2	356.5	114	<7	$^{a}370.0$	$^{a}378.0$	$^{a}381.0$	$^{a}385.0$	$^{a}386.0$	$^{a}387.0$	$^{a}388.0$	$^{a}389.0$	$^{a}390.0$	$^{a}391.5$	$^{a}393.0$	$^{b}394.0$	$^{b}389.0$	$^{b}390.0$	$^{b}391.5$	$^{b}391.0$	$^{b}393.0$	$^{b}394.0$
5	3.54	501	342.1	368.2	114	<7	$^{b}400.0$	$^{b}397.0$	$^{b}399.0$	$^{b}395.0$	$^{b}402.0$	$^{b}402.0$	$^{b}401.0$	$^{b}402.0$	$^{b}399.0$	$^{b}398.0$	$^{b}402.0$	$^{b}402.0$	$^{b}395.0$	$^{b}396.5$	$^{b}398.0$	$^{b}395.0$	$^{b}400.0$	$^{b}400.0$
6	3.52	602	296.5	335.9	114	~7	$^{b}402.0$	$^{c}398.0$	$^{b}399.0$	$^{b}398.0$	$^{b}403.0$	$^{b}407.0$	$^{b}403.0$	$^{b}405.0$	$^{b}402.0$	$^{b}403.0$	$^{b}402.0$	$^{b}399.0$	$^{b}403.0$	$^{b}404.0$	$^{b}403.0$	$^{b}399.0$	$^{b}405.0$	$^{b}403.0$
10	7.05	646	293.2	314.3	114	<7	$^{a}389.0$	$^{c}399.0$	$^{c}398.0$	$^{c}397.0$	$^{c}401.0$	$^{c}401.5$	$^{c}401.5$	$^{b}404.0$	$^{b}404.0$	$^{b}403.0$	$^{b}405.0$	-----	-----	$^{b}403.0$	-----	$^{b}398.0$	$^{b}404.0$	$^{b}403.0$
12	7.05	224	350.9	314.3	114	<7	$^{a}375.0$	$^{a}380.0$	$^{a}383.0$	$^{a}384.0$	$^{a}385.0$	$^{a}386.5$	$^{a}388.0$	$^{a}389.0$	$^{a}389.0$	$^{b}390.0$	$^{b}390.0$	$^{b}390.0$	$^{b}391.5$	$^{b}390.0$	$^{b}392.0$	$^{b}390.0$	$^{b}392.0$	$^{b}393.0$
13	7.05	372	351.5	314.3	114	<7	$^{c}391.5$	$^{b}397.0$	$^{b}397.0$	$^{c}395.0$	$^{b}401.0$	$^{b}396.5$	$^{b}401.0$	$^{b}402.0$	$^{b}396.0$	$^{b}401.0$	$^{b}401.5$	$^{b}401.5$	$^{b}395.0$	$^{b}396.0$	$^{b}396.0$	$^{b}393.0$	$^{b}402.0$	$^{b}399.0$
14	7.01	589	347.3	314.3	114	<7	$^{c}399.0$	$^{c}399.0$	$^{b}400.0$	$^{b}397.0$	$^{b}404.0$	$^{b}405.0$	$^{b}403.0$	$^{c}404.0$	$^{b}401.0$	$^{b}401.0$	$^{b}404.0$	$^{b}401.5$	$^{b}398.0$	$^{b}399.0$	$^{b}399.0$	$^{b}394.0$	$^{b}403.0$	$^{b}401.0$
28	7.02	649	375.9	394.3	687	10	$^{a}433.0$	$^{a}443.0$	$^{a}445.0$	$^{b}445.0$	$^{b}445.0$	$^{c}446.0$	$^{c}446.0$	$^{c}447.0$	$^{b}448.0$	$^{b}448.0$	$^{b}449.0$	$^{b}449.0$	$^{b}449.0$	$^{b}448.0$	$^{b}451.5$	$^{b}446.5$	$^{b}452.0$	$^{b}451.5$
161	28.1	3215	293.2	319.6	112	13	$^{c}414.0$	$^{c}414.0$	$^{c}414.0$	$^{b}415.0$	$^{b}420.0$	$^{b}420.0$	$^{b}416.5$	$^{b}421.0$	$^{b}425.0$	$^{b}420.0$	$^{b}421.0$	$^{b}421.0$	$^{b}421.0$	$^{b}420.0$	$^{b}425.0$	$^{b}417.0$	$^{b}424.0$	$^{b}422.0$
162	28.1	3215	298.2	324.3	112	12	$^{c}415.0$	$^{c}414.0$	$^{c}415.0$	$^{b}416.5$	$^{b}421.0$	$^{b}420.0$	$^{c}419.0$	$^{b}421.0$	$^{b}425.0$	$^{b}419.0$	$^{b}418.0$	$^{b}420.0$	$^{b}419.0$	$^{b}419.0$	$^{b}425.0$	$^{b}416.5$	$^{b}423.0$	$^{b}422.0$
163	28.0	3215	301.5	327.6	112	12	$^{c}414.0$	$^{c}414.0$	$^{c}415.0$	$^{c}416.5$	$^{b}420.0$	$^{b}420.0$	$^{b}420.0$	$^{b}420.0$	$^{b}421.5$	$^{b}418.0$	$^{b}418.0$	$^{b}419.0$	$^{b}419.0$	$^{b}419.0$	$^{b}425.0$	$^{b}416.5$	$^{b}423.0$	$^{b}422.0$
164	28.0	3184	303.4	329.8	112	13	$^{b}414.0$	$^{c}413.0$	$^{b}415.0$	$^{c}416.0$	$^{b}420.0$	$^{b}419.0$	$^{b}418.0$	$^{b}419.0$	$^{b}421.0$	$^{b}418.0$	$^{b}419.0$	$^{b}419.0$	$^{b}419.0$	$^{b}418.0$	$^{b}424.0$	$^{b}415.0$	$^{b}421.5$	$^{b}420.0$
165	28.1	3184	307.1	333.4	112	14	$^{c}413.0$	$^{c}412.0$	$^{c}414.0$	$^{c}416.0$	$^{b}419.0$	$^{b}419.0$	$^{c}418.0$	$^{b}419.0$	$^{b}419.0$	$^{b}418.0$	$^{c}421.0$	$^{b}421.0$	$^{b}421.0$	$^{b}421.0$	$^{b}425.0$	$^{b}416.5$	$^{b}422.0$	$^{b}420.0$
166	28.0	3184	310.9	337.1	112	13	$^{c}415.0$	$^{c}413.0$	$^{b}416.5$	$^{c}416.5$	$^{b}420.0$	$^{c}419.0$	$^{c}420.0$	$^{b}420.0$	$^{b}421.5$	$^{b}418.0$	$^{b}419.0$	$^{c}420.0$	$^{b}419.0$	$^{b}418.0$	$^{b}424.0$	$^{b}416.0$	$^{b}421.5$	$^{b}421.0$
167	28.1	3184	313.2	339.3	112	14	$^{c}414.0$	$^{c}413.0$	$^{c}415.0$	$^{c}416.5$	$^{c}420.0$	$^{c}419.0$	$^{c}418.0$	$^{c}420.0$	$^{b}421.5$	$^{b}418.0$	$^{b}420.0$	$^{b}418.0$	$^{b}419.0$	$^{b}419.0$	$^{b}422.0$	$^{b}415.0$	$^{b}420.0$	$^{b}419.0$
168	28.1	3184	315.1	340.9	112	14	$^{c}415.0$	$^{c}414.0$	$^{b}416.5$	$^{c}416.5$	$^{b}421.5$	$^{b}420.0$	$^{c}419.0$	$^{b}420.0$	$^{b}421.5$	$^{b}419.0$	$^{b}420.0$	$^{b}419.0$	$^{b}419.0$	$^{b}418.0$	$^{b}423.0$	$^{b}415.0$	$^{b}421.0$	$^{b}420.0$
169	28.1	3184	318.7	344.3	112	14	$^{c}415.0$	$^{b}414.0$	$^{c}416.5$	$^{c}417.0$	$^{b}421.0$	$^{b}420.0$	$^{b}420.0$	$^{c}419.0$	$^{b}420.0$	$^{b}416.5$	$^{b}418.0$	$^{b}419.0$	$^{b}418.0$	$^{b}416.5$	$^{b}421.5$	$^{b}414.0$	$^{b}419.0$	$^{b}420.0$
170	28.0	3184	320.9	346.8	112	13/14	$^{c}416.5$	$^{c}415.0$	$^{c}417.0$	$^{c}418.0$	$^{b}421.5$	$^{b}420.0$	$^{b}419.0$	$^{b}419.0$	$^{b}420.0$	$^{b}419.5$	$^{b}417.0$	$^{b}419.0$	$^{b}418.0$	$^{b}416.5$	$^{b}422.0$	$^{b}414.0$	$^{b}421.0$	$^{b}420.0$
227	28.0	3184	297.1	323.4	308	12	$^{c}436.0$	$^{c}437.0$	$^{c}439.0$	$^{c}439.0$	$^{c}441.0$	$^{c}441.0$	$^{b}441.5$	$^{c}442.0$	$^{b}444.0$	$^{c}444.0$	$^{b}444.0$	$^{b}444.0$	$^{b}445.0$	$^{b}446.5$	$^{b}451.0$	$^{b}443.0$	$^{b}447.0$	$^{b}446.0$
228	28.0	3184	301.2	327.6	308	12	$^{b}436.0$	$^{c}436.0$	$^{c}438.0$	$^{c}439.0$	$^{b}440.0$	$^{b}440.0$	$^{c}441.0$	$^{c}441.5$	$^{b}444.0$	$^{b}444.0$	$^{b}444.0$	$^{c}444.0$	$^{b}445.0$	$^{b}446.0$	$^{b}450.0$	$^{b}443.0$	$^{b}446.5$	$^{b}446.5$
229	28.0	3184	304.8	330.7	308	13	$^{b}436.0$	$^{c}436.0$	$^{c}439.0$	$^{c}439.0$	$^{b}440.0$	$^{b}440.0$	$^{b}441.0$	$^{b}441.5$	$^{b}444.0$	$^{b}444.0$	$^{b}444.0$	$^{b}444.0$	$^{b}445.0$	$^{b}446.0$	$^{b}450.0$	$^{b}443.0$	$^{b}446.5$	$^{b}446.5$
230	28.0	3215	307.6	333.7	308	14	$^{b}436.0$	$^{c}438.0$	$^{c}439.0$	$^{c}439.0$	$^{c}441.0$	$^{c}441.0$	$^{b}441.5$	$^{c}441.5$	$^{b}444.0$	$^{b}443.0$	$^{b}444.0$	$^{b}444.0$	$^{b}445.0$	$^{b}446.5$	$^{b}451.0$	$^{b}443.0$	$^{b}447.0$	$^{b}447.0$
231	28.0	3184	311.5	337.6	308	14	$^{c}438.0$	$^{c}438.0$	$^{c}440.0$	$^{c}440.0$	$^{c}442.0$	$^{c}441.5$	$^{c}442.0$	$^{b}443.0$	$^{c}445.0$	$^{b}444.0$	$^{b}444.0$	$^{b}444.0$	$^{b}445.0$	$^{b}446.0$	$^{b}450.0$	$^{b}444.0$	$^{b}447.0$	$^{b}447.0$
232	28.0	3215	315.4	341.8	308	14	$^{b}437.0$	$^{c}438.0$	$^{c}440.0$	$^{c}440.0$	$^{b}442.0$	$^{b}441.5$	$^{c}443.0$	$^{b}443.0$	$^{b}445.0$	$^{b}444.0$	$^{b}444.0$	$^{b}444.0$	$^{c}444.5$	$^{b}446.0$	$^{b}446.5$	$^{b}450.0$	$^{b}444.0$	$^{b}446.5$
233	28.0	3215	320.9	347.1	308	14	$^{b}439.0$	$^{c}438.0$	$^{b}441.0$	$^{c}441.0$	$^{b}443.0$	$^{c}443.0$	$^{c}443.0$	$^{c}443.0$	$^{c}446.0$	$^{b}444.0$	$^{b}444.0$	$^{b}444.0$	$^{c}444.0$	$^{b}446.0$	$^{b}450.0$	$^{b}444.0$	$^{b}446.5$	$^{b}446.5$
234	28.0	3215	323.7	349.8	308	14	$^{c}440.0$	$^{c}440.0$	$^{b}442.0$	$^{c}442.0$	$^{b}443.0$	$^{b}444.0$	$^{c}444.0$	$^{b}444.0$	$^{b}446.0$	$^{b}445.0$	$^{b}445.0$	$^{b}444.0$	$^{b}445.0$	$^{b}446.0$	$^{b}450.0$	$^{b}444.0$	$^{b}447.0$	$^{b}447.0$
235	28.0	3215	327.1	353.2	308	14	$^{c}439.0$	$^{c}439.0$	$^{c}441.5$	$^{c}443.0$	$^{b}444.0$	$^{b}444.0$	$^{b}444.0$	$^{b}444.0$	$^{b}446.5$	$^{b}445.0$	$^{b}444.0$	$^{b}444.0$	$^{c}445.0$	$^{b}446.5$	$^{b}450.0$	$^{b}444.0$	$^{b}446.5$	$^{b}448.0$
236	28.0	3215	331.2	357.3	308	14	$^{c}440.0$	$^{c}439.0$	$^{b}443.0$	$^{c}443.0$	$^{c}444.0$	$^{b}445.0$	$^{b}444.0$	$^{b}445.0$	$^{b}446.5$	$^{b}446.0$	$^{b}445.0$	$^{b}444.0$	$^{c}445.0$	$^{b}446.5$	$^{b}451.0$	$^{b}444.0$	$^{b}446.5$	$^{b}447.0$
237	28.0	3247	335.1	361.2	308	14	$^{c}443.0$	$^{c}441.5$	$^{c}444.0$	$^{c}444.0$	$^{c}445.0$	$^{b}445.0$	$^{c}445.0$	$^{c}445.0$	$^{c}447.0$	$^{b}446.0$	$^{b}446.0$	$^{b}445.0$	$^{c}447.0$	$^{b}447.0$	$^{b}452.0$	$^{b}444.0$	$^{b}446.5$	$^{b}446.5$
238	27.7	3247	338.2	364.3	308	14	$^{c}443.0$	$^{c}443.0$	$^{c}445.0$	$^{c}445.0$	$^{c}446.5$	$^{b}445.0$	$^{c}445.0$	$^{b}445.0$	$^{b}448.0$	$^{b}447.0$	$^{b}446.5$	$^{b}445.0$	$^{b}448.0$	$^{b}447.0$	$^{b}452.0$	$^{b}444.0$	$^{b}446.5$	$^{b}446.5$
239	28.0	3247	339.6	365.7	308	14	$^{c}443.0$	$^{c}441.5$	$^{c}444.0$	$^{c}445.0$	$^{c}446.5$	$^{b}446.0$	$^{b}446.0$	$^{c}445.0$	$^{b}448.0$	$^{c}446.0$	$^{b}446.5$	$^{b}446.0$	$^{b}448.0$	$^{b}448.0$	$^{b}450.0$	$^{b}444.0$	$^{b}446.5$	$^{b}446.5$
240	28.0	3247	340.9	366.8	308	14/15	$^{c}444.0$	$^{c}443.0$	$^{c}445.0$	$^{c}446.0$	$^{c}446.5$	$^{c}446.0$	$^{c}446.0$	$^{c}446.5$	$^{b}448.0$	$^{b}446.0$	$^{c}446.5$	$^{b}445.0$	$^{b}448.0$	$^{b}448.0$	$^{b}451.0$	$^{b}444.0$	$^{b}447.0$	$^{b}446.5$
241	28.0	3278	343.7	366.8	308	14/15	$^{c}443.0$	$^{c}443.0$	$^{c}445.0$	$^{c}445.0$	$^{c}446.5$	$^{c}444.0$	$^{c}445.0$	$^{b}445.0$	$^{b}446.5$	$^{c}446.0$	$^{c}446.0$	$^{b}445.0$	$^{b}446.5$	$^{b}445.0$	$^{b}450.0$	$^{b}444.0$	$^{b}446.5$	$^{b}446.5$
242	28.0	3247	347.1	373.2	309	14/16	$^{c}443.0$	$^{c}443.0$	$^{c}444.0$	$^{b}444.0$	$^{b}445.0$	$^{b}444.0$	$^{b}445.0$	$^{c}444.0$	$^{b}446.0$	$^{c}445.0$	$^{b}445.0$	$^{b}445.0$	$^{b}446.0$	$^{b}446.0$	$^{b}449.0$	$^{b}443.0$	$^{b}446.0$	$^{b}446.0$
243	27.7	3215	349.6	375.4	309	14/16	$^{c}441.5$	$^{c}441.0$	$^{c}444.0$	$^{c}444.0$	$^{b}444.0$	$^{b}444.0$	$^{b}444.0$	$^{c}444.0$	$^{b}445.0$	$^{c}444.0$	$^{c}444.0$	$^{c}444.0$	$^{b}446.0$	$^{b}445.0$	$^{b}449.0$	$^{b}443.0$	$^{b}445.0$	$^{b}445.0$
244	28.0	3184	354.6	380.4	308	14/17	$^{c}442.0$	$^{c}441.0$	$^{c}444.0$	$^{c}442.0$	$^{c}444.0$	$^{c}443.0$	$^{b}444.0$	$^{c}444.0$	$^{c}445.0$	$^{b}444.0$	$^{b}444.0$	$^{c}444.0$	$^{b}445.0$	$^{b}444.0$	$^{b}448.0$	$^{b}442.0$	$^{b}444.0$	$^{b}445.0$
245	27.7	3215	357.3	382.9	308	14/19	$^{c}443.0$	$^{c}441.5$	$^{c}445.0$	$^{c}445.0$	$^{b}444.0$	$^{b}444.0$	$^{b}444.0$	$^{b}444.0$	$^{c}445.0$	$^{b}444.0$	$^{b}444.0$	$^{b}444.0$	$^{b}444.0$	$^{b}444.0$	$^{b}446.5$	$^{b}441.5$	$^{b}444.0$	$^{b}445.0$
246	28.0	3215	361.8	387.6	308	16/23	$^{c}444.0$	$^{b}443.0$	$^{b}444.0$	$^{b}443.0$	$^{b}445.0$	$^{b}444.0$	$^{b}445.0$	$^{c}444.0$	$^{b}445.0$	$^{b}444.0$	$^{c}444.0$	$^{b}443.0$	$^{b}443.0$	$^{b}444.0$	$^{b}448.0$	$^{b}441.5$	$^{b}445.0$	$^{b}444.0$
247	28.0	3215	364.8	390.4	308	17/26	$^{c}443.0$	$^{c}441.5$	$^{c}444.0$	$^{b}443.0$	$^{c}444.0$	$^{b}444.0$	$^{c}444.0$	$^{b}444.0$	$^{c}445.0$	$^{b}443.0$	$^{b}443.0$	$^{b}442.0$	$^{b}444.0$	$^{b}442.0$	$^{b}446.5$	$^{b}440.0$	$^{b}444.0$	$^{b}444.0$
248	27.7	3215	369.3	394.6	308	23/32	$^{c}442.0$	$^{c}441.0$	$^{c}444.0$	$^{b}443.0$	$^{c}444.0$	$^{c}443.0$	$^{b}444.0$	$^{b}443.0$	$^{b}444.0$	$^{b}443.0$	$^{b}441.0$	$^{b}441.0$	$^{b}441.5$	$^{b}442.0$	$^{b}445.0$	$^{b}439.0$	$^{b}442.0$	$^{b}443.0$
249	28.0	3215	373.2	398.4	308	28/37	$^{c}444.0$	$^{b}443.0$	$^{b}444.0$	$^{b}442.0$	$^{b}444.0$	$^{b}443.0$	$^{c}444.0$	$^{b}443.0$	$^{b}444.0$	$^{b}441.5$	$^{b}441.0$	$^{b}441.0$	$^{b}442.0$	$^{b}443.0$	$^{b}445.0$	$^{b}439.0$	$^{b}442.0$	$^{b}443.0$
250	28.4	3215	379.3	404.3	308	35/41	$^{c}444.0$	$^{c}444.0$	$^{b}445.0$	$^{b}443.0$	$^{c}445.0$	$^{b}444.0$	$^{b}444.0$	$^{b}443.0$	$^{b}444.0$	$^{b}442.0$	$^{b}441.5$	$^{b}442.0$	$^{b}442.0$	$^{b}442.0$	$^{b}445.0$	$^{b}439.0$	$^{b}441.5$	$^{b}442.0$

81	28.1	3184	304.8	330.9	688	12	[a]441.5	[a]450.0	[a]452.0	[a]453.0	[b]455.0	[b]455.0	[b]455.0	[b]455.0	[b]457.0	[b]457.0	[b]456.5	[b]454.0	[b]455.0	[b]456.0	[b]460.0	[b]456.0	[b]456.5	[b]458.0
82	28.1	3184	317.6	343.2	687	12	[a]446.0	[a]452.0	[b]456.0	[b]456.0	[b]455.0	[b]455.0	[b]457.0	[b]458.0	[b]459.0	[b]459.0	[b]459.0	[b]455.0	[b]458.0	[b]458.0	[b]462.0	[b]458.0	[b]458.0	[b]460.0
83	28.1	3184	324.3	349.8	687	12	[a]449.0	[b]453.0	[b]455.0	[b]455.0	[b]458.0	[b]458.0	[b]459.0	[b]459.0	[b]461.5	[b]460.0	[b]450.0	[b]457.0	[b]459.0	[b]460.0	[b]464.0	[b]459.0	[b]460.0	[b]461.0
84	28.1	3184	329.0	354.8	687	12	[b]453.0	[b]455.0	[b]457.0	[b]458.0	[b]460.0	[b]459.0	[b]460.0	[b]461.5	[b]463.0	[b]463.0	[b]452.0	[b]450.0	[b]461.5	[b]462.0	[b]466.0	[b]460.0	[b]462.0	[b]465.0
85	28.1	3184	334.3	359.8	687	12	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	[b]462.0	[b]462.0	[b]466.5	[b]461.0	[b]463.0	[b]465.0
86	28.1	3184	336.5	362.1	688	12	[b]455.0	[b]455.0	[b]457.0	[b]458.0	[b]461.5	[b]462.0	[b]462.0	[b]463.0	[b]464.0	[b]463.0	[b]453.0	[b]460.0	[b]462.0	[b]461.0	[b]466.5	[b]461.5	[b]463.0	[b]466.0
87	28.1	3184	342.1	367.6	688	12	[b]456.0	[b]457.0	[b]459.0	[b]460.0	[b]462.0	[b]462.0	[b]463.0	[b]463.0	[b]465.0	[b]465.0	[b]453.0	[b]451.0	[b]463.0	[b]461.5	[b]467.0	[b]462.0	[b]463.0	[b]466.5
88	28.1	3184	346.8	372.1	688	12	[b]458.0	[b]458.0	460.0	[b]461.5	[b]463.0	[b]462.0	[b]463.0	[b]464.0	[b]465.0	[b]464.0	[b]454.0	[b]451.5	[b]463.0	[b]462.0	[b]469.0	[b]463.0	[b]465.0	[b]468.0
89	28.1	3184	352.3	377.6	688	12	[b]458.0	[b]459.0	462.0	[b]462.0	[b]464.0	[b]464.0	[b]464.0	[b]464.0	[b]466.0	[b]465.0	[b]454.0	[b]462.0	[b]463.0	[b]463.0	[b]469.0	[b]463.0	[b]465.0	[b]469.0
90	28.0	3215	357.6	383.2	688	12	[b]460.0	[b]461.0	463.0	[b]464.0	[b]465.0	[b]465.0	465.0	[b]465.0	[b]466.5	[b]465.0	[b]455.0	[b]463.0	[b]464.0	[b]463.0	[b]470.0	[b]463.0	[b]466.5	[b]470.0
91	28.0	3184	360.9	386.5	688	12	[b]460.0	[b]460.0	[b]463.0	[b]463.0	[b]465.0	[b]464.0	[b]465.0	[b]465.0	[b]466.0	[b]465.0	[b]455.0	[b]463.0	[b]463.0	[b]463.0	[b]469.0	[b]463.0	[b]466.0	[b]468.0
92	28.0	3184	364.3	389.8	689	12	[b]461.5	[b]462.0	[b]464.0	[b]464.0	[b]465.0	[b]465.0	[b]466.0	[b]465.0	[b]466.5	[b]465.0	[b]455.0	[b]453.0	[b]464.0	[b]463.0	[b]470.0	[b]463.0	[b]466.0	[b]469.0
93	28.0	3184	367.6	393.2	688	12/13	[b]462.0	[b]462.0	[b]464.0	[b]464.0	[b]465.0	[b]465.0	[b]465.0	[b]465.0	[b]466.0	[b]465.0	[b]455.0	[b]463.0	[b]464.0	[b]463.0	[b]469.0	[b]463.0	[b]466.0	[b]469.0
94	28.0	3184	370.9	396.5	688	12	[b]463.0	[b]464.0	465.0	[b]465.0	[b]467.0	[b]466.0	[b]467.0	[b]466.5	[b]469.0	[b]465.0	[b]456.0	[b]454.0	[b]464.0	[b]463.0	[b]470.0	[b]464.0	[b]467.0	[b]470.0
95	28.0	3184	377.1	402.6	687	12/14	[b]465.0	[b]465.0	[b]467.0	[b]467.0	[b]468.0	[b]467.0	[b]467.0	[b]467.0	[b]468.0	[b]466.5	[b]456.0	[b]453.0	[b]463.0	[b]463.0	[b]470.0	[b]464.0	[b]467.0	[b]469.0
96	28.0	3184	379.8	405.4	688	12/15	[b]465.0	[b]465.0	[b]467.0	[b]466.0	[b]467.0	[b]467.0	[b]467.0	[b]467.0	[b]468.0	[b]467.0	[b]456.5	[b]463.0	[b]464.0	[b]463.0	[b]470.0	[b]465.0	[b]466.5	[b]470.0
97	28.0	3184	383.7	409.0	689	12/16	[b]465.0	[b]465.0	[b]466.5	[b]466.0	[b]467.0	[b]466.0	[b]466.5	[b]467.0	[b]467.0	[b]466.5	[b]456.0	[b]463.0	[b]463.0	[b]463.0	[b]469.0	[b]465.0	[b]467.0	[b]469.0
98	28.0	3184	387.1	412.1	689	13/17	[b]465.0	[b]465.0	466.0	[b]466.5	[b]467.0	[b]467.0	[b]467.0	[b]466.5	[b]467.0	[b]465.0	[b]455.0	[b]463.0	[b]464.0	[b]463.0	[b]469.0	[b]464.0	[b]466.5	[b]469.0
99	28.0	3184	388.7	413.7	687	14/17	[b]465.0	[b]465.0	[b]466.0	[b]466.0	[b]466.5	[b]466.5	[b]466.0	[b]466.5	[b]467.0	[b]465.0	[b]454.0	[b]462.0	[b]463.0	[b]462.0	[b]469.0	[b]464.0	[b]466.0	[b]469.0
100	28.0	3184	392.6	417.6	687	16/19	[b]465.0	[b]465.0	[b]466.0	[b]466.0	[b]466.5	[b]466.0	[b]466.0	[b]466.0	[b]466.0	[b]465.0	[b]454.0	[b]461.5	[b]462.0	[b]461.5	[b]469.0	[b]464.0	[b]465.0	[b]468.0
101	28.1	3184	395.4	420.1	687	17/22	[b]465.0	[b]465.0	[b]466.0	466.0	[b]466.0	[b]465.0	465.0	[b]464.0	[b]466.0	[b]465.0	[b]454.0	[b]461.5	[b]463.0	[b]463.0	[b]468.0	[b]463.0	[b]466.0	[b]468.0
102	28.0	3184	398.2	422.6	687	18/25	[b]466.0	[b]466.0	[b]466.0	466.0	[b]466.0	[b]465.0	[b]465.0	[b]464.0	[b]465.0	[b]464.0	[b]454.0	[b]453.0	[b]464.0	[b]463.0	[b]468.0	[b]463.0	[b]465.0	[b]467.0
103	28.0	3184	406.2	430.4	689	27/30	[b]466.0	[b]466.0	[b]466.0	[b]465.0	[b]466.0	[b]465.0	[b]465.0	[b]464.0	[b]465.0	[b]464.0	[b]453.0	[b]461.0	[b]461.0	[b]461.0	[b]467.0	[b]463.0	[b]465.0	[b]466.5
104	28.0	3184	402.9	427.1	687	24/28	[b]466.0	[b]466.0	[b]466.0	[b]466.0	[b]466.0	[b]465.0	[b]465.0	[b]464.0	[b]465.0	[b]464.0	[b]453.0	[b]451.0	[b]461.0	[b]462.0	[b]467.0	[b]463.0	[b]465.0	[b]467.0
105	28.1	3215	378.2	403.2	688	12/14	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	[b]471.5	[b]465.0	[b]467.0	[b]471.0
106	28.1	3184	376.5	401.5	688	12/14	[b]463.0	[b]464.0	[b]466.0	[b]465.0	[b]466.0	[b]465.0	[b]466.0	[b]465.0	[b]466.5	[b]465.0	[b]455.0	[b]462.0	[b]463.0	[b]464.0	[b]470.0	[b]465.0	[b]467.0	[b]470.0
107	28.1	3184	374.8	399.8	687	12/14	[b]463.0	[b]463.0	[b]465.0	[b]465.0	[b]467.0	[b]466.0	[b]466.0	[b]466.0	[b]466.5	[b]465.0	[b]456.0	[b]453.0	[b]464.0	[b]465.0	[b]470.0	[b]465.0	[b]467.0	[b]470.0
108	28.0	3184	355.1	380.4	689	12	[b]460.0	[b]460.0	[b]463.0	[b]463.0	[b]464.0	[b]465.0	465.0	[b]465.0	[b]466.0	[b]465.0	[b]455.0	[b]463.0	[b]464.0	[b]464.0	[b]470.0	[b]465.0	[b]467.0	[b]470.0
109	28.4	3215	348.7	374.0	687	12	[b]458.0	[b]458.0	[b]461.0	461.0	[b]463.0	[b]462.0	464.0	[b]464.0	[b]465.0	[b]464.0	[b]455.0	[b]462.0	[b]464.0	[b]464.0	[b]470.0	[b]465.0	[b]467.0	[b]470.0
110	28.0	4760	298.2	337.1	687	12	[b]466.0	[b]466.0	[b]469.0	[b]468.0	[b]470.0	[b]469.0	470.0	[b]470.0	[b]473.0	[b]473.0	[b]471.0	[b]469.0	[b]471.0	[b]472.0	[b]477.0	[b]472.0	[b]473.0	[b]476.0
111	28.1	4854	303.7	343.7	687	12	[b]466.0	[b]468.0	[b]469.0	[b]469.0	[b]470.0	[b]470.0	[b]471.0	[b]471.0	[b]474.0	[b]473.0	[b]473.0	[b]470.0	[b]472.0	[b]473.0	[b]478.0	[b]473.0	[b]474.0	[b]479.0
112	28.0	4823	310.1	346.8	687	12	[b]466.5	[b]467.0	[b]468.0	[b]468.0	[b]470.0	[b]469.0	[b]470.0	[b]470.0	[b]474.0	[b]472.0	[b]471.5	[b]469.0	[b]471.0	[b]473.0	[b]478.0	[b]473.0	[b]474.0	[b]478.0
113	28.0	4854	311.5	351.2	688	12	[b]466.5	[b]468.0	[b]469.0	[b]469.0	[b]470.0	[b]470.0	[b]470.0	[b]470.0	[b]474.0	[b]470.0	[b]472.0	[b]459.0	[b]471.5	[b]473.0	[b]478.0	[b]472.0	[b]475.0	[b]478.0
114	28.0	4791	314.0	353.4	688	12	[b]468.0	[b]468.0	[b]469.0	[b]469.0	[b]470.0	[b]470.0	[b]471.0	[b]471.0	[b]473.0	[b]473.0	[b]471.0	[b]459.0	[b]470.0	[b]471.5	[b]478.0	[b]471.0	[b]474.0	[b]478.0
115	28.0	4791	318.2	357.6	688	12	[b]468.0	[b]469.0	[b]469.0	[b]470.0	[b]471.0	[b]470.0	[b]471.0	[b]470.0	[b]473.0	[b]471.0	[b]472.0	[b]469.0	[b]471.0	[b]471.5	[b]478.0	[b]471.0	[b]475.0	[b]479.0
116	28.1	4791	324.0	362.9	688	12/13	[b]469.0	[b]469.0	[b]470.0	[b]469.0	[b]471.0	[b]471.0	[b]471.5	[b]471.0	[b]474.0	[b]471.5	[b]471.5	[b]469.0	[b]471.0	[b]471.5	[b]479.0	[b]471.0	[b]475.0	[b]479.0
117	28.0	4854	325.9	365.1	688	12/13	[b]469.0	[b]469.0	[b]471.0	[b]471.0	[b]471.0	[b]471.5	[b]471.5	[b]471.5	[b]474.0	[b]473.0	[b]472.0	[b]470.0	[b]471.0	[b]474.0	[b]479.0	[b]471.5	[b]475.0	[b]479.0
118	28.0	4823	328.4	367.6	687	13	[b]469.0	[b]469.0	[b]471.0	[b]470.0	[b]471.5	[b]471.0	[b]471.5	[b]472.0	[b]474.0	[b]472.0	[b]471.5	[b]470.0	[b]471.0	[b]472.0	[b]479.0	[b]471.5	[b]475.0	[b]479.0
119	28.0	4823	332.6	371.8	687	13/14	[b]469.0	[b]469.0	[b]470.0	[b]470.0	[b]471.5	[b]471.0	[b]471.5	[b]471.5	[b]474.0	[b]471.5	[b]471.0	[b]469.0	[b]471.0	[b]471.5	[b]479.0	[b]471.0	[b]475.0	[b]478.0
120	28.0	4791	335.4	374.3	687	13/14	[b]469.0	[b]469.0	[b]470.0	[b]469.0	[b]471.0	[b]471.0	[b]471.5	[b]471.0	[b]474.0	[b]471.5	[b]471.0	[b]469.0	[b]470.0	[b]471.5	[b]478.0	[b]470.0	[b]474.0	[b]477.0
121	28.0	4854	338.7	378.2	687	12/14	[b]469.0	[b]469.0	[b]471.0	[b]470.0	[b]471.5	[b]471.5	[b]471.5	[b]471.5	[b]474.0	[b]471.5	[b]471.0	[b]469.0	[b]470.0	[b]471.0	[b]476.5	[b]470.0	[b]474.0	[b]478.0
122	28.0	4823	340.4	379.8	687	13/14	[b]469.0	[b]469.0	[b]471.5	[b]470.0	[b]473.0	[b]471.5	[b]471.5	[b]471.5	[b]474.0	[b]472.0	[b]471.5	[b]459.0	[b]470.0	[b]471.5	[b]476.5	[b]470.0	[b]474.0	[b]477.0
123	28.0	4791	343.7	382.6	687	13/14	[b]470.0	[b]470.0	[b]471.5	[b]471.5	[b]472.0	[b]471.5	[b]472.0	[b]473.0	[b]475.0	[b]474.0	[b]473.0	[b]470.0	[b]471.0	[b]473.0	[b]477.0	[b]471.0	[b]474.0	[b]479.0
124	28.0	4886	348.7	387.6	687	13/15	[b]471.5	[b]471.5	[b]474.0	[b]474.0	[b]475.0	[b]474.0	[b]475.0	[b]474.0	[b]476.5	[b]474.0	[b]474.0	[b]470.0	[b]472.0	[b]474.0	[b]479.0	[b]471.5	[b]475.0	[b]474.0
125	28.0	4823	354.0	392.9	687	14/16	[b]473.0	[b]473.0	[b]474.0	[b]473.0	[b]475.0	[b]474.0	[b]475.0	[b]475.0	[b]476.5	[b]475.0	[b]474.0	[b]470.0	[b]471.5	[b]474.0	[b]477.0	[b]470.0	[b]475.0	[b]474.0
126	28.1	4823	356.2	394.8	687	12/18	[b]471.5	[b]471.5	[b]474.0	[b]474.0	[b]475.0	[b]475.0	[b]475.0	[b]474.0	[b]476.5	[b]474.0	[b]474.0	[b]470.0	[b]471.5	[b]474.0	[b]477.0	[b]471.5	[b]475.0	[b]480.0
127	28.1	4854	359.6	398.2	687	11/21	[b]474.0	[b]474.0	[b]475.0	[b]474.0	[b]475.0	[b]474.0	[b]475.0	[b]475.0	[b]476.5	[b]475.0	[b]474.0	[b]470.0	[b]471.5	[b]474.0	[b]476.5	[b]471.5	[b]475.0	[b]480.0
128	28.1	4823	364.3	402.9	689	13/20	[b]473.0	[b]473.0	[b]474.0	[b]473.0	[b]475.0	[b]473.0	[b]475.0	[b]474.0	[b]475.0	[b]474.0	[b]473.0	[b]470.0	[b]470.0	[b]473.0	[b]473.0	[b]471.5	[b]475.0	[b]479.0
129	28.0	4791	367.3	405.4	688	10/21	[b]474.0	[b]474.0	[b]475.0	[b]474.0	[b]475.0	[b]474.0	[b]475.0	[b]474.0	[b]475.0	[b]473.0	[b]471.0	[b]469.0	[b]470.0	[b]473.0	[b]473.0	[b]471.5	[b]474.0	[b]479.0
130	28.0	4791	370.9	408.7	687	12/24	[b]474.0	[b]474.0	[b]475.0	[b]474.0	[b]475.0	[b]474.0	[b]475.0	[b]474.0	[b]475.0	[b]473.0	[b]473.0	[b]469.0	[b]471.0	[b]473.0	[b]473.0	[b]472.0	[b]474.0	[b]479.0
131	28.0	4791	373.2	410.9	687	12/26	[b]474.0	[b]474.0	[b]475.0	[b]474.0	[b]475.0	[b]474.0	[b]475.0	[b]474.0	[b]475.0	[b]474.0	[b]473.0	[b]470.0	[b]471.0	[b]473.0	[b]474.0	[b]471.5	[b]474.0	[b]479.0
132	28.1	4854	369.8	408.2	687	10/26	[b]476.0	[b]475.0	[b]477.0	[b]475.0	[b]477.0	[b]475.0	[b]477.0	[b]475.0	[b]476.5	[b]475.0	[b]474.0	[b]471.5	[b]473.0	[b]475.0	[b]475.0	[b]473.0	[b]477.0	[b]481.5
133	28.1	4791	364.8	403.2	687	12/22	[b]475.0	[b]475.0	[b]477.0	[b]475.0	[b]478.0	[b]475.0	[b]476.5	[b]475.0	[b]476.0	[b]475.0	[b]474.0	[b]471.5	[b]473.0	[b]475.0	[b]476.5	[b]473.0	[b]476.0	[b]479.0
134	28.1	4823	353.2	391.5	687	13/17	[b]474.0	[b]475.0	[b]476.5	[b]476.5	[b]478.0	[b]476.5	[b]478.0	[b]476.5	[b]477.0	[b]476.5	[b]475.0	[b]473.0	[b]476.0	[b]476.5	[b]478.0	[b]473.0	[b]477.0	[b]481.5
135	28.0	4791	347.1	385.9	687	14/15	[b]475.0	[b]475.0	[b]477.0	[b]476.5	[b]478.0	[b]478.0	[b]479.0	[b]478.0	[b]480.0	[b]478.0	[b]477.0	[b]475.0	[b]476.0	[b]478.0	[b]480.0	[b]475.0	[b]477.0	[b]484.0
136	28.0	4823	332.1	370.9	688	12/13	[b]474.0	[b]474.0	[b]476.5	[b]475.0	[b]477.0	[b]476.5	[b]478.0	[b]477.0	[b]479.0	[b]478.0	[b]477.0	[b]475.0	[b]476.5	[b]479.0	[b]480.0	[b]475.0	[b]478.0	[b]484.0
303	28.0	4791	365.4	403.7	688	12/21	[b]472.0	[b]473.0	[b]474.0	[b]473.0	[b]474.0	[b]475.0	[b]475.0	[b]475.0	[b]478.0	[b]475.0	[b]474.0	[b]474.0	[b]473.0	[b]476.0	[b]477.0	[b]470.0	[b]474.0	[b]474.0
304	28.1	4791	369.8	407.6	689	12/24	[b]473.0	[b]473.0	[b]474.0	[b]473.0	[b]475.0	[b]474.0	[b]476.0	[b]475.0	[b]477.0	[b]474.0	[b]474.0	[b]474.0	[b]473.0	[b]474.0	[b]475.0	[b]469.0	[b]474.0	[b]473.0
305	28.0	4791	374.3	412.1	688	12/28	[b]472.0	[b]474.0	[b]474.0	[b]474.0	[b]475.0	[b]474.0	[b]475.0	[b]475.0	[b]478.0	[b]475.0	[b]474.0	[b]473.0	[b]474.0	[b]476.0	[b]476.0	[b]469.0	[b]474.0	[b]473.0
306	28.1	4791	376.5	414.3	688	12/29	[b]472.0	[b]472.0	[b]474.0	[b]472.0	[b]474.0	[b]473.0	[b]473.0	[b]472.0	[b]474.0	[b]472.0	[b]474.0	[b]471.0	[b]472.0	[b]474.0	[b]475.0	[b]469.0	[b]472.0	[b]472.0
307	28.0	4760	379.3	417.1	688	14/31	[b]473.0	[b]473.0	[b]474.0	[b]472.0	[b]473.0	[b]473.0	[b]473.0	[b]470.0	[b]472.0	[b]472.0	[b]472.0	[b]471.0	[b]472.0	[b]472.0	[b]473.0	[b]467.0	[b]471.5	[b]471.0
308	28.0	4791	381.5	419.0	688	14/34	[b]471.5	[b]471.5	[b]472.0	[b]471.5	[b]472.0	[b]471.5	[b]472.0	[b]470.0	[b]471.5	[b]471.5	[b]459.0	[b]476.0	[b]472.0	[b]474.0	[b]473.0	[b]466.5	[b]469.0	[b]471.0
309	28.0	4823	387.6	424.8	687	21/48	[b]472.0	[b]471.5	[b]474.0	[b]471.0	[b]473.0	[b]471.0	[b]472.0	[b]469.0	[b]471.5	[b]471.0	[b]470.0	[b]470.0	[b]471.5	[b]469.0	[b]473.0	[b]466.5	[b]469.0	[b]470.0
310	28.0	4791	392.1	429.3	687	31/45	[b]473.0	[b]471.5	[b]473.0	[b]471.5	[b]471.5	[b]471.0	[b]471.5	[b]470.0	[b]471.5	[b]470.0	[b]458.0	[b]469.0	[b]471.5	[b]474.0	[b]473.0	[b]465.0	[b]468.0	[b]470.0
311	28.1	4823	394.0	431.2	688	34/48	[b]473.0	[b]471.5	[b]473.0	[b]470.0	[b]471.5	[b]470.0	[b]471.5	[b]469.0	[b]471.0	[b]470.0	[b]458.0	[b]469.0	[b]471.0	[b]474.0	[b]473.0	[b]465.0	[b]468.0	[b]466.5
312	28.0	4823	397.1	433.7	688	43/50	[b]473.0	[b]471.5	[b]473.0	[b]471.0	[b]471.5	[b]471.0	[b]471.5	[b]470.0	[b]471.5	[b]471.5	[b]458.0	[b]469.0	[b]470.0	[b]473.0	[b]471.5	[b]465.0	[b]465.0	[b]466.0

[a]Nonboiling.

[b]Subcooled boiling.

TABLE VII. - HEAT-TRANSFER AND PRESSURE DROP DATA FOR 0.584-CENTIMETER INSIDE DIAMETER BY 14.6-CENTIMETER-LONG TEST SECTIONS 230-25, 230-25B, 230-25C, AND 230-25D

[G = mass velocity, kg/(sec)(m^2); q = heat flux, kW/m^2; T_i = inlet temperature, K; T_e = exit temperature, K; P_e = exit pressure, kN/m^2 abs; ΔP = pressure drop, kN/m^2.]

Run	G	q	T_i	T_e	P_e	ΔP	Inner-wall temperature, T_w, K												
Axial distance from start of heating, z, cm							0.635	1.94	3.17	4.44	5.71	6.98	8.25	9.52	10.79	12.06	12.70	13.30	14.04	13.97
3	28.1	2106	293.2	310.9	115	<7	[a]390.0	[b]415.0	[b]415.0	-----	[b]403.0	[b]408.0	[b]409.0	[b]409.0	[b]410.0	[b]411.0	[b]409.0	[b]409.0	[b]408.0	[b]408.0
4	28.1	2783	293.2	316.5	115	<7	[a]416.5	[b]431.5	[b]431.5	-----	[b]414.0	[b]416.5	[b]418.0	[b]416.5	[b]418.0	[b]418.0	[b]416.5	[b]416.0	[b]414.0	[b]415.0
5	28.4	4129	293.7	327.6	115	<7	[b]419.0	[b]435.0	[b]418.0	-----	[b]416.0	[b]415.0	[b]419.0	[b]414.0	[b]419.0	[b]416.5	[b]414.0	[b]412.0	[b]413.0	[b]415.0
6	28.1	4570	293.7	331.5	115	7	[b]420.0	[b]419.0	[b]418.0	-----	[b]418.0	[b]419.0	[b]419.0	[b]415.0	[b]419.0	[b]418.0	[b]413.0	[b]413.0	[b]415.0	[b]416.0
7	28.7	4823	293.7	333.7	115	7	[b]422.0	[b]420.0	[b]419.0	-----	[b]418.0	[b]420.0	[b]421.5	[b]416.0	[b]420.0	[b]419.0	[b]415.0	[b]414.0	[b]416.0	[b]418.0
8	28.1	4949	294.3	334.8	115	7	[b]423.0	[b]421.0	[b]420.0	-----	[b]419.0	[b]421.0	[b]423.0	[b]474.0	[b]420.0	[b]419.0	[b]417.0	[b]416.0	[b]418.0	[b]419.0
9	28.1	5043	294.3	335.9	115	8	[b]424.0	[b]420.0	[b]420.0	-----	[b]420.0	[b]421.0	[b]423.0	[b]419.0	[b]421.0	[b]420.0	[b]418.0	[b]417.0	[b]418.0	[b]420.0
[c]10	28.1	5201	294.3	337.1	115	8	[b]422.0	[b]421.0	[b]421.0	-----	[b]420.0	[b]421.5	[b]423.0	[b]420.0	[b]421.5	[b]420.0	[b]418.0	[b]419.0	[b]419.0	[b]421.0
11	28.4	3845	313.2	344.3	115	6	[b]427.0	[b]424.0	[b]421.0	-----	[b]419.0	[b]417.0	[b]420.0	[b]416.5	[b]418.0	[b]416.0	[b]414.0	[b]415.0	[b]415.0	[b]416.0
12	28.1	4066	312.6	345.9	115	8	[b]425.0	[b]422.0	[b]420.0	-----	[b]419.0	[b]419.0	[b]420.0	[b]417.0	[b]419.0	[b]417.0	[b]416.0	[b]417.0	[b]416.5	[b]418.0
13	28.4	4224	313.2	347.6	115	11	[b]426.0	[b]424.0	[b]423.0	-----	[b]420.0	[b]420.0	[b]422.0	[b]417.0	[b]419.0	[b]420.0	[b]419.0	[b]419.0	[b]418.0	[b]419.0
14	28.1	4413	313.2	348.7	115	13	[b]426.0	[b]424.0	[b]422.0	-----	[b]421.0	[b]419.0	[b]422.0	[b]418.0	[b]420.0	[b]420.0	[b]419.0	[b]419.0	[b]420.0	[b]420.0
15	28.1	4602	313.2	350.9	115	15	[b]425.0	[b]425.0	[b]424.0	-----	[b]421.0	[b]420.0	[b]422.0	[b]419.0	[b]421.5	[b]423.0	[b]420.0	[b]420.0	[b]420.0	[b]422.0
[c]16	28.1	4823	313.2	352.6	115	19	[b]426.0	[b]426.0	[b]424.0	-----	[b]420.0	[b]420.0	[b]423.0	[b]421.0	[b]423.0	[b]423.0	[b]420.0	[b]420.0	[b]420.0	[b]421.5
18	27.8	2818	331.5	355.4	115	12	[b]417.0	[b]413.0	[b]413.0	-----	[b]406.5	[b]407.0	[b]408.0	[b]402.0	[b]405.0	[b]405.0	[b]403.0	[b]403.0	[b]400.0	[b]403.0
19	27.8	3184	331.5	358.7	115	16	[b]429.0	[b]425.0	[b]419.0	-----	[b]420.0	[b]421.0	[b]423.0	[b]419.0	[b]421.0	[b]420.0	[b]416.5	[b]419.0	[b]416.0	[b]419.0
20	28.4	3530	330.9	360.7	115	20	[b]428.0	[b]426.5	[b]420.0	-----	[b]419.0	[b]419.0	[b]423.0	[b]418.0	[b]421.5	[b]420.0	[b]415.0	[b]417.0	[b]415.0	[b]417.0
21	27.6	3940	331.5	363.7	115	26	[b]429.0	[b]428.0	[b]423.0	-----	[b]420.0	[b]422.0	[b]424.0	[b]421.0	[b]421.0	[b]421.0	[b]421.5	[b]417.0	[b]416.0	[b]418.0
22	28.1	4224	330.9	364.8	115	30	[b]429.0	[b]428.0	[b]422.0	-----	[b]420.0	[b]423.0	[b]425.0	[b]420.0	[b]421.5	[b]422.0	[b]418.0	[b]418.0	[b]416.5	[b]419.0
23	28.1	4602	330.9	368.2	115	36	[b]433.0	[b]428.0	[b]426.5	-----	[b]425.0	[b]427.0	[b]428.0	[b]424.0	[b]424.0	[b]426.5	[b]421.5	[b]421.5	[b]419.0	[b]421.5
Axial distance from start of heating, z, cm							0.61	1.90	3.17	4.44	5.71	6.98	8.25	9.52	10.79	12.11	12.70	13.33	13.39	13.97
2B	28.7	3593	293.7	322.1	114	10	[b]414.0	[b]411.0	[b]412.0	[b]414.0	[b]415.0	[b]415.0	[b]414.0	[b]414.0	[b]414.0	[b]408.0	[b]409.0	[b]408.0	[b]412.0	[b]410.0
4B	45.9	4066	294.3	315.4	115	12	[b]404.0	[b]400.0	[b]402.0	[b]400.0	[b]401.5	[b]402.0	[b]400.0	[b]401.0	[b]401.0	[b]399.0	[b]400.0	[b]401.5	[b]401.5	[b]403.0
5B	45.9	6367	295.4	328.2	115	16	[b]425.0	[b]424.0	[b]425.0	[b]424.0	[b]425.0	[b]425.0	[b]420.0	[b]423.0	[b]420.0	[b]416.5	[b]419.0	[b]421.5	[b]420.0	[b]421.0
6B	45.9	6714	295.9	329.8	115	17	[b]425.0	[b]425.0	[b]426.0	[b]425.0	[b]426.0	[b]426.5	[b]423.0	[b]424.0	[b]421.0	[b]418.0	[b]421.0	[b]424.0	[b]422.0	[b]423.0
8B	45.9	6146	304.3	334.8	115	17	[b]425.0	[b]425.0	[b]426.0	[b]424.0	[b]425.0	[b]425.0	[b]423.0	[b]423.0	[b]420.0	[b]418.0	[b]420.0	[b]423.0	[b]419.0	[b]423.0
10B	45.6	3814	323.7	343.2	115	14	[b]425.0	[b]422.0	[b]421.5	[b]418.0	[b]416.5	[b]414.0	[b]414.0	[b]414.0	[b]412.0	[b]410.0	[b]412.0	[b]414.0	[b]414.0	[b]415.0
11B	45.9	4570	323.7	346.5	115	19	[b]422.0	[b]420.0	[b]421.0	[b]418.0	[b]416.0	[b]416.5	[b]415.0	[b]416.0	[b]414.0	[b]411.0	[b]413.0	[b]415.0	[b]416.0	[b]414.0
12B	45.9	4066	330.4	350.9	115	23	[b]426.5	[b]424.0	[b]426.0	[b]424.0	[b]421.5	[b]421.5	[b]421.0	[b]420.0	[b]418.0	[b]415.0	[b]418.0	[b]419.0	[b]411.0	[b]418.0
14B	45.9	4507	324.3	346.5	115	19	[b]423.0	[b]420.0	[b]422.0	[b]420.0	[b]418.0	[b]417.0	[b]416.0	[b]417.0	[b]414.0	[b]412.0	[b]414.0	[b]416.5	[b]415.0	[b]415.0
16B	28.2	4696	294.3	333.2	310	10	[b]447.0	[b]448.0	[b]448.0	[b]448.0	[b]449.0	[b]449.0	[b]448.0	[b]448.0	[b]448.0	[b]445.0	[b]447.0	[b]449.0	[b]446.5	[b]450.0
17B	28.4	5138	294.3	337.1	308	10	[b]444.0	[b]445.0	[b]446.0	[b]446.0	[b]446.0	[b]446.5	[b]444.0	[b]446.0	[b]445.0	[b]441.5	[b]444.0	[b]445.0	[b]448.0	[b]447.0
18B	28.2	5737	294.8	341.5	306	11	[b]446.5	[b]446.0	[b]448.0	[b]446.0	[b]446.5	[b]446.5	[b]444.0	[b]445.0	[b]444.0	[b]443.0	[b]444.0	[b]446.0	[b]449.0	[b]449.0
19B	28.2	5989	294.8	343.7	308	12	[b]448.0	[b]448.0	[b]448.0	[b]448.0	[b]448.0	[b]448.0	[b]446.5	[b]448.0	[b]446.5	[b]445.0	[b]445.0	[b]447.0	[b]449.0	[b]449.0
20B	28.2	6462	294.8	347.6	308	10/14	[b]448.0	[b]448.0	[b]447.0	[b]446.0	[b]447.0	[b]447.0	[b]445.0	[b]446.5	[b]445.0	[b]444.0	[b]444.0	[b]446.0	[b]448.0	[b]448.0
21B	28.2	6903	294.8	352.1	308	10/16	[b]448.0	[b]448.0	[b]448.0	[b]447.0	[b]448.0	[b]448.0	[b]446.0	[b]447.0	[b]446.0	[b]445.0	[b]445.0	[b]447.0	[b]449.0	[b]448.0
22B	28.4	6934	294.8	354.3	308	10/18	[b]449.0	[b]449.0	[b]449.0	[b]447.0	[b]449.0	[b]449.0	[b]446.0	[b]448.0	[b]446.0	[b]446.0	[b]446.0	[b]447.0	[b]450.0	[b]449.0
24B	28.7	4444	310.9	344.3	310	10	[b]441.5	[b]441.0	[b]439.0	[b]438.0	[b]439.0	[b]439.0	[b]436.5	[b]438.0	[b]436.0	[b]435.0	[b]435.0	[b]436.5	[b]437.0	[b]438.0
25B	28.4	6430	310.9	362.6	310	10/17	[b]448.0	[b]446.5	[b]448.0	[b]445.0	[b]448.0	[b]448.0	[b]444.0	[b]446.0	[b]444.0	[b]443.0	[b]444.0	[b]445.0	[b]446.5	[b]446.5
26B	28.2	6682	310.9	364.8	310	0/21	[b]446.0	[b]446.0	[b]447.0	[b]445.0	[b]446.0	[b]444.0	[b]445.0	[b]444.0	[b]442.0	[b]443.0	[b]443.0	[b]443.0	[b]445.0	[b]445.0
28B	28.2	3247	332.1	357.6	309	10	[b]430.0	[b]428.0	[b]428.0	[b]428.0	[b]429.0	[b]428.0	[b]427.0	[b]428.0	[b]427.0	[b]425.0	[b]428.0	[b]429.0	[b]431.0	[b]430.0
29B	28.4	4633	331.5	370.4	309	11/15	[b]445.0	[b]443.0	[b]444.0	[b]443.0	[b]444.0	[b]444.0	[b]442.0	[b]443.0	[b]441.0	[b]440.0	[b]441.0	[b]441.5	[b]443.0	[b]442.0

31B	28.4	3972	353.7	385.4	310	6/22	[b]436.5	[b]436.5	[b]436.5	[b]436.0	[b]437.0	[b]436.5	[b]435.0	[b]435.0	[b]434.0	[b]433.0	[b]434.0	[b]435.0	[b]436.5	[b]436.0
32B	28.2	4287	352.6	387.1	310	3/31	[b]439.0	[b]439.0	[b]439.0	[b]438.0	[b]439.0	[b]439.0	[b]436.5	[b]437.0	[b]435.0	[b]435.0	[b]436.0	[b]437.0	[b]437.0	[b]439.0
33B	46.0	5264	319.3	345.4	115	22	[a]421.0	[b]436.0	[b]436.0	[b]433.0	[b]435.0	[b]434.0	[b]433.0	[b]434.0	[b]433.0	[b]433.0	[b]423.0	[b]423.0	[b]418.0	[b]418.0
34B	45.9	6745	319.6	353.2	115	41/55	[b]426.5	[b]424.0	[b]425.0	[b]423.0	[b]425.0	[b]425.0	[b]423.0	[b]424.0	[b]423.0	[b]422.0	[b]422.0	[b]421.0	[b]422.0	[b]421.0
35B	45.9	6966	317.6	352.6	115	41/55	[b]428.0	[b]424.0	[b]426.5	[b]424.0	[b]426.5	[b]426.5	[b]424.0	[b]425.0	[b]424.0	[b]423.0	[b]423.0	[b]423.0	[b]423.0	[b]423.0
37B	14.3	1768	294.8	322.6	114	8	[b]416.0	[b]404.0	[b]404.0	[b]406.5	[b]406.5	[b]406.5	[b]406.5	[b]407.0	-----	-----	-----	-----	[b]404.0	-----
38B	14.4	3341	294.3	347.1	114	10	[b]404.0	[b]406.0	[b]408.0	[b]409.0	[b]409.0	[b]410.0	[b]408.0	[b]408.0	[b]407.0	[b]406.5	[b]408.0	[b]408.0	[b]410.0	[b]409.0
39B	45.9	5453	312.1	338.7	115	17	[b]423.0	[b]416.0	[b]417.0	[b]415.0	[b]415.0	[b]414.0	[b]414.0	[b]415.0	[b]413.0	[b]414.0	[b]414.0	[b]414.0	[b]416.0	[b]415.0
Axial distance from start of heating, z, cm							0.635	1.90	3.14	4.44	5.71	6.98	8.25	9.52	10.82	12.06	12.70	13.28	14.00	14.00
3C	28.7	4917	294.3	334.8	114	6	[b]409.0	[b]408.0	[b]409.0	[b]411.0	[b]409.0	[b]411.0	----	[b]410.0	[b]406.0	[b]409.0	[b]409.0	[b]411.5	[b]419.0	[b]411.0
4C	28.7	4570	305.4	341.5	115	8	[b]415.0	[b]411.0	[b]411.0	[b]414.0	[b]408.0	[b]411.0	----	[b]411.0	[b]406.5	[b]409.0	[b]410.0	[b]412.0	[b]419.0	[b]412.0
5C	28.1	3940	314.3	345.9	115	8	[b]419.0	[b]412.0	[b]411.5	[b]412.0	[b]407.0	[b]409.0	----	[b]410.0	[b]406.0	[b]409.0	[b]409.0	[b]411.5	[b]417.0	[b]411.5
6C	28.4	3688	323.2	350.9	115	8	[b]420.0	[b]410.0	[b]411.0	[b]410.0	[b]406.5	[b]406.5	----	[b]408.0	[b]405.0	[b]405.5	[b]409.0	[b]409.0	[b]415.0	[b]409.0
7C	28.1	2957	332.1	355.4	115	8	[b]425.0	[b]411.0	[b]408.0	[b]410.0	[b]406.0	[b]408.0	----	[b]410.0	[b]407.0	[b]409.0	[b]409.0	[b]413.0	[b]415.0	[b]409.0
8C	28.1	3404	348.7	373.7	114	37/41	[b]416.5	[b]415.0	[b]412.0	[b]414.0	[b]412.0	[b]415.0	----	[b]415.0	[b]411.0	[b]413.0	[b]412.0	[b]414.0	[b]418.0	[b]411.5
25C	105.0	10276	302.6	324.8	119	28/34	[b]413.0	[b]410.0	[b]408.0	[b]412.0	[b]409.0	[b]414.0	----	[b]409.0	[b]407.0	[b]409.0	[b]408.0	[b]410.0	[b]408.0	[b]407.0
26C	105.0	8573	313.2	332.6	119	28/36	[b]416.0	[b]413.0	[b]412.0	[b]416.0	[b]413.0	[b]417.0	----	[b]413.0	[b]415.0	[b]413.0	[b]413.0	[b]414.0	[b]412.0	[b]411.5
9C	70.3	8321	299.8	327.6	112	23	[b]424.0	[b]423.0	[b]419.0	[b]424.0	[b]419.0	[b]423.0	----	[b]419.0	[b]416.5	[b]419.0	[b]419.0	[b]421.5	[b]430.0	[b]419.0
14C	70.3	5579	324.8	343.2	116	19	[b]415.0	[b]408.0	[b]407.0	[b]410.0	[b]406.0	[b]408.0	----	[b]409.0	[b]406.5	[b]408.0	[b]409.0	[b]410.0	[b]413.0	[b]409.0
16C	70.6	5674	332.1	350.9	116	53	[b]418.0	[b]409.0	[b]409.0	[b]409.0	[b]405.0	[b]408.0	----	[b]409.0	[b]406.5	[b]408.0	[b]406.0	[b]408.0	[b]413.0	[b]405.0
18C	70.9	4854	339.3	355.4	116	56	[b]409.0	[b]408.0	[b]406.5	[b]408.0	[b]404.0	[b]408.0	----	[b]409.0	[b]408.0	[b]408.0	[b]406.0	[b]407.0	[b]409.0	[b]405.0
21C	70.5	5295	350.9	368.7	115	77	[b]422.0	[b]418.0	[b]416.5	[b]419.0	[b]416.0	[b]419.0	----	[b]418.0	[b]415.0	[b]415.0	[b]414.0	[b]414.0	[b]414.0	[b]410.0
Axial distance from start of heating, z, cm							0.61	1.90	3.12	4.48	5.71	6.96	8.25	9.52	10.79	12.06	12.70	13.33	13.97	13.97
3D	104.3	7439	319.3	335.9	119	24/28	[a]412.0	[a]416.0	[b]416.5	[b]416.5	[b]418.0	[b]415.0	[b]415.0	[b]413.0	[b]413.0	[b]413.0	[b]414.0	[b]414.0	[b]412.0	[b]406.5
7D	103.6	4917	338.2	349.3	119	21/22	[a]393.0	[a]401.5	[b]403.0	[b]399.0	[b]409.0	[b]409.0	[b]409.0	[b]409.0	[b]410.0	[b]411.0	[b]413.0	[b]413.0	[b]410.0	[b]405.0
10D	103.6	4476	349.8	359.8	119	47/49	[a]394.0	[a]402.0	[a]404.0	[b]408.0	[b]409.0	[b]409.0	[b]409.0	[b]408.0	[b]408.0	[b]409.0	[b]408.0	[b]408.0	[b]407.0	[b]403.0
12D	27.4	6777	291.5	347.1	445	<7	[b]447.0	[b]446.5	[b]446.0	[b]448.0	[b]449.0	[b]447.0	[b]448.0	[b]446.5	[b]446.5	[b]447.0	[b]450.0	[b]451.0	[b]455.0	[b]445.0
16D	28.2	5327	333.2	375.4	446	0/10	[b]445.0	[b]444.0	[b]444.0	[b]445.0	[b]445.0	[b]444.0	[b]444.0	[b]443.0	[b]442.0	[b]443.0	[b]444.0	[b]444.0	[b]444.0	[b]440.0
22D	28.0	3908	385.9	415.9	446	10/34	[b]439.0	[b]438.0	[b]436.5	[b]437.0	[b]436.5	[b]436.0	[b]435.0	[b]434.0	[b]434.0	[b]434.0	[b]435.0	[b]436.5	[b]436.5	[b]435.0
24D	14.7	3341	291.5	344.3	445	<7	[b]437.0	[b]437.0	[b]436.0	[b]436.5	[b]437.0	[b]435.0	[b]436.5	[b]436.0	[b]435.0	[b]437.0	[b]438.0	[b]439.0	[b]439.0	[b]438.0
30D	14.7	3719	344.3	402.1	446	0/12	[b]439.0	[b]439.0	[b]438.0	[b]439.0	[b]438.0	[b]438.0	[b]438.0	[b]436.0	[b]436.0	[b]436.5	[b]437.0	[b]438.0	[b]436.5	[b]436.0
31D	14.4	895	295.4	309.3	113	<7	[a]356.5	[a]374.0	[a]383.0	[a]387.0	[a]391.5	[a]392.0	[a]394.0	[a]395.0	[a]396.5	[a]397.0	[b]398.0	[b]398.0	[b]398.0	[b]395.0
32D	14.7	3184	295.9	345.9	114	<7	[a]398.0	[a]399.0	[a]401.5	[a]403.0	[b]403.0	[b]402.0	[b]402.0	[b]403.0	[b]402.0	[b]403.0	[b]401.5	[b]404.0	[b]405.0	[b]401.0
37D	14.4	3133	295.9	345.9	689	6	[b]450.0	[b]450.0	[b]450.0	[b]450.0	[b]450.0	[b]449.0	[b]451.0	[b]451.5	[b]451.5	[b]453.0	[b]454.0	[b]455.0	[b]454.0	[b]452.0
38D	14.7	4823	296.5	372.1	689	8/10	[b]456.0	[b]456.5	[b]457.0	[b]458.0	[b]458.0	[b]457.0	[b]457.0	[b]456.5	[b]456.5	[b]458.0	[b]459.0	[b]459.0	[b]456.5	[b]455.0
47D	14.4	3111	389.3	434.3	687	12/17	[b]453.0	[b]451.5	[b]451.5	[b]451.5	[b]451.5	[b]450.0	[b]450.0	[b]450.0	[b]450.0	[b]450.0	[b]451.0	[b]451.0	[b]448.0	[b]449.0
48D	28.2	8353	297.1	364.3	687	9/13	[a]461.5	[b]465.0	[b]464.0	[b]467.0	[b]467.0	[b]465.0	[b]465.0	[b]465.0	[b]465.0	[b]465.0	[b]456.5	[b]466.0	[b]464.0	[b]460.0
56D	28.2	4381	399.8	433.2	687	31/38	[b]454.0	[b]454.0	[b]453.0	[b]454.0	[b]454.0	[b]453.0	[b]453.0	[b]453.0	[b]453.0	[b]454.0	[b]455.0	[b]455.0	[b]452.0	[b]451.0
57D	141.2	11410	306.5	325.9	123	38/55	[a]419.0	[b]421.5	[b]421.5	[b]425.0	[b]426.5	[b]423.0	[b]424.0	[b]422.0	[b]422.0	[b]422.0	[b]424.0	[b]423.0	[b]421.5	[b]412.0

[a]Nonboiling.

[b]Subcooled boiling.

[c]Automatic shutdown after data taken.

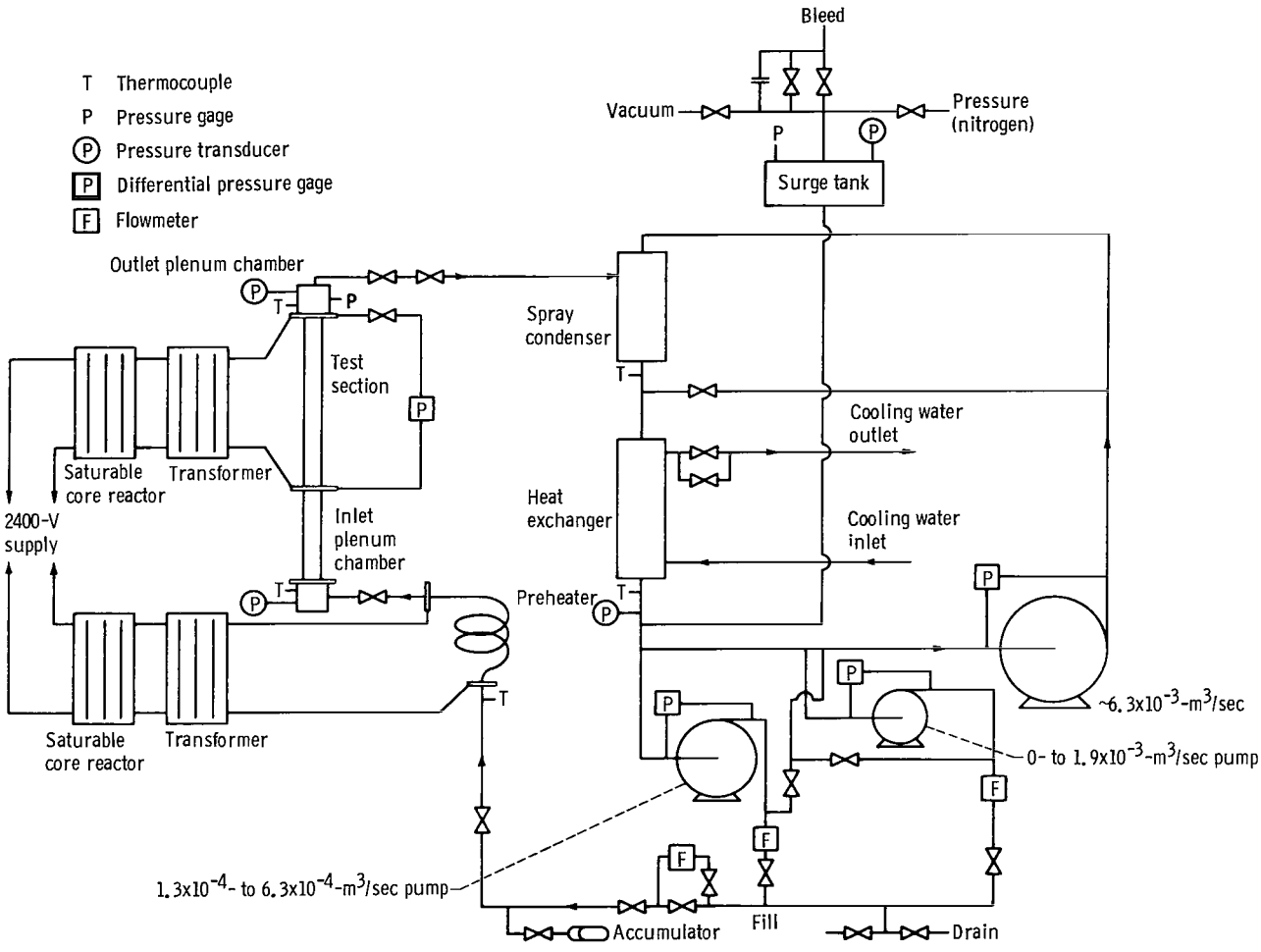


Figure 1. - System flow diagram.

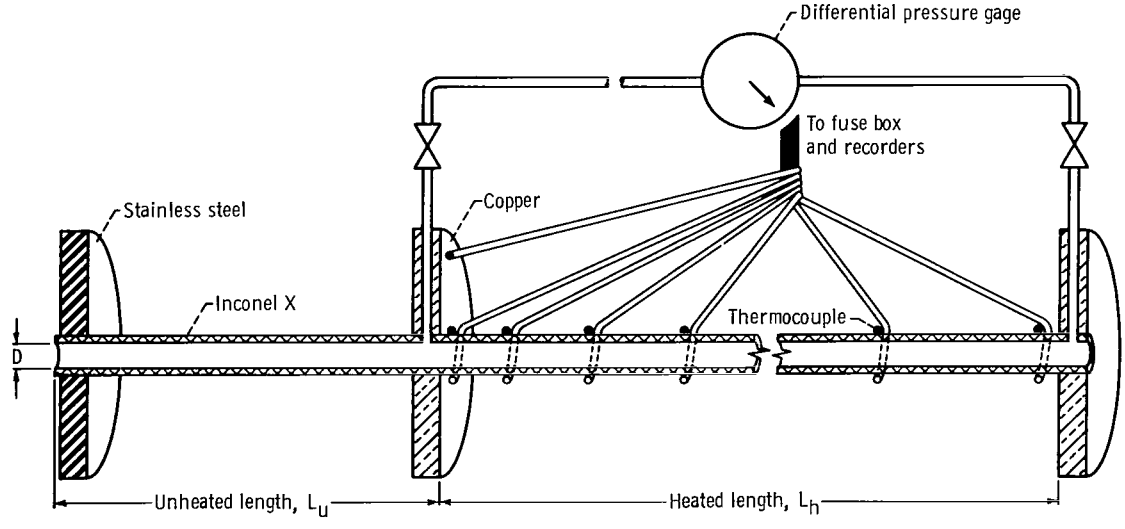


Figure 2. - Schematic diagram of typical test section.

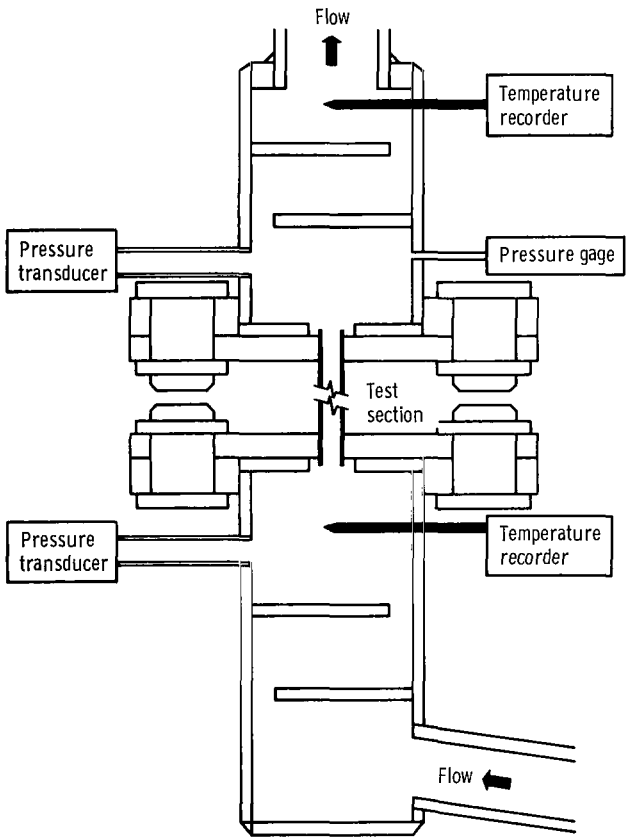


Figure 3. - Plenum chambers.

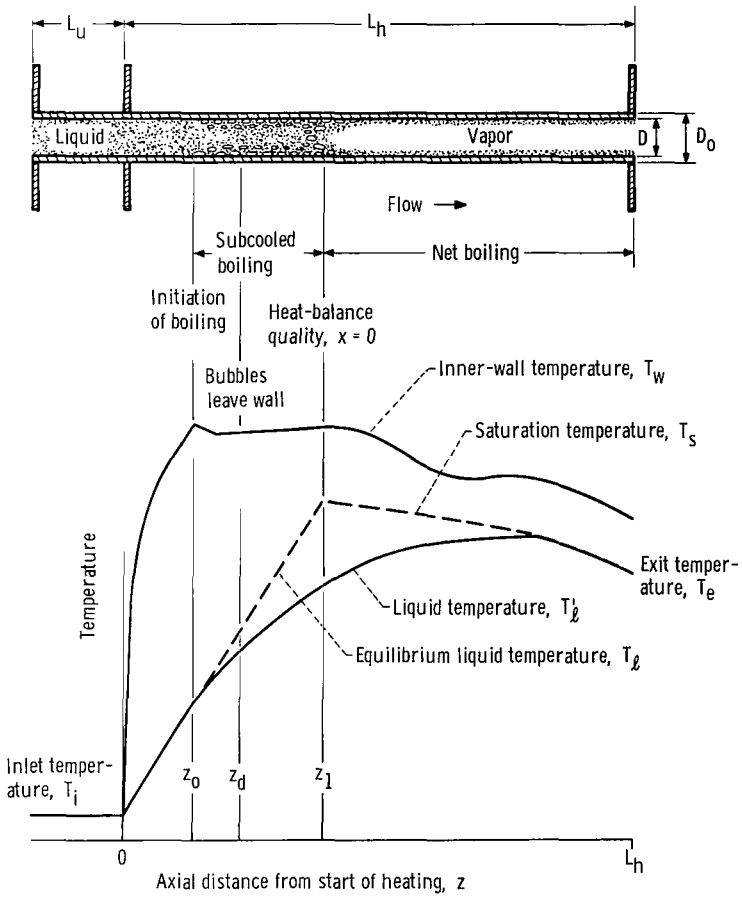
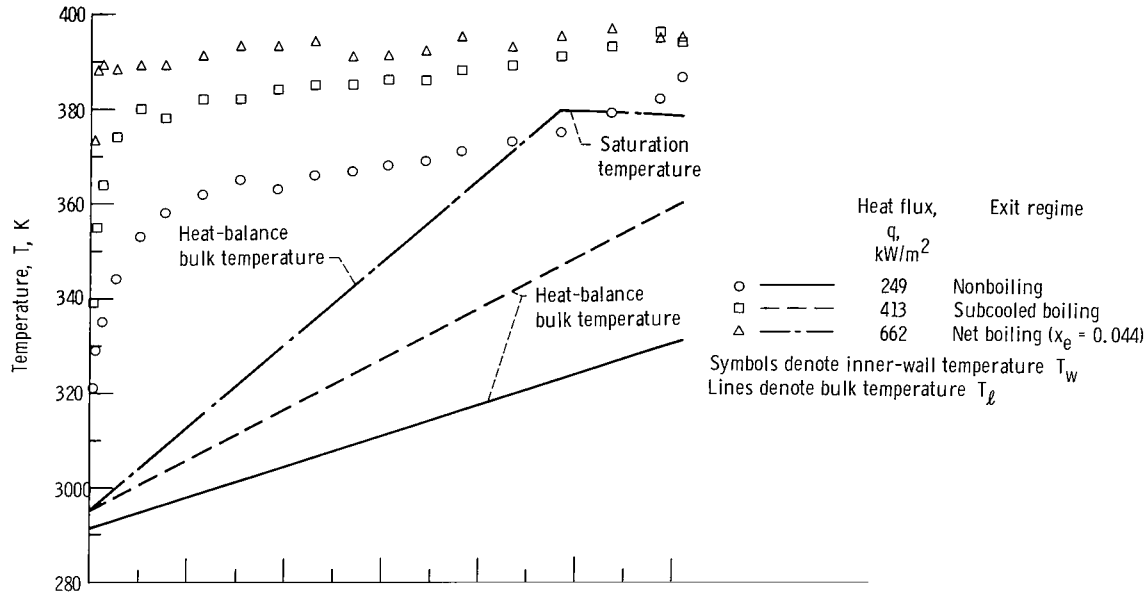
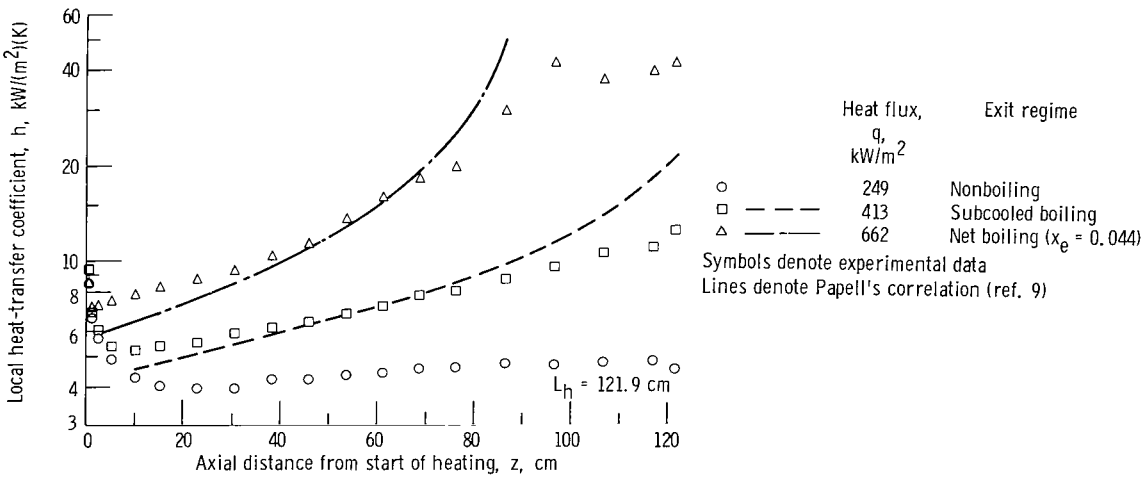


Figure 4. - Typical temperature and voidage profiles with definition of terminology.

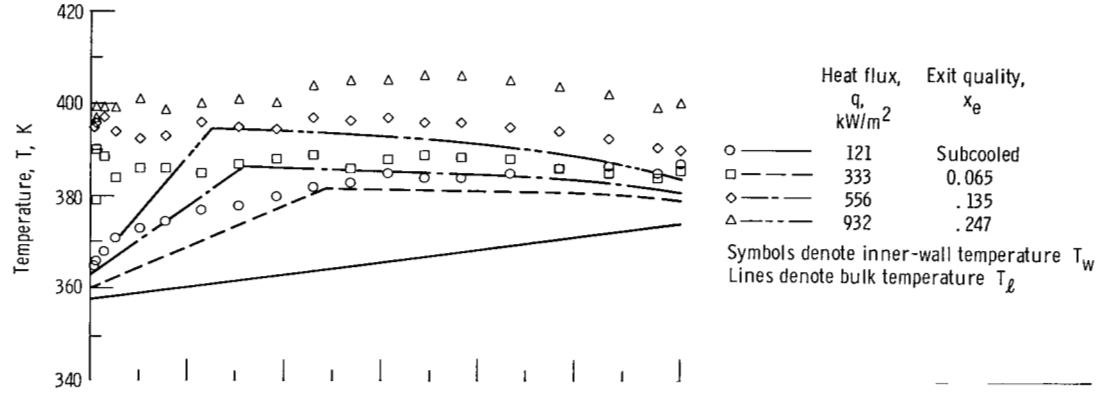


(a) Local bulk and inner-wall temperatures plotted against distance.

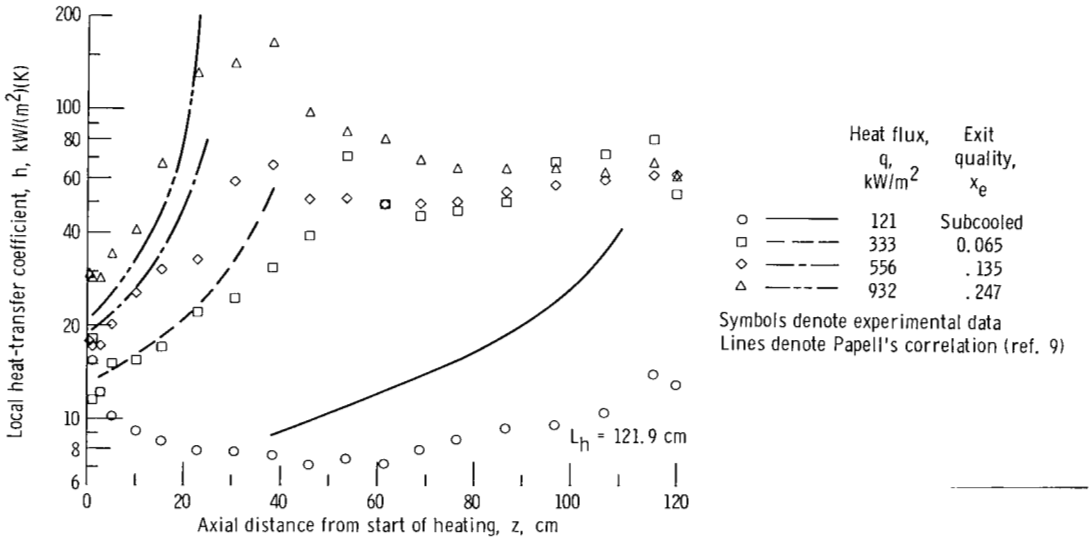


(b) Local heat-transfer coefficient plotted against distance.

Figure 5. - Typical heat-transfer data for large subcooling at inlet (~83 K). Tube inside diameter D = 1.219 centimeters; mass velocity $G \approx 5.9$ kg/(sec)(m^2); exit pressure $P_e \approx 117$ kN/m^2 abs.



(a) Local bulk and inner-wall temperatures plotted against distance.



(b) Local heat-transfer coefficients plotted against distance.

Figure 6. - Typical heat-transfer data for small subcooling at inlet (~22 K). Tube inside diameter D = 1.219 centimeters; mass velocity $G \approx 5.9$ kg/(sec)(m^2); exit pressure P_e = 119 to 146 kN/m^2 abs.

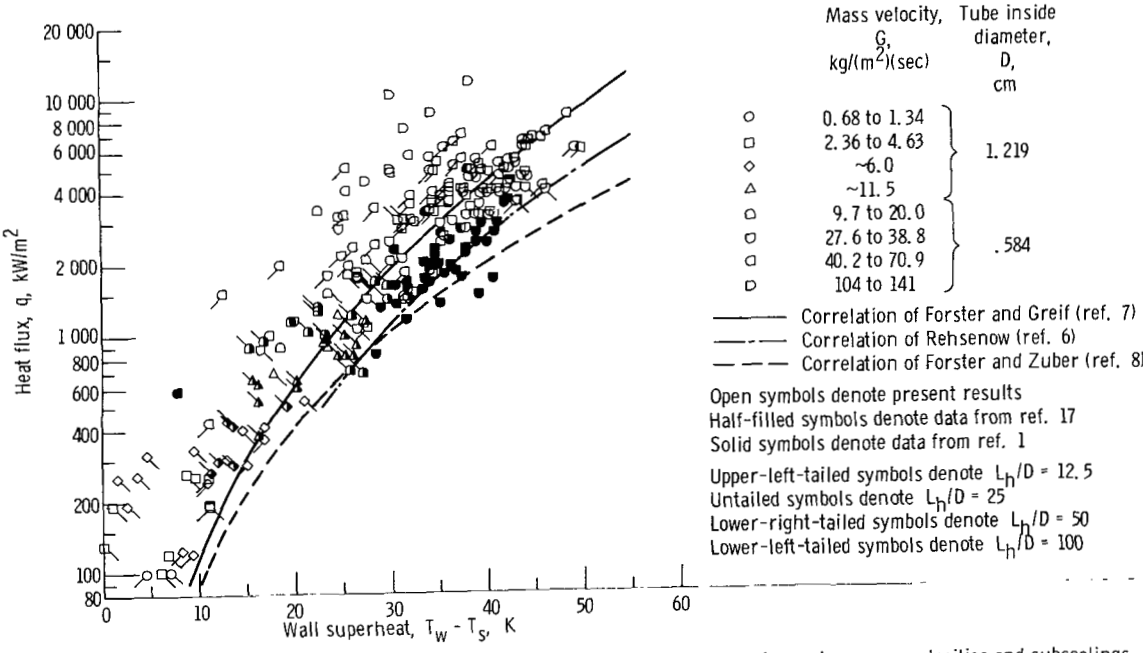


Figure 7. - Heat flux plotted against wall superheat during subcooled boiling for various mass velocities and subcoolings. Exit pressure $P_e \approx 114$ kN/m^2 abs.

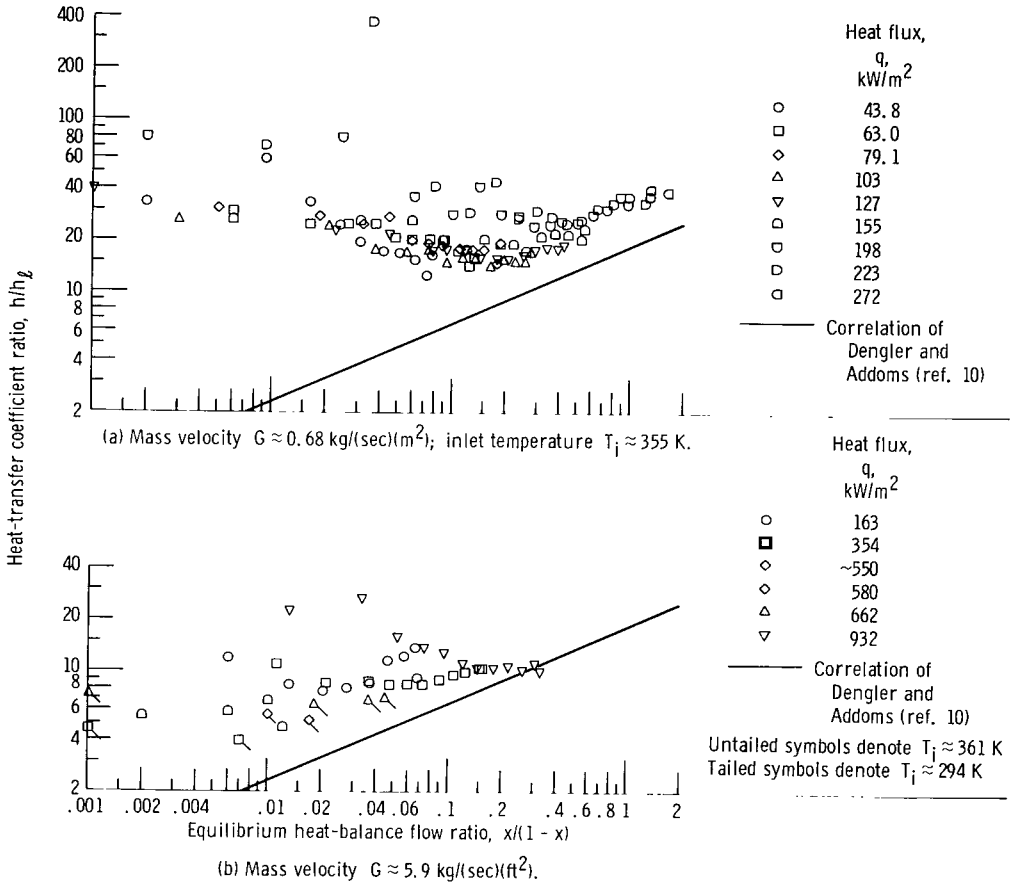


Figure 8. - Ratio of boiling to liquid heat-transfer coefficients plotted against equilibrium heat-balance flow ratio x/(1 - x). Test section 480-100M (table I); exit pressure $P_e \approx 117$ kN/m^2 abs.

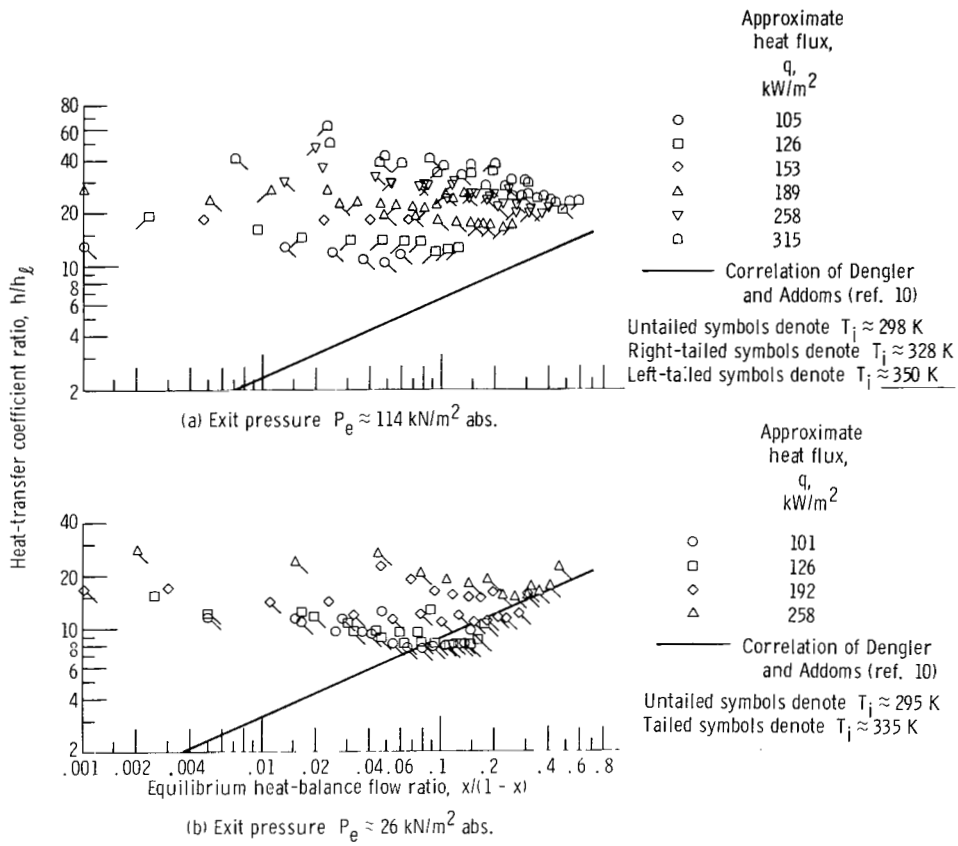
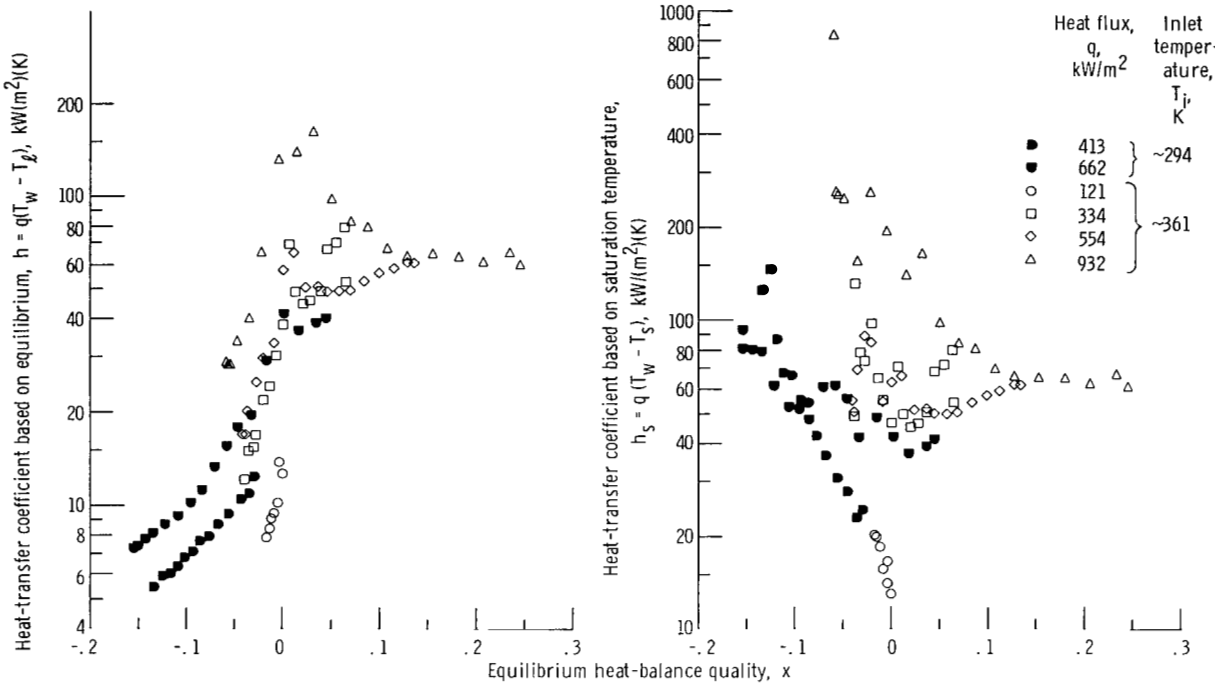
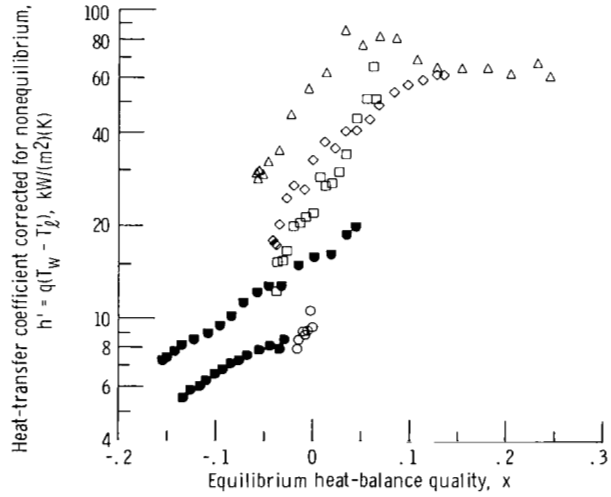


Figure 9. - Ratio of boiling to liquid heat-transfer coefficients plotted against equilibrium heat-balance flow ratio x/(1 - x). Test section 480-50M (table II); mass velocity $G \approx 0.68$ kg/(sec)(m^2).



(a) Heat-transfer coefficient based on equilibrium heat-balance or saturation temperature.

(b) Heat-transfer coefficient based on saturation temperature.



(c) Heat-transfer coefficient corrected for nonequilibrium.

Figure 10. - Heat-transfer coefficient plotted against equilibrium heat-balance quality for various methods of calculating heat-transfer coefficient. Test section 480-100M (table I); mass velocity $G \approx 5.9$ kg/(sec)(m^2); exit pressure $P_e \approx 119$ to 146 kN/m^2 abs.

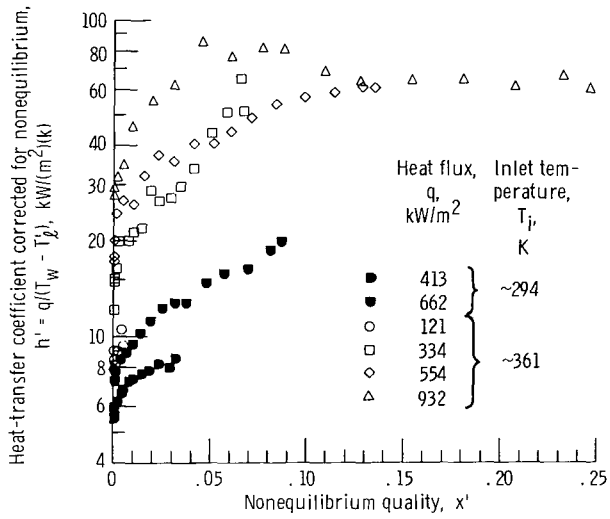


Figure 11. - Heat-transfer coefficient corrected for nonequilibrium plotted against nonequilibrium quality. Test section 480-100M (table I); mass velocity $G \approx 5.94$ kg/(sec)(m^2); exit pressure $P_e \approx 119$ to 146 kN/m^2 abs.

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