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High Dryout Quality Film Boiling and Steam Cooling Heat Transfer Data from a Rod Bundle

G. L. Yoder
T. M. Anklam
D. G. Morris
C. B. Mullins

Prepared for the U.S. Nuclear Regulatory Commission
Office of Nuclear Regulatory Research
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Prepared by the
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830
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NOMENCLATURE

a	liquid absorption coefficient
A	bundle flow area
BOHL	bottom of heated length
d	droplet diameter
C	rod pitch
C_D	drag coefficient
C_i	radiation conductances
D	rod diameter
D_e	hydraulic diameter
D_{he}	heated equivalent diameter
G	mass flux
h	heat transfer coefficient
h_{fg}	latent heat of vaporization
Δh	inlet subcooling
i	current
k	thermal conductivity
L_m	mean beam length
P	pressure
Pr	Prandtl Number
Q	total heat flow rate at any location
Q''_{con}	convective component of surface heat flux
Q''_{tot}	total surface heat flux (including radiation)
R	rod linear resistance
r	radius

Re	Reynolds number $\left(\frac{GD_e}{\mu}\right)$
T	temperature
V_o	inlet volumetric flow
V_ℓ	liquid velocity
V_v	vapor velocity
We_c	critical Weber number
X	equilibrium quality
X_a	actual flow quality

<u>Greek</u>

α	void fraction
μ	viscosity
ρ	density
σ	standard deviation

<u>Subscripts</u>

b	burnout (dryout)
BN	Boron Nitride
B	bulk vapor conditions
c	correlation
con	convective
cnt	contact resistance
e	experimental
f	saturated liquid conditions
fl	film
G	at level G

g	saturated vapor conditions
h-c	heated rod to cold rod
h-v	heated rod to vapor
h-ℓ	heated rod to liquid
is	inside sheath
ℓ	liquid
o	inlet
s	saturation
ss	stainless steel
surf	rod surface
T/C	thermocouple
v	bulk vapor conditions
w	rod surface

Superscripts

'	per unit length
''	per unit area

SUMMARY

A series of intermediate flow, steady state heat transfer experiments was completed February 1981, at the Oak Ridge National Laboratory Thermal-Hydraulic Test Facility. Two steady state test series reported previously provided data in the high-flow film boiling region[1] and in the low-flow steam cooling region.[2,3] The experiments reported here provide data in the parameter range which lies between the steady state steam cooling and higher flow film boiling tests. The test series includes experiments both with and without liquid entrainment above the dryout point. The data can be used in assessing and developing film boiling and single phase vapor heat transfer correlations used in reactor analysis codes. The experiments conducted were high-pressure and high-temperature steady state tests with water flowing upward through an 8 x 8 rod bundle. The rod bundle used in the experiments contains four unheated rods and has flat axial and radial power profiles. The heated pin diameter and rod pitch are typical of later generation pressurized-water reactors (PWRs) with 17 x 17 fuel assemblies. The bundle is heavily instrumented with thermocouples, and flow measurement sites are positioned at each end of the test section containing the rod bundle.

Equilibrium fluid conditions within the bundle can easily be calculated using mass and energy conservation equations. Accurate calculations are possible because of the steady state nature of the tests. However, nonequilibrium conditions probably exist within the bundle, and a more sophisticated calculational method is needed if nonequilibrium bundle fluid conditions are desired.

Comparisons were made between experimentally determined heat transfer coefficients (heat fluxes) and those determined from six film boiling correlations and one single-phase vapor correlation. These correlations are:

1. Dougall-Rohsenow,
2. Dougall-Rohsenow (wall Prandtl number),
3. Groeneveld 5.7,
4. Groeneveld 5.9,
5. Condie-Bengston IV,

6. Groeneveld-Delorme, and
7. Dittus-Boelter.

Uncertainties in experimental heat transfer coefficients and in three film boiling heat transfer coefficients were also calculated (Dougall-Rohsenow, Groeneveld 5.9, and Groeneveld 5.7).

The heat transfer coefficients of the Dougall-Rohsenow correlation are sometimes high (by as much as 50%) compared with experimentally determined heat transfer coefficients discussed in this report. This is possibly caused by thermodynamic nonequilibrium in the flow. Because the Dougall-Rohsenow correlation is basically a Dittus-Boelter correlation for vapor (not accounting for wall-to-liquid heat transfer and assuming perfect vapor-to-liquid heat transfer), an error in the fluid quality will result in an error in the vapor Reynolds number ($Re_v = G X D_e/\mu_v \alpha$) used in the correlation. Therefore, the heat transfer coefficient produced would be in error. Nonequilibrium also implies that liquid can be present in the flow when equilibrium qualities are >1. This also reduces the vapor Reynolds number compared with equilibrium assumptions and would cause the Dittus-Boelter single-phase vapor correlation (assessed only when equilibrium quality was >1) to overpredict heat transfer coefficients. The Groeneveld 5.7, Groeneveld 5.9, and Condie-Bengston IV correlations yield heat transfer coefficients that are more conservative than the Dougall-Rohsenow correlation. The Groeneveld-Delorme correlation tends to underpredict the experimental heat fluxes.

ABSTRACT

A series of eight steady-state rod bundle tests has been performed at the Oak Ridge National Laboratory in the Thermal Hydraulic Test Facility to gather data in both the low flow film boiling region and high flow steam cooling region. This test series includes experiments both with and without liquid entrainment above the dryout point. These experiments covered the following parameter ranges:

Mass flux	43 - 260 kg/m²s
	(3.1×10^4 - 1.9×10^5 lbm/ft²h)
Heat flux	100 - 470 kW/m²
	(3.1×10^4 - 1.5×10^5 Btu/ft²h)
Pressure	3.8 - 8.5 MPa
	(550 - 1230 psi)

Bundle fluid conditions were calculated using steady-state energy and mass conservation equations. The experimental heat transfer data have been compared to several film boiling heat transfer correlations and one vapor correlation. Results of these comparisons support the conclusions reached in the analysis of prior ORNL transient and steady state tests (3.03.6AR, 3.06.6B, 3.08.6C, series 3.07.9, series 3.02.10, and series 3.09.10). Results indicate that the Dougall-Rohsenow correlation often overpredicts the heat transfer coefficient, while the Groeneveld 5.7 and Condie-Bengston IV correlations tend to underpredict, however they are in better agreement with the data. The Groeneveld-Delorme correlation underpredicts heat fluxes. The Dittus-Boelter correlation was evaluated only when equilibrium qualities were greater than one, and tends to overpredict the heat transfer coefficient.

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1. INTRODUCTION

A series of eight intermediate flow, steady state film boiling experiments was completed in February 1981 at the Oak Ridge National Laboratory (ORNL) Thermal-Hydraulic Test Facility (THTF). These experiments provided steady state rod bundle film boiling and steam cooling data over a range of flow conditions. These tests provide data from which accurate bundle fluid conditions and rod surface conditions can be determined. These in turn can be used to assess or develop film boiling and single-phase vapor heat transfer correlations. These tests also provide a means of obtaining data in the intermediate-flow film boiling data ranges requested by the

Nuclear Regulatory Commission (NRC) Office of Nuclear Reactor Regulation (NRR).[4] This report presents an evaluation of steady state rod bundle post-critical heat flux (CHF) heat transfer. The following seven correlations are assessed in this document:

1. Dougall-Rohsenow,[5]
2. Dougall-Rohsenow (wall Pr),[6]
3. Groeneveld 5.7,[7]
4. Groeneveld 5.9,[7]
5. Condie-Bengston IV,[8]
6. Groeneveld-Delorme,[9] and
7. Dittus-Boelter.[10]

The experimental data were obtained from high-pressure, high-temperature, steady state tests with water flowing upward through the rod bundle. Assessments of the seven correlations were made for all of the tests. The test conditions for each run are shown in Table 1.1.

Table 1.1. THTF intermediate-flow steady-state film boiling and steam cooling data ranges

Test	Pressure		Mass flux		Average total heat flux		X_b	X_o	X_G
	psi	MPa	lb_m/ft^2 h x 10^6	kg/m^2 s	Btu/ft^2 h x 10^5	kW/m^2			
IA	1231.0	8.49	0.315	42.7	0.324	100.0	1.00	-0.128	1.588
IB	1188.8	8.20	0.609	82.5	0.507	160.0	0.974	-0.136	1.253
IC	1205.2	8.32	0.812	110.0	0.600	189.0	0.971	-0.002	1.215
ID	1168.7	8.06	1.07	146.0	0.872	275.0	1.00	-0.025	1.276
IE	550.6	3.80	0.651	88.4	0.621	196.0	0.974	-0.052	1.261
IF	584.1	4.03	1.27	172.0	1.07	336.0	0.878	-0.059	1.114
IG	564.6	3.90	1.90	258.3	1.41	444.0	0.792	-0.035	0.998
IH	1200.6	8.28	1.92	261.0	1.50	474.0	0.815	-0.222	1.075

X_b is the dryout or burnout quality.

X_o is the test section inlet quality.

X_G is the quality at level G (see Fig. 2.3).

Chapter 2 contains a description of the THTF and the experimental procedure. The data reduction scheme is presented in Chap. 3, while correlation comparisons are presented in Chap. 4. The conclusions are discussed in Chap. 5.

2. FACILITY DESCRIPTION AND EXPERIMENTAL PROCEDURE

The intermediate flow film boiling experiments were conducted with the THTF in the configuration diagramed in Fig. 2.1. The inlet flow lines were of small diameter to allow accurate control of the low inlet flow. The THTF is a heavily instrumented, nonnuclear, pressurized-water loop containing 64 full-length (3.66-m or 12-ft) rods arranged in an 8 x 8 bundle [D_e = 0.0106 m (0.0349 ft)]; 60 of the rods are electrically heated. The instrumentation located in the outlet and inlet spool pieces is listed in Table 2.1.

Rods 19, 22, 36, and 46 are the four unheated rods in the 8 x 8 bundle, as shown in Fig. 2.2. During test IB rod 60 was inoperable, and in tests IC and ID, both rod 26 and 60 were inoperable. The axial locations of the fuel rod simulator (FRS) thermocouples are shown schematically in Fig. 2.3. Rod geometry (listed in Table 2.2) is typical of later generation PWRs with 17 x 17 fuel assemblies. The axial and radial power profile is flat. Figure 2.4 shows a simplified cross section of a typical

Table 2.1. Instrumentation located in selected spool pieces

Instrument	Outlet nozzle spool piece	Vertical outlet spool piece	Inlet flow measurement
Turbine meter	FE-202	FE-216	FE-250 FE-260
Drag Target	FMFE-206	FMFE-220	FMFE-264
Pressure tap	PE-209	PE-224	PE-258
Thermocouple	TE-208	TE-222	TE-256
Densitometer	DE-204	DE-218	DE-20

Table 2.2. Bundle geometry

Rod pitch, mm (in.)	12.7 (0.501)
Rod diameter, mm (in.)	9.50 (0.374)
Hydraulic diameter, mm (in.)	10.6 (0.42)
Heated equivalent diameter, mm (in.)	13.8 (0.54)

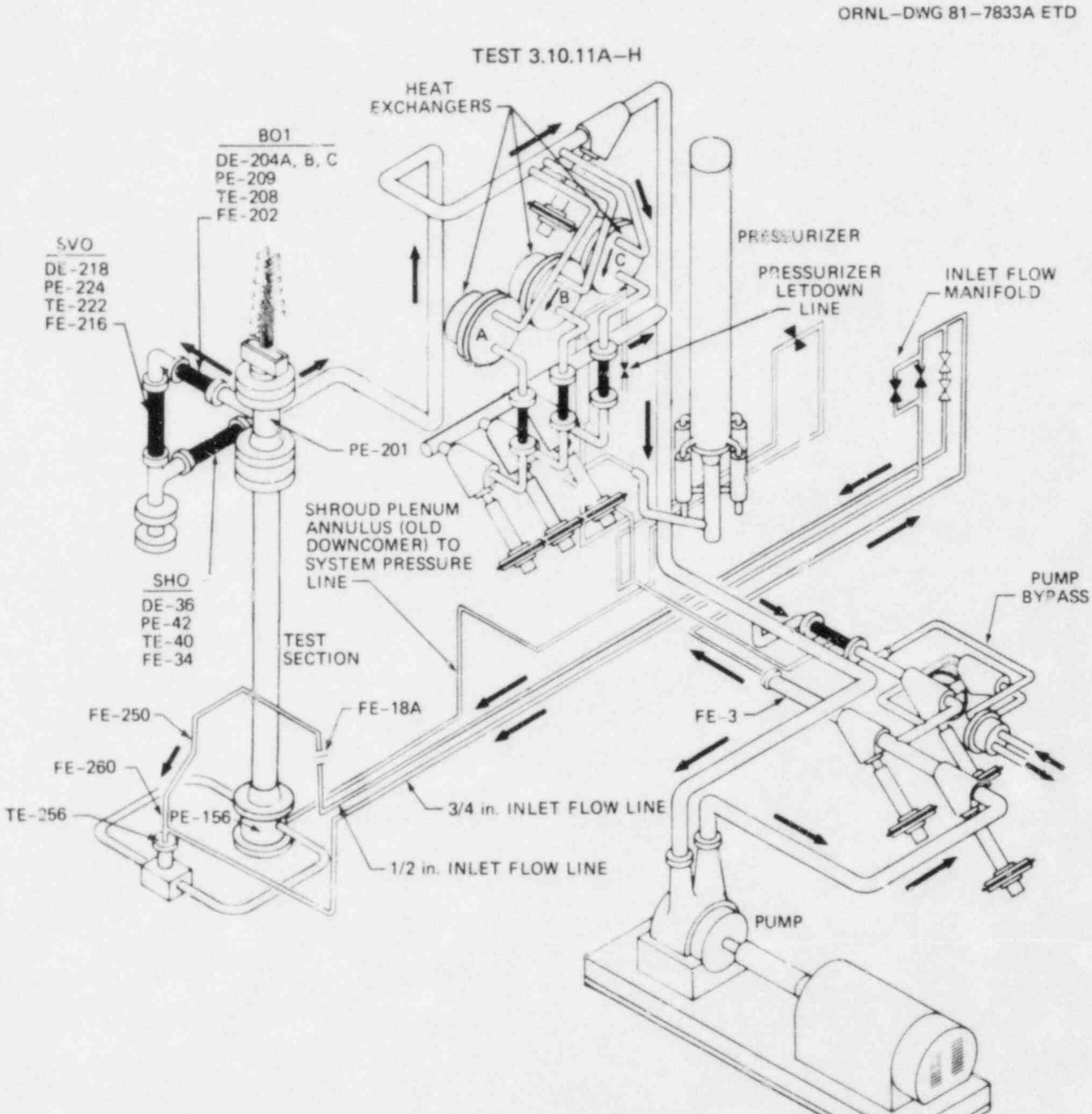

Fig. 2.1. THTF configuration for test series 3.10.11A-IH.

ORNL-DWG 77-5718

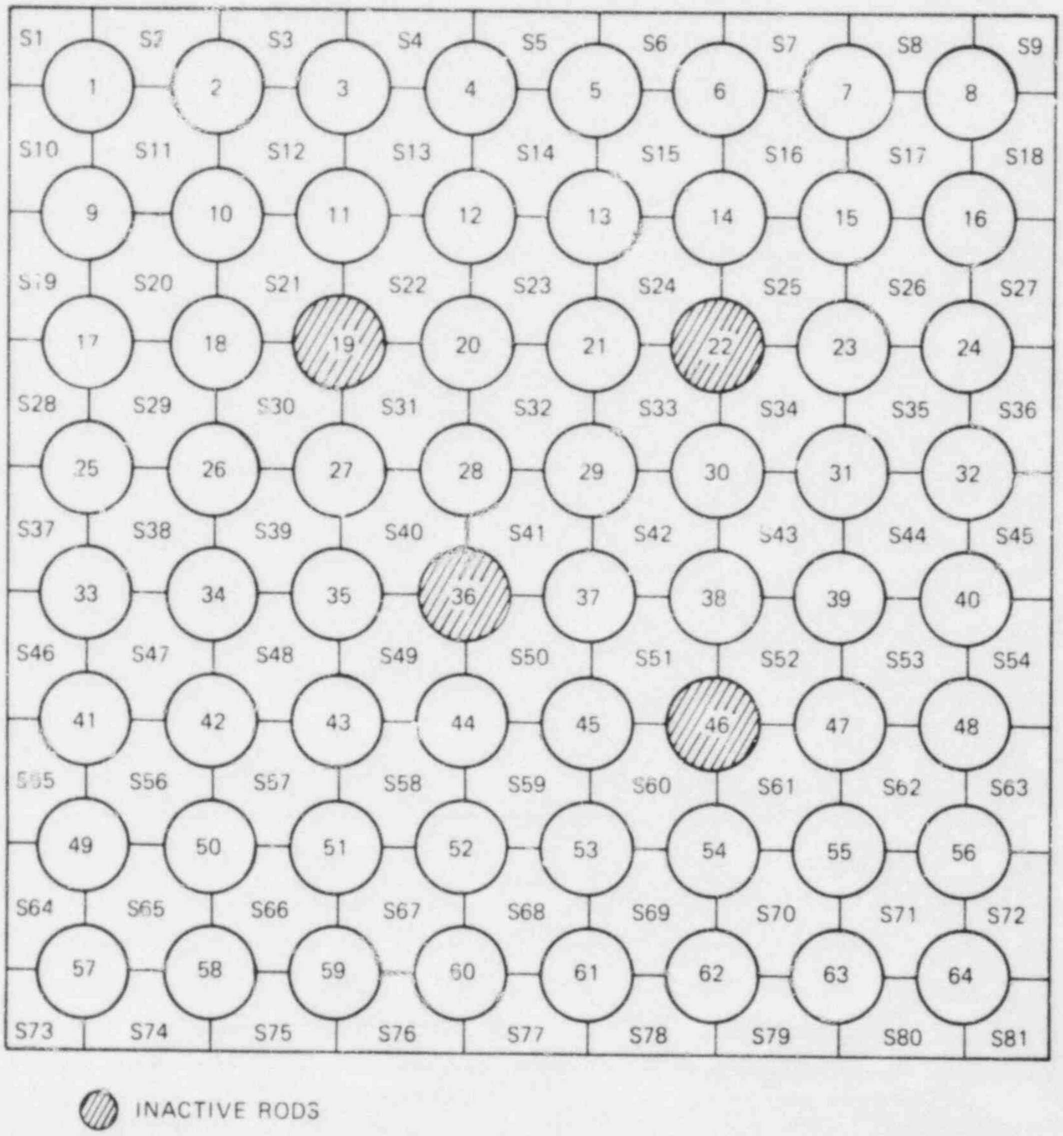

Fig. 2.2. Identification of THTF heater rods, subchannel location and inactive rods in THTF bundle 3.

fuel rod simulator. Subchannel thermocouples, located at the top of the bundle, were used to indicate liquid entrainment.

During steady state operation of the THTF, fluid flows from the pump (Fig. 2.1) through flow control valves and the inlet fluid measurement system before it enters the test section, where it is heated as it flows past the rods. The fluid leaves the test section from the upper plenum, passes through the outlet spool pieces, and heat exchangers, and returns

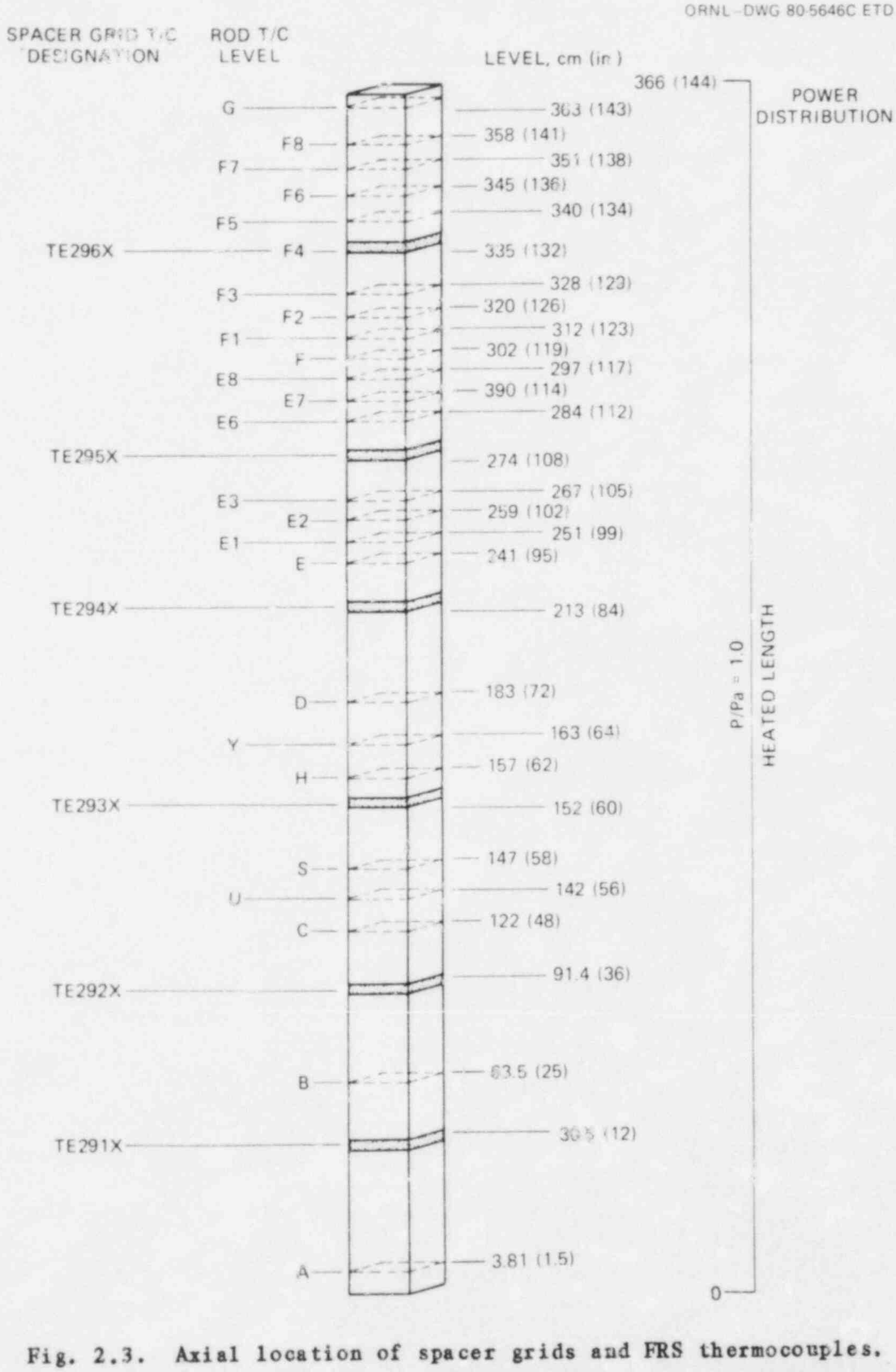

Fig. 2.3. Axial location of spacer grids and FRS thermocouples.

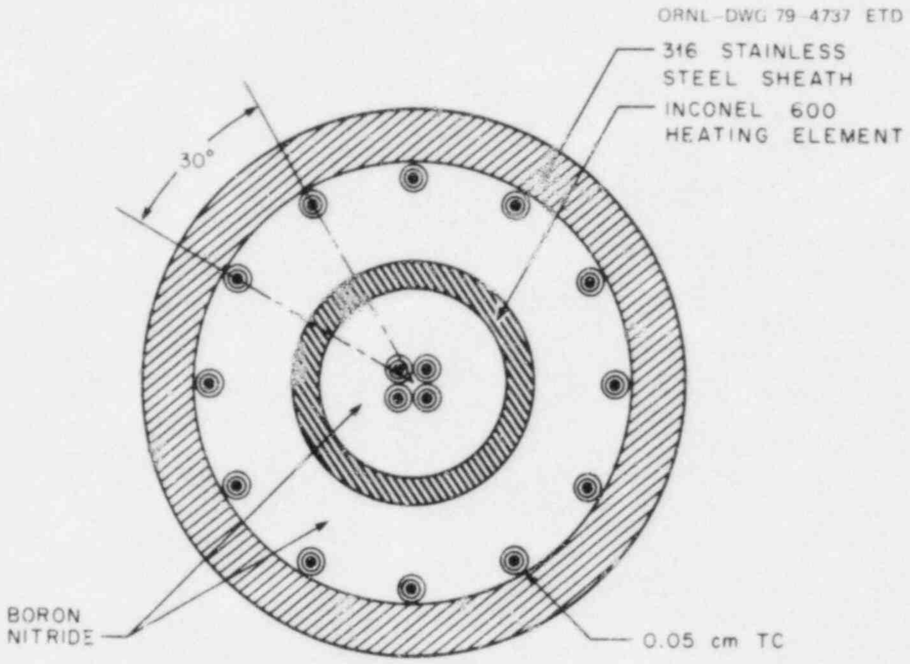

Fig. 2.4. Cross section of a typical FRS.

to the pump. A complete description of the THTF facility can be found in Ref. 11.

Inlet flow for each steady state test was established and the loop was adjusted to provide the desired inlet fluid temperature and inlet pressure. The bundle power was then increased until the dryout point was at the desired position in the bundle. The steady state operating point was assumed to have been reached when operating pressure and rod surface temperatures stabilized. Instruments were scanned for 20 s during each experiment. Standard deviations of the rod voltage and current during the scans were on the order of 0.1 V and 0.2 A, respectively.

3. DATA REDUCTION

Characterization of bundle heat transfer requires knowledge of both rod surface conditions and local fluid conditions. Two heat transfer coefficients can be defined, depending on the intended use of these equations.

$$h_s = \frac{Q''_{con}}{T_w - T_s} \quad , \qquad (1)$$

where T_s is the saturation temperature, and Q''_{con} is the convective heat flux component. Also,

$$h_B = \frac{Q''_{con}}{T_W - T_B} \qquad (2)$$

can be defined, where T_B is the equilibrium bulk vapor temperature. These equations will be equivalent when the equilibrium quality is less than one.

Accurate surface conditions are ensured by careful measurement of rod parameters such as heater cross-sectional areas, rod dimensions, and rod linear resistance. Rod resistance (a function of temperature) along with measured rod current is used to calculate the total heat flux leaving the rod surface.

$$Q''_{tot} = \frac{i^2 \; R(T)}{2 \; \pi \; r_w} \; . \qquad (3)$$

Rods are calibrated in situ, and values for local boron nitride thermal conductivity, thermocouple contact resistance, and thermocouple bead position are determined.[12] These values and the linear heat flow rate are used in a numerical one-dimensional conduction equation to calculate the rod surface temperature knowing the measured inside sheath temperature. The analytical form of the equation follows:

$$T_w = T_{TC} - \frac{Q'}{2\pi}\left(\frac{\ln\frac{r_{is}}{r_{TC}}}{K_{BN}} + \frac{1}{r_{is}\,h_{cnt}} + \frac{\ln\frac{r_w}{r_{is}}}{K_{ss}}\right). \tag{4}$$

Convective heat fluxes, Q''_{con}, used in Eqs. (1) and (2) were calculated by subtracting the radiative component of heat flux from the total heat flux leaving the rod, Q''_{tot} [Eq. (3)]. A calculation of radiation heat transfer from the hot rod to the unheated portions of the bundle, the steam, and the liquid droplets was included in the analysis presented in Appendix A.

Local level average fluid conditions were calculated from a steady state energy balance using measured inlet conditions T_o and V_o and assuming negligible pressure drop through the bundle. The bundle inlet fluid was always subcooled to ensure accurate measurement of inlet volumetric flow. Measured bundle pressure and fluid inlet temperature were used to calculate the inlet enthalpy. The total heat absorbed by the fluid up to the point of interest was calculated by adding the contribution from each individual rod on a level-by-level basis.

Losses within the test section can occur through the shroud wall which surrounds the bundle. These losses can become particularly important under very low power conditions. Thermocouples imbedded within the shroud wall allow these losses to be calculated. Losses were important in only one test within this test series. Overall heat losses for test IA were determined to be ~2.7% of the total input power to the bundle. Losses above the dryout point, in the steam cooling region were ~4% of the power input above dryout. These losses were subtracted from the total input power in order to arrive at the corrected heat input to the fluid, Q' [used in Eq. (5)]. The method used to calculate losses through the shroud is presented in Appendix A.6 of Ref. 2. In all tests other than IA, the shroud wall losses were found to be negligible.

An energy balance at any axial location then yields an equation for equilibrium quality in terms of known parameters:

$$X = \frac{Q}{\rho_o V_o h_{fg}} - \frac{\Delta h}{h_{fg}} . \tag{5}$$

The equilibrium quality defined by Eq. (5) may yield qualities greater than one since it is a thermodynamic rather than a mass-based quality. Once equilibrium quality and pressure at any location are known, equilibrium fluid properties at that location are also known.

Experimental heat transfer coefficients (Eqs. 1 and 2) are calculated only when rod surface temperatures are 222°C (400°F) above the saturation temperature. This superheat is somewhat arbitrary, but it ensures that the rod surface will be in stable film boiling, and that entrance length heat transfer effects near the dryout location will be minimized.

Seven heat transfer coefficient correlations were evaluated for comparison with the experimental heat transfer coefficients. A compilation of these correlations follows. Also included is the appropriate experimental heat transfer coefficient (included in parentheses) used for comparison with correlation-predicted values. The Groeneveld-Delorme correlation-predicted heat flux is compared with the convective heat flux.

Dougall-Rohsenow (h_s):

$$h_c = 0.023 \frac{K_g}{D_e} Pr_g^{0.4} \left\{ Re_g \left[X + \frac{\rho_g}{\rho_f} (1 - X) \right] \right\}^{0.8} \tag{6}$$

Dougall-Rohsenow (wall Pr) (h_s)

$$h_c = 0.023 \frac{K_g}{D_e} Pr_w^{0.4} \left\{ Re_g \left[X + \frac{\rho_g}{\rho_f} (1 - X) \right] \right\}^{0.8} \tag{7}$$

Groeneveld 5.7 (h_s)

$$h_c = \frac{0.052 \frac{K_g}{D_e} Pr_w^{1.26} \left\{ Re_g \left[X + \frac{\rho_g}{\rho_f} (1 - X) \right] \right\}^{0.688}}{\left[1.0 - 0.1 (1 - X)^{0.4} \left(\frac{\rho_f}{\rho_g} - 1 \right)^{0.4} \right]^{1.06}} \tag{8}$$

Groeneveld 5.9 (h_s)

$$h_c = \frac{0.00327 \frac{K_g}{D_e} Pr_w^{1.32} \left\{ Re_g \left[X + \frac{\rho_g}{\rho_f} (1 - X) \right] \right\}^{0.901}}{\left[1.0 - 0.1 (1 - X)^{0.4} \left(\frac{\rho_f}{\rho_g} - 1 \right)^{0.4} \right]^{1.5}} \qquad (9)$$

Condie-Bengston IV (English Units) (h_s)

$$h_c = 0.03175 \frac{K_g^{0.4593} Pr_w^{2.2598} Re_g^{[0.6249 + 0.2043 \ln (X + 1)]}}{D_e^{0.8095} (X + 1)^{2.0514}} \qquad (10)$$

Groeneveld-Delorme (Q''_{con})

$$Q_c'' = 0.008348 \frac{K_{f1}}{D_e} \left\{ \frac{GD_e}{\mu_{f1}} \left[X_a + \frac{\rho_v}{\rho_f} (1 - X_a) \right] \right\}^{0.8774} Pr_{f1}^{0.6112} (T_w - T_v) \qquad (11)$$

where X_a is determined from a correlation dependent on flow and saturated fluid conditions.

One single-phase vapor correlation is also evaluated when equilibrium quality is greater than one.

Dittus-Boelter (h_B)

$$h_c = 0.023 \frac{K_B}{D_e} Re_B^{0.8} Pr_B^{0.4} \qquad (12)$$

Uncertainties in the fluid and surface conditions were used to calculate uncertainties in both the experimental and correlation heat transfer coefficients. Uncertainty analysis was carried out for the Dougall-Rohsenow, Groeneveld 5.7, and Groeneveld 5.9 correlations. Details of the analysis method used in calculating uncertainties in both experimental and correlation heat transfer coefficients are presented in Ref. 1.

4. RESULTS

Correlation Comparisons

Results for each of the tests are presented in tabular form in SI units in Appendix B at the end of this report. These results are divided into five separate sections:

Section 1 - level average fluid and surface conditions

Section 2 - major level data - X < 1

Section 3 - major level data - X > 1

Section 4 - intermediate level data - X < 1

Section 5 - intermediate level data - X > 1

In some tests, sections are omitted where qualities were always greater than one (Sects. 2 and 4 omitted) or always less than one (Sects. 3 and 5 omitted) between the dryout point and the top of the bundle. Fluid and surface conditions along with their cross-sectional standard deviations (1σ values) are presented in the first section. Surface conditions presented are the average conditions for each level. Surface heat flux presented here is the convective component only. Standard deviations of the surface conditions are the bundle cross-sectional standard deviations (as opposed to measurement uncertainty) and are thus an indication of the variation across the bundle at one axial location. Each thermocouple level has a differing number of instrumented rods. The major levels (A, B, C, D, E, F, and G) have the greatest number of thermocouple locations. The averages and standard deviations for these levels would be more significant than the averages and standard deviations at other levels having fewer thermocouple locations. Surface conditions were averaged only when rod superheat was 222°C (400°F) or greater. If only one rod was above this superheat at a given axial level, the cross-sectional uncertainty will therefore be zero for that level. If no rods were in film boiling [i.e., $(T_w - T_s) < 400°F$] at a level, that level is omitted from the table.

The second and third sections for each test show only the major level thermocouple information (levels A, B, C, D, E, F, G). Major level thermocouples should show little or no influence of the spacer grids.

The second section presented for each test shows heat transfer correlation comparisons when the equilibrium qualities are less than 1. Uncertainties for three of these correlations are also presented (Dougall-Rohsenow, Groeneveld 5.7 and Groeneveld 5.9). The fractional standard deviation (fsd) for the Dougall-Rohsenow correlation with Pr evaluated at the wall temperature is expected to be similar to the fsd for the standard Dougall-Rohsenow equation because Pr is insensitive to variations in both pressure and temperature at high temperatures (i.e., the wall temperature). Surface conditions in this section and the remainder of the sections for each test are local surface conditions. Both the experimental heat transfer coefficient and its uncertainty are also presented. Correlation uncertainty and experimental heat transfer coefficient uncertainty in this section and in the remainder of the sections for each test reflect measurement uncertainties and represent one standard deviation. Correlations presented in this section are

1. Dougall-Rohsenow heat transfer coefficient,
2. Dougall-Rohsenow (wall Pr) heat transfer coefficient,
3. Groeneveld 5.7 heat transfer coefficient,
4. Groeneveld 5.9 heat transfer coefficient,
5. Condie-Bengston IV heat transfer coefficient, and
6. Groeneveld-Delorme heat flux.

The Dougall-Rohsenow correlation was developed from the single-phase Dittus-Boelter equation using the vapor velocity based on the equilibrium quality. It therefore assumes perfect vapor-to-liquid heat transfer and does not account for drop-wall interactions. Thus, it does not account for non-equilibrium which may be present in the flow.

The Groeneveld 5.7 and 5.9 equations, along with the Condie-Bengston IV correlation, were correlated using dispersed flow heat transfer data. They would therefore account partially for the nonequilibrium in the flow and the presence of droplets.

The Groeneveld-Delorme correlation was also developed from dispersed flow data. It explicitly accounts for nonequilibrium within the flow and contains a correlation for actual quality (actual mass based flowing quality) as a function of flow conditions.

The third section presented shows heat transfer correlation comparisons and uncertainties when equilibrium qualities are greater than one. Both experimental heat transfer coefficients based on $(T_w - T_{sat})$ and experimental coefficients based on $(T_w - T_{bulk})$ are tabulated. Correlations in this table are

1. Dittus-Boelter heat transfer coefficient,
2. Condie-Bengston IV heat transfer coefficient, and
3. Groeneveld-Delorme heat flux.

Condie-Bengston IV and the Groeneveld-Delorme correlations are only presented when dryout quality is less than 1.

The Dittus-Boelter correlation is a single-phase heat transfer coefficient developed from several types of single-phase data. The Condie-Bengston IV and Groeneveld-Delorme equations were described previously.

The fourth and fifth sections for each test present information for the intermediate-level thermocouples (E1, E2, E3, E6, E7, E8, F1, F2, F3, F4, F5, F6, F7, F8). Calibration of these thermocouples could include effects due to the presence of spacer grids in the bundle. The calibration procedure assumes that a single phase heat transfer coefficient is applicable when water alone is flowing through the heated bundle. This heat transfer coefficient includes no grid spacer effects and thus the calibration would tend to wash out some of the grid effects present during testing. By comparing intermediate-level thermocouple calibrations with major level thermocouple calibrations, it is estimated that the error in surface temperature due to this effect is on the order of 6°C (10°F) immediately downstream of the grid where it would probably have the largest impact. The effect diminishes as distance from the grid increases and is negligible at the major level thermocouple locations. It should also be very small at thermocouple locations immediately upstream of the grid.

The fourth section presents intermediate-level information for equilibrium qualities less than one. The same correlation comparisons are presented as in the second section.

The fifth section presents intermediate-level information for equilibrium qualities greater than one. The same correlation comparisons are presented as in the third section.

Values from rod 54 were not presented for any tests. Centerline thermocouples which are used in the calibration procedure were not functioning properly in rod 54. This led to high uncertainty values in surface conditions, although the absolute values of the surface conditions were reasonable.

Plots which show correlation comparisons for all tests are presented in Figs. 4.1 through 4.7. Any data point lying above and to the left of the diagonal line in the figures indicates that predicted heat transfer coefficients (heat fluxes) are lower than the experimentally measured heat transfer coefficient (heat flux). Data lying below and to the right indicate an overprediction of the heat transfer coefficient (heat flux).

At one axial level, the data tend to form a vertical string (see Fig. 4.1). The vertical scatter at one axial level is primarily caused by radial variations in the fluid conditions and their effect on surface temperatures, since uncertainties in experimental heat transfer coefficients (as indicated in the tables in Appendix B) are significantly smaller than

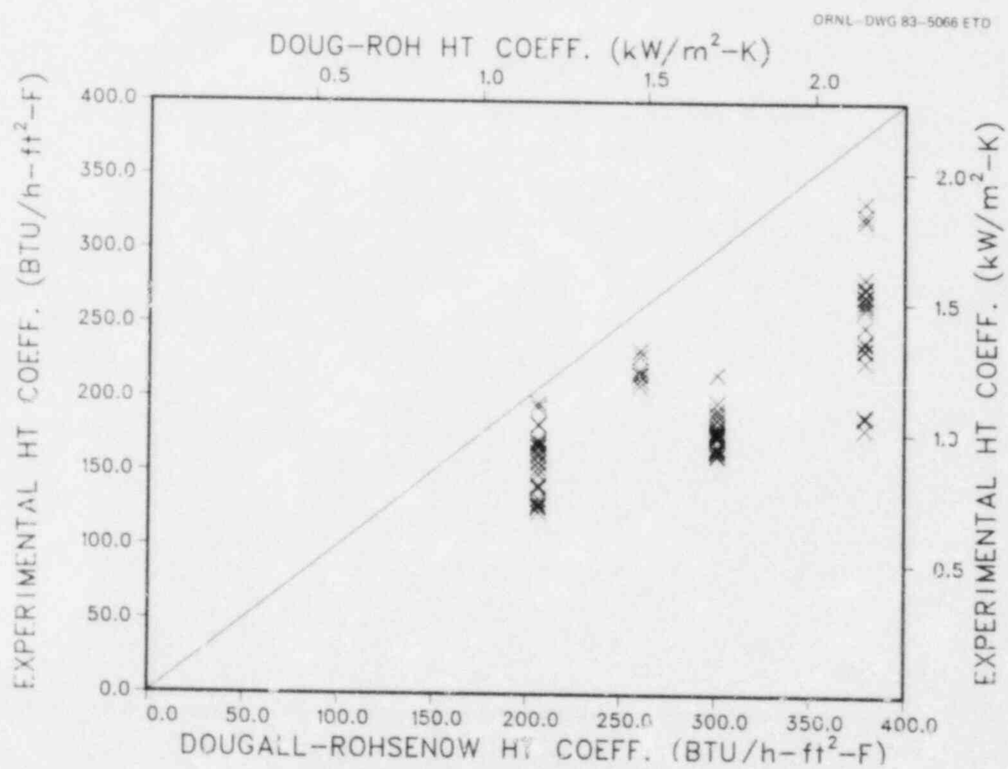

Fig. 4.1. Dougall-Rohsenow correlation comparison.

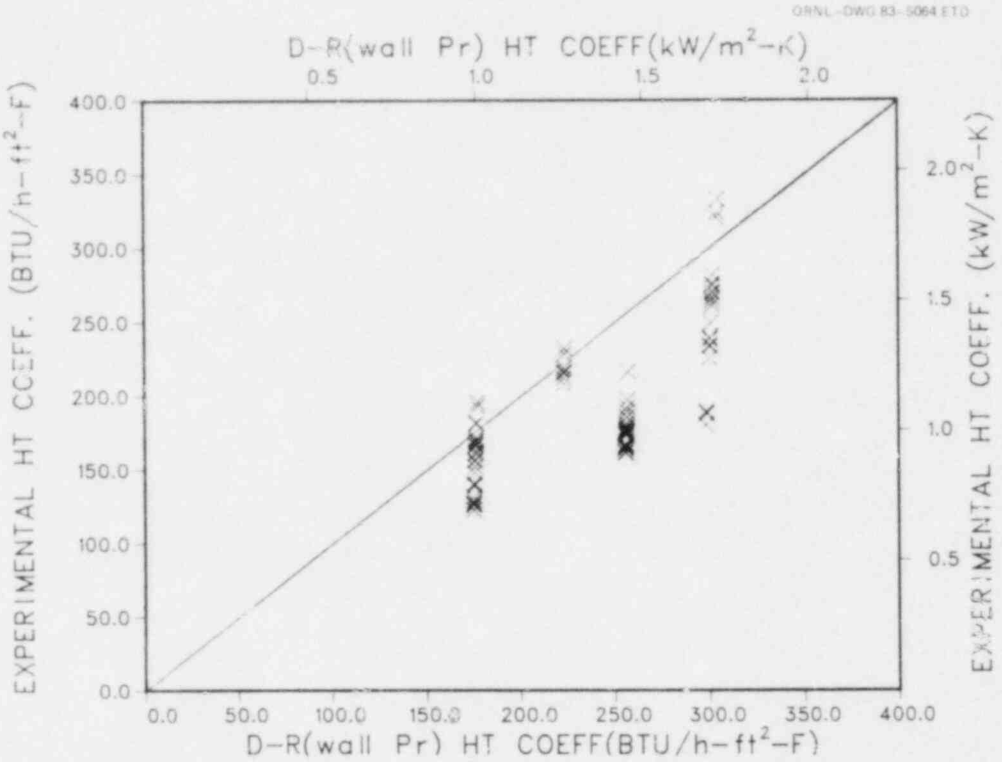

Fig. 4.2. Dougall-Rohsenow (Pr_{wall}) correlation comparison.

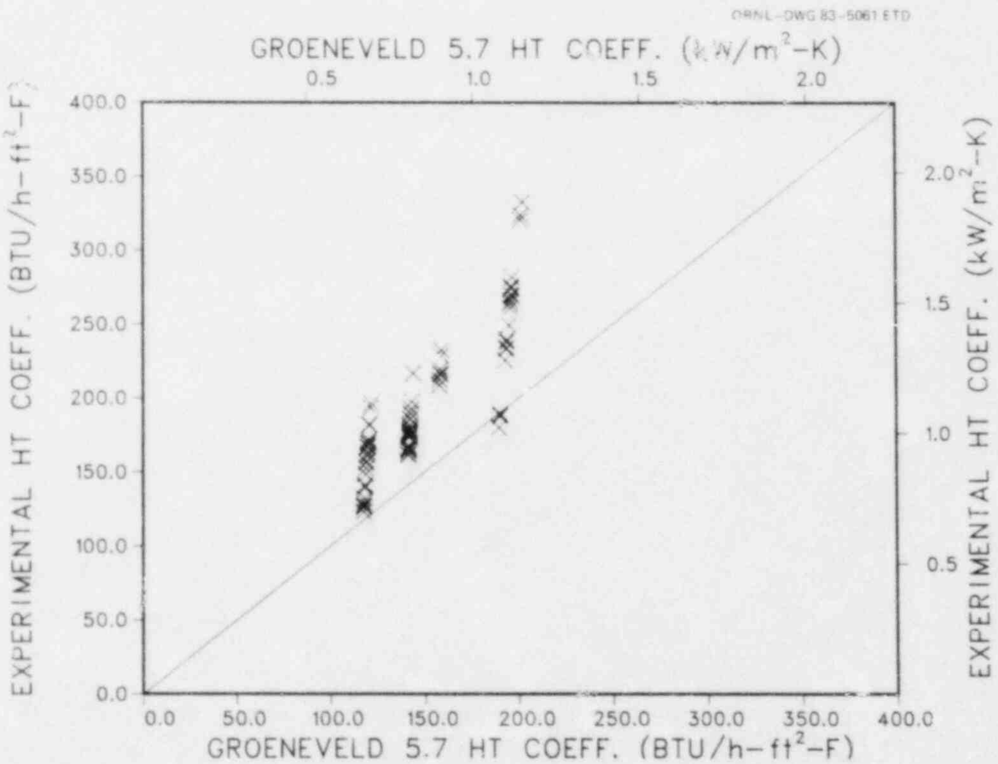

Fig. 4.3. Groeneveld 5.7 correlation comparison.

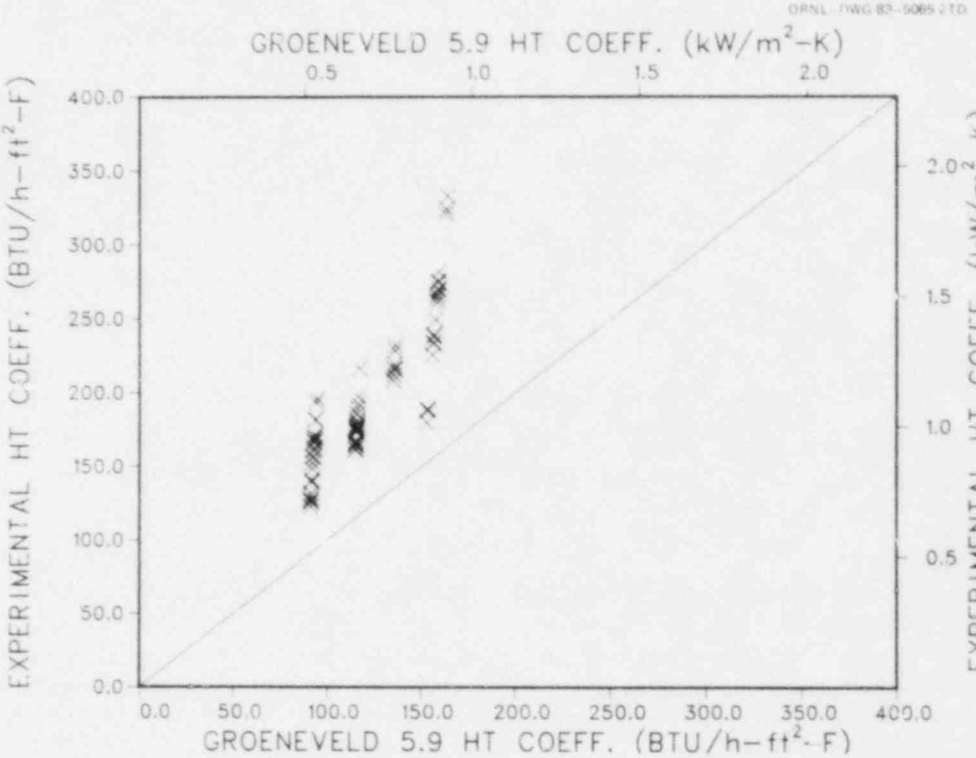

Fig. 4.4. Groeneveld 5.9 correlation comparison.

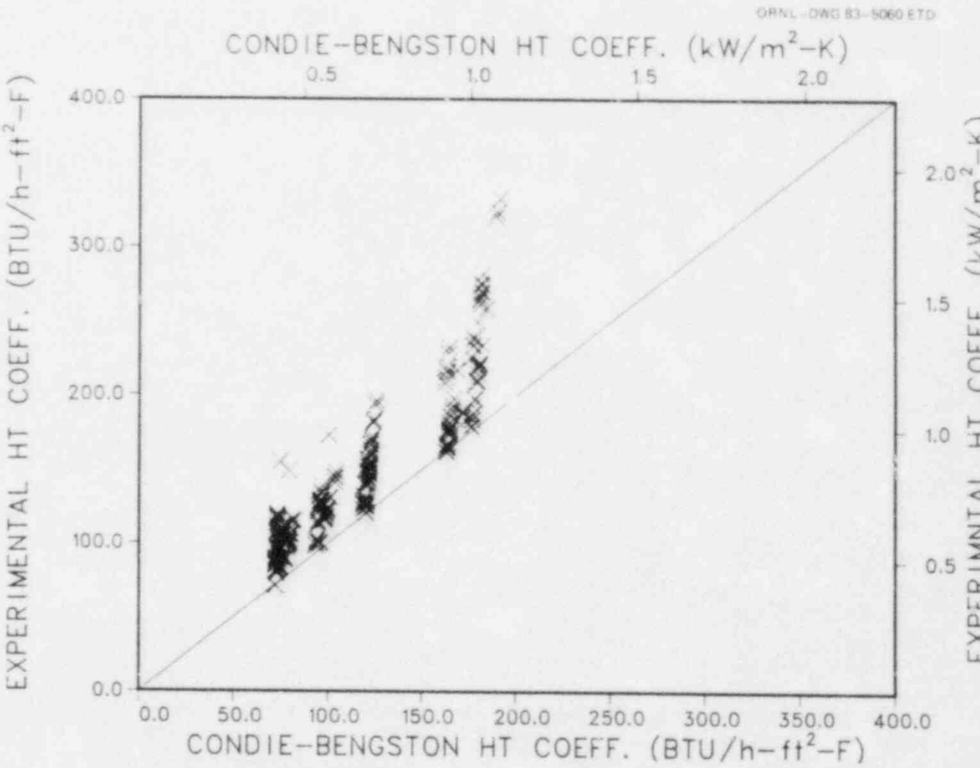

Fig. 4.5. Condie Bengston IV correlation comparison.

the data scatter. The slope in the vertical data strings for the Groeneveld and Condie-Bengston IV plots reflect the surface temperature variation and its effect on the wall Prandtl numbers used in these correlations. Scatter in the Groeneveld-Delorme correlation is horizontal. Wall temperature variations are now incorporated in the correlation predicted heat flux since $Q_{GD} = h_{GD} (T_w - T_v)$.

In general, results of these tests show that both Dougall-Rohsenow correlations tend to overpredict heat transfer coefficents, although using the Prandtl number evaluated at the wall temperature improves the prediction. The Groeneveld-5.7, Groeneveld-5.9, and Condie Bengston IV correlations predict heat transfer coefficients that are lower than experimental values. The Groeneveld-Delorme correlation predicts heat fluxes that are 50% to 100% lower than experimental heat fluxes. The Dittus-Boelter correlation tends to overpredict the observed experimental heat transfer coefficients.

The Dougall-Rohsenow correlation was not developed from two-phase data and does not account for nonequilibrium effects. Nonequilibrium within the flow would tend to decrease experimental heat transfer coefficients and could explain the discrepancy between both Dougall-Rohsenow correlations and the data.

All other film boiling correlations presented were developed from two phase data and would account partially for nonequilibrium within the flow. At the dryout point (the point beyond which liquid no longer comes in contact with the heated surface), there should be no vapor superheat and the flow should be in equilibrium, since all heat added previously to dryout is used to evaporate liquid on the rod surface. None of these correlations explicitly accounts for this phenomenon. In particular, the Groeneveld-Delorme correlation predicts the existance of some nonequilibrium at dryout, causing the predicted heat transfer coefficients to be low. As distance from dryout increases, the amount of nonequilibrium in the flow increases, and the Groeneveld-Delorme predictions tend to improve. Because nonequilibrium is present in all heated dispersed flows to some extent, liquid is present in the flow even after the equilibrium quality reaches one (if $X_b < 1$). Thus, the Dittus- Boelter correlation which assumes that single-phase conditions exist beyond equilibrium qualities of one tends to overpredict heat transfer coefficients for

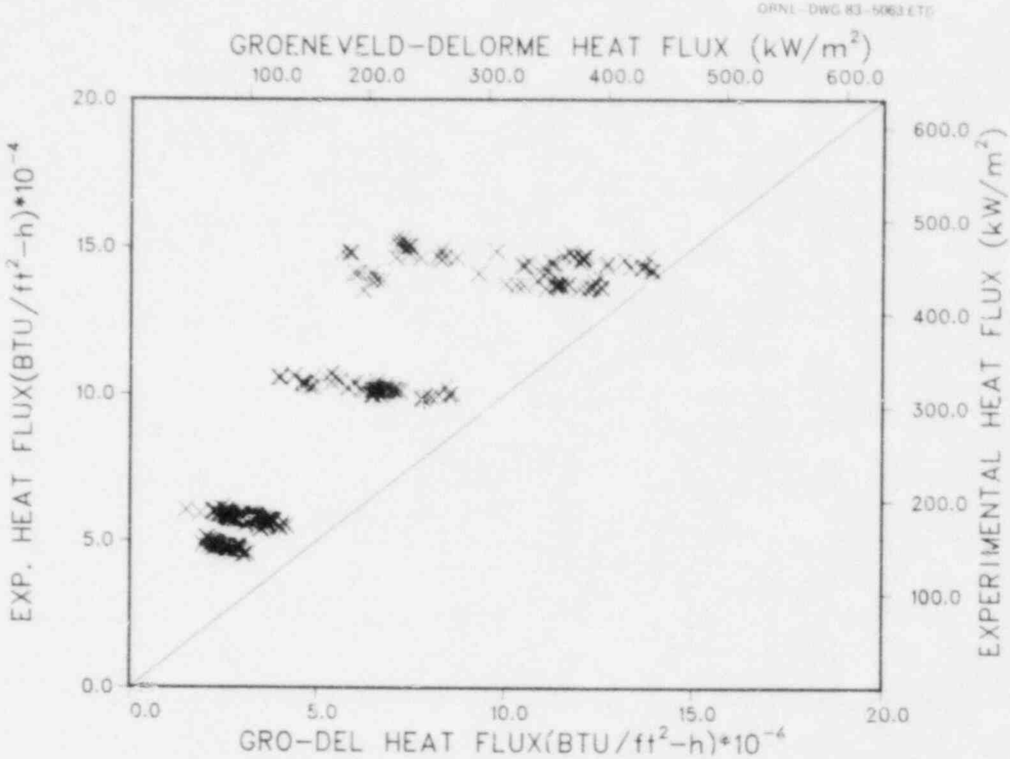

Fig. 4.6. Groeneveld-Delorme correlation comparison.

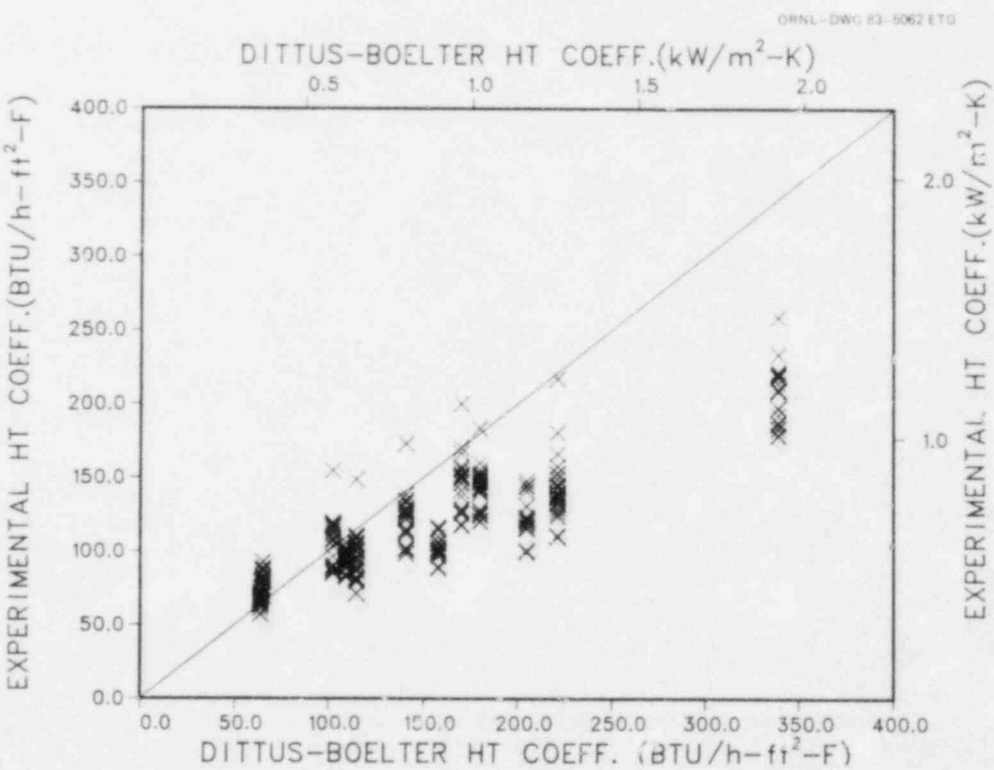

Fig. 4.7. Dittus-Boelter correlation comparison.

reasons similar to those discussed for the Dougall-Rohsenow correlation.

These conclusions agree with results obtained in the 3 transient (3.03.6AR, 3.06.6B, and 3.08.6C), the 22 high-flow steady state tests (test series 3.07.9) and the low flow steam cooling tests (test series 3.09.10 and 3.02.10) previously conducted in the THTF (see Refs. 13, 1, 2, and 3).

The degree to which the Dougall-Rohsenow and Dittus-Boelter equations are in error is somewhat less in the tests presented here than in the previously reported ORNL steady state tests.[1] This can be explained by looking at the nonequilibrium differences between the two test series. Nonequilibrium within a fluid occurs when the vapor and liquid phases are at differing temperatures. Two factors affect the degree of nonequilibrium or vapor superheat present in dispersed flows: the vapor-droplet heat transfer, and the distance from dryout.

If the relative departure from thermal equilibrium from test to test is thought of as an indication of the heated rod-vapor-liquid droplet heat transfer interactions, then a qualitative assessment of nonequilibrium can be made. If droplet-rod interactions are ignored, and it is assumed that the droplets are at the saturation temperature, complete equilibrium occurs when all heat added to the two-phase fluid is used for droplet evaporation. This implies perfect droplet-vapor heat transfer since all heat is initially transferred to the vapor phase. In this case, both vapor and liquid are at the saturation temperature. In order to develop the maximum degree of nonequilibrium, all heat entering the fluid is used to superheat the vapor phase, and none is used to evaporate the liquid droplets. The limiting example of this case is single phase vapor heat transfer, where all heat added is used to superheat the vapor. As stated previously, the departure from equilibrium increases as distance from the dryout location increases. This is caused by heat addition from the heated surface to the vapor phase.

Since dryout quality is 100% in tests IA and ID, pure vapor heat transfer would exist above that point. Tests IB, IC, and IE would have some liquid present, but due to their high dryout quality, would probably

behave like pure vapor flow. In these tests, a vapor heat transfer coefficient should predict the data reasonably well. As can be seen in Appendix B, this, in fact, is the case with errors less than about 40% for the Dittus-Boelter equation. This is in contrast to the lower quality dryout tests in this series and in the previous steady state test series where errors were sometimes as high as 60%.

The dryout locations for tests IF, IG, and IH were at level F, 0.61 m (2 ft) below the top of the bundle. Only 61 m of heated length was available to superheat the vapor from the saturation temperature at dryout. In comparison to several previously reported ORNL steady state tests[1] this length beyond dryout is short, and a lesser amount of vapor superheat would be expected in the tests reported here. An equilibrium correlation such as Dougall-Rohsenow or Dougall-Rohsenow (Pr_w) would perform better on these tests than on tests where there is a large degree of nonequilibrium. In these tests, Dougall-Rohsenow overpredicts the data by as much as 50% (Fig. 4.1) while in the earlier steady state test series, it overpredicted heat transfer coefficients by up to 150%. Conclusions reached in the previous steady state report are consistent with the data presented here when nonequilibrium differences between the two test series are taken into account.

The axial temperature profile along the total length of the bundle for each of the tests is shown in Figs. 4.8 through 4.15. Temperatures in these plots are level average temperatures. Vertical lines on these plots designate spacer grid locations. Two effects are readily apparent from the figures: the dryout point and grid spacer effects.

<u>Dryout point</u>

Dryout within a rod bundle does not necessarily occur at one axial level. Figures 4.8 through 4.15 show how dryout appears for each of these tests. In analyzing the data, thermocouples were divided into those which appeared to be dry and those which appeared to be wet. A value of rod superheat of 30 K was used to distinguish between wet and dry rods. This superheat was chosen as the cutoff temperature by using the Thom[14] nucleate boiling correlation to calculate the maximum wall superheat possible for any of the test conditions (~15 K). This temperature was added to the

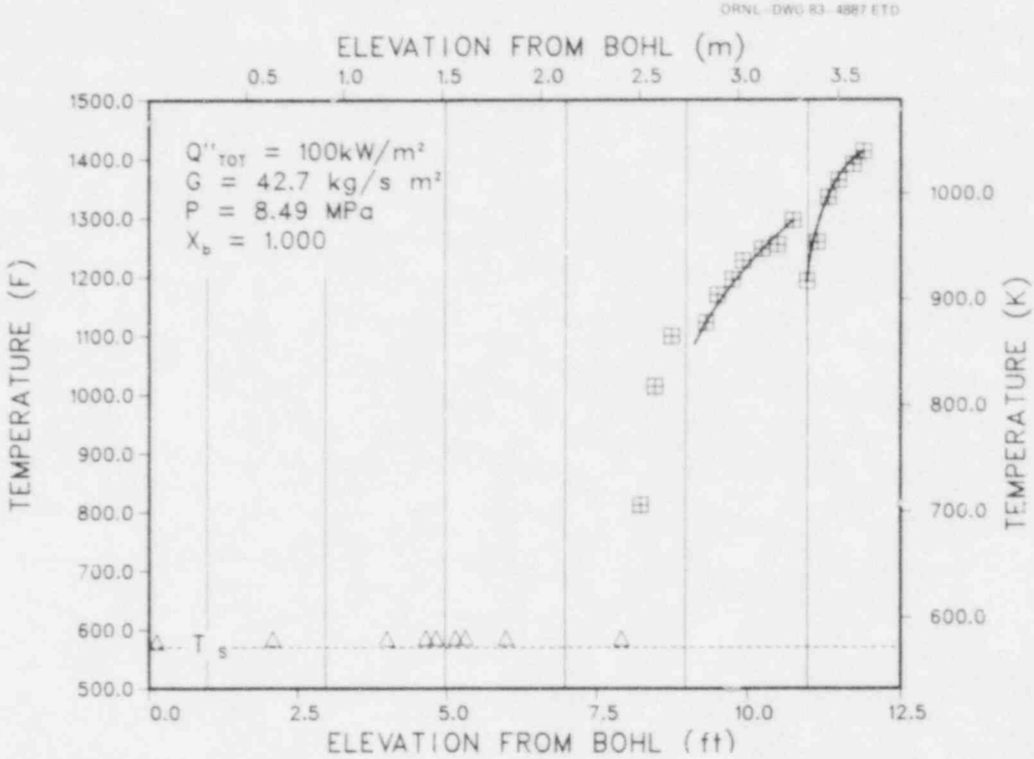

Fig. 4.8. Average temperature profile along bundle – Test IA.

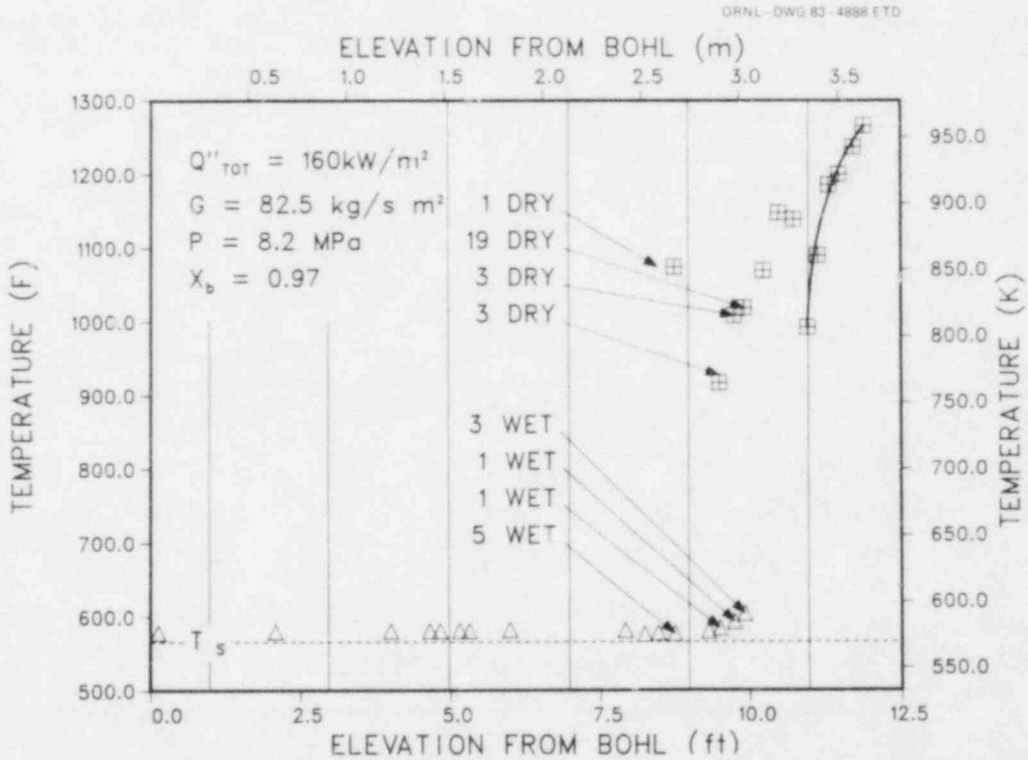

Fig. 4.9. Average temperature profile along bundle – Test IB.

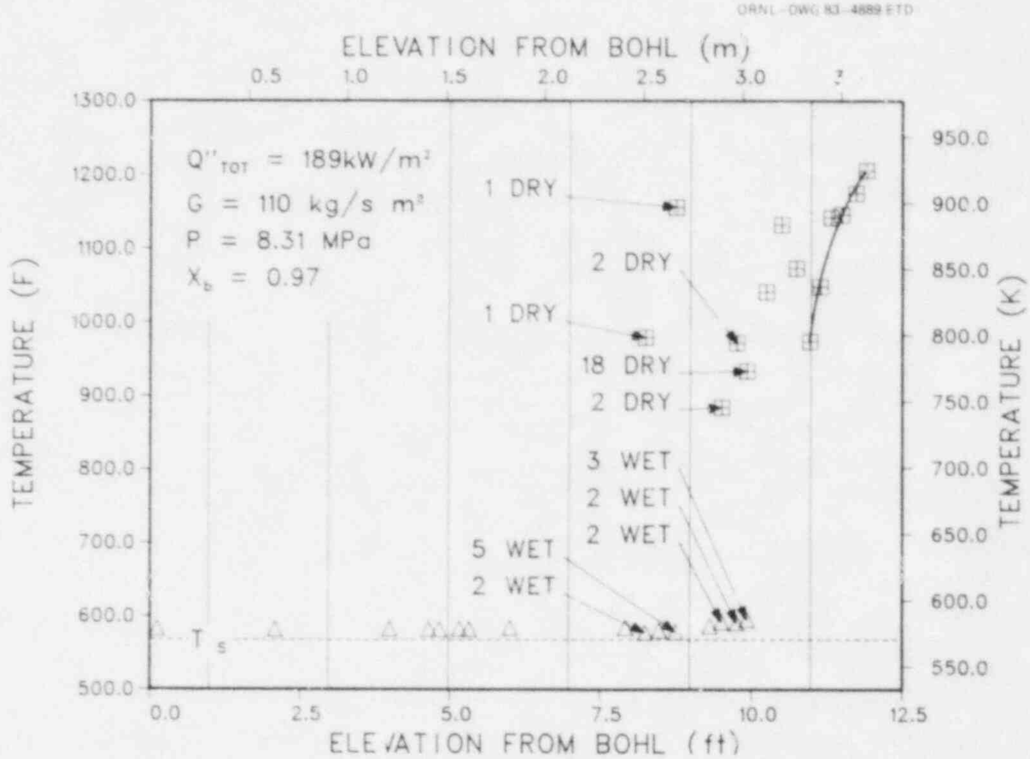

Fig. 4.10. Average temperature profile along bundle - Test IC.

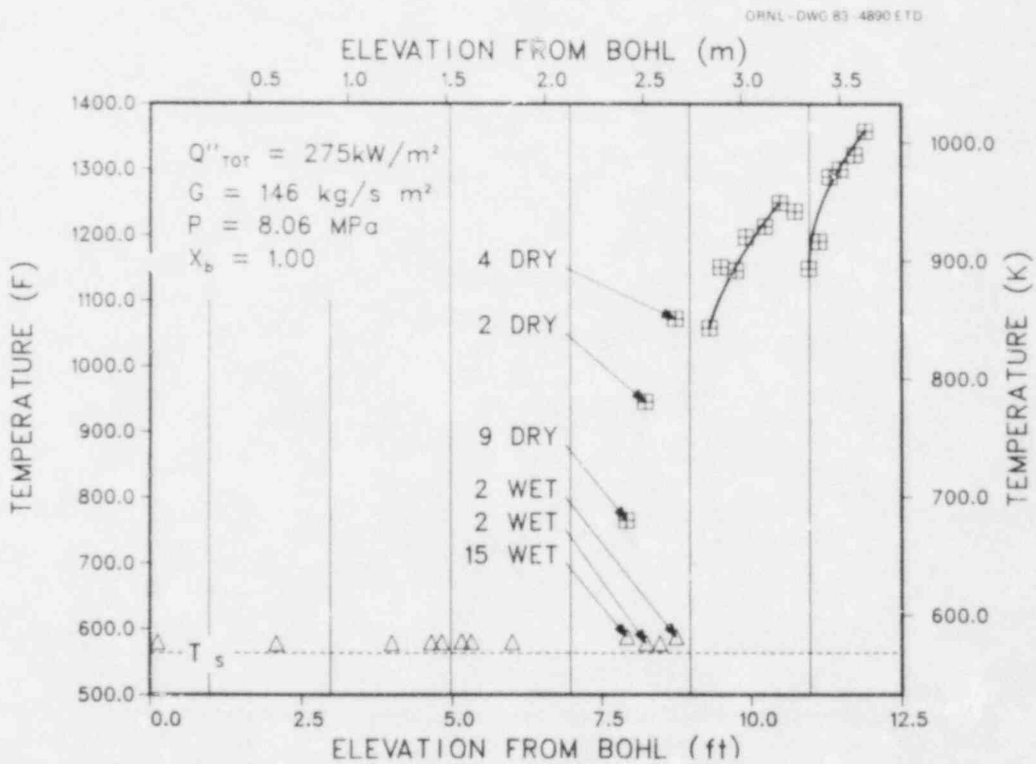

Fig. 4.11. Average temperature profile along bundle - Test ID.

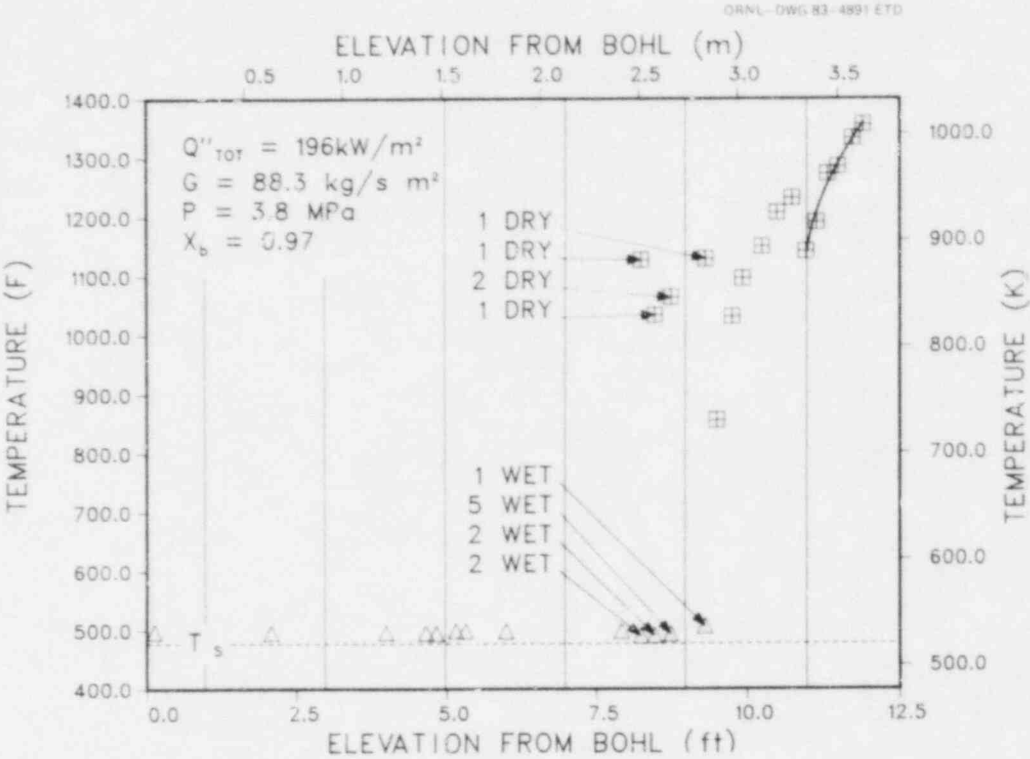

Fig. 4.12. Average temperature profile along bundle - Test IE.

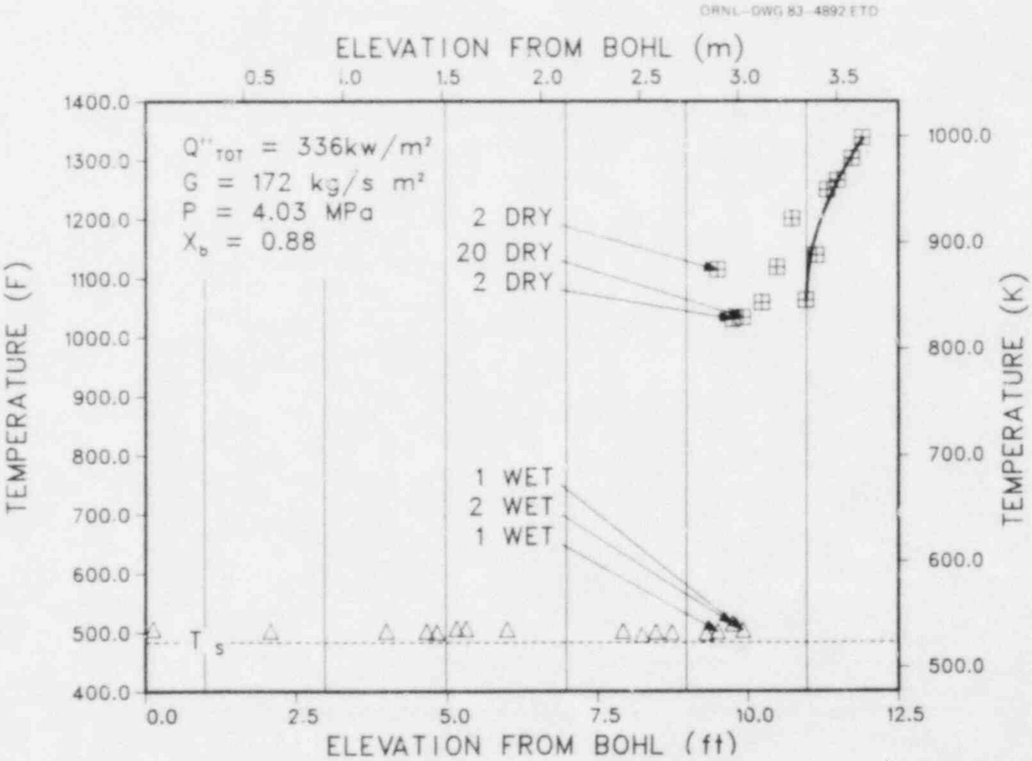

Fig. 4.13. Average temperature profile along bundle - Test IF.

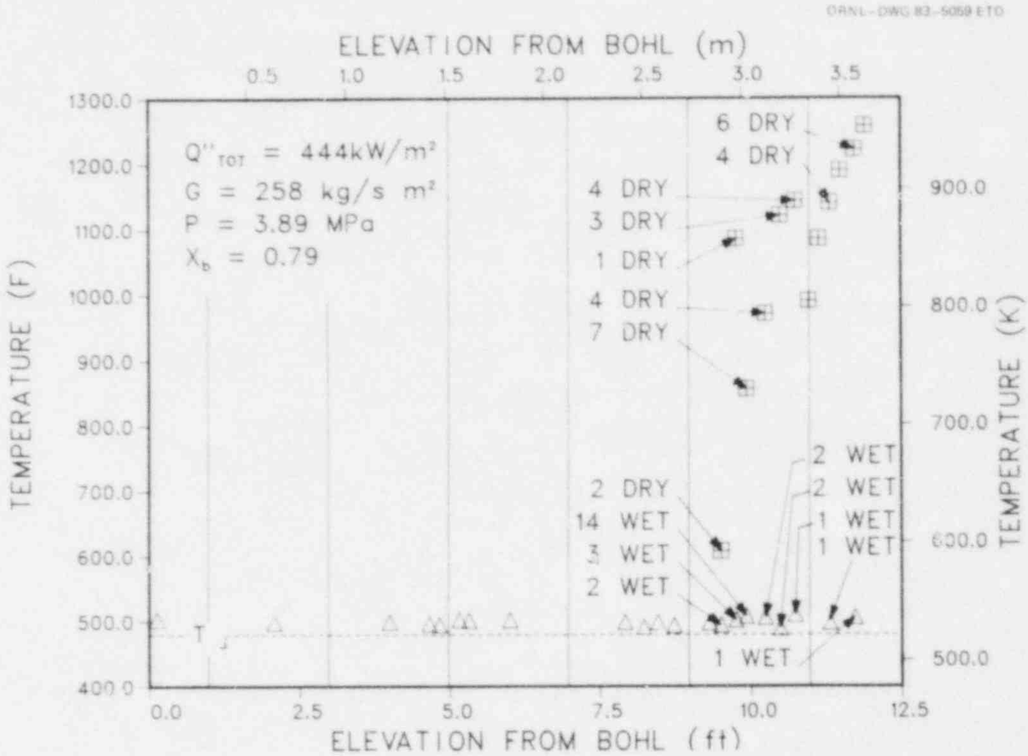

Fig. 4.14. Average temperature profile along bundle - Test IG.

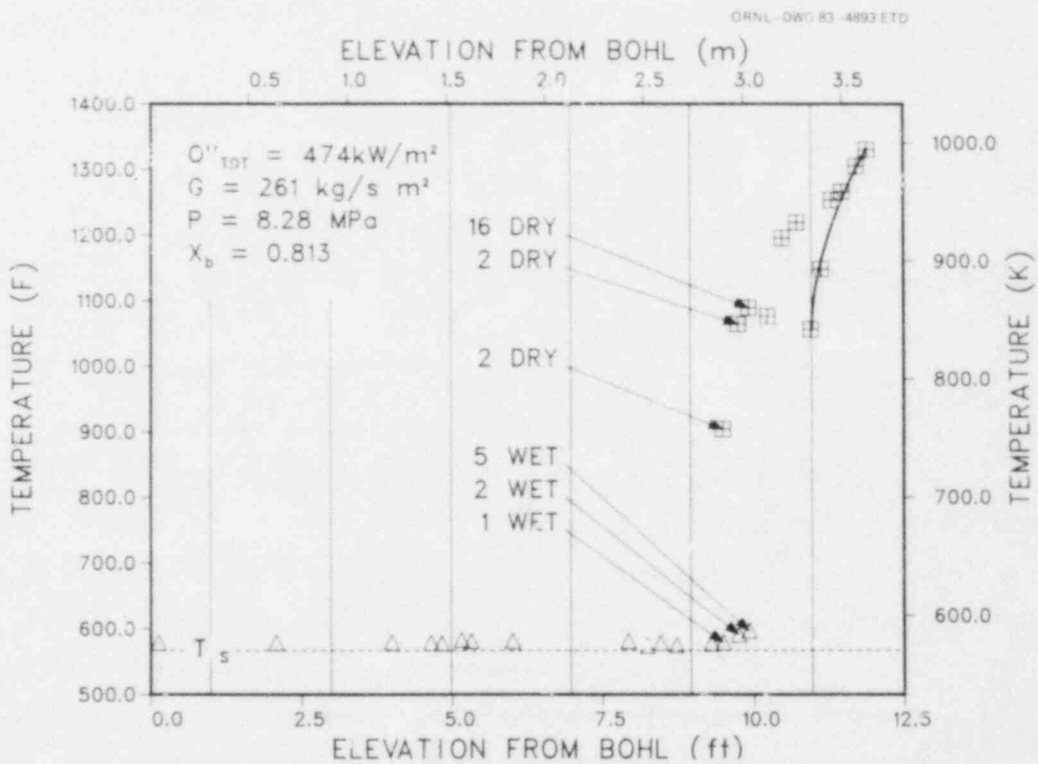

Fig. 4.15. Average temperature profile along bundle - Test IH.

maximum surface temperature uncertainty in any of the tests (~15 K, a 2σ value).

As the temperature profiles are traversed axially (Figs. 4.8 through 4.15), a point is reached where at least one rod appears to be dry (symbol ⊞). In many of the tests, some rods still remain wet at this axial level. This is shown on the figures as two data points at that axial location. One point is the average temperature of the dry rods (⊞) (as defined above) and the other is the average temperature of the wet rods (Δ). Also shown is the number of rods which appear to be wet and the number of rods which appear to be dry. [If only one type of rod (either wet or dry) was detected at a level, the number is not indicated.] The total number of rods instrumented with thermocouples changes from axial location to axial location. Thus, level E7 has 3 rods instrumented, level E8, 4 rods, level F, 21 rods, etc. (see Fig. 4.15). In some tests [e.g., test IC (Fig. 4.10)] the distance between the first level which shows a dry rod and the level where all rods are dry is about 0.61 m (2 ft). Table 1.1 shows the best estimate, bundle average, dryout quality, X_b, for each of the intermediate flow tests. CHF data for the transient tests (3.03.6AR, 3.06.6B, 3.08.6C) and the higher flow steady state tests (test series 3.07.9) is available in tabular form in Ref. 15.

Grid spacer effects

Low-pressure drop, egg crate type spacer grids without swirl inducers are spaced at 0.61 m (2 ft) intervals along the THTF bundle. Closely spaced thermocouples are located axially above and below the two topmost grids to investigate grid effects during film boiling. The effect of the grids is pronounced in Figs. 4.8 through 4.15. Grid spacer locations are indicated by solid vertical lines. Lines sketched through the data show the local temperature profile variation caused by the grids.

Surface temperatures downstream of the grid are up to 60 K (100°F) lower than temperatures upstream of the grid. These results are consistent with results obtained by other investigators.[16,17] These effects last approximately 20 to 30 hydraulic diameters downstream of the grid. This length is consistent with entrance length studies,[18,19] and suggests a boundary layer breakup/rebuild process at the grid. Grid spacer data

for the higher flow steady state tests (series 3.07.9) can be found in Refs. 1 and 20, and for the steam cooling tests (series 3.09.10) in Refs. 2 and 21.

Liquid Entrainment Point

A point of particular interest in flow boiling analyses is the point where flow conditions cause liquid entrainment from the wetted portion of the core. If the flow exceeds this value, liquid will be entrained above the dryout point, and dispersed flow film boiling will be present. If the flow is below this value, steam cooling will exist above dryout.

The test series presented in this report spans the flow range both above and below the liquid entrainment point. Thermocouples located at the top of the bundle heated length are positioned within subchannels between rods, and indicate the fluid conditions at the top of the bundle. If these thermocouples indicate saturation temperature, liquid is probably present at that point within the bundle. If these thermocouples show noticeably higher temperatures than saturation, the steam is either dry and superheated, or only a small amount of liquid is present in the flow. Thus, these thermocouples provide an indication of the liquid carryover. During five of these tests, the subchannel thermocouples indicated a superheat temperature: tests IA, IB, IC, ID, and IE apparently had little droplet entrainment at the subchannel thermocouple locations. Subchannel thermocouples in tests IF, IG, and IH were at least partially wetted, indicating that liquid entrainment was present in these tests. A note of caution is needed when interpreting this data. As is mentioned in Appendix A, unheated FRSs were present in tests IB, IC, and ID. In all of these tests, the FRS thermocouples located above the dryout point in the unheated rods were at or near the saturation temperature. These thermocouples were therefore indicating that liquid was probably present on the rods.

One other indication of the degree of carryover is the quality at dryout. In tests IA through IE, dryout was at or near 100% quality, indicating little or no liquid was present after dryout, and therefore very little liquid would be entrained above dryout. In tests IF, IG, and IH, dryout occured at qualities less than 100% and some liquid would have to be entrained above that point.

5. CONCLUSIONS

An analysis of eight steady state, low-flow film boiling and high flow steam cooling tests has been performed. Mass and energy conservation relationships were used to calculate equilibrium fluid conditions within the rod bundle. These fluid conditions, along with calculated rod surface temperatures, were used to evaluate six film boiling correlations and one single-phase vapor correlation:

1. Dougall-Rohsenow,
2. Dougall-Rohsenow (wall Pr),
3. Groeneveld 5.7,
4. Groeneveld 5.9,
5. Condie-Bengston IV,
6. Groeneveld-Delorme, and
7. Dittus-Boelter.

The correlations were then compared with experimentally determined heat transfer coefficients.

The Groeneveld 5.7, Groeneveld 5.9, and Condie-Bengston IV correlations perform better than either Dougall-Rohsenow correlation. The Dougall-Rohsenow and Dittus-Boelter correlations predict heat transfer coefficients that are often 50% higher than the experimentally determined heat transfer coefficients discussed in this report. This is probably due to thermodynamic nonequilibrium which can exist in the flow. The Groeneveld-Delorme correlation, which explicitly accounts for nonequilibrium in the flow, predicts low heat fluxes near burnout that improve as distance from burnout increases.

The conclusions reached concerning the accuracy of the film boiling and single phase correlations concur with those reached in reports describing the three Transient Film Boiling experiments, tests 3.03.6AR, 3.06.6B, 3.08.6C,[13] the higher flow steady state test series,[1] and the low flow steam cooling tests.[2,3]

Data was also presented which shows that bundle CHF behavior may be nonuniform under some steady state test conditions. In some tests dryout occurred over a 0.66 m (2 ft) axial interval.

The effect of grid spacers within the bundle was found to be significant, decreasing temperatures as much as 110 K (200°F) across the grid. These effects persisted about 20 to 30 hydraulic diameters downstream of the grid and indicated that the boundary layer breakup/rebuild process is important near the grid.

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Appendix A

RADIATION

A radiation model has been developed which includes radiation exchange between four heat sources/sinks within the bundle: Heated rods, unheated rods and shroud wall, flowing steam, and liquid droplets. Radiation exchange between heated rods which were at slightly different temperatures was assumed to be negligible compared to the other heat flow paths. Three of the tests (tests IB, IC, ID) were conducted with at least one FRS unheated. Thermocouples located above dryout on these unheated rods indicated that the rod was at the saturation temperature (i.e. the rod was wet). The radiation analysis therefore assumed that the unheated rod and shroud wall were at the saturation temperature.

View factors between the heated rods and unheated portion of the bundle were calculated using the Hottel crossed string method. Figure A.1 shows a sample of the crossed string geometry used to calculate the view factor between a rod one row removed from the shroud and the nearest shroud wall. View factors were calculated between each heated rod and the four shroud walls, and between each heated rod and the cold rods within the bundle. These calculations were performed assuming all rods within the bundle (including the unheated rods) were of the same diameter. The unheated rods are in fact, 0.7 mm (0.028 in.) larger in diameter than the heated rods. This assumption causes little error in the radiation calculations. A summary of these view factors for each heated rod is presented

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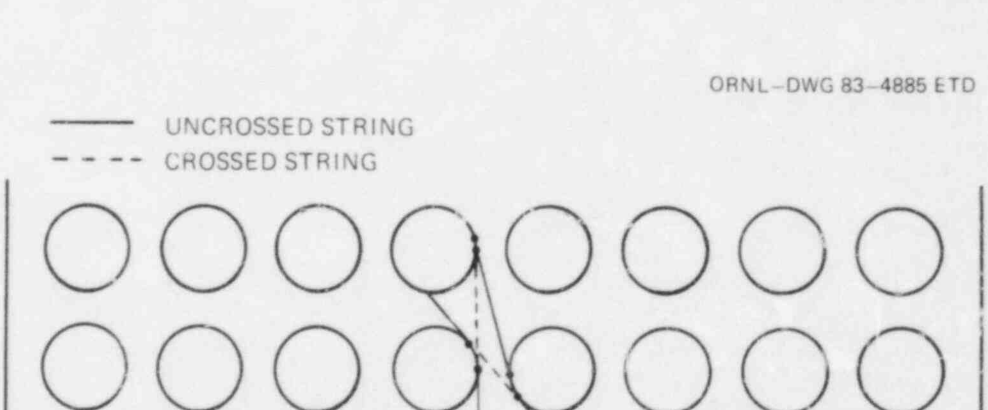

Fig. A.1. Example of crossed string geometry.

in Table A.1. Rod numbers correspond to those in Fig. 2.2. View factors in Table A.1 are for the bundle under normal conditions (four unheated rods).

Radiation exchange was calculated using a four node network analysis developed for the bundle. This network follows closely the three node analysis presented by Sun,[22] however, it includes the presence of cold surfaces within the bundle. The assumptions used by Sun and also used in this model are: grey, diffuse surfaces, and an optically thin droplet field. The vapor is assumed to be semigrey. In this analysis, vapor absorption is assumed to dominate, and vapor properties are based on the incoming radiation. Figure A.2 shows the radiation network used. The

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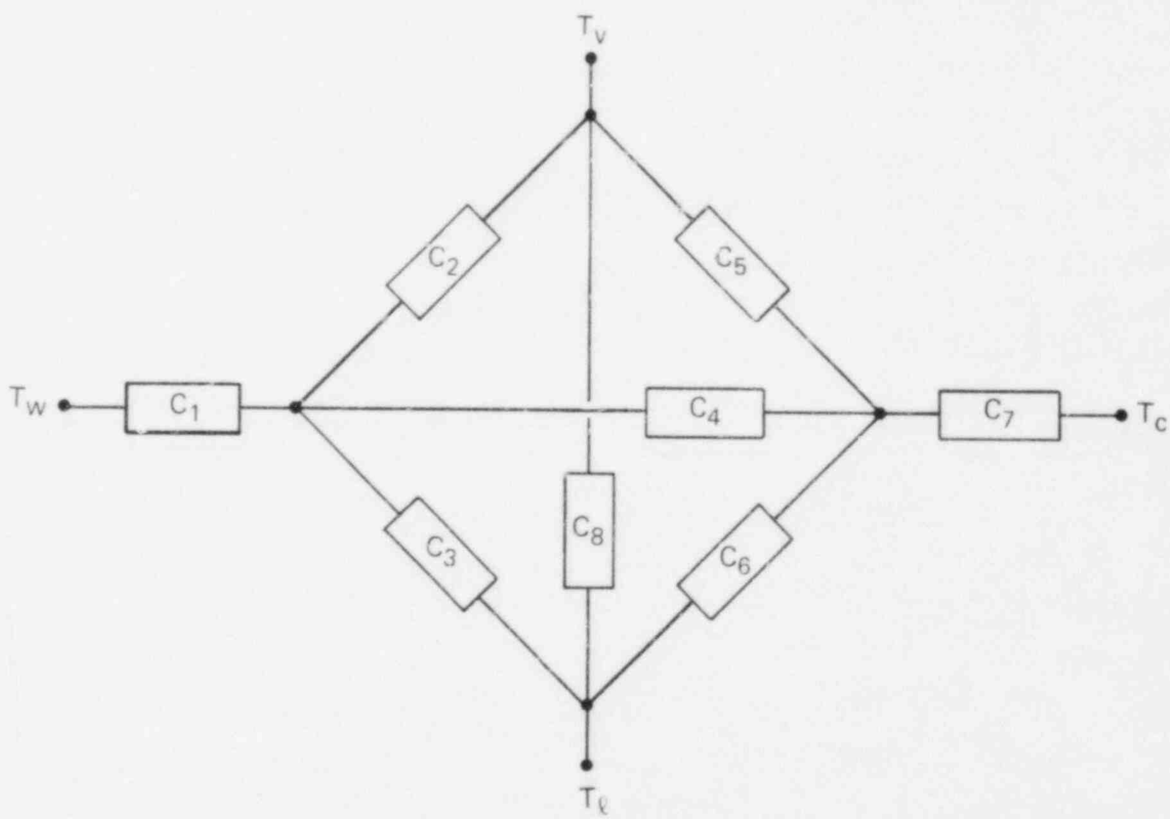

Fig. A.2. Radiation network.

Table A.1. Hot rod view factors

Rod No.	View factor hot to cold rods	View factor hot rod to shroud
1	0.0	6.25×10^{-1}
2	1.66×10^{-2}	3.95×10^{-1}
3	5.37×10^{-4}	3.78×10^{-1}
4	1.66×10^{-2}	3.76×10^{-1}
5	1.73×10^{-2}	3.76×10^{-1}
6	0.0	3.78×10^{-1}
7	1.68×10^{-2}	3.95×10^{-1}
8	0.0	6.25×10^{-1}
9	1.68×10^{-2}	3.95×10^{-1}
10	8.57×10^{-2}	7.93×10^{-2}
11	1.29×10^{-1}	4.64×10^{-2}
12	1.02×10^{-1}	4.30×10^{-2}
13	1.04×10^{-1}	4.30×10^{-2}
14	1.28×10^{-1}	4.64×10^{-2}
15	8.63×10^{-2}	7.93×10^{-2}
16	1.68×10^{-2}	3.95×10^{-1}
17	0.0	3.78×10^{-1}
18	1.26×10^{-1}	4.64×10^{-2}
20	1.26×10^{-1}	1.00×10^{-2}
21	1.44×10^{-1}	1.00×10^{-2}
23	1.28×10^{-1}	4.64×10^{-2}
24	0.0	3.78×10^{-1}
25	1.87×10^{-2}	3.76×10^{-1}
26	1.02×10^{-1}	4.30×10^{-2}
27	2.13×10^{-1}	1.00×10^{-2}
28	2.27×10^{-1}	6.62×10^{-3}
29	2.04×10^{-1}	6.62×10^{-3}
30	1.43×10^{-1}	1.00×10^{-2}
31	1.04×10^{-1}	4.30×10^{-2}
32	1.73×10^{-2}	3.76×10^{-1}
33	2.21×10^{-4}	3.76×10^{-1}
34	1.71×10^{-2}	4.30×10^{-2}
35	1.28×10^{-1}	1.00×10^{-2}
37	2.27×10^{-1}	5.62×10^{-3}
38	1.26×10^{-1}	1.00×10^{-2}
39	1.02×10^{-1}	4.30×10^{-2}
40	1.66×10^{-2}	3.76×10^{-2}
41	1.93×10^{-3}	3.78×10^{-1}
42	1.85×10^{-2}	4.64×10^{-2}
43	8.52×10^{-2}	1.35×10^{-2}
44	1.28×10^{-1}	1.00×10^{-2}
45	2.13×10^{-1}	1.00×10^{-2}
47	1.29×10^{-1}	4.64×10^{-2}
48	5.37×10^{-4}	3.78×10^{-1}
49	2.21×10^{-4}	3.95×10^{-1}
50	1.07×10^{-1}	7.93×10^{-2}
51	1.85×10^{-2}	4.64×10^{-2}
52	1.71×10^{-2}	[illegible]$.30 \times 10^{-2}$
53	1.02×10^{-1}	4.30×10^{-2}
54	1.26×10^{-1}	4.64×10^{-2}
55	8.57×10^{-2}	7.93×10^{-2}
56	1.66×10^{-2}	3.95×10^{-1}
57	0.0	6.25×10^{-1}
58	2.21×10^{-4}	3.95×10^{-1}
59	1.93×10^{-3}	3.78×10^{-1}
60	2.21×10^{-4}	3.76×10^{-1}
61	1.87×10^{-2}	3.76×10^{-1}
62	0.0	3.78×10^{-1}
63	1.68×10^{-2}	3.95×10^{-1}
64	0.0	6.25×10^{-1}

individual radiation fluxes calculated from this network are as follows:

$$Q_{h-v} = \frac{C_1 \left(C_2 + \frac{C_4 \, C_5}{C_c}\right)}{C_1 + C_2 + C_3 + C_4 - \frac{C_4^2}{C_c}} \, \sigma \, (T_w^4 - T_v^4) \qquad (1)$$

$$Q_{h-\ell} = \frac{C_1 \left(C_3 + \frac{C_4 \, C_6}{C_c}\right)}{C_1 + C_2 + C_3 + C_4 - \frac{C_4^2}{C_c}} \, \sigma \, (T_w^4 - T_\ell^4) \qquad (2)$$

$$Q_{h-c} = \frac{C_1 \left[C_4 - \frac{C_4}{C_c} (C_4 + C_5 + C_6)\right]}{C_1 + C_2 + C_3 + C_4 - \frac{C_4^2}{C_c}} \, \sigma \, (T_w^4 - T_c^4) \qquad (3)$$

$$Q_{v-\ell} = \left[C_8 + \frac{C_5 \, C_6}{C_c} + \left(C_3 + \frac{C_4 \, C_6}{C_c}\right)\left(\frac{C_2 + \frac{C_4 \, C_5}{C_c}}{C_1 + C_2 + C_3 + C_4 - \frac{C_4^2}{C_c}}\right)\right] \qquad (4)$$

$$\sigma \, (T_v^4 - T_\ell^4)$$

$$Q_{v-c} = \frac{C_7 \left(C_5 \, \frac{C_1 + C_2 + C_3 + C_4}{C_c} + \frac{C_2 \, C_4}{C_c}\right)}{C_1 + C_2 + C_3 + C_4 - \frac{C_4^2}{C_c}} \, \sigma \, (T_v^4 - T_c^4) \qquad (5)$$

$$Q_{\ell-c} = \frac{C_7}{C_c} \left[C_6 + \frac{\left(C_3 + \frac{C_4 \, C_6}{C_c}\right) C_4}{C_1 + C_2 + C_3 + C_4 - \frac{C_4^2}{C_c}}\right] \sigma \, (T_\ell^4 - T_c^4) \qquad (6)$$

Table A.2 lists the equation for each conductance, C_i. The second subscript on the vapor emissivity indicates the temperature at which it is

Table A.2. Thermal conductances in the radiation network

Equation
$C_1 = A_h \dfrac{\varepsilon_h}{1 - \varepsilon_h}$
$C_2 = A_h (1 - \varepsilon_\ell) \varepsilon_{v,T_h}$
$C_3 = A_h (1 - \varepsilon_{v,T_h}) \varepsilon_\ell$
$C_4 = A_h F_{h-c} (1 - \varepsilon_\ell) (1 - \varepsilon_{v,T_v})$
$C_5 = A_c (1 - \varepsilon_\ell) \varepsilon_{v,T_c}$
$C_6 = A_c (1 - \varepsilon_{v,T_c}) \varepsilon_\ell$
$C_7 = A_c \dfrac{\varepsilon_c}{1 - \varepsilon_c}$
$C_8 = (A_h + A_c) \varepsilon_{v,T_v} \varepsilon_\ell$
$C_c = C_4 + C_5 + C_6 + C_7$

evaluated. Emissivities for all of the rods and the shroud were assumed to be 0.5 ± 0.1. Vapor emissivity was calculated at the high pressure limit as was done by Anklam.[2] Uncertainty in the vapor emissivity was assumed to be ±25%. The liquid droplet cloud was assumed to be grey and diffuse with liquid emissivity evaluated as in Ref. 22

$$\varepsilon_\ell = 1 - \exp (a_\ell L_m) , \tag{7}$$

where a_ℓ is the liquid absorption coefficient, and L_m is the mean beam

length recommended by Hottel[23] for tube banks,

$$L_m = 3.5\ (C - D)\ , \tag{8}$$

C is the rod pitch, and D is the rod diameter.

The liquid absorptivity, a_ℓ was determined by Sun[22] to be

$$a_\ell = 0.74\ (3/2)\ \frac{(1 - \alpha)}{d}\ , \tag{9}$$

where α is the local vapor void fraction and d the local droplet diameter. In this analysis, the droplet diameter and void fraction were calculated by assuming that the drops were sized according to a Weber number criterion ($We_c = 6.5$). A force balance on the drops, including gravity, droplet acceleration, and droplet drag has been used[24] to develop a model for droplet slip ratio.

$$\left(\frac{V_v}{V_\ell} - 1\right)^2 = \left[\frac{16}{3}\ \frac{\rho_\ell}{\rho_v}\ \frac{Q''}{G\ h_{fg}}\ \frac{1}{C_D X} + \frac{4}{3}\ \frac{\rho_v\ (\rho_\ell - \rho_v)\ D_{he}\ g}{G^2}\ \left(\frac{V_v}{V_\ell}\right)^2\ \frac{\alpha^2}{C_D X^2}\right]\ \frac{d}{D_{he}} \tag{10}$$

This equation, along with the definitions of vapor and liquid velocities

$$V_v = \frac{G\ X}{\rho_v \alpha} \tag{11}$$

$$V_\ell = \frac{G\ (1 - X)}{\rho_\ell\ (1 - \alpha)}\ , \tag{12}$$

void fraction

$$\alpha = \frac{1}{\frac{V_v}{V_\ell}\ \frac{\rho_v}{\rho_\ell}\ \frac{(1 - X)}{X} + 1}\ , \tag{13}$$

and the critical Weber number criterion

$$We_c = 6.5 = \frac{\rho_v\ (V_v - V_\ell)^2\ d}{\sigma\ g_c}\ , \tag{14}$$

has been used in an iterative solution scheme to determine the droplet diameter, d, and the local void fraction, α, for use in Eq. (9). Due to the assumption of equilibrium conditions, and the uncertainty in the droplet size calculations, the uncertainty in the calculated liquid emissivity was somewhat arbitrarily assumed to be $\pm 50\%$.

The flow was assumed to be in thermodynamic equilibrium. For tests where burnout qualities were ~100% (IA, IB, IC, ID, IE) this assumption should be very good when calculating radiation to the steam. However, in the other tests where burnout qualities were less than 100%, some degree of thermodynamic non-equilibrium must exist. As the degree of nonequilibrium increases, actual steam temperatures within the flow increase over that which would be calculated using equilibrium assumptions; thus hot rod to steam radiation would be expected to be smaller than that presented here. The amount of liquid in the flow would be larger than that calculated using equilibrium assumptions, and radiation to the liquid would therefore be larger than that presented here. Table A.3 shows the path of

Table A.3. Radiation component of heat flux in percent of total heat flux leaving the rods

Test	Level	Hot rod to vapor radiation (%)	Hot rod to liquid radiation (%)	Hot rod to cold surface radiation (%)	Total radiation (%)
IA	F	9.75	0.0	1.87	11.6
	G	11.65	0.0	2.77	14.4
IB	F	4.57	0.0	0.98	5.55
	G	7.32	0.0	1.28	8.60
IC	F	4.10	0.0	1.05	5.15
	G	5.31	0.0	0.99	6.30
ID	F	4.09	0.0	0.78	4.87
	G	5.52	0.0	1.04	6.56
IE	F	4.67	0.0	1.27	5.94
	G	6.60	0.0	1.81	8.41
IF	F	2.78	0.09	0.72	3.59
	G	4.17	0.0	0.94	5.11
IG	F	1.73	0.16	0.34	2.23
	G	2.72	0.0	0.55	3.27
IH	F	2.00	0.23	0.39	2.62
	G	3.27	0.0	0.51	3.78

radiative heat flow from the rods. Radiation heat transfer is presented as a percent of the total heat flux leaving the rods for two levels in each test. These values are level average values and indicate the relative importance of radiation paths for each of the tests.

The convective heat flux, Q''_{con} is calculated by subtracting each of the radiative fluxes from the experimentally determined heat flux leaving the rod:

$$Q''_{con} = Q'' - Q''_{h-v} - Q''_{h-\ell} - Q''_{h-c} \quad (15)$$

Uncertainty in the convective heat flux was calculated by propagating uncertainties in radiative properties through $C_1 - C_8$ (Table A.2), Eqs. (1) through (6), and Eq. (15). The calculated value for Q''_{con} was used in all correlation comparisons presented in this report.

Appendix B

INTERMEDIATE FLOW DATA AND CORRELATION COMPARISONS

Appendix B contains tables listing fluid conditions, surface conditions, and correlation-predicted and experimentally determined heat transfer coefficients (heat fluxes). Also included are one standard deviation uncertainities for several of these quantities. Tests are identified on each page of the tables, and the nomenclature is given on the header page preceding each test tabulation. Because thermocouples can be located at three azimuthal locations on a rod at any given level, some rod numbers appear more than once in the tabulation at a single level.

INTERMEDIATE FLOW TEST IA

FLUID CONDITIONS

CORRELATION COMPARISONS

SI UNITS

NOMENCLATURE

HCB - CONDIE-BENGSTON HEAT TRANSFEER COEFFICIENT
HDB - DITTUS-BOELTER HEAT TRANSFER COEFFICIENT
HDR - DOUGALL-ROHSENOW HEAT TRANSFER COEFFICIENT
HDRPW - DOUGALL-ROHSENOW HEAT TRANSFER COEFFICIENT, WALL PRANDTL NUMBER
HEXP - EXPERIMENTAL HEAT TRANSFER COEFFICIENT Q/(TSURF-TBULK)
HEXPS - EXPERIMENTAL HEAT TRANSFER COEFFICIENT Q/(TSURF-TSAT)
HG57 - GROENEVELD 5.7 HEAT TRANSFER COEFFICIENT
HG59 - GROENEVELD 5.9 HEAT TRANSFER COEFFICIENT
QCON - CONVECTIVE HEAT FLUX
QGD - GROENEVELD-DELORME HEAT FLUX
QTOT - TOTAL HEAT FLUX (INCLUDING RADIATION)
SDTSRF - CROSS-SECTIONAL STANDARD DEVIATION OF THE SURFACE TEMPERATURE
SDQ - CROSS-SECTIONAL STANDARD DEVIATION OF THE CONVECTIVE HEAT FLUX
TBULK - BULK VAPOR TEMPERATURE
TSAT - SATURATION TEMPERATURE
TSRF(TSURF) - SURFACE TEMPERATURE
TF - EQUILIBRIUM FLUID TEMPERATURE
UHDR - UNCERTAINTY, DOUGALL-ROHSENOW HEAT TRANSFER COEFFICIENT
UHEXP - UNCERTAINTY, EXPERIMENTAL HEAT TRANSFER COEFFICIENT
UHEXPS - UNCERTAINTY, EXPERIMENTAL HEAT TRANSFER COEFFICIENT
UHG57 - UNCERTAINTY, GROENEVELD 5.7 HEAT TRANSFER COEFFICIENT
UHG59 - UNCERTAINTY, GROENEVELD 5.9 HEAT TRANSFER COEFFICIENT
UNC - UNCERTAINTY
UTF - UNCERTAINTY, EQUILIBRIUM FLUID TEMPERATURE
UX - UNCERTAINTY, EQUILIBRIUM QUALITY
X - EQUILIBRIUM QUALITY

*********** INTERMEDIATE FLOW TEST IA ***********

LEVEL AVERAGE FLUID AND SURFACE CONDITIONS

MASS FLUX 3.146E+04 LBM/SQFT H   UNC. MASS FLUX 9.832E+02 LBM/SQFT H   PRESSURE 1231.0 PSI   UNC. PRESSURE 7.50 PSI
42.69 KG/SQM S   1.3342 KG/SQM S   8.49 MPA   0.052 MPA

LEVEL	Q		SDQ		TSRF		SDTSRF		TF		UTF		X	UX
	ENG	SI	ENG	SI	ENG	SI	ENG	SI	ENG	SI	ENG	SI		
F	0.286	90.2	0.007	2.30	1227.1	664.3	21.79	12.105	794.5	423.9	49.259	27.4	1.2970	.0566
G	0.277	87.1	0.007	2.22	1412.2	767.1	24.96	13.867	1067.3	575.8	64.980	36.1	1.5882	.0661
E2	0.282	88.8	0.008	2.54	1054.5	568.4	16.26	9.035	622.7	328.5	35.609	19.8	1.0844	.0497
E3	0.291	91.5	0.008	2.55	1099.4	593.3	68.26	37.925	652.2	344.9	39.782	22.1	1.1233	.0513
E6	0.285	89.9	0.006	1.94	1121.5	605.6	31.82	17.678	719.0	382.0	43.513	24.2	1.2068	.0538
E7	0.292	91.9	0.008	2.60	1169.0	632.0	34.79	19.330	742.9	395.3	45.081	25.0	1.2349	.0546
E8	0.293	92.2	0.003	1.01	1195.2	646.6	21.14	11.745	773.3	412.2	47.508	26.4	1.2719	.0558
F1	0.285	89.8	0.009	2.70	1246.7	675.1	14.49	8.048	837.1	447.6	52.478	29.2	1.3443	.0582
F2	0.286	90.1	0.009	2.87	1254.0	679.2	53.52	29.735	870.7	466.3	54.707	30.4	1.3812	.0595
F3	0.281	88.7	0.009	2.93	1295.2	702.1	23.44	13.021	904.9	485.3	56.157	31.2	1.4182	.0610
F4	0.289	91.0	0.008	2.49	1192.0	644.9	8.49	4.714	936.1	502.6	58.441	32.5	1.4521	.0622
F5	0.287	90.5	0.012	3.89	1258.0	681.4	21.52	11.954	959.7	515.7	59.344	33.0	1.4770	.0628
F6	0.281	88.6	0.004	1.22	1333.5	723.4	20.36	11.313	985.2	529.9	60.756	33.8	1.5033	.0635
F7	0.279	87.9	0.007	2.28	1363.1	739.8	12.71	7.061	1008.6	542.9	62.341	34.6	1.5282	.0643
F8	0.277	87.3	0.008	2.41	1390.1	754.8	24.81	13.784	1042.8	561.9	63.494	35.3	1.5633	.0654

NOMENCLATURE

	ENG	SI
Q	BTU/H FT**2 X 1E5	KW/M**2
SDQ	BTU/H FT**2 X 1E5	KW/M**2
TSRF	DEG F	DEG C
SDTSRF	DEG F	DEG C
TF	DEG F	DEG C
UTF	DEG F	DEG C

********** INTERMEDIATE FLOW TEST IA **********

PRIMARY LEVELS

EQUILIBRIUM QUALITY GREATER THAN ONE

ROD NO	X	TSURF DEG C	QCON(QTOT) KW/M**2	HEXPS	UHEXPS	HEXP KW/M**2 C	UHEXP	HOB
LEVEL F								
3	1.30	665.3	91.2(103.9)	0.249	0.019	0.378	0.053	0.364
4	1.30	631.4	93.6(103.9)	0.282	0.020	0.451	0.070	0.364
7	1.30	661.4	90.8(103.4)	0.251	0.019	0.382	0.054	0.364
7	1.30	660.9	90.8(103.4)	0.251	0.019	0.383	0.054	0.364
10	1.30	673.1	89.6(101.4)	0.240	0.018	0.360	0.049	0.364
10	1.30	672.0	89.7(101.4)	0.241	0.018	0.362	0.050	0.364
10	1.30	670.3	89.8(101.4)	0.242	0.018	0.364	0.050	0.364
13	1.30	669.2	91.9(103.3)	0.249	0.019	0.375	0.052	0.364
13	1.30	671.4	91.8(103.3)	0.247	0.019	0.371	0.051	0.364
14	1.30	664.8	90.3(101.5)	0.247	0.019	0.375	0.053	0.364
15	1.30	658.7	89.6(100.4)	0.249	0.019	0.382	0.054	0.364
16	1.30	664.2	87.2(100.0)	0.239	0.018	0.363	0.051	0.364
17	1.30	655.9	89.2(101.2)	0.250	0.019	0.385	0.055	0.364
18	1.30	639.2	91.4(100.9)	0.269	0.019	0.424	0.064	0.364
20	1.30	653.1	92.2(102.5)	0.261	0.019	0.402	0.058	0.364
28	1.30	652.0	88.8(99.6)	0.252	0.019	0.389	0.057	0.364
28	1.30	650.9	88.9(99.6)	0.253	0.019	0.392	0.057	0.364
28	1.30	652.6	88.7(99.6)	0.251	0.019	0.388	0.056	0.364
31	1.30	670.3	90.9(102.3)	0.245	0.019	0.369	0.051	0.364
31	1.30	670.3	90.9(102.3)	0.245	0.019	0.369	0.051	0.364
34	1.30	665.3	92.9(103.3)	0.254	0.019	0.385	0.054	0.364
37	1.30	649.8	92.0(102.7)	0.263	0.019	0.408	0.060	0.364
38	1.30	663.1	91.3(102.2)	0.251	0.019	0.382	0.054	0.364
42	1.30	669.2	89.6(100.4)	0.242	0.018	0.365	0.051	0.364
45	1.30	662.6	92.2(103.7)	0.254	0.019	0.387	0.054	0.364
45	1.30	662.0	92.2(103.7)	0.254	0.019	0.387	0.055	0.364
53	1.30	667.0	94.9(106.1)	0.258	0.019	0.390	0.054	0.364
53	1.30	665.3	95.0(106.1)	0.260	0.019	0.393	0.055	0.364
59	1.30	669.8	89.1(102.1)	0.241	0.019	0.362	0.050	0.364
59	1.30	665.3	89.4(102.1)	0.244	0.019	0.370	0.052	0.364
59	1.30	671.4	89.0(102.1)	0.239	0.019	0.359	0.050	0.364
60	1.30	677.6	88.0(101.6)	0.233	0.018	0.347	0.048	0.364
64	1.30	688.7	86.1(102.2)	0.221	0.019	0.325	0.044	0.364
64	1.30	689.2	86.0(102.2)	0.221	0.019	0.324	0.044	0.364
64	1.30	687.6	86.2(102.2)	0.222	0.019	0.327	0.045	0.364
LEVEL G								
1	1.59	740.3	86.5(102.0)	0.196	0.017	0.526	0.139	0.371
14	1.59	754.8	88.9(101.7)	0.195	0.016	0.497	0.119	0.371
[illegible]	1.59	772.6	83.2(100.2)	0.176	0.016	0.423	0.094	0.371
16	1.59	770.3	83.5(100.2)	0.177	0.016	0.429	0.096	0.371
18	1.59	752.0	88.6(101.1)	0.196	0.016	0.503	0.122	0.371
18	1.59	745.9	89.1(101.1)	0.200	0.016	0.524	0.132	0.371
18	1.59	755.9	88.2(101.1)	0.193	0.016	0.490	0.116	0.371
20	1.59	759.8	89.8(102.6)	0.195	0.016	0.488	0.114	0.371
21	1.59	757.6	90.4(103.2)	0.197	0.016	0.497	0.117	0.371
34	1.59	791.4	88.7(103.5)	0.180	0.016	0.411	0.083	0.371
37	1.59	767.0	88.2(102.8)	0.189	0.016	0.461	0.104	0.371
38	1.59	765.3	89.1(102.6)	0.191	0.016	0.470	0.106	0.371
42	1.59	793.1	85.6(100.9)	0.173	0.016	0.394	0.080	0.371
42	1.59	793.7	85.5(100.5)	0.173	0.016	0.392	0.079	0.371
45	1.59	773.1	88.8(103.8)	0.187	0.016	0.450	0.098	0.371
45	1.59	770.9	89.0(103.8)	0.189	0.016	0.456	0.101	0.371
45	1.59	771.4	89.0(103.8)	0.188	0.016	0.455	0.100	0.371
47	1.59	762.6	88.2(101.7)	0.190	0.016	0.472	0.108	0.371
50	1.59	785.3	86.5(100.9)	0.178	0.016	0.413	0.086	0.371
58	1.59	775.9	85.8(103.0)	0.180	0.016	0.429	0.093	0.371
60	1.59	765.9	85.9(101.8)	0.184	0.016	0.452	0.103	0.371
64	1.59	763.1	84.5(102.4)	0.182	0.017	0.451	0.105	0.371
64	1.59	760.9	84.7(102.4)	0.183	0.017	0.457	0.107	0.371

********** INTERMEDIATE FLOW TEST IA **********

INTERMEDIATE LEVELS

EQUILIBRIUM QUALITY GREATER THAN ONE

ROD NO	X	TSURF DEG C	QCON(QTOT) KW/M**2	HEXPS	UHEXPS	HEXP KW/M**2 C	UHEXP	HDB
LEVEL E2								
60	1.08	574.8	90.6(99.4)	0.329	0.022	0.368	0.039	0.439
LEVEL E3								
14	1.12	551.4	93.5(100.0)	0.371	0.024	0.453	0.058	0.408
17	1.12	623.1	88.3(99.6)	0.273	0.020	0.317	0.035	0.408
34	1.12	626.4	92.1(101.8)	0.282	0.020	0.327	0.035	0.408
37	1.12	534.1	95.1(101.1)	0.405	0.026	0.503	0.069	0.408
38	1.12	582.6	92.8(100.7)	0.328	0.022	0.391	0.046	0.408
50	1.12	612.0	90.2(99.3)	0.289	0.020	0.338	0.037	0.408
60	1.12	623.7	88.8(100.1)	0.274	0.020	0.318	0.035	0.408
LEVEL E6								
60	1.21	618.1	91.3(101.6)	0.286	0.020	0.387	0.049	0.376
LEVEL E7								
1	1.23	650.9	88.3(101.9)	0.251	0.019	0.345	0.044	0.371
34	1.23	642.0	93.6(103.3)	0.273	0.020	0.380	0.048	0.371
37	1.23	606.4	94.0(102.6)	0.306	0.021	0.445	0.063	0.371
50	1.23	628.7	91.7(100.8)	0.279	0.020	0.393	0.052	0.371
LEVEL E8								
14	1.27	650.9	90.9(101.5)	0.259	0.019	0.381	0.052	0.366
34	1.27	657.0	93.1(103.3)	0.260	0.019	0.380	0.051	0.366
37	1.27	629.8	92.9(102.6)	0.281	0.020	0.427	0.062	0.366
38	1.27	648.7	91.9(102.2)	0.263	0.019	0.389	0.053	0.366
LEVEL F1								
17	1.34	676.4	88.2(101.1)	0.234	0.018	0.386	0.060	0.361
21	1.34	663.1	92.7(103.0)	0.255	0.019	0.430	0.069	0.361
34	1.34	687.6	92.0(103.3)	0.237	0.018	0.383	0.057	0.361
37	1.34	674.2	90.9(102.6)	0.242	0.018	0.401	0.062	0.361
50	1.34	678.1	89.9(100.8)	0.237	0.018	0.390	0.060	0.361
LEVEL F2								
14	1.38	700.9	88.9(101.5)	0.221	0.018	0.379	0.060	0.360
17	1.38	688.1	87.9(101.1)	0.226	0.018	0.396	0.065	0.360
38	1.38	635.3	94.3(102.2)	0.281	0.019	0.558	0.116	0.360
50	1.38	692.6	89.5(100.8)	0.228	0.018	0.395	0.064	0.360
LEVEL F3								
14	1.42	709.8	88.8(101.5)	0.216	0.017	0.395	0.066	0.361
17	1.42	699.2	87.6(101.1)	0.219	0.017	0.409	0.071	0.361
21	1.42	679.2	92.8(103.0)	0.244	0.018	0.478	0.090	0.361
34	1.42	716.4	91.1(103.3)	0.218	0.017	0.394	0.064	0.361
60	1.42	708.7	87.3(101.6)	0.213	0.017	0.391	0.066	0.361
LEVEL F4								
60	1.45	648.1	92.8(101.6)	0.266	0.018	0.638	0.168	0.362
LEVEL F5								
21	1.48	669.2	94.7(103.1)	0.256	0.018	0.617	0.155	0.363
60	1.48	693.1	89.8(101.7)	0.228	0.017	0.506	0.110	0.363
LEVEL F6								
1	1.50	703.1	88.2(102.0)	0.218	0.017	0.509	0.117	0.365
17	1.50	719.2	87.6(101.2)	0.209	0.017	0.463	0.097	0.365
37	1.50	725.9	89.7(102.6)	0.210	0.017	0.458	0.093	0.365
38	1.50	725.9	90.3(102.3)	0.212	0.017	0.461	0.093	0.365
50	1.50	735.3	88.6(100.8)	0.203	0.016	0.431	0.084	0.365
60	1.50	730.9	87.1(101.7)	0.202	0.017	0.434	0.087	0.365

********** INTERMEDIATE FLOW TEST IA **********

INTERMEDIATE LEVELS

EQUILIBRIUM QUALITY GREATER THAN ONE

ROD NO	X	TSURF DEG C	QCON(QTOT) KW/M**2	HEXPS	UHEXPS	HEXP	UHEXP	HDB
				KW/M**2 C				
LEVEL F7								
14	1.53	734.8	89.0(101.5)	0.204	0.016	0.464	0.099	0.366
17	1.53	734.8	86.7(101.1)	0.199	0.017	0.452	0.097	0.366
21	1.53	729.8	91.1(103.0)	0.212	0.017	0.488	0.106	0.366
37	1.53	743.7	88.7(102.5)	0.200	0.016	0.642	0.090	0.366
38	1.53	741.4	89.5(102.2)	0.202	0.016	0.451	0.093	0.366
50	1.53	751.4	87.9(100.9)	0.195	0.016	0.422	0.083	0.366
60	1.53	745.9	86.2(101.6)	0.193	0.016	0.425	0.087	0.366
LEVEL F8								
1	1.56	737.6	86.2(102.0)	0.197	0.017	0.491	0.118	0.369
14	1.56	744.8	89.1(101.6)	0.200	0.016	0.487	0.111	0.369
17	1.56	752.0	86.1(101.2)	0.190	0.016	0.453	0.100	0.369
21	1.56	747.6	90.6(103.2)	0.232	0.016	0.488	0.109	0.369
34	1.56	783.7	88.8(103.4)	0.183	0.016	0.400	0.077	0.369
37	1.56	757.6	88.5(102.7)	0.193	0.016	0.452	0.097	0.369
60	1.56	760.3	85.8(101.7)	0.186	0.016	0.432	0.092	0.369

INTERMEDIATE FLOW TEST 1B

FLUID CONDITIONS

CORRELATION COMPARISONS

SI UNITS

NOMENCLATURE

HCB	- CONDIE-BENGSTON HEAT TRANSFER COEFFICIENT	TSAT	- SATURATION TEMPERATURE
HDB	- DITTUS-BOELTER HEAT TRANSFER COEFFICIENT	TSRF(TSURF)	- SURFACE TEMPERATURE
HDR	- DOUGALL-ROHSENOW HEAT TRANSFER COEFFICIENT	TF	- EQUILIBRIUM FLUID TEMPERATURE
HDRPW	- DOUGALL-ROHSENOW HEAT TRANSFER COEFFICIENT, WALL PRANDTL NUMBER	UHDR	- UNCERTAINTY, DOUGALL-ROHSENOW HEAT TRANSFER COEFFICIENT
HEXP	- EXPERIMENTAL HEAT TRANSFER COEFFICIENT Q/(TSURF-TBULK)	UHEXP	- UNCERTAINTY, EXPERIMENTAL HEAT TRANSFER COEFFICIENT
HEXPS	- EXPERIMENTAL HEAT TRANSFER COEFFICIENT Q/(TSURF-TSAT)	UHEXPS	- UNCERTAINTY, EXPERIMENTAL HEAT TRANSFER COEFFICIENT
HG57	- GROENEVELD 5.7 HEAT TRANSFER COEFFICIENT	UHG57	- UNCERTAINTY, GROENEVELD 5.7 HEAT TRANSFER COEFFICIENT
HG59	- GROENEVELD 5.9 HEAT TRANSFER COEFFICIENT		
QCON	- CONVECTIVE HEAT FLUX	UHG59	- UNCERTAINTY, GROENEVELD 5.9 HEAT TRANSFER COEFFICIENT
QGD	- GROENEVELD-DELORME HEAT FLUX		
QTOT	- TOTAL HEAT FLUX (INCLUDING RADIATION)	UNC	- UNCERTAINTY
SDTSRF	- CROSS-SECTIONAL STANDARD DEVIATION OF THE SURFACE TEMPERATURE	UTF	- UNCERTAINTY, EQUILIBRIUM FLUID TEMPERATURE
SDQ	- CROSS-SECTIONAL STANDARD DEVIATION OF THE CONVECTIVE HEAT FLUX	UX	- UNCERTAINTY, EQUILIBRIUM QUALITY
		X	- EQUILIBRIUM QUALITY
TBULK	- BULK VAPOR TEMPERATURE		

*********** INTERMEDIATE FLOW TEST IB ***********

LEVEL AVERAGE FLUID AND SURFACE CONDITIONS

MASS FLUX	6.085E+04 LBM/SQFT H	UNC. MASS FLUX	1.900E+03 LBM/SQFT H	PRESSURE	1188.8 PSI	UNC. PRESSURE	7.50 PSI
	82.57 KG/SQM S		2.5786 KG/SQM S		8.20 MPA		0.052 MPA

LEVEL	QCON		SDQ		TSRF		SDTSRF		TF		UTF		X	UX
	ENG	SI	ENG	SI	ENG	SI	ENG	SI	ENG	SI	ENG	SI		
F	0.490	154.3	0.010	3.18	1054.3	568.3	30.98	17.212	579.3	304.4	27.081	15.0	1.0246	.0463
G	0.473	148.3	0.010	3.[illegible]8	1266.5	686.2	28.80	15.997	758.2	403.8	46.569	25.9	1.2530	.0537
E7	0.483	152.1	0.009	2.7[illegible]	1043.0	562.0	55.15	30.641	565.9	297.0	0.848	0.5	.9740	.0447
E8	0.496	156.1	0.006	1.90	1009.4	543.3	15.47	8.592	567.5	297.9	27.207	15.1	1.0041	.0456
F1	0.486	153.0	0.012	3.67	1070.3	577.2	40.19	22.327	604.9	318.6	34.637	19.2	1.0632	.0476
F2	0.480	151.3	0.007	2.23	1148.0	620.3	90.33	50.183	627.8	331.3	37.664	20.9	1.0934	.0487
F3	0.480	151.2	0.013	4.23	1139.4	615.6	19.88	11.046	653.4	345.6	39.633	22.0	1.1235	.0498
F5	0.479	150.8	0.019	6.04	1090.0	588.1	9.90	5.500	688.4	365.0	41.617	23.1	1.1693	.0513
F6	0.478	150.7	0.005	1.70	1185.8	641.3	22.16	12.313	704.9	374.2	42.270	23.5	1.1891	.0518
F7	0.475	149.8	0.010	3.13	1200.3	649.4	2[illegible].64	14.243	721.3	383.3	43.491	24.2	1.2078	.0524
F8	0.472	148.7	0.012	3.71	1236.9	669.7	28.25	15.692	742.6	395.1	45.254	25.1	1.2343	.0532

NOMENCLATURE

	ENG	SI
Q	BTU/H FT**2 X 1E5	KW/M**2
SDQ	BTU/H FT**2 X 1E5	KW/M**2
TSRF	DEG F	DEG C
SDTSRF	DEG F	DEG C
TF	DEG F	DEG C
UTF	DEG F	DEG C

********** INTERMEDIATE FLOW TEST 18 **********

PRIMARY LEVELS

EQUILIBRIUM QUALITY GREATER THAN ONE

ROD NO	X	TSURF DEG C	QCON(QTOT) KW/M**2	HEXPS	UHEXPS	HEXP	UHEXP	HDB	HCB KW/M**2 C	QGD KW/M**2
				KW/M**2 C						
LEVEL F										
3	1.02	579.2	156.6(166.1)	0.555	0.035	0.570	0.05	0.896	0.447	75.3
4	1.02	562.6	156.9(165.6)	0.591	0.037	0.608	0.05	0.896	0.454	69.7
7	1.02	569.2	155.3(164.3)	0.570	0.036	0.586	0.05	0.896	0.451	71.9
7	1.02	569.8	155.2(164.3)	0.569	0.036	0.585	0.05	0.896	0.451	72.1
16	1.02	554.8	151.4(159.6)	0.587	0.036	0.605	0.05	0.896	0.457	67.2
17	1.02	575.9	152.0(161.3)	0.545	0.034	0.560	0.05	0.896	0.448	74.1
18	1.02	538.7	153.8(160.5)	0.636	0.039	0.656	0.06	0.896	0.466	61.8
28	1.02	568.1	150.2(158.5)	0.554	0.035	0.570	0.05	0.896	0.451	71.5
28	1.02	565.9	150.3(158.5)	0.559	0.035	0.575	0.05	0.896	0.452	70.8
28	1.02	567.0	150.3(158.5)	0.557	0.035	0.572	0.05	0.896	0.452	71.2
34	1.02	556.4	158.3(165.3)	0.610	0.038	0.628	0.05	0.896	0.457	67.6
37	1.02	569.8	154.7(163.0)	0.567	0.036	0.583	0.05	0.896	0.451	72.1
38	1.02	563.7	155.8(163.4)	0.584	0.036	0.601	0.05	0.896	0.453	70.1
42	1.02	538.7	154.2(160.5)	0.638	0.039	0.658	0.06	0.896	0.466	61.8
45	1.02	563.1	156.7(164.8)	0.589	0.036	0.606	0.05	0.896	0.454	69.9
45	1.02	562.6	156.8(164.8)	0.590	0.036	0.607	0.05	0.896	0.454	69.7
53	1.02	546.4	161.1(168.4)	0.646	0.040	0.666	0.06	0.896	0.462	64.3
53	1.02	550.3	161.0(168.4)	0.635	0.039	0.655	0.06	0.896	0.460	65.6
59	1.02	575.9	152.5(162.2)	0.547	0.034	0.562	0.05	0.896	0.448	74.1
59	1.02	574.2	152.6(162.2)	0.550	0.035	0.566	0.05	0.896	0.449	73.6
59	1.02	580.9	152.2(162.2)	0.536	0.034	0.550	0.05	0.896	0.446	75.8
64	1.02	600.3	151.6(163.4)	0.500	0.032	0.512	0.04	0.896	0.440	82.4
64	1.02	604.2	151.4(163.4)	0.493	0.032	0.505	0.04	0.896	0.438	83.7
64	1.07	600.9	151.6(163.4)	0.499	0.032	0.511	0.04	0.896	0.439	82.6
LEVEL G										
1	1.25	681.4	146.7(162.8)	0.381	0.026	0.528	0.06	0.621	0.426	86.7
14	1.25	655.9	150.3(161.5)	0.419	0.027	0.596	0.07	0.621	0.431	77.2
16	1.25	704.2	143.1(159.6)	0.351	0.025	0.476	0.05	0.621	0.422	95.2
16	1.25	705.9	142.9(159.6)	0.349	0.025	0.473	0.05	0.621	0.422	95.8
18	1.25	672.0	148.1(160.5)	0.395	0.026	0.552	0.07	0.621	0.428	83.2
18	1.25	667.6	148.5(160.5)	0.401	0.027	0.563	0.07	0.621	0.429	81.5
18	1.25	675.3	147.9(160.5)	0.391	0.026	0.545	0.06	0.621	0.427	84.4
20	1.25	667.6	151.2(162.9)	0.408	0.027	0.573	0.07	0.621	0.429	81.5
21	1.25	666.4	151.5(163.2)	0.410	0.027	0.577	0.07	0.621	0.429	81.1
34	1.25	695.3	152.4(165.3)	0.383	0.026	0.523	0.06	0.621	0.424	91.9
37	1.25	690.3	148.9(163.0)	0.379	0.026	0.520	0.06	0.621	0.425	90.0
38	1.25	692.6	150.0(163.4)	0.379	0.026	0.519	0.06	0.621	0.424	90.7
42	1.25	693.1	148.2(161.1)	0.374	0.026	0.512	0.06	0.621	0.424	91.0
42	1.25	694.8	148.1(161.1)	0.372	0.025	0.509	0.06	0.621	0.424	91.6
45	1.25	694.8	150.9(165.4)	0.379	0.026	0.519	0.06	0.621	0.424	91.6
45	1.25	688.1	151.4(165.4)	0.387	0.026	0.532	0.06	0.621	0.425	89.1
45	1.25	689.8	151.3(165.4)	0.385	0.026	0.529	0.06	0.621	0.425	89.8
47	1.25	669.8	150.8(163.0)	0.405	0.027	0.567	0.07	0.621	0.428	82.3
50	1.25	672.6	149.6(161.4)	0.398	0.026	0.557	0.07	0.621	0.428	83.3
58	1.25	700.3	147.7(163.9)	0.366	0.026	0.498	0.06	0.621	0.423	93.7
64	1.25	713.1	144.5(163.4)	0.347	0.025	0.467	0.05	0.621	0.421	98.5
64	1.25	713.7	144.4(163.4)	0.347	0.025	0.456	0.05	0.621	0.421	98.7

*********** INTERMEDIATE FLOW TEST ;B ***********

INTERMEDIATE LEVELS

EQUILIBRIUM QUALITY LESS THAN ONE

ROD NO	X	TSURF DEG C	QCON(QTOT) KW/M**2	HEXP	UHEXP	HDR	UHDR	HDRPW	HG57	UHG57	HG59	UHG59	HCB	QGD KW/M**2
				KW/M**2 C										
LEVEL E7														
1	0.97	583.7	150.2(160.9)	0.524	0.033	0.933	0.022	0.746	0.508	0.029	0.318	0.027	0.444	74.4
37	0.97	540.3	154.1(161.1)	0.633	0.039	0.933	0.022	0.751	0.520	0.030	0.327	0.027	0.463	60.4

********** INTERMEDIATE FLOW TEST 18 **********

INTERMEDIATE LEVELS

EQUILIBRIUM QUALITY GREATER THAN ONE

ROD NO	X	TSURF DEG C	QCON(QTOT) KW/M**2	HEXPS	UHEXPS	HEXP KW/M**2 C	UHEXP	HOB	HCB KW/M**2 C	QGD KW/M**2
LEVEL E8										
34	1.00	537.1	158.1(164.3)	0.659	0.040	0.661	0.06	0.952	0.466	63.5
37	1.00	553.1	154.4(162.1)	0.603	0.037	0.605	0.05	0.952	0.458	68.8
38	1.00	539.8	155.8(162.5)	0.642	0.039	0.644	0.06	0.952	0.465	64.3
LEVEL F1										
17	1.06	603.7	150.5(161.1)	0.491	0.031	0.528	0.05	0.804	0.440	79.3
21	1.06	568.1	155.4(163.1)	0.573	0.035	0.623	0.06	0.804	0.453	67.3
34	1.06	589.8	156.9(165.2)	0.536	0.034	0.579	0.06	0.804	0.444	74.5
37	1.06	595.3	153.4(162.9)	0.514	0.032	0.554	0.05	0.804	0.442	76.5
50	1.06	547.6	154.6(161.2)	0.617	0.038	0.675	0.07	0.804	0.462	60.5
LEVEL F2										
14	1.09	598.1	152.4(161.6)	0.506	0.032	0.571	0.06	0.747	0.442	73.8
17	1.09	617.6	149.9(161.3)	0.468	0.030	0.524	0.05	0.747	0.436	80.4
38	1.09	690.9	148.9(163.4)	0.378	0.026	0.414	0.04	0.747	0.420	106.6
50	1.09	574.8	153.8(161.4)	0.553	0.034	0.632	0.07	0.747	0.451	65.9
LEVEL F3										
14	1.12	614.8	151.7(161.6)	0.477	0.030	0.564	0.06	0.703	0.438	76.2
17	1.12	629.8	149.4(161.3)	0.449	0.029	0.526	0.05	0.703	0.434	81.4
21	1.12	603.1	154.1(163.2)	0.503	0.032	0.598	0.06	0.703	0.441	72.3
34	1.12	623.1	155.7(165.3)	0.477	0.030	0.561	0.06	0.703	0.436	79.1
LEVEL F5										
21	1.17	592.0	155.0(163.2)	0.526	0.033	0.683	0.08	0.658	0.446	63.2
LEVEL F6										
1	1.19	644.2	149.1(162.8)	0.429	0.029	0.552	0.06	0.645	0.432	79.3
17	1.19	645.3	148.8(161.3)	0.427	0.028	0.549	0.06	0.645	0.432	79.6
37	1.19	650.9	151.1(163.0)	0.427	0.028	0.546	0.06	0.645	0.431	81.6
38	1.19	646.4	152.5(163.4)	0.436	0.028	0.560	0.06	0.645	0.432	80.0
50	1.19	619.8	152.1(161.4)	0.471	0.030	0.619	0.07	0.645	0.438	70.6
LEVEL F7										
14	1.21	631.4	151.5(161.6)	0.453	0.029	0.610	0.07	0.636	0.436	72.7
17	1.21	660.3	147.9(161.3)	0.407	0.027	0.534	0.06	0.636	0.429	83.0
21	1.21	639.2	152.7(163.2)	0.446	0.029	0.597	0.07	0.636	0.434	75.5
37	1.21	666.4	150.2(163.0)	0.407	0.027	0.530	0.06	0.636	0.428	85.3
38	1.21	665.3	151.4(163.4)	0.411	0.027	0.537	0.06	0.636	0.428	84.9
50	1.21	640.9	151.1(161.4)	0.439	0.028	0.587	0.07	0.636	0.433	76.0
LEVEL F8										
1	1.23	678.7	146.8(162.8)	0.384	0.027	0.518	0.06	0.626	0.426	87.0
14	1.23	642.6	151.0(161.6)	0.437	0.028	0.610	0.08	0.626	0.434	73.9
17	1.23	677.0	146.9(161.3)	0.387	0.026	0.521	0.06	0.626	0.427	86.4
21	1.23	655.9	152.0(163.2)	0.423	0.028	0.583	0.07	0.626	0.431	78.7
34	1.23	686.4	152.8(165.3)	0.392	0.026	0.525	0.06	0.626	0.425	90.0
37	1.23	680.9	149.4(163.0)	0.389	0.026	0.523	0.06	0.626	0.426	87.9

INTERMEDIATE FLOW TEST IC

FLUID CONDITIONS

CORRELATION COMPARISONS

SI UNITS

NOMENCLATURE

HCB - CONDIE-BENGSTON HEAT TRANSFEER COEFFICIENT
HDB - DITTUS-BOELTER HEAT TRANSFER COEFFICIENT
HDR - DOUGALL-ROHSENOW HEAT TRANSFER COEFFICIENT
HDRPW - DOUGALL-ROHSENOW HEAT TRANSFER COEFFICIENT, WALL PRANDTL NUMBER
HEXP - EXPERIMENTAL HEAT TRANSFER COEFFICIENT Q/(TSURF-TBULK)
HEXPS - EXPERIMENTAL HEAT TRANSFER COEFFICIENT Q/(TSURF-TSAT)
HG57 - GROENEVELD 5.7 HEAT TRANSFER COEFFICIENT
HG59 - GROENEVELD 5.9 HEAT TRANSFER COEFFICIENT
QCON - CONVECTIVE HEAT FLUX
QGD - GROENEVELD-DELORME HEAT FLUX
QTOT - TOTAL HEAT FLUX (INCLUDING RADIATION)
SDTSRF - CROSS-SECTIONAL STANDARD DEVIATION OF THE SURFACE TEMPERATURE
SDQ - CROSS-SECTIONAL STANDARD DEVIATION OF THE CONVECTIVE HEAT FLUX
TBULK - BULK VAPOR TEMPERATURE
TSAT - SATURATION TEMPERATURE
TSRF(TSURF) - SURFACE TEMPERATURE
TF - EQUILIBRIUM FLUID TEMPERATURE
UHDR - UNCERTAINTY, DOUGALL-ROHSENOW HEAT TRANSFER COEFFICIENT
UHEXP - UNCERTAINTY, EXPERIMENTAL HEAT TRANSFER COEFFICIENT
UHEXPS - UNCERTAINTY, EXPERIMENTAL HEAT TRANSFER COEFFICIENT
UHG57 - UNCERTAINTY, GROENEVELD 5.7 HEAT TRANSFER COEFFICIENT
UHG59 - UNCERTAINTY, GROENEVELD 5.9 HEAT TRANSFER COEFFICIENT
UNC - UNCERTAINTY
UTF - UNCERTAINTY, EQUILIBRIUM FLUID TEMPERATURE
UX - UNCERTAINTY, EQUILIBRIUM QUALITY
X - EQUILIBRIUM QUALITY

********** INTERMEDIATE FLOW TEST IC **********

LEVEL AVERAGE FLUID AND SURFACE CONDITIONS

MASS FLUX 8.118E+04 LBM/SQFT H UNC. MASS FLUX 2.552E+03 LBM/SQFT H PRESSURE 1205.2 PSI UNC. PRESSURE 7.50 PSI
110.16 KG/SQM S 3.4629 KG/SQM S 8.32 MPA 0.052 MPA

LEVEL	QCON		SDQ		TSRF		SDTSRF		TF		UTF		X	UX
	ENG	SI	ENG	SI	ENG	SI	ENG	SI	ENG	SI	ENG	SI		
F	0.582	183.3	0.009	2.98	1052.6	567.3	52.38	29.099	576.3	302.7	22.245	12.4	1.0153	.0410
G	0.571	180.0	0.013	4.18	1204.5	651.7	52.14	28.965	727.0	386.5	39.407	21.9	1.2152	.0476
E7	0.571	179.8	0.000	0.00	1078.0	581.4	0.00	0.000	567.7	298.0	0.762	0.4	.9710	.0396
E8	0.586	184.6	0.000	0.00	1008.0	542.6	0.00	0.000	567.7	298.0	0.762	0.4	.9974	.0404
F1	0.583	183.7	0.014	4.37	1040.3	560.5	33.37	18.541	596.7	314.0	27.830	15.5	1.0491	.0422
F2	0.576	181.5	0.014	4.45	1130.6	610.7	165.77	92.095	614.8	324.1	31.606	17.6	1.0754	.0431
F3	0.581	183.0	0.016	5.16	1071.6	587.9	27.96	15.534	634.9	335.3	34.501	19.2	1.1018	.0441
F5	0.574	180.9	0.024	7.48	1046.5	563.9	17.68	9.821	668.1	353.7	36.351	20.2	1.1419	.0454
F6	0.579	182.4	0.006	1.98	1140.6	616.2	21.36	11.867	681.0	360.9	36.988	20.5	1.1593	.0459
F7	0.576	181.3	0.012	3.67	1145.0	618.7	25.13	13.959	693.8	368.0	37.716	21.0	1.1757	.0464
F8	0.574	180.7	0.014	4.40	1173.9	634.7	30.22	16.791	712.8	378.6	38.498	21.4	1.1988	.0471

NOMENCLATURE

	ENG	SI
Q	BTU/H FT**2 X 1E5	KW/M**2
SDQ	BTU/H FT**2 X 1E5	KW/M**2
TSRF	DEG F	DEG C
SDTSRF	DEG F	DEG C
TF	DEG F	DEG C
UTF	DEG F	DEG C

********** INTERMEDIATE FLOW TEST 1C **********

PRIMARY LEVELS

EQUILIBRIUM QUALITY GREATER THAN ONE

ROD NO	X	TSURF DEG C	QCON(QTOT) KW/M**2	HEXPS	UHEXPS	HEXP KW/M**2 C	UHEXP	HDB	HCB KW/M**2 C	QGD KW/M**2
LEVEL F										
3	1.02	574.2	186.6(195.8)	0.675	0.042	0.687	0.05	1.163	0.561	102.3
4	1.02	573.7	186.0(195.2)	0.675	0.041	0.686	0.05	1.163	0.562	102.2
7	1.02	582.6	183.9(193.7)	0.646	0.040	0.657	0.05	1.163	0.557	106.0
7	1.02	580.3	184.0(193.7)	0.652	0.040	0.663	0.05	1.163	0.558	105.1
15	1.02	529.4	182.3(188.6)	0.787	0.048	0.804	0.07	1.163	0.590	83.3
16	1.02	572.0	178.8(188.0)	0.653	0.040	0.664	0.05	1.163	0.562	101.5
17	1.02	548.7	183.1(191.3)	0.730	0.044	0.745	0.06	1.163	0.576	91.5
18	1.02	527.6	184.6(191.2)	0.804	0.049	0.821	0.07	1.163	0.592	82.5
37	1.02	565.9	185.1(193.3)	0.691	0.043	0.703	0.05	1.163	0.566	98.8
38	1.02	553.1	186.5(193.7)	0.731	0.044	0.745	0.06	1.163	0.573	93.3
45	1.02	530.1	187.6(194.1)	0.808	0.049	0.825	0.07	1.163	0.589	83.6
45	1.02	526.1	187.7(194.1)	0.823	0.050	0.840	0.07	1.163	0.593	82.0
59	1.02	565.3	181.9(191.1)	0.680	0.042	0.693	0.05	1.163	0.566	98.6
59	1.02	562.5	182.0(191.1)	0.688	0.042	0.700	0.05	1.163	0.568	97.3
59	1.02	571.4	181.5(191.1)	0.664	0.041	0.676	0.05	1.163	0.563	101.2
64	1.02	614.8	179.3(192.0)	0.566	0.036	0.575	0.04	1.163	0.544	120.2
64	1.02	618.7	179.0(192.0)	0.558	0.036	0.567	0.04	1.163	0.542	121.9
64	1.02	615.3	179.3(192.0)	0.565	0.036	0.573	0.04	1.163	0.544	120.5
LEVEL G										
1	1.22	664.2	177.9(192.9)	0.486	0.032	0.641	0.07	0.800	0.539	115.2
14	1.22	619.8	181.8(191.2)	0.565	0.035	0.779	0.09	0.800	0.552	94.3
16	1.22	685.9	172.6(188.0)	0.445	0.030	0.576	0.06	0.800	0.534	125.6
16	1.22	689.8	172.3(188.0)	0.440	0.029	0.568	0.06	0.800	0.533	127.4
18	1.22	627.6	180.6(191.2)	0.548	0.034	0.749	0.08	0.800	0.549	97.9
18	1.22	624.8	180.8(191.2)	0.553	0.035	0.759	0.09	0.800	0.550	96.7
18	1.22	634.8	180.2(191.2)	0.535	0.034	0.726	0.08	0.800	0.547	101.2
20	1.22	577.0	185.4(192.4)	0.664	0.040	0.973	0.13	0.800	0.570	74.9
20	1.22	636.4	182.1(192.4)	0.538	0.034	0.728	0.08	0.800	0.547	102.1
21	1.22	627.6	183.2(192.9)	0.556	0.034	0.760	0.09	0.800	0.549	97.9
34	1.22	645.3	186.1(197.1)	0.536	0.034	0.719	0.08	0.800	0.544	106.2
37	1.22	650.9	181.6(193.3)	0.515	0.033	0.687	0.07	0.800	0.542	108.9
38	1.22	644.2	183.1(193.7)	0.529	0.033	0.710	0.08	0.800	0.544	105.6
42	1.22	668.1	180.5(192.1)	0.488	0.032	0.641	0.07	0.800	0.538	117.2
42	1.22	672.0	180.2(192.1)	0.482	0.031	0.631	0.06	0.800	0.537	119.0
45	1.22	647.6	183.6(195.1)	0.525	0.033	0.703	0.08	0.800	0.543	107.4
45	1.22	641.4	184.1(195.1)	0.536	0.034	0.722	0.08	0.800	0.545	104.4
45	1.22	640.9	184.1(195.1)	0.537	0.034	0.723	0.08	0.800	0.545	104.1
47	1.22	648.7	181.4(192.5)	0.517	0.033	0.692	0.07	0.800	0.543	107.7
50	1.22	664.2	180.1(191.7)	0.492	0.031	0.648	0.07	0.800	0.539	115.2
58	1.22	692.6	176.8(192.6)	0.448	0.030	0.578	0.06	0.800	0.532	128.9
64	1.22	699.2	174.0(192.0)	0.434	0.030	0.556	0.05	0.800	0.531	132.2
64	1.22	699.2	174.0(192.0)	0.434	0.030	0.556	0.05	0.800	0.531	132.2

*********** INTERMEDIATE FLOW TEST IC **********

INTERMEDIATE LEVELS

EQUILIBRIUM QUALITY LESS THAN ONE

ROD NO	X	TSURF DEG C	QCON(QTOT) KW/M**2	HEXP	UHEXP	HDR	UHDR	HDRPW	HG57	UHG57	HG59	UHG59	HCB	QGD KW/M**2
				---------- KW/M**2 C										
LEVEL E7														
1	0.97	581.4	179.8(190.3)	0.634	0.040	1.182	0.022	0.943	0.624	0.035	0.416	0.035	0.555	100.4
LEVEL E8														
37	1.00	542.6	184.6(191.7)	0.755	0.046	1.206	0.043	0.969	0.618	0.037	0.406	0.033	0.579	89.5

********** INTERMEDIATE FLOW TEST IC **********

INTERMEDIATE LEVELS

EQUILIBRIUM QUALITY GREATER THAN ONE

ROD NO	X	TSURF DEG C	QCON(QTOT) KW/M**2	HEXPS	UHEXPS	HEXP KW/M**2 C	UHEXP	HDB	HCB KW/M**2 C	QGD KW/M**2
LEVEL F1										
17	1.05	575.9	182.5(192.0)	0.657	0.040	0.697	0.06	1.056	0.562	98.2
21	1.05	553.1	185.5(192.6)	0.727	0.044	0.776	0.07	1.056	0.575	88.3
34	1.05	553.7	189.5(196.8)	0.741	0.045	0.791	0.07	1.056	0.575	88.5
37	1.05	589.2	183.7(193.0)	0.631	0.039	0.668	0.06	1.056	0.556	104.2
50	1.05	553.1	184.5(191.4)	0.723	0.044	0.772	0.07	1.056	0.575	88.3
LEVEL F2										
14	1.08	536.6	184.8(191.1)	0.774	0.047	0.870	0.09	0.987	0.588	77.4
17	1.08	589.8	182.2(192.3)	0.624	0.039	0.686	0.06	0.987	0.557	100.7
38	1.08	744.8	175.1(193.7)	0.392	0.028	0.416	0.03	0.987	0.516	173.7
50	1.08	571.4	184.1(191.7)	0.673	0.041	0.745	0.07	0.987	0.566	92.7
LEVEL F3										
14	1.10	560.9	183.9(191.2)	0.700	0.043	0.815	0.09	0.930	0.573	84.4
17	1.10	602.0	181.6(192.3)	0.597	0.037	0.681	0.07	0.930	0.553	102.6
21	1.10	568.7	185.4(192.9)	0.685	0.042	0.794	0.08	0.930	0.569	88.0
34	1.10	580.9	188.9(197.1)	0.668	0.041	0.769	0.08	0.930	0.562	93.3
LEVEL F5										
21	1.14	557.0	186.2(192.9)	0.719	0.043	0.916	0.11	0.859	0.578	76.5
LEVEL F6										
1	1.16	633.1	179.8(192.9)	0.537	0.034	0.661	0.07	0.840	0.545	107.8
17	1.16	610.9	181.5(192.3)	0.580	0.036	0.726	0.08	0.840	0.553	97.6
37	1.16	614.2	183.5(193.3)	0.580	0.036	0.724	0.08	0.840	0.551	99.2
38	1.16	601.4	185.1(193.7)	0.610	0.037	0.769	0.08	0.840	0.556	93.3
50	1.16	621.4	182.2(191.7)	0.563	0.035	0.699	0.07	0.840	0.549	102.4
LEVEL F7										
14	1.18	600.9	182.5(191.2)	0.602	0.037	0.784	0.09	0.825	0.557	90.9
17	1.18	624.8	180.7(192.3)	0.553	0.035	0.704	0.07	0.825	0.548	101.5
21	1.18	603.1	184.2(192.9)	0.604	0.037	0.784	0.09	0.825	0.556	91.7
37	1.18	628.1	182.7(193.3)	0.553	0.035	0.703	0.07	0.825	0.547	103.2
38	1.18	618.7	184.3(193.7)	0.575	0.036	0.735	0.08	0.825	0.551	98.8
50	1.18	640.3	181.3(191.7)	0.529	0.033	0.666	0.07	0.825	0.543	108.8
LEVEL F8										
1	1.20	662.6	177.9(192.9)	0.488	0.032	0.626	0.06	0.808	0.538	116.0
14	1.20	610.9	182.1(191.2)	0.582	0.036	0.784	0.09	0.808	0.555	92.0
17	1.20	640.9	179.8(192.3)	0.524	0.033	0.685	0.07	0.808	0.544	105.9
21	1.20	619.2	183.5(192.9)	0.571	0.035	0.763	0.08	0.808	0.551	95.9
34	1.20	636.4	186.5(197.1)	0.551	0.035	0.723	0.08	0.808	0.546	103.8
37	1.20	642.0	182.1(193.3)	0.529	0.033	[illegible]	0.07	0.808	0.544	106.5

INTERMEDIATE FLOW TEST ID

FLUID CONDITIONS

CORRELATION COMPARISONS

SI UNITS

NOMENCLATURE

- HCB - CONDIE-BENGSTON HEAT TRANSFEER COEFFICIENT
- HDB - DITTUS-BOELTER HEAT TRANSFER COEFFICIENT
- HDR - DOUGALL-ROHSENOW HEAT TRANSFER COEFFICIENT
- HDRPW - DOUGALL-ROHSENOW HEAT TRANSFER COEFFICIENT, WALL PRANDTL NUMBER
- HEXP - EXPERIMENTAL HEAT TRANSFER COEFFICIENT Q/(TSURF-TBULK)
- HEXPS - EXPERIMENTAL HEAT TRANSFER COEFFICIENT Q/(TSURF-TSAT)
- HG57 - GROENEVELD 5.7 HEAT TRANSFER COEFFICIENT
- HG59 - GROENEVELD 5.9 HEAT TRANSFER COEFFICIENT
- QCON - CONVECTIVE HEAT FLUX
- QGD - GROENEVELD-DELORME HEAT FLUX
- QTOT - TOTAL HEAT FLUX (INCLUDING RADIATION)
- SDTSRF - CROSS-SECTIONAL STANDARD DEVIATION OF THE SURFACE TEMPERATURE
- SDQ - CROSS-SECTIONAL STANDARD DEVIATION OF THE CONVECTIVE HEAT FLUX
- TBULK - BULK VAPOR TEMPERATURE
- TSAT - SATURATION TEMPERATURE
- TSRF(TSURF) - SURFACE TEMPERATURE
- TF - EQUILIBRIUM FLUID TEMPERATURE
- UHDR - UNCERTAINTY, DOUGALL-ROHSENOW HEAT TRANSFER COEFFICIENT
- UHEXP - UNCERTAINTY, EXPERIMENTAL HEAT TRANSFER COEFFICIENT
- UHEXPS - UNCERTAINTY, EXPERIMENTAL HEAT TRANSFER COEFFICIENT
- UHG57 - UNCERTAINTY, GROENEVELD 5.7 HEAT TRANSFER COEFFICIENT
- UHG59 - UNCERTAINTY, GROENEVELD 5.9 HEAT TRANSFER COEFFICIENT
- UNC - UNCERTAINTY
- TF - UNCERTAINTY, EQUILIBRIUM FLUID TEMPERATURE
- UX - UNCERTAINTY, EQUILIBRIUM QUALITY
- X - EQUILIBRIUM QUALITY

*********** INTERMEDIATE FLOW TEST ID ***********

LEVEL AVERAGE FLUID AND SURFACE CONDITIONS

MASS FLUX 1.074E+05 LBM/SQFT H UNC. MASS FLUX 3.376E+03 LBM/SQFT H PRESSURE 1168.7 PSI UNC. PRESSURE 7.50 PSI
145.71 KG/SQM S 4.5806 KG/SQM S 8.06 MPA 0.052 MPA

LEVEL	QCON		SDQ		TSRF		SDTSRF		TF		UTF		X	UX
	ENG	SI	ENG	SI	ENG	SI	ENG	SI	ENG	SI	ENG	SI		
F	0.831	261.8	0.017	5.32	1196.9	647.5	67.96	37.754	602.6	317.3	33.391	18.6	1.0619	.0440
G	0.814	256.3	0.019	5.91	1357.5	736.7	65.32	36.290	779.4	415.5	45.876	25.5	1.2758	.0511
E7	0.841	265.0	0.017	5.40	1150.5	621.7	61.78	34.323	570.4	299.4	25.811	14.3	1.0144	.0425
E8	0.846	266.3	0.010	3.11	1146.2	619.4	21.65	12.030	588.7	309.6	29.741	16.5	1.0427	.0434
F1	0.828	260.9	0.022	6.99	1213.2	656.6	33.63	18.681	631.7	333.5	35.609	19.8	1.0981	.0453
F2	0.822	258.9	0.004	1.20	1249.0	676.4	26.85	14.917	654.2	346.0	37.204	20.7	1.1264	.0463
F3	0.824	259.6	0.027	8.35	1236.4	669.4	42.27	23.484	676.2	358.2	38.361	21.3	1.1547	.0474
F5	0.819	257.8	0.042	13.28	1189.5	643.4	75.66	42.034	712.7	378.5	40.720	22.6	1.1976	.0487
F6	0.825	259.8	0.010	3.07	1289.0	698.7	27.88	15.491	727.5	386.7	41.814	23.2	1.2161	.0492
F7	0.819	257.9	0.019	6.14	1300.4	705.0	40.59	22.550	742.0	394.8	42.916	23.8	1.2336	.0498
F8	0.818	257.7	0.021	6.63	1321.6	716.8	27.10	15.054	763.5	406.7	44.755	24.9	1.2583	.0505

NOMENCLATURE

	ENG	SI
Q	BTU/H FT**2 X 1E5	KW/M**2
SDQ	BTU/H FT**2 X 1E5	KW/M**2
TSRF	DEG F	DEG C
SDTSRF	DEG F	DEG C
TF	DEG F	DEG C
UTF	DEG F	DEG C

********** INTERMEDIATE FLOW TEST ID **********

PRIMARY LEVELS

EQUILIBRIUM QUALITY GREATER THAN ONE

ROD NO	X	TSURF DEG C	QCON(QTOT) KW/M**2	HEXPS	UHEXPS	HEXP	UHEXP	HDB
				KW/M**2 C				
LEVEL F								
3	1.06	675.9	263.8(279.3)	0.694	0.043	0.736	0.060	1.254
4	1.06	666.4	263.0(277.9)	0.709	0.044	0.753	0.062	1.254
7	1.06	685.9	259.9(276.5)	0.666	0.042	0.705	0.057	1.254
7	1.06	684.8	260.0(276.5)	0.668	0.042	0.708	0.057	1.254
10	1.06	645.3	259.5(271.5)	0.742	0.046	0.791	0.067	1.254
10	1.06	649.8	259.2(271.5)	0.732	0.045	0.780	0.065	1.254
10	1.06	644.8	259.6(271.5)	0.744	0.046	0.793	0.067	1.254
13	1.06	648.7	264.9(276.9)	0.750	0.046	0.799	0.067	1.254
13	1.06	654.8	264.5(276.9)	0.737	0.046	0.784	0.065	1.254
14	1.06	609.8	262.7(272.7)	0.836	0.051	0.898	0.079	1.254
15	1.06	641.4	257.4(269.2)	0.745	0.046	0.794	0.067	1.254
16	1.06	670.3	254.3(269.6)	0.679	0.043	0.720	0.059	1.254
17	1.06	650.3	259.5(273.6)	0.732	0.045	0.779	0.065	1.254
18	1.06	575.3	265.6(274.3)	0.950	0.057	1.029	0.096	1.254
20	1.06	532.8	267.0(273.1)	1.126	0.067	1.239	0.132	1.254
20	1.06	595.9	264.0(273.1)	0.879	0.053	0.946	0.086	1.254
31	1.06	635.9	263.5(274.8)	0.774	0.047	0.827	0.070	1.254
31	1.06	638.1	263.3(274.8)	0.769	0.047	0.821	0.069	1.254
34	1.06	634.8	270.0(281.5)	0.796	0.049	0.851	0.072	1.254
37	1.06	638.1	264.9(276.9)	0.773	0.048	0.826	0.071	1.254
38	1.06	642.0	265.5(277.1)	0.767	0.047	0.818	0.069	1.254
42	1.06	648.1	261.9(273.3)	0.743	0.046	0.792	0.066	1.254
45	1.06	625.3	267.8(279.0)	0.812	0.049	0.869	0.075	1.254
45	1.06	624.8	267.8(279.0)	0.814	0.049	0.871	0.075	1.254
53	1.06	645.3	271.8(284.2)	0.777	0.048	0.829	0.070	1.254
53	1.06	646.4	271.8(284.2)	0.775	0.047	0.826	0.069	1.254
59	1.06	654.2	257.7(272.5)	0.719	0.045	0.755	0.064	1.254
59	1.06	649.8	258.0(272.5)	0.729	0.045	0.776	0.065	1.254
59	1.06	659.2	257.4(272.3)	0.708	0.044	0.753	0.063	1.254
64	1.06	721.4	254.0(275.2)	0.597	0.039	0.628	0.050	1.254
64	1.06	723.1	253.8(275.2)	0.594	0.039	0.625	0.050	1.254
64	1.06	719.8	254.1(275.2)	0.599	0.039	0.631	0.051	1.254
LEVEL G								
1	1.28	736.4	255.4(276.4)	0.579	0.038	0.796	0.083	0.966
14	1.28	710.9	258.1(273.0)	0.622	0.039	0.874	0.096	0.966
16	1.28	783.7	245.9(269.6)	0.504	0.034	0.668	0.066	0.966
16	1.28	783.1	246.0(269.6)	0.505	0.034	0.659	0.066	0.966
18	1.28	692.6	259.8(274.3)	0.655	0.041	0.938	0.106	0.966
18	1.28	687.0	260.2(274.3)	0.665	0.041	0.959	0.110	0.966
18	1.28	707.6	258.6(274.3)	0.628	0.039	0.886	0.097	0.966
20	1.28	649.2	262.7(273.1)	0.743	0.045	1.124	0.144	0.966
20	1.28	718.1	257.9(273.1)	0.611	0.038	0.852	0.091	0.966
21	1.28	705.9	256.7(271.0)	0.626	0.039	0.884	0.097	0.966
34	1.28	736.4	264.4(281.5)	0.602	0.038	0.824	0.085	0.966
37	1.28	723.1	260.6(277.0)	0.610	0.039	0.847	0.090	0.966
38	1.28	732.6	261.3(277.5)	0.598	0.038	0.824	0.086	0.966
42	1.28	770.9	255.0(273.3)	0.537	0.036	0.717	0.072	0.966
42	1.28	775.3	254.6(273.3)	0.531	0.035	0.708	0.069	0.966
45	1.28	727.6	262.3(279.2)	0.607	0.038	0.841	0.088	0.966
45	1.28	722.0	262.8(279.2)	0.616	0.039	0.858	0.091	0.966
45	1.28	724.8	262.6(279.2)	0.612	0.039	0.849	0.090	0.966
47	1.28	748.1	257.6(275.5)	0.569	0.037	0.775	0.079	0.966
50	1.28	765.9	254.4(272.8)	0.541	0.035	0.726	0.072	0.966
58	1.28	771.4	252.5(274.8)	0.531	0.035	0.710	0.070	0.966
64	1.28	790.3	248.3(274.9)	0.502	0.034	0.662	0.065	0.966
64	1.28	788.1	248.5(274.9)	0.505	0.035	0.667	0.065	0.966

*********** INTERMEDIATE FLOW TEST ID ***********

INTERMEDIATE LEVELS

EQUILIBRIUM QUALITY GREATER THAN ONE

ROD NO	X	TSURF DEG C	QCON(QTOT) KW/M**2	HEXPS	UHEXPS	HEXP	UHEXP	HDB
				KW/M**2 C				
LEVEL E7								
1	1.01	673.1	258.8(275.8)	0.686	0.043	0.693	0.051	1.442
34	1.01	603.1	271.6(281.5)	0.883	0.054	0.894	0.069	1.442
37	1.01	603.1	266.6(276.8)	0.867	0.052	0.878	0.068	1.442
50	1.01	607.6	263.1(272.8)	0.844	0.051	0.854	0.065	1.442
LEVEL E8								
14	1.04	603.1	263.0(272.7)	0.856	0.052	0.896	0.075	1.323
34	1.04	624.2	270.5(281.5)	0.823	0.050	0.860	0.070	1.323
37	1.04	618.7	265.8(276.8)	0.823	0.050	0.860	0.070	1.323
38	1.04	631.4	266.0(277.1)	0.792	0.048	0.827	0.066	1.323
LEVEL F1								
17	1.10	670.9	258.2(273.5)	0.688	0.043	0.765	0.066	1.150
21	1.10	622.6	266.0(276.3)	0.814	0.049	0.920	0.085	1.150
34	1.10	654.8	269.0(281.5)	0.749	0.046	0.837	0.074	1.150
37	1.10	667.6	263.1(276.8)	0.707	0.044	0.788	0.068	1.150
50	1.10	672.0	259.9(272.8)	0.691	0.043	0.768	0.066	1.150
LEVEL F2								
14	1.13	660.3	260.1(272.7)	0.713	0.044	0.827	0.076	1.091
17	1.13	679.2	257.7(273.6)	0.672	0.042	0.773	0.069	1.091
50	1.13	689.8	258.9(272.8)	0.657	0.041	0.753	0.066	1.091
LEVEL F3								
14	1.15	675.3	259.3(272.7)	0.683	0.042	0.818	0.076	1.049
17	1.15	687.0	257.3(273.6)	0.657	0.041	0.782	0.071	1.049
21	1.15	629.8	265.9(276.3)	0.796	0.048	0.975	0.098	1.049
34	1.15	668.7	268.4(281.5)	0.720	0.044	0.865	0.081	1.049
LEVEL F5								
21	1.20	613.7	267.2(276.3)	0.840	0.050	1.136	0.132	1.004
LEVEL F6								
1	1.22	702.6	257.7(276.0)	0.633	0.041	0.816	0.081	0.992
17	1.22	689.2	257.7(273.8)	0.655	0.041	0.852	0.086	0.992
37	1.22	689.8	262.3(276.8)	0.666	0.041	0.866	0.087	0.992
38	1.22	687.6	263.9(277.3)	0.673	0.042	0.877	0.088	0.992
50	1.22	724.2	257.4(273.1)	0.601	0.038	0.763	0.072	0.992
LEVEL F7								
14	1.23	698.7	258.3(272.7)	0.641	0.040	0.850	0.087	0.983
17	1.23	704.2	256.5(273.6)	0.628	0.040	0.829	0.084	0.983
21	1.23	667.6	264.3(276.4)	0.711	0.043	0.969	0.105	0.983
37	1.23	703.1	261.5(276.8)	0.642	0.040	0.848	0.086	0.983
38	1.23	704.2	262.7(277.1)	0.643	0.040	0.849	0.085	0.983
50	1.23	744.2	256.3(273.4)	0.571	0.037	0.733	0.070	0.983
LEVEL F8								
1	1.26	733.7	255.3(276.2)	0.583	0.038	0.781	0.079	0.972
14	1.26	704.8	258.3(272.9)	0.631	0.039	0.867	0.092	0.972
17	1.26	721.4	255.5(273.9)	0.600	0.038	0.812	0.084	0.972
21	1.26	689.8	263.3(276.6)	0.668	0.041	0.930	0.102	0.972
34	1.26	727.0	265.3(281.8)	0.615	0.039	0.828	0.084	0.972
37	1.26	715.3	261.1(277.0)	0.622	0.039	0.846	0.088	0.972

INTERMEDIATE FLOW TEST IE

FLUID CONDITIONS

CORRELATION COMPARISONS

SI UNITS

NOMENCLATURE

HCB - CONDIE-BENGSTON HEAT TRANSFEER COEFFICIENT
HDB - DITTUS-BOELTER HEAT TRANSFER COEFFICIENT
HDR - DOUGALL-ROHSENOW HEAT TRANSFER COEFFICIENT
HDRPW - DOUGALL-ROHSENOW HEAT TRANSFER COEFFICIENT, WALL PRANDTL NUMBER
HEXP - EXPERIMENTAL HEAT TRANSFER COEFFICIENT Q/(TSURF-TBULK)
HEXPS - EXPERIMENTAL HEAT TRANSFER COEFFICIENT Q/(TSURF-TSAT)
HG57 - GROENEVELD 5.7 HEAT TRANSFER COEFFICIENT
HG59 - GROENEVELD 5.9 HEAT TRANSFER COEFFICIENT
QCON - CONVECTIVE HEAT FLUX
QGD - GROENEVELD-DELORME HEAT FLUX
QTOT - TOTAL HEAT FLUX (INCLUDING RADIATION)
SDTSRF - CROSS-SECTIONAL STANDARD DEVIATION OF THE SURFACE TEMPERATURE
SDQ - CROSS-SECTIONAL STANDARD DEVIATION OF THE CONVECTIVE HEAT FLUX
TBULK - BULK VAPOR TEMPERATURE
TSAT - SATURATION TEMPERATURE
TSRF(TSURF) - SURFACE TEMPERATURE
TF - EQUILIBRIUM FLUID TEMPERATURE
UHDR - UNCERTAINTY, DOUGALL-ROHSENOW HEAT TRANSFER COEFFICIENT
UHEXP - UNCERTAINTY, EXPERIMENTAL HEAT TRANSFER COEFFICIENT
UHEXPS - UNCERTAINTY, EXPERIMENTAL HEAT TRANSFER COEFFICIENT
UHG57 - UNCERTAINTY, GROENEVELD 5.7 HEAT TRANSFER COEFFICIENT
UHG59 - UNCERTAINTY, GROENEVELD 5.9 HEAT TRANSFER COEFFICIENT
UNC - UNCERTAINTY
UTF - UNCERTAINTY, EQUILIBRIUM FLUID TEMPERATURE
UX - UNCERTAINTY, EQUILIBRIUM QUALITY
X - EQUILIBRIUM QUALITY

********** INTERMEDIATE FLOW TEST IE **********

LEVEL AVERAGE FLUID AND SURFACE CONDITIONS

MASS FLUX	6.511E+04	LBM/SQFT H	UNC. MASS FLUX	2.028E+03	LBM/SQFT H	PRESSURE	550.6	PSI	UNC. PRESSURE	7.50	PSI
	88.35	KG/SQM S		2.7520	KG/SQM S		3.80	MPA		0.052	MPA

LEVEL	QCON		SDQ		TSRF		SDTSRF		TF		UTF		X	UX
	ENG	SI	ENG	SI	ENG	SI	ENG	SI	ENG	SI	ENG	SI		
F	0.586	184.7	0.017	5.41	1148.1	620.4	86.67	48.152	524.4	273.9	47.489	26.4	1.0440	.0433
G	0.568	178.9	0.018	5.63	1355.9	735.8	73.98	41.103	787.8	420.2	64.436	35.8	1.2608	.0504
E6	0.576	181.6	0.000	0.00	1129.0	609.8	0.00	0.000	477.1	247.6	1.436	0.8	.9741	.0411
E7	0.588	185.2	0.026	8.20	1145.5	618.9	89.80	49.890	477.1	247.6	1.436	0.8	.9959	.0418
E8	0.603	190.0	0.002	0.63	1030.7	555.2	66.92	37.177	502.3	261.6	41.491	23.1	1.0246	.0426
F1	0.586	184.7	0.019	6.09	1150.2	621.5	71.41	39.674	565.1	296.5	52.132	29.0	1.0807	.0445
F2	0.587	184.8	0.010	3.19	1207.0	653.1	38.29	21.275	599.6	315.7	54.500	30.3	1.1093	.0456
F3	0.578	181.9	0.021	6.60	1231.7	666.8	68.45	38.028	634.8	335.2	56.876	31.6	1.1380	.0467
F4	0.570	179.4	0.011	3.47	1142.0	617.0	59.40	32.998	666.0	352.5	58.308	32.4	1.1637	.0476
F5	0.576	181.5	0.028	8.75	1190.7	644.0	80.50	44.723	687.4	364.5	59.508	33.1	1.1814	.0480
F6	0.575	181.1	0.013	4.22	1272.5	689.5	52.73	29.294	710.5	377.3	60.663	33.7	1.2002	.0486
F7	0.575	181.0	0.018	5.62	1285.4	696.7	52.86	29.366	733.4	390.0	61.638	34.2	1.2180	.0491
F8	0.569	179.3	0.018	5.79	1333.1	723.2	58.64	32.579	765.4	407.8	63.008	35.0	1.2431	.0498

NOMENCLATURE

	ENG	SI
Q	BTU/H FT**2 X 1E5	KW/M**2
SDQ	BTU/H FT**2 X 1E5	KW/M**2
TSRF	DEG F	DEG C
SDTSRF	DEG F	DEG C
TF	DEG F	DEG C
UTF	DEG F	DEG C

********** INTERMEDIATE FLOW TEST IE **********

PRIMARY LEVELS

EQUILIBRIUM QUALITY GREATER THAN ONE

ROD NO	X	TSURF DEG C	QCON(QTOT) KW/M**2	HEXPS	UHEXPS	HEXP	UHEXP	HDB	HCB KW/M**2 C	QGD KW/M**2
				KW/M**2 C						
LEVEL F										
3	1.04	648.1	186.3(199.6)	0.465	0.030	0.498	0.05	0.652	0.415	95.6
4	1.04	637.6	185.4(198.3)	0.476	0.030	0.510	0.05	0.652	0.417	92.0
7	1.04	672.0	182.9(198.3)	0.431	0.028	0.459	0.04	0.652	0.412	104.1
7	1.04	672.0	182.9(198.3)	0.431	0.028	0.459	0.04	0.652	0.412	104.1
10	1.04	585.3	185.7(194.2)	0.550	0.034	0.596	0.06	0.652	0.426	74.3
10	1.04	594.2	185.3(194.2)	0.535	0.033	0.578	0.06	0.652	0.424	77.2
10	1.04	587.6	185.6(194.2)	0.546	0.033	0.592	0.06	0.652	0.425	75.1
13	1.04	606.4	190.3(199.6)	0.530	0.032	0.572	0.06	0.652	0.422	81.2
13	1.04	607.6	190.2(199.6)	0.528	0.032	0.570	0.06	0.652	0.422	81.7
14	1.04	576.4	188.0(196.1)	0.572	0.035	0.621	0.07	0.652	0.428	71.4
15	1.04	613.7	184.1(193.9)	0.503	0.031	0.542	0.05	0.652	0.420	83.7
16	1.04	617.0	181.0(192.8)	0.490	0.031	0.526	0.05	0.652	0.420	84.9
17	1.04	641.4	181.5(194.6)	0.461	0.029	0.494	0.05	0.652	0.416	93.3
20	1.04	497.7	190.7(195.6)	0.763	0.045	0.852	0.12	0.652	0.452	47.3
31	1.04	577.0	190.0(198.0)	0.577	0.035	0.627	0.07	0.652	0.428	71.5
31	1.04	577.6	189.9(198.0)	0.576	0.035	0.626	0.07	0.652	0.428	71.7
34	1.04	621.4	189.9(199.2)	0.508	0.031	0.546	0.05	0.652	0.419	86.4
37	1.04	575.3	188.3(196.7)	0.575	0.035	0.625	0.07	0.652	0.428	71.1
38	1.04	572.6	189.1(196.8)	0.582	0.035	0.633	0.07	0.652	0.427	70.1
42	1.04	611.4	185.7(194.6)	0.510	0.031	0.550	0.06	0.652	0.421	83.1
53	1.04	594.2	193.2(201.9)	0.557	0.034	0.603	0.06	0.652	0.424	77.2
53	1.04	593.7	193.2(201.9)	0.558	0.034	0.604	0.06	0.652	0.424	77.1
59	1.04	659.2	180.2(194.4)	0.438	0.028	0.468	0.04	0.652	0.414	99.6
59	1.04	658.1	180.2(194.4)	0.439	0.028	0.469	0.04	0.652	0.414	99.2
59	1.04	663.1	179.9(194.4)	0.433	0.028	0.462	0.04	0.652	0.413	100.9
60	1.04	669.2	179.0(193.9)	0.425	0.028	0.453	0.04	0.652	0.412	103.0
64	1.04	704.2	174.9(194.6)	0.383	0.026	0.406	0.04	0.652	0.409	115.8
64	1.04	704.8	174.8(194.6)	0.382	0.026	0.406	0.04	0.652	0.408	116.0
64	1.04	702.6	175.0(194.6)	0.385	0.026	0.408	0.04	0.652	0.409	115.1
LEVEL G										
1	1.26	742.0	174.7(195.8)	0.353	0.025	0.543	0.07	0.583	0.412	97.1
14	1.26	712.0	182.7(196.3)	0.393	0.025	0.626	0.09	0.583	0.415	86.0
16	1.26	777.0	170.9(192.9)	0.323	0.023	0.479	0.06	0.583	0.410	110.7
16	1.26	777.6	170.8(192.9)	0.322	0.023	0.478	0.06	0.583	0.410	110.9
18	1.26	719.8	180.5(194.6)	0.382	0.025	0.602	0.08	0.583	0.414	88.9
18	1.26	704.8	181.5(194.6)	0.397	0.025	0.638	0.09	0.583	0.416	83.2
18	1.26	728.1	179.9(194.6)	0.374	0.025	0.584	0.08	0.583	0.414	92.0
20	1.26	636.4	187.2(195.7)	0.481	0.029	0.866	0.16	0.583	0.424	59.4
20	1.26	699.8	183.5(195.7)	0.406	0.026	0.656	0.10	0.583	0.416	81.5
21	1.26	700.3	186.8(199.3)	0.413	0.026	0.667	0.10	0.583	0.416	81.6
34	1.26	783.7	182.4(199.3)	0.340	0.023	0.502	0.06	0.583	0.410	113.3
37	1.26	698.1	183.5(196.7)	0.407	0.026	0.660	0.10	0.583	0.416	80.9
38	1.26	703.7	184.3(196.8)	0.404	0.026	0.650	0.10	0.583	0.416	82.9
42	1.26	783.7	177.8(194.8)	0.332	0.023	0.489	0.06	0.583	0.410	113.3
42	1.26	789.8	177.3(194.8)	0.327	0.023	0.480	0.06	0.583	0.409	115.7
45	1.26	696.4	185.4(198.5)	0.413	0.026	0.671	0.10	0.583	0.417	80.2
45	1.26	700.9	185.1(198.5)	0.408	0.026	0.660	0.10	0.583	0.416	81.8
47	1.26	717.6	181.2(195.2)	0.386	0.025	0.609	0.09	0.583	0.415	88.0
50	1.26	770.3	178.7(195.0)	0.342	0.023	0.510	0.06	0.583	0.411	108.0
58	1.26	783.1	173.8(196.2)	0.325	0.023	0.479	0.06	0.583	0.410	113.1
60	1.26	768.7	173.6(194.4)	0.333	0.024	0.498	0.06	0.583	0.411	107.6
64	1.26	775.9	170.5(195.2)	0.323	0.024	0.479	0.06	0.583	0.410	110.2
64	1.26	774.8	170.7(195.2)	0.324	0.024	0.481	0.06	0.583	0.410	110.0

*********** INTERMEDIATE FLOW TEST IE ***********

INTERMEDIATE LEVELS

EQUILIBRIUM QUALITY LESS THAN ONE

ROD NO	X	TSURF DEG C	QCON(QTOT) KW/M**2	HEXP	UHEXP	HDR	UHDR	HDRPW	HG57	UHG57	HG59	UHG59	HCB	QGD KW/M**2
				KW/M**2 C										
LEVEL E6														
6C	0.97	609.8	181.6(192.8)	0.501	0.031	0.705	0.016	0.605	0.411	0.037	0.273	0.033	0.419	83.6
LEVEL E7														
1	1.00	654.2	179.4(195.2)	0.441	0.029	0.717	0.027	0.612	0.388	0.035	0.252	0.03[illegible]	0.413	103.0
34	1.00	583.7	191.0(198.9)	0.568	0.035	0.717	0.027	0.615	0.395	0.035	0.257	0.032	0.424	79.2

********** INTERMEDIATE FLOW TEST IE **********

INTERMEDIATE LEVELS

EQUILIBRIUM QUALITY GREATER THAN ONE

ROD NO	X	TSURF DEG C	QCON(QTOT) KW/M**2	HEXPS	UHEXPS	HEXP KW/M**2 C	UHEXP	HDB	HCB KW/M**2 C	QGD KW/M**2
LEVEL E8										
14	1.02	569.8	189.1(196.1)	0.626	0.038	0.656	0.07	0.681	0.434	66.2
34	1.02	609.2	190.3(199.2)	0.526	0.032	0.547	0.05	0.681	0.421	85.5
37	1.02	528.2	190.2(196.7)	0.678	0.040	0.713	0.06	0.681	0.440	59.5
38	1.02	533.5	190.5(196.8)	0.666	0.040	0.701	0.07	0.681	0.438	61.1
LEVEL F1										
17	1.08	664.8	180.1(194.4)	0.432	0.028	0.489	0.05	0.617	0.414	95.8
21	1.08	554.8	192.3(199.2)	0.626	0.037	0.745	0.10	0.617	0.434	58.9
34	1.08	653.1	188.6(199.2)	0.465	0.029	0.529	0.05	0.617	0.416	91.7
37	1.08	609.2	186.9(196.7)	0.517	0.032	0.598	0.07	0.617	0.423	76.5
50	1.08	637.6	184.8(194.9)	0.474	0.029	0.542	0.06	0.617	0.418	86.3
LEVEL F2										
14	1.11	640.9	185.3(196.1)	0.471	0.029	0.570	0.07	0.599	0.418	82.9
17	1.11	671.4	179.9(194.4)	0.424	0.027	0.506	0.05	0.599	0.414	93.5
38	1.11	622.0	187.2(196.8)	0.500	0.031	0.611	0.07	0.599	0.421	76.5
50	1.11	660.9	183.9(194.9)	0.445	0.028	0.533	0.06	0.599	0.416	89.8
LEVEL F3										
14	1.14	658.7	184.5(196.1)	0.449	0.028	0.570	0.07	0.588	0.417	84.8
17	1.14	678.1	179.7(194.4)	0.417	0.027	0.524	0.06	0.588	0.415	91.7
21	1.14	602.0	190.7(199.2)	0.538	0.033	0.715	0.10	0.588	0.426	65.8
34	1.14	691.4	187.0(199.2)	0.421	0.027	0.525	0.06	0.588	0.413	96.3
60	1.14	713.1	176.5(193.9)	0.379	0.026	0.467	0.05	0.588	0.411	104.3
LEVEL F4										
60	1.16	640.3	181.8(193.9)	0.463	0.029	0.632	0.08	0.581	0.420	74.6
LEVEL F5										
21	1.18	599.2	191.3(199.2)	0.544	0.033	0.815	0.13	0.578	0.428	58.0
60	1.18	688.7	178.7(193.9)	0.405	0.026	0.551	0.07	0.578	0.415	88.3
LEVEL F6										
1	1.20	698.1	177.7(195.6)	0.394	0.027	0.554	0.07	0.577	0.414	88.8
17	1.20	693.7	179.2(194.5)	0.402	0.026	0.566	0.07	0.577	0.415	87.3
37	1.20	656.4	185.3(196.7)	0.453	0.028	0.664	0.09	0.577	0.419	74.1
38	1.20	652.6	186.6(196.8)	0.461	0.029	0.678	0.10	0.577	0.420	72.8
50	1.20	710.9	181.9(195.0)	0.393	0.025	0.545	0.07	0.577	0.413	93.6
60	1.20	725.3	176.1(193.9)	0.369	0.025	0.506	0.06	0.577	0.412	98.8
LEVEL F7										
14	1.22	690.3	183.4(196.1)	0.414	0.026	0.611	0.08	0.578	0.416	83.7
17	1.22	710.3	178.1(194.4)	0.385	0.025	0.556	0.07	0.578	0.414	90.9
21	1.22	663.1	188.4(199.2)	0.453	0.028	0.690	0.10	0.578	0.419	73.9
37	1.22	672.0	184.6(196.7)	0.435	0.027	0.655	0.09	0.578	0.418	77.0
38	1.22	671.4	185.7(196.8)	0.438	0.027	0.660	0.09	0.578	0.418	76.9
50	1.22	732.0	180.9(195.1)	0.373	0.025	0.529	0.06	0.578	0.412	98.9
60	1.22	743.1	174.8(193.9)	0.353	0.024	0.495	0.06	0.578	0.411	103.0
LEVEL F8										
1	1.24	739.2	174.7(195.8)	0.355	0.025	0.527	0.07	0.581	0.412	98.0
14	1.24	700.3	183.2(196.2)	0.405	0.026	0.626	0.09	0.581	0.416	83.5
17	1.24	727.6	177.1(194.5)	0.369	0.025	0.554	0.07	0.581	0.413	93.6
21	1.24	687.0	187.4(199.3)	0.426	0.027	0.671	0.10	0.581	0.417	78.8
34	1.24	772.6	183.0(199.3)	0.349	0.024	0.502	0.06	0.581	0.410	110.8
37	1.24	689.8	183.9(196.8)	0.416	0.026	0.652	0.09	0.581	0.417	79.7
60	1.24	762.0	173.6(193.9)	0.337	0.024	0.490	0.06	0.581	0.410	136.7

INTERMEDIATE FLOW TEST IF

FLUID CONDITIONS

CORRELATION COMPARISONS

SI UNITS

NOMENCLATURE

HCB	- CONDIE-BENGSTON HEAT TRANSFEER COEFFICIENT	TSAT	- SATURATION TEMPERATURE
HDB	- DITTUS-BOELTER HEAT TRANSFER COEFFICIENT	TSRF(TSURF)	- SURFACE TEMPERATURE
HDR	- DOUGALL-ROHSENOW HEAT TRANSFER COEFFICIENT	TF	- EQUILIBRIUM FLUID TEMPERATURE
HDRPW	- DOUGALL-ROHSENOW HEAT TRANSFER COEFFICIENT, WALL PRANDTL NUMBER	UHDR	- UNCERTAINTY, DOUGALL-ROHSENOW HEAT TRANSFER COEFFICIENT
HEXP	- EXPERIMENTAL HEAT TRANSFER COEFFICIENT Q/(TSURF-TBULK)	UHEXP	- UNCERTAINTY, EXPERIMENTAL HEAT TRANSFER COEFFICIENT
HEXPS	- EXPERIMENTAL HEAT TRANSFER COEFFICIENT Q/(TSURF-TSAT)	UHEXPS	- UNCERTAINTY, EXPERIMENTAL HEAT TRANSFER COEFFICIENT
HG57	- GROENEVELD 5.7 HEAT TRANSFER COEFFICIENT	UHG57	- UNCERTAINTY, GROENEVELD 5.7 HEAT TRANSFER COEFFICIENT
HG59	- GROENEVELD 5.9 HEAT TRANSFER COEFFICIENT	UHG59	- UNCERTAINTY, GROENEVELD 5.9 HEAT TRANSFER COEFFICIENT
QCON	- CONVECTIVE HEAT FLUX	UNC	- UNCERTAINTY
QGD	- GROENEVELD-DELORME HEAT FLUX	UTF	- UNCERTAINTY, EQUILIBRIUM FLUID TEMPERATURE
QTOT	- TOTAL HEAT FLUX (INCLUDING RADIATION)	UX	- UNCERTAINTY, EQUILIBRIUM QUALITY
SDTSRF	- CROSS-SECTIONAL STANDARD DEVIATION OF THE SURFACE TEMPERATURE	X	- EQUILIBRIUM QUALITY
SDQ	- CROSS-SECTIONAL STANDARD DEVIATION OF THE CONVECTIVE HEAT FLUX		
TBULK	- BULK VAPOR TEMPERATURE		

********** INTERMEDIATE FLOW TEST IF **********

LEVEL AVERAGE FLUID AND SURFACE CONDITIONS

MASS FLUX 1.266E+05 LBM/SQFT H   UNC. MASS FLUX 3.944E+03 LBM/SQFT H   PRESSURE 584.1 PSI   UNC. PRESSURE 7.50 PSI

171.82 KG/SQM S   5.3522 KG/SQM S   4.03 MPA   0.052 MPA

LEVEL	QCON		SDQ		TSRF		SDTSRF		TF		UTF		X	UX
	ENG	SI	ENG	SI	ENG	SI	ENG	SI	ENG	SI	ENG	SI		
F	1.035	325.9	0.025	7.66	1155.7	624.6	91.26	50.699	483.3	251.0	1.389	0.8	.9207	.0388
G	1.009	317.9	0.020	6.15	1338.1	725.9	68.52	38.069	607.2	319.9	52.848	29.4	1.1140	.0451
E7	1.037	326.8	0.016	5.12	1114.5	601.7	36.06	20.035	483.3	251.0	1.389	0.8	.8778	.0375
E8	1.049	330.4	0.000	0.00	1031.2	555.4	200.54	111.41	483.3	251.0	1.389	0.8	.9033	.0383
F1	1.018	320.5	0.028	8.92	1162.0	628.1	56.62	31.456	483.3	251.0	1.389	0.8	.9534	.0399
F2	1.026	323.2	0.010	3.20	1188.5	642.8	48.16	26.753	483.3	251.0	1.389	0.8	.9789	.0409
F3	1.022	321.9	0.037	11.55	1200.8	649.7	64.92	36.067	486.9	253.0	43.094	23.9	1.0044	.0418
F5	1.013	318.9	0.066	20.71	1139.0	615.3	50.91	28.284	528.4	276.1	47.240	26.2	1.0432	.0431
F6	1.018	320.8	0.006	1.84	1250.0	677.0	45.95	25.528	546.3	286.1	48.033	26.7	1.0600	.0435
F7	1.009	317.9	0.030	9.57	1265.6	685.7	46.84	26.020	564.3	296.1	48.491	26.9	1.0758	.0440
F8	1.014	319.3	0.029	9.13	1303.1	706.5	48.70	27.056	589.7	310.2	51.048	28.4	1.0982	.0446

NOMENCLATURE

	ENG	SI
Q	BTU/H FT**2 X 1E5	KW/M**2
SDQ	BTU/H FT**2 X 1E5	KW/M**2
TSRF	DEG F	DEG C
SDTSRF	DEG F	DEG C
TF	DEG F	DEG C
UTF	DEG F	DEG C

********** INTERMEDIATE FLOW TEST 1F **********

PRIMARY LEVELS

EQUILIBRIUM QUALITY LESS THAN ONE

ROD NO	X	TSURF DEG C	QCON(QTOT) KW/M**2	HEXP	UHEXP	HDR	UHDR	HDRPW	HG57	UHG57	HG59	UHG59	HCB	QGD KW/M**2
				KW/M**2 C										
LEVEL F														
3	0.92	636.4	333.0(345.8)	0.864	0.052	1.171	0.024	0.997	0.674	0.022	0.523	0.024	0.686	173.0
4	0.92	603.7	333.0(344.0)	0.944	0.056	1.171	0.024	0.999	0.679	0.022	0.527	0.024	0.695	154.0
7	0.92	665.3	327.3(342.5)	0.790	0.048	1.171	0.024	0.995	0.671	0.022	0.520	0.024	0.679	190.2
7	0.92	661.4	327.6(342.5)	0.798	0.048	1.171	0.024	0.995	0.671	0.022	0.520	0.024	0.680	187.8
10	0.92	591.4	326.7(335.8)	0.960	0.057	1.171	0.024	1.000	0.682	0.022	0.529	0.024	0.699	147.0
10	0.92	595.3	326.7(335.8)	0.949	0.057	1.171	0.024	1.000	0.681	0.022	0.528	0.024	0.698	149.0
10	0.92	590.3	326.7(335.8)	0.963	0.058	1.171	0.024	1.000	0.682	0.022	0.529	0.024	0.700	146.3
13	0.92	576.4	334.8(343.1)	1.029	0.061	1.171	0.024	1.001	0.685	0.022	0.531	0.025	0.705	138.6
13	0.92	575.3	334.8(343.1)	1.033	0.062	1.171	0.024	1.002	0.685	0.022	0.531	0.025	0.705	137.9
15	0.92	605.9	323.5(333.2)	0.912	0.054	1.171	0.024	0.999	0.679	0.022	0.527	0.024	0.695	155.1
16	0.92	600.3	322.9(334.0)	0.924	0.055	1.171	0.024	0.999	0.680	0.022	0.527	0.024	0.696	152.0
31	0.92	550.9	333.3(340.4)	1.111	0.066	1.171	0.024	1.004	0.690	0.023	0.536	0.025	0.715	124.7
31	0.92	554.8	333.0(340.4)	1.098	0.065	1.171	0.024	1.004	0.689	0.023	0.535	0.025	0.713	126.6
34	0.92	643.1	330.1(340.8)	0.842	0.050	1.171	0.024	0.996	0.674	0.022	0.522	0.024	0.684	176.9
38	0.92	586.4	326.3(335.0)	0.973	0.058	1.171	0.024	1.001	0.683	0.022	0.530	0.024	0.701	144.2
42	0.92	654.2	321.9(333.2)	0.798	0.048	1.171	0.024	0.996	0.672	0.022	0.521	0.024	0.682	183.5
53	0.92	630.3	337.4(348.2)	0.889	0.053	1.171	0.024	0.997	0.675	0.022	0.524	0.024	0.688	169.2
53	0.92	632.0	337.4(348.2)	0.886	0.053	1.171	0.024	0.997	0.675	0.022	0.523	0.024	0.687	170.3
59	0.92	687.6	319.7(336.3)	0.732	0.045	1.171	0.024	0.994	0.668	0.022	0.518	0.024	0.675	203.7
59	0.92	679.2	320.4(336.3)	0.748	0.046	1.171	0.024	0.994	0.669	0.022	0.519	0.024	0.677	198.7
59	0.92	693.1	319.4(336.3)	0.723	0.045	1.171	0.024	0.994	0.668	0.022	0.517	0.024	0.674	207.0
64	0.92	688.1	314.6(333.2)	0.720	0.044	1.171	0.024	0.994	0.668	0.022	0.518	0.024	0.675	203.8
64	0.92	700.3	313.6(333.2)	0.698	0.043	1.171	0.024	0.993	0.667	0.022	0.517	0.024	0.673	211.6
64	0.92	690.9	314.4(333.2)	0.715	0.044	1.171	0.024	0.994	0.668	0.022	0.518	0.024	0.674	205.6

********** INTERMEDIATE FLOW TEST IF **********

PRIMARY LEVELS

EQUILIBRIUM QUALITY GREATER THAN ONE

ROD NO	X	TSURF DEG C	QCON(QTOT) KW/M**2	HEXPS	UHEXPS	HEXP KW/M**2 C	UHEXP	HDB	HCB KW/M**2 C	QGD KW/M**2
LEVEL G										
1	1.11	724.2	317.8(338.8)	0.672	0.042	0.786	0.08	1.023	0.689	227.6
14	1.11	696.4	323.8(337.8)	0.727	0.045	0.860	0.09	1.023	0.694	208.5
16	1.11	753.7	312.8(334.2)	0.622	0.039	0.721	0.07	1.023	0.685	248.3
16	1.11	760.3	312.2(334.2)	0.613	0.039	0.709	0.07	1.023	0.684	252.9
18	1.11	692.6	319.4(333.4)	0.723	0.044	0.857	0.09	1.023	0.694	206.1
18	1.11	676.4	320.7(333.4)	0.754	0.045	0.899	0.09	1.023	0.697	195.2
18	1.11	696.4	319.4(333.4)	0.717	0.044	0.848	0.08	1.023	0.694	208.5
20	1.11	638.1	328.2(338.5)	0.848	0.050	1.031	0.12	1.023	0.706	169.9
20	1.11	706.4	324.1(338.5)	0.712	0.043	0.839	0.08	1.023	0.692	215.4
21	1.11	695.4	328.5(342.5)	0.738	0.045	0.873	0.09	1.023	0.694	208.5
34	1.11	777.0	322.9(341.0)	0.614	0.039	0.706	0.06	1.023	0.683	265.0
37	1.11	706.4	319.1(334.4)	0.701	0.043	0.825	0.08	1.023	0.692	215.4
38	1.11	709.2	321.0(335.4)	0.701	0.043	0.824	0.08	1.023	0.691	217.4
42	1.11	782.0	314.9(333.4)	0.593	0.039	0.682	0.06	1.023	0.682	268.4
42	1.11	781.4	315.0(333.4)	0.594	0.037	0.682	0.06	1.023	0.682	268.0
45	1.11	717.6	320.0(336.2)	0.686	0.042	0.805	0.08	1.023	0.690	223.1
45	1.11	714.8	320.4(336.2)	0.691	0.042	0.811	0.08	1.023	0.691	221.1
45	1.11	722.0	319.7(336.2)	0.679	0.042	0.795	0.08	1.023	0.689	226.0
47	1.11	702.6	317.5(332.0)	0.703	0.043	0.830	0.08	1.023	0.693	212.9
50	1.11	769.8	314.9(332.7)	0.607	0.038	0.700	0.06	1.023	0.683	259.6
58	1.11	785.3	315.6(339.7)	0.591	0.038	0.678	0.06	1.023	0.682	270.9
64	1.11	749.8	310.6(334.0)	0.623	0.040	0.722	0.07	1.023	0.686	245.4
64	1.11	751.4	310.4(334.0)	0.620	0.040	0.719	0.07	1.023	0.685	246.6

********** INTERMEDIATE FLOW TEST IF **********

INTERMEDIATE LEVELS

EQUILIBRIUM QUALITY LESS THAN ONE

ROD NO	X	TSURF DEG C	QCON(QTOT) KW/M**2	HEXP	UHEXP	HDR	UHDR	HDRPW	HG57	UHG57	HG59	UHG59	HCB	QGD KW/M**2
				KW/M**2 C										
LEVEL E7														
34	0.88	615.9	330.4(339.8)	0.906	0.054	1.129	0.023	0.962	0.681	0.016	0.531	0.017	0.687	147.2
50	0.88	587.6	323.2(331.6)	0.960	0.057	1.129	0.023	0.964	0.686	0.016	0.535	0.018	0.696	131.9
LEVEL E8														
34	0.90	634.2	330.4(340.7)	0.862	0.052	1.154	0.023	0.982	0.677	0.019	0.526	0.021	0.685	165.7
38	0.90	476.7	330.4(334.9)	1.465	0.087	1.154	0.023	1.001	0.718	0.020	0.560	0.022	0.760	82.2
LEVEL F1														
17	0.95	612.0	323.2(334.7)	0.895	0.053	1.203	0.024	1.026	0.669	0.036	0.515	0.039	0.696	170.4
34	0.95	665.3	328.9(340.8)	0.794	0.048	1.203	0.024	1.022	0.662	0.036	0.509	0.038	0.683	203.1
37	0.95	597.6	324.5(334.1)	0.936	0.056	1.203	0.024	1.027	0.671	0.036	0.517	0.039	0.701	161.6
50	0.95	658.7	320.7(332.5)	0.787	0.047	1.203	0.024	1.023	0.663	0.035	0.509	0.038	0.684	198.8
LEVEL F2														
14	0.98	617.0	327.3(337.5)	0.894	0.054	1.228	0.027	1.047	0.653	0.056	0.496	0.059	0.698	183.1
17	0.98	635.3	321.9(334.7)	0.838	0.050	1.228	0.027	1.046	0.650	0.056	0.494	0.058	0.693	194.7
38	0.98	638.7	323.8(335.0)	0.835	0.050	1.228	0.027	1.045	0.650	0.056	0.494	0.058	0.692	196.7
50	0.98	680.3	319.7(332.5)	0.745	0.045	1.228	0.027	1.043	0.645	0.056	0.490	0.058	0.683	223.5

********** INTERMEDIATE FLOW TEST IF **********

INTERMEDIATE LEVELS

EQUILIBRIUM QUALITY GREATER THAN ONE

ROD NO	X	TSURF DEG C	QCON(QTOT) KW/M**2	HEXPS	UHEXPS	HEXP KW/M**2 C	UHEXP	HDB	HCB KW/M**2 C	QGD KW/M**2
LEVEL F3										
14	1.00	642.6	326.0(337.5)	0.833	0.050	0.837	0.07	1.246	0.694	203.9
17	1.00	645.9	321.0(334.7)	0.815	0.049	0.817	0.07	1.246	0.693	211.1
21	1.00	600.3	333.0(342.2)	0.953	0.056	0.959	0.09	1.246	0.706	181.9
34	1.00	700.9	327.0(340.8)	0.727	0.044	0.730	0.06	1.246	0.682	247.8
LEVEL F5										
21	1.04	595.3	333.6(342.2)	0.969	0.057	1.045	0.11	1.124	0.701	165.4
LEVEL F6										
1	1.06	692.0	320.0(338.4)	0.726	0.045	0.788	0.07	1.090	0.689	222.9
17	1.06	663.1	320.7(335.0)	0.776	0.047	0.850	0.08	1.090	0.695	203.5
37	1.06	659.2	321.3(334.1)	0.787	0.047	0.861	0.08	1.090	0.696	201.1
38	1.06	655.9	323.5(335.2)	0.799	0.048	0.875	0.08	1.090	0.696	198.7
50	1.06	714.8	318.5(333.0)	0.687	0.042	0.743	0.07	1.090	0.685	238.5
LEVEL F7										
14	1.08	675.9	324.5(337.5)	0.764	0.046	0.854	0.08	1.064	0.694	206.9
17	1.08	680.9	319.1(334.7)	0.742	0.045	0.829	0.08	1.064	0.693	210.1
21	1.08	658.7	330.4(342.2)	0.811	0.048	0.911	0.09	1.064	0.697	195.6
37	1.08	675.9	310.6(324.3)	0.731	0.044	0.818	0.08	1.064	0.694	206.9
38	1.08	678.1	322.2(333.0)	0.755	0.045	0.843	0.08	1.064	0.693	208.2
50	1.08	740.9	317.2(333.4)	0.648	0.040	0.713	0.06	1.064	0.683	251.0
LEVEL F8										
1	1.10	726.4	317.5(338.8)	0.668	0.042	0.763	0.07	1.036	0.687	233.2
14	1.10	683.7	324.1(337.7)	0.749	0.045	0.868	0.09	1.036	0.694	204.1
17	1.10	695.9	318.8(335.1)	0.717	0.044	0.826	0.08	1.036	0.692	212.5
21	1.10	681.4	329.5(342.6)	0.766	0.046	0.888	0.09	1.036	0.695	202.6
34	1.10	757.6	324.5(341.2)	0.641	0.040	0.725	0.06	1.036	0.683	255.0
37	1.10	695.3	319.7(334.5)	0.720	0.044	0.830	0.08	1.036	0.692	212.1

INTERMEDIATE FLOW TEST IG

FLUID CONDITIONS

CORRELATION COMPARISONS

SI UNITS

NOMENCLATURE

HCB	- CONDIE-BENGSTON HEAT TRANSFEER COEFFICIENT	TSAT	- SATURATION TEMPERATURE
HDB	- DITTUS-BOELTER HEAT TRANSFER COEFFICIENT	TSRF(TSURF)	- SURFACE TEMPERATURE
HDR	- DOUGALL-ROHSENOW HEAT TRANSFER COEFFICIENT	TF	- EQUILIBRIUM FLUID TEMPERATURE
HDRPW	- DOUGALL-ROHSENOW HEAT TRANSFER COEFFICIENT, WALL PRANDTL NUMBER	UHDR	- UNCERTAINTY, DOUGALL-ROHSENOW HEAT TRANSFER COEFFICIENT
HEXP	- EXPERIMENTAL HEAT TRANSFER COEFFICIENT Q/(TSURF-TBULK)	UHEXP	- UNCERTAINTY, EXPERIMENTAL HEAT TRANSFER COEFFICIENT
HEXPS	- EXPERIMENTAL HEAT TRANSFER COEFFICIENT Q/(TSURF-TSAT)	UHEXPS	- UNCERTAINTY, EXPERIMENTAL HEAT TRANSFER COEFFICIENT
HG57	- GROENEVELD 5.7 HEAT TRANSFER COEFFICIENT	UHG57	- UNCERTAINTY, GROENEVELD 5.7 HEAT TRANSFER COEFFICIENT
HG59	- GROENEVELD 5.9 HEAT TRANSFER COEFFICIENT		
QCON	- CONVECTIVE HEAT FLUX	UHG59	- UNCERTAINTY, GROENEVELD 5.9 HEAT TRANSFER COEFFICIENT
QGD	- GROENEVELD-DELORME HEAT FLUX		
QTOT	- TOTAL HEAT FLUX (INCLUDING RADIATION)	UNC	- UNCERTAINTY
SDTSRF	- CROSS-SECTIONAL STANDARD DEVIATION OF THE SURFACE TEMPERATURE	UTF	- UNCERTAINTY, EQUILIBRIUM FLUID TEMPERATURE
SDQ	- CROSS-SECTIONAL STANDARD DEVIATION OF THE CONVECTIVE HEAT FLUX	UX	- UNCERTAINTY, EQUILIBRIUM QUALITY
		X	- EQUILIBRIUM QUALITY
TBULK	- BULK VAPOR TEMPERATURE		

*********** INTERMEDIATE FLOW TEST IG **********

LEVEL AVERAGE FLUID AND SURFACE CONDITIONS

MASS FLUX 1.904E+05 LBM/SQFT H UNC. MASS FLUX 5.933E+03 LBM/SQFT H PRESSURE 564.6 PSI UNC. PRESSURE 7.50 PSI

258.33 KG/SQM S 8.0515 KG/SQM S 3.90 MPA 0.052 MPA

LEVEL	QCON		SDQ		TSRF		SDTSRF		TF		UTF		X	UX
	ENG	SI	ENG	SI	ENG	SI	ENG	SI	ENG	SI	ENG	SI		
F	1.393	438.8	0.021	6.71	1116.6	602.9	20.32	11.290	479.7	249.0	1.389	0.8	.8286	.0344
G	1.372	432.1	0.024	7.45	1259.4	682.2	50.20	27.892	479.7	249.0	1.389	0.8	.9976	.0399
E8	1.384	436.0	0.000	0.00	1086.0	585.9	0.00	0.000	479.7	249.0	1.389	0.8	.8136	.0339
F1	1.349	424.8	0.051	15.95	1101.3	594.4	74.10	41.165	479.7	249.0	1.389	0.8	.8569	.0354
F2	1.386	436.6	0.013	4.13	1122.0	605.9	41.57	23.094	479.7	249.0	1.389	0.8	.8790	.0362
F3	1.378	434.1	0.055	17.27	1144.3	618.2	56.95	31.637	479.7	249.0	1.389	0.8	.9012	.0370
F5	1.361	428.6	0.081	25.61	1085.5	585.6	17.68	9.821	479.7	249.0	1.389	0.8	.9351	.0381
F6	1.381	435.0	0.010	3.10	1141.3	616.6	63.18	35.099	479.7	249.0	1.389	0.8	.9499	.0385
F7	1.364	429.5	0.041	12.89	1190.7	644.1	32.68	18.155	479.7	249.0	1.389	0.8	.9639	.0389
F8	1.372	432.2	0.042	13.32	1223.0	662.0	38.11	21.170	479.7	249.0	1.389	0.8	.9835	.0395

NOMENCLATURE

	ENG	SI
Q	BTU/H FT**2 X 1E5	KW/M**2
SDQ	BTU/H FT**2 X 1E5	KW/M**2
TSRF	DEG F	DEG C
SDTSRF	DEG F	DEG C
TF	DEG F	DEG C
UTF	DEG F	DEG C

********** INTERMEDIATE FLOW TEST IG **********

PRIMARY LEVELS

EQUILIBRIUM QUALITY LESS THAN ONE

ROD NO	X	TSURF DEG C	QCON(QTOT) KW/M**2	HEXP	UHEXP	HDR	UHDR	HDRPW	HG57	UHG57	HG59	UHG59	HCB	QGD KW/M**2
				KW/M**2 C										
LEVEL F														
34	0.83	607.0	444.8(454.0)	1.243	0.074	1.479	0.029	1.264	0.897	0.017	0.757	0.020	0.925	203.8
42	0.83	597.6	426.2(435.0)	1.[illegible]23	0.073	1.479	0.029	1.265	0.899	0.017	0.769	0.020	0.929	196.7
53	0.83	587.0	444.8(453.4)	1.316	0.078	1.479	0.029	1.266	0.901	0.017	0.771	0.020	0.934	189.2
53	0.83	592.0	444.5(453.4)	1.296	0.077	1.479	0.029	1.265	0.900	0.017	0.770	0.020	0.931	192.7
59	0.83	612.6	437.2(448.8)	1.203	0.072	1.479	0.029	1.263	0.895	0.017	0.765	0.020	0.923	207.9
59	0.83	605.3	437.5(448.8)	1.228	0.073	1.479	0.029	1.264	0.897	0.017	0.768	0.020	0.926	202.9
59	0.83	618.7	436.9(448.8)	1.182	0.071	1.479	0.029	1.263	0.894	0.017	0.765	0.020	0.920	212.8
LEVEL G														
14	1.00	663.7	436.9(449.5)	1.054	0.064	1.708	0.063	1.455	0.809	0.071	0.657	0.081	0.938	342.2
16	1.00	708.1	429.7(447.8)	0.936	0.057	1.708	0.063	1.452	0.804	0.071	0.653	0.080	0.927	385.7
16	1.00	717.6	428.7(447.8)	0.915	0.056	1.708	0.063	1.451	0.803	0.071	0.652	0.080	0.925	395.3
18	1.00	645.3	432.2(444.1)	1.091	0.065	1.708	0.063	1.456	0.812	0.072	0.660	0.081	0.944	325.1
18	1.00	635.9	432.8(444.1)	1.119	0.066	1.708	0.063	1.457	0.813	0.072	0.561	0.081	0.947	315.9
18	1.00	651.4	431.9(444.1)	1.073	0.064	1.108	0.063	1.456	0.811	0.072	0.659	0.081	0.942	330.6
20	1.00	610.9	444.5(454.2)	1.228	0.072	1.708	0.063	1.460	0.818	0.072	0.565	0.082	0.956	292.7
20	1.00	678.1	441.0(454.2)	1.028	0.061	1.708	0.063	1.454	0.807	0.072	0.656	0.080	0.934	356.5
21	1.00	669.2	442.3(455.2)	1.053	0.062	1.708	0.063	1.454	0.808	0.072	0.657	0.081	0.936	347.7
34	1.00	716.4	439.4(454.2)	0.940	0.057	1.708	0.063	1.451	0.803	0.071	0.552	0.080	0.925	394.1
37	1.00	679.2	430.3(444.9)	1.000	0.060	1.708	0.063	1.453	0.807	0.072	0.555	0.080	0.934	357.6
38	1.00	679.2	433.1(446.4)	1.007	0.060	1.708	0.063	1.453	0.807	0.072	0.656	0.080	0.934	357.6
42	1.00	716.4	429.7(444.5)	0.919	0.059	1.708	0.063	1.451	0.803	0.071	0.552	0.080	0.925	394.1
42	1.00	710.9	430.0(444.5)	0.931	0.056	1.708	0.063	1.451	0.803	0.071	0.653	0.080	0.92[illegible]	3[illegible]8.5
45	1.00	689.2	433.1(448.0)	0.984	0.059	1.708	0.063	1.453	0.806	0.072	0.655	0.082	0.931	367.1
45	1.00	683.1	433.4(448.0)	0.999	0.060	1.708	0.063	1.453	0.806	0.072	0.555	0.080	0.933	361.4
45	1.00	689.8	433.1(448.0)	0.983	0.059	1.708	0.063	1.453	0.806	0.072	0.655	0.080	0.931	367.7
47	1.00	670.9	428.4(441.8)	1.016	0.061	1.708	0.063	1.454	0.808	0.072	0.557	0.081	0.936	349.3
50	1.00	683.1	430.3(443.3)	0.991	0.059	1.708	0.063	1.453	0.806	0.072	0.655	0.080	0.933	361.4
58	1.00	711.4	436.0(454.5)	0.943	0.057	1.708	0.063	1.451	0.803	0.071	0.653	0.080	0.926	389.1
64	1.00	699.2	427.8(447.3)	0.950	0.058	1.708	0.063	1.452	0.805	0.072	0.554	0.080	0.929	377.1
64	1.00	705.3	427.1(447.3)	0.936	0.057	1.708	0.063	1.452	0.804	0.071	0.653	0.080	0.927	382.9

********** INTERMEDIATE FLOW TEST IG **********

INTERMEDIATE LEVELS

EQUILIBRIUM QUALITY LESS THAN ONE

ROD NO	X	TSURF DEG C	QCON(QTOT) KW/M**2	HEXP	UHEXP	HDR	UHDR	HDRPW	HG57	UHG57	HG59	UHG59	HCB	QGD KW/M**2
				-----	-----	KW/M**2 C	-----	-----	-----	-----	KW/M**2 C	-----	-----	
LEVEL E8														
34	0.81	585.9	436.0(444.1)	1.294	0.077	1.458	0.029	1.248	0.899	0.016	0.770	0.019	0.931	182.6
LEVEL F1														
34	0.86	629.8	438.5(448.5)	1.152	0.069	1.518	0.030	1.295	0.894	0.019	0.764	0.023	0.922	233.8
50	0.86	604.2	428.7(437.8)	1.207	0.071	1.518	0.030	1.297	0.899	0.019	0.768	0.023	0.932	213.8
LEVEL F2														
14	0.88	579.2	441.0(449.4)	1.336	0.081	1.548	0.030	1.326	0.905	0.022	0.772	0.026	0.947	203.9
38	0.88	619.2	436.0(446.2)	1.178	0.070	1.548	0.030	1.322	0.896	0.021	0.764	0.026	0.930	235.4
50	0.88	619.2	432.8(442.5)	1.169	0.069	1.548	0.030	1.322	0.896	0.021	0.764	0.026	0.930	235.4
LEVEL F3														
14	0.90	610.3	439.1(449.2)	1.215	0.073	1.578	0.031	1.348	0.896	0.025	0.762	0.030	0.938	239.1
21	0.90	580.9	446.4(454.7)	1.345	0.079	1.578	0.031	1.352	0.903	0.025	0.768	0.033	0.951	215.2
34	0.90	657.0	442.3(453.6)	1.084	0.065	1.578	0.031	1.344	0.887	0.025	0.754	0.029	0.922	278.4
LEVEL F5														
21	0.94	578.7	446.7(455.0)	1.355	0.080	1.624	0.031	1.392	0.895	0.035	0.757	0.041	0.959	229.7
LEVEL F6														
17	0.95	564.8	439.1(447.9)	1.391	0.083	1.644	0.031	1.411	0.892	0.044	0.752	0.052	0.969	226.0
37	0.95	630.9	433.1(444.6)	1.134	0.067	1.644	0.031	1.403	0.877	0.043	0.738	0.051	0.940	283.0
38	0.95	628.1	435.6(446.2)	1.149	0.068	1.644	0.031	1.403	0.878	0.043	0.739	0.051	0.941	280.8
50	0.95	642.6	432.2(443.1)	1.098	0.065	1.644	0.031	1.402	0.875	0.043	0.736	0.051	0.936	293.3
LEVEL F7														
14	0.96	640.3	437.5(449.1)	1.118	0.067	1.663	0.031	1.418	0.867	0.064	0.726	0.073	0.939	300.0
17	0.96	610.9	436.6(447.9)	1.207	0.071	1.663	0.031	1.421	0.873	0.065	0.731	0.074	0.950	273.5
21	0.96	635.9	443.5(454.6)	1.146	0.068	1.663	0.031	1.419	0.868	0.064	0.727	0.074	0.940	295.9
37	0.96	648.1	417.1(429.7)	1.045	0.062	1.663	0.031	1.417	0.866	0.064	0.725	0.073	0.936	306.9
38	0.96	650.9	434.1(445.9)	1.080	0.064	1.663	0.031	1.417	0.865	0.064	0.724	0.073	0.936	309.6
50	0.96	669.8	430.9(443.2)	1.024	0.061	1.663	0.031	1.416	0.862	0.064	0.722	0.073	0.930	327.1
LEVEL F8														
14	0.98	649.8	437.5(449.5)	1.092	0.065	1.690	0.039	1.440	0.845	0.074	0.700	0.085	0.940	321.2
17	0.98	634.8	435.0(447.9)	1.128	0.067	1.690	0.039	1.441	0.848	0.074	0.702	0.084	0.945	307.3
21	0.98	653.7	442.9(455.0)	1.095	0.065	1.690	0.039	1.440	0.845	0.074	0.699	0.084	0.938	325.0
34	0.98	696.4	440.4(454.0)	0.984	0.059	1.690	0.039	1.436	0.839	0.073	0.694	0.083	0.927	365.9
37	0.98	667.0	430.9(444.6)	1.031	0.062	1.690	0.039	1.438	0.843	0.074	0.698	0.084	0.934	337.5

INTERMEDIATE FLOW TEST IH

FLUID CONDITIONS

CORRELATION COMPARISONS

SI UNITS

NOMENCLATURE

HCB - CONDIE-BENGSTON HEAT TRANSFEER COEFFICIENT
HDB - DITTUS-BOELTER HEAT TRANSFER COEFFICIENT
HDR - DOUGALL-ROHSENOW HEAT TRANSFER COEFFICIENT
HDRPW - DOUGALL-ROHSENOW HEAT TRANSFER COEFFICIENT, WALL PRANDTL NUMBER
HEXP - EXPERIMENTAL HEAT TRANSFER COEFFICIENT Q/(TSURF-TBULK)
HEXPS - EXPERIMENTAL HEAT TRANSFER COEFFICIENT Q/(TSURF-TSAT)
HG57 - GROENEVELD 5.7 HEAT TRANSFER COEFFICIENT
HG59 - GROENEVELD 5.9 HEAT TRANSFER COEFFICIENT
QCON - CONVECTIVE HEAT FLUX
QGD - GROENEVELD-DELORME HEAT FLUX
QTOT - TOTAL HEAT FLUX (INCLUDING RADIATION)
SDTSRF - CROSS-SECTIONAL STANDARD DEVIATION OF THE SURFACE TEMPERATURE
SDQ - CROSS-SECTIONAL STANDARD DEVIATION OF THE CONVECTIVE HEAT FLUX
TBULK - BULK VAPOR TEMPERATURE
TSAT - SATURATION TEMPERATURE
TSRF(TSURF) - SURFACE TEMPERATURE
TF - EQUILIBRIUM FLUID TEMPERATURE
UHDR - UNCERTAINTY, DOUGALL-ROHSENOW HEAT TRANSFER COEFFICIENT
UHEXP - UNCERTAINTY, EXPERIMENTAL HEAT TRANSFER COEFFICIENT
UHEXPS - UNCERTAINTY, EXPERIMENTAL HEAT TRANSFER COEFFICIENT
UHG57 - UNCERTAINTY, GROENEVELD 5.7 HEAT TRANSFER COEFFICIENT
UHG59 - UNCERTAINTY, GROENEVELD 5.9 HEAT TRANSFER COEFFICIENT
UNC - UNCERTAINTY
UTF - UNCERTAINTY, EQUILIBRIUM FLUID TEMPERATURE
UX - UNCERTAINTY, EQUILIBRIUM QUALITY
X - EQUILIBRIUM QUALITY

********** INTERMEDIATE FLOW TEST IH **********

LEVEL AVERAGE FLUID AND SURFACE CONDITIONS

MASS FLUX 1.922E+05 LBM/SQFT H   UNC. MASS FLUX 5.987E+03 LBM/SQFT H   PRESSURE 1200.6 PSI   UNC. PRESSURE 7.50 PSI
260.80 KG/SQM S   8.1246 KG/SQM S   8.28 MPA   0.052 MPA

LEVEL	QCON		SDQ		TSRF		SDTSRF		TF		UTF		X	UX
	ENG	SI	ENG	SI	ENG	SI	ENG	SI	ENG	SI	ENG	SI		
F	1.479	466.0	0.028	8.89	1160.5	627.3	95.90	53.280	567.3	297.7	0.793	0.4	.8624	.0431
G	1.448	456.3	0.024	7.65	1330.0	721.4	58.09	32.275	614.2	323.8	37.105	20.6	1.0750	.0500
E7	1.491	469.7	0.000	0.00	1108.0	598.1	0.00	0.000	567.3	297.7	0.793	0.4	.8153	.0416
E8	1.490	469.3	0.000	0.00	1166.0	630.3	0.00	0.000	567.3	297.7	0.793	0.4	.8433	.0425
F1	1.454	458.0	0.037	11.62	1163.0	628.7	53.65	29.804	567.3	297.7	0.793	0.4	.8983	.0443
F2	1.466	461.7	0.013	4.05	1195.0	646.4	34.79	19.325	567.3	297.7	0.793	0.4	.9264	.0453
F3	1.457	459.1	0.045	14.25	1219.2	659.9	43.96	24.420	567.3	297.7	0.793	0.4	.9545	.0464
F5	1.444	454.9	0.079	24.95	1148.0	620.3	16.97	9.428	567.3	297.7	0.793	0.4	.9971	.0477
F6	1.459	459.5	0.009	2.83	1252.6	678.4	23.66	13.144	575.7	302.4	27.284	15.2	1.0155	.0482
F7	1.450	456.9	0.036	11.24	1266.1	686.0	24.20	13.446	586.0	308.1	28.873	16.0	1.0330	.0487
F8	1.452	457.5	0.036	11.39	1305.0	707.6	41.04	22.800	601.9	316.9	34.296	19.1	1.0576	.0495

NOMENCLATURE

	ENG	SI
Q	BTU/H FT**2 X 1E5	KW/M**2
SDQ	BTU/H FT**2 X 1E5	KW/M**2
TSRF	DEG F	DEG C
SDTSRF	DEG F	DEG C
TF	DEG F	DEG C
UTF	DEG F	DEG C

********** INTERMEDIATE FLOW TEST IH **********

PRIMARY LEVELS

EQUILIBRIUM QUALITY LESS THAN ONE

ROD NO	X	TSURF DEG C	QCON(QTOT) KW/M**2	HEXP	UHEXP	HDR	UHDR	HDRPW	HG57	UHG57	HG59	UHG59	HCB	QGD KW/M**2
				KW/M**2 C										
LEVEL F														
7	0.86	614.2	473.8(485.4)	1.497	0.091	2.150	0.050	1.709	1.109	0.017	0.895	0.019	1.024	236.1
7	0.86	607.6	474.4(485.4)	1.531	0.092	2.150	0.050	1.710	1.112	0.017	0.897	0.019	1.028	230.6
10	0.86	545.3	467.1(474.0)	1.886	0.117	2.150	0.050	1.728	1.148	0.018	0.927	0.020	1.088	179.4
10	0.86	554.2	466.5(474.0)	1.819	0.113	2.150	0.050	1.724	1.141	0.018	0.922	0.020	1.077	186.7
10	0.86	552.0	466.8(474.0)	1.836	0.114	2.150	0.050	1.725	1.143	0.018	0.923	0.020	1.080	184.8
13	0.86	611.4	473.8(484.0)	1.510	0.091	2.150	0.050	1.710	1.110	0.017	0.896	0.019	1.026	234.0
13	0.86	602.6	474.4(484.0)	1.556	0.095	2.150	0.050	1.711	1.114	0.017	0.899	0.019	1.032	226.5
15	0.86	599.8	461.2(470.9)	1.527	0.091	2.150	0.050	1.712	1.116	0.017	0.900	0.019	1.034	224.1
16	0.86	623.7	460.8(473.0)	1.414	0.085	2.150	0.050	1.707	1.106	0.017	0.892	0.019	1.017	244.4
34	0.86	643.7	469.3(480.8)	1.357	0.082	2.150	0.050	1.704	1.098	0.017	0.886	0.018	1.006	261.4
38	0.86	612.6	466.2(476.5)	1.481	0.089	2.150	0.050	1.709	1.110	0.017	0.895	0.019	1.025	234.9
42	0.86	643.7	459.0(470.4)	1.327	0.081	2.150	0.050	1.704	1.098	0.017	0.886	0.018	1.006	261.4
53	0.86	599.8	482.3(491.6)	1.596	0.097	2.150	0.050	1.712	1.116	0.017	0.900	0.019	1.034	224.1
53	0.86	605.9	481.6(491.6)	1.563	0.094	2.150	0.050	1.711	1.113	0.017	0.898	0.019	1.030	229.4
59	0.86	647.0	462.1(475.8)	1.323	0.080	2.150	0.050	1.703	1.097	0.017	0.885	0.018	1.004	264.1
59	0.86	640.9	462.7(475.8)	1.348	0.081	2.150	0.050	1.704	1.099	0.017	0.887	0.018	1.007	259.0
59	0.86	658.7	461.5(475.8)	1.278	0.078	2.150	0.050	1.701	1.094	0.017	0.882	0.018	0.998	274.2
64	0.86	720.3	453.0(474.0)	1.072	0.065	2.150	0.050	1.694	1.078	0.016	0.869	0.018	0.973	329.1
64	0.86	739.8	451.1(474.0)	1.020	0.063	2.150	0.050	1.692	1.075	0.016	0.865	0.018	0.967	346.7
64	0.86	723.1	452.7(474.0)	1.064	0.065	2.150	0.050	1.694	1.078	0.016	0.868	0.018	0.972	331.7

********** INTERMEDIATE FLOW TEST IH **********

PRIMARY LEVELS

EQUILIBRIUM QUALITY GREATER THAN ONE

ROD NO	X	TSURF DEG C	QCON(QTOT) KW/M**2	HEXPS	UHEXPS	HEXP	UHEXP	HDB	HCB KW/M**2 C	QGD KW/M**2
				KW/M**2 C						
LEVEL G										
1	1.07	731.4	455.2(477.2)	1.049	0.065	1.117	0.09	1.923	1.009	399.7
14	1.07	698.1	462.7(478.3)	1.156	0.072	1.236	0.10	1.923	1.021	363.8
16	1.07	749.2	450.8(472.7)	0.998	0.062	1.060	0.08	1.923	1.004	418.8
16	1.07	758.1	450.1(472.7)	0.978	0.061	1.036	0.08	1.923	1.001	428.7
18	1.07	688.1	455.8(470.6)	1.167	0.070	1.251	0.10	1.923	1.0[illegible]	353.2
18	1.07	670.9	457.1(470.6)	1.225	0.074	1.317	0.11	1.923	1.033	334.9
18	1.07	690.3	455.8(470.6)	1.161	0.070	1.243	0.10	1.923	1.024	355.3
20	1.07	644.8	468.1(479.6)	1.349	0.080	1.458	0.13	1.923	1.046	307.9
20	1.07	715.3	463.4(479.6)	1.109	0.067	1.183	0.10	1.923	1.015	382.0
21	1.07	703.1	467.1(482.7)	1.152	0.069	1.232	0.10	1.923	1.019	369.2
34	1.07	762.6	461.8(480.8)	0.993	0.061	1.052	0.08	1.923	1.000	433.7
37	1.07	713.1	458.6(475.7)	1.104	0.067	1.178	0.10	1.923	1.015	379.6
38	1.07	713.1	461.2(477.5)	1.110	0.067	1.184	0.10	1.923	1.015	379.6
42	1.07	760.3	451.7(470.7)	0.976	0.065	1.035	0.09	1.923	1.001	431.2
42	1.07	759.8	451.7(470.7)	0.978	0.060	1.036	0.08	1.923	1.001	430.6
45	1.07	713.7	461.2(478.1)	1.109	0.067	1.183	0.10	1.923	1.015	380.2
45	1.07	705.3	461.8(478.1)	1.133	0.068	1.210	0.10	1.923	1.018	371.7
45	1.07	712.6	461.2(478.1)	1.112	0.067	1.186	0.10	1.923	1.016	379.0
47	1.07	710.[illegible]	456.4(472.8)	1.105	0.067	1.179	0.10	1.923	1.016	377.4
50	1.07	730.9	452.7(469.7)	1.045	0.064	1.112	0.09	1.923	1.009	399.1
58	1.07	745.3	458.6(480.0)	1.025	0.063	1.088	0.09	1.923	1.005	414.5
64	1.07	765.3	447.3(472.8)	0.957	0.059	1.013	0.08	1.923	0.999	436.5
64	1.07	767.6	447.3(472.8)	0.952	0.059	1.008	0.08	1.923	0.999	438.9

********** INTERMEDIATE FLOW TEST IH **********

INTERMEDIATE LEVELS

EQUILIBRIUM QUALITY LESS THAN ONE

ROD NO	X	TSURF DEG C	QCON(QTOT) KW/M**2	HEXP	UHEXP	HDR	UHDR	HDRPW	HG57	UHG57	HG59	UHG59	HCB	QGD KW/M**2
				KW/M**2 C										
LEVEL E7														
34	0.82	598.1	469.7(478.7)	1.563	0.095	2.062	0.049	1.643	1.100	0.015	0.885	0.016	1.026	204.4
LEVEL E8														
34	0.84	630.3	469.3(480.1)	1.411	0.086	2.114	0.049	1.678	1.097	0.016	0.884	0.017	1.010	241.6
LEVEL F1														
17	0.90	588.7	462.7(472.8)	1.590	0.095	2.216	0.050	1.768	1.129	0.021	0.912	0.024	1.050	229.9
34	0.90	666.4	458.1(480.8)	1.269	0.077	2.215	0.050	1.753	1.100	0.020	0.887	0.023	1.001	298.9
37	0.90	636.4	462.7(474.8)	1.366	0.082	2.215	0.050	1.758	1.109	0.020	0.895	0.023	1.017	271.8
50	0.90	640.9	458.3(469.7)	1.335	0.080	2.216	0.050	1.757	1.108	0.020	0.894	0.023	1.014	275.9
LEVEL F2														
14	0.93	620.9	466.5(477.3)	1.443	0.089	2.268	0.051	1.801	1.118	0.027	0.901	0.031	1.032	271.5
17	0.93	642.6	459.6(472.8)	1.333	0.079	2.268	0.051	1.797	1.110	0.027	0.894	0.031	1.019	291.4
38	0.93	664.2	463.4(476.5)	1.264	0.076	2.268	0.051	1.794	1.103	0.027	0.889	0.031	1.008	311.8
50	0.93	656.1	457.4(469.7)	1.269	0.076	2.268	0.051	1.795	1.105	0.027	0.890	0.031	1.011	306.2
LEVEL F3														
14	0.95	650.9	464.6(477.3)	1.316	0.080	2.319	0.052	1.836	1.105	0.049	0.887	0.055	1.020	314.7
17	0.95	658.7	458.3(472.8)	1.270	0.076	2.319	0.052	1.835	1.102	0.049	0.885	0.055	1.016	322.1
21	0.95	630.9	471.6(482.7)	1.415	0.084	2.319	0.052	1.840	1.112	0.049	0.893	0.055	1.031	295.5
34	0.95	698.1	465.9(480.8)	1.164	0.071	2.319	0.052	1.830	1.092	0.048	0.877	0.054	0.999	360.5
LEVEL F5														
21	1.00	613.7	472.5(482.7)	1.495	0.089	2.396	0.100	1.905	1.078	0.063	0.851	0.059	1.051	302.1

********** INTERMEDIATE FLOW TEST IH **********

INTERMEDIATE LEVELS

EQUILIBRIUM QUALITY GREATER THAN ONE

ROD NO	X	TSURF DEG C	QCON(QTOT) KW/M**2	HEXPS	UHEXPS	HEXP	UHEXP	HDB	HCB KW/M**2 C	QGD KW/M**2
				KW/M**2 C						
LEVEL F6										
1	1.02	697.0	458.6(477.8)	1.149	0.072	1.162	0.09	2.275	1.010	382.7
17	1.02	668.1	458.3(473.4)	1.237	0.075	1.253	0.09	2.275	1.023	352.9
37	1.02	673.7	460.5(475.0)	1.225	0.074	1.240	0.09	2.275	1.020	358.7
38	1.02	666.4	463.7(477.0)	1.257	0.075	1.274	0.09	2.275	1.024	351.2
50	1.02	687.0	456.1(470.2)	1.172	0.071	1.186	0.09	2.275	1.015	372.4
LEVEL F7										
14	1.03	681.4	462.7(477.3)	1.206	0.074	1.239	0.09	2.156	1.020	360.5
17	1.03	683.7	456.4(472.8)	1.183	0.071	1.215	0.09	2.156	1.019	362.8
21	1.03	668.1	469.3(482.7)	1.267	0.076	1.304	0.10	2.156	1.026	346.7
37	1.03	688.7	459.3(474.8)	1.175	0.071	1.207	0.09	2.156	1.017	368.1
38	1.03	686.4	461.8(476.5)	1.188	0.071	1.221	0.09	2.156	1.018	365.7
50	1.03	712.6	454.9(470.6)	1.096	0.067	1.125	0.08	2.156	1.008	392.9
LEVEL F8										
1	1.06	[illegible]14.2	456.4(478.8)	1.046	0.065	1.094	0.08	2.006	1.005	407.0
14	1.06	686.4	463.4(478.1)	1.192	0.072	1.254	0.10	2.006	1.023	355.9
17	1.06	698.7	456.7(473.8)	1.139	0.069	1.197	0.09	2.006	1.018	369.0
21	1.06	687.0	469.0(483.8)	1.205	0.072	1.267	0.10	2.006	1.022	356.5
34	1.06	744.2	464.0(481.9)	1.039	0.064	1.086	0.08	2.006	1.002	417.4
37	1.06	705.3	459.3(475.8)	1.127	0.068	1.182	0.09	2.006	1.015	376.1

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16. ABSTRACT (200 words or less)

A series of eight steady-state rod bundle tests has been performed at the Oak Ridge National Laboratory in the Thermal Hydraulic Test Facility to gather data in both the low flow film boiling region and high flow steam cooling region. This test series includes experiments both with and without liquid entrainment above the dryout point.

Bundle fluid conditions were calculated using steady-state energy and mass conservation equations. The experimental heat transfer data have been compared to several film boiling heat transfer correlations and one vapor correlation. Results of these comparisons support the conclusions reached in the analysis of prior ORNL transient and steady state tests (3.03.6AR, 3.06.6B, 3.08.6C, series 3.07.9, series 3.02.10, and series 3.09.10). Results indicate that the Dougall-Rohsenow correlation often overpredicts the heat transfer coefficient, while the Groeneveld 5.7 and Condie-Bengston IV correlations tend to underpredict, however they are in better agreement with the data. The Groeneveld-Delorme correlation underpredicts heat fluxes. The Dittus-Boelter correlation was evaluated only when equilibrium qualities were greater than one, and tends to overpredict the heat transfer coefficient.

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