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TWO-PHASE FLOW AND HEAT TRANSFER
IN MULTIROD GEOMETRIES
AIR-WATER FLOW STRUCTURE DATA FOR A
ROUND TUBE,
CONCENTRIC AND ECCENTRIC ANNULUS,
AND NINE-ROD BUNDLE

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ATOMIC POWER EQUIPMENT DEPARTMENT
GENERAL ELECTRIC
SAN JOSE, CALIFORNIA

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SECTION I

SUMMARY

The equipment and instrumentation for flow structure experiments of vertically upward air-water flow in a round tube, eccentric and concentric annulus, and a nine-rod array are discussed. The following quantities were measured for a series of runs:

- a. At one elevation, profiles of local void fraction, air linear velocity, and water linear velocity were obtained (isokinetic sampling technique).
- b. The film flow rate on solid surfaces (porous or perforated walls).
- c. Local time-dependent liquid or vapor fraction (continuity probe).
- d. Average void fraction (quick-closing valves).
- e. System temperature, pressure, and pressure fluctuations (thermocouples, Bourdon gage, and PACE transducers).
- f. Mean air and water flow rates (rotometer and orifice and manometer, respectively).
- g. Pressure drop (manometers).
- h. Wall shear probe (Preston impact tube).

The quality varied from 11 to 62%. The total mass flow ranged from 0.12×10^6 to 0.70×10^6 lb/h-ft², resulting in superficial air velocities from 48 to 72 ft/sec and superficial water velocities from 7 to 23 ft/sec. The flows are in the annular—dispersed flow regime. Results from these data are presented on graphs and in tables.

SECTION II

INTRODUCTION

There are compelling economic reasons for improving the performance of nuclear power reactors. Most of these reactors use rod-type fuel geometries. In many of these reactors, the coolant employed to remove heat from the reactor core is a liquid at the coolant channel inlet and a two-phase mixture of liquid and vapor at the coolant channel exit. To improve the performance, a more complete knowledge is needed of the characteristics of two-phase flow and heat transfer in rod-type fuel geometries.

Many investigators are searching for fundamental understanding of such two-phase flow structures by studying the simpler case of two-component (e.g., air-water) flow without heat transfer. Previous structure studies of air-water flows in round tubes have been reported. However, at the time these data were obtained, there were no known flow structure data of air-water flow in a concentric or eccentric annulus or a nine-rod array. Hence, the purpose of this report is to present the round tube, annulus, and nine-rod array air-water flow structure data obtained under Task A of P.A. 44, and to describe the test equipment.

The spatial distribution of void fraction and air and water linear velocities has been obtained by the isokinetic sampling probe technique. A continuity probe also was used to determine the local void fraction. Quick-closing valve void fraction data and total pressure drop data are reported. The wall liquid film flow rate and thickness were determined. Some preliminary static pressure fluctuation data in a round tube are reported.

SECTION III

EXPERIMENTAL EQUIPMENT, INSTRUMENTATION, AND PROCEDURES

3.1 TEST EQUIPMENT AND FLOW MEASUREMENTS

Ascending flow of air and water has been studied in a special air-water test facility located in Building R-Tower at the General Electric Company in San Jose, California. The round tube test section is a vertical, 12-foot-long, 0.995-inch-i.d., smooth, round tube. A 0.500-inch-diameter rod may be placed in the center of the tube for concentric annulus operation, or at an eccentric position (0.125 inch offset from the pipe centerline) for eccentric annulus operation, or removed altogether for simple round tube operation. An inlet device consisting of three concentric flow-directing tubes introduces the water on the walls of the tube and/or rod, and introduces the air in the gap between the surfaces (Figure 1).

The nine-rod test section is a vertical, 20-foot-long (260 hydraulic diameters) rod bundle preceded by an entrance section 6 feet long (77 hydraulic diameters). This bundle is oversized as compared to current boiling water reactor rod bundle size, as shown in Figure 2. One-inch-diameter rods in a square array are located in a "square" channel (4.29 inches on a side). The water is introduced evenly on all nine rods through porous segments after the air flow has been introduced between the rods. This inlet system was expected to give fully developed flow in the 10-foot main test section between the isolation valves (Figure 2).

For the tube and annulus tests, demineralized and filtered water is recirculated by a Westco (250-foot head at 20 gpm) pump. Air and water are separated in an 80-gallon, gravity-type separation tank at atmospheric pressure. The water flow rates introduced on the inner rod and outer tube may be separately controlled and measured, using calibrated orifices and 100-inch water-over-oil manometers. The once-through flow of air is supplied by a 110-scfm reciprocating Ingersoll-Rand compressor. The air is first cooled in a settling tank, and then it flows through an oil-and-water separator and CUNO full-flow (5-micron) filter before entering the test section. Air flow rate is measured with a Schutte and Koerting Model 4HCF rotometer. Temperatures throughout the system are measured by a Honeywell self-balancing potentiometer. System pressure is measured by a Heise bourdon-type gage. The system can operate at pressures from 1 to 6 atmospheres. Most data reported here were obtained at about 90 psia. The average test section mass quality was determined by the aforementioned separate measurements of the inlet water flow rate (calibrated orifices) and the inlet air flow (by rotometer).

For the nine-rod tests, demineralized and filtered (CUNO Model CG19S4, 5 to 15 microns) water is recirculated by an Ingersoll-Rand pump. Air and water leaving the test section are separated in a gravity-type separation tank at system pressure. The air is recirculated by a rotary blower (Fuller Type C-100, 75 hp). An after-cooler removes the work of compression: a centrifugal separator and desiccant-type dryer (C.M. Kemp MBI E.B.10) remove water, oil, and oil vapor. The water and air flow rates are separately measured with calibrated orifices and manometers. System pressure is measured by a Heise gage. The system can operate at pressures up to 100 psig.

FIGURE 1. LINE DIAGRAM FOR R-TOWER ANNULAR TEST LOOP, 100 psig, 150°F AIR-WATER SYSTEM

FIGURE 2. GENERAL LAYOUT FOR NINE-ROD AIR-WATER TEST FACILITY

3.2 INSTRUMENTATION

3.2.1 Average Void Fraction

Average void fraction in the central 10 feet of test section was measured by isolation of flow samples with two guillotine-type, quick-closing valves, and subsequent measurement of the trapped liquid volume. The void data reported are an average of five samples; individual readings differ from the mean value by less than $\pm 5\%$. One round tube test section quick-closing valve is shown in Figures 3A and 3B. A nine-rod quick-closing valve is shown in Figure 4.

3.2.2 Pressure Drop

Accurate pressure drop data were obtained from water-purged pressure taps placed at several positions along the test section and connected to water-over-oil U-tube manometers. Pressure drop data were reduced using the WADR computer code described in Appendix B.

3.3 ISOKINETIC SAMPLING PROBE

Detailed phase and velocity distributions were obtained using the isokinetic sampling probe technique. A comprehensive description of the isokinetic technique as employed here is given in a separate report. ⁽¹⁾ The annulus—round tube probe was traversed radially across the test section at a fixed axial position located 10.5 feet from the inlet. This position corresponds to 125 hydraulic diameters from the inlet for the tube, and 250 diameters for the annuli tests. The flow at this point was shown to be fully developed by subsequent identical (within the uncertainty of isokinetic technique) profile measurements at a position 9 feet from the entry for a typical flow condition.

In the nine-rod section, isokinetic sampling probes were mounted in three of the rods (Figure 2). Shown in Figure 5 are the disassembled component parts and the assembly of an instrumented rod. The instrument control casting is shown in Figure 6. The flow area is probed by traversing the probe in and out normal to its rod and moving the probe circumferentially by rotating the rod.

"Isokinetic" sampling is sampling of both phases through a pitot-like tube at such a rate that the velocity of either phase is not altered at the probe tip. The isokinetic technique consists of two parts:

- a. A theoretical momentum analysis relating the dynamic pressure indicated by the probe to the void fraction and superficial mass velocity of each phase:

$$\Delta P_I = \Delta P_I (\alpha, G_{\ell}^*, G_g^*).$$

- b. Experimental measurement of these superficial mass velocities (G_{ℓ}^* , G_g^*) and the dynamic pressure (ΔP_I) so that local void fraction α [and other local variables— V_g , V_{ℓ} , χ , η , W_g , W_{ℓ}] can be determined from Part a.

FIGURE 3A. INSTRUMENT PANEL AT LOWER END OF ANNULAR TEST SECTION

FIGURE 3B. INSTRUMENT CONTROL PANEL AT UPPER END OF ANNULAR TEST SECTION

FIGURE 4. ONE NINE-ROD QUICK-CLOSING ISOLATION VALVE (PNEUMATICALLY OPERATED)

The analysis (Part a.) employed is similar to that suggested by Adorni, et al.⁽²⁾ which is based on the following key assumptions: (a) Under impact conditions, none of the gas or liquid approaching the probe is diverted from their paths (i. e., the paths which they would follow in the absence of the probe) until within a certain distance of the probe. The air then starts on its diversion path, but no water is diverted until all the air is diverted. (b) The slip ratio is constant (but not necessarily unity) during the deceleration at the tip of the probe. The analysis yields:

$$\Delta P_I = \frac{\alpha^2}{2} \rho_g V_g^2 + \frac{1-\alpha^2}{2} \rho_l V_l^2. \quad (1)$$

Introducing the superficial mass velocities defined by

$$G_g^* = \alpha \rho_g V_g; \quad G_l^* = (1-\alpha) \rho_l V_l, \quad (2)$$

We can manipulate Equation (1) to give the desired expression between local void fraction and the "measured" quantities—dynamic pressure and superficial mass velocities of both phases:

$$\alpha = \frac{\Delta P_I - G_g^{*2}/2\rho_g - G_l^{*2}/2\rho_l}{\Delta P_I - G_g^{*2}/2\rho_g + G_l^{*2}/2\rho_l} \quad (3)$$

FIGURE 5. A DISASSEMBLED INSTRUMENTED ROD FOR NINE-ROD TEST

FIGURE 6. INSTRUMENT CONTROL CASTING FOR NINE-ROD AIR-WATER TESTS. Two 1-inch-o.d. instrumented rods are in place. Assembly is shown upside down from its correct test orientation.

Now the remaining variables required to define the local two-phase structure can be calculated from simple equations containing α , G_g^* , and G_l^* :

$$\eta = V_g/V_l = \frac{G_g^*/2\rho_g \alpha}{G_l^*/2\rho_l (1-\alpha)} , \quad (4)$$

$$\chi = \frac{G_g^*}{G_g^* + G_l^*} . \quad (5)$$

It remains only to measure ΔP_I , G_g^* , and G_l^* (Part b.). The same probe measures the dynamic pressure when the sampling rate is zero.

Several probe geometries were tried (e.g., References 3 and 4) and the probe geometry (0.035-inch i.d.) shown in Figure 7 was adopted. A continuous; very low (negligible, compared to gas sampling rates) purging of the pressure lines to the probe and wall taps with N_2 -gas was necessary to eliminate errors caused by the presence of interfaces in the pressure lines.

According to the line diagram of Figure 8, the following experimental procedure was employed to obtain two-phase isokinetic sampling data:

PHOTOGRAPH OF PROBE

FIGURE 7. PREFERRED ISOKINETIC PROBE

FIGURE 8. LINE DIAGRAM OF ISOKINETIC SAMPLING INSTRUMENT ARRANGEMENT

- a. Set up two-phase flow conditions near those where measurements are intended in the test section, and draw a two-phase mixture into the probe pressure line; set the purge rate (using V1) to the minimum flow which will move this water out of the line.
- b. Set up a single-phase gas flow to about the same impact pressure as in step a. and set the wall pressure line purge rate (using V2) to make the manometer reading the same with purging as it is with no purging on either line. Lock valves V1 and V2 in fixed position.
- c. Set up desired two-phase flow conditions and move probe to desired position.
- d. Purge all liquid from lines using air purge by opening valves V11, V12, V14, and V15, and closing all others.
- e. Ready dynamic pressure by opening valves V11, V12, V17, V18, V8, and V9 (leave V1 and V2 at positions set in step b. for all data), and closing all others. (The same dynamic pressure is observed when sensed with the probe pressure or probe sampling lines.)
- f. Set the desired sample flow (i. e., set "isokinetic" sampling conditions—see later discussion on what this should be) by adjusting the metering valve (V3) with valves V17, V18, V8, V9, V11, V12, and V13 open, one of the valves V4, V5, V6, or V7 open for measurement, and all others closed. (V1 and V2 still set as in step b. : purge is on.)

Setting the sample flow control valve (V3) so that the sample is obtained isokinetically is one of the more difficult experimental problems of this technique. Ideally, the probe pressure tap would measure the static pressure just at the inlet of the sample line: then, the sample flow could be adjusted until this probe pressure was equal to the freestream static pressure at the same cross section of the channel (zero manometer deflection). The equality of these pressures would indicate no stream line curvature near the probe and true "isokinetic" sampling.

In actuality, however, the pressure tap is located some distance inside the probe inlet (2.5 diameters for the probe of Figure 7) and so disturbances at the inlet and pressure drop in that inlet length make the pressure measured by the probe pressure tap something different from the freestream static value when isokinetic sampling occurs.

When the pressures are equated, a nonisokinetic sample rate is obtained. This situation is magnified for small diameter probes: for a 0.035-inch diameter sample-probe, the errors introduced by neglecting this effect are not negligible.

The same phenomena occur in the simpler single-phase isokinetic sampling situation. In this case, however, the pressure drop in the probe tip can be calculated from laminar flow theory,⁽⁵⁾ and the behavior of the actual probe can be compared to the theory. Application of Bernoulli's Equation along the central sample stream line yields

$$G_s = \left\{ (2\rho) \left[\frac{G_\infty^2}{2\rho} - (P_s - P_\infty) - \Delta P \right] \right\}^{1/2},$$

where G_s is the sample flow mass velocity, G_∞ is the freestream mass velocity calculated exactly from the dynamic pressure, P_∞ is the freestream static pressure, P_s is static pressure measured at probe pressure tap, P_o is the impact pressure, and ΔP is the probe-tip pressure drop between the probe tip and the probe pressure tap. When G_s is zero, $P_s = P_o$, $\Delta P = 0$, and the above equation reduces to:

$$G_\infty = \left[(P_o - P_\infty) / 2\rho \right]^{1/2}.$$

Dividing G_s by G_∞ yields

$$G_s/G_\infty = \left[\frac{1 - P^*}{1 + \beta} \right]^{1/2},$$

where

$$\beta = \frac{2\Delta P}{\rho G_s^2}, \text{ and}$$

$$P^* = \frac{P_s - P_\infty}{P_o - P_\infty}.$$

β is the nondimensional probe-tip pressure drop and is given in Goldstein⁽⁵⁾ as a unique tabulated function of

$$\left(\frac{2\chi\mu}{d^2 G_s} \right).$$

Thus, for a given probe geometry, a given fluid, and a given freestream mass flow rate, the above equation provides a relation between G_s/G_∞ and P^* .

Data are compared with this theory for one air flow rate and one water flow rate in Figure 9. The agreement is generally good: the air data fall about 5% above the theory and the water data fall about 2.5% below the theory. The effect of G_∞ on the solution is shown by theoretical curves at three values of G_∞ . Although there is a flow effect, it is not extremely large. The larger difference between the air and liquid curves indicates that P^* setting for two-phase flow may be quality dependent. The data of Figure 9 show that if isokinetic sampling were set by adjusting the sample rate until $P_s = P_\infty$ ($P^* = 0$) in these cases, the flows would be considerably different from the true isokinetic condition of G_s/G_∞ equal to one. To obtain isokinetic sampling, the nondimensional pressure setting,

FIGURE 9. SAMPLING PROBE CHARACTERISTICS IN SINGLE-PHASE FLOW, SAMPLE AREA = 9.6×10^{-4} in. 2

$$\left(P^* = \frac{P_s - P_\infty}{P_o - P_\infty} \right),$$

would have to be -0.15 for the air case and -0.70 for the water case instead of zero.

The proper sample rate was well predicted in single-phase flow by relating the pressure drop in the probe tip to impact pressure by a constant of proportionality, P^* . By analogy, a similar relationship is presumed for two-phase flow. Note that both the gas sample rate and the liquid sample rate depend upon P^* as shown in Figure 10. The liquid sample flow rate is dependent on P^* when the water flow is relatively large: in the annular-dispersed regime example, this occurs near the solid wall.

The recommended sampling procedure establishes (as close as possible) true isokinetic sampling conditions at the probe by setting P^* to the "correct" nonzero value. The same P^* setting is used for all profile traverse positions for a given flow condition, as shown in Figure 10. In sample geometries such as a round tube or concentric annulus, the "correct" P^* value is determined by an iteration scheme: P^* is varied until the total air flow determined by integrating the local values is equal to the known total air flow entering the test section. The same check is not easily applied to the water flow when the flow regime is annular-dispersed, as a significant part of the water flows in a thin film on the wall.

For complex geometries, the flow is sampled at a fixed P^* setting predetermined from tests with the same probe in simple geometries at similar flow conditions. For the air-water tests at 90 psia, 80°F, in eccentric annuli and nine-rod channel geometries, a P^* setting of -0.25 gave good results for average profile qualities below 40%; above 40% quality, a $P^* = -0.50$ was used under these conditions.

The iteration procedure is facilitated by the linearity of the sample rate versus P^* relation near the isokinetic setting: thus, only two sample rates are required to establish completely the flow rate versus P^* relation at each probe position.

This method is not exact. Although the pressure drop in the probe inlet is expected to be proportional to the total pressure, the constant of proportionality, P^* , probably depends upon the local flow rates, local quality, local void fraction, and the ratio of droplet size to probe area, and so may be different at different positions across the test section. (An approximate analysis showed that the expected variation is not large.)

A further deficiency is that uncertainty in integration of the air flow results in uncertainty in P^* . The accuracy of the integrated air flow depends on flow regime, channel geometry, relative probe size, and uncertainty in each air flow data point. Nevertheless, choosing the P^* setting so that the integrated air flow profile equals the total air flow is a sensible criterion which yields meaningful results for annular-dispersed flow. The dependence of average two-phase flow parameters for air-water flow in a round tube upon P^* setting is shown in Figure 11 (see other sample results in the following subsections). Note the good agreement between the average void fraction determined by integrating the void fraction profile and that determined by quick-closing valves. Such good agreement was usually observed. The isokinetic setting

FIGURE 10. ISOKINETIC SAMPLING DATA ILLUSTRATING SENSITIVITY OF DATA TO THE "ISOKINETIC SETTING," P^* ; A TYPICAL PROFILE IN A ROUND TUBE

FIGURE 11. EFFECT OF ISOKINETIC SETTING ON TWO-PHASE RESULTS IN A ROUND PIPE. ($G_{TOTAL} = 0.35 \text{ lb/sec-in.}^2$, $x = 22\%$)

was not based on matching the two measures of average void fraction because, as shown in Figure 11, the integrated void fraction is insensitive to P^* .

The isokinetic sampling probe data were reduced, using the TPHAS computer code which is described in detail in Appendixes A. 1 and A. 6.

3.4 LIQUID FILM SAMPLING

In the round tube and annulus tests, measurements of the low-quality film flow rate on both the inner and outer solid surfaces were made, using the porous-wall film-suction devices shown in Figures 12, 13A, and 13B. The circumference of the porous rings are divided into two segments to allow a semi-local measurement of film-flow rate. The flow rate from each segment is properly balanced by equating the pressure in the respective plenums. The pressure differential was measured with a U-tube manometer (see Figure 3B). The outer tube and inner rod could be rotated to investigate the variation of film flow rate with position. In the nine-rod test, a section of the three instrumented rods is made of perforated metal in order to draw off the liquid film on the rod, as shown in Figure 5. The interpretation of these data is discussed under Results (Section IV).

3.5 PRESSURE FLUCTUATION MEASUREMENTS

Static pressure fluctuations are an inherent characteristic of two-phase flow. Some laboratories are presently investigating these pressure fluctuations themselves as a means of studying two-phase flow.⁽⁶⁾ However, the measurements taken here were only for the purpose of documenting the levels of pressure oscillation.

Wall pressure was measured with PACE differential pressure transducers which were connected to 1/16-inch-diameter wall taps by purged 1/4-inch lines about 10 inches long. The output signals were amplified and recorded on a Sanborn recorder (see typical result in Figure 14) whose frequency response is flat to 50 cps. The following pressure signals were recorded simultaneously:

- a. Absolute pressure at 130 inches up the test section from the inlet on the west side of pipe (0 degree reference).
- b. Pressure difference between west side (0 degree) and east side of pipe (180 degrees) at 130 inches up the test section, and
- c. Absolute pressure at 63 inches up the test section on east side of pipe.

The dominant harmonic of the wall-pressure fluctuations at the two taps separated by 67 inches (between a. and c. above) is in-phase. This indicates that the fluctuations are not caused by a "local" effect but are true test section static pressure oscillations (Figure 14). However, the finite differential pressure signal read between two pressure taps located 180 degrees apart at the same elevation (case b. above) shows some local difference in pressure fluctuations.

FIGURE 12. POROUS-WALL LIQUID FILM SUCTION DEVICE FOR ANNULUS

FIGURE 13A. POROUS SINTERED BRONZE INSERT (1/2 inch o.d., 1.1 inch long)
FOR LIQUID FILM MEASUREMENT ON ROD OF AN ANNULUS

FIGURE 13B. POROUS SINTERED BRONZE INSERT (0.995 inch i.d.) FOR FILM
MEASUREMENT ON CIRCULAR TUBE WALL

FIGURE 14. SAMPLE TRACE OF PRESSURE FLUCTUATIONS IN AIR-WATER UPFLOW IN 1-INCH ROUND PIPE. $W_{Air} = 0.108$ lb/sec, $W_{Water} = 0.848$ lb/sec. $P = 62$ psia.

The amplitude of the peak-to-peak pressure fluctuations (nondimensionalized on the average value) is given as a function of average quality for several flows in Figure 15. The amplitudes at qualities of both zero and unity are less than 0.3% of the average pressure. Consequently, the amplitude versus test quality relation goes from near zero at zero quality, through a peak near 5% quality, and then gradually falls back to zero with increasing quality (see Figure 15). However, the exact relationship is not well established by the data, so perhaps the most important conclusion is that the static pressure fluctuation peak-to-peak amplitude is in the order of 1 to 6% of the mean pressure and is quality (or flow regime) dependent. The results appear to be independent of pressure level as flows at pressures of 37 to 93 psia were included.

The frequency (of the dominant harmonic) of the static pressure fluctuations is shown (in Figure 16) to be in the order of 3 to 5 cps, except for two high-quality runs where frequencies below 1 cps were observed. These data were obtained by visual observation of the near-periodic pressure fluctuations such as shown in Figure 14 and are not the result of a spectral analysis of the pressure signals.

The dominant frequencies of the differential pressure between pressure taps 180 degrees apart lie between 13 and 18 cps, compared to the 3 to 5 cps for the absolute static pressure dominant fluctuations. No further analysis of the recorded pressure oscillations has been made at this time. However, random pressure oscillations are a very significant feature of two-phase flow systems and a complete consideration of two-phase hydrodynamics requires consideration of the pressure field oscillation, especially in low-pressure systems.

3.6 CONTINUITY PROBE

A continuity probe provided information on the time-dependent nature of air-water flow structure at a point in space (see Figure 17). The continuity probe consists of two 0.018-inch-diameter wires encased in a 1/8-inch o.d. stainless steel tube, and insulated everywhere except between the opposing ends of the wires. The gap between these wire tips can be varied, but is set at 0.019 inch in Figure 17 and for the data presented here. The usefulness of the probe is lessened by the dependence of the results upon this gap setting.

The probe is placed in the flow so that the flow would be out of the page in Figure 17. The wires are then attached in parallel with one leg of a Wheatstone bridge circuit. The bridge is balanced with air alone flowing across the probe. Then, when an air and water mixture is introduced and a water drop bridges the gap between the wires, the bridge is unbalanced due to the change in resistance provided by the current path through the water: the unbalanced voltage is amplified and recorded.

Typical signals obtained by recording this signal on a Sanborn strip recorder are shown in Figures 18A and 18B. These data were obtained in the upward flow of air and water at test conditions for T02 (see Tables 1A and 1B for summary of tube test conditions). In spite of the difficulty of interpreting these data, considerable qualitative information on the flow structure may be deduced. It is apparent that the flow near the center of the tube is mostly air with occasional drops of water entrained. As the wall is approached, more and more water is encountered, until near the wall, there is mostly water flow with occasional air bubbles entrained. Neither is the core flow entirely air, nor is the wall flow entirely liquid. There

FIGURE 15. STATIC PRESSURE FLUCTUATION AMPLITUDE, AIR-WATER VERTICAL UPFLOW IN ROUND TUBE (37 P_{TEST} 93 psia)

FIGURE 16. WALL (STATIC) PRESSURE FLUCTUATION FREQUENCIES, AIR-WATER UPFLOW IN 1-INCH PIPE (37 $\leq P_{TEST} \leq 93$ psia)

FIGURE 17. CONTINUITY PROBE FOR TWO-PHASE FLOW STRUCTURE INVESTIGATIONS.
PROBE STEM IS 1/8-in.o.d. TUBE

is no sharp change in the nature of the signal as the wall is approached which would indicate a steady, clearly-defined liquid film thickness or a clearly defined vapor core. The fluctuations between liquid and gas phase are of a "regular" turbulent nature, which would indicate that a gross slugging of the two-phase mixture is not occurring.

If one assumes that the signal has just two levels—that of either liquid or of vapor—then the time average of the signal will give a measure of the void fraction at that point. Sample time—average local void fraction profiles obtained in this way are illustrated in Figure 19. The void fraction values obtained are low compared with those obtained with the isokinetic probe, as shown in Figure 20.

For example, for test run No. T04 ($\bar{\chi} = 0.11$), the value of average void fraction (time and spatial average) obtained by three methods are:

$$\begin{aligned}\bar{\alpha} \text{ by quick closing valves} &= 0.82 \\ \bar{\alpha} \text{ by isokinetic probe} &= 0.82 - 0.87 \text{ (depends upon integration technique near wall)} \\ \bar{\alpha} \text{ by continuity probe} &= 0.61\end{aligned}$$

The low values of α obtained with the continuity probe make it apparent that it can be used best (in its present form) for qualitative flow structure information only.

$Y = 0.000$ Inch (Wall)

$Y = 0.050$ Inch

$Y = 0.010$ Inch

$Y = 0.075$ Inch

FIGURE 18A. TYPICAL SIGNAL TRACE FROM CONTINUITY PROBE. FLOW CONDITIONS ARE FOR RUN NO. T02 (SEE TABLE 1)

Y = 0.100 Inch

Y = 0.200 Inch

Y = 0.500 Inch (Centerline)

FIGURE 18B. TYPICAL SIGNAL TRACE FROM CONTINUITY PROBE (CONTINUED)

TABLE 1A
AIR-WATER FLOW STRUCTURE TESTS
ROUND TUBE, CONCENTRIC ANNULUS, AND ECCENTRIC ANNULUS TEST CONDITIONS AND AVERAGE RESULTS

	Test No.	Average Mass Quality $\bar{X}$	Average Void Fraction by QCV $\bar{\alpha}$	Air Flow Rate W_A (lb/sec)	Water Flow Rate W_W (lb/sec)	Test Pressure (psia)	Test Temperature ($^{\circ}$ F)	Average Slip Ratio $\bar{\eta}$	Air Density ρ_A (lb _m /ft ³)	Linear Air Velocity $\bar{V}_A$ (ft/sec)	Linear Water Velocity $\bar{V}_W$ (ft/sec)	Tube Film Flow (Water) W_{FT} (cc/sec)	Rod Film Flow (Water) W_{FR} (cc/sec)	$\frac{W_{FT}}{W_W}$	$\frac{W_{FR}}{W_W}$	$\frac{W_{FR}}{W_{FT}}$	$\frac{W_{FR}+W_{FT}}{W_W}$	Average Void Fraction by Profile Integration $\bar{\alpha}$
Concentric Annulus	A01	0.140	0.885	0.110	0.676	83.9	66.5	3.06	0.431	71.5	23.4	70*	11*	0.23	0.036	0.16	0.27	0.857
	A02	0.267	0.933	0.112	0.306	86.1	82.0	3.82	0.429	69.3	18.2	46	5	0.33	0.036	0.11	0.37	0.902
	A03	0.379	0.944	0.085	0.140	88.3	85.0	5.12	0.438	50.9	9.95	24	3.3	0.38	0.052	0.14	0.44	0.916
	A04	0.490	0.966	0.087	0.091	88.7	85.0	4.75	0.440	50.5	10.6	17	1.7	0.41	0.041	0.10	0.45	0.923
	A05	0.624	0.978	0.087	0.053	91.6	89.5	5.15	0.450	49.0	9.50	12.5	1.6	0.52	0.066	0.13	0.59	0.898
	A06	0.370	0.939	0.112	0.190	87.4	85.5	5.49	0.433	68.2	12.4	34	27*	0.40	0.031	0.079	0.43	0.915
	A07	0.613	0.983	0.111	0.071	92.1	92.5	3.76	0.450	62.2	16.5	14.5	1.7	0.45	0.052	0.120	0.50	0.927
	A08	0.371	0.962	0.083	0.141	68.9	80.5	4.22	0.344	62.2	14.8	27	3.3	0.42	0.051	0.120	0.47	0.980
	A09	0.116	0.854	0.089	0.678	91.2	84.0	3.09	0.452	57.2	18.5	65*	10*	0.21	0.032	0.150	0.23	0.831
	A10	0.226	0.913	0.088	0.302	90.9	83.0	3.85	0.452	52.8	13.7	40	6*	0.29	0.044	0.150	0.33	0.890
ECC Annulus	EA1	0.147	0.861	0.114	0.665	88.5	91.0	4.01	0.434	75.6	18.9	90*	16*	0.30	0.035	0.110	0.335	-
	EA6	0.377	0.943	0.114	0.187	90.5	83.5	5.05	0.450	66.3	13.1	12.6	4	0.148	0.047	0.320	0.195	-

* Film flows not well defined.

TABLE 1A. (Continued)

	Test No.	Average Mass Quality $\bar{x}$	Average Void Fraction by QCV $\bar{\alpha}$	Air Flow Rate $\dot{W}_A$ (lb/sec)	Water Flow Rate $\dot{W}_W$ (lb/sec)	Test Pressure (psia)	Test Temperature (°F)	Average Slip Ratio $\bar{\eta}$	Air Density ρ_A (lb _m /ft ³)	Linear Air Velocity $\bar{V}_A$ (ft/sec)	Linear Water Velocity $\bar{V}_W$ (ft/sec)	Tube Film Flow (Water) $\dot{W}_{FT}$ (cc/sec)	Rod Film Flow (Water) $\dot{W}_{FR}$ (cc/sec)	$\frac{\dot{W}_{FT}}{\dot{W}_W}$	$\frac{\dot{W}_{FR}}{\dot{W}_W}$	$\frac{\dot{W}_{FR}}{\dot{W}_{FT}}$	$\frac{\dot{W}_{FR} + \dot{W}_{FT}}{\dot{W}_W}$	Average Void Fraction by Profile Integration $\bar{\alpha}$
Round	T01	0.38	0.94	0.112	0.182	88.4	83	5.2	0.440	49.8	9.6	21.5	N.A.	0.260	N.A.	N.A.	N.A.	0.965
	TM01	0.36	0.92	0.104	0.186	84.8	90	8.4	0.368	56.4	6.74		N.A.		N.A.	N.A.	N.A.	0.919
	T02	0.29	0.92	0.107	0.260	87.7	85	4.9	0.434	49.2	10.1	24.0	N.A.	0.203	N.A.	N.A.	N.A.	0.960
	TM02	0.29	0.92	0.102	0.261	88.0	96	7.6	0.416	51.44	6.81		N.A.		N.A.	N.A.	N.A.	0.888
	T03	0.22	0.90	0.108	0.396	89.1	78	4.2	0.447	49.8	11.9	29.0	N.A.	0.160	N.A.	N.A.	N.A.	0.961
	TM03	0.21	0.88	0.105	0.399	98.5	99	5.9	0.408	53.9	9.17		N.A.		N.A.	N.A.	N.A.	0.872
	T04 T04R	0.11	0.83	0.112	0.894	87.6	75	3.5	0.442	56.3	16.0	33.5*	N.A.	0.082	N.A.	N.A.	N.A.	0.860
	T05	0.48	0.96	0.111	0.121	88.7	85	5.3	0.438	49.0	9.5	16.1	N.A.	0.291	N.A.	N.A.	N.A.	0.936
	T06 T06R	0.62	0.97	0.111	0.069	86.7	80	6.9	0.434	48.8	7.1	10.3	N.A.	0.327	N.A.	N.A.	N.A.	0.955

* Film flows not well defined.
N.A. = Not applicable

TABLE 1B

NINE-ROD AIR-WATER TESTSUMMARY OF TEST CONDITIONS AND RESULTS

Test No.	Pressure (psia)	Temperature (°F)	Quality	W _{Air} (lb _m /sec)	W _{Water} (lb _m /sec)	Average Void Fraction	X _{LM}	° _G ²	° _L ²	Average Slip Ratio
9R1	109.5	101.0	0.228	1.24	4.20	No Data	0.394	13.67	8.79	No Data
9R2	93.9	90.0	0.399	2.81	4.23	0.956	0.180	4.43	136.4	4.10
9R3a	95.9	90.0	0.157	0.697	3.75	0.769	0.574	9.71	29.47	7.38
9R3b	95.9	90.0	0.156	0.700	3.78	0.772	0.575	7.16	21.64	7.26
9R3c	93.7	95.0	0.153	0.631	3.76	0.815	0.574	13.23	40.11	5.64
9R4a	95.9	95.0	0.115	0.490	3.76	0.768	0.782	19.10	31.24	5.26
9R4b	94.4	84.0	0.115	0.493	3.79	0.755	0.795	18.54	29.37	5.61
9R4c	94.4	84.0	0.115	0.493	3.79	0.758	0.795	18.98	30.06	5.53
9R5	94.9	93.5	0.252	0.676	2.01	0.840	0.323	7.90	71.50	8.61

FIGURE 19. ROUND TUBE (0.995 in. i.d.) AVERAGE VOID FRACTION BY CONTINUITY PROBE

FIGURE 20. COMPARISON OF LOCAL CONTINUITY AND ISOKINETIC PROBE VOID FRACTION DATA

SECTION IV

EXPERIMENTAL RESULTS

Flow structure investigations were made on six round tube flow conditions, ten concentric annuli, two eccentric annuli, and five nine-rod flows. Total flows, system pressure, pressure drops, average void fraction, velocity and phase distribution profiles, liquid film flow rate, and wall shear probe data were obtained. The flow was vertically upward. The quality varied from 11 to 62%. The total mass flow ranged from 0.12×10^6 to 0.70×10^6 lb/h-ft², resulting in superficial air velocities from 48 to 72 ft/sec and superficial water velocities from 7 to 23 ft/sec. The flows are in the annular-dispersed flow regime. A summary of the flow conditions and some of the average results for these flow structure tests is given in Tables 1A and 1B.

4.1 ISOKINETIC PROBE RESULTS

The flow structure data obtained with the isokinetic probe were reduced, using the computer code TPHAS. The complete listing of the calculations and the computed results from this code for the round tube and annulus is presented in Appendixes A. 1 through A. 5. The listing of the nine-rod TPHAS and computed results is presented in Appendixes A. 6 and A. 7.

On the round tube and annulus results listings are the isokinetic sampling flow rate data taken at two P* settings. As pointed out in Section III, the proper isokinetic setting was selected by linear interpolation. With the exception of the TM01, TM02, and TM03 results, the round tube P* was selected by matching the profile-integrated air mass velocity with the average air mass velocity. In the TM01, TM02, and TM03 runs, the profile-integrated water mass velocity agreed closely with the average water mass velocity, while nearly matching the profile-integrated air mass velocity with the average air mass velocity. Because both air and water mass continuity are nearly satisfied in the lower-quality runs TM01, TM02, TM03, and T04R, these data are considered good.

In the higher-quality runs T05 and T06, there is a smaller amount of liquid in the core so that the percentage error in matching the profile-integrated water mass velocity with the average water mass velocity is larger. Illustrated in Figures 21 through 23 are void fraction, fictitious water mass velocity, and linear air velocity profiles for the round tube. Shown in Figures 24 through 26 are void fraction, fictitious air mass velocity, and fictitious water mass velocity profiles for the concentric annulus at the same total flows and qualities as the tube.

The eccentric annulus geometry was investigated with the isokinetic probe for a 38% quality flow. The mass velocity profiles at five angular positions around the tube (Figure 27) show that the core quality is relatively low at the position where the gap is a minimum (0 degree). Figures 28 and 29 further demonstrate that the highest local air linear velocities and circumferential qualities are located where the gap is a maximum (180 degrees). (Note that the results are asymmetric about the 180-degree position, slightly compromising the quantitative results.)

FIGURE 21. LOCAL VOID FRACTION PROFILE. AIR-WATER UPFLOW AT $P = 87$ psia IN 1-inch ROUND TUBE. ($W_{AIR} = \text{CONSTANT} = 0.11 \text{ lb}_m/\text{sec.}$) VOID FRACTION DETERMINED BY ISOKINETIC SAMPLING METHOD.

FIGURE 22. FICTITIOUS WATER MASS VELOCITY DETERMINED BY ISOKINETIC PROBE. AIR-WATER UPFLOW IN 1-INCH TUBE AT $P = 87$ psia ($W_{\text{Air}} = 0.11 \text{ lb}_m/\text{sec}$).

FIGURE 23. LINEAR AIR VELOCITY (ft/sec) VERSUS RADIAL POSITION IN 1- INCH TUBE

FIGURE 24. VOID FRACTION PROFILES IN CONCENTRIC ANNULUS

FIGURE 25. CONCENTRIC ANNULUS TITIOUS AIR MASS VELOCITY PROFILES

FIGURE 26. CONCENTRIC ANNULUS FICTITIOUS WATER MASS VELOCITY PROFILES AT ONE AIR FLOW RATE

QUALITY PROFILES

AIR AND WATER AT 90 psia
 $\bar{x} = 38\%$ $\dot{W}_a = 0.114 \text{ lb./sec}$
 $\dot{W}_w = 0.189 \text{ lb./sec}$

FIGURE 27. MASS QUALITY PROFILES IN ECCENTRIC ANNULUS

TWO-PHASE, AIR-H₂O $\bar{x} = 0.38$

LINEAR AIR VELOCITY (ft/sec)

$\bar{V}_a = 66.2$ ft/sec

$\dot{W}_a = 0.114$; $\dot{W}_w = 0.187$ lb/sec

FIGURE 28. CONTOUR MAP OF LINEAR AIR VELOCITY IN THE ECCENTRIC ANNULUS

ECCENTRIC ANNULUS

CIRCUMFERENTIAL QUALITY VARIATION

$\bar{x} = 38\%$, AIR-H₂O

FIGURE 29. CIRCUMFERENTIAL QUALITY VARIATION IN ECCENTRIC ANNULUS

The nine-rod bundle geometry investigation used the three isokinetic probes built into the three instrumented rods (described in Section II). With the exception of the 9R-2 run, there was some difficulty in matching the probe-traversed wall-to-wall distance with the measured nominal distances given in Figure 2. Thus, to determine qualitative flow distribution maps from these data, all traverse distances were multiplied by the ratio of the local nominal wall-to-wall distance to probe-traversed wall-to-wall distance.

In the 9R-2 run (38% quality) only two-phase flow in the corner region was investigated. The flow structure appears to be annular-dispersed: i. e., the bulk of the liquid flow is concentrated near the rod and channel walls. The two-phase data taken are summarized in Figures 30, 31, and 32. Average qualities for the 0-degree and 45-degree traverses were found to be about 27%, compared to the average test-section quality of 38%, whereas the average quality for the 90-degree traverse was 39%. This variation in quality with angular position is probably due to a slight misalignment of the corner rod (wall-to-wall spacing at 0 degree was 0.240 inch compared to 0.265 inch at 90 degrees). Air flow rate is dependent on the width of the flow passage: velocity is observed to increase rapidly as the gap size is increased.

Contour data maps of local quality, local void fraction, and local linear air and linear water velocity for the 9R-3 run (16% quality) are shown in Figures 33 through 36. Note the large difference between the corner region and the open regions between rods. For example, the maximum quality between the corner rod and the corner wall is 5%, whereas the maximum quality in the open regions is above 40%.

4.2 PRESSURE DROP AND VOID FRACTION RESULTS

Pressure drop and average void fraction (quick closing valves) data (also flow, pressure, and temperature information) were taken for some 140 flow conditions in the tube, concentric annulus, and eccentric annulus. These data are summarized in Table 2. The total pressure gradient, the frictional component of pressure drop, and the pressure drop correlating parameters suggested by Martinelli and Lockhart⁽⁷⁾ are also listed in Table 2 and Table 1B. These data were reduced using the computer code WADR, which is described in Appendix B.

The single-phase pressure drop data are summarized by a graph of friction factor versus Reynolds number (based on hydraulic diameter) in Figure 37. The data show good agreement with the usual smooth tube correlations⁽⁸⁾ except for one series of four air points, which are low. The single-phase data show the apparatus and instrumentation to be suitable for smooth-tube studies of two-phase flow.

Two-phase pressure drop data are presented in Figure 38 on Lockhart-Martinelli⁽¹²⁾ coordinates: ϕ_L^2 versus $1/X_{LM}$. No effect of geometry may be discerned. The pressure drop data are in fair agreement with the turbulent-turbulent correlation, but lie about 10% above it at higher qualities (for $1/X_{LM} > 2$). The measured average void fraction data lie entirely above the Martinelli correlation. While experimental difficulties associated with measuring average void with quick closing valves tend to give high values of void (e.g., water adhering to the test section wall), experimental error cannot entirely explain the difference. The Martinelli correlation is apparently inadequate for vertical upflow of air and water in these geometries.

FIGURE 30. VOID FRACTION AND VELOCITY PROFILES - RUN 9R-2

FIGURE 31. NONDIMENSIONALIZED AIR AND WATER SUPERFICIAL MASS VELOCITY — RUN 9R-2

FIGURE 32. NONDIMENSIONALIZED AIR AND WATER LINEAR VELOCITY — RUN 9R-2

FIGURE 33. QUALITY MAP — NINE-ROD AIR-WATER FLOW AT 96 psia, 80°F. Average Quality = 16%

$$G_{\text{Air}} = 0.0642 \text{ lb}_m \text{ h-ft}^2, G_{\text{Water}} = 0.342 \text{ lb}_m \text{ h-ft}^2$$

FIGURE 34. VOID FRACTION MAP — NINE-ROD AIR-WATER FLOW AT 96 psia, 80°F. Quality = 16%
 $G_{\text{Air}} = 0.064 \text{ lb}_m \cdot \text{h}^{-1} \cdot \text{ft}^2$, $G_{\text{Water}} = 0.342 \text{ lb}_m \cdot \text{h}^{-1} \cdot \text{ft}^2$

FIGURE 35. LINEAR AIR VELOCITY MAP — NINE-ROD AIR-WATER FLOW AT 96 psia, 80°F.
 Quality = 16%, $G_{\text{Air}} = 0.064 \text{ lb}_m \text{ h-ft}^2$, $G_{\text{Water}} = 0.342 \text{ lb}_m \text{ h-ft}^2$.

FIGURE 36. LINEAR WATER VELOCITY MAP — NINE-ROD AIR-WATER FLOW AT 97 psia, 80°F (9R3). Quality = 16%, $G_{\text{Air}} = 0.064 \text{ lb}_m \text{ h-ft}^2$, $G_{\text{Water}} = 0.342 \text{ lb}_m \text{ h-ft}^2$.

TABLE 2
PRESSURE DROP, VOID FRACTION DATA SUMMARY

Geometry	Test No.	Temperature T (°F)	Pressure P (psia)	Total Mass Velocity $G \times 10^{-6}$ (lb/h-ft ²)	Mass Quality $\bar{x}$	Average Void Fraction $\bar{\alpha}$	Total Pressure Gradient $(\Delta P / \Delta Z)_T \times 10^3$ (psi/in.)	Friction Pressure Gradient $(\Delta P / \Delta Z)_f \times 10^3$ (psi/in.)	Flow Modulus X_{LM}	N.D. Pressure Gradient ϕ_l^2	N.D. Pressure Gradient ϕ_g^2
<div style="display: flex; align-items: center; justify-content: center;"> <div style="writing-mode: vertical-rl; transform: rotate(180deg);">Tube</div> <div style="height: 500px; border-left: 1px solid black; margin: 0 10px; position: relative;"> <div style="position: absolute; top: 0; left: -5px;">↑</div> <div style="position: absolute; bottom: 0; left: -5px;">↓</div> </div> </div>	T01	83	88.4	0.195	0.3805	0.9436	12.7	10.5	0.195	151.0	6.17
	T02	85	87.7	0.242	0.2909	0.9237	15.0	12.0	0.279	91.0	7.60
	T03	78	89.1	0.333	0.2150	0.9013	20.4	39.4	0.400	59.59	9.54
	T04	76	91.4	0.655	0.1152	0.8160	39.4	32.5	0.795	27.81	17.59
	T04R	75	87.6	0.670	0.1112	0.8333	36.0	29.8	0.808	24.15	15.78
	T05	85	88.7	0.154	0.4808	0.9622	11.7	10.1	0.131	312.02	5.39
	T06	80	86.7	0.119	0.6176	0.9712	12.6	10.2	0.0796	956.4	6.06
	T01SP	100	87.7	0.195	0.3825	0.9442	12.7	10.5	0.1833	160.0	5.40
	T02SP	94.5	89.4	0.240	0.3128	0.9247	15.3	12.3	0.2450	105.0	6.33
	T03SP	103.5	89.5	0.338	0.2173	0.8994	19.8	15.9	0.3756	59.4	8.40
	T04SP	100	90.4	0.667	0.1116	0.8151	35.8	28.9	0.7756	25.0	15.0
	T05SP	95	88.5	0.153	0.4751	0.9622	10.7	9.1	0.1312	284.5	4.90
	T07SP	98	89.7	0.112	0.6688	0.9756	8.0	6.9	0.0637	870.0	3.52
	TM01	89.5	84.8	0.196	0.3640	0.9464	12.6	10.5	0.1962	146.7	5.65
	TM02	95.5	88.0	0.243	0.2886	0.9287	14.4	11.6	0.2690	91.54	6.63
	TM03	98.5	82.5	0.332	0.2073	0.8846	18.9	14.5	0.3843	53.88	7.96
	TM05	100	82.4	0.132	0.4578	0.9654	10.3	8.8	0.1333	265.5	4.72
	SM09	86.7	83.9	0.120	0.0576	0.7596	10.4	1.6	1.4692	0.41	0.88
	SM10	84.8	82.3	0.572	0.0850	0.8000	27.1	19.7	1.0024	20.69	20.79
	SM11	100	90.3	0.172	0.2799	0.9019	9.6	5.8	0.2805	84.15	6.62
	SM12	97	89.7	0.103	0.4776	0.9439	6.2	3.9	0.1303	251.8	4.28
	SM13	97.8	89.2	0.689	0.6954	0.9692	3.6	2.2	0.0569	778.2	2.52
	S08	103.5	89.3	0.095	0.7750	0.9801	7.4	6.4	0.0389	2230	3.38
	S09	100	83.4	1.214	0.0595	0.7949	65.5	57.9	1.3821	15.37	29.36
	S10	85.5	89.3	0.592	0.0832	0.7918	25.2	17.5	1.0647	17.21	19.51
	S11	93	89.9	0.173	0.2815	0.9075	10.2	6.6	0.2821	92.91	7.40
	S13	97	89.7	0.070	0.7013	0.9715	3.6	2.4	0.0558	844.7	2.63
	S14	81	70.0	0.693	0.1096	0.8495	40.7	35.1	0.7237	27.14	14.21
	S15	93.5	34.7	0.232	0.3190	0.9271	15.3	12.4	0.2329	114.4	6.20
	S16	106.0	61.7	0.119	0.6266	0.9833	9.4	8.6	0.0615	793.8	3.0

TABLE 2 (Continued)

Geometry	Test No.	Temperature T (°F)	Pressure P (psia)	Total Mass Velocity $G \times 10^{-6}$ (lb/h-ft ²)	Mass Quality $\bar{x}$	Average Void Fraction $\bar{\alpha}$	Total Pressure Gradient $(\Delta P/\Delta Z)_T \times 10^3$ (psi/in.)	Friction Pressure Gradient $(\Delta P/\Delta Z)_f \times 10^3$ (psi/in.)	Flow Modulus X_{LM}	N.D. Pressure Gradient ϕ_L^2	N.D. Pressure Gradient ϕ_G^2
Annulus	A01	66.5	83.9	0.702	0.1403	0.8855	77.4	73.0	0.6357	24.53	9.91
	A02	82.0	86.1	0.373	0.2669	0.9327	67.8	65.2	0.3018	94.33	8.59
	A03	85.0	88.3	0.201	0.3792	0.9444	31.8	29.5	0.1906	176.7	6.42
	A04	85.0	88.7	0.159	0.4900	0.9663	24.9	23.4	0.1271	305.0	4.93
	A05	89.5	91.6	0.125	0.6241	0.9781	18.6	17.6	0.0782	618.8	3.78
	A06	85.5	87.4	0.270	0.3707	0.9393	65.2	62.8	0.1958	216.6	8.30
	A07	92.5	92.1	0.163	0.6131	0.9832	29.4	28.6	0.0813	343.6	3.92
	A08	80.5	68.9	0.200	0.3713	0.9621	37.3	35.8	0.1752	120.8	6.41
	A09	84.0	91.2	0.685	0.1158	0.8539	87.6	82.1	0.7764	28.59	17.23
	A10	83.0	90.9	0.349	0.2262	0.9128	53.2	49.8	0.3770	74.09	10.53
Eccentric Annulus	EA1	91.0	88.5	0.697	0.1469	0.8607	91.0	85.8	0.5890	31.34	10.87
	EA1R	105.0	85.7	0.699	0.1440	0.8692	91.4	86.5	0.5753	32.11	10.62
	EA6	87.5	91.2	0.267	0.3800	0.9528	43.9	41.9	0.1921	151.0	5.57
	EA6R	83.5	90.5	0.269	0.3773	0.9433	44.3	42.0	0.1951	147.8	5.62
Tube	AA1	106.0	74.1	0.109	1.000	1.000	11.4	11.2			1.02
	T01E	68.0	87.2	0.199	0.3752	0.9448	57.0	54.7	0.1999	173.5	6.93
	T02E	78.0	87.6	0.246	0.3008	0.9256	54.8	51.8	0.2643	111.3	7.77
	T03E	72.0	88.2	0.341	0.2204	0.8968	50.8	46.9	0.3922	60.12	9.25
	T04E	76.0	88.2	0.669	0.1062	0.8141	36.6	29.6	0.8485	23.22	16.72
	T05E	89.0	86.9	0.155	0.4695	0.9609	60.4	58.8	0.1343	299.8	5.41
	S12	96.5	88.9	0.103	0.4880	0.9508	6.1	4.1	0.1251	272.4	4.26
	S13R	101.5	89.2	0.071	0.6739	0.9671	3.7	2.2	0.0607	666.1	2.46

TABLE 2. (Continued)

Geometry	Test No.	Temperature T (°F)	Pressure P (psia)	Total Mass Velocity G×10 ⁻⁶ (lb/h-ft ²)	Mass Quality $\bar{x}$	Average Void Fraction $\bar{\alpha}$	Total Pressure Gradient ($\Delta P/\Delta Z$) _T ×10 ³ (psi/in.)	Friction Pressure Gradient ($\Delta P/\Delta Z$) _f ×10 ³ (psi/in.)	Flow Modulus X _{LM}	N.D. Pressure Gradient ϕ_L^2	N.D. Pressure Gradient ϕ_G^2	Re×10 ⁻⁴	f
Tube Shakedown, Preliminary Data	1	68	115	0.272	0	0		0.2538				0.926	0.0262
	2			0.383								1.30	0.0242
	3			0.530								1.80	0.0272
	4			0.752								2.56	0.0231
	5			1.16								3.94	0.0212
	6			1.13								3.87	
	7			1.73								5.90	0.0197
	8			2.34								8.00	0.0182
	9	62		0.425								1.44	0.0207
	10	62		0.558								1.89	0.0242
All Liquid Tube	11	65		0.288								0.974	0.0329
	12			0.360								1.22	0.0296
	13			0.520								1.76	0.0281
	14			0.570								1.93	0.0260
	15			1.01								3.42	0.0236
	16			1.13								3.82	0.0238
	17			1.47								4.97	0.0221
	18			1.74								5.87	0.0212
	19			2.24								7.57	0.0197
	20	66	95	2.54								8.59	0.0194
Tube	21		79	0.536	0.0923	0.814	~2.6	~2.0	Faulty Manometer				
	22		95	0.653	0.0928	0.788	~2.6	~1.9					
	23	68	89	0.264	0.284	0.912	14.5	11.0	0.292		6.50		
	24	72	89	0.271	0.259	0.913	15.1	11.7	0.318		7.11		
	25	66	90	0.403	0.171	0.862	20.8	15.6	0.536		10.1		
	26	67	92	0.423	0.150	0.849	20.7	15.0	0.617		11.6		
	27	67	99	0.627	0.0942	0.804	25.8	18.5	1.025		17.2		
	28	104	93	0.130	0.572	0.951	12.7	10.6	0.0922		5.77		
	29	97	94	0.152	0.491	0.945	11.8	9.62	0.125		5.30		
	30	85	95	0.228	0.330	0.918	15.5	12.3	0.240		7.22		

TABLE 2, (Continued)

Geometry	Test No.	Temperature T (°F)	Pressure P (psia)	Total Mass Velocity $G \times 10^{-6}$ (lb/h-ft ²)	Mass Quality $\bar{X}$	Average Void Fraction $\bar{\alpha}$	Total Pressure Gradient $(\Delta P/\Delta Z)_T \times 10^3$ (psi/in.)	Friction Pressure Gradient $(\Delta P/\Delta Z)_f \times 10^3$ (psi/in.)	Flow Modulus X_{LM}	N.D. Pressure Gradient ϕ_l^2	N.D. Pressure Gradient ϕ_g^2	$Re \times 10^{-4}$	f
Tube	31	82	95	0.291	0.258	0.897	18.6	14.6	0.319		8.32		
	32	76	97	0.450	0.166	0.850	24.1	18.4	0.558		10.9		
	33	75	82	0.532	0.131	0.845	29.5	23.7	0.662		13.5		
Concentric Annulus	34	125	88	0.075	1.0	1.0	2.10	1.87	0		0.92		
	35	114	89	0.112	0.664	0.964	7.91	6.37	0.0636		3.28		
	36	112	94	0.117	0.632	0.957	8.42	6.61	0.0728		3.61		
Concentric Annulus	37	65	86	0.924	0.0	0.0	43.3	7.22				1.52	0.0315
	38	65	84	1.288			48.9	12.9				2.12	0.0288
	39	65	76	1.572			54.7	18.5				2.59	0.0278
Concentric Annulus	40	67	63	0.073			36.3	0.220				0.122	0.149
	41	73	86	0.171			36.4	0.279				0.312	0.0356
	42	68	78	0.367			37.5	1.36				0.620	0.0375
Concentric Annulus	43	67	71	0.604	0.0	0.0	39.4	3.34				1.00	0.0340
	44	105	52	0.104	1.0	1.0	9.64	9.50				9.30	0.0129
	45	108	60	0.078			6.13	5.97				6.92	0.0167
Concentric Annulus	46	98	61	0.066			3.31	3.14				6.0	0.0125
	47	99	87	0.045	1.0	1.0	1.93	1.69				4.10	0.0206
	48	89	96	0.228	0.435	0.932	37.6	34.9	0.160	200	5.14		
Concentric Annulus	49	82	94	0.198	0.359	0.910	24.6	21.0	0.229	114	5.65		
	50	Power Failure Interrupted Data Run											
	51	89	93	0.429	0.231	0.938	39.2	36.7	0.365	39.4	5.27		
Concentric Annulus	52	75	95	0.401	0.175	0.879	48.6	44.0	0.522	45.2	12.3		
	53	90	92	0.226	0.424	0.933	40.1	37.4	0.163	214	5.65		
	54	95	95	0.227	0.416	0.944	36.2	34.0	0.169	190	5.40		
Concentric Annulus	55	88	99	0.206	0.354	0.927	25.9	23.0	0.225	127	6.12		
	56	86	95	0.292	0.332	0.932	47.8	45.1	0.238	123	6.98		
	57	96	100	0.0388	1.0	1.0	1.56	1.28	0			3.06	0.0324
Concentric Annulus	58	114	101	0.0631			3.09	2.82	0			5.59	0.0201
	59	147	97	0.0957			7.36	7.11	0			8.12	0.0145
	60	90	102	0.0267			1.95	1.66	0			2.44	0.069
Concentric Annulus	61	107	104	0.0457	1.0	1.0	2.31	2.03	0			4.07	0.0286

TABLE 2 (Continued)

Geometry	Test No.	Temperature T (°F)	Pressure P (psia)	Total Mass Velocity $G \times 10^{-6}$ (lb/h-ft ²)	Mass Quality $\bar{x}$	Average Void Fraction $\bar{\alpha}$	Total Pressure Gradient $(\Delta P/\Delta Z)_T \times 10^3$ (psi/in.)	Friction Pressure Gradient $(\Delta P/\Delta Z)_f \times 10^3$ (psi/in.)	Flow Modulus X_{LM}	N.D. Pressure Gradient ϕ_l^2	N.D. Pressure Gradient ϕ_g^2	$Re \times 10^{-4}$	f
Concentric Annulus	62	152	98	0.100	1.0	1.0	7.31	7.06	0			8.46	0.0181
	63	160	93	0.122	1.0	1.0	11.5	11.3	0			10.2	0.0189
	64	76	100	0.330	0.183	0.868	34.4	29.3	0.505	43.7	11.3		
	65	79	95	0.344	0.254	0.885	48.7	42.3	0.336	72.2	8.42		
	66	81	94	0.282	0.348	0.944	44.2	41.9	0.228	127	6.27		
	67	73	93	0.426	0.0	0.0	37.8	16.9	∞	1.10		0.777	0.0349
	68	75	96	0.468	0.102	0.814	40.4	33.4	0.938	22.1	19.0		
	69	74	93	0.506	0.162	0.874	59.9	55.1	0.561	35.8	11.4		
	70	74	94	0.496	0.143	0.860	51.2	45.9	0.646	29.8	12.5		
	71	80	93	0.507	0.165	0.878	61.1	56.4	0.548	36.7	10.9		
Tube	72	73	97	0.439	0.0	0.0	36.8	0.73	∞	1.04		1.62	0.0282
	73	77	99	0.481	0.833	0.759	22.5	13.6	1.14	19.3	26.1		
	74	78	94	0.511	0.141	0.850	27.5	21.8	0.653	31.0	14.0		
	75	79	99	0.501	0.123	0.832	25.5	19.2	0.770	27.2	16.8		
	76	78	94	0.517	0.149	0.829	26.0	19.6	0.617	27.9	11.1		
	77	80	95	0.522	0.157	0.838	26.7	20.6	0.582	29.3	10.5		
	78	73	97	0.768	0.0	0.0	38.1	1.98	∞	103		2.78	0.0251
	79	73	101	0.814	0.123	0.70	30.1	18.9	1.89	9.58	39.6		
	80	74	94	0.851	0.128	0.792	36.5	28.8	1.32	14.0	25.5		
	81	76	93	0.840	0.127	0.800	38.3	30.7	1.10	15.9	20.2		
	82	72	99	1.092	0.165	0.0	39.7	36.1	∞	1.00		3.96	0.0228
	83	73	95	1.138	0.172	0.669	38.5	26.4	2.59	7.10	49.9		
	84	74	94	1.153	0.053	0.752	48.6	39.5	1.73	10.8	34.0		
	85	74	93	1.160	0.059	0.763	53.2	44.4	1.57	12.1	30.4		
	86	73	94	0.848	0.089	0.813	42.0	35.0	1.04	17.6	19.5		
	87	74	92	0.854	0.097	0.819	44.5	38.0	0.948	19.3	18.4		
	88	74	88	0.857	0.103	0.824	47.3	40.8	0.882	20.8	17.0		
	89	73	92	1.163	0.063	0.778	55.3	47.1	1.45	12.9	28.5

FIGURE 37. SINGLE-PHASE FRICTION FACTOR VERSUS REYNOLDS NUMBER—ROUND TUBE (1 in. i.d.) AND ANNULI (1 in. i.d. AND 0.5 in. o.d. ROD) WITH AIR AND WATER FLOW

FIGURE 38. TWO-PHASE PRESSURE DROP AND AVERAGE VOID FRACTION FOR VERTICAL UPWARD FLOW IN A ROUND TUBE (1-inch o.d.), CONCENTRIC ANNULUS (1-inch i.d. tube, 0.5-inch o.d. rod), AND NINE-ROD SQUARE ARRAY (1-inch rods in 4.29-inch channel) FOR AIR-WATER AT 90 TO 100 psia, 80°F.

4.3 PRESTON SHEAR PROBE RESULTS

Consider steady, turbulent, single-phase flow in a circular duct of constant cross section, at a position far removed from the duct inlet. There is a universality of the velocity profile near the wall which is related directly to the wall shear and fluid properties, and is independent of the duct diameter. This universality is expressed by the law of the wall, and applies even to the turbulent boundary layer flow over a flat plate, provided the pressure gradient is small. The law of the wall is expressed symbolically as

$$\frac{V}{U_\tau} = f\left(\frac{yU_\tau}{\nu}\right),$$

where V is the velocity a distance y from the wall, $U_\tau = \left(\frac{\tau_w g_c}{\rho}\right)^{1/2}$ is the friction velocity, and ν is the kinematic viscosity.

Let an impact probe be placed in contact with the wall so that its axis is parallel with the wall and its open end faces upstream. If the probe diameter is small enough that the probe is within the region for which the law of the wall applies, then

$$\frac{\Delta P_I g_c}{\rho U_\tau^2} = f\left(\frac{U_\tau d}{\nu}\right),$$

where ΔP_I is the impact pressure measured by the probe, and d is the outside diameter of the tube from which the probe is constructed.

The foregoing is one expression of the relationship between wall shear and impact pressure, which may be presented in a more convenient form:⁽⁹⁾ namely,

$$\frac{\tau_w g_c d^2}{4\rho \nu^2} = f\left(\frac{\Delta P_I g_c d^2}{4\rho \nu^2}\right).$$

The simple impact tube, when used in this manner to measure wall shear, is known as a Preston tube.

An impact tube with an outside diameter of 0.025 inch and an inside diameter of 0.0125 inch was filed on one side so that when the probe is against the wall, the wall-to-probe center-line distance is 0.008 inch. A single-phase (air) velocity profile taken with the probe, plotted in nondimensional (U^+ versus y^+) coordinates, shows the standard "law of the wall" form (Figure 39). The data have been corrected for both velocity gradient and wall effects, using the correction technique of McMillan.⁽¹⁰⁾ The results are in good agreement with Nikuradse's data for $Re = 1.1 \times 10^5$.⁽⁸⁾ The Preston calibration point (pitot tube against the wall) associated with this profile is shown, in Figure 40, to be in good agreement with the NPL⁽¹¹⁾ and Patel⁽¹²⁾ correlations.

If the Preston shear probe technique is to be successful in two-phase flow, it will reflect some type of universal structure near the wall. The dynamic pressure profiles of Figure 41

FIGURE 39. NONDIMENSIONAL VELOCITY DISTRIBUTION — AIR FLOW

FIGURE 40. NONDIMENSIONAL PRESTON-TYPE SHEAR PROBE CALIBRATION AIR-WATER AT 90 psia, 100°F

FIGURE 41. DYNAMIC PRESSURE VERSUS POSITION IN TUBE. AIR AND WATER FLOW AT 90 psia IN 0.995 i.d. TUBE AT VARIOUS QUALITIES. $W_A = 0.11$ lb./sec.

show some consistency inside the local peaks which occur near the wall. (Earlier isokinetic sampling profiles have shown the flow structure at these conditions to be annular-dispersed.) In spite of the lack of complete understanding of the flow structure, the data (Figures 40 and 42) show this Preston-tube correlation technique to have promise as an indirect method of two-phase wall-shear determination. The data shown in Figure 40 were taken at a constant air flow rate of 0.11 lb/sec. and the water flow rate was varied to provide mass qualities from 11 to 62%. The nondimensional data (using liquid properties) form a single, smooth curve—but one which is not identical with the single-phase curve.

Later data (S and SM series) are delineated in Figure 42, and show considerable scatter. However, there was some doubt about the accuracy of the S-series data and the tests were therefore repeated (SM series), in part, along with some of the flow conditions from the original set of data. Except for runs 12 and 13, the SM-series data fall within +30% of the single-phase curve. Runs 12 and 13 are both high quality and relatively low mass velocity conditions. This results in a very thin liquid film which is thinner than the probe. Reasonable correlation of shear-probe data for these conditions probably has to be done with mixed-mean properties rather than liquid properties. In this regard, the effects of properties can be seen in Figure 42 where runs SM12 and SM13 have been nondimensionalized with air properties and are shown as solid symbols. In this case, the data points are moved closer to the single-phase calibration curves with air properties than those with water properties (comparable points are marked with similar diagonal lines).

The usefulness of the Preston tube for wall shear measurement is limited, at this stage of development, by lack of proof of a universal nondimensional velocity profile in the film region, and the further practical difficulty of making probes small enough to remain within the wall-film region.

4.4 LIQUID FILM SAMPLE RESULTS

The results of drawing off a sample through a porous wall section of the round tube are presented in Figure 43. These data are for a series of data runs where the air flow rate was held constant and the liquid rate varied. The data were taken in such detail that considerable information about the flow near the wall may be deduced. A typical sample curve and a tentative model that accounts for the observed results are shown in Figures 44A and 44B.

The model consists of a very thin layer of solid ($\chi = 0$) water flowing against the wall, and an irregular layer of very low quality fluid flowing above the solid water. As the valve is opened to draw off the film, only the solid water is drawn off at first (W_L). Then, as the valve is opened farther, a sample of nearly constant quality (but very low quality) fluid is obtained, until a rate of liquid equal to W_{SF} is reached. At this point, it is presumed that just the film below the troughs of the waves is being sampled (W_{SF}). The quality in this very low quality region can be determined by the slope of the line in this region. The quality determined in this manner is plotted against total average system quality in Figure 45.

As the control valve is opened farther, intermittent samples of high quality fluid are obtained with the film flow. This supports the concept of the wavy structure shown in the model (Figure 44A). The slope of the water sample rate versus the air sample rate curve changes

FIGURE 42. NONDIMENSIONAL PRESTON-TYPE SHEAR PROBE DATA — AIR-WATER FLOW

FIGURE 43. LIQUID FILM SAMPLES, ROUND TUBE

67-01275

FIGURE 44A: TENTATIVE VERY-LOW-QUALITY FILM MODEL

67-01276

FIGURE 44B. TYPICAL FILM SAMPLE DRAWN OFF THROUGH POROUS WALL. RELATION OF PARTS OF CURVE TO VERY-LOW-QUALITY FILM MODEL.

FIGURE 45. QUALITY OF VERY-LOW-QUALITY FILM FLOW VERSUS TOTAL SYSTEM QUALITY FOR AIR-WATER UPFLOW IN 1-INCH TUBE WITH $W_{\text{Air}} = 0.11 \text{ lb/sec}$ AND PRESSURE $\cong 87 \text{ psia}$

abruptly in this region. At a water rate of W_{IF} , the curve settles to another slope indicative of higher quality flow outside the film. At this point, it is assumed that the entire film is being sampled. As the sampling valve is opened farther, a curve of finite slope is obtained, indicating that outside the film the core is not entirely vapor.

Under this model, the truest measure of the total liquid flow in the very low quality film is W_{IF} . But W_{IF} is difficult to determine experimentally, so W_{F} is defined as shown in Figure 44B (the intersection of two straight lines), and is used to consider the trends in film flow rates. W_{F} divided by the total liquid flow is given as a function of total average system quality in Figure 46. It is observed that at total system qualities as high as 60%, the liquid flow in the film is still less than one-third of the total liquid flow; the remainder is dispersed in the core region. This regime is often called "annular-dispersed" flow. A summary of W_{L} , W_{SF} , W_{F} and W_{IF} is given for the various flows of this tube series in Figure 47.

The results from drawing off film flow rate samples through a porous wall rod and tube are presented for the concentric annulus, also, in Figure 46. Like the tube runs, the air flow rate was held constant and the liquid rate varied. The same trends with changing mean quality are observed for the tube alone and the tube in the concentric annulus. Note that the fraction of liquid flowing on the rod is nearly constant for qualities greater than 25%, and that the rod film flow rate is much lower than the tube flow rate. The rod perimeter is just one-half the tube perimeter, but the rod film flow rate is much less than half the tube film flow rate. Hence,

FIGURE 46. TUBE AND CONCENTRIC ANNULUS LIQUID FLOW RATES IN FILMS ON TUBE AND ROD WALLS

FIGURE 47. FILM FLOW FROM VARIOUS REGIONS OF THE VERY-LOW-QUALITY FILM MODEL AS A FUNCTION OF TOTAL AVERAGE MASS QUALITY

the liquid film flow rate per unit perimeter is also less for the rod than for the tube by about 60%. These results suggest that under boiling conditions a higher heat flux would be required to accomplish film dryout on the tube than on the rod. A number of experimenters have demonstrated that this is indeed the case (see, for example, the work of Becker and Hernborg).⁽¹³⁾

The circumferential film flow rate results for the 38% quality eccentric annulus run are shown in Figure 48, where a water inventory is presented. Note that the minimum in the liquid film flow, both inner and outer surfaces, occurs where the gap is smallest ($\theta = 0$). When this information is combined with the air flow (Figure 28) and gap spacing, the average quality as a function of angular position is obtained, as shown in Figure 29. It is seen that in the narrow gap region, the mass flow is relatively low, the film-flow rate is relatively low, but the average quality is also low. If this were a two-phase boiling heat transfer situation, one might conclude that the low mass flow and low liquid film flow rate would be detrimental to the heat transfer at the close spacing position, but this effect would be somewhat counteracted by the lower overall quality in this region. However, any conclusions about heat transfer trends from these adiabatic two-component flow results should be drawn with caution.

Liquid film flow rate has been measured on the three instrumented rods of the nine-rod geometry by drawing the low quality film through perforated sections of the rods (Section III). The total liquid flows in the films on the three rods are listed in Figure 49 for one flow condition, along with a sketch of their positions. If it is assumed that the same flow occurs on all similar rods in the bundle, then there is a total (nine rods) rod liquid film flow of $287 \text{ cm}^3/\text{sec}$, or 17% of the total liquid flow.

The relative variation of film flow around the corner rod and wall rod was determined by dividing the perforated wall into a local segment (52 degrees on rod II and 56 degrees on rod I) and the remainder. The relative variation around the rods (Figure 49) is not large—in the order of $\pm 10\%$. Note that, like the eccentric annulus, the minimums occur at the positions of smallest flow gap, lowest flow, and lowest shear. If it is assumed that the same average liquid film flow occurs on the channel wall, the total film flow on all wetted surfaces is $460 \text{ cm}^3/\text{sec}$ or 27% of the total liquid flow.

4.5 FILM THICKNESS

The mean liquid film thickness in the round tube geometry was measured. A resistance probe (see Figure 50) was used to measure the electrical resistance from a known probe position to the tube wall. The resistance probe was traversed away from the wall, with the resistance recorded by a Sanborn recorder. An increase in resistance indicates that the probe is outside of the liquid film.

Recorded resistance traces from two of the higher quality runs are shown in Figure 51. The liquid film thickness is established due to the distinct resistance change with probe position. However, for runs with mass qualities below 0.50, the film thickness is less clearly defined. The tracer pin oscillates rapidly between high and low resistance over a considerable range of probe positions. For these runs, the film thickness is defined as being the point where the tracer pin has a 50-50 residence time at high and low resistance. In the quality range of 0.10 to 0.50, it is possible to determine this point to ± 0.005 inch.

FIGURE 48. WATER FLOW INVENTORY IN ECCENTRIC ANNULUS. Isokinetic Sampling Data in Core Region Combined with Liquid Film Flow Data.

FIGURE 49. LIQUID FILM FLOW CIRCUMFERENTIAL VARIATION FOR NINE-ROD AIR-WATER TEST AT 16% QUALITY.

FIGURE 50. RESISTANCE PROBE TIP FOR LIQUID FILM DETERMINATION

Film thicknesses have been calculated for the test conditions, based on data reported by CISE. ⁽²⁾ The CISE data were obtained with higher density gas; hence, some extrapolation was necessary. The results are shown in Figure 52, along with the results from the resistance probe tests. The CISE data are consistently above the present resistance probe data, but the agreement is generally good.

Impact pressure profiles for air-water flow have been reported (Figure 41) which show a peak in impact pressure as the impact probe is traversed away from the wall. The location of the peak in impact pressure is shown on Figure 52 as a function of quality. Note that the peak location falls consistently above the film thickness but that the trend with quality is the same as that of the film thickness. This suggests that the peak in impact pressure is related to the liquid film. The pressure peak appears to occur when the probe is approximately three-quarters of the way out of the liquid film.

NOTE: NUMBERS ON TRACES INDICATE
DISTANCE FROM WALL IN MILS
(0.001 INCH)

LOCATION OF
LIQUID FILM
SURFACE

RUN SM12
AIR MASS FLOW RATE - 0.074 lb/sec
AVERAGE QUALITY - 0.478
TEST PRESSURE - 89.7 psia

LOCATION OF LIQUID
FILM SURFACE

RUN SM13
AIR MASS FLOW RATE - 0.072 lb/sec
AVERAGE QUALITY - 0.695
TEST PRESSURE - 89.2 psia

FIGURE 51. RESISTANCE PROBE TRACES TO
DETERMINE LIQUID FILM THICKNESS

FIGURE 52. COMPARISON OF FILM THICKNESS WITH LOCATION OF PEAK IN IMPACT PRESSURE

SECTION V

DISCUSSION AND CONCLUSIONS

The "homogeneous" sampling technique employed by Gill, Hewitt, and Hitchon⁽¹⁴⁾ is compared to the isokinetic method in Figure 53. The "homogeneous" method consists of (a) assuming the flow is locally homogeneous with a single velocity, V_m , and mixed mean density, $\rho_m = \alpha \rho_g + (1 - \alpha) \rho_l$; i. e., local void given by

$$\alpha_{\text{homo}} = 1 / \left[1 + \frac{\rho_g G_l^*}{\rho_l G_g^*} \right] : \text{(b) measuring impact pressure and local}$$

liquid flow with a simple pitot tube by assuming liquid sample rate is independent of total sample flow (as shown in Figure 10, this assumption is valid only when the local void is very high): and (c) calculating local gas flow from the single fluid equation:

$$\Delta P_I = 1/2 \rho_m V_m^2 : \text{i. e. .}$$

$$\Delta P_I = \frac{(G_g^* + G_l^*) (G_g^* \rho_l + G_l^* \rho_g)}{2 \rho_g \rho_l} .$$

The same data (taken isokinetically) are reduced using both methods in Figure 53. It will be noted that the simpler "homogeneous" method provides adequate definition of the local quality, superficial gas flow rate, and void fraction profiles in the core region. The homogeneous velocity approximates the linear air velocity, but the homogeneous velocity is higher in the core and lower near the wall than the isokinetic air velocity. However, the homogeneous method gives no information about slip ratio or liquid velocity since a slip ratio of unity is assumed. The agreement shown in Figure 53 is typical: some other flows showed better and some much poorer agreement between the two methods. The results shown in Figure 53 were obtained by different isokinetic settings ($P^* = -0.499$ for iso and $P^* = -0.623$ for homo) in order to match the integrated air-mass velocity. This is not surprising since the reduction equations are different.

The simpler "homogeneous" method appears to be most useful for investigation of the core region of annular-dispersed flows where the void fraction is high and very detailed flow structure is not necessary, whereas the additional experimental effort associated with isokinetic sampling is mandatory to investigate properly the entire flow structure or where information on the linear velocities of both phases is sought. The isokinetic reduction method results for the round tube show a fair correlation of local void fraction and local quality in Figure 54. The implied slip ratio variation with quality is also shown to be quite different from unity.

The uncertainties associated with the isokinetic results (and in fact results from any sampling technique) should be borne in mind. The equations used in reducing isokinetic sampling data result from using assumptions in the derivation. Since the proper isokinetic setting cannot be currently determined a priori, one must rely on choosing the correct

FIGURE 53. COMPARISON OF DATA REDUCED BY THE ISOKINETIC AND BRITISH HOMOGENEOUS METHODS

FIGURE 54. LOCAL VOID - LOCAL QUALITY RELATIONSHIP

setting by satisfying the mass continuity equations. However, this method of determining the setting is compromised since there is no reason to believe that the isokinetic setting is constant over the flow cross section. Because of these current uncertainties in this technique, the sampling data at two settings have been presented for the annulus and round tube. At some future time when the a priori correct setting can be determined, these data can be re-evaluated using the linear interpolation technique described in Section III.

The continuity probe results are qualitatively adequate in that the trend of the film thickness and local void fraction variation with quality is determined. However, it is felt that these results are as much as 50% uncertain.

The Preston tube results reflect a universal wall region structure. As long as the probe lies between the wall and the impact pressure peak, it is felt that reliable wall shear stresses can be determined. A larger probe would lie outside the universal wall region structure and indicate erroneous wall shear stresses.

In conclusion, much air-water data have been obtained for the four geometries: round tube, concentric annulus, eccentric annulus, and nine-rod channel. Data for the first three, in particular, have been obtained for the same range of pressures, qualities, and mass velocities. The nine-rod data are for the same pressures and qualities but the mass velocities are lower. The results for the four geometries are complementary with respect to each other, and are intended to give insight concerning the two-phase flow structure in even more complex geometries—specifically the coolant channels of modern power reactors.

Several types of two-phase measurements were made in each type of geometry. Moreover, an effort was made to develop instruments for these measurements which could subsequently be used in high-pressure steam-water. The isokinetic probe, Preston tube, and porous wall are examples of such instruments which can be (and have been⁽¹⁵⁾) so used.

It is hoped that the results reported here will be found useful by other investigators for comparison with their results and for consideration in analytical modeling, to the extent that the state of the art in two-phase flow may be further advanced.

APPENDIX A

ISOKINETIC PROBE RESULTS TABULATION

Subsections A.1 through A.7 contain tabulations on Round Tube and Annulus TPHAS Data Reduction Program, Round Tube Results, British Homogeneous Reduction of Round Tube Data, Concentric Annulus Results, Eccentric Annulus Results, Nine-Rod TPHAS Data Reduction Program, and Nine-Rod Results.

A.1 ROUND TUBE AND ANNULUS TPHAS DATA REDUCTION PROGRAM

```

0001      I      TPHA5
0002      C      THIS CODE PROCESSES ISOKINETIC SAMPLING DATA IN AIR-WATER
0003      C      FLOW. THE OUTPUT INCLUDES LOCAL VALUES OF VOID FRACTION, LINEAR
0004      C      VELOCITIES, QUALITY, AND SLIP RATIO.
0005      C      USE ONLY ORIFICES NOS 1, 2, OR 3 (NOT 4).
0006      C      DIMENSION Y(20),DHI(5,20), DHS(5,20), DHSL(5,20), DHSL(5,20), DHSL(5,20)
0007      C      DIMENSION HGA(5,20), TGA(20), HGW(5,20), TGW(20), HS(5,20)
0008      C      DIMENSION TGA(20), VPS(20), DOIV(20), DTOV(20)
0009      C      DIMENSION RAND(20), GAND(20), GWND(20), GLND(20), RTIO(20)
0010      C      DIMENSION HI(20), RI(20), GR(20), C(20), R(20), A(20)
0011      C      DIMENSION DLPR(20), VOID(20), SLIP(20), QUAL(20), DTG(20)
0012      C      DIMENSION DHIL(5,20), DHIR(5,20), VELA(20), VELW(20)
0013      C      DIMENSION TGAF(20), PLOT(20), HUKA(20)
0014      C      DIMENSION RS(20), GRS(20), GPR(20), GW(20)
0015      C      DIMENSION TGWF(20), CW(20), HW(20), AW(20), OPER(20)
0016      C      DIMENSION CV(20), BV(20), AV(20), VP(20)
0017      C      DIMENSION VAS1(5,20), VAS2(5,20), TAS1(5,20), TAS2(5,20)
0018      C      DIMENSION VWS1(5,20), VWS2(5,20), TWS1(5,20), TWS2(5,20)
0019      C      KIN = IDFTAP(6HITAPIT, 1, 0)
0020      C      KOUT= IDFTAP(6HITAPOT, 2, 0)
0021      C      1 CALL CASE (K)
0022      C      2 FORMAT( 10F8.2 )
0023      C      3 FORMAT( 10F8.6 )
0024      C      4 FORMAT (I3)
0025      C      READ(KIN, 4) (N)
0026      C      READ(KIN, 2) TEST, TM, P*TM
0027      C      READ(KIN, 3) (Y(I), I=1,N)
0028      C      READ(KIN, 2) (DHIL(1,I), I=1,N)
0029      C      READ(KIN, 2) (DHIR(1,I), I=1,N)
0030      C      READ(KIN, 2) (DHIL(2,I), I=1,N)
0031      C      READ(KIN, 2) (DHIR(2,I), I=1,N)
0032      C      READ(KIN, 2) (DHSL(1,I), I=1,N)
0033      C      READ(KIN, 2) (DHSR(1,I), I=1,N)
0034      C      READ(KIN, 2) (DHSL(2,I), I=1,N)
0035      C      READ(KIN, 2) (DHSR(2,I), I=1,N)
0036      C      READ(KIN, 2) (VAS1(1,I), I=1,N)
0037      C      READ(KIN, 2) (VAS1(2,I), I=1,N)
0038      C      READ(KIN, 2) (VAS2(1,I), I=1,N)
0039      C      READ(KIN, 2) (VAS2(2,I), I=1,N)
0040      C      READ(KIN, 2) (TAS1(1,I), I=1,N)
0041      C      READ(KIN, 2) (TAS1(2,I), I=1,N)
0042      C      READ(KIN, 2) (TAS2(1,I), I=1,N)
0043      C      READ(KIN, 2) (TAS2(2,I), I=1,N)
0044      C      READ(KIN, 2) (VWS1(1,I), I=1,N)
0045      C      READ(KIN, 2) (VWS1(2,I), I=1,N)
0046      C      READ(KIN, 2) (VWS2(1,I), I=1,N)
0047      C      READ(KIN, 2) (VWS2(2,I), I=1,N)
0048      C      READ(KIN, 2) (TWS1(1,I), I=1,N)
0049      C      READ(KIN, 2) (TWS1(2,I), I=1,N)
0050      C      READ(KIN, 2) (TWS2(1,I), I=1,N)
0051      C      READ(KIN, 2) (TWS2(2,I), I=1,N)
0052      C      READ(KIN, 2) (ROTOM, ROTO, ORFS, ORFE, DHSL, DHSR, DHIL, DHSL)
0053      C      READ(KIN, 2) PRSA, TEMPA, PRST, TEMPT, VICO
0054      C      IF (TEST) 10, 10, 20
0055      C      10 FAREA = 0.7776
0056      C      K = N/2
0057

```



```

0058      WRITE(KCUT,25)TN
0059      25 FORMAT(24X,32H.T.U.B.E.T.E.S.T.S.E.C.T.I.O.N.7X,22H.T.E.S.T.N.U.
0060      1 M B E R ,F9.0)
0061      GO TO 30
0062      20 FAREA = 0.5812
0063      K = (N+1)/2
0064      WRITE(KCUT,15)TN
0065      15 FORMAT(18X,38H.A.N.N.U.L.U.S.T.E.S.T.S.E.C.T.I.O.N.7X,22H.T.E.S.
0066      1T N U * B E R ,F9.0)
0067      30 CONTINUE
0068      IF( ROTOM ) 40,40,50
0069      40 CFM = 0.1370*ROTO + 2.40
0070      GO TO 60
0071      50 CFM = 0.208*ROTO + 0.40
0072      GO TO 60
0073      60 CONTINUE
0074      DENA = 0.0753*(((PRST + 14.7)/ 14.7)*(530.0 / (TEMPT + 460.0)))
0075      DENAR = 0.0753*(((PRSA + 14.7)/ 14.7)*(530.0 / (TEMPA + 460.0)))
0076      ASFW = (0.004575* CFM)*(SORT(DENAR))
0077      AVGA = ASFW / FAREA
0078      DH50 = DH5L - DH5R
0079      IF (2.0 - ORF5) 80, 90, 100
0080      80 G5W = 0.0968*SORT(DH50)
0081      GO TO 110
0082      90 G5W = 0.0385*SORT(DH50)
0083      GO TO 110
0084      100 G5W = 0.0177*SORT(DH50)
0085      110 CONTINUE
0086      DH60 = DH6L - DH6R
0087      IF (2.0 - ORF6) 120, 130, 140
0088      120 G6W = 0.0935*SORT(DH60)
0089      GO TO 150
0090      130 G6W = 0.0403*SORT(DH60)
0091      GO TO 150
0092      140 G6W = 0.0
0093      150 CONTINUE
0094      WSWF = G5W + G6W
0095      GTW = WSWF / FAREA
0096      ATQUAL = AVGA / (GTW + AVGA)
0097      DO 260 I = 1,N
0098      DHI(1,I) = DHIL(1,I) - DHIR(1,I)
0099      DHI(2,I) = DHIL(2,I) - DHIR(2,I)
0100      HI(I) = ( DHI(1,I) + DHI(2,I) ) / 2.0
0101      DHS(1,I) = DHSL(1,I) - DHSR(1,I)
0102      HS(1,I) = DHS(1,I)/HI(I)
0103      DHS(2,I) = DHSL(2,I) - DHSR(2,I)
0104      HS(2,I) = DHS(2,I)/HI(I)
0105      HGA(1,I) = 0.001362*((VAS1(1,I)/TAS1(1,I))+(VAS1(2,I)/TAS1(2,I)))
0106      HGA(2,I) = 0.001362*((VAS2(1,I)/TAS2(1,I))+(VAS2(2,I)/TAS2(2,I)))
0107      HGW(1,I) = 1.134*((VWS1(1,I)/TWS1(1,I))+(VWS1(2,I)/TWS1(2,I)))
0108      HGW(2,I) = 1.134*((VWS2(1,I)/TWS2(1,I))+(VWS2(2,I)/TWS2(2,I)))
0109      R(I) = 0.4725 - Y(I)
0110      PLOT(I) = R(I) / 0.4975
0111      260 CONTINUE
0112      HNW = -0.10
0113      DO 380 J=1,5
0114      DO 265 I=1,N

```

```

0115      TGAF(I) = ((HS(1,I)-HNN)/((HS(1,I)-HS(2,I)))*(HGA(2,I)-HGA(1,I))
0116      1      +HGA(1,I)
0117      GR(I) = R(I) * TGAF(I)
0118      TGWF(I) = ((HS(1,I)-HNN)/((HS(1,I)-HS(2,I)))*(HGW(2,I)-HGW(1,I))
0119      1      +HGW(1,I)
0120      GW(I) = R(I)*TGWF(I)
0121      265 CONTINUE
0122      IF (R(1)-R(N))270,290,310
0123      270 IF (TEST)280,280,285
0124      280 DO 281 I= 1, N
0125          RS(I) = R(I)
0126          GRS(I) = GR(I)
0127          GRW(I) = GW(I)
0128          RS(N+1) = 0.4975
0129          GRS(N+1) = 0.0
0130          GRW(N+1) = 0.0
0131      281 CONTINUE
0132      GO TO 360
0133      285 DO 286 I=1,N
0134          RS(I+1) = R(I)
0135          GRS(I+1) = GR(I)
0136          GRW(I+1) = GW(I)
0137          RS(1) = 0.250
0138          GRS(1) = 0.0
0139          GRW(1) = 0.0
0140          RS(N+2) = 0.4975
0141          GRS(N+2) = 0.0
0142          GRW(N+2) = 0.0
0143      286 CONTINUE
0144      290 CONTINUE
0145      GO TO 360
0146      310 IF (TEST)320,320,340
0147      320 DO 330 I= 1, N
0148          RS(I+1) = R(I)
0149          GRS(I+1) = GR(I)
0150          GRW(I+1) = GW(I)
0151          RS(1) = 0.4975
0152          GRS(1) = 0.0
0153          GRW(1) = 0.0
0154      330 CONTINUE
0155      GO TO 360
0156      340 DO 350 I=1, N
0157          RS(I+1) = R(I)
0158          GRS(I+1) = GR(I)
0159          GRW(I+1) = GW(I)
0160          RS(1) = 0.4975
0161          GRS(1) = 0.0
0162          GRW(1) = 0.0
0163          RS(N+2) = 0.250
0164          GRS(N+2) = 0.0
0165          GRW(N+2) = 0.0
0166      350 CONTINUE
0167      360 CONTINUE
0168      SUM = 0.0
0169      DO 370 I=1,K
0170          C(I) = ((GRS(2*I-1) - GRS(2*I)) / (RS(2*I-1) - RS(2*I+1)))
0171      1      - (GRS(2*I-1) - GRS(2*I)) / (RS(2*I-1) - RS(2*I))

```

```

0172      2 / (RS(2*I+1) - RS(2*I))
0173      B(I) = ((GRS(2*I-1) - GRS(2*I)) / (RS(2*I-1) - RS(2*I)))
0174      1 - C(I) * (RS(2*I-1) + RS(2*I))
0175      A(I) = GRS(2*I-1) - B(I)*RS(2*I-1) - C(I)*(RS(2*I-1)**2.0)
0176      SUM = SUM + A(I)*(RS(2*I+1) - RS(2*I-1))
0177      1 + 0.5*B(I)*(RS(2*I+1)**2.0 - RS(2*I-1)**2.0)
0178      2 + (C(I) / 3.0)*(RS(2*I+1)**3.0 - RS(2*I-1)**3.0)
0179 370 CONTINUE
0180      SUM = ARS(SUM)
0181      BG = 6.2834*(SUM/FAREA)
0182      ER = (AVGA - BG) / AVGA
0183      M = N/2
0184      HNW1 = ((TGAF(M-1)*(1.0+ER)-HGA(1,M-1))
0185      1 / (HGA(2,M-1)-HGA(1,M-1)))*(HS(2,M-1)
0186      2 -HS(1,M-1))+HS(1,M-1)
0187      HNW2 = ((TGAF(M)*(1.0+ER)-HGA(1,M))
0188      1 / (HGA(2,M)-HGA(1,M)))*(HS(2,M)
0189      2 -HS(1,M))+HS(1,M)
0190      HNW3 = ((TGAF(M+1)*(1.0+ER)-HGA(1,M+1))
0191      1 / (HGA(2,M+1)-HGA(1,M+1)))*(HS(2,M+1)
0192      2 -HS(1,M+1))+HS(1,M+1)
0193      DBER(J) = ER
0194      HNW(J) = 0.3333*(HNW1 +HNW2 +HNW3)
0195      HNW = HNW(J)
0196 380 CONTINUE
0197      SUMW = 0.0
0198      DO 385 I=1,K
0199      CW(I) = ((GRW(2*I-1) - GRW(2*I)) / (RS(2*I-1) - RS(2*I+1))
0200      1 - (GRW(2*I-1) - GRW(2*I)) / (RS(2*I-1) - RS(2*I)))
0201      2 / (RS(2*I+1) - RS(2*I))
0202      RW(I) = ((GRW(2*I-1) - GRW(2*I)) / (RS(2*I-1) - RS(2*I)))
0203      1 - CW(I)*(RS(2*I-1) + RS(2*I))
0204      AW(I) = GRW(2*I-1) - RW(I)*RS(2*I-1) - CW(I)*(RS(2*I-1)**2.0)
0205      SUMW = SUMW + AW(I)*(RS(2*I+1) - RS(2*I-1))
0206      1 + 0.5*RW(I)*(RS(2*I+1)**2.0 - RS(2*I-1)**2.0)
0207      2 + (CW(I) / 3.0)*(RS(2*I+1)**3.0 - RS(2*I-1)**3.0)
0208 385 CONTINUE
0209      SUMW = ARS(SUMW)
0210      BGW = 6.2834*(SUMW/FAREA)
0211      ERW = (GTW - BGW) / GTW
0212      DO 390 I=1,N
0213      TGA(I) = ((HS(1,I)-HNW)/(HS(1,I)-HS(2,I)))*(HGA(2,I)-HGA(1,I))
0214      1 +HGA(1,I)
0215      TGW(I) = ((HS(1,I)-HNW)/(HS(1,I)-HS(2,I)))*(HGW(2,I)-HGW(1,I))
0216      1 +HGW(1,I)
0217      RTIO(I) = ((HS(1,I)/(HS(1,I)-HS(2,I)))*(HGA(2,I)-HGA(1,I))
0218      1 +HGA(1,I))/TGA(I)
0219      PSIA = 0.063
0220      DLPR(I) = PSIA * HI(I)
0221      QUAL(I) = TGA(I) / (TGA(I) + TGW(I))
0222      VOID(I) = (DLPR(I)-((2.24*(TGA(I)**2.0))/(DENA))
0223      1 - (0.0359*(TGW(I)**2.0)))/(DLPR(I)
0224      2 - ((2.24*(TGA(I)**2.0))/(DENA)) + (0.0359*(TGW(I)**2.0)))
0225      SLIP(I) = ((62.2)/(DENA)) * (TGA(I)/TGW(I))
0226      1 * (1.0 - VOID(I)) / (VOID(I))
0227      VELA(I) = (144.0 * TGA(I))/(DENA * VOID(I))
0228      VELW(I) = (144.0 * TGW(I))/(62.2 * (1.0 - VOID(I)))

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0229      VRS(I)=VOID(I)*R(I)
0230      390 CONTINUE
0231      IF (TEST)400,405,410
0232      400 DO 402 I= 1,N
0233          RS(I+1)= R(I)
0234          VR(I+1)=VRS(I)
0235          RS(1) = 0.4975
0236          VR(1) = 0.0
0237          RS(N+2)= R(N)-0.025
0238          VR(N+2)= 0.0
0239      402 CONTINUE
0240      GO TO 450
0241      405 DO 407 I= 1,N
0242          RS(I+1) =R(I)
0243          VR(I+1)=VRS(I)
0244          RS(1) =0.4975
0245          VR(1) =0.0
0246      407 CONTINUE
0247      GO TO 450
0248      410 DO 412 I =1,N
0249          RS(I+1) = R(I)
0250          VR(I+1)=VRS(I)
0251          RS(1) = 0.4975
0252          VR(1) = 0.0
0253          RS(N+2) = 0.250
0254          VR(N+2) = 0.0
0255      412 CONTINUE
0256      450 CONTINUE
0257      SUMV = 0.0
0258      DO475 I=1,K
0259          CV(I) = ((VR(2*I-1)-VR(2*I+1)) / (RS(2*I-1)- RS(2*I+1))
0260              1 - (VR(2*I-1) -VR(2*I)) / (RS(2*I-1)- RS(2*I)))
0261              2 / (RS(2*I+1) -RS(2*I))
0262          BV(I) = ((VR(2*I-1) - VR(2*I)) / (RS(2*I-1) - RS(2*I)))
0263              1 -CV(I) * (RS(2*I-1) + RS(2*I))
0264          AV(I) = VR(2*I-1) -BV(I)*RS(2*I-1) - CV(I)*(RS(2*I-1)**2.0)
0265          SUMV = SUMV + AV(I)*(RS(2*I+1)-RS(2*I-1))
0266              1 + 0.5*BIV(I)*(RS(2*I+1)**2.0 - RS(2*I-1)**2.0)
0267              2 + (CV(I) / 3.0)*(RS(2*I+1)**3.0 - RS(2*I-1)**3.0)
0268      475 CONTINUE
0269      SUMV =ABS(SUMV)
0270      AVOID = 6.2834 * (SUMV/FAREA)
0271      DO 480 I=1,N
0272          AVA=(144.0*AVGA) / (DENA*VIOD)
0273          AVW=(144.0*GTW) / (62.3*(1.0-VIOD))
0274          DIOV(I)=VELA(I) / AVA
0275          DOIV(I)=VELW(I) / AVW
0276          GAND(I)=TGA(I) / AVGA
0277          GWND(I)=TGW(I) / GTW
0278          QLND(I)=QUAL(I) / ATQUAL
0279          RAND(I)=VELW(I) / AVW
0280      480 CONTINUE
0281      WRITE(KOUT,545)FAREA,DENA
0282      545 FORMAT(44H0FLOW AREA OF TEST SECTION (INCHES) ,F7.4,8X,50H
0283      1 DENSITY OF TEST AIR (LBM/FT3) 1° ,F7.4)
0284      WRITE(KOUT,546)HNH,VIOD
0285      546 FORMAT(44H0APPROX. ISOINETIC SETTING OF MANOMETER ,F7.4,8X,50H

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0286      1 AVERAGE VOID FRACTION (QUICK CLOSING VALVES)  ,F7.4)
0287      WRITE(KOUT,547)ATQUAL,AVOID
0288      547 FORMAT(44H0AVERAGE TOTAL QUALITY  ,F7.4,8X,50H
0289      1 AVERAGE VOID FRACTION (INTEGRATED)  ,F7.4)
0290      WRITE(KOUT,540)AVGA,GTW
0291      540 FORMAT(44H0AIR MASS VELOCITY (LBM/SEC-IN2)  ,F7.4,8X,50H
0292      1 WATER MASS VELOCITY (LBM/SEC-IN2)  ,F7.4)
0293      WRITE(KOUT,550)BG,BGW
0294      550 FORMAT(44H0INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)  ,F7.4,8X,50H
0295      1 INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)  ,F7.4)
0296      WRITE(KOUT,560)ER,ERW
0297      560 FORMAT(44H0ERROR IN AIRFLOW (INTEGRATED TO TRUE)  ,F7.4,8X,50H
0298      1 ERROR IN WATERFLOW (INTEGRATED TO TRUE)  ,F7.4)
0299      WRITE(KOUT,548)AVA,AVW
0300      548 FORMAT(44H0AVERAGE LINEAR AIR VELOCITY  ,F7.4,8X,50H
0301      1 AVERAGE LINEAR WATER VELOCITY  ,F7.4)
0302      WRITE (KOUT,555)
0303      555 FORMAT (2H0 )
0304      WRITE (KOUT,555)
0305      WRITE ( KOUT, 700 ) ( R(I), I=1,N )
0306      700 FORMAT( 31HORADIUS TO CL OF PROBE (IN) , 10F9.4 )
0307      WRITE ( KOUT, 780 ) ( PLOT(I), I=1,N )
0308      780 FORMAT( 31HOR(I) / TOTAL RADIUS , 10F9.4 )
0309      WRITE( KOUT, 820 ) ( DLPR(I), I=1,N )
0310      820 FORMAT( 31H0IMPACT PRESSURE (PSIA) , 10F9.4 )
0311      WRITE( KOUT, 720 ) ( HS(1,I), I=1,N )
0312      720 FORMAT( 31H0MANO SET AT SAMPLE 1 UNITLESS , 10F9.4 )
0313      WRITE( KOUT, 730 ) ( HS(2,I), I=1,N )
0314      730 FORMAT( 31H0MANO SET AT SAMPLE 2 UNITLESS , 10F9.4 )
0315      WRITE( KOUT, 740 ) ( HGA(1,I), I=1,N )
0316      740 FORMAT( 31H0COLLECT 1 AIR RATE(LB/SEC-IN2), 10F9.4 )
0317      WRITE( KOUT, 750 ) ( HGA(2,I), I=1,N )
0318      750 FORMAT( 31H0COLLECT 2 AIR RATE(LB/SEC-IN2), 10F9.4 )
0319      WRITE( KOUT, 760 ) ( HGW(1,I), I=1,N )
0320      760 FORMAT( 31H0COLLECT 1 H2O RATE(LB/SEC-IN2), 10F9.4 )
0321      WRITE( KOUT, 770 ) ( HGW(2,I), I=1,N )
0322      770 FORMAT( 31H0COLLECT 2 H2O RATE(LB/SEC-IN2), 10F9.4 )
0323      WRITE( KOUT, 790 ) ( TGA(I), I=1,N )
0324      790 FORMAT( 31H0ISO AIR MASS VEL (LBM/SEC-IN2), 10F9.4 )
0325      WRITE( KOUT, 795 ) ( GAND(I), I=1,N )
0326      795 FORMAT( 31H0NONDIM AIR MASS VELOCITY , 10F9.4 )
0327      WRITE( KOUT, 800 ) ( TGW(I), I=1,N )
0328      800 FORMAT( 31H0ISO H2O MASS VEL (LBM/SEC-IN2), 10F9.4 )
0329      WRITE( KOUT, 805 ) ( GWND(I), I=1,N )
0330      805 FORMAT(31H0NONDIM H2O MASS VELOCITY , 10F9.4 )
0331      WRITE( KOUT, 810 ) ( QUAL(I), I=1,N )
0332      810 FORMAT( 31H0LOCAL QUALITY , 10F9.4 )
0333      WRITE( KOUT, 815 ) ( QLND(I), I=1,N )
0334      815 FORMAT( 31H0NONDIMENSIONAL QUALITY , 10F9.4 )
0335      WRITE( KOUT, 830 ) ( VOID(I), I=1,N )
0336      830 FORMAT( 31H0LOCAL VOID FRACTION , 10F9.4 )
0337      WRITE( KOUT, 840 ) ( SLIP(I), I=1,N )
0338      840 FORMAT( 31H0LOCAL SLIP RATIO , 10F9.4 )
0339      WRITE( KOUT, 850 ) ( VELA(I), I=1,N )
0340      850 FORMAT( 31H0LINEAR VEL AIR (FT/SEC) , 10F9.4 )
0341      WRITE( KOUT, 855 ) ( DIQV(I), I=1,N )
0342      855 FORMAT( 31H0NONDIM LINEAR AIR VELOCITY , 10F9.4 )

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0343 WRITE( KOUT, 860 ) ( VFLW(I), I=1,N )
0344 860 FORMAT( 31H0LINEAR VEL WATER (FT/SEC) , 10F9.4 )
0345 WRITE( KOUT, 856 ) ( QOIV(I), I=1,N )
0346 856 FORMAT( 31H0NONDIM LINEAR H2O VELOCITY , 10F9.4 )
0347 GO TO 1
0348 END
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A.2 ROUND TUBE RESULTS

START OF CASE NO. 1 118366 0409.
T U R N E T E S T S E C T I O N T E S T M U N D E R 1.

FLOW AREA OF TEST SECTION (INCHES)	0.7776	DENSITY OF TEST AIR (LBM/FT3)	0.4526
APPROX. ISOKINETIC SETTING OF MANOMETER	0.9343	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.9440
AVERAGE TOTAL QUALITY	0.3782	AVERAGE VOID FRACTION (INTEGRATED)	0.9659
AIR MASS VELOCITY (LBM/SEC-IN2)	0.1448	WATER MASS VELOCITY (LBM/SEC-IN2)	0.2380
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.1456	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.0361
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.0060	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	0.8482
AVERAGE LINEAR AIR VELOCITY	48.7833	AVERAGE LINEAR WATER VELOCITY	9.8219

RADIUS TO CL OF PROPE (IN)	0.4725	0.4475	0.4225	0.3975	0.3725	0.3225	0.2725	0.1725	0.0725	-0.0025
R(I) / TOTAL RADIUS	0.9497	0.8995	0.8492	0.7990	0.7487	0.6482	0.5477	0.3467	0.1457	-0.0050
IMPACT PRESSURE (PSIA)	0.3307	0.2803	0.2394	0.2205	0.2268	0.2646	0.2898	0.3150	0.3181	0.3181
MANO SET AT SAMPLE 1 UNITLESS	-0.2286	-0.2921	-0.3947	-0.4000	-0.3889	-0.3095	-0.4783	-0.4000	-0.4356	-0.3762
MANO SET AT SAMPLE 2 UNITLESS	-0.0381	0.	0.	-0.0571	-0.0556	-0.1190	0.	-0.0400	-0.0792	0.0396
COLLECT 1 AIR RATE (LB/SEC-IN2)	0.1233	0.1267	0.1382	0.1482	0.1476	0.1605	0.1794	0.1852	0.1912	0.1972
COLLECT 2 AIR RATE (LB/SEC-IN2)	0.1216	0.1269	0.1377	0.1416	0.1439	0.1579	0.1774	0.1845	0.1906	0.1961
COLLECT 1 H2O RATE (LB/SEC-IN2)	0.0737	0.0647	0.0590	0.0533	0.0488	0.0476	0.0485	0.0460	0.0436	0.0444
COLLECT 2 H2O RATE (LB/SEC-IN2)	0.0658	0.0624	0.0544	0.0533	0.0454	0.0479	0.0420	0.0435	0.0436	0.0450
ISO AIR MASS VEL (LBM/SEC-IN2)	0.1130	0.1276	0.1366	0.1225	0.1329	0.1433	0.1735	0.1925	0.1989	0.1940
NONDIM AIR MASS VELOCITY	0.7808	0.9813	0.9436	0.8461	0.9183	0.9901	1.1985	1.2604	1.3050	1.3399
ISO H2O MASS VEL (LBM/SEC-IN2)	0.0251	0.0551	0.0435	0.0534	0.0353	0.0494	0.0292	0.0369	0.0438	0.0462
NONDIM H2O MASS VELOCITY	0.1053	0.2317	0.1829	0.2244	0.1485	0.2076	0.1229	0.1552	0.1940	0.1941
LOCAL QUALITY	0.8185	0.6992	0.7583	0.6964	0.7900	0.7436	0.8558	0.8316	0.8118	0.8077
NONDIMENSIONAL QUALITY	2.1641	1.2460	2.0049	1.8411	2.0985	1.9661	2.2625	2.1987	2.1464	2.1354
LOCAL VOID FRACTION	0.9998	0.9989	0.9991	0.9986	0.9994	0.9980	0.9996	0.9993	0.9990	0.9998
LOCAL SLIP RATIO	0.1045	0.3476	0.3991	0.0415	0.3320	0.4291	0.3554	0.4427	0.5768	0.6701
LINEAR VEL AIR (FT/SEC)	35.9618	40.6293	43.4959	39.0171	42.3181	45.6468	55.2161	58.0916	60.1540	61.7756
NONDIM LINEAR AIR VELOCITY	0.7372	0.8329	0.8916	0.7998	0.8675	0.9357	1.1319	1.1906	1.2331	1.2663
LINEAR VEL WATER (FT/SEC)	344.2693	116.8968	109.9733	88.3795	127.1525	106.3796	155.3561	131.1966	104.2938	92.1907
NONDIM LINEAR H2O VELOCITY	35.0511	11.9016	11.0949	8.9982	12.9458	10.8308	15.8173	13.3575	10.6185	9.3862

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CASE SEQUENCE NO.

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T O R E T E S T S E C T I O N

T E S T N U M B E R

M O I.

FLOW AREA OF TEST SECTION (INCHES)	0.7776	DENSITY OF TEST AIR (LBM/FT3)	0.3680
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.4114	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.9464
AVERAGE TOTAL QUALITY	0.3580	AVERAGE VOID FRACTION (INTEGRATED)	0.9187
AIR MASS VELOCITY (LBM/SEC-IN2)	0.1324	WATER MASS VELOCITY (LBM/SEC-IN2)	0.2374
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.1322	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.2371
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.0011	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	0.0017
AVERAGE LINEAR AIR VELOCITY	56.3926	AVERAGE LINEAR WATER VELOCITY	6.7385

RADIUS TO CL OF PROBE (IN)	0.4725	0.4675	0.4475	0.4225	0.3975	0.3725	0.1725	-0.0025
R(r) / TOTAL RADIUS	0.9497	0.9397	0.8995	0.8492	0.7991	0.7487	0.3467	-0.0050
IMPACT PRESSURE (PSIA)	0.2829	0.2425	0.2016	0.1764	0.1871	0.2016	0.3163	0.3604
MANO SET AT SAMPLE 1 UNITLESS	-0.4833	-0.5195	-0.4625	-0.4714	-0.4613	-0.4625	-0.4323	-0.5804
MANO SET AT SAMPLE 2 UNITLESS	-0.0267	-0.1039	-0.0687	0.	-0.0464	-0.1250	-0.0239	-0.0385
COLLECT 1 AIR RATE (LB/SEC-IN2)	0.0370	0.0573	0.0918	0.1136	0.1261	0.1429	0.1947	0.2285
COLLECT 2 AIR RATE (LB/SEC-IN2)	0.0221	0.0364	0.0617	0.0804	0.0928	0.1190	0.1571	0.1774
COLLECT 1 H2O RATE (LB/SEC-IN2)	1.1606	0.8361	0.3996	0.1725	0.1021	0.0805	0.0792	0.0837
COLLECT 2 H2O RATE (LB/SEC-IN2)	0.9563	0.7261	0.3412	0.1599	0.0974	0.0793	0.0772	0.0771
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0347	0.0518	0.0878	0.1093	0.1222	0.1392	0.1928	0.2125
NONDIM AIR MASS VELOCITY	0.2621	0.3912	0.6639	0.8255	0.9233	1.0514	1.4562	1.6050
ISO H2O MASS VEL (LBM/SEC-IN2)	1.1285	0.8075	0.3925	0.1709	0.1015	0.0803	0.0791	0.0817
NONDIM H2O MASS VELOCITY	4.7536	3.4014	1.6512	0.7199	0.4275	0.3382	0.3332	0.3441
LOCAL QUALITY	0.0296	0.0603	0.1831	0.3992	0.5463	0.6342	0.7090	0.7224
NONDIMENSIONAL QUALITY	0.0832	0.1684	0.5115	1.0899	1.5257	1.7715	1.9804	2.0179
LOCAL VOID FRACTION	0.7154	0.8124	0.9311	0.9800	0.9923	0.9945	0.9950	0.9944
LOCAL SLIP RATIO	2.065	2.505	2.804	2.210	1.571	1.629	2.063	2.474
LINEAR VEL AIR (FT/SEC)	18.959	24.971	36.932	43.658	48.186	54.793	75.828	83.639
NONDIM LINEAR AIR VELOCITY	0.3362	0.4428	0.6549	0.7742	0.8545	0.9716	1.3446	1.4832
LINEAR VEL WATER (FT/SEC)	9.180	9.967	13.162	19.757	30.681	33.644	36.757	33.802
NONDIM LINEAR H2O VELOCITY	1.3623	1.4791	1.9543	2.9320	4.5531	4.9928	5.4548	5.0162

A-12

GEAP-5739

START OF CASE NO.	2	110365	04092	TEST SECTION	TEST NUMBER	2.
TUBE TEST						
FLOW AREA OF TEST SECTION (INCHES)	0.7776			DENSITY OF TEST AIR (LBM/FT ³)	0.8477	
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.0100			AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.9240	
AVERAGE TOTAL QUALITY	0.2911			AVERAGE VOID FRACTION (INTEGRATED)	0.9590	
AIR MASS VELOCITY (LBM/SEC-IN ²)	0.1373			WATER MASS VELOCITY (LBM/SEC-IN ²)	0.3343	
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN ²)	0.1373			INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN ²)	0.1230	
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.0000			ERROR IN WATERFLOW (INTEGRATED TO TRUE)	0.6322	
AVERAGE LINEAR AIR VELOCITY	47.7919			AVERAGE LINEAR WATER VELOCITY	10.1683	

RADIUS TO CL OF PROBE (IN)	0.4725	0.4475	0.4225	0.3975	0.3725	0.3225	0.2725	0.1725	0.0725	0.
R(I) / TOTAL RADIUS	0.9497	0.8995	0.8492	0.7990	0.7487	0.6982	0.5477	0.3467	0.1457	0.
IMPACT PRESSURE (PSIA)	0.3692	0.3150	0.2608	0.2495	0.2520	0.2646	0.3087	0.3528	0.3654	0.3654
MANO SET AT SAMPLE 1 UNITLESS	-0.3584	-0.4600	-0.4944	-0.4545	-0.4500	-0.4762	-0.5306	-0.3929	-0.5517	-0.4828
MANO SET AT SAMPLE 2 UNITLESS	-0.0512	-0.0680	0.	-0.1010	-0.0750	0.	-0.0816	0.	0.1074	0.1379
COLLECT 1 AIR RATE (LB/SEC-IN ²)	0.1638	0.1640	0.1747	0.1684	0.1676	0.1952	0.2177	0.2207	0.2557	0.2471
COLLECT 2 AIR RATE (LB/SEC-IN ²)	0.1083	0.1139	0.1294	0.1270	0.1399	0.1451	0.1681	0.1687	0.1633	0.1616
COLLECT 1 H ₂ O RATE (LB/SEC-IN ²)	0.3437	0.3290	0.1831	0.1270	0.0942	0.0736	0.0636	0.0637	0.0618	0.0637
COLLECT 2 H ₂ O RATE (LB/SEC-IN ²)	0.3016	0.2751	0.1814	0.1156	0.0855	0.0715	0.0677	0.0622	0.0634	0.0629
ISO AIR MASS VEL (LBM/SEC-IN ²)	0.1036	0.1075	0.1303	0.1173	0.1351	0.1461	0.1601	0.1700	0.1793	0.1820
NONDIM AIR MASS VELOCITY	0.7545	0.7832	0.9400	0.8547	0.9540	1.0646	1.1665	1.2396	1.3063	1.3257
ISO H ₂ O MASS VEL (LBM/SEC-IN ²)	0.2960	0.2634	0.1815	0.1127	0.0840	0.0715	0.0684	0.0622	0.0631	0.0631
NONDIM H ₂ O MASS VELOCITY	0.8853	0.8028	0.5429	0.3371	0.2513	0.2139	0.2046	0.1860	0.1889	0.1887
LOCAL QUALITY	0.2592	0.2860	0.4170	0.5131	0.6165	0.6714	0.7007	0.7322	0.7396	0.7426
NONDIMENSIONAL QUALITY	0.8905	0.9926	1.4356	1.7524	2.1179	2.3065	2.4072	2.5154	2.5408	2.5511
LOCAL VOID FRACTION	0.9803	0.9801	0.9880	0.9950	0.9968	0.9977	0.9981	0.9987	0.9986	0.9986
LOCAL SLIP RATIO	0.9793	1.1309	1.2143	0.7323	0.7058	0.6620	0.6063	0.5073	0.5528	0.5741
LINEAR VEL AIR (FT/SEC)	33.9204	35.2800	42.4164	37.9357	43.5694	47.1204	51.6054	54.7699	57.7669	58.6265
NONDIM LINEAR AIR VELOCITY	0.7112	0.7384	0.8875	0.7938	0.9121	0.9859	1.0798	1.1460	1.2007	1.2267
LINEAR VEL H ₂ O (FT/SEC)	34.7098	31.2035	34.9305	51.8011	61.7563	71.1932	85.1184	107.9738	104.4016	102.1250
NONDIM LINEAR H ₂ O VELOCITY	3.4135	3.0687	3.4352	5.0944	6.0734	7.0005	9.3710	10.6187	10.2762	10.0435

CASE ID NO.

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PAGE NO. 3

T U B E T E S T S E C T I O N

T E S T N U M B E R

M02.

FLOW AREA OF TEST SECTION (INCHES)	0.7776	DENSITY OF TEST AIR (LBM/FT ³)	0.4156
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2436	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.9237
AVERAGE TOTAL QUALITY	0.2923	AVERAGE VOID FRACTION (INTEGRATED)	0.8875
AIR MASS VELOCITY (LBM/SEC-IN ²)	0.1372	WATER MASS VELOCITY (LBM/SEC-IN ²)	0.3321
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN ²)	0.1372	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN ²)	0.3094
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	0.0685
AVERAGE LINEAR AIR VELOCITY	51.4450	AVERAGE LINEAR WATER VELOCITY	6.8123

RADIUS TO CL OF PROBE (IN)	0.4657	0.4407	0.4157	0.3657	0.2977	0.1977	0.0977	-0.0023
R(1) / TOTAL RADIUS	0.9361	0.8858	0.8356	0.7351	0.5984	0.3974	0.1964	-0.0046
IMPACT PRESSURE (PSIA)	0.4000	0.3166	0.2520	0.2079	0.2394	0.3024	0.3339	0.3591
MANO SET AT SAMPLE 1 UNITLESS	-0.3228	-0.2189	-0.5000	-0.3636	-0.5789	-0.4563	-0.4528	-0.4561
MANO SET AT SAMPLE 2 UNITLESS	-0.0315	-0.0398	-0.0500	-0.0606	-0.0526	0.	0.	-0.0702
COLLECT 1 AIR RATE (LB/SEC-IN ²)	0.0596	0.0906	0.1442	0.1516	0.1997	0.2205	0.2412	0.2481
COLLECT 2 AIR RATE (LB/SEC-IN ²)	0.0424	0.0707	0.0965	0.1234	0.1485	0.1660	0.1806	0.2020
COLLECT 1 H ₂ O RATE (LB/SEC-IN ²)	1.3114	0.6189	0.2983	0.1184	0.0907	0.0881	0.0787	0.0786
COLLECT 2 H ₂ O RATE (LB/SEC-IN ²)	1.2174	0.5756	0.2788	0.1106	0.0871	0.0885	0.0734	0.0876
ISO AIR MASS VEL (LBM/SEC-IN ²)	0.0549	0.0934	0.1170	0.1404	0.1671	0.1950	0.2132	0.2227
NONDIM AIR MASS VELOCITY	0.4001	0.6808	0.8528	1.0233	1.2179	1.4213	1.5539	1.6232
ISO H ₂ O MASS VEL (LBM/SEC-IN ²)	1.2858	0.6249	0.2872	0.1153	0.0884	0.0869	0.0762	0.0835
NONDIM H ₂ O MASS VELOCITY	3.8717	1.8817	0.8648	0.3472	0.2662	0.2617	0.2294	0.2514
LOCAL QUALITY	0.0410	0.1300	0.2895	0.5491	0.6539	0.6918	0.7366	0.7272
NONDIMENSIONAL QUALITY	0.1403	0.4447	0.9904	1.8785	2.2371	2.3667	2.5200	2.4879
LOCAL VOID FRACTION	0.7321	0.9011	0.9673	0.9907	0.9937	0.9945	0.9953	0.9946
LOCAL SLIP RATIO	2.338	2.453	2.058	1.718	1.786	1.869	1.966	2.180
LINEAR VEL AIR (FT/SEC)	25.978	35.893	41.881	49.087	58.217	67.898	74.181	77.545
NONDIM LINEAR AIR VELOCITY	0.5050	0.6978	0.8142	0.9543	1.1317	1.3199	1.4421	1.5075
LINEAR VEL WATER (FT/SEC)	11.113	14.633	20.349	28.568	32.588	36.327	37.740	35.571
NONDIM LINEAR H ₂ O VELOCITY	1.6313	2.1480	2.9871	4.1936	4.7837	5.3326	5.5400	5.2216

A-14

GEAP-5739

START OF CASE NO.	3	110366	0409.	
		T U R E	T E S T	S E C T I O N
				T E S T N U M B E R
				3.
FLOW AREA OF TEST SECTION (INCHES)		0.7776	DENSITY OF TEST AIR (LBM/FT3)	0.4510
APPROX. ISOKINETIC SETTING OF MANOMETER		-0.0656	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.9010
AVERAGE TOTAL QUALITY		0.2142	AVERAGE VOID FRACTION (INTEGRATED)	0.9602
AIR MASS VELOCITY (LBM/SEC-IN2)		0.1395	WATER MASS VELOCITY (LBM/SEC-IN2)	0.5115
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)		0.1395	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.1539
ERROR IN AIRFLOW (INTEGRATED TO TRUE)		0.0000	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	0.6991
AVERAGE LINEAR AIR VELOCITY		49.4229	AVERAGE LINEAR WATER VELOCITY	11.9429

RADIUS TO CL. OF PROBE (IN)	0.4725	0.4475	0.4225	0.3975	0.3725	0.3225	0.2725	0.1725	0.0725	0.
R(1) / TOTAL RADIUS	0.9497	0.8995	0.8492	0.7990	0.7487	0.6482	0.5477	0.3467	0.1457	0.
IMPACT PRESSURE (PSIA)	0.4851	0.4643	0.4441	0.4297	0.4095	0.3799	0.3780	0.4347	0.4536	0.4410
MANO SET AT SAMPLE 1 UNITLESS	-0.3377	-0.2985	-0.3121	-0.2933	-0.4308	-0.4312	-0.4000	-0.5217	-0.4444	-0.3857
MANO SET AT SAMPLE 2 UNITLESS	0.1039	-0.0407	0.0284	0.0293	0.	0.	0.0333	0.0580	-0.0833	0.0571
COLLECT 1 AIR RATE (LB/SEC-IN2)	0.1587	0.1389	0.1573	0.1595	0.1899	0.1976	0.2049	0.2487	0.2442	0.2266
COLLECT 2 AIR RATE (LB/SEC-IN2)	0.0965	0.0896	0.0999	0.1038	0.1240	0.1393	0.1466	0.1698	0.1940	0.1572
COLLECT 1 H2O RATE (LB/SEC-IN2)	0.2960	0.2428	0.1736	0.1520	0.1463	0.1167	0.1315	0.1349	0.1361	0.1371
COLLECT 2 H2O RATE (LB/SEC-IN2)	0.2676	0.2292	0.1565	0.1303	0.1304	0.1305	0.1293	0.1270	0.1213	0.1327
ISO. AIR MASS VEL (LBM/SEC-IN2)	0.1204	0.0944	0.1156	0.1202	0.1340	0.1482	0.1599	0.1866	0.1916	0.1764
NONDIM AIR MASS VELOCITY	0.8632	0.6768	0.8292	0.8620	0.9608	1.0624	1.1467	1.3382	1.3735	1.2652
ISO H2O MASS VEL (LBM/SEC-IN2)	0.2785	0.2305	0.1612	0.1367	0.1328	0.1284	0.1298	0.1287	0.1206	0.1340
NONDIM H2O MASS VELOCITY	0.5445	0.4506	0.3152	0.2672	0.2597	0.2510	0.2537	0.2516	0.2358	0.2619
LOCAL QUALITY	0.3018	0.2905	0.4177	0.4679	0.5022	0.5357	0.5520	0.5918	0.6136	0.5684
NONDIMENSIONAL QUALITY	1.4088	1.3561	1.9499	2.1842	2.3442	2.5009	2.5768	2.7627	2.8644	2.6534
LOCAL VOID FRACTION	0.9866	0.9910	0.9951	0.9963	0.9961	0.9956	0.9952	0.9955	0.9962	0.9955
LOCAL SLIP RATIO	0.8091	0.5152	0.4899	0.4556	0.5513	0.6969	0.8208	0.9109	0.8448	0.8192
LINEAR VEL AIR (FT/SEC)	38.9602	30.4122	37.1067	38.5293	42.9537	47.5144	51.3083	59.8620	61.3998	56.5934
NONDIM LINEAR AIR VELOCITY	0.7883	0.6153	0.7509	0.7796	0.8691	0.9614	1.0381	1.2112	1.2423	1.1451
LINEAR VEL WATER (FT/SEC)	48.1510	59.0287	75.7352	84.5695	77.9124	68.1758	62.5074	65.7155	72.6799	69.0812
NONDIM LINEAR H2O VELOCITY	4.0318	4.0426	6.3415	7.0811	6.5237	5.7095	5.2339	5.5025	6.0956	5.7843

CASE ID NO. TURE TEST SECTION CASE SEQUENCE NO. 0 110168 1910.9 PAGE NO. 2
TEST NUMBER MO3.

FLOW AREA OF TEST SECTION (INCHES)	0.7776	DENSITY OF TEST AIR (LBM/FT3)	0.4082
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.8846
AVERAGE TOTAL QUALITY	0.2078	AVERAGE VOID FRACTION (INTEGRATED)	0.8722
AIR MASS VELOCITY (LBM/SEC-IN2)	0.1331	WATER MASS VELOCITY (LBM/SEC-IN2)	0.5076
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.1331	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.5136
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.0003	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-0.0119
AVERAGE LINEAR AIR VELOCITY	53.8502	AVERAGE LINEAR WATER VELOCITY	9.1657

RADIUS TO CL OF PROBE (IN)	0.4725	0.4675	0.4475	0.4225	0.3975	0.3725	0.1725	-0.0025
R(1) / TOTAL RADIUS	0.9497	0.9397	0.8995	0.8492	0.7990	0.7487	0.3467	-0.0050
IMPACT PRESSURE (PSIA)	0.4681	0.4785	0.4155	0.3276	0.3024	0.3364	0.4618	0.5116
HAND SET AT SAMPLE 1 UNITLESS	-0.5074	-0.5411	-0.4503	-0.4385	-0.5800	-0.4719	-0.4052	-0.4507
HAND SET AT SAMPLE 2 UNITLESS	-0.0767	-0.0448	-0.0334	0.0423	0.	-0.0637	0.0235	-0.0419
COLLECT 1 AIR RATE (LB/SEC-IN2)	0.0216	0.0288	0.0627	0.1031	0.1481	0.1699	0.2318	0.2654
COLLECT 2 AIR RATE (LB/SEC-IN2)	0.0143	0.0166	0.0384	0.0650	0.1009	0.1185	0.1757	0.2068
COLLECT 1 H2O RATE (LB/SEC-IN2)	2.2874	2.1227	1.2165	0.6456	0.3854	0.2394	0.1147	0.1247
COLLECT 2 H2O RATE (LB/SEC-IN2)	1.9323	1.7101	1.6395	0.5523	0.3393	0.2326	0.1157	0.1190
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0173	0.0216	0.0510	0.0882	0.1245	0.1420	0.2115	0.2367
NONDIM AIR MASS VELOCITY	0.1300	0.1623	0.3832	0.6627	0.9354	1.0669	1.5890	1.7784
ISO H2O MASS VEL (LBM/SEC-IN2)	2.0752	1.8807	1.1314	0.6090	0.3624	0.2357	0.1151	0.1219
NONDIM H2O MASS VELOCITY	4.0883	3.7051	2.2280	1.1998	0.7139	0.4643	0.2268	0.2401
LOCAL QUALITY	0.0083	0.0114	0.0432	0.1265	0.2556	0.3759	0.6476	0.6600
NONDIMENSIONAL QUALITY	0.0399	0.0549	0.2079	0.6088	1.2310	1.8090	3.1165	3.1761
LOCAL VOID FRACTION	0.5021	0.5788	0.7945	0.9107	0.9575	0.9825	0.9956	0.9948
LOCAL SLIP RATIO	1.257	1.275	1.778	2.163	2.322	1.636	1.233	1.550
LINEAR VEL AIR (FT/SEC)	12.128	13.179	22.655	34.156	45.673	50.977	74.925	83.917
NONDIM LINEAR AIR VELOCITY	0.2252	0.2447	0.4207	0.6343	0.8519	0.9466	1.3914	1.5583
LINEAR VEL WATER (FT/SEC)	9.650	10.337	12.743	15.791	19.757	31.164	60.770	54.155
NONDIM LINEAR H2O VELOCITY	1.0528	1.1278	1.3903	1.7228	2.1555	3.4001	6.6302	5.9084

START OF CASE NO. 4 110366 0409.
TUBE TEST SECTION TEST NUMBER 4.

FLOW AREA OF TEST SECTION (INCHES)	0.7776	DENSITY OF TEST AIR (LBM/FT3)	0.4645
APPROX. ISOKINETIC SETTING OF MANOMETER	0.2037	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.8160
AVERAGE TOTAL QUALITY	0.1140	AVERAGE VOID FRACTION (INTEGRATED)	0.9391
AIR MASS VELOCITY (LBM/SEC-IN2)	0.1473	WATER MASS VELOCITY (LBM/SEC-IN2)	1.1450
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.1473	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.6168
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.0000	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	0.4613
AVERAGE LINEAR AIR VELOCITY	55.9831	AVERAGE LINEAR WATER VELOCITY	14.3830

RADIUS TO CL OF PROBE (IN)	0.4725	0.4475	0.4225	0.3975	0.3725	0.3475	0.3225	0.2975	0.2725	0.2475	-0.0025
R(I) / TOTAL RADIUS	0.5497	0.2995	0.2492	0.1990	0.1487	0.0982	0.0477	0.3467	0.1457	0.1457	-0.0050
IMPACT PRESSURE (PSIA)	1.2789	1.2978	1.2978	1.2411	1.1781	1.2096	1.1466	1.1088	1.0080	1.0899	
MANO SET AT SAMPLE 1 UNITLESS	-0.5123	-0.4660	-0.4563	-0.5381	-0.5775	-0.4688	-0.5385	-0.5000	-0.5375	-0.5549	
MANO SET AT SAMPLE 2 UNITLESS	-0.0197	0.	0.	0.0203	0.0321	0.0312	0.0440	0.0114	0.	0.	
COLLECT 1 AIR RATE (LB/SEC-IN2)	0.2637	0.2640	0.2779	0.2972	0.3015	0.3094	0.3312	0.3383	0.3489	0.3319	
COLLECT 2 AIR RATE (LB/SEC-IN2)	0.1679	0.1677	0.1797	0.1845	0.1799	0.1925	0.2056	0.2280	0.1977	0.2106	
COLLECT 1 H2O RATE (LB/SEC-IN2)	1.0455	1.0569	0.9412	0.7972	0.7031	0.5670	0.4962	0.4196	0.4309	0.4797	
COLLECT 2 H2O RATE (LB/SEC-IN2)	0.9979	0.9991	0.8879	0.6849	0.6577	0.5330	0.4763	0.3969	0.3994	0.4420	
ISO AIR MASS VEL (LBM/SEC-IN2)	0.1244	0.1257	0.1358	0.1474	0.1457	0.1522	0.1712	0.1865	0.1555	0.1661	
NONDIM AIR MASS VELOCITY	0.8445	0.8530	0.9217	1.0005	0.9890	1.0329	1.1619	1.2662	1.0554	1.1274	
ISO H2O MASS VEL (LBM/SEC-IN2)	0.9763	0.9738	0.9641	0.6481	0.6450	0.5212	0.4708	0.3884	0.3874	0.4282	
NONDIM H2O MASS VELOCITY	0.8527	0.8505	0.7547	0.5660	0.5633	0.4553	0.4112	0.3392	0.3384	0.3740	
LOCAL QUALITY	0.1130	0.1143	0.1358	0.1853	0.1843	0.2260	0.2667	0.3245	0.2864	0.2795	
NONDIMENSIONAL QUALITY	0.9914	1.0026	1.1912	1.6254	1.6165	1.9821	2.3388	2.8461	2.5122	2.4514	
LOCAL VOID FRACTION	0.9447	0.9458	0.9566	0.9738	0.9726	0.9824	0.9843	0.9886	0.9880	0.9863	
LOCAL SLIP RATIO	0.9984	0.9909	0.9546	0.8193	0.8519	0.7010	0.7772	0.7448	0.6538	0.7198	
LINEAR VEL AIR (FT/SEC)	40.8339	41.1993	44.0147	46.9361	46.4518	48.0306	53.9262	58.5138	48.7999	52.2180	
NONDIM LINEAR AIR VELOCITY	0.7294	0.7359	0.7862	0.8384	0.8297	0.8579	0.9633	1.0452	0.8717	0.9327	
LINEAR VEL WATER (FT/SEC)	40.9009	41.5777	46.1068	57.2346	54.5246	68.5180	69.3886	78.5681	74.6362	72.5402	
NONDIM LINEAR H2O VELOCITY	2.8437	2.8908	3.2057	3.9828	3.7909	4.7638	4.8244	5.4626	5.1892	5.0435	

START OF CASE NO. 5 110365	TEST SECTION				TEST NUMBER				PR		
FLOW AREA OF TEST SECTION (INCHES)	0.7776				DENSITY OF TEST AIR (LBM/FT ³)				0.0569		
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.0160				AVERAGE VOID FRACTION (QUICK CLOSING VALVES)				0.8330		
AVERAGE TOTAL QUALITY	0.1154				AVERAGE VOID FRACTION (INTEGRATED)				0.8595		
AIR MASS VELOCITY (LBM/SEC-IN ²)	0.1445				WATER MASS VELOCITY (LBM/SEC-IN ²)				1.1639		
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN ²)	0.1445				INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN ²)				1.1374		
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.0000				ERROR IN WATERFLOW (INTEGRATED TO TRUE)				0.0262		
AVERAGE LINEAR AIR VELOCITY	54.6599				AVERAGE LINEAR WATER VELOCITY				16.1092		
RADIUS TO CL OF PROBE (IN)	0.4725	0.4475	0.4225	0.3975	0.3725	0.3225	0.2725	0.1725	0.0725	-0.0025	
R(I) / TOTAL RADIUS	0.9497	0.8995	0.8493	0.7990	0.7487	0.6482	0.5477	0.3467	0.1457	-0.0050	
IMPACT PRESSURE (PSIA)	1.1151	1.2852	1.3387	1.2569	1.2222	1.1277	1.0080	1.0269	1.0325	1.0332	
MANO SET AT SAMPLE 1 UNITLESS	-0.5932	-0.3824	-0.3906	-0.4110	-0.4175	-0.5028	-0.4125	-0.4049	-0.4348	-0.4878	
MANO SET AT SAMPLE 2 UNITLESS	-0.6395	0.0196	0.	0.	0.	-0.0670	0.	-0.0613	0.0364	0.	
COLLECT 1 AIR RATE (LBM/SEC-IN ²)	0.0531	0.1056	0.1558	0.2175	0.2410	0.2756	0.2769	0.2276	0.3326	0.3373	
COLLECT 2 AIR RATE (LBM/SEC-IN ²)	0.0297	0.0716	0.1031	0.1502	0.1601	0.1765	0.1812	0.2285	0.2218	0.2350	
COLLECT 1 H ₂ O RATE (LBM/SEC-IN ²)	3.6791	2.6343	2.0629	1.4704	1.1381	0.5985	0.5670	0.3422	0.3527	0.3402	
COLLECT 2 H ₂ O RATE (LBM/SEC-IN ²)	2.6193	2.3021	1.8573	1.3552	1.6773	0.7027	0.5446	0.3852	0.3404	0.3285	
ISO AIR MASS VEL (LBM/SEC-IN ²)	0.0287	0.0746	0.1052	0.1527	0.1632	0.1649	0.1849	0.2123	0.2329	0.2383	
NONDIM AIR MASS VELOCITY	0.1989	0.5152	0.7282	1.0570	1.1299	1.1414	1.2797	1.5182	1.6121	1.6498	
ISO H ₂ O MASS VEL (LBM/SEC-IN ²)	2.5827	2.3315	1.8657	1.3597	1.0796	0.7032	0.5455	0.3833	0.3416	0.3289	
NONDIM H ₂ O MASS VELOCITY	2.2190	2.0032	1.6030	1.1692	0.9276	0.6042	0.4696	0.3293	0.2935	0.2826	
LOCAL QUALITY	0.0110	0.0310	0.0534	0.1010	0.1313	0.1829	0.2531	0.3539	0.4054	0.4202	
NONDIMENSIONAL QUALITY	0.0996	0.2837	0.4834	0.8145	1.1894	1.7202	2.2925	3.2960	3.6714	3.8052	
LOCAL VOID FRACTION	0.6454	0.7314	0.8227	0.8962	0.9262	0.9649	0.9749	0.9869	0.9892	0.9898	
LOCAL SLIP RATIO	0.8321	1.5990	1.6546	1.8859	1.6410	1.1605	1.1879	1.0458	1.0107	1.0205	
LINEAR VEL AIR (FT/SEC)	14.0294	32.1335	40.3951	54.0651	55.5469	53.8521	59.7664	70.0540	74.2004	75.8935	
NONDIM LINEAR AIR VELOCITY	0.2567	0.5879	0.7374	0.9891	1.0162	0.9853	1.0934	1.2816	1.3575	1.3885	
LINEAR VEL WATER (FT/SEC)	16.8607	20.0955	24.3583	28.6693	33.8504	46.4090	50.3123	66.9842	73.4133	74.3660	
NONDIM LINEAR H ₂ O VELOCITY	1.0466	1.2475	1.5121	1.7726	2.1013	2.9809	3.1232	4.1581	4.5572	4.6164	

START OF CASE NO. 6 110366 0410.
 TUBE TEST SECTION TEST NUMBER 5.

FLOW AREA OF TEST SECTION (INCHES)	0.7776	DENSITY OF TEST AIR (LBM/FT3)	0.4480
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.4994	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.9620
AVERAGE TOTAL QUALITY	0.4784	AVERAGE VOID FRACTION (INTEGRATED)	0.9355
AIR MASS VELOCITY (LBM/SEC-IN2)	0.1436	WATER MASS VELOCITY (LBM/SEC-IN2)	0.1566
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.1436	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.1132
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.0000	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	0.2772
AVERAGE LINEAR AIR VELOCITY	47.9814	AVERAGE LINEAR WATER VELOCITY	9.5235

RADIUS TO CL OF PROBE (IN)	0.4725	0.4475	0.4225	0.3975	0.3725	0.3225	0.2725	0.1725	0.0725	-0.0025
R(I) / TOTAL RADIUS	0.9497	0.8995	0.8492	0.7990	0.7487	0.6492	0.5477	0.3467	0.1457	-0.0050
IMPACT PRESSURE (PSIA)	0.1134	0.1260	0.1417	0.1433	0.1512	0.1575	0.2016	0.2268	0.2646	0.2709
MANO SET AT SAMPLE 1 UNITLESS	-0.8889	-0.4500	-0.3111	-0.4396	-0.4167	-0.3600	-0.3437	-0.3611	-0.5714	-0.5591
MANO SET AT SAMPLE 2 UNITLESS	0.	0.	0.1778	0.	0.1667	0.	0.	0.	0.0476	0.
COLLECT 1 AIR RATE (LB/SEC-IN2)	0.0618	0.0800	0.1156	0.1161	0.1416	0.1552	0.1648	0.1842	0.2219	0.2264
COLLECT 2 AIR RATE (LB/SEC-IN2)	0.0445	0.0540	0.0659	0.0881	0.0920	0.1177	0.1341	0.1459	0.1655	0.1683
COLLECT 1 H2O RATE (LB/SEC-IN2)	0.5879	0.2211	0.0869	0.0522	0.0352	0.0215	0.0231	0.0221	0.0219	0.0234
COLLECT 2 H2O RATE (LB/SEC-IN2)	0.5330	0.1950	0.0816	0.0465	0.0340	0.0204	0.0242	0.0233	0.0234	0.0223
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0542	0.0827	0.1349	0.1129	0.1486	0.1698	0.1787	0.1989	0.2153	0.2203
NONDIM AIR MASS VELOCITY	0.3775	0.5761	0.9396	0.8350	1.0350	1.1821	1.2440	1.3849	1.4993	1.5341
ISO H2O MASS VEL (LBM/SEC-IN2)	0.5638	0.2240	0.0887	0.0529	0.0353	0.0220	0.0225	0.0216	0.0221	0.0233
NONDIM H2O MASS VELOCITY	3.6011	1.4306	0.5666	0.3381	0.2256	0.1404	0.1439	0.1381	0.1411	0.1489
LOCAL QUALITY	0.0877	0.2697	0.6033	0.6938	0.8080	0.8854	0.8880	0.9020	0.9069	0.9043
NONDIMENSIONAL QUALITY	0.1833	0.5638	1.2611	1.4591	1.6889	1.8506	1.8560	1.8853	1.8957	1.8991
LOCAL VOID FRACTION	0.7927	0.9615	0.9889	0.9972	0.9978	0.9974	0.9991	0.9988	0.9989	0.9986
LOCAL SLIP RATIO	3.4899	2.0529	2.3665	2.8872	1.2861	2.7793	0.9556	1.4776	1.4460	1.8165
LINEAR VEL AIR (FT/SEC)	21.9782	27.6545	43.8560	39.6592	47.8794	54.7056	57.4706	63.9989	69.2771	70.9096
NONDIM LINEAR AIR VELOCITY	0.4581	0.5764	0.9140	0.8056	0.9979	1.1401	1.1978	1.3338	1.4438	1.4779
LINEAR VEL WATER (FT/SEC)	6.2976	13.4712	18.5325	43.5683	37.2292	19.6834	60.1414	43.3122	47.9109	39.0366
NONDIM LINEAR H2O VELOCITY	0.6613	1.4145	1.9460	4.5748	3.9092	2.0668	6.3151	4.5479	5.0308	4.0990

START OF CASE NO. 7 110366 0410.
 TUBE TEST SECTION TEST NUMBER 6.

FLOW AREA OF TEST SECTION (INCHES)	0.7776	DENSITY OF TEST AIR (LRM/FT3)	0.4457
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.5928	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.9710
AVERAGE TOTAL QUALITY	0.6200	AVERAGE VOID FRACTION (INTEGRATED)	0.9549
AIR MASS VELOCITY (LRM/SEC-IN2)	0.1438	WATER MASS VELOCITY (LRM/SEC-IN2)	0.0882
INTEGRATED AIR MASS VELOCITY (LRM/SEC-IN2)	0.1433	INTEGRATED WATER MASS VELOCITY (LRM/SEC-IN2)	0.0436
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.0034	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	0.5057
AVERAGE LINEAR AIR VELOCITY	47.9626	AVERAGE LINEAR WATER VELOCITY	7.0265

RADIUS TO CL OF PROBE (IN)	0.4725	0.4475	0.4225	0.3975	0.3725	0.3225	0.2725	0.1725	0.0725	-0.0025
R(I) / TOTAL RADIUS	0.9497	0.8995	0.8492	0.7990	0.7487	0.6482	0.5477	0.3467	0.1457	-0.0050
IMPACT PRESSURE (PSIA)	0.0661	0.0819	0.0882	0.0913	0.0961	0.1165	0.1449	0.1732	0.1984	0.2016
MANO SET AT SAMPLE 1 UNITLESS	-0.0571	-0.6385	-0.6422	-0.8276	-0.7869	-0.8108	-0.7826	-0.5091	-0.4762	-0.3438
MANO SET AT SAMPLE 2 UNITLESS	0.2857	-0.2308	0.	0.2414	-0.2295	0.1081	-0.2609	0.4000	0.0952	0.
COLLECT 1 AIR RATE (LR/SEC-IN2)	0.0639	0.1029	0.1130	0.1513	0.1532	0.1788	0.2033	0.1856	0.2211	0.1729
COLLECT 2 AIR RATE (LR/SEC-IN2)	0.0254	0.0663	0.0623	0.0629	0.0914	0.0835	0.1760	0.1001	0.1529	0.1520
COLLECT 1 H2O RATE (LR/SEC-IN2)	0.2562	0.0930	0.0322	0.0166	0.0098	0.0049	0.0053	0.0045	0.0076	0.0053
COLLECT 2 H2O RATE (LR/SEC-IN2)	0.1486	0.2828	0.0318	0.0121	0.0094	0.0039	0.0072	0.0057	0.0068	0.0061
ISO AIR MASS VEL (LRM/SEC-IN2)	0.0550	0.1094	0.1091	0.1319	0.1317	0.1562	0.1937	0.1935	0.2351	0.1890
NONDIM AIR MASS VELOCITY	0.3821	0.7693	0.7583	0.9171	0.9157	1.0856	1.3466	1.3453	1.6343	1.3072
ISO H2O MASS VEL (LRM/SEC-IN2)	0.2313	0.0948	0.0328	0.0156	0.0097	0.0047	0.0060	0.0044	0.0077	0.0047
NONDIM H2O MASS VELOCITY	2.6234	1.0750	0.3720	0.1774	0.1100	0.0531	0.0678	0.0503	0.0875	0.0537
LOCAL QUALITY	0.1920	0.5357	0.7683	0.8940	0.9314	0.9709	0.9701	0.9776	0.9682	0.9754
NONDIMENSIONAL QUALITY	0.3097	0.8641	1.2400	1.4420	1.5023	1.5659	1.5646	1.5768	1.5616	1.5733
LOCAL VOID FRACTION	0.9274	0.9708	0.9973	0.9955	0.9992	1.0003	1.0001	1.0001	1.0001	0.9999
LOCAL SLIP RATIO	2.5971	4.8359	1.2640	5.3349	1.4410	-1.2192	-0.2658	-0.5751	-0.2292	0.3734
LINEAR VEL AIR (FT/SEC)	19.1496	36.3935	35.3391	42.8171	42.5882	50.4404	62.5797	62.5149	75.9474	69.7567
NONDIM LINEAR AIR VELOCITY	0.4001	0.7604	0.7383	0.8946	0.8890	1.0539	1.3075	1.3061	1.5868	1.2694
LINEAR VEL WATER (FT/SEC)	7.3734	7.5257	27.9577	9.0199	29.5550	-41.3710	-235.4749	-108.7105	-331.3639	162.7188
NONDIM LINEAR H2O VELOCITY	1.0494	1.0710	3.9789	1.1414	4.2062	-5.8878	-33.5124	-15.4715	-47.1592	23.1579

START OF CASE NO. 8 110366 0410. TUBE TEST SECTION TEST NUMBER 6R

FLOW AREA OF TEST SECTION (INCHES)	0.7776	DENSITY OF TEST AIR (LBM/FT3)	0.4479
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.8752	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.9710
AVERAGE TOTAL QUALITY	0.6196	AVERAGE VOID FRACTION (INTEGRATED)	0.9372
AIR MASS VELOCITY (LBM/SEC-IN2)	0.1433	WATER MASS VELOCITY (LBM/SEC-IN2)	0.0880
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.1432	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.0378
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.0013	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	0.5700
AVERAGE LINEAR AIR VELOCITY	47.4654	AVERAGE LINEAR WATER VELOCITY	7.0148

RADIUS TO CL OF PROBE (IN)	0.4725	0.4475	0.4225	0.3225	0.1725	-0.0025
R(I) / TOTAL RADIUS	0.9497	0.8995	0.8492	0.6492	0.3467	-0.0050
IMPACT PRESSURE (PSIA)	0.0567	0.0441	0.0724	0.1088	0.1417	0.1764
MANO SET AT SAMPLE 1 UNITLESS	-0.8889	-0.7143	-1.0435	-0.9375	-0.5333	-0.3571
MANO SET AT SAMPLE 2 UNITLESS	0.	0.	0.	-0.2500	0.	0.1429
COLLECT 1 AIR RATE (LB/SEC-IN2)	0.0740	0.0931	0.1206	0.1756	0.1750	0.1923
COLLECT 2 AIR RATE (LB/SEC-IN2)	0.0234	0.0399	0.0531	0.1301	0.1315	0.1307
COLLECT 1 H2O RATE (LB/SEC-IN2)	0.2359	0.1021	0.0399	0.0067	0.0057	0.
COLLECT 2 H2O RATE (LB/SEC-IN2)	0.1576	0.0828	0.0378	0.0068	0.0053	0.0054
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0740	0.1051	0.1098	0.1715	0.2029	0.2560
NONDIM AIR MASS VELOCITY	0.5162	0.7333	0.7657	1.1961	1.4154	1.7862
ISO H2O MASS VEL (LBM/SEC-IN2)	0.2347	0.1064	0.0396	0.0067	0.0059	-0.0056
NONDIM H2O MASS VELOCITY	2.6664	1.2090	0.4497	0.0755	0.0672	-0.0641
LOCAL QUALITY	0.2397	0.4969	0.7350	0.9622	0.9717	1.0225
NONDIMENSIONAL QUALITY	0.3669	0.8021	1.1862	1.5530	1.5683	1.6503
LOCAL VOID FRACTION	0.8736	1.0756	0.9908	1.0001	1.0000	1.0000
LOCAL SLIP RATIO	6.3344	-9.6447	3.5656	-0.2491	-0.1865	0.0951
LINEAR VEL AIR (FT/SEC)	27.2338	31.4198	35.6153	55.1241	65.2312	82.3219
NONDIM LINEAR AIR VELOCITY	0.5738	0.6620	0.7503	1.1614	1.3743	1.7344
LINEAR VEL WATER (FT/SEC)	4.2993	-3.2577	9.9885	-221.3348	-349.7232	865.9692
NONDIM LINEAR H2O VELOCITY	0.6129	-0.4644	1.4239	-31.5526	-49.8552	123.4492

A.3 BRITISH HOMOGENEOUS REDUCTION OF ROUND TUBE DATA

SNUMB = 08468, ACTIVITY # = 02, REPORT CODE = 06, RECORD COUNT = 00765

TUBE TEST SECTION				TEST NUMBER 5.						
FLOW AREA OF TEST SECTION (INCHES)	0.7776			DENSITY OF TEST AIR (LBM/FT3)						0.4480
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.6233			AVERAGE VOID FRACTION (QUICK CLOSING VALVES)						0.9622
AVERAGE TOTAL QUALITY	0.4784			AVERAGE VOID FRACTION (INTEGRATED)						0.9300
AIR MASS VELOCITY (LBM/SEC-IN2)	0.1436			WATER MASS VELOCITY (LBM/SEC-IN2)						0.1566
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.1455			INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)						0.1147
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.0133			ERROR IN WATERFLOW (INTEGRATED TO TRUE)						0.2677
AVERAGE LINEAR AIR VELOCITY	47.9700			AVERAGE LINEAR WATER VELOCITY						5.1296
RADIUS TO CL OF PROBE (IN)	0.4725	0.4475	0.4225	0.3975	0.3725	0.3225	0.2725	0.1725	0.0725	-0.0025
R(1) / TOTAL RADIUS	0.9497	0.8995	0.8492	0.7990	0.7487	0.6482	0.5477	0.3467	0.1457	-0.0050
IMPACT PRESSURE (PSIA)	0.1134	0.1260	0.1417	0.1433	0.1512	0.1575	0.2016	0.2268	0.2646	0.2709
MANO SET AT SAMPLE 1 UNITLESS	-0.8889	-0.4500	-0.3111	-0.4396	-0.4167	-0.3600	-0.3437	-0.3611	-0.5714	-0.5581
MANO SET AT SAMPLE 2 UNITLESS	0.		0.1778	0.	0.1667	0.	0.	0.	0.0476	0.
COLLECT 1 AIR RATE (LBM/SEC-IN2)	0.0618	0.0800	0.1156	0.1161	0.1416	0.1552	0.1648	0.1842	0.2219	0.2264
COLLECT 2 AIR RATE (LBM/SEC-IN2)	0.0445	0.0548	0.0654	0.0881	0.0920	0.1177	0.1341	0.1459	0.1655	0.1683
COLLECT 1 H2O RATE (LBM/SEC-IN2)	0.5879	0.2211	0.0866	0.0522	0.0352	0.0215	0.0231	0.0221	0.0219	0.0234
COLLECT 2 H2O RATE (LBM/SEC-IN2)	0.5330	0.1950	0.0816	0.0465	0.0341	0.0204	0.0242	0.0233	0.0234	0.0223
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0566	0.0897	0.1477	0.1278	0.1592	0.1827	0.1897	0.2120	0.2266	0.2332
NONDIM AIR MASS VELOCITY	0.3942	0.6247	1.0286	0.8900	1.1086	1.2723	1.3210	1.4763	1.5780	1.6240
ISO H2O MASS VEL (LBM/SEC-IN2)	0.5715	0.2312	0.0900	0.0545	0.0356	0.0224	0.0221	0.0212	0.0218	0.0236
NONDIM H2O MASS VELOCITY	3.6494	1.4764	0.5747	0.3480	0.2273	0.1430	0.1411	0.1354	0.1392	0.1507
LOCAL QUALITY	0.0553	0.2560	0.5890	0.7255	0.8153	0.8817	0.8958	0.9053	0.9097	0.9038
NONDIMENSIONAL QUALITY	0.1156	0.5351	1.2312	1.5165	1.7042	1.8430	1.8725	1.8923	1.9015	1.8892
LOCAL VOID FRACTION	0.8905	0.9795	0.9950	0.9973	0.9984	0.9990	0.9992	0.9992	0.9993	0.9992
LOCAL SLIP RATIO	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998	0.998
LINEAR VEL AIR (FT/SEC)	12.067	26.101	41.664	46.444	50.542	53.624	61.147	65.199	70.591	71.196
NONDIM LINEAR AIR VELOCITY	0.2516	0.5441	0.8685	0.9682	1.0536	1.1179	1.2747	1.3592	1.4716	1.4842
LINEAR VEL WATER (FT/SEC)	12.086	26.143	41.731	46.518	50.623	53.710	61.246	65.303	70.705	71.310
NONDIM LINEAR H2O VELOCITY	2.3561	5.0965	8.1353	9.0685	9.8688	10.4706	11.9397	12.7306	13.7837	13.9017

A.4 CONCENTRIC ANNULUS RESULTS

START OF CASE NO. 9 110366 0410.
 ANNULUS TEST SECTION TEST NUMBER 1.

FLOW AREA OF TEST SECTION (INCHES)	0.5812	DENSITY OF TEST AIR (LBM/FT3)	0.04501
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2280	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.8850
AVERAGE TOTAL QUALITY	0.1403	AVERAGE VOID FRACTION (INTEGRATED)	0.8566
AIR MASS VELOCITY (LBM/SEC-IN2)	0.1902	WATER MASS VELOCITY (LBM/SEC-IN2)	1.1659
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.1902	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.9493
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.0000	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	0.1858
AVERAGE LINEAR AIR VELOCITY	68.7513	AVERAGE LINEAR WATER VELOCITY	23.4341

RADIUS TO CL OF PROBE (IN)	0.4725	0.4475	0.4225	0.3725	0.3225	0.2975	0.2745
R(I) / TOTAL RADIUS	0.9497	0.8995	0.8492	0.7487	0.6482	0.5980	0.5518
IMPACT PRESSURE (PSIA)	1.5561	1.4049	1.2267	1.2348	1.1214	1.0072	0.7749
MANO SET AT SAMPLE 1 UNITLESS	-0.5607	-0.5785	-0.4981	-0.4643	-0.4635	-0.5104	-0.4228
MANO SET AT SAMPLE 2 UNITLESS	-0.0729	-0.0628	-0.0359	-0.0153	-0.0337	-0.0625	0.
COLLECT 1 AIR RATE (LB/SEC-IN2)	0.1601	0.2104	0.2724	0.3222	0.3145	0.2895	0.1741
COLLECT 2 AIR RATE (LB/SEC-IN2)	0.0973	0.1212	0.1717	0.2198	0.2078	0.2121	0.1190
COLLECT 1 H2O RATE (LB/SEC-IN2)	2.6332	1.8017	0.9493	0.4797	0.3918	0.4184	0.9247
COLLECT 2 H2O RATE (LB/SEC-IN2)	2.3706	1.6624	0.8074	0.4590	0.3806	0.3980	0.8346
ISO AIR MASS VEL (LBM/SEC-IN2)	0.1104	0.1524	0.2136	0.2678	0.2561	0.2497	0.1487
NONDIM AIR MASS VELOCITY	0.5806	0.8010	1.1228	1.4079	1.3463	1.2655	0.7820
ISO H2O MASS VEL (LBM/SEC-IN2)	2.4541	1.7071	0.8664	0.4741	0.3857	0.4056	0.8832
NONDIM H2O MASS VELOCITY	2.1048	1.4641	0.7431	0.4066	0.3308	0.3479	0.7575
LOCAL QUALITY	0.0431	0.0819	0.1070	0.3610	0.3990	0.3724	0.1441
NONDIMENSIONAL QUALITY	0.3070	0.5842	1.4109	2.5737	2.9450	2.6555	1.0277
LOCAL VOID FRACTION	0.7474	0.8499	0.9475	0.9818	0.9867	0.9811	0.9192
LOCAL SLIP RATIO	2.1018	2.1780	1.8865	1.4479	1.2406	1.5801	2.0465
LINEAR VEL AIR (FT/SEC)	47.2673	57.3471	72.1003	87.2555	83.0219	78.4843	51.7641
NONDIM LINEAR AIR VELOCITY	0.6875	0.8341	1.0407	1.2691	1.2076	1.1416	0.7529
LINEAR VEL WATER (FT/SEC)	22.4088	26.3306	33.2196	60.2617	66.9230	49.6720	25.2938
NONDIM LINEAR H2O VELOCITY	0.9597	1.1236	1.6309	2.5715	2.8558	2.1196	1.0794

START OF CASE NO. 10 110366 0410.
ANNULUS TEST SECTION TEST NUMBER 2.

FLOW AREA OF TEST SECTION (INCHES)	0.5812	DENSITY OF TEST AIR (LBM/FT ³)	0.4476
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.3732	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.9380
AVERAGE TOTAL QUALITY	0.2696	AVERAGE VOID FRACTION (INTEGRATED)	0.9921
AIR MASS VELOCITY (LBM/SEC-IN ²)	0.1940	WATER MASS VELOCITY (LBM/SEC-IN ²)	0.5257
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN ²)	0.1940	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN ²)	0.3327
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.0000	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	0.3672
AVERAGE LINEAR AIR VELOCITY	66.5495	AVERAGE LINEAR WATER VELOCITY	19.5998

RADIUS TO CL OF PROBE (IN)	0.4725	0.4475	0.4225	0.3725	0.3225	0.2975	0.2745
R(I) / TOTAL RADIUS	0.9497	0.8995	0.8492	0.7497	0.6482	0.5980	0.5518
IMPACT PRESSURE (PSIA)	0.5544	0.4882	0.5213	0.6394	0.6536	0.5528	0.4536
MANO SET AT SAMPLE 1 UNITLESS	-0.3295	-0.4516	-0.3384	-0.4138	-0.2988	-0.4444	-0.3611
MANO SET AT SAMPLE 2 UNITLESS	0.0682	0.	-0.0604	0.	0.	-0.0228	-0.0625
COLLECT 1 AIR RATE (LB/SEC-IN ²)	0.1292	0.1754	0.2043	0.2520	0.2503	0.2418	0.1580
COLLECT 2 AIR RATE (LB/SEC-IN ²)	0.0731	0.1110	0.1623	0.1916	0.1922	0.1729	0.1230
COLLECT 1 H ₂ O RATE (LB/SEC-IN ²)	0.8554	0.4890	0.2257	0.1780	0.1758	0.1848	0.4450
COLLECT 2 H ₂ O RATE (LB/SEC-IN ²)	0.7674	0.4534	0.2239	0.1769	0.1724	0.1905	0.4162
ISO AIR MASS VEL (LBM/SEC-IN ²)	0.1353	0.1642	0.2096	0.2524	0.2648	0.2301	0.1594
NONDIM AIR MASS VELOCITY	0.6974	0.8464	1.0800	1.3010	1.3646	1.1860	0.8217
ISO H ₂ O MASS VEL (LBM/SEC-IN ²)	0.8651	0.4829	0.2259	0.1779	0.1766	0.1858	0.4461
NONDIM H ₂ O MASS VELOCITY	1.6455	0.9184	0.4297	0.3394	0.3359	0.3534	0.8486
LOCAL QUALITY	0.1353	0.2538	0.4813	0.5866	0.5999	0.5533	0.2633
NONDIMENSIONAL QUALITY	0.5018	0.9414	1.7852	2.1759	2.2252	2.0524	0.9766
LOCAL VOID FRACTION	0.8903	0.9537	0.9879	0.9929	0.9926	0.9914	0.9572
LOCAL SLIP RATIO	2.6795	2.2938	1.5757	1.4030	1.5467	1.4887	2.2231
LINEAR VEL AIR (FT/SEC)	48.9000	55.3970	68.2413	81.7898	85.8147	74.6741	53.5889
NONDIM LINEAR AIR VELOCITY	0.7348	0.8324	1.0254	1.2290	1.2895	1.1221	0.8052
LINEAR VEL WATER (FT/SEC)	18.2498	24.1504	43.3073	58.2971	55.4810	50.1611	24.1050
NONDIM LINEAR H ₂ O VELOCITY	0.9311	1.2322	2.2096	2.9744	2.8307	2.5593	1.2299

START OF CASE NO. 11 110366 0410.
 AMMULUS TEST SECTION TEST NUMBER 3.

FLOW AREA OF TEST SECTION (INCHES)	0.5812	DENSITY OF TEST AIR (LBM/FT3)	0.04472
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2937	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.9440
AVERAGE TOTAL QUALITY	0.3781	AVERAGE VOID FRACTION (INTEGRATED)	0.9157
AIR MASS VELOCITY (LBM/SEC-IN2)	0.1472	WATER MASS VELOCITY (LBM/SEC-IN2)	0.2421
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.1472	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.1278
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.0000	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	0.4723
AVERAGE LINEAR AIR VELOCITY	50.1489	AVERAGE LINEAR WATER VELOCITY	9.9929

RADIUS TO CL OF PROBE (IN)	0.4725	0.4475	0.4225	0.3725	0.3225	0.2975	0.2745
R(1) / TOTAL RADIUS	0.5497	0.5495	0.5492	0.7487	0.6482	0.5980	0.5512
IMPACT PRESSURE (PSIA)	0.2394	0.2236	0.2047	0.2331	0.2646	0.2221	0.2199
MANO SET AT SAMPLE 1 UNITLESS	-0.4211	-0.6197	-0.9692	-0.7568	-0.5238	-0.4113	-0.8309
MANO SET AT SAMPLE 2 UNITLESS	0.1242	0.1690	0.3077	-0.2162	0.1667	-0.2553	0.1146
COLLECT 1 AIR RATE (LB/SEC-IN2)	0.1303	0.1293	0.2440	0.2581	0.2062	0.1802	0.1808
COLLECT 2 AIR RATE (LB/SEC-IN2)	0.0569	0.0342	0.0806	0.2042	0.1209	0.1607	0.1004
COLLECT 1 H2O RATE (LB/SEC-IN2)	0.4173	0.2155	0.0760	0.0352	0.0340	0.0612	0.2722
COLLECT 2 H2O RATE (LB/SEC-IN2)	0.3482	0.1429	0.0601	0.0312	0.0329	0.0612	0.2007
ISO AIR MASS VEL (LBM/SEC-IN2)	0.1148	0.0894	0.1576	0.2119	0.1778	0.1655	0.1351
NONDIM AIR MASS VELOCITY	0.7804	0.6076	1.0708	1.4400	1.2079	1.1244	0.9182
ISO H2O MASS VEL (LBM/SEC-IN2)	0.4011	0.1855	0.0676	0.0318	0.0336	0.0612	0.2316
NONDIM H2O MASS VELOCITY	1.6567	0.7660	0.2791	0.1312	0.1390	0.2529	0.9565
LOCAL QUALITY	0.2226	0.3253	0.6990	0.8697	0.8409	0.7299	0.3685
NONDIMENSIONAL QUALITY	0.5208	0.3605	1.8512	2.3004	2.2242	1.9307	0.9747
LOCAL VOID FRACTION	0.9355	0.9866	0.9959	0.9914	0.9992	0.9968	0.9705
LOCAL SLIP RATIO	2.7415	0.9071	1.3220	9.0464	0.5605	1.1906	2.4663
LINEAR VEL AIR (FT/SEC)	39.4091	29.1544	50.8991	68.7604	57.2246	53.4007	44.7895
NONDIM LINEAR AIR VELOCITY	0.7874	0.5814	1.0150	1.3711	1.1411	1.0648	0.8931
LINEAR VEL WATER (FT/SEC)	14.4040	32.1408	38.4722	9.5455	102.0982	44.8518	18.1606
NONDIM LINEAR H2O VELOCITY	1.4014	3.2164	3.9506	0.8552	10.2171	4.4884	1.8173

START OF CASE NO. 12 110365
ANNULUS TEST SECTION

0410.

TEST NUMBER 4.

FLOW AREA OF TEST SECTION (INCHES)	0.5812	DENSITY OF TEST AIR (LBM/FT3)	0.4458
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.5102	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.9660
AVERAGE TOTAL QUALITY	0.4953	AVERAGE VOID FRACTION (INTEGRATED)	0.9230
AIR MASS VELOCITY (LBM/SEC-IN2)	0.1524	WATER MASS VELOCITY (LBM/SEC-IN2)	0.1553
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.1524	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.0662
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.0002	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	0.5738
AVERAGE LINEAR AIR VELOCITY	50.9589	AVERAGE LINEAR WATER VELOCITY	10.5567

RADIUS TO CL OF PROBE (IN)	0.4725	0.4475	0.4225	0.3725	0.3225	0.2975	0.2745
R(1) / TOTAL RADIUS	0.9497	0.8995	0.8492	0.7497	0.6482	0.5990	0.5518
IMPACT PRESSURE (PSIA)	0.1260	0.1323	0.1386	0.1654	0.1811	0.1575	0.1449
MANO SET AT SAMPLE 1 UNITLESS	-0.5000	-0.3810	-0.3636	-0.4571	-0.4174	-0.6000	-0.4783
MANO SET AT SAMPLE 2 UNITLESS	0.	0.	0.2273	0.	0.0696	-0.0800	0.
COLLECT 1 AIR RATE (LB/SEC-IN2)	0.1134	0.1296	0.1512	0.1672	0.1956	0.1882	0.1326
COLLECT 2 AIR RATE (LB/SEC-IN2)	0.0712	0.0655	0.0751	0.1479	0.1310	0.1254	0.1068
COLLECT 1 H2O RATE (LB/SEC-IN2)	0.2245	0.1134	0.0238	0.0113	0.0170	0.0306	0.1191
COLLECT 2 H2O RATE (LB/SEC-IN2)	0.1905	0.0939	0.0295	0.0136	0.0138	0.0261	0.1077
ISO AIR MASS VEL (LBM/SEC-IN2)	0.1142	0.1500	0.1781	0.1694	0.2079	0.1774	0.1343
NONDIM AIR MASS VELOCITY	0.7495	0.9845	1.1161	1.1116	1.3640	1.1637	0.8812
ISO H2O MASS VEL (LBM/SEC-IN2)	0.2252	0.1234	0.0224	0.0111	0.0176	0.0298	0.1198
NONDIM H2O MASS VELOCITY	1.4504	0.7947	0.1443	0.0713	0.1134	0.1921	0.7717
LOCAL QUALITY	0.3365	0.5487	0.8836	0.9386	0.9219	0.8560	0.5284
NONDIMENSIONAL QUALITY	0.6794	1.1078	1.7839	1.8950	1.8612	1.7282	1.0669
LOCAL VOID FRACTION	0.9415	0.9446	1.0053	0.9996	1.0006	1.1258	0.9812
LOCAL SLIP RATIO	4.3967	9.9527	-5.6311	0.8880	-1.0192	-92.6740	2.9975
LINEAR VEL AIR (FT/SEC)	39.1892	51.3086	54.6483	54.7434	67.1014	50.8851	44.2074
NONDIM LINEAR AIR VELOCITY	0.7690	1.0069	1.0724	1.0743	1.3168	0.9986	0.8675
LINEAR VEL WATER (FT/SEC)	8.9133	5.1552	-9.7048	61.6491	-65.8376	-0.5491	14.7480
NONDIM LINEAR H2O VELOCITY	0.8443	0.4883	-0.9193	5.8308	-6.2365	-0.0520	1.3970

START OF CASE NO. 13 110366 0410.
ANNULUS TEST SECTION TEST NUMBER 5.

FLOW AREA OF TEST SECTION (INCHES)	0.5812	DENSITY OF TEST AIR (LBM/FT3)	0.4460
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.4347	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.9780
AVERAGE TOTAL QUALITY	0.6246	AVERAGE VOID FRACTION (INTEGRATED)	0.8976
AIR MASS VELOCITY (LBM/SEC-IN2)	0.1495	WATER MASS VELOCITY (LBM/SEC-IN2)	0.0898
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.1495	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.0466
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.0000	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	0.4808
AVERAGE LINEAR AIR VELOCITY	49.3416	AVERAGE LINEAR WATER VELOCITY	0.4375

RADIUS TO CL OF PROBE (IN)	0.4725	0.4475	0.4225	0.3725	0.3225	0.2975	0.2745
R(I) / TOTAL RADIUS	0.9497	0.8995	0.8492	0.7437	0.6482	0.5980	0.5518
IMPACT PRESSURE (PSIA)	0.1260	0.1496	0.1559	0.1543	0.1701	0.1622	0.1575
MANO SET AT SAMPLE 1 UNITLESS	-0.2500	-0.2421	-0.6061	-0.2449	-0.6667	-0.6990	-0.5400
MANO SET AT SAMPLE 2 UNITLESS	0.2500	0.3158	0.4646	0.5714	-0.0741	0.2330	0.1200
COLLECT 1 AIR RATE (LB/SEC-IN2)	0.1185	0.2027	0.1994	0.1244	0.2014	0.1999	0.1558
COLLECT 2 AIR RATE (LB/SEC-IN2)	0.0599	0.0648	0.0410	0.0735	0.1563	0.1125	0.1023
COLLECT 1 H2O RATE (LB/SEC-IN2)	0.1043	0.0431	0.0919	0.	0.	0.0096	0.0624
COLLECT 2 H2O RATE (LB/SEC-IN2)	0.0896	0.0340	0.0113	0.	0.0034	0.0040	0.0442
ISO AIR MASS VEL (LBM/SEC-IN2)	0.1402	0.1542	0.1741	0.1363	0.1838	0.1751	0.1473
NONDIM AIR MASS VELOCITY	0.9379	1.0315	1.1646	0.9119	1.2297	1.1715	0.9855
ISO H2O MASS VEL (LBM/SEC-IN2)	0.1098	0.0399	0.0790	0.	0.0013	0.0080	0.0595
NONDIM H2O MASS VELOCITY	1.2221	0.4442	0.8791	0.	0.0148	0.0894	0.6621
LOCAL QUALITY	0.5608	0.7944	0.6877	1.0000	0.9928	0.9561	0.7124
NONDIMENSIONAL QUALITY	0.8970	1.2712	1.1013	1.6010	1.5895	1.5308	1.1405
LOCAL VOID FRACTION	0.9688	0.9962	0.8874	1.0000	0.9997	0.9994	0.9948
LOCAL SLIP RATIO	5.7360	2.0398	38.9874	0.	5.4238	1.7099	1.8123
LINEAR VEL AIR (FT/SEC)	46.7191	49.9635	63.3266	44.0027	59.3552	56.5652	47.8066
NONDIM LINEAR AIR VELOCITY	0.9469	1.0126	1.2834	0.8918	1.2629	1.1464	0.9689
LINEAR VEL WATER (FT/SEC)	8.1449	24.4947	1.6243	0.	10.9434	37.0810	26.3780
NONDIM LINEAR H2O VELOCITY	0.8630	2.5954	0.1721	0.	1.1596	3.5053	2.7951

START OF CASE NO. 14 110366	0410.	TEST NUMBER	6.
ANNULUS TEST SECTION			
FLOW AREA OF TEST SECTION (INCHES)	0.5912	DENSITY OF TEST AIR (LBM/FT3)	0.4482
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.6159	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.9390
AVERAGE TOTAL QUALITY	0.3710	AVERAGE VOID FRACTION (INTEGRATED)	0.9147
AIR MASS VELOCITY (LBM/SEC-IN2)	0.1920	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3256
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.1919	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.1790
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.0006	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	0.4503
AVERAGE LINEAR AIR VELOCITY	65.6874	AVERAGE LINEAR WATER VELOCITY	12.3370

RADIUS TO CL OF PROBE (IN)	0.4725	0.4475	0.4225	0.3725	0.3225	0.2975	0.2745
R(I) / TOTAL RADIUS	0.9497	0.8995	0.8493	0.7487	0.6482	0.5980	0.5518
IMPACT PRESSURE (PSIA)	0.3182	0.3717	0.4600	0.4509	0.4284	0.2756	0.3591
MANO SET AT SAMPLE 1 UNITLESS	-0.5149	-0.4407	-0.3937	-0.4658	-0.4412	-0.8457	-0.5430
MANO SET AT SAMPLE 2 UNITLESS	0.1386	0.1356	0.0315	0.0274	0.0294	-0.1143	0.0351
COLLECT 1 AIR RATE (LB/SEC-IN2)	0.1445	0.1243	0.1802	0.2109	0.2037	0.2034	0.1604
COLLECT 2 AIR RATE (LB/SEC-IN2)	0.0601	0.0292	0.1291	0.1416	0.1415	0.1285	0.1002
COLLECT 1 H2O RATE (LB/SEC-IN2)	0.4162	0.2291	0.1247	0.1077	0.1000	0.1372	0.2461
COLLECT 2 H2O RATE (LB/SEC-IN2)	0.3379	0.1644	0.1203	0.0998	0.0987	0.1281	0.2064
ISO AIR MASS VEL (LBM/SEC-IN2)	0.1576	0.1532	0.2205	0.2437	0.2268	0.1799	0.1720
NONDIM AIR MASS VELOCITY	0.6208	0.7977	1.1480	1.2692	1.1810	0.9368	0.9260
ISO H2O MASS VEL (LBM/SEC-IN2)	0.4283	0.2487	0.1271	0.1101	0.1013	0.1344	0.2510
NONDIM H2O MASS VELOCITY	1.3154	0.7639	0.3903	0.3383	0.3126	0.4127	0.7710
LOCAL QUALITY	0.2690	0.3811	0.6345	0.6887	0.6902	0.5724	0.4149
NONDIMENSIONAL QUALITY	0.7251	1.0274	1.7100	1.8566	1.8607	1.5431	1.1184
LOCAL VOID FRACTION	0.9344	0.9827	0.9926	0.9947	0.9957	0.9887	0.9777
LOCAL SLIP RATIO	3.5871	1.5045	1.7867	1.6435	1.3440	2.1250	2.2416
LINEAR VEL AIR (FT/SEC)	54.1834	50.0678	71.3894	70.7038	73.1632	58.4429	58.4765
NONDIM LINEAR AIR VELOCITY	0.8249	0.7622	1.0868	1.1982	1.1138	0.8897	0.8902
LINEAR VEL WATER (FT/SEC)	15.1649	33.2792	39.9552	47.8873	54.4382	27.5027	26.0866
NONDIM LINEAR H2O VELOCITY	1.2244	2.6975	3.2387	3.8816	4.4126	2.2293	2.1145

START OF CASE NO. 15 110366 0410.
ANNULUS TEST SECTION TEST NUMBER 7.

FLOW AREA OF TEST SECTION (INCHES)	0.5812	DENSITY OF TEST AIR (LBM/FT3)	0.4336
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.4775	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.9830
AVERAGE TOTAL QUALITY	0.6080	AVERAGE VOID FRACTION (INTEGRATED)	0.9273
AIR MASS VELOCITY (LBM/SEC-IN2)	0.1919	WATER MASS VELOCITY (LBM/SEC-IN2)	0.1237
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.1919	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.0447
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.0000	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	0.6386
AVERAGE LINEAR AIR VELOCITY	64.8235	AVERAGE LINEAR WATER VELOCITY	16.8196

RADIUS TO CL OF PROBE (IN)	0.4725	0.4475	0.4225	0.3725	0.3225	0.2975	0.2745
R(I) / TOTAL RADIUS	0.9497	0.8925	0.8492	0.7487	0.6482	0.5980	0.5518
IMPACT PRESSURE (PSIA)	0.1701	0.2142	0.2520	0.3118	0.2772	0.2520	0.2142
MANO SET AT SAMPLE 1 UNITLESS	-0.5370	-0.5294	-0.3501	-0.3636	-0.2641	-0.5000	-0.3824
MANO SET AT SAMPLE 2 UNITLESS	0.1481	0.	0.1625	0.0808	0.1364	0.0500	0.2052
COLLECT 1 AIR RATE (LB/SEC-IN2)	0.1518	0.1831	0.2002	0.2419	0.2115	0.2165	0.1672
COLLECT 2 AIR RATE (LB/SEC-IN2)	0.0867	0.1367	0.1476	0.1848	0.1759	0.1581	0.1165
COLLECT 1 H2O RATE (LB/SEC-IN2)	0.1225	0.6448	0.0232	0.0210	0.0198	0.0295	0.0930
COLLECT 2 H2O RATE (LB/SEC-IN2)	0.1065	0.0438	0.0232	0.0215	0.0244	0.0249	0.0771
ISO AIR MASS VEL (LBM/SEC-IN2)	0.1461	0.1705	0.2132	0.2566	0.2278	0.2141	0.1754
NONDIM AIR MASS VELOCITY	0.7614	0.9302	1.1112	1.3371	1.1873	1.1156	0.9140
ISO H2O MASS VEL (LBM/SEC-IN2)	0.1211	0.6447	0.0232	0.0208	0.0178	0.0293	0.0956
NONDIM H2O MASS VELOCITY	0.9789	0.3613	0.1871	0.1684	0.1436	0.2368	0.7725
LOCAL QUALITY	0.5468	0.7998	0.9817	0.9240	0.9277	0.8796	0.6473
NONDIMENSIONAL QUALITY	0.8593	1.3154	1.4530	1.5212	1.5258	1.4467	1.0646
LOCAL VOID FRACTION	0.9826	0.9971	0.9977	1.0011	0.9975	0.9960	0.9882
LOCAL SLIP RATIO	3.0727	1.4591	2.9301	-1.9500	4.6026	4.2417	3.1405
LINEAR VEL AIR (FT/SEC)	49.3802	59.4500	70.9666	85.1025	75.8469	71.3782	58.9387
NONDIM LINEAR AIR VELOCITY	0.7618	0.9171	1.0948	1.3129	1.1701	1.1011	0.9092
LINEAR VEL WATER (FT/SEC)	16.0705	35.8330	23.8139	-43.6458	16.4793	16.8278	18.7673
NONDIM LINEAR H2O VELOCITY	0.9555	2.1304	1.4159	-2.5949	0.9798	1.0005	1.1158

START OF CASE NO. 16 110366

0410.

ANNULUS TEST SECTION

TEST NUMBER

R.

FLOW AREA OF TEST SECTION (INCHES)	0.5812	DENSITY OF TEST AIR (LBM/FT ³)	0.3425
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.3293	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.9620
AVERAGE TOTAL QUALITY	0.3724	AVERAGE VOID FRACTION (INTEGRATED)	0.9183
AIR MASS VELOCITY (LBM/SEC-IN ²)	0.1432	WATER MASS VELOCITY (LBM/SEC-IN ²)	0.2413
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN ²)	0.1432	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN ²)	0.1399
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.0000	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	0.4204
AVERAGE LINEAR AIR VELOCITY	62.5813	AVERAGE LINEAR WATER VELOCITY	14.6797

RADIUS TO CL OF PROBE (IN)	0.4725	0.4475	0.4225	0.3725	0.3225	0.2975	0.2745
R(I) / TOTAL RADIUS	0.9497	0.8995	0.8492	0.7497	0.6482	0.5980	0.5518
IMPACT PRESSURE (PSIA)	0.2866	0.2740	0.2725	0.3118	0.3339	0.3087	0.2677
MANO SET AT SAMPLE 1 UNITLESS	-0.4615	-0.4538	-0.5780	-0.5253	-0.4717	-0.4082	-0.4235
MANO SET AT SAMPLE 2 UNITLESS	0.0879	0.	0.1156	0.1212	0.0755	-0.0612	0.0471
COLLECT 1 AIR RATE (LB/SEC-IN ²)	0.1100	0.1464	0.1811	0.2012	0.2010	0.1780	0.1513
COLLECT 2 AIR RATE (LB/SEC-IN ²)	0.0645	0.0999	0.1120	0.1311	0.1391	0.1349	0.1008
COLLECT 1 H ₂ O RATE (LB/SEC-IN ²)	0.4252	0.1860	0.0794	0.0522	0.0533	0.0703	0.2529
COLLECT 2 H ₂ O RATE (LB/SEC-IN ²)	0.3606	0.1792	0.0737	0.0476	0.0493	0.0680	0.2245
ISO AIR MASS VEL (LBM/SEC-IN ²)	0.0991	0.1332	0.1566	0.1799	0.1849	0.1682	0.1412
NONDIM AIR MASS VELOCITY	0.6918	0.9302	1.0938	1.2565	1.2910	1.1745	0.9859
ISO H ₂ O MASS VEL (LBM/SEC-IN ²)	0.4097	0.1840	0.0773	0.0508	0.0523	0.0698	0.2472
NONDIM H ₂ O MASS VELOCITY	1.6976	0.7626	0.3205	0.2104	0.2166	0.2892	1.0243
LOCAL QUALITY	0.1947	0.4199	0.6694	0.7709	0.7796	0.7067	0.3635
NONDIMENSIONAL QUALITY	0.5229	1.1275	1.7976	2.0942	2.0934	1.8978	0.9761
LOCAL VOID FRACTION	0.9473	0.9847	0.9962	0.9982	0.9982	0.9972	0.9686
LOCAL SLIP RATIO	2.4453	2.0386	1.4130	1.1913	1.1422	1.2389	3.3654
LINEAR VEL AIR (FT/SEC)	43.9706	56.8685	66.1057	75.7856	77.8587	70.9067	61.2781
NONDIM LINEAR AIR VELOCITY	0.7026	0.9087	1.0563	1.2110	1.2441	1.1330	0.9792
LINEAR VEL WATER (FT/SEC)	17.9820	27.8959	46.7846	63.6173	68.1629	57.2347	18.2081
NONDIM LINEAR H ₂ O VELOCITY	1.2250	1.9003	3.1870	4.3337	4.6433	3.8989	1.2404

START OF CASE NO. 17 110366	0411.	TEST NUMBER 9.
ANNULUS TEST SECTION		
FLOW AREA OF TEST SECTION (INCHES)	0.5812	DENSITY OF TEST AIR (LBM/FT3) 0.4403
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2300	AVERAGE VOID FRACTION (QUICK CLOSING VALVES) 0.8540
AVERAGE TOTAL QUALITY	0.1167	AVERAGE VOID FRACTION (INTEGRATED) 0.8311
AIR MASS VELOCITY (LBM/SEC-IN2)	0.1545	WATER MASS VELOCITY (LBM/SEC-IN2) 1.1697
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.1545	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2) 1.0565
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.0000	ERROR IN WATERFLOW (INTEGRATED TO TRUE) 0.0968
AVERAGE LINEAR AIR VELOCITY	59.1675	AVERAGE LINEAR WATER VELOCITY 18.5182

RADIUS TO CL OF PROBE (IN)	0.4725	0.4475	0.4225	0.3725	0.3225	0.2975	0.2745
R(I) / TOTAL RADIUS	0.9097	0.9995	0.8492	0.7497	0.6482	0.5980	0.5518
IMPACT PRESSURE (PSIA)	1.4962	1.3545	1.3104	0.8253	0.6300	0.6048	0.7749
MANO SET AT SAMPLE 1 UNITLESS	-0.4168	-0.4977	-0.4809	-0.5032	-0.4400	-0.5417	-0.3902
MANO SET AT SAMPLE 2 UNITLESS	-0.0547	0.0186	0.	0.	0.	0.0417	0.0488
COLLECT 1 AIR RATE (LB/SEC-IN2)	0.0892	0.1798	0.2470	0.2608	0.2320	0.2199	0.1362
COLLECT 2 AIR RATE (LB/SEC-IN2)	0.0576	0.1099	0.1447	0.1676	0.1643	0.1340	0.0976
COLLECT 1 H2O RATE (LB/SEC-IN2)	3.1238	1.9842	1.9366	0.3379	0.2132	0.3691	1.2526
COLLECT 2 H2O RATE (LB/SEC-IN2)	2.8405	1.9393	0.9243	0.3175	0.2189	0.3314	1.1160
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0729	0.1435	0.1936	0.2101	0.1997	0.1740	0.1221
NONDIM AIR MASS VELOCITY	0.4719	0.9292	1.2539	1.3603	1.2928	1.1264	0.7909
ISO H2O MASS VEL (LBM/SEC-IN2)	2.9777	1.9091	1.0096	0.3268	0.2159	0.3490	1.2027
NONDIM H2O MASS VELOCITY	2.5457	1.6321	0.8631	0.2794	0.1846	0.2983	1.0282
LOCAL QUALITY	0.0239	0.0699	0.1609	0.3913	0.4205	0.3327	0.0922
NONDIMENSIONAL QUALITY	0.2048	0.5994	1.3704	3.3545	4.1190	2.8521	0.7900
LOCAL VOID FRACTION	0.6439	0.8104	0.9367	0.9973	0.9922	0.9808	0.8617
LOCAL SLIP RATIO	1.9132	2.4847	1.8309	1.1675	1.0282	1.3800	2.3021
LINEAR VEL AIR (FT/SEC)	37.6329	57.9321	67.6110	69.6102	65.3383	58.0306	46.3484
NONDIM LINEAR AIR VELOCITY	0.6259	0.9791	1.1427	1.1766	1.1127	0.9808	0.7833
LINEAR VEL WATER (FT/SEC)	19.3562	23.3160	36.9282	50.6310	64.0299	42.0513	20.1327
NONDIM LINEAR H2O VELOCITY	1.0453	1.2591	1.9942	3.2281	3.4577	2.2708	1.0872

START OF CASE NO. 12 110366 0411.
ANNULUS TEST SECTION TEST NUMBER 10.

FLOW AREA OF TEST SECTION (INCHES)	0.5812	DENSITY OF TEST AIR (LBM/FT3)	0.4444
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2386	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.9130
AVERAGE TOTAL QUALITY	0.2264	AVERAGE VOID FRACTION (INTEGRATED)	0.8902
AIR MASS VELOCITY (LBM/SEC-IN2)	0.1521	WATER MASS VELOCITY (LBM/SEC-IN2)	0.5198
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.1521	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.3553
ERROR IN AIR FLOW (INTEGRATED TO TRUE)	0.0000	ERROR IN WATER FLOW (INTEGRATED TO TRUE)	0.3164
AVERAGE LINEAR AIR VELOCITY	53.9363	AVERAGE LINEAR WATER VELOCITY	13.8094

RADIUS TO CL OF PROBE (IN)	0.4725	0.4475	0.4225	0.3725	0.3225	0.2975	0.2745
R(I) / TOTAL RADIUS	0.9497	0.8925	0.8497	0.7487	0.6482	0.5980	0.5518
IMPACT PRESSURE (PSIA)	0.5229	0.4153	0.4095	0.4032	0.3969	0.3276	0.3874
MANO SET AT SAMPLE 1 UNITLESS	-0.4458	-0.5000	-0.4000	-0.4062	-0.3651	-0.2308	-0.6667
MANO SET AT SAMPLE 2 UNITLESS	-0.0843	0.	0.	0.0937	-0.0635	0.1538	0.
COLLECT 1 AIR RATE (LB/SEC-IN2)	0.1134	0.1670	0.1946	0.2195	0.2180	0.1710	0.2074
COLLECT 2 AIR RATE (LB/SEC-IN2)	0.0750	0.1065	0.1453	0.1564	0.1751	0.1217	0.0990
COLLECT 1 H2O RATE (LB/SEC-IN2)	1.1351	0.5681	0.2257	0.1099	0.0942	0.1417	0.7087
COLLECT 2 H2O RATE (LB/SEC-IN2)	1.0104	0.5375	0.2245	0.0975	0.0931	0.1327	0.5525
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0914	0.1354	0.1746	0.1934	0.2000	0.1720	0.1378
NONDIM AIR MASS VELOCITY	0.6008	0.8899	1.1477	1.3041	1.3148	1.1307	0.9059
ISO H2O MASS VEL (LBM/SEC-IN2)	1.0636	0.5521	0.2252	0.0998	0.0937	0.1419	0.6084
NONDIM H2O MASS VELOCITY	2.0463	1.0622	0.4333	0.1920	0.1803	0.2731	1.1706
LOCAL QUALITY	0.0791	0.1969	0.4367	0.6653	0.6809	0.5479	0.1846
NONDIMENSIONAL QUALITY	0.3495	0.8697	1.9288	2.9388	3.0075	2.4200	0.8156
LOCAL VOID FRACTION	0.8442	0.9345	0.9859	0.9965	0.9968	0.9919	0.9129
LOCAL SLIP RATIO	2.2189	2.4037	1.5552	0.9727	0.9664	1.3800	3.0255
LINEAR VEL AIR (FT/SEC)	35.0748	46.9375	57.3796	64.5033	65.0178	56.1852	48.9099
NONDIM LINEAR AIR VELOCITY	0.6497	0.8694	1.0629	1.1948	1.2043	1.0407	0.9060
LINEAR VEL WATER (FT/SEC)	15.8070	19.5273	36.8962	66.3108	67.2769	40.7136	16.1656
NONDIM LINEAR H2O VELOCITY	1.1446	1.4141	2.6718	4.8018	4.8718	2.9482	1.1706

A.5 ECCENTRIC ANNULUS RESULTS

SNUMB = 06473, ACTIVITY # = 02, REPORT CODE = 06, RECORD COUNT = 00510

ANNULUS TEST SECTION		TEST NUMBER 1	
FLOW AREA OF TEST SECTION (INCHES)	0.5812	DENSITY OF TEST AIR (LBM/FT ³)	0.4462
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.9430
AVERAGE TOTAL QUALITY	0.3787	ANGULAR POSITION (DEG.)	0.
AIR MASS VELOCITY (LBM/SEC-IN ²)	0.1956	WATER MASS VELOCITY (LBM/SEC-IN ²)	0.3210
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN ²)	0.0589	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN ²)	0.2123
ERROR IN AIRFLOW INTEGRATED TO TRUE	0.6989	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	0.3385
AVERAGE LINEAR AIR VELOCITY	66.3000	AVERAGE LINEAR WATER VELOCITY	13.1000

RADIUS TO CL OF PROBE (IN)	0.4725	0.4575	0.4355	0.4225	0.4045
R(1) / TOTAL RADIUS	0.9497	0.9196	0.8754	0.8492	0.8131
IMPACT PRESSURE (PSIA)	0.3276	0.3182	0.2709	0.2646	0.2583
MANO SET AT SAMPLE 1 UNITLESS	-0.4615	-0.5248	-0.5455	-0.5000	-0.5610
MANO SET AT SAMPLE 2 UNITLESS	0.	-0.2679	-0.0581	-0.1667	-0.0976
COLLECT 1 AIR RATE (LB/SEC-IN ²)	0.1028	0.1479	0.1756	0.1796	0.1672
COLLECT 2 AIR RATE (LB/SEC-IN ²)	0.0659	0.1180	0.1309	0.1472	0.1287
COLLECT 1 H ₂ O RATE (LB/SEC-IN ²)	0.8233	0.4808	0.2517	0.1939	0.3017
COLLECT 2 H ₂ O RATE (LB/SEC-IN ²)	0.6305	0.4445	0.2302	0.1614	0.2359
1ST AIR MASS VEL (LBM/SEC-IN ²)	0.0859	0.1220	0.1489	0.1553	0.1413
NONDIM AIR MASS VELOCITY	0.4392	0.6237	0.7612	0.7940	0.7224
1ST H ₂ O MASS VEL (LBM/SEC-IN ²)	0.7349	0.4493	0.2387	0.1846	0.2575
NONDIM H ₂ O MASS VELOCITY	2.2894	1.3997	0.7436	0.5751	0.8022
LOCAL QUALITY	0.1047	0.2185	0.3842	0.4570	0.3544
NONDIMENSIONAL QUALITY	0.2765	0.5638	1.0145	1.2068	0.9358
LOCAL VOID FRACTION	0.8749	0.9422	0.9747	0.9831	0.9703
LOCAL SLIP RATIO	2.331	2.323	2.258	2.017	2.341
LINEAR VEL AIR (FT/SEC)	31.694	41.787	49.308	50.987	47.008
NONDIM LINEAR AIR VELOCITY	0.4780	0.6303	0.7437	0.7690	0.7090
LINEAR VEL WATER (FT/SEC)	13.598	17.938	21.833	25.281	20.081
NONDIM LINEAR H ₂ O VELOCITY	1.0380	1.3751	1.6666	1.9298	1.5329

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 ANNULUS TEST SECTION TEST NUMBER 2.

FLOW AREA OF TEST SECTION (INCHES)	0.5812	DENSITY OF TEST AIR (LBM/FT3)	0.4483
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.9430
AVERAGE TOTAL QUALITY	0.3803	ANGULAR POSITION (DEG.)	45.000
AIR MASS VELOCITY (LBM/SEC-IN2)	0.1965	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3201
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.1094	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.1755
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.4430	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	0.4516
AVERAGE LINEAR AIR VELOCITY	66.3000	AVERAGE LINEAR WATER VELOCITY	13.1000

RADIUS TO CL OF PROBE (IN)	0.4725	0.4535	0.4095	0.3725	0.3665
R(1) / TOTAL RADIUS	0.9497	0.9116	0.8231	0.7487	0.7367
IMPACT PRESSURE (PSIA)	0.3622	0.3402	0.2961	0.2603	0.2709
MANO SET AT SAMPLE 1 UNITLESS	-0.4261	-0.5000	-0.4574	-0.4607	-0.5581
MANO SET AT SAMPLE 2 UNITLESS	-0.0522	0.	-0.0749	0.	-0.0314
COLLECT 1 AIR RATE (LB/SEC-IN2)	0.1645	0.1852	0.2202	0.2113	0.2137
COLLECT 2 AIR RATE (LB/SEC-IN2)	0.1205	0.1259	0.1811	0.1571	0.1658
COLLECT 1 H2O RATE (LB/SEC-IN2)	0.3912	0.2812	0.0828	0.0839	0.1043
COLLECT 2 H2O RATE (LB/SEC-IN2)	0.3527	0.2744	0.0794	0.0805	0.0953
ISO AIR MASS VEL (LBM/SEC-IN2)	0.1438	0.1556	0.1990	0.1865	0.1828
NCNDIM AIR MASS VELOCITY	0.7318	0.7919	1.0127	0.9491	0.9303
ISO H2O MASS VEL (LBM/SEC-IN2)	0.3731	0.2778	0.0809	0.0324	0.0985
NCNDIM H2O MASS VELOCITY	1.1656	0.8679	0.2527	0.2574	0.3077
LOCAL QUALITY	0.2782	0.3589	0.7109	0.6937	0.6499
NCNDIMENSIONAL QUALITY	0.7315	0.9437	1.8693	1.8241	1.7389
LOCAL VOID FRACTION	0.9621	0.9750	0.9952	0.9954	0.9933
LOCAL SLIP RATIO	2.104	1.988	1.637	1.439	1.729
LINEAR VEL AIR (FT/SEC)	48.004	51.242	64.226	60.180	59.095
NCNDIM LINEAR AIR VELOCITY	0.7240	0.7729	0.9687	0.9077	0.8913
LINEAR VEL WATER (FT/SEC)	22.811	25.773	39.224	41.809	34.176
NCNDIM LINEAR H2O VELOCITY	1.7413	1.9674	2.9942	3.1915	2.6089

FLOW AREA OF TEST SECTION (INCHES)	0.5812	DENSITY OF TEST AIR (LBM/FT3)	0.4541
APPROX. ISO KINETIC SETTING OF MANOMETER	-0.2500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.9430
AVERAGE TOTAL QUALITY	0.3772	ANGULAR POSITION (DEG.)	90.000
AIR MASS VELOCITY (LBM/SEC-IN2)	0.1970	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3252
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.2259	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.2450
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.1466	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	0.2460
AVERAGE LINEAR AIR VELOCITY	66.3000	AVERAGE LINEAR WATER VELOCITY	13.1000

RADIUS TO CL OF PROBE (IN)	0.4725	0.4275	0.3575	0.2875	0.2715
R(r)/TOTAL RADIUS	0.9497	0.9593	0.7186	0.5779	0.5457
IMPACT PRESSURE (PSIA)	0.5276	0.4993	0.5890	0.4662	0.4200
MANO SET AT SAMPLE 1 UNITLESS	-0.5433	-0.4858	-0.5829	-0.4797	-0.4944
MANO SET AT SAMPLE 2 UNITLESS	-0.0836	-0.0442	-0.0214	0.	-0.0449
COLLECT 1 AIR RATE (LB/SEC-IN2)	0.1902	0.2745	0.3303	0.2813	0.2530
COLLECT 2 AIR RATE (LB/SEC-IN2)	0.1333	0.2103	0.2454	0.2217	0.2072
COLLECT 1 H2O RATE (LB/SEC-IN2)	0.6260	0.1508	0.1179	0.0995	0.1089
COLLECT 2 H2O RATE (LB/SEC-IN2)	0.5900	0.1452	0.1168	0.0987	0.1043
ISO AIR MASS VEL (LBM/SEC-IN2)	0.1539	0.2403	0.2800	0.2527	0.2330
NONDIM AIR MASS VELOCITY	0.7812	1.2198	1.4213	1.2827	1.1827
ISO H2O MASS VEL (LBM/SEC-IN2)	0.6030	0.1478	0.1173	0.0992	0.1064
NONDIM H2O MASS VELOCITY	1.8542	0.4545	0.3607	0.3050	0.3272
LOCAL QUALITY	0.2033	0.6191	0.7048	0.7180	0.6865
NONDIMENSIONAL QUALITY	0.9390	1.6413	1.8695	1.9035	1.8200
LOCAL VOID FRACTION	0.9384	0.9927	0.9951	0.9953	0.9947
LOCAL SLIP RATIO	2.295	1.634	1.600	1.636	1.601
LINEAR VEL AIR (FT/SEC)	52.012	76.754	89.225	80.524	74.290
NONDIM LINEAR AIR VELOCITY	0.7845	1.1577	1.3458	1.2145	1.1205
LINEAR VEL WATER (FT/SEC)	22.663	46.969	55.773	49.207	46.393
NONDIM LINEAR H2O VELOCITY	1.7300	3.5854	4.2575	3.7563	3.5415

CASE ID NO. ANNUOUS TEST SECTION 0 110468 1153.5 PAGE NO. 3
TEST NUMBER 4.

FLOW AREA OF TEST SECTION (INCHES)	0.5812	DENSITY OF TEST AIR (LBM/FT3)	0.4442
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.9430
AVERAGE TOTAL QUALITY	0.3762	ANGULAR POSITION (DEG.)	135.000
AIR MASS VELOCITY (LBM/SEC-IN2)	0.1949	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3232
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.3328	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.2661
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.7074	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	0.1766
AVERAGE LINEAR AIR VELOCITY	66.3000	AVERAGE LINEAR WATER VELOCITY	13.1000

RADIUS TO CL OF PROBE (IN)	0.4725	0.4095	0.3215	0.2335	0.1945
R(I) / TOTAL RADIUS	0.9497	0.8231	0.6462	0.4693	0.3910
IMPACT PRESSURE P(IA)	0.5623	0.6457	0.8505	0.6615	0.5197
MANO SET AT SAMPLE 1 UNITLESS	-0.4538	-0.5171	-0.1963	-0.4619	-0.4545
MANO SET AT SAMPLE 2 UNITLESS	0.	-0.0780	0.	0.	-0.0606
COLLECT 1 AIR RATE (LB/SEC-IN2)	0.2182	0.3298	0.3306	0.3349	0.2792
COLLECT 2 AIR RATE (LB/SEC-IN2)	0.1499	0.2614	0.2921	0.2639	0.2253
COLLECT 1 H2O RATE (LB/SEC-IN2)	0.4910	0.1463	0.1542	0.1338	0.1531
COLLECT 2 H2O RATE (LB/SEC-IN2)	0.4468	0.1417	0.1554	0.1315	0.1452
ISO AIR MASS VEL (LBM/SEC-IN2)	0.1875	0.2882	0.3412	0.3024	0.2512
NCNDIM AIR MASS VELOCITY	0.9620	1.4787	1.7506	1.5516	1.2839
ISO H2O MASS VEL (LBM/SEC-IN2)	0.4712	0.1435	0.1539	0.1328	0.1490
NCNDIM H2O MASS VELOCITY	1.4579	0.4440	0.4762	0.4109	0.4610
LOCAL QUALITY	0.2847	0.6675	0.6891	0.6949	0.6277
NCNDIMENSIONAL QUALITY	0.7568	1.7743	1.8317	1.8472	1.6685
LOCAL VOID FRACTION	0.9594	0.9935	0.9936	0.9937	0.9921
LOCAL SLIP RATIO	2.357	1.839	2.011	2.020	1.874
LINEAR VEL AIR (FT/SEC)	63.364	94.044	111.332	98.649	82.080
NCNDIM LINEAR AIR VELOCITY	0.9557	1.4185	1.6792	1.4879	1.2380
LINEAR VEL WATER (FT/SEC)	26.889	51.138	55.362	48.829	43.801
NCNDIM LINEAR H2O VELOCITY	2.0526	3.9037	4.2261	3.7274	3.3436

CASE ID NO. 110468 1153.5 PAGE NO. 4
 STIMULUS TEST SECTION TEST NUMBER 5.

FLOW AREA OF TEST SECTION (INCHES)	0.5812	DENSITY OF TEST AIR (LBM/FT3)	0.4597
APPROX. ISO KINETIC SETTING OF MANOMETER	-0.2500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.9430
AVERAGE TOTAL QUALITY	0.3827	ANGULAR POSITION (DEG.)	180.000
AIR MASS VELOCITY (LBM/SEC-IN2)	0.1976	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3188
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.3468	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.3675
ERROR IN AIRFLOW, INTEGRATED TO TRUE)	-0.7546	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-0.1528
AVERAGE LINEAR AIR VELOCITY	66.3000	AVERAGE LINEAR WATER VELOCITY	13.1000

RADIUS TO CL OF PROBE (IN)	0.4725	0.4045	0.3055	0.2175	0.1595
R(i) / TOTAL RADIUS	0.9497	0.8131	0.6151	0.4372	0.3206
IMPACT PRESSURE (PSIA)	0.5733	0.6221	0.8316	0.6898	0.5481
MANO SET AT SAMPLE 1 UNITLESS	-0.4451	-0.4203	-0.2424	-0.3699	-0.4655
MANO SET AT SAMPLE 2 UNITLESS	0.	0.	-0.0152	-0.0137	-0.0460
COLLECT 1 AIR RATE (LB/SEC-IN2)	0.1956	0.3129	0.3433	0.3328	0.2479
COLLECT 2 AIR RATE (LB/SEC-IN2)	0.1369	0.2478	0.2971	0.2738	0.1880
COLLECT 1 H2O RATE (LB/SEC-IN2)	0.6600	0.1349	0.1440	0.1281	0.4005
COLLECT 2 H2O RATE (LB/SEC-IN2)	0.6090	0.1304	0.1452	0.1259	0.3468
ISO AIR MASS VEL (LBM/SEC-IN2)	0.1698	0.2865	0.3449	0.3130	0.2171
NONDIM AIR MASS VELOCITY	0.8593	1.4499	1.7454	1.5840	1.0987
ISO H2O MASS VEL (LBM/SEC-IN2)	0.6376	0.1331	0.1440	0.1274	0.3729
NONDIM H2O MASS VELOCITY	2.0000	0.4175	0.4517	0.3996	1.1697
LOCAL QUALITY	0.2103	0.6828	0.7055	0.7107	0.3679
NONDIMENSIONAL QUALITY	0.5495	1.7842	1.8435	1.8571	0.9613
LOCAL VOID FRACTION	0.9347	0.9943	0.9941	0.9945	0.9691
LOCAL SLIP RATIO	2.516	1.673	1.920	1.827	2.509
LINEAR VEL AIR (FT/SEC)	56.915	90.269	108.669	98.575	70.168
NONDIM LINEAR AIR VELOCITY	0.8584	1.3615	1.6390	1.4868	1.0583
LINEAR VEL WATER (FT/SEC)	22.622	53.949	56.612	53.954	27.966
NONDIM LINEAR H2O VELOCITY	1.7269	4.1182	4.3215	4.1186	2.1348

CASE ID NO.	CASE SEQUENCE NO.	0	110468	1153.5	PAGE NO.	5
ANNULUS TEST SECTION			TEST NUMBER			6.
FLOW AREA OF TEST SECTION (INCHES)	0.5812	DENSITY OF TEST AIR (LBM/FT3)	0.4571			
APPROX. ISO KINETIC SETTING OF MANOMETER	-0.2500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.9430			
AVERAGE TOTAL QUALITY	0.3820	ANGULAR POSITION (DEG.)	225.000			
AIR MASS VELOCITY (LBM/SEC-IN2)	0.1959	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3169			
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.2899	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.4245			
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.4801	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-0.3394			
AVERAGE LINEAR AIR VELOCITY	66.3000	AVERAGE LINEAR WATER VELOCITY	13.1000			

RADIUS TO CL OF PROBE (IN)	0.4725	0.4095	0.3215	0.2335	0.1975
R(1) / TOTAL RADIUS	0.9497	0.8231	0.6462	0.4693	0.3970
IMPACT PRESSURE (PSIA)	0.5843	0.5623	0.7190	0.5701	0.4630
MANO SET AT SAMPLE 1 UNITLESS	-0.7116	-0.4762	-0.3656	-0.4365	-0.4354
MANO SET AT SAMPLE 2 UNITLESS	-0.0323	-0.0336	-0.0264	0.	0.
COLLECT 1 AIR RATE (LB/SEC-IN2)	0.1772	0.2995	0.3367	0.3072	0.2465
COLLECT 2 AIR RATE (LB/SEC-IN2)	0.1086	0.2348	0.2793	0.2441	0.1906
COLLECT 1 H2O RATE (LB/SEC-IN2)	1.0070	0.1429	0.1247	0.1055	0.2257
COLLECT 2 H2O RATE (LB/SEC-IN2)	0.8584	0.1327	0.1213	0.1043	0.2087
ISO AIR MASS VEL (LBM/SEC-IN2)	0.1306	0.2664	0.3171	0.2803	0.2227
NCNDIM AIR MASS VELOCITY	0.6667	1.3599	1.6187	1.4308	1.1368
ISO H2O MASS VEL (LBM/SEC-IN2)	0.9060	0.1377	0.1236	0.1050	0.2184
NCNDIM H2O MASS VELOCITY	2.8989	0.4345	0.3900	0.3313	0.6892
LCCAL QUALITY	0.1260	0.6593	0.7196	0.7275	0.5048
NCNDIMENSIONAL QUALITY	0.3298	1.7259	1.8838	1.9045	1.3215
LCCAL VOID FRACTION	0.8888	0.9937	0.9951	0.9957	0.9845
LCCAL SLIP RATIO	2.453	1.677	1.727	1.555	2.177
LINEAR VEL AIR (FT/SEC)	46.284	84.468	100.392	88.669	71.255
NCNDIM LINEAR AIR VELOCITY	0.6981	1.2740	1.5142	1.3374	1.0747
LINEAR VEL WATER (FT/SEC)	18.876	50.360	58.141	57.020	32.733
NCNDIM LINEAR H2O VELOCITY	1.4405	3.8458	4.4382	4.3527	2.4987

CASE ID NO. ANNULUS TEST SECTION CASE SEQUENCE NO. 0 110468 1153.5 PAGE NO. 6
TEST NUMBER 7.

FLOW AREA OF TEST SECTION (INCHES)	0.5812	DENSITY OF TEST AIR (LBM/FT3)	0.4477
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.9430
AVERAGE TOTAL QUALITY	0.3801	ANGULAR POSITION (DEG.)	270.000
AIR MASS VELOCITY (LBM/SEC-IN2)	0.1970	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3213
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.2238	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.2612
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.1361	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	0.1871
AVERAGE LINEAR AIR VELOCITY	66.3000	AVERAGE LINEAR WATER VELOCITY	13.1000

RADIUS TO CL OF PROBE (IN)	0.4725	0.4275	0.3575	0.2875	0.2685
R(I) / TOTAL RADIUS	0.9497	0.8593	0.7186	0.5779	0.5397
IMPACT PRESSURE (PSIA)	0.5355	0.4662	0.5245	0.4410	0.4095
MANO SET AT SAMPLE 1 UNITLESS	-0.4294	-0.3986	-0.4505	-0.3143	-0.3615
MANO SET AT SAMPLE 2 UNITLESS	-0.0824	-0.0811	0.	0.	0.
COLLECT 1 AIR RATE (LB/SEC-IN2)	0.1734	0.2498	0.3016	0.2693	0.2504
COLLECT 2 AIR RATE (LB/SEC-IN2)	0.1331	0.2060	0.2367	0.2143	0.2061
COLLECT 1 H2O RATE (LB/SEC-IN2)	0.6940	0.1616	0.0953	0.0794	0.1134
COLLECT 2 H2O RATE (LB/SEC-IN2)	0.6305	0.1508	0.0933	0.0816	0.1055
ISO AIR MASS VEL (LBM/SEC-IN2)	0.1526	0.2293	0.2727	0.2580	0.2367
NCNDIM AIR MASS VELOCITY	0.7746	1.1640	1.3843	1.3096	1.2015
ISO H2O MASS VEL (LBM/SEC-IN2)	0.6612	0.1566	0.0953	0.0798	0.1110
NCNDIM H2O MASS VELOCITY	2.0579	0.4874	0.2966	0.2484	0.3455
LOCAL QUALITY	0.1875	0.5943	0.7411	0.7637	0.6809
NCNDIMENSIONAL QUALITY	0.4933	1.5635	1.9498	2.0092	1.7914
LOCAL VOID FRACTION	0.9278	0.9914	0.9957	0.9958	0.9932
LOCAL SLIP RATIO	2.495	1.770	1.704	1.911	2.036
LINEAR VEL AIR (FT/SEC)	52.893	74.397	88.091	83.360	76.666
NCNDIM LINEAR AIR VELOCITY	0.7978	1.1221	1.3287	1.2573	1.1563
LINEAR VEL WATER (FT/SEC)	21.201	42.020	51.701	43.629	37.656
NCNDIM LINEAR H2O VELOCITY	1.6184	3.2076	3.9466	3.3305	2.8745

CASE ID NO.	CASE SEQUENCE NO.	0	110468	1153.5	PAGE NO.	7
ANNULUS TEST SECTION			TEST NUMBER		8.	

FLOW AREA OF TEST SECTION (INCHES)	0.5812	DENSITY OF TEST AIR (LBM/FT3)	0.4444
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.9430
AVERAGE TOTAL QUALITY	0.3792	ANGULAR POSITION (DEG.)	315.000
AIR MASS VELOCITY (LBM/SEC-IN2)	0.1965	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3216
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.1097	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.1791
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.4414	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	0.4432
AVERAGE LINEAR AIR VELOCITY	66.3000	AVERAGE LINEAR WATER VELOCITY	13.1000

RADIUS TO CL OF PROBE (IN)	0.4725	0.4535	0.4095	0.3925	0.3655
R(I) / TOTAL RADIUS	0.9497	0.9116	0.8231	0.7889	0.7347
IMPACT PRESSURE (PSIA)	0.4426	0.4032	0.3244	0.3087	0.2992
MANO SET AT SAMPLE 1 UNITLESS	-0.5338	-0.3516	-0.3786	-0.3571	-0.3895
MANO SET AT SAMPLE 2 UNITLESS	0.	0.0312	0.	0.	-0.0632
COLLECT 1 AIR RATE (LB/SEC-IN2)	0.1591	0.1735	0.2143	0.2156	0.2000
COLLECT 2 AIR RATE (LB/SEC-IN2)	0.1001	0.1220	0.1747	0.1761	0.1688
COLLECT 1 H2O RATE (LB/SEC-IN2)	0.7156	0.3935	0.0975	0.0794	0.1599
COLLECT 2 H2O RATE (LB/SEC-IN2)	0.6135	0.3595	0.0953	0.0782	0.1554
ISO AIR MASS VEL (LBM/SEC-IN2)	0.1277	0.1599	0.2009	0.2038	0.1867
NCNDIM AIR MASS VELOCITY	0.6499	0.8137	1.0224	1.0372	0.9501
ISO H2O MASS VEL (LBM/SEC-IN2)	0.6613	0.3845	0.0968	0.0790	0.1580
NCNDIM H2O MASS VELOCITY	2.0563	1.1956	0.3010	0.2456	0.4913
LOCAL QUALITY	0.1618	0.2937	0.6749	0.7205	0.5416
NCNDIMENSIONAL QUALITY	0.4267	0.7745	1.7798	1.9001	1.4283
LOCAL VOID FRACTION	0.9165	0.9621	0.9945	0.9955	0.9856
LOCAL SLIP RATIO	2.462	2.296	1.617	1.632	2.414
LINEAR VEL AIR (FT/SEC)	45.144	53.849	65.448	66.327	61.367
NCNDIM LINEAR AIR VELOCITY	0.6809	0.8122	0.9871	1.0004	0.9256
LINEAR VEL WATER (FT/SEC)	18.388	23.455	40.468	40.644	25.420
NCNDIM LINEAR H2O VELOCITY	1.4037	1.7905	3.0892	3.1026	1.9405

A.6 NINE-ROD TPHAS DATA REDUCTION PROGRAM

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0001      I      TPHAS
0002      C      THIS CODE PROCESSES ISOKINETIC SAMPLING DATA IN AIR-
0003      C      WATER FLOW. THE OUTPUT INCLUDES LOCAL VALUES OF VOID
0004      C      FRACTION, LINEAR VELOCITIES, QUALITY AND SLIP RATIO.
0005      C      THIS VERSION WILL HANDLE THE 9-ROD TEST SECTION DATA.
0006      DIMENSION Y(20),DHI(5,20),DHS(5,20)
0007      DIMENSION DIOV(20), GAND(20), GWND(20), QLND(20), RTIO(20)
0008      DIMENSION DOIV(20), DHS(5,20), DHSR(5,20)
0009      DIMENSION HGA(5,20), TGA(20), HGW(5,20), TGW(20), HS(5,20)
0010      DIMENSION HI(20), R(20), GR(20), C(20), B(20), A(20)
0011      DIMENSION DLPR(20), VOID(20), SLIP(20), QUAL(20), PTG(20)
0012      DIMENSION DHIL(5,20), DHIR(5,20), VELA(20), VELW(20)
0013      DIMENSION PLOT(20), RS(20), GRS(20), GRW(20), GW(20)
0014      DIMENSION CW(20), BW(20), AW(20), DBER(20)
0015      DIMENSION VAS1(5,20), VAS2(5,20), TAS1(5,20), TAS2(5,20)
0016      DIMENSION VWS1(5,20), VWS2(5,20), TWS1(5,20), TWS2(5,20)
0017      DATA MTAPIT,MTAPOT,6HITAPIT,6HITAPOT/
0018      KIN = IDFTAP(MTAPIT,1,0)
0019      KOUT = IDFTAP(MTAPOT,2,0)
0020      1 CALL CASE (K)
0021      2 FORMAT( 10F8.2 )
0022      3 FORMAT( 10F8.6 )
0023      4 FORMAT (I3)
0024      READ(KIN, 4)(N)
0025      READ(KIN,2)( TEST,TN,PTN,THETA)
0026      READ(KIN,3)(SGM,SGMA,SGMB,D)
0027      READ(KIN, 3)(Y(I), I=1,N )
0028      READ(KIN, 2)(DHIL(1,I), I=1,N)
0029      READ(KIN, 2)(DHIL(2,I), I=1,N)
0030      READ(KIN, 2)(DHIL(3,I), I=1,N)
0031      READ(KIN, 2)(DHIL(4,I), I=1,N)
0032      READ(KIN, 2)(DHIL(5,I), I=1,N)
0033      READ(KIN, 2)(DHSR(1,I), I=1,N)
0034      READ(KIN, 2) (VAS1(1,I),I=1,N)
0035      READ(KIN, 2) (VAS1(2,I),I=1,N)
0036      READ(KIN, 2) (TAS1(1,I),I=1,N)
0037      READ(KIN, 2) (TAS1(2,I),I=1,N)
0038      READ(KIN, 2) (VWS1(1,I),I=1,N)
0039      READ(KIN, 2) (VWS1(2,I),I=1,N)
0040      READ(KIN, 2) (TWS1(1,I),I=1,N)
0041      READ(KIN, 2) (TWS1(2,I),I=1,N)
0042      READ(KIN,2) ORFA,ORFW,DHAL,DHAR,DHVL,DHWR
0043      READ (KIN, 2) PRSA,TEMPA,PRST,TEMPT,PRSW,TEMPW,AVOID
0044      F AREA = 10.95
0045      HNW = -0.200
0046      IF( TEST) 10,10,20
0047      10 K = N/2
0048      GO TO 60
0049      20 K =(N+1)/2
0050      GO TO 60
0051      60 CONTINUE
0052      DENA = 0.0753*(((PRST + 14.7)/ 14.7)*(530.0 / (TEMPT + 460.0)))
0053      DENAO = 0.0753*(((PRSA+14.7)/14.7)*(530.0/(TEMPA+460.0)))
0054      IF(ORFA) 62,64,66
0055      62 AOC = 3.630
0056      GO TO 67
0057      64 AOC = 1.160

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0058      GO TO 67
0059      66 AOC = 0.367
0060      GO TO 67
0061      67 CONTINUE
0062      DHA0 = ABS(DHAL-DHAR)
0063      ARG = ((PRSA+14.7)*SGMA*62.3*DHA0)/((TEMPA+460.0)*1728.0)
0064      ASFW = AOC*SQRT(ARG)
0065      AVGA = ASFW / FAREA
0066      DHWO = ABS(DHWL-DHWR)
0067      IF(ORFW) 70,70,80
0068      70 IF(ORFW+5.0) 82,84,86
0069      80 IF(ORFW-5.0) 88,90,92
0070      82 WOC = 60.20
0071      GO TO 120
0072      84 WOC = 35.20
0073      GO TO 120
0074      86 WOC = 18.80
0075      GO TO 120
0076      88 WOC = 8.240
0077      GO TO 120
0078      90 WOC = 3.830
0079      GO TO 120
0080      92 WOC = 0.896
0081      GO TO 120
0082      120 CONTINUE
0083      WSWF = WOC*SQRT(((SGMB-1.00)*62.3*DHWO)/1728.0)
0084      GTW = WSWF / FAREA
0085      ATQUAL = AVGA / (GTW + AVGA)
0086      DO 260 I = 1, N
0087      DHI(1,I) = DHIL(1,I) - DHIR(1,I)
0088      DHI(2,I) = DHIL(2,I) - DHIR(2,I)
0089      HI(I) = (DHI(1,I) + DHI(2,I)) / 2.0
0090      DHS(1,I) = DHSL(1,I) - DHSR(1,I)
0091      HS(1,I) = DHS(1,I)/HI(I)
0092      HGA(1,I) = 0.001306*((VAS1(1,I)/TAS1(1,I))+(VAS1(2,I)/TAS1(2,I)))
0093      HGW(1,I) = 1.0806*((VWS1(1,I)/TWS1(1,I))+(VWS1(2,I)/TWS1(2,I)))
0094      R(I) = Y(I) + 0.025
0095      PLOT(I) = R(I)/D
0096      260 CONTINUE
0097      DO 380 J=1,1
0098      DO 265 I=1,N
0099      GR(I) = (R(I)+0.500)*HGA(1,I)
0100      GW(I) = (R(I)+0.500)*HGW(1,I)
0101      265 CONTINUE
0102      320 DO 330 I= 1, N
0103      RS(I+1) = R(I)+0.500
0104      GRS(I+1) = GR(I)
0105      GRW(I+1) = GW(I)
0106      RS(1) = 0.500
0107      GRS(1) = 0.0
0108      GRW(1) = 0.0
0109      330 CONTINUE
0110      IF(TEST) 332,332,334
0111      332 GO TO 339
0112      334 CONTINUE
0113      RS(N+2) = D + 0.500
0114      GRS(N+2) = 0.0

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0115      GRW(N+2) = 0.0
0116      GO TO 339
0117 339  CONTINUE
0118      SUM = 0.0
0119      DO 370 I=1,K
0120      C(I) = ((GRS(2*I-1) - GRS(2*I+1)) / (RS(2*I-1) - RS(2*I+1)))
0121      1  -(GRS(2*I-1) - GRS(2*I)) / (RS(2*I-1) - RS(2*I))
0122      2  / (RS(2*I+1) - RS(2*I))
0123      B(I) = ((GRS(2*I-1) - GRS(2*I)) / (RS(2*I-1) - RS(2*I)))
0124      1  - C(I) * (RS(2*I-1) + RS(2*I))
0125      A(I) = GRS(2*I-1) - B(I)*RS(2*I-1) - C(I)*(RS(2*I-1)**2.0)
0126      SUM = SUM + A(I)*(RS(2*I+1) - RS(2*I-1))
0127      1  + 0.5*B(I)*(RS(2*I+1)**2.0 - RS(2*I-1)**2.0)
0128      2  + (C(I) / 3.0)*(RS(2*I+1)**3.0 - (RS(2*I-1)**3.0))
0129 370  CONTINUE
0130      SUM = ABS(SUM)
0131      BG = (2.0*SUM)/(D**2.0+D)
0132      ER = (AVGA - BG) / AVGA
0133 380  CONTINUE
0134 381  CONTINUE
0135      SUMW = 0.0
0136      DO 385 I=1,K
0137      CW(I) = ((GRW(2*I-1) - GRW(2*I+1)) / (RS(2*I-1) - RS(2*I+1)))
0138      1  -(GRW(2*I-1) - GRW(2*I)) / (RS(2*I-1) - RS(2*I))
0139      2  / (RS(2*I+1) - RS(2*I))
0140      BW(I) = ((GRW(2*I-1) - GRW(2*I)) / (RS(2*I-1) - RS(2*I)))
0141      1  -CW(I)* (RS(2*I-1) + RS(2*I))
0142      AW(I) = GRW(2*I-1) - BW(I)*RS(2*I-1) - CW(I)*(RS(2*I-1)**2.0)
0143      SUMW = SUMW + AW(I)*(RS(2*I+1) - RS(2*I-1))
0144      1  + 0.5*BW(I)*(RS(2*I+1)**2.0 - RS(2*I-1)**2.0)
0145      2  + (CW(I) / 3.0)*(RS(2*I+1)**3.0 - RS(2*I-1)**3.0)
0146 385  CONTINUE
0147      SUMW = ABS(SUMW)
0148      BGW = (2.0*SUMW)/(D**2.0+D)
0149      ERW = (GTW - BGW) / GTW
0150      DO 390 I=1,N
0151      TGA(I) = HGA(1,I)
0152      TGW(I) = HGW(1,I)
0153      DLPR(I) = SGM*62.3*HI(I)/1728.0
0154      QUAL(I) = TGA(I) / (TGA(I) + TGW(I))
0155      VOID(I) = (DLPR(I) - ((2.24*(TGA(I)**2.0)/(DENA)))
0156      1  -(0.0359*(TGW(I)**2.0)/(DLPR(I))
0157      2  -((2.24*(TGA(I)**2.0)/(DENA)) + (0.0359*(TGW(I)**2.0)))
0158      SLIP(I) = ((62.2)/(DENA)) * (TGA(I)/TGW(I))
0159      1  * ((1.0 - VOID(I)) / (VOID(I)))
0160      VELA(I) = (144.0 * TGA(I))/(DENA * VOID(I))
0161      VELW(I) = (144.0 * TGW(I))/(62.2 * (1.0 - VOID(I)))
0162      AVA = (144.0 * AVGA) / (DENA * AVOID)
0163      AVW = (144.0 * GTW) / (62.3 * (1.0 - AVOID))
0164      QLND(I) = QUAL(I) / ATQUAL
0165      GAND(I) = TGA(I) / AVGA
0166      GWND(I) = TGW(I) / GTW
0167      DIOV(I) = VELA(I) / AVA
0168      DOIV(I) = VELW(I) / AVW
0169 390  CONTINUE
0170      ITEST=TN
0171      WRITE(KOUT,501)ITEST

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0172      501 FORMAT(71H0
0173      1 N U M B E R ,I2)
0174      IPR0BE=PTN
0175      WRITE(KOUT,502)IPR0BE
0176      502 FORMAT(72H0
0177      1 N U M B E R ,I1)
0178      WRITE (KOUT,503)(THETA)
0179      503 FORMAT(83H0
0180      1 O N ( D E G R E E S ) ,F5.1)
0181      WRITE (KOUT,555)
0182      555 FORMAT (2H0 )
0183      WRITE(KOUT,509)D,ATQUAL
0184      509 FORMAT(44H0WALL TO WALL DISTANCE (INCHES)
0185      1 AVERAGE TOTAL QUALITY
0186      WRITE(KOUT,520)FAREA,AVOID
0187      520 FORMAT(44H0FLOW AREA OF TEST SECTION (INCHES)
0188      1 AVERAGE VOID FRACTION (QUICK CLOSING VALVES)
0189      WRITE(KOUT,530)PRST,AVA
0190      530 FORMAT(44H0TEST SECTION PRESSURE (LBF/IN2)
0191      1 AVERAGE LINEAR AIR VELOCITY (FT/SEC)
0192      WRITE(KOUT,543)DENA,AVW
0193      543 FORMAT(44H0DENSITY OF TEST AIR (LBM/FT3)
0194      1 AVERAGE LINEAR WATER VELOCITY
0195      WRITE(KOUT,540)AVGA,GTW
0196      540 FORMAT(44H0AIR MASS VELOCITY (LBM/SEC-IN2)
0197      1 WATER MASS VELOCITY (LBM/SEC-IN2)
0198      WRITE(KOUT,550)BG,BGW
0199      550 FORMAT(44H0INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)
0200      1 INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)
0201      WRITE(KOUT,560)ER,ERW
0202      560 FORMAT(44H0ERROR IN AIRFLOW(INTEGRATED TO TRUE)
0203      1 ERROR IN WATERFLOW (INTEGRATED TO TRUE)
0204      WRITE(KOUT,570)HNW
0205      570 FORMAT(44H0APPROX. ISOKINETIC SETTING OF MANOMETER
0206      WRITE (KOUT,555)
0207      WRITE (KOUT,555)
0208      WRITE( KOUT, 700 )( R(I), I=1,N )
0209      700 FORMAT( 31HORADIUS TO CL OF PROBE (IN) , 10F9.4 )
0210      WRITE( KOUT, 780 )( PLOT(I), I=1,N )
0211      780 FORMAT( 31HOR(I)/(D) , 10F9.4 )
0212      WRITE( KOUT, 820 )( DLPR(I), I=1,N )
0213      820 FORMAT( 31H0IMPACT PRESSURE (PSIA) , 10F9.4 )
0214      WRITE( KOUT, 720 )( HS(1,I), I=1,N )
0215      720 FORMAT( 31H0ACTUAL ISO SETTING OF MANO , 10F9.4 )
0216      WRITE( KOUT, 790 )( TGA(I), I=1,N )
0217      790 FORMAT( 31H0ISO AIR MASS VEL (LBM/SEC-IN2), 10F9.4 )
0218      WRITE( KOUT, 795 )( GAND(I), I=1,N )
0219      795 FORMAT( 31H0NONDIM AIR MASS VELOCITY , 10F9.4 )
0220      WRITE( KOUT, 800 )( TGW(I), I=1,N )
0221      800 FORMAT( 31H0ISO H2O MASS VEL (LBM/SEC-IN2), 10F9.4 )
0222      WRITE( KOUT, 805 )( GWND(I), I=1,N )
0223      805 FORMAT(31H0NONDIM H2O MASS VELOCITY , 10F9.4 )
0224      WRITE( KOUT, 850 )( VELA(I), I=1,N )
0225      850 FORMAT( 31H0LINEAR VEL AIR (FT/SEC) , 10F9.3 )
0226      WRITE( KOUT, 855 )( DIOV(I), I=1,N )
0227      855 FORMAT( 31H0NONDIM LINEAR AIR VELOCITY , 10F9.4 )
0228      WRITE( KOUT, 860 )( VELW(I), I=1,N )

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T E S T

P R O B E

A N G U L A R P O S I T I

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0229      860 FORMAT( 31H0LINEAR VEL WATER (FT/SEC) , 10F9.3 )
0230      WRITE( KOUT, 856 ) ( DOIV(I), I=1,N)
0231      856 FORMAT( 31H0NONDIM LINEAR H2O VELOCITY , 10F9.4 )
0232      WRITE( KOUT, 810 ) ( QUAL(I), I=1,N )
0233      810 FORMAT( 31H0LOCAL QUALITY , 10F9.4 )
0234      WRITE( KOUT, 815 ) ( QLND(I), I=1,N)
0235      815 FORMAT( 31H0NONDIMENSIONAL QUALITY , 10F9.4 )
0236      WRITE( KOUT, 830 ) ( VOID(I), I=1,N )
0237      830 FORMAT( 31H0LOCAL VOID FRACTION , 10F9.4 )
0238      WRITE( KOUT, 840 ) ( SLIP(I), I=1,N )
0239      840 FORMAT( 31H0LOCAL SLIP RATIO , 10F9.3 )
0240      GO TO 1
0241      END
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A.7 NINE-ROD RESULTS

START OF CASE NO. 1 102066

1927.

TEST NUMBER 92

PROBE NUMBER 2

ANGULAR POSITION (DEGREES) 0.

WALL TO WALL DISTANCE (INCHES)	0.2400	AVERAGE TOTAL QUALITY	0.2763
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.9564
TEST SECTION PRESSURE (LBF/IN2)	84.5000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	45.1947
DENSITY OF TEST AIR (LBM/FT3)	0.4893	AVERAGE LINEAR WATER VELOCITY	20.3943
AIR MASS VELOCITY (LBM/SEC-IN2)	0.1469	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3847
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.1526	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.3986
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.0389	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-0.0362
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.0650	0.1150	0.1750	0.2150
R(I)/(D)	0.1042	0.2708	0.4792	0.7292	0.8958
IMPACT PRESSURE (PSIA)	0.2488	0.3930	0.5408	0.2884	0.2740
ACTUAL ISO SETTING OF MANO ,	-0.2174	-0.2018	-0.2000	-0.2000	-0.1842
ISO AIR MASS VEL (LBM/SEC-IN2)	0.1304	0.1971	0.2263	0.1626	0.0614
NONDIM AIR MASS VELOCITY	0.8880	1.3417	1.5404	1.1070	0.4179
ISO H2O MASS VEL (LBM/SEC-IN2)	0.4339	0.1891	0.2482	0.1836	0.9151
NONDIM H2O MASS VELOCITY	1.1278	0.4916	0.6452	0.4773	2.3787
LINEAR VEL AIR (FT/SEC)	41.543	58.690	67.552	48.546	22.852
NONDIM LINEAR AIR VELOCITY	0.9192	1.2986	1.4947	1.0742	0.5056
LINEAR VEL WATER (FT/SEC)	13.203	36.913	40.097	29.607	10.107
NONDIM LINEAR H2O VELOCITY	0.6474	1.8100	1.9661	1.4517	0.4956
LOCAL QUALITY	0.2311	0.5103	0.4769	0.4696	0.0629
NONDIMENSIONAL QUALITY	0.8365	1.8469	1.7258	1.6996	0.2275
LOCAL VOID FRACTION	0.9239	0.9881	0.9857	0.9856	0.7904
LOCAL SLIP RATIO	3.146	1.590	1.685	1.640	2.261

START OF CASE NO. 2 102066

1927.

TEST NUMBER 92

PROBE NUMBER 2

ANGULAR POSITION (DEGREES) 45.0

WALL TO WALL DISTANCE (INCHES)	0.2450	AVERAGE TOTAL QUALITY	0.2785
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.9564
TEST SECTION PRESSURE (LBF/IN2)	85.5000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	45.3788
DENSITY OF TEST AIR (LBM/FT3)	0.4942	AVERAGE LINEAR WATER VELOCITY	20.4539
AIR MASS VELOCITY (LBM/SEC-IN2)	0.1490	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3858
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.1043	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.3829
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.2995	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	0.0076
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.0700	0.1250	0.1700	0.2200
R(I)/(D)	0.1020	0.2857	0.5102	0.6939	0.8980
IMPACT PRESSURE (PSIA)	0.1684	0.1749	0.1749	0.1640	0.2304
ACTUAL ISO SETTING OF MANO	-0.2570	-0.2680	-0.1485	-0.2352	-0.2160
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0823	0.1480	0.1423	0.1203	0.0516
NONDIM AIR MASS VELOCITY	0.5524	0.9938	0.9553	0.8076	0.3464
ISO H2O MASS VEL (LBM/SEC-IN2)	0.4620	0.1226	0.0886	0.1507	0.9034
NONDIM H2O MASS VELOCITY	1.1973	0.3179	0.2297	0.3907	2.3414
LINEAR VEL AIR (FT/SEC)	26.799	43.753	41.741	35.636	19.697
NONDIM LINEAR AIR VELOCITY	0.5906	0.9642	0.9198	0.7853	0.4340
LINEAR VEL WATER (FT/SEC)	10.145	19.999	30.337	21.233	8.838
NONDIM LINEAR H2O VELOCITY	0.4960	0.9778	1.4832	1.0381	0.4321
LOCAL QUALITY	0.1512	0.5469	0.6163	0.4438	0.0540
NONDIMENSIONAL QUALITY	0.5428	1.9634	2.2124	1.5934	0.1940
LOCAL VOID FRACTION	0.8946	0.9858	0.9932	0.9836	0.7634
LOCAL SLIP RATIO	2.642	2.188	1.376	1.678	2.229

START OF CASE NO. 3 102066

1927.

TEST NUMBER 92

PROBE NUMBER 2

ANGULAR POSITION (DEGREES) 90.0

WALL TO WALL DISTANCE (INCHES)	0.2650	AVERAGE TOTAL QUALITY	0.2785
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.9564
TEST SECTION PRESSURE (LBF/IN2)	85.5000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	45.3788
DENSITY OF TEST AIR (LBM/FT3)	0.4942	AVERAGE LINEAR WATER VELOCITY	20.4539
AIR MASS VELOCITY (LBM/SEC-IN2)	0.1490	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3858
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.1638	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.3108
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.0995	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	0.1944
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.0650	0.1250	0.1850	0.2400
R(I)/(ID)	0.0943	0.2453	0.4717	0.6981	0.9057
IMPACT PRESSURE (PSIA)	0.2434	0.2812	0.3750	0.2992	0.2650
ACTUAL ISO SETTING OF MANO	-0.2074	-0.2051	-0.1923	-0.1928	-0.1905
ISO AIR MASS VEL (LBM/SEC-IN2)	0.1137	0.1867	0.2184	0.1943	0.1027
NONDIM AIR MASS VELOCITY	0.7632	1.2532	1.4660	1.3045	0.6894
ISO H2O MASS VEL (LBM/SEC-IN2)	0.4545	0.1428	0.1501	0.1242	0.5967
NONDIM H2O MASS VELOCITY	1.1781	0.3701	0.3889	0.3220	1.5466
LINEAR VEL AIR (FT/SEC)	35.892	55.040	64.277	57.108	33.660
NONDIM LINEAR AIR VELOCITY	0.7909	1.2129	1.4164	1.2585	0.7418
LINEAR VEL WATER (FT/SEC)	13.635	28.002	34.300	33.395	12.427
NONDIM LINEAR H2O VELOCITY	0.6666	1.3690	1.6770	1.6327	0.6076
LOCAL QUALITY	0.2001	0.5666	0.5927	0.6100	0.1468
NONDIMENSIONAL QUALITY	0.7183	2.0342	2.1279	2.1901	0.5271
LOCAL VOID FRACTION	0.9228	0.9882	0.9899	0.9914	0.8888
LOCAL SLIP RATIO	2.632	1.966	1.874	1.710	2.709

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1927.

TEST NUMBER 93

PROBE NUMBER 1

ANGULAR POSITION (DEGREES) 0.

WALL TO WALL DISTANCE (INCHES)	0.3550	AVERAGE TOTAL QUALITY	0.1514
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7852
TEST SECTION PRESSURE (LBF/IN2)	82.0000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	24.0700
DENSITY OF TEST AIR (LBM/FT3)	0.4730	AVERAGE LINEAR WATER VELOCITY	3.7455
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0621	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3481
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.0440	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.6937
ERROR IN AIRFLOW(INTEGRATED TO TRUE)	0.2909	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-0.9930
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.0900	0.1650	0.2450	0.3300
R(I)/(ID)	0.0704	0.2535	0.4648	0.6901	0.9296
IMPACT PRESSURE (PSIA)	0.0926	0.0706	0.0785	0.1067	0.1381
ACTUAL ISO SETTING OF MANO	-0.5763	0.6222	-0.4800	-0.1176	-0.3182
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0415	0.0191	0.0715	0.0472	0.0165
NONDIM AIR MASS VELOCITY	0.6688	0.3084	1.1516	0.7598	0.2660
ISO H2O MASS VEL (LBM/SEC-IN2)	0.7445	0.2265	0.2537	0.3682	1.1265
NONDIM H2O MASS VELOCITY	2.1389	0.6506	0.7288	1.0578	3.2363
LINEAR VEL AIR (FT/SEC)	20.435	6.148	23.700	15.892	10.049
NONDIM LINEAR AIR VELOCITY	0.8490	0.2554	0.9846	0.6602	0.4175
LINEAR VEL WATER (FT/SEC)	4.518	10.069	7.190	8.848	5.220
NONDIM LINEAR H2O VELOCITY	1.2063	2.6882	1.9196	2.3623	1.3936
LOCAL QUALITY	0.0528	0.0779	0.2199	0.1136	0.0145
NONDIMENSIONAL QUALITY	0.3490	0.5150	1.4525	0.7503	0.0955
LOCAL VOID FRACTION	0.6185	0.9479	0.9183	0.9037	0.5004
LOCAL SLIP RATIO	4.523	0.611	3.296	1.796	1.925

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1927.

TEST NUMBER 93

PROBE NUMBER 1

ANGULAR POSITION (DEGREES) 45.0

WALL TO WALL DISTANCE (INCHES)	0.3500	AVERAGE TOTAL QUALITY	0.1581
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7852
TEST SECTION PRESSURE (LBF/IN2)	82.3000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	24.4894
DENSITY OF TEST AIR (LBM/FT3)	0.4810	AVERAGE LINEAR WATER VELOCITY	3.6804
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0642	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3420
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.1089	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.3720
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.6958	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-0.0876
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.0900	0.1650	0.2450	0.3250
R(I)/(D)	0.0714	0.2571	0.4714	0.7000	0.9286
IMPACT PRESSURE (PSIA)	0.1885	0.1665	0.1571	0.1445	0.1853
ACTUAL ISO SETTING OF MANO	-0.4000	-0.2264	-0.1600	-0.0870	-0.2034
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0462	0.0753	0.0972	0.1011	0.1357
NONDIM AIR MASS VELOCITY	0.7187	1.1717	1.5126	1.5739	2.1126
ISO H2O MASS VEL (LBM/SEC-IN2)	0.9505	0.5616	0.2375	0.1460	0.1511
NONDIM H2O MASS VELOCITY	2.7790	1.6421	0.6944	0.4268	0.4417
LINEAR VEL AIR (FT/SEC)	19.955	26.494	30.146	30.747	41.297
NONDIM LINEAR AIR VELOCITY	0.8149	1.0819	1.2310	1.2555	1.6863
LINEAR VEL WATER (FT/SEC)	7.157	8.694	15.630	21.575	21.431
NONDIM LINEAR H2O VELOCITY	1.9447	2.3621	4.2470	5.8623	5.8230
LOCAL QUALITY	0.0463	0.1182	0.2903	0.4092	0.4732
NONDIMENSIONAL QUALITY	0.2930	0.7474	1.8362	2.5881	2.9930
LOCAL VOID FRACTION	0.6926	0.8504	0.9648	0.9843	0.9837
LOCAL SLIP RATIO	2.788	3.048	1.929	1.425	1.927

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1927.

TEST NUMBER 93

PROBE NUMBER 1

ANGULAR POSITION (DEGREES) 45.0

WALL TO WALL DISTANCE (INCHES)	0.3650	AVERAGE TOTAL QUALITY	0.1520
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7852
TEST SECTION PRESSURE (LBF/IN2)	78.0000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	24.4689
DENSITY OF TEST AIR (LBM/FT3)	0.4543	AVERAGE LINEAR WATER VELOCITY	3.6392
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0606	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3382
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.0660	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.5650
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.0894	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-0.6705
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1350	0.2550	0.3650
R(I)/(D)	0.0685	0.3699	0.6986	1.0000
IMPACT PRESSURE (PSIA)	0.1351	0.1068	0.1068	0.1256
ACTUAL ISO SETTING OF MANO	-0.1860	-0.3529	-0.3529	-0.4000
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0279	0.0718	0.0757	0.0587
NONDIM AIR MASS VELOCITY	0.4606	1.1849	1.2490	0.9690
ISO H2O MASS VEL (LBM/SEC-IN2)	1.1195	0.2593	0.2215	0.4644
NONDIM H2O MASS VELOCITY	3.3101	0.7668	0.6550	1.3732
LINEAR VEL AIR (FT/SEC)	18.084	24.157	25.097	21.474
NONDIM LINEAR AIR VELOCITY	0.7391	0.9873	1.0257	0.8776
LINEAR VEL WATER (FT/SEC)	5.076	10.416	11.689	8.080
NONDIM LINEAR H2O VELOCITY	1.3947	2.8623	3.2118	2.2203
LOCAL QUALITY	0.0243	0.2169	0.2547	0.1123
NONDIMENSIONAL QUALITY	0.1601	1.4269	1.6758	0.7387
LOCAL VOID FRACTION	0.4894	0.9424	0.9561	0.8669
LOCAL SLIP RATIO	3.563	2.319	2.147	2.658

START OF CASE NO. 7 102066

1927.

TEST NUMBER 93

PROBE NUMBER 1

ANGULAR POSITION (DEGREES) 90.0

WALL TO WALL DISTANCE (INCHES)	0.3900	AVERAGE TOTAL QUALITY	0.1573
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7852
TEST SECTION PRESSURE (LBF/IN2)	92.5000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	24.1207
DENSITY OF TEST AIR (LBM/FT3)	0.4746	AVERAGE LINEAR WATER VELOCITY	3.5976
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0624	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3343
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.0768	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.3519
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.2300	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-0.0526
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1050	0.1900	0.2900	0.3650
R(I)/(D)	0.0641	0.2692	0.4872	0.7436	0.9359
IMPACT PRESSURE (PSIA)	0.1445	0.1131	0.1005	0.1005	0.1005
ACTUAL ISO SETTING OF MANO	-0.2174	-0.3333	-0.5000	-0.3750	-0.2062
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0316	0.0729	0.0811	0.0801	0.0760
NONDIM AIR MASS VELOCITY	0.5055	1.1676	1.2988	1.2835	1.2172
ISO H2O MASS VEL (LBM/SEC-IN2)	0.8628	0.3240	0.1833	0.1728	0.2157
NONDIM H2O MASS VELOCITY	2.5805	0.9692	0.5484	0.5169	0.6451
LINEAR VEL AIR (FT/SEC)	14.100	24.093	25.469	25.063	24.130
NONDIM LINEAR AIR VELOCITY	0.5846	0.9989	1.0559	1.0391	1.0004
LINEAR VEL WATER (FT/SEC)	6.223	9.133	12.433	13.302	11.202
NONDIM LINEAR H2O VELOCITY	1.7298	2.5386	3.4559	3.6974	3.1138
LOCAL QUALITY	0.0353	0.1836	0.3066	0.3168	0.2605
NONDIMENSIONAL QUALITY	0.2243	1.1672	1.9488	2.0134	1.6558
LOCAL VOID FRACTION	0.6790	0.9179	0.9659	0.9699	0.9554
LOCAL SLIP RATIO	2.266	2.638	2.048	1.884	2.154

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1927.

TEST NUMBER 93

PROBE NUMBER 2

ANGULAR POSITION (DEGREES) 0.

WALL TO WALL DISTANCE (INCHES)	0.4400	AVERAGE TOTAL QUALITY	0.1596
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7852
TEST SECTION PRESSURE (LBF/IN2)	81.7000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	24.4498
DENSITY OF TEST AIR (LBM/FT3)	0.4785	AVERAGE LINEAR WATER VELOCITY	3.6148
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0638	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3359
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.0182	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.9563
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.7145	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-1.8467
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1100	0.2110	0.3130	0.4150
R(I)/(D)	0.0568	0.2500	0.4795	0.7114	0.9432
IMPACT PRESSURE (PSIA)	0.0629	0.0755	0.0755	0.0880	0.0880
ACTUAL ISO SETTING OF MANO	-0.3000	-0.3333	-0.4167	-0.4286	-0.4286
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0158	0.0173	0.0102	0.0125	0.0205
NONDIM AIR MASS VELOCITY	0.2476	0.2714	0.1596	0.1964	0.3218
ISO H2O MASS VEL (LBM/SEC-IN2)	0.6905	0.6048	0.9176	0.9495	0.7988
NONDIM H2O MASS VELOCITY	2.0557	1.8005	2.7315	2.8265	2.3781
LINEAR VEL AIR (FT/SEC)	8.404	7.456	7.203	8.212	10.661
NONDIM LINEAR AIR VELOCITY	0.3437	0.3049	0.2946	0.3359	0.4360
LINEAR VEL WATER (FT/SEC)	3.681	4.648	3.696	4.063	4.398
NONDIM LINEAR H2O VELOCITY	1.0182	1.2858	1.0226	1.1241	1.2167
LOCAL QUALITY	0.0224	0.0278	0.0110	0.0130	0.0251
NONDIMENSIONAL QUALITY	0.1401	0.1743	0.0688	0.0816	0.1570
LOCAL VOID FRACTION	0.5657	0.6987	0.4253	0.4590	0.5795
LOCAL SLIP RATIO	2.283	1.604	1.949	2.021	2.424

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1927.

TEST NUMBER 93

PROBE NUMBER 2

ANGULAR POSITION (DEGREES) 0.

WALL TO WALL DISTANCE (INCHES)	0.3620	AVERAGE TOTAL QUALITY	0.1558
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7852
TEST SECTION PRESSURE (LBF/IN2)	82.0000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	24.5281
DENSITY OF TEST AIR (LBM/FT3)	0.4772	AVERAGE LINEAR WATER VELOCITY	3.7210
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0638	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3458
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.0185	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.6866
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.7107	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-0.9856
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.0920	0.1740	0.2550	0.3370
R(I)/(D)	0.0691	0.2541	0.4807	0.7044	0.9309
IMPACT PRESSURE (PSIA)	0.0628	0.0503	0.0503	0.0628	0.0754
ACTUAL ISO SETTING OF MANO	-0.4000	-0.5000	-0.3750	-0.3000	-0.3667
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0179	0.0352	0.0215	0.0091	0.0091
NONDIM AIR MASS VELOCITY	0.2811	0.5516	0.3374	0.1421	0.1432
ISO H2O MASS VEL (LBM/SEC-IN2)	0.6579	0.3237	0.3888	0.7233	0.8735
NONDIM H2O MASS VELOCITY	1.9024	0.9361	1.1244	2.0916	2.5262
LINEAR VEL AIR (FT/SEC)	9.090	12.589	8.151	5.090	5.930
NONDIM LINEAR AIR VELOCITY	0.3706	0.5132	0.3323	0.2075	0.2418
LINEAR VEL WATER (FT/SEC)	3.767	4.801	4.437	3.621	3.779
NONDIM LINEAR H2O VELOCITY	1.0123	1.2903	1.1925	0.9730	1.0157
LOCAL QUALITY	0.0266	0.0981	0.0525	0.0124	0.0104
NONDIMENSIONAL QUALITY	0.1704	0.6296	0.3368	0.0795	0.0664
LOCAL VOID FRACTION	0.5957	0.8439	0.7971	0.5375	0.4649
LOCAL SLIP RATIO	2.413	2.622	1.837	1.406	1.569

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1927.

TEST NUMBER 93

PROBE NUMBER 2

ANGULAR POSITION (DEGREES) 0.

WALL TO WALL DISTANCE (INCHES)	0.3620	AVERAGE TOTAL QUALITY	0.1564
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7852
TEST SECTION PRESSURE (LBF/IN2)	80.1000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	24.8999
DENSITY OF TEST AIR (LBM/FT3)	0.4722	AVERAGE LINEAR WATER VELOCITY	3.7210
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0641	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3458
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.0185	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.6866
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.7120	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-0.9856
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.0920	0.1740	0.2550	0.3370
R(I)/(D)	0.0691	0.2541	0.4807	0.7044	0.9309
IMPACT PRESSURE (PSIA)	0.0628	0.0503	0.0503	0.0628	0.0754
ACTUAL ISO SETTING OF MANO	-0.4000	-0.5000	-0.3750	-0.3000	-0.3667
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0179	0.0352	0.0215	0.0091	0.0091
NONDIM AIR MASS VELOCITY	0.2799	0.5491	0.3358	0.1414	0.1425
ISO H2O MASS VEL (LBM/SEC-IN2)	0.6579	0.3237	0.3888	0.7233	0.8735
NONDIM H2O MASS VELOCITY	1.9024	0.9361	1.1244	2.0916	2.5262
LINEAR VEL AIR (FT/SEC)	9.187	12.725	8.238	5.144	5.993
NONDIM LINEAR AIR VELOCITY	0.3690	0.5110	0.3308	0.2066	0.2407
LINEAR VEL WATER (FT/SEC)	3.766	4.795	4.435	3.621	3.779
NONDIM LINEAR H2O VELOCITY	1.0120	1.2887	1.1920	0.9730	1.0156
LOCAL QUALITY	0.0266	0.0981	0.0525	0.0124	0.0104
NONDIMENSIONAL QUALITY	0.1698	0.6272	0.3355	0.0792	0.0662
LOCAL VOID FRACTION	0.5956	0.8437	0.7971	0.5375	0.4649
LOCAL SLIP RATIO	2.440	2.654	1.857	1.421	1.586

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TEST NUMBER 93

PROBE NUMBER 2

ANGULAR POSITION (DEGREES) 45.0

WALL TO WALL DISTANCE (INCHES)	0.3630	AVERAGE TOTAL QUALITY	0.1603
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7852
TEST SECTION PRESSURE (LBF/IN2)	81.5000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	24.6277
DENSITY OF TEST AIR (LBM/FT3)	0.4740	AVERAGE LINEAR WATER VELOCITY	3.5878
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0637	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3334
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.0175	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.6935
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.7252	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-1.0800
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.0920	0.1740	0.2550	0.3380
R(I)/(D)	0.0689	0.2534	0.4793	0.7025	0.9311
IMPACT PRESSURE (PSIA)	0.0505	0.0379	0.0442	0.0505	0.0757
ACTUAL ISO SETTING OF MANO	-0.5000	-0.6667	-0.4286	-0.3750	-0.2500
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0163	0.0284	0.0157	0.0117	0.0133
NONDIM AIR MASS VELOCITY	0.2563	0.4466	0.2460	0.1845	0.2083
ISO H2O MASS VEL (LBM/SEC-IN2)	0.5400	0.3892	0.5182	0.6919	0.9204
NONDIM H2O MASS VELOCITY	1.6197	1.1673	1.5541	2.0753	2.4607
LINEAR VEL AIR (FT/SEC)	7.634	11.921	7.506	7.327	7.867
NONDIM LINEAR AIR VELOCITY	0.3100	0.4841	0.3048	0.2975	0.3194
LINEAR VEL WATER (FT/SEC)	3.564	3.270	3.276	3.123	3.893
NONDIM LINEAR H2O VELOCITY	0.9933	0.9115	0.9131	0.8704	1.0850
LOCAL QUALITY	0.0293	0.0681	0.0293	0.0167	0.0159
NONDIMENSIONAL QUALITY	0.1829	0.4246	0.1830	0.1041	0.0992
LOCAL VOID FRACTION	0.6492	0.7245	0.6338	0.4870	0.5120
LOCAL SLIP RATIO	2.142	3.645	2.291	2.346	2.021

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TEST NUMBER 93

PROBE NUMBER 2

ANGULAR POSITION (DEGREES) 90.0

WALL TO WALL DISTANCE (INCHES)	0.2680	AVERAGE TOTAL QUALITY	0.1559
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7852
TEST SECTION PRESSURE (LBF/IN2)	82.0000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	24.5116
DENSITY OF TEST AIR (LBM/FT3)	0.4772	AVERAGE LINEAR WATER VELOCITY	3.7172
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0638	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3454
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.0136	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.5538
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.7864	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-0.6032
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.0730	0.1350	0.1980	0.2430
R(I)/(D)	0.0933	0.2724	0.5037	0.7388	0.9067
IMPACT PRESSURE (PSIA)	0.0502	0.0424	0.0392	0.0533	0.0612
ACTUAL ISO SETTING OF MANO	-0.8750	-0.8148	-0.5600	-0.1765	-0.5128
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0173	0.0216	0.0127	0.0100	0.0110
NONDIM AIR MASS VELOCITY	0.2705	0.3392	0.1985	0.1561	0.1719
ISO H2O MASS VEL (LBM/SEC-IN2)	0.5886	0.4322	0.4589	0.5922	0.7382
NONDIM H2O MASS VELOCITY	1.7040	1.2513	1.3283	1.7144	2.1370
LINEAR VEL AIR (FT/SEC)	8.768	9.146	5.690	4.883	6.464
NONDIM LINEAR AIR VELOCITY	0.3577	0.3731	0.2322	0.1992	0.2637
LINEAR VEL WATER (FT/SEC)	3.355	3.496	3.234	3.564	3.502
NONDIM LINEAR H2O VELOCITY	0.9025	0.9405	0.8700	0.9588	0.9421
LOCAL QUALITY	0.0285	0.0477	0.0269	0.0165	0.0146
NONDIMENSIONAL QUALITY	0.1827	0.3058	0.1723	0.1061	0.0939
LOCAL VOID FRACTION	0.5938	0.7138	0.6715	0.6153	0.5120
LOCAL SLIP RATIO	2.614	2.616	1.759	1.370	1.846

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TEST NUMBER 93

PROBE NUMBER 2

ANGULAR POSITION (DEGREES) 135.0

WALL TO WALL DISTANCE (INCHES)	0.3130	AVERAGE TOTAL QUALITY	0.1574
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7852
TEST SECTION PRESSURE (LBF/IN2)	83.5000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	24.4860
DENSITY OF TEST AIR (LBM/FT3)	0.4808	AVERAGE LINEAR WATER VELOCITY	3.6981
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0642	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3437
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.0346	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.4969
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.4614	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-0.4459
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1110	0.2120	0.3130
R(I)/(D)	0.0799	0.3546	0.6773	1.0000
IMPACT PRESSURE (PSIA)	0.0799	0.0611	0.0689	0.0783
ACTUAL ISO SETTING OF MANO	-0.2745	-0.6154	-0.3636	-0.3200
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0144	0.0446	0.0384	0.0309
NONDIM AIR MASS VELOCITY	0.2244	0.6951	0.5975	0.4806
ISO H2O MASS VEL (LBM/SEC-IN2)	0.7669	0.3618	0.3350	0.4703
NONDIM H2O MASS VELOCITY	2.2314	1.0528	0.9747	1.3685
LINEAR VEL AIR (FT/SEC)	7.467	16.032	13.083	11.466
NONDIM LINEAR AIR VELOCITY	0.3050	0.6547	0.5343	0.4683
LINEAR VEL WATER (FT/SEC)	4.205	5.035	6.361	5.609
NONDIM LINEAR H2O VELOCITY	1.1371	1.3615	1.7200	1.5167
LOCAL QUALITY	0.0184	0.1098	0.1027	0.0616
NONDIMENSIONAL QUALITY	0.1172	0.6976	0.6528	0.3911
LOCAL VOID FRACTION	0.5778	0.8336	0.8781	0.8059
LOCAL SLIP RATIO	1.776	3.184	2.057	2.044

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1928.

TEST NUMBER 93

PROBE NUMBER 2

ANGULAR POSITION (DEGREES) 135.0

WALL TO WALL DISTANCE (INCHES)	0.3130	AVERAGE TOTAL QUALITY	0.1677
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7852
TEST SECTION PRESSURE (LBF/IN2)	88.4000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	24.7855
DENSITY OF TEST AIR (LBM/FT3)	0.5087	AVERAGE LINEAR WATER VELOCITY	3.6710
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0688	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3411
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.0346	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.4969
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.4972	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-0.4566
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1110	0.2120	0.3130
R(I)/(D)	0.0799	0.3546	0.6773	1.0000
IMPACT PRESSURE (PSIA)	0.0799	0.0611	0.0689	0.0783
ACTUAL ISO SETTING OF MANO	-0.2745	-0.6154	-0.3636	-0.3200
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0144	0.0446	0.0384	0.0309
NONDIM AIR MASS VELOCITY	0.2095	0.6490	0.5579	0.4487
ISO H2O MASS VEL (LBM/SEC-IN2)	0.7669	0.3618	0.3350	0.4703
NONDIM H2O MASS VELOCITY	2.2479	1.0606	0.9819	1.3786
LINEAR VEL AIR (FT/SEC)	7.055	15.125	12.355	10.829
NONDIM LINEAR AIR VELOCITY	0.2846	0.6102	0.4985	0.4369
LINEAR VEL WATER (FT/SEC)	4.207	5.080	6.397	5.626
NONDIM LINEAR H2O VELOCITY	1.1462	1.3839	1.7425	1.5324
LOCAL QUALITY	0.0184	0.1098	0.1027	0.0616
NONDIMENSIONAL QUALITY	0.1099	0.6546	0.6125	0.3670
LOCAL VOID FRACTION	0.5780	0.8351	0.8788	0.8065
LOCAL SLIP RATIO	1.677	2.977	1.931	1.925

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1928.

TEST NUMBER 93

PROBE NUMBER 2

ANGULAR POSITION (DEGREES) 180.0

WALL TO WALL DISTANCE (INCHES)	0.4460	AVERAGE TOTAL QUALITY	0.1597
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7852
TEST SECTION PRESSURE (LBF/IN2)	83.9000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	24.0169
DENSITY OF TEST AIR (LBM/FT3)	0.4865	AVERAGE LINEAR WATER VELOCITY	3.6081
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0637	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3353
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.0628	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.6626
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.0143	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-0.9761
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1290	0.2370	0.3450	0.4210
R(I)/(D)	0.0561	0.2892	0.5314	0.7735	0.9439
IMPACT PRESSURE (PSIA)	0.1486	0.0954	0.0954	0.0995	0.1420
ACTUAL ISO SETTING OF MANO	-0.2105	-0.3279	-0.2623	-0.2516	-0.2863
ISO AIR MASS VEL (LPM/SEC-IN2)	0.0231	0.0835	0.0889	0.0648	0.0212
NONDIM AIR MASS VELOCITY	0.3618	1.3107	1.3945	1.0172	0.3332
ISO H2O MASS VEL (LPM/SEC-IN2)	1.0693	0.2189	0.1593	0.2726	1.1361
NONDIM H2O MASS VELOCITY	3.1890	0.6529	0.4751	0.8130	3.3884
LINEAR VEL AIR (FT/SEC)	12.150	26.098	27.121	20.502	12.505
NONDIM LINEAR AIR VELOCITY	0.5059	1.0867	1.1293	0.8537	0.5207
LINEAR VEL WATER (FT/SEC)	5.645	9.578	12.141	9.796	5.287
NONDIM LINEAR H2O VELOCITY	1.5646	2.6546	3.3649	2.7151	1.4654
LOCAL QUALITY	0.0211	0.2761	0.3580	0.1921	0.0183
NONDIMENSIONAL QUALITY	0.1322	1.7292	2.2422	1.2029	0.1149
LOCAL VOID FRACTION	0.5615	0.9471	0.9696	0.9356	0.5025
LOCAL SLIP RATIO	2.152	2.725	2.234	2.093	2.365

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TEST NUMBER 93

PROBE NUMBER 2

ANGULAR POSITION (DEGREES) 225.0

WALL TO WALL DISTANCE (INCHES)	0.4210	AVERAGE TOTAL QUALITY	0.1511
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7852
TEST SECTION PRESSURE (LBF/IN2)	84.3000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	22.7740
DENSITY OF TEST AIR (LBM/FT3)	0.4874	AVERAGE LINEAR WATER VELOCITY	3.6587
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0605	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3400
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.0872	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.5228
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.4408	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-0.5376
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1480	0.2870	0.4210
R(I)/(D)	0.0594	0.3515	0.6817	1.0000
IMPACT PRESSURE (PSIA)	0.2002	0.1314	0.1408	0.1502
ACTUAL ISO SETTING OF MANO	-0.2188	-0.2381	-0.1778	-0.0625
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0250	0.0965	0.0981	0.0991
NONDIM AIR MASS VELOCITY	0.4127	1.5939	1.6216	1.6380
ISO H2O MASS VEL (LBM/SEC-IN2)	1.2212	0.2149	0.1676	0.1729
NONDIM H2O MASS VELOCITY	3.5918	0.6321	0.4929	0.5085
LINEAR VEL AIR (FT/SEC)	12.875	29.589	29.610	29.896
NONDIM LINEAR AIR VELOCITY	0.5654	1.2992	1.3002	1.3127
LINEAR VEL WATER (FT/SEC)	6.624	13.545	18.765	19.782
NONDIM LINEAR H2O VELOCITY	1.8106	3.7021	5.1288	5.4068
LOCAL QUALITY	0.0200	0.3098	0.3693	0.3644
NONDIMENSIONAL QUALITY	0.1326	2.0501	2.4444	2.4118
LOCAL VOID FRACTION	0.5732	0.9633	0.9793	0.9798
LOCAL SLIP RATIO	1.944	2.185	1.578	1.511

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1928.

TEST NUMBER 93

PROBE NUMBER 2

ANGULAR POSITION (DEGREES) 270.0

WALL TO WALL DISTANCE (INCHES)	0.4460	AVERAGE TOTAL QUALITY	0.1352
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7852
TEST SECTION PRESSURE (LBF/IN2)	83.6000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	22.0096
DENSITY OF TEST AIR (LBM/FT3)	0.4848	AVERAGE LINEAR WATER VELOCITY	4.0041
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0582	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3721
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.0690	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.7343
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.1857	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-0.9734
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.0540	0.2230	0.3320	0.4210
R(I)/(D)	0.0561	0.1211	0.5000	0.7444	0.9439
IMPACT PRESSURE (PSIA)	0.1908	0.1189	0.1189	0.1596	0.2127
ACTUAL ISO SETTING OF MANO	-0.1967	-0.4211	-0.3158	-0.3137	-0.1471
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0207	0.0883	0.0955	0.0568	0.0228
NONDIM AIR MASS VELOCITY	0.3560	1.5179	1.6407	0.9769	0.3923
ISO H2O MASS VEL (LBM/SEC-IN2)	1.3400	0.2839	0.2233	0.6844	1.3501
NONDIM H2O MASS VELOCITY	3.6010	0.7630	0.6002	1.8392	3.6282
LINEAR VEL AIR (FT/SEC)	12.528	28.131	29.708	21.325	12.901
NONDIM LINEAR AIR VELOCITY	0.5692	1.2781	1.3498	0.9689	0.5862
LINEAR VEL WATER (FT/SEC)	6.096	9.738	11.343	7.606	6.586
NONDIM LINEAR H2O VELOCITY	1.5223	2.4319	2.8329	1.8996	1.6449
LOCAL QUALITY	0.0152	0.2373	0.2994	0.0767	0.0166
NONDIMENSIONAL QUALITY	0.1126	1.7547	2.2144	0.5671	0.1229
LOCAL VOID FRACTION	0.4911	0.9325	0.9544	0.7917	0.5254
LOCAL SLIP RATIO	2.055	2.889	2.619	2.804	1.959

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TEST NUMBER 93

PROBE NUMBER 2

ANGULAR POSITION (DEGREES) 315.0

WALL TO WALL DISTANCE (INCHES)	0.4200	AVERAGE TOTAL QUALITY	0.1354
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7852
TEST SECTION PRESSURE (LBF/IN2)	83.0000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	22.2447
DENSITY OF TEST AIR (LBM/FT3)	0.4801	AVERAGE LINEAR WATER VELOCITY	4.0016
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0582	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3719
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.0583	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.6910
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.0017	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-0.8583
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1800	0.3260	0.4200
R(I)/(D)	0.0595	0.4286	0.7762	1.0000
IMPACT PRESSURE (PSIA)	0.1380	0.0878	0.0847	0.0894
ACTUAL ISO SETTING OF MANO	-0.2727	-0.4286	-0.2222	-0.3158
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0185	0.0734	0.0616	0.0579
NONDIM AIR MASS VELOCITY	0.3182	1.2612	1.0574	0.9937
ISO H2O MASS VEL (LBM/SEC-IN2)	1.1309	0.2804	0.2264	0.2970
NONDIM H2O MASS VELOCITY	3.0413	0.7540	0.6087	0.7987
LINEAR VEL AIR (FT/SEC)	11.199	24.106	19.511	18.913
NONDIM LINEAR AIR VELOCITY	0.5035	1.0837	0.8771	0.8502
LINEAR VEL WATER (FT/SEC)	5.198	7.530	9.806	8.352
NONDIM LINEAR H2O VELOCITY	1.2991	1.8818	2.4506	2.0872
LOCAL QUALITY	0.0161	0.2076	0.2138	0.1630
NONDIMENSIONAL QUALITY	0.1191	1.5330	1.5795	1.2043
LOCAL VOID FRACTION	0.4963	0.9138	0.9466	0.9177
LOCAL SLIP RATIO	2.154	3.201	1.990	2.264

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TEST NUMBER 93

PROBE NUMBER 3

ANGULAR POSITION (DEGREES) 90.0

WALL TO WALL DISTANCE (INCHES)	0.4550	AVERAGE TOTAL QUALITY	0.1362
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7852
TEST SECTION PRESSURE (LBF/IN ²)	84.0000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	22.6069
DENSITY OF TEST AIR (LBM/FT ³)	0.4872	AVERAGE LINEAR WATER VELOCITY	4.0995
AIR MASS VELOCITY (LBM/SEC-IN ²)	0.0601	WATER MASS VELOCITY (LBM/SEC-IN ²)	0.3810
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN ²)	0.0442	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN ²)	0.9171
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.2633	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-1.4073
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1250	0.2350	0.3450	0.4300
R(I)/(D)	0.0549	0.2747	0.5165	0.7582	0.9451
IMPACT PRESSURE (PSIA)	0.2639	0.1476	0.2199	0.2890	0.
ACTUAL ISO SETTING OF MANO	-0.1905	-0.1809	-0.2286	-0.1739	0.
ISO AIR MASS VEL (LBM/SEC-IN ²)	0.0228	0.0973	0.0657	0.0271	0.
NONDIM AIR MASS VELOCITY	0.3794	1.6195	1.0942	0.4519	0.
ISO H ₂ O MASS VEL (LBM/SEC-IN ²)	1.6749	0.3057	0.7694	1.6055	0.
NONDIM H ₂ O MASS VELOCITY	4.3965	0.8023	2.0196	4.2142	0.
LINEAR VEL AIR (FT/SEC)	15.172	30.660	24.042	15.710	0.
NONDIM LINEAR AIR VELOCITY	0.6711	1.3562	1.0635	0.6949	0.
LINEAR VEL WATER (FT/SEC)	6.972	11.340	9.273	7.594	0.
NONDIM LINEAR H ₂ O VELOCITY	1.7008	2.7661	2.2620	1.8525	0.
LOCAL QUALITY	0.0134	0.2414	0.0787	0.0166	0.
NONDIMENSIONAL QUALITY	0.0986	1.7726	0.5779	0.1221	0.
LOCAL VOID FRACTION	0.4438	0.9376	0.8079	0.5106	0.
LOCAL SLIP RATIO	2.176	2.704	2.593	2.069	0.

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TEST NUMBER 93

PROBE NUMBER 3

ANGULAR POSITION (DEGREES) 90.0

WALL TO WALL DISTANCE (INCHES)	0.4550	AVERAGE TOTAL QUALITY	0.1586
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7852
TEST SECTION PRESSURE (LBF/IN2)	83.0000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	24.3859
DENSITY OF TEST AIR (LBM/FT3)	0.4849	AVERAGE LINEAR WATER VELOCITY	3.6804
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0645	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3420
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.0960	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.7397
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.4888	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-1.1628
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1250	0.2350	0.3450	0.4300
R(I)/(ID)	0.0549	0.2747	0.5165	0.7582	0.9451
IMPACT PRESSURE (PSIA)	0.2639	0.1853	0.1633	0.1885	0.2010
ACTUAL ISO SETTING OF MANO	-0.2143	-0.2373	-0.2308	-0.2000	-0.2187
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0298	0.1025	0.1131	0.0909	0.0787
NONDIM AIR MASS VELOCITY	0.4629	1.5897	1.7537	1.4095	1.2209
ISO H2O MASS VEL (LBM/SEC-IN2)	1.5977	0.3561	0.2376	0.4647	0.6909
NONDIM H2O MASS VELOCITY	4.6714	1.0411	0.6947	1.3586	2.0200
LINEAR VEL AIR (FT/SEC)	18.528	32.533	34.911	29.925	28.539
NONDIM LINEAR AIR VELOCITY	0.7598	1.3341	1.4316	1.2271	1.1703
LINEAR VEL WATER (FT/SEC)	7.091	12.800	14.425	10.968	8.846
NONDIM LINEAR H2O VELOCITY	1.9268	3.4779	3.9194	2.9802	2.4035
LOCAL QUALITY	0.0183	0.2235	0.3224	0.1636	0.1023
NONDIMENSIONAL QUALITY	0.1156	1.4092	2.0328	1.0314	0.6449
LOCAL VOID FRACTION	0.4784	0.9356	0.9619	0.9019	0.8192
LOCAL SLIP RATIO	2.613	2.542	2.420	2.728	3.226

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PROBE NUMBER 3

ANGULAR POSITION (DEGREES) 135.0

WALL TO WALL DISTANCE (INCHES)	0.4280	AVERAGE TOTAL QUALITY	0.1547
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7852
TEST SECTION PRESSURE (LBF/IN ²)	85.1000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	24.1230
DENSITY OF TEST AIR (LBM/FT ³)	0.4796	AVERAGE LINEAR WATER VELOCITY	3.7094
AIR MASS VELOCITY (LBM/SEC-IN ²)	0.0631	WATER MASS VELOCITY (LBM/SEC-IN ²)	0.3447
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN ²)	0.1230	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN ²)	0.3613
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.9495	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-0.0480
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1530	0.2920	0.4280
R(I)/(D)	0.0584	0.3575	0.6822	1.0090
IMPACT PRESSURE (PSIA)	0.1791	0.2019	0.1706	0.2520
ACTUAL ISO SETTING OF MANO	-0.2413	-0.2016	-0.1284	-0.1366
ISO AIR MASS VEL (LBM/SEC-IN ²)	0.1427	0.1296	0.1030	0.0188
NONDIM AIR MASS VELOCITY	2.2629	2.0538	1.6336	0.2977
ISO H ₂ O MASS VEL (LBM/SEC-IN ²)	0.1538	0.1513	0.2376	1.2421
NONDIM H ₂ O MASS VELOCITY	0.4460	0.4389	0.6893	3.6032
LINEAR VEL AIR (FT/SEC)	43.738	39.423	31.997	8.841
NONDIM LINEAR AIR VELOCITY	1.8131	1.6343	1.3264	0.3665
LINEAR VEL WATER (FT/SEC)	17.774	26.504	16.697	7.937
NONDIM LINEAR H ₂ O VELOCITY	4.7916	7.1451	4.5014	2.1398
LOCAL QUALITY	0.4814	0.4613	0.3025	0.0149
NONDIMENSIONAL QUALITY	3.1123	2.9823	1.9556	0.0963
LOCAL VOID FRACTION	0.9800	0.9868	0.9671	0.6377
LOCAL SLIP RATIO	2.461	1.487	1.916	1.114

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TEST NUMBER 93

PROBE NUMBER 3

ANGULAR POSITION (DEGREES) 180.0

WALL TO WALL DISTANCE (INCHES)	0.4910	AVERAGE TOTAL QUALITY	0.1543
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7852
TEST SECTION PRESSURE (LBF/IN2)	84.5000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	23.5519
DENSITY OF TEST AIR (LBM/FT3)	0.4860	AVERAGE LINEAR WATER VELOCITY	3.6811
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0624	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3421
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.1110	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.6428
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.7789	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-0.8790
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1250	0.2430	0.3530	0.4660
R(I)/(O)	0.0509	0.2546	0.4949	0.7189	0.9491
IMPACT PRESSURE (PSIA)	0.2718	0.1890	0.1781	0.1625	0.1531
ACTUAL ISO SETTING OF MANO	-0.3678	-0.1983	-0.2105	-0.2692	-0.2449
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0304	0.0806	0.1231	0.1104	0.0908
NONDIM AIR MASS VELOCITY	0.4877	1.2906	1.9720	1.7680	1.4545
ISO H2O MASS VEL (LBM/SEC-IN2)	1.9485	0.4487	0.2158	0.2159	0.2808
NONDIM H2O MASS VELOCITY	5.6960	1.3116	0.6308	0.6311	0.8209
LINEAR VEL AIR (FT/SEC)	27.757	26.139	37.612	33.740	28.255
NONDIM LINEAR AIR VELOCITY	1.1786	1.1099	1.5970	1.4326	1.1997
LINEAR VEL WATER (FT/SEC)	6.683	11.953	16.425	16.130	13.541
NONDIM LINEAR H2O VELOCITY	1.8154	3.2473	4.4620	4.3819	3.6785
LOCAL QUALITY	0.0154	0.1522	0.3632	0.3382	0.2443
NONDIMENSIONAL QUALITY	0.0997	0.9865	2.3539	2.1920	1.5833
LOCAL VOID FRACTION	0.3250	0.9131	0.9696	0.9690	0.9520
LOCAL SLIP RATIO	4.154	2.187	2.290	2.092	2.087

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TEST NUMBER 93

PROBE NUMBER 3

ANGULAR POSITION (DEGREES) 225.0

WALL TO WALL DISTANCE (INCHES)	0.4750	AVERAGE TOTAL QUALITY	0.1570
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7852
TEST SECTION PRESSURE (LBF/IN2)	83.9000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	24.0583
DENSITY OF TEST AIR (LBM/FT3)	0.4841	AVERAGE LINEAR WATER VELOCITY	3.6684
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0635	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3409
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.1011	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.8063
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.5921	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-1.3653
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1670	0.0542	0.4750
R(I)/(D)	0.0526	0.3516	0.1141	1.0000
IMPACT PRESSURE (PSIA)	0.2870	0.1997	0.1966	0.1872
ACTUAL ISO SETTING OF MANO ,	-0.1957	-0.2187	-0.2540	-0.0667
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0234	0.1091	0.1277	0.1311
NONDIM AIR MASS VELOCITY	0.3685	1.7185	2.0102	2.0644
ISO H2O MASS VEL (LBM/SEC-IN2)	1.7398	0.3346	0.2135	0.1577
NONDIM H2O MASS VELOCITY	5.1033	0.9816	0.6264	0.4626
LINEAR VEL AIR (FT/SEC)	15.566	34.321	39.014	39.650
NONDIM LINEAR AIR VELOCITY	0.6470	1.4266	1.6217	1.6481
LINEAR VEL WATER (FT/SEC)	7.287	14.317	18.541	22.198
NONDIM LINEAR H2O VELOCITY	1.9863	3.9027	5.0541	6.0511
LOCAL QUALITY	0.0133	0.2459	0.3741	0.4540
NONDIMENSIONAL QUALITY	0.0845	1.5661	2.3827	2.8910
LOCAL VOID FRACTION	0.4472	0.9459	0.9733	0.9836
LOCAL SLIP RATIO	2.136	2.397	2.104	1.786

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TEST NUMBER 93

PROBE NUMBER 3

ANGULAR POSITION (DEGREES) 270.0

WALL TO WALL DISTANCE (INCHES)	0.5000	AVERAGE TOTAL QUALITY	0.1566
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7852
TEST SECTION PRESSURE (LBF/IN2)	83.3000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	24.1090
DENSITY OF TEST AIR (LBM/FT3)	0.4837	AVERAGE LINEAR WATER VELOCITY	3.6843
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0636	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3424
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.0969	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.9517
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.5243	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-1.7795
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1330	0.2500	0.3670	0.4750
R(I)/(D)	0.0500	0.2660	0.5000	0.7340	0.9500
IMPACT PRESSURE (PSIA)	0.2828	0.1812	0.1750	0.1906	0.2312
ACTUAL ISO SETTING OF MANO	-0.1768	-0.2759	-0.1786	-0.1639	-0.2162
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0240	0.1172	0.1168	0.1043	0.0564
NONDIM AIR MASS VELOCITY	0.3766	1.8433	1.8367	1.6396	0.8869
ISO H2O MASS VEL (LBM/SEC-IN2)	1.7677	0.3328	0.2377	0.4266	1.0515
NONDIM H2O MASS VELOCITY	5.1628	0.9721	0.6943	1.2460	3.0711
LINEAR VEL AIR (FT/SEC)	16.656	37.336	36.055	34.071	24.329
NONDIM LINEAR AIR VELOCITY	0.6909	1.5487	1.4955	1.4132	1.0091
LINEAR VEL WATER (FT/SEC)	7.155	11.777	15.437	11.094	7.855
NONDIM LINEAR H2O VELOCITY	1.9421	3.1965	4.1900	3.0110	2.1321
LOCAL QUALITY	0.0134	0.2605	0.3295	0.1964	0.0509
NONDIMENSIONAL QUALITY	0.0853	1.6628	2.1032	1.2538	0.3250
LOCAL VOID FRACTION	0.4281	0.9346	0.9643	0.9110	0.6901
LOCAL SLIP RATIO	2.328	3.170	2.336	3.071	3.097

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TEST NUMBER 93

PROBE NUMBER 3

ANGULAR POSITION (DEGREES) 315.0

WALL TO WALL DISTANCE (INCHES)	0.4750	AVERAGE TOTAL QUALITY	0.1594
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7852
TEST SECTION PRESSURE (LBF/IN2)	83.9000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	24.8912
DENSITY OF TEST AIR (LBM/FT3)	0.4841	AVERAGE LINEAR WATER VELOCITY	3.7275
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0657	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3464
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.1084	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.7274
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.6498	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-1.1000
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1670	0.3190	0.4750
R(I)/(ID)	0.0526	0.3516	0.6716	1.0000
IMPACT PRESSURE (PSIA)	0.2508	0.1755	0.1708	0.1724
ACTUAL ISO SETTING OF MANO	-0.2250	-0.2500	-0.2459	-0.0727
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0249	0.1110	0.1292	0.1153
NONDIM AIR MASS VELOCITY	0.3786	1.6896	1.9669	1.7551
ISO H2O MASS VEL (LBM/SEC-IN2)	1.6557	0.3211	0.2029	0.1744
NONDIM H2O MASS VELOCITY	4.7798	0.9269	0.5859	0.5150
LINEAR VEL AIR (FT/SEC)	17.145	35.151	39.677	35.018
NONDIM LINEAR AIR VELOCITY	0.6888	1.4122	1.5940	1.4068
LINEAR VEL WATER (FT/SEC)	6.744	12.272	15.094	20.245
NONDIM LINEAR H2O VELOCITY	1.8093	3.2923	4.0504	5.4312
LOCAL QUALITY	0.0148	0.2569	0.3890	0.3926
NONDIMENSIONAL QUALITY	0.0928	1.6114	2.4402	2.4627
LOCAL VOID FRACTION	0.4316	0.9394	0.9689	0.9796
LOCAL SLIP RATIO	2.542	2.864	2.628	1.730

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TEST NUMBER 94

PROBE NUMBER 1

ANGULAR POSITION (DEGREES) 0.

WALL TO WALL DISTANCE (INCHES)	0.3710	AVERAGE TOTAL QUALITY	0.1155
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7603
TEST SECTION PRESSURE (LBF/IN2)	81.9000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	17.3561
DENSITY OF TEST AIR (LBM/FT3)	0.4839	AVERAGE LINEAR WATER VELOCITY	3.2756
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0443	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3397
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.0483	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.8233
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.0882	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-1.4237
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.0960	0.1800	0.2700	0.3460
R(I)/(ID)	0.0674	0.2588	0.4852	0.7278	0.9326
IMPACT PRESSURE (PSIA)	0.1509	0.1257	0.1194	0.1383	0.1603
ACTUAL ISO SETTING OF MANO ,	-0.1667	-0.2000	-0.2105	-0.2273	-0.2353
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0238	0.0582	0.0711	0.0497	0.0196
NONDIM AIR MASS VELOCITY	0.5375	1.3136	1.6043	1.1216	0.4431
ISO H2O MASS VEL (LBM/SEC-IN2)	0.9716	0.4752	0.3890	0.6484	1.1995
NONDIM H2O MASS VELOCITY	2.8601	1.3990	1.1452	1.9087	3.5310
LINEAR VEL AIR (FT/SEC)	11.297	20.093	23.709	18.798	11.498
NONDIM LINEAR AIR VELOCITY	0.6509	1.1577	1.3660	1.0831	0.6625
LINEAR VEL WATER (FT/SEC)	6.045	8.015	8.409	7.059	5.650
NONDIM LINEAR H2O VELOCITY	1.8454	2.4470	2.5672	2.1551	1.7248
LOCAL QUALITY	0.0239	0.1092	0.1546	0.0712	0.0161
NONDIMENSIONAL QUALITY	0.2074	0.9456	1.3389	0.6170	0.1396
LOCAL VOID FRACTION	0.6279	0.8627	0.8929	0.7874	0.5085
LOCAL SLIP RATIO	1.869	2.507	2.819	2.663	2.035

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TEST NUMBER 94

PROBE NUMBER 1

ANGULAR POSITION (DEGREES) 0.

WALL TO WALL DISTANCE (INCHES)	0.3570	AVERAGE TOTAL QUALITY	0.1131
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7603
TEST SECTION PRESSURE (LBF/IN2)	79.5000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	17.8690
DENSITY OF TEST AIR (LBM/FT3)	0.4684	AVERAGE LINEAR WATER VELOCITY	3.3407
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0442	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3464
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.0420	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	1.2686
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.0499	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-2.6619
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.0960	0.1860	0.2750	0.3520
R(I)/(D)	0.0700	0.2689	0.5210	0.7703	0.9860
IMPACT PRESSURE (PSIA)	0.1259	0.1007	0.0944	0.0881	0.1133
ACTUAL ISO SETTING OF MANO	-0.3500	-0.2500	-0.2667	-0.2143	-0.2778
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0204	0.0455	0.0511	0.0226	0.0127
NONDIM AIR MASS VELOCITY	0.4609	1.0299	1.1553	0.5109	0.2882
ISO H2O MASS VEL (LBM/SEC-IN2)	0.9357	0.3131	0.3352	0.5177	1.0132
NONDIM H2O MASS VELOCITY	2.7008	0.9037	0.9674	1.4942	2.9247
LINEAR VEL AIR (FT/SEC)	10.517	15.119	17.319	8.696	7.728
NONDIM LINEAR AIR VELOCITY	0.5886	0.8461	0.9692	0.4866	0.4325
LINEAR VEL WATER (FT/SEC)	5.354	9.718	8.275	5.938	4.755
NONDIM LINEAR H2O VELOCITY	1.6028	2.9089	2.4770	1.7775	1.4233
LOCAL QUALITY	0.0213	0.1269	0.1322	0.0418	0.0124
NONDIMENSIONAL QUALITY	0.1883	1.1219	1.1685	0.3694	0.1097
LOCAL VOID FRACTION	0.5954	0.9254	0.9062	0.7982	0.5067
LOCAL SLIP RATIO	1.964	1.556	2.093	1.464	1.625

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TEST NUMBER 94

PROBE NUMBER 1

ANGULAR POSITION (DEGREES) 45.0

WALL TO WALL DISTANCE (INCHES)	0.2750	AVERAGE TOTAL QUALITY	0.1117
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7603
TEST SECTION PRESSURE (LBF/IN2)	82.1000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	17.0389
DENSITY OF TEST AIR (LBM/FT3)	0.4778	AVERAGE LINEAR WATER VELOCITY	3.2953
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0430	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3417
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.0493	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.4479
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.1469	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-0.3106
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.0960	0.1860	0.2750
R(I)/(D)	0.0909	0.3491	0.6764	1.0000
IMPACT PRESSURE (PSIA)	0.1265	0.1093	0.1093	0.1093
ACTUAL ISO SETTING OF MANO	-0.1235	-0.1429	-0.0857	-0.2000
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0195	0.0426	0.0555	0.0792
NONDIM AIR MASS VELOCITY	0.4542	0.9904	1.2920	1.8423
ISO H2O MASS VEL (LBM/SEC-IN2)	0.8312	0.4539	0.2593	0.2512
NONDIM H2O MASS VELOCITY	2.4324	1.3281	0.7589	0.7352
LINEAR VEL AIR (FT/SEC)	8.806	14.862	17.612	25.259
NONDIM LINEAR AIR VELOCITY	0.5168	0.8722	1.0336	1.4824
LINEAR VEL WATER (FT/SEC)	5.800	7.688	12.093	10.547
NONDIM LINEAR H2O VELOCITY	1.7600	2.3330	3.6699	3.2007
LOCAL QUALITY	0.0229	0.0858	0.1764	0.2397
NONDIMENSIONAL QUALITY	0.2054	0.7676	1.5786	2.1449
LOCAL VOID FRACTION	0.6682	0.8633	0.9504	0.9449
LOCAL SLIP RATIO	1.518	1.933	1.456	2.395

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1929.

TEST NUMBER 94

PROBE NUMBER 1

ANGULAR POSITION (DEGREES) 90.0

WALL TO WALL DISTANCE (INCHES)	0.4130	AVERAGE TOTAL QUALITY	0.1142
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7603
TEST SECTION PRESSURE (LBF/IN2)	83.2000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	17.2970
DENSITY OF TEST AIR (LBM/FT3)	0.4859	AVERAGE LINEAR WATER VELOCITY	3.3193
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0444	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3442
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.0603	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.6692
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.3593	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-0.9442
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1080	0.2060	0.3080	0.3880
R(I)/(D)	0.0605	0.2615	0.4988	0.7458	0.9395
IMPACT PRESSURE (PSIA)	0.1761	0.1446	0.1195	0.1383	0.1886
ACTUAL ISO SETTING OF MANO	-0.3214	-0.2609	-0.2105	-0.1818	-0.2000
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0300	0.0704	0.0745	0.0745	0.0286
NONDIM AIR MASS VELOCITY	0.6762	1.5871	1.6797	1.6786	0.6436
ISO H2O MASS VEL (LBM/SEC-IN2)	1.1011	0.3944	0.2265	0.2804	1.0030
NONDIM H2O MASS VELOCITY	3.1989	1.1459	0.6579	0.8146	2.9137
LINEAR VEL AIR (FT/SEC)	14.923	22.878	22.974	23.209	12.573
NONDIM LINEAR AIR VELOCITY	0.8628	1.3227	1.3282	1.3418	0.7269
LINEAR VEL WATER (FT/SEC)	6.308	10.410	13.624	13.290	7.104
NONDIM LINEAR H2O VELOCITY	1.9006	3.1361	4.1046	4.0039	2.1403
LOCAL QUALITY	0.0265	0.1515	0.2476	0.2099	0.0277
NONDIMENSIONAL QUALITY	0.2323	1.3267	2.1685	1.8381	0.2424
LOCAL VOID FRACTION	0.5959	0.9123	0.9615	0.9512	0.6732
LOCAL SLIP RATIO	2.366	2.198	1.686	1.746	1.770

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TEST NUMBER 94

PROBE NUMBER 1

ANGULAR POSITION (DEGREES) 135.0

WALL TO WALL DISTANCE (INCHES)	0.3620	AVERAGE TOTAL QUALITY	0.1149
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7603
TEST SECTION PRESSURE (LBF/IN ²)	84.0000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	17.6471
DENSITY OF TEST AIR (LBM/FT ³)	0.4819	AVERAGE LINEAR WATER VELOCITY	3.3361
AIR MASS VELOCITY (LBM/SEC-IN ²)	0.0449	WATER MASS VELOCITY (LBM/SEC-IN ²)	0.3460
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN ²)	0.0867	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN ²)	0.5369
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.9312	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-0.5520
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1270	0.2460	0.3620
R(I)/(D)	0.0691	0.3508	0.6796	1.0000
IMPACT PRESSURE (PSIA)	0.2035	0.1628	0.1565	0.1565
ACTUAL ISO SETTING OF MANO	-0.1169	-0.4231	-0.2400	-0.1600
ISO AIR MASS VEL (LBM/SEC-IN ²)	0.0213	0.0939	0.1017	0.1049
NONDIM AIR MASS VELOCITY	0.4733	2.0914	2.2641	2.3352
ISO H ₂ O MASS VEL (LBM/SEC-IN ²)	1.0040	0.4909	0.2680	0.2032
NONDIM H ₂ O MASS VELOCITY	2.9019	1.4191	0.7746	0.5872
LINEAR VEL AIR (FT/SEC)	9.133	32.351	31.856	32.225
NONDIM LINEAR AIR VELOCITY	0.5175	1.8332	1.8052	1.8261
LINEAR VEL WATER (FT/SEC)	7.630	8.568	13.364	16.968
NONDIM LINEAR H ₂ O VELOCITY	2.2872	2.5683	4.0059	5.0863
LOCAL QUALITY	0.0207	0.1606	0.2750	0.3404
NONDIMENSIONAL QUALITY	0.1805	1.3977	2.3940	2.9633
LOCAL VOID FRACTION	0.6954	0.8673	0.9536	0.9723
LOCAL SLIP RATIO	1.197	3.776	2.384	1.899

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TEST NUMBER 94

PROBE NUMBER 1

ANGULAR POSITION (DEGREES) 315.0

WALL TO WALL DISTANCE (INCHES)	0.3270	AVERAGE TOTAL QUALITY	0.1147
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7603
TEST SECTION PRESSURE (LBF/IN2)	64.0000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	17.6943
DENSITY OF TEST AIR (LBM/FT3)	0.4819	AVERAGE LINEAR WATER VELOCITY	3.3495
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0450	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3474
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.0562	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.5371
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.2476	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-0.5463
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1150	0.2190	0.3270
R(I)/ID)	0.0765	0.3517	0.6697	1.0000
IMPACT PRESSURE (PSIA)	0.1352	0.1069	0.0943	0.0975
ACTUAL ISO SETTING OF MANO	-0.4651	-0.2353	-0.2000	-0.2581
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0239	0.0542	0.0632	0.0698
NONDIM AIR MASS VELOCITY	0.5300	1.2048	1.4039	1.5506
ISO H2O MASS VEL (LBM/SEC-IN2)	1.0595	0.4422	0.2751	0.2537
NONDIM H2O MASS VELOCITY	3.0502	1.2729	0.7921	0.7303
LINEAR VEL AIR (FT/SEC)	13.361	18.848	20.292	22.190
NONDIM LINEAR AIR VELOCITY	0.7551	1.0652	1.1468	1.2541
LINEAR VEL WATER (FT/SEC)	5.260	7.309	9.195	9.801
NONDIM LINEAR H2O VELOCITY	1.5704	2.1822	2.7452	2.9262
LOCAL QUALITY	0.0220	0.1093	0.1868	0.2158
NONDIMENSIONAL QUALITY	0.1920	0.9523	1.6281	1.8807
LOCAL VOID FRACTION	0.5337	0.8600	0.9307	0.9401
LOCAL SLIP RATIO	2.540	2.579	2.207	2.264

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1929.

TEST NUMBER 94

PROBE NUMBER 2

ANGULAR POSITION (DEGREES) 0.

WALL TO WALL DISTANCE (INCHES)	0.3630	AVERAGE TOTAL QUALITY	0.1166
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7603
TEST SECTION PRESSURE (LBF/IN ²)	83.0000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	17.7116
DENSITY OF TEST AIR (LBM/FT ³)	0.4814	AVERAGE LINEAR WATER VELOCITY	3.2879
AIR MASS VELOCITY (LBM/SEC-IN ²)	0.0450	WATER MASS VELOCITY (LBM/SEC-IN ²)	0.3410
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN ²)	0.0129	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN ²)	0.6557
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.7123	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-0.9230
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.0920	0.1740	0.2550	0.3380
R(I)/(D)	0.0689	0.2534	0.4793	0.7025	0.9311
IMPACT PRESSURE (PSIA)	0.0534	0.0503	0.0550	0.0525	0.0534
ACTUAL ISO SETTING OF MANO	-0.2353	-0.5000	-0.1143	0.	-0.3529
ISO AIR MASS VEL (LBM/SEC-IN ²)	0.0127	0.0258	0.0117	0.0073	0.0084
NONDIM AIR MASS VELOCITY	0.2811	0.5739	0.2597	0.1623	0.1870
ISO H ₂ O MASS VEL (LBM/SEC-IN ²)	0.6048	0.3782	0.5098	0.5597	0.7579
NONDIM H ₂ O MASS VELOCITY	1.7739	1.1093	1.4952	1.6415	2.2227
LINEAR VEL AIR (FT/SEC)	6.299	9.616	4.946	3.384	5.715
NONDIM LINEAR AIR VELOCITY	0.3557	0.5429	0.2793	0.1910	0.3227
LINEAR VEL WATER (FT/SEC)	3.509	4.461	4.029	3.658	3.137
NONDIM LINEAR H ₂ O VELOCITY	1.0673	1.3567	1.2254	1.1125	0.9540
LOCAL QUALITY	0.0205	0.0639	0.0224	0.0129	0.0110
NONDIMENSIONAL QUALITY	0.1757	0.5483	0.1922	0.1105	0.0942
LOCAL VOID FRACTION	0.6010	0.8037	0.7070	0.6457	0.4406
LOCAL SLIP RATIO	1.795	2.156	1.228	0.925	1.822

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PROBE NUMBER 2

ANGULAR POSITION (DEGREES) 45.0

WALL TO WALL DISTANCE (INCHES)	0.3130	AVERAGE TOTAL QUALITY	0.1089
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7603
TEST SECTION PRESSURE (LBF/IN2)	81.1000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	17.1289
DENSITY OF TEST AIR (LBM/FT3)	0.4720	AVERAGE LINEAR WATER VELOCITY	3.3672
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0427	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3492
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.0075	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.3749
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.8236	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-0.0735
APPROX. ISO KINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1110	0.2110	0.3130
R(I)/(D)	0.0799	0.3546	0.6741	1.0000
IMPACT PRESSURE (PSIA)	0.0437	0.0250	0.0375	0.0375
ACTUAL ISO SETTING OF MANO	-0.7143	-0.2500	-0.1667	0.
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0125	0.0082	0.0043	0.0042
NONDIM AIR MASS VELOCITY	0.2921	0.1930	0.1002	0.0995
ISO H2O MASS VEL (LBM/SEC-IN2)	0.5133	0.2431	0.3098	0.3296
NONDIM H2O MASS VELOCITY	1.4699	0.6963	0.8871	0.9438
LINEAR VEL AIR (FT/SEC)	5.949	2.987	1.570	1.597
NONDIM LINEAR AIR VELOCITY	0.3473	0.1744	0.0916	0.0932
LINEAR VEL WATER (FT/SEC)	3.296	3.553	4.252	4.041
NONDIM LINEAR H2O VELOCITY	0.9787	1.0553	1.2628	1.2001
LOCAL QUALITY	0.0237	0.0328	0.0136	0.0127
NONDIMENSIONAL QUALITY	0.2177	0.3009	0.1250	0.1167
LOCAL VOID FRACTION	0.6394	0.8416	0.8313	0.8112
LOCAL SLIP RATIO	1.805	0.841	0.369	0.395

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TEST NUMBER 94

PROBE NUMBER 2

ANGULAR POSITION (DEGREES) 90.0

WALL TO WALL DISTANCE (INCHES)	0.2880	AVERAGE TOTAL QUALITY	0.1155
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7603
TEST SECTION PRESSURE (LBF/IN2)	81.2000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	18.0211
DENSITY OF TEST AIR (LBM/FT3)	0.4734	AVERAGE LINEAR WATER VELOCITY	3.3262
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0450	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3449
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.0088	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.5267
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.8056	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-0.5268
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

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RADIUS TO CL OF PROBE (IN)	0.0250	0.0730	0.1350	0.1980	0.2630
R(I)/(D)	0.0868	0.2535	0.4687	0.6875	0.9132
IMPACT PRESSURE (PSIA)	0.0442	0.0379	0.0379	0.0379	0.0442
ACTUAL ISO SETTING OF MANO	-0.2857	-0.3333	-0.3333	-0.3333	-0.2857
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0094	0.0135	0.0087	0.0063	0.0070
NONDIM AIR MASS VELOCITY	0.2085	0.2995	0.1939	0.1403	0.1549
ISO H2O MASS VEL (LBM/SEC-IN2)	0.5076	0.4374	0.4912	0.5128	0.5503
NONDIM H2O MASS VELOCITY	1.4717	1.2681	1.4240	1.4866	1.5953
LINEAR VEL AIR (FT/SEC)	4.388	5.975	4.252	3.209	3.518
NONDIM LINEAR AIR VELOCITY	0.2435	0.3316	0.2360	0.1781	0.1952
LINEAR VEL WATER (FT/SEC)	3.366	3.233	3.030	2.962	3.211
NONDIM LINEAR H2O VELOCITY	1.0121	0.9721	0.9109	0.8905	0.9655
LOCAL QUALITY	0.0182	0.0299	0.0175	0.0122	0.0125
NONDIMENSIONAL QUALITY	0.1572	0.2590	0.1512	0.1054	0.1084
LOCAL VOID FRACTION	0.6509	0.6868	0.6247	0.5992	0.6033
LOCAL SLIP RATIO	1.304	1.848	1.403	1.083	1.095

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TEST NUMBER 94

PROBE NUMBER 2

ANGULAR POSITION (DEGREES) 225.0

WALL TO WALL DISTANCE (INCHES)	0.4250	AVERAGE TOTAL QUALITY	0.1148
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7603
TEST SECTION PRESSURE (LBF/IN2)	84.0000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	17.6663
DENSITY OF TEST AIR (LBM/FT3)	0.4819	AVERAGE LINEAR WATER VELOCITY	3.3413
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0450	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3465
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.0782	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.5695
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.7391	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-0.6434
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1480	0.2860	0.4250
R(I)/(D)	0.0588	0.3482	0.6729	1.0000
IMPACT PRESSURE (PSIA)	0.1536	0.1630	0.1019	0.1082
ACTUAL ISO SETTING OF MANO	-0.2041	-0.1808	-0.2338	-0.2319
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0167	0.0935	0.0885	0.0889
NONDIM AIR MASS VELOCITY	0.3711	2.0807	1.9686	1.9767
ISO H2O MASS VEL (LBM/SEC-IN2)	1.2340	0.3294	0.2158	0.1869
NONDIM H2O MASS VELOCITY	3.5614	0.9507	0.6228	0.5392
LINEAR VEL AIR (FT/SEC)	10.565	29.785	27.826	27.527
NONDIM LINEAR AIR VELOCITY	0.5981	1.6860	1.5751	1.5582
LINEAR VEL WATER (FT/SEC)	5.409	12.360	10.038	12.538
NONDIM LINEAR H2O VELOCITY	1.6188	3.6992	3.0041	3.7523
LOCAL QUALITY	0.0133	0.2211	0.2909	0.3225
NONDIMENSIONAL QUALITY	0.1162	1.9257	2.5325	2.8095
LOCAL VOID FRACTION	0.4718	0.9383	0.9502	0.9655
LOCAL SLIP RATIO	1.953	2.410	2.772	2.196

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1929.

TEST NUMBER 94

PROBE NUMBER 2

ANGULAR POSITION (DEGREES) 315.0

WALL TO WALL DISTANCE (INCHES)	0.4250	AVERAGE TOTAL QUALITY	0.1162
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7603
TEST SECTION PRESSURE (LBF/IN2)	84.3000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	17.8279
DENSITY OF TEST AIR (LBM/FT3)	0.4808	AVERAGE LINEAR WATER VELOCITY	3.3203
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0453	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3443
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.0442	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.5464
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.0227	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-0.5869
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1550	0.2990	0.4250
R(I)/(D)	0.0588	0.3647	0.7035	1.0000
IMPACT PRESSURE (PSIA)	0.0502	0.0439	0.0596	0.0377
ACTUAL ISO SETTING OF MANO	-0.6250	-0.5714	-0.7895	-0.4167
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0159	0.0337	0.0582	0.0349
NONDIM AIR MASS VELOCITY	0.3520	0.7457	1.2849	0.7705
ISO H2O MASS VEL (LBM/SEC-IN2)	0.9696	0.2646	0.2810	0.3026
NONDIM H2O MASS VELOCITY	2.8160	0.7685	0.8160	0.8787
LINEAR VEL AIR (FT/SEC)	25.852	11.514	19.822	12.835
NONDIM LINEAR AIR VELOCITY	1.4501	0.6458	1.1118	0.7199
LINEAR VEL WATER (FT/SEC)	2.753	5.014	5.360	3.760
NONDIM LINEAR H2O VELOCITY	0.8291	1.5100	1.6145	1.1324
LOCAL QUALITY	0.0162	0.1131	0.1715	0.1033
NONDIMENSIONAL QUALITY	0.1392	0.9736	1.4762	0.8895
LOCAL VOID FRACTION	0.1846	0.8778	0.8787	0.8137
LOCAL SLIP RATIO	9.391	2.297	3.698	3.413

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1929.

TEST NUMBER 94

PROBE NUMBER 3

ANGULAR POSITION (DEGREES) 0.

WALL TO WALL DISTANCE (INCHES)	0.4900	AVERAGE TOTAL QUALITY	0.1156
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7603
TEST SECTION PRESSURE (LBF/IN2)	84.4000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	17.5048
DENSITY OF TEST AIR (LBM/FT3)	0.4848	AVERAGE LINEAR WATER VELOCITY	3.3060
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0448	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3428
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.0564	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	1.2883
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.2597	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-2.7578
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1250	0.2360	0.3460	0.4650
R(I)/(D)	0.0510	0.2551	0.4816	0.7061	0.9490
IMPACT PRESSURE (PSIA)	0.2133	0.1506	0.1349	0.1512	0.2321
ACTUAL ISO SETTING OF MANO	-0.2353	-0.3333	-0.2326	-0.2490	-0.1892
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0250	0.0854	0.0775	0.0318	0.0274
NONDIM AIR MASS VELOCITY	0.5575	1.9059	1.7295	0.7089	0.6124
ISO H2O MASS VEL (LBM/SEC-IN2)	1.5358	0.4338	0.3458	1.2408	1.3904
NONDIM H2O MASS VELOCITY	4.4797	1.2652	1.0086	3.6192	4.0555
LINEAR VEL AIR (FT/SEC)	17.415	28.477	24.939	20.865	15.255
NONDIM LINEAR AIR VELOCITY	0.9949	1.6268	1.4247	1.1919	0.8714
LINEAR VEL WATER (FT/SEC)	6.195	9.190	10.390	5.244	6.911
NONDIM LINEAR H2O VELOCITY	1.8739	2.7796	3.1427	1.5862	2.0906
LOCAL QUALITY	0.0160	0.1645	0.1831	0.0250	0.0194
NONDIMENSIONAL QUALITY	0.1385	1.4231	1.5839	0.2159	0.1674
LOCAL VOID FRACTION	0.4261	0.8907	0.9229	0.4522	0.5343
LOCAL SLIP RATIO	2.811	3.099	2.400	3.979	2.207

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1929.

TEST NUMBER 94

PROBE NUMBER 3

ANGULAR POSITION (DEGREES) 0.

WALL TO WALL DISTANCE (INCHES)	0.3990	AVERAGE TOTAL QUALITY	0.1144
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7603
TEST SECTION PRESSURE (LBF/IN2)	82.3000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	17.5077
DENSITY OF TEST AIR (LBM/FT3)	0.4788	AVERAGE LINEAR WATER VELOCITY	3.3042
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0443	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3427
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.0469	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	1.0778
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.0591	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-2.1454
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1050	0.1950	0.2850	0.3740
R(I)/(D)	0.0627	0.2632	0.4887	0.7143	0.9373
IMPACT PRESSURE (PSIA)	0.2141	0.1385	0.1259	0.1511	0.2078
ACTUAL ISO SETTING OF MANO	-0.2059	-0.2727	-0.2000	-0.2500	-0.2030
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0209	0.0673	0.0672	0.0495	0.0161
NONDIM AIR MASS VELOCITY	0.4714	1.5197	1.5182	1.1185	0.3644
ISO H2O MASS VEL (LBM/SEC-IN2)	1.4711	0.4642	0.3343	0.6801	1.5284
NONDIM H2O MASS VELOCITY	4.2932	1.3547	0.9757	1.9848	4.4605
LINEAR VEL AIR (FT/SEC)	13.533	23.084	21.817	18.907	11.482
NONDIM LINEAR AIR VELOCITY	0.7729	1.3185	1.2462	1.0799	0.6558
LINEAR VEL WATER (FT/SEC)	5.350	8.689	10.495	7.408	6.127
NONDIM LINEAR H2O VELOCITY	1.9219	2.6297	3.1763	2.2420	1.8543
LOCAL QUALITY	0.0140	0.1266	0.1674	0.0679	0.0104
NONDIMENSIONAL QUALITY	0.1223	1.1064	1.4630	0.5932	0.0913
LOCAL VOID FRACTION	0.4637	0.8763	0.9263	0.7875	0.4225
LOCAL SLIP RATIO	2.131	2.657	2.079	2.552	1.874

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1929.

TEST NUMBER 94

PROBE NUMBER 3

ANGULAR POSITION (DEGREES) 22.5

WALL TO WALL DISTANCE (INCHES)	0.4510	AVERAGE TOTAL QUALITY	0.1145
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7603
TEST SECTION PRESSURE (LBF/IN2)	82.4000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	17.7449
DENSITY OF TEST AIR (LBM/FT3)	0.4741	AVERAGE LINEAR WATER VELOCITY	3.3142
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0444	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3437
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.0860	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.7694
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.9353	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-1.2386
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1610	0.3060	0.4510
R(I)/(D)	0.0554	0.3570	0.6785	1.0000
IMPACT PRESSURE (PSIA)	0.2134	0.1381	0.1255	0.1255
ACTUAL ISO SETTING OF MANO	-0.2941	-0.4545	-0.4000	-0.4000
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0294	0.0932	0.0930	0.0980
NONDIM AIR MASS VELOCITY	0.6612	2.0987	2.0929	2.2064
ISO H2O MASS VEL (LBM/SEC-IN2)	1.6317	0.3776	0.2591	0.2588
NONDIM H2O MASS VELOCITY	4.7475	1.0988	0.7538	0.7531
LINEAR VEL AIR (FT/SEC)	23.910	31.469	29.890	31.609
NONDIM LINEAR AIR VELOCITY	1.3474	1.7734	1.6844	1.7813
LINEAR VEL WATER (FT/SEC)	6.025	8.722	10.841	10.285
NONDIM LINEAR H2O VELOCITY	1.8181	2.6316	3.2712	3.1933
LOCAL QUALITY	0.0177	0.1980	0.2641	0.2747
NONDIMENSIONAL QUALITY	0.1545	1.7299	2.3073	2.3998
LOCAL VOID FRACTION	0.3731	0.8998	0.9447	0.9417
LOCAL SLIP RATIO	3.968	3.608	2.757	3.073

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1929.

TEST NUMBER 94

PROBE NUMBER 3

ANGULAR POSITION (DEGREES) 45.0

WALL TO WALL DISTANCE (INCHES)	0.4510	AVERAGE TOTAL QUALITY	0.1155
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.7603
TEST SECTION PRESSURE (LBF/IN2)	84.0000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	17.5675
DENSITY OF TEST AIR (LBM/FT3)	0.4828	AVERAGE LINEAR WATER VELOCITY	3.3081
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0448	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3431
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.0838	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.7387
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.8722	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-1.1531
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1620	0.3050	0.4510
R(I)/(D)	0.0554	0.3592	0.6763	1.0000
IMPACT PRESSURE (PSIA)	0.2134	0.1381	0.1255	0.1255
ACTUAL ISO SETTING OF MANO	-0.1765	-0.3636	-0.4000	-0.3500
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0221	0.0839	0.0974	0.0980
NONDIM AIR MASS VELOCITY	0.4927	1.8725	2.1756	2.1887
ISO H2O MASS VEL (LBM/SEC-IN2)	1.5113	0.4534	0.2485	0.2160
NONDIM H2O MASS VELOCITY	4.4054	1.3216	0.7245	0.6297
LINEAR VEL AIR (FT/SEC)	14.938	28.774	30.684	30.469
NONDIM LINEAR AIR VELOCITY	0.8503	1.6379	1.7466	1.7344
LINEAR VEL WATER (FT/SEC)	6.254	8.025	10.861	12.336
NONDIM LINEAR H2O VELOCITY	1.8906	2.4259	3.2831	3.7289
LOCAL QUALITY	0.0144	0.1561	0.2816	0.3121
NONDIMENSIONAL QUALITY	0.1246	1.3518	2.4390	2.7032
LOCAL VOID FRACTION	0.4406	0.8692	0.9470	0.9595
LOCAL SLIP RATIO	2.388	3.585	2.825	2.470

START OF CASE NO. 41 102066

1929.

TEST NUMBER 95

PROBE NUMBER 1

ANGULAR POSITION (DEGREES) 0.

WALL TO WALL DISTANCE (INCHES)	0.4000	AVERAGE TOTAL QUALITY	0.2500
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.8403
TEST SECTION PRESSURE (LBF/IN2)	83.8000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	21.8654
DENSITY OF TEST AIR (LBM/FT3)	0.4845	AVERAGE LINEAR WATER VELOCITY	2.6846
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0618	WATER MASS VELOCITY (LBM/SEC-IN2)	0.1855
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.0844	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.5925
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.3662	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-2.1943
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1030	0.1930	0.2870	0.3750
R(I)/(D)	0.0625	0.2575	0.4825	0.7175	0.9375
IMPACT PRESSURE (PSIA)	0.1377	0.1220	0.1189	0.1158	0.1455
ACTUAL ISO SETTING OF MANO	-0.2727	-0.4615	-0.2632	-0.2973	-0.1290
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0594	0.1060	0.1129	0.0795	0.0355
NONDIM AIR MASS VELOCITY	0.9604	1.7149	1.8259	1.2869	0.5742
ISO H2O MASS VEL (LBM/SEC-IN2)	0.6378	0.2923	0.1942	0.4430	0.8933
NONDIM H2O MASS VELOCITY	3.4386	1.5757	1.0471	2.3886	4.8163
LINEAR VEL AIR (FT/SEC)	22.473	34.393	35.097	27.840	15.997
NONDIM LINEAR AIR VELOCITY	1.0278	1.5730	1.6052	1.2732	0.7316
LINEAR VEL WATER (FT/SEC)	6.874	8.067	10.184	6.808	6.075
NONDIM LINEAR H2O VELOCITY	2.5605	3.0051	3.7934	2.5359	2.2628
LOCAL QUALITY	0.0851	0.2662	0.3675	0.1522	0.0382
NONDIMENSIONAL QUALITY	0.3407	1.0649	1.4704	0.6090	0.1529
LOCAL VOID FRACTION	0.7852	0.9161	0.9558	0.8493	0.6595
LOCAL SLIP RATIO	3.269	4.263	3.446	4.089	2.633

START OF CASE No. 2 102066

1929.

TEST NUMBER 95

PROBE NUMBER 1

ANGULAR POSITION (DEGREES) 0.

WALL TO WALL DISTANCE (INCHES)	0.3720	AVERAGE TOTAL QUALITY	0.0917
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.8403
TEST SECTION PRESSURE (LBF/IN2)	81.2000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	12.5986
DENSITY OF TEST AIR (LBM/FT3)	0.4717	AVERAGE LINEAR WATER VELOCITY	4.9685
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0347	WATER MASS VELOCITY (LBM/SEC-IN2)	0.3433
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.0504	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.9942
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.4526	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-1.8960
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.0950	0.1800	0.2640	0.3470
R(I)/(D)	0.0672	0.2554	0.4839	0.7204	0.9328
IMPACT PRESSURE (PSIA)	0.1385	0.1259	0.1543	0.1606	0.1731
ACTUAL ISO SETTING OF MANO ,	-0.5455	-0.2500	-0.1633	-0.3137	-0.5818
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0412	0.0574	0.0602	0.0462	0.0302
NONDIM AIR MASS VELOCITY	1.1895	1.6544	1.7372	1.3313	0.8720
ISO H2O MASS VEL (LBM/SEC-IN2)	1.1659	0.6156	0.5022	0.7013	1.4034
NONDIM H2O MASS VELOCITY	3.3962	1.7933	1.4629	2.0430	4.0881
LINEAR VEL AIR (FT/SEC)	27.645	22.444	20.993	17.843	22.539
NONDIM LINEAR AIR VELOCITY	2.1943	1.7815	1.6663	1.4162	1.7890
LINEAR VEL WATER (FT/SEC)	4.957	6.490	9.379	7.728	5.503
NONDIM LINEAR H2O VELOCITY	0.9977	1.3061	1.8877	1.5554	1.1076
LOCAL QUALITY	0.0342	0.0852	0.1071	0.0618	0.0211
NONDIMENSIONAL QUALITY	0.3724	0.9292	1.1674	0.6731	0.2299
LOCAL VOID FRACTION	0.4555	0.7804	0.8760	0.7899	0.4096
LOCAL SLIP RATIO	5.577	3.458	2.238	2.309	4.096

START OF CASE NO. 43 102066

1930.

TEST NUMBER 95

PROBE NUMBER 1

ANGULAR POSITION (DEGREES) 45.0

WALL TO WALL DISTANCE (INCHES)	0.3660	AVERAGE TOTAL QUALITY	0.2511
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.8403
TEST SECTION PRESSURE (LBF/IN2)	81.3000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	22.0859
DENSITY OF TEST AIR (LBM/FT3)	0.4782	AVERAGE LINEAR WATER VELOCITY	2.6606
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0616	WATER MASS VELOCITY (LBM/SEC-IN2)	0.1838
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.1160	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.5285
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.8828	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-1.8748
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1540	0.3030	0.3660
R(I)/(D)	0.0683	0.4208	0.8279	1.0600
IMPACT PRESSURE (PSIA)	0.2010	0.1319	0.1508	0.1382
ACTUAL ISO SETTING OF MANO	-0.3125	-0.2857	-0.1667	-0.1818
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0517	0.1199	0.1271	0.1236
NONDIM AIR MASS VELOCITY	0.8387	1.9447	2.0620	2.0061
ISO H2O MASS VEL (LBM/SEC-IN2)	1.0946	0.1812	0.0938	0.1078
NONDIM H2O MASS VELOCITY	5.9545	0.9856	0.5104	0.5867
LINEAR VEL AIR (FT/SEC)	24.767	37.431	38.592	37.701
NONDIM LINEAR AIR VELOCITY	1.1214	1.6948	1.7474	1.7070
LINEAR VEL WATER (FT/SEC)	6.820	11.713	25.924	20.038
NONDIM LINEAR H2O VELOCITY	2.5634	4.4024	9.7437	7.5313
LOCAL QUALITY	0.0451	0.3982	0.5753	0.5341
NONDIMENSIONAL QUALITY	0.1796	1.5857	2.2912	2.1272
LOCAL VOID FRACTION	0.6284	0.9642	0.9916	0.9875
LOCAL SLIP RATIO	3.631	3.196	1.489	1.881

START OF CASE NO. 44 102066

1930.

TEST NUMBER 95

PROBE NUMBER 1

ANGULAR POSITION (DEGREES) 90.0

WALL TO WALL DISTANCE (INCHES)	0.3720	AVERAGE TOTAL QUALITY	0.2452
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.8403
TEST SECTION PRESSURE (LBF/IN2)	79.4000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	22.1118
DENSITY OF TEST AIR (LBM/FT3)	0.4688	AVERAGE LINEAR WATER VELOCITY	2.6954
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0605	WATER MASS VELOCITY (LBM/SEC-IN2)	0.1862
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.1220	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.4553
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-1.0170	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-1.4448
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.0960	0.1800	0.2680	0.3470
R(I)/(D)	0.0672	0.2581	0.4839	0.7204	0.9328
IMPACT PRESSURE (PSIA)	0.1885	0.1697	0.1885	0.1760	0.1979
ACTUAL ISO SETTING OF MANO ,	-0.2000	-0.1111	-0.1333	-0.2143	-0.2381
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0537	0.1141	0.1389	0.1641	0.0852
NONDIM AIR MASS VELOCITY	0.8874	1.8867	2.2957	2.7134	1.4094
ISO H2O MASS VEL (LBM/SEC-IN2)	0.9706	0.2319	0.1101	0.0973	0.6646
NONDIM H2O MASS VELOCITY	5.2117	1.2450	0.5912	0.5225	3.5685
LINEAR VEL AIR (FT/SEC)	24.402	36.338	43.042	51.146	31.823
NONDIM LINEAR AIR VELOCITY	1.1036	1.6434	1.9466	2.3131	1.4392
LINEAR VEL WATER (FT/SEC)	6.929	15.210	28.354	15.769	8.688
NONDIM LINEAR H2O VELOCITY	2.5707	5.6429	10.5193	5.8504	3.2234
LOCAL QUALITY	0.0524	0.3298	0.5577	0.6278	0.1137
NONDIMENSIONAL QUALITY	0.2138	1.3454	2.2750	2.5608	0.4638
LOCAL VOID FRACTION	0.6757	0.9647	0.9910	0.9857	0.8229
LOCAL SLIP RATIO	3.522	2.389	1.518	3.243	3.663

START OF CASE NO. 45 102066

1930.

TEST NUMBER 95

PROBE NUMBER 1

ANGULAR POSITION (DEGREES) 135.0

WALL TO WALL DISTANCE (INCHES)	0.4050	AVERAGE TOTAL QUALITY	0.2517
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.8403
TEST SECTION PRESSURE (LBF/IN2)	83.8000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	21.7192
DENSITY OF TEST AIR (LBM/FT3)	0.4907	AVERAGE LINEAR WATER VELOCITY	2.6759
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0622	WATER MASS VELOCITY (LBM/SEC-IN2)	0.1849
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.1658	INTEGRATED WATER MASS VELOCITY (LPM/SEC-IN2)	0.4030
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-1.6658	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-1.1795
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1450	0.3030	0.4050
R(I)/(D)	0.0617	0.3580	0.7481	1.0000
IMPACT PRESSURE (PSIA)	0.2260	0.1914	0.1758	0.1789
ACTUAL ISO SETTING OF MANO ,	-0.3333	-0.3279	-0.3571	-0.4211
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0814	0.1633	0.1787	0.1753
NONDIM AIR MASS VELOCITY	1.3097	2.6260	2.8735	2.8184
ISO H2O MASS VEL (LBM/SEC-IN2)	0.9613	0.2159	0.0929	0.0799
NONDIM H2O MASS VELOCITY	5.1992	1.1678	0.5024	0.4323
LINEAR VEL AIR (FT/SEC)	33.661	50.284	53.538	52.052
NONDIM LINEAR AIR VELOCITY	1.5498	2.3152	2.4650	2.3966
LINEAR VEL WATER (FT/SEC)	7.677	10.659	10.514	15.684
NONDIM LINEAR H2O VELOCITY	2.8688	3.9833	3.9289	5.8613
LOCAL QUALITY	0.0781	0.4306	0.6580	0.6868
NONDIMENSIONAL QUALITY	0.3103	1.7110	2.6142	2.7287
LOCAL VOID FRACTION	0.7101	0.9531	0.9795	0.9882
LOCAL SLIP RATIO	4.385	4.717	5.092	3.319

START OF CASE NO. 46 102066

1930.

TEST NUMBER 95

PROBE NUMBER 1

ANGULAR POSITION (DEGREES) 315.0

WALL TO WALL DISTANCE (INCHES)	0.3960	AVERAGE TOTAL QUALITY	0.2456
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.8403
TEST SECTION PRESSURE (LBF/IN2)	79.6000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	22.2473
DENSITY OF TEST AIR (LBM/FT3)	0.4698	AVERAGE LINEAR WATER VELOCITY	2.7113
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0610	WATER MASS VELOCITY (LBM/SEC-IN2)	0.1873
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.1554	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.4447
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-1.5474	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-1.3738
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1470	0.2880	0.3960
R(I)/(D)	0.0631	0.3712	0.7273	1.0000
IMPACT PRESSURE (PSIA)	0.2262	0.2324	0.2324	0.2109
ACTUAL ISO SETTING OF MANO	-0.1667	-0.1622	-0.1622	-0.1714
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0660	0.1561	0.1732	0.1646
NONDIM AIR MASS VELOCITY	1.0815	2.5598	2.8404	2.6997
ISO H2O MASS VEL (LBM/SEC-IN2)	0.9784	0.2353	0.1102	0.1778
NONDIM H2O MASS VELOCITY	5.2230	1.2563	0.5881	0.9490
LINEAR VEL AIR (FT/SEC)	28.342	49.520	53.620	51.749
NONDIM LINEAR AIR VELOCITY	1.2740	2.2259	2.4102	2.3261
LINEAR VEL WATER (FT/SEC)	7.902	16.198	26.284	16.643
NONDIM LINEAR H2O VELOCITY	2.9145	5.9743	9.6941	6.1383
LOCAL QUALITY	0.0632	0.3988	0.6113	0.4808
NONDIMENSIONAL QUALITY	0.2571	1.6238	2.4889	1.9578
LOCAL VOID FRACTION	0.7133	0.9664	0.9903	0.9753
LOCAL SLIP RATIO	3.587	3.057	2.040	3.109

START OF CASE NO. 47 102065

1930.

TEST NUMBER 95

PROBE NUMBER 2

ANGULAR POSITION (DEGREES) 0.

WALL TO WALL DISTANCE (INCHES)	0.4500	AVERAGE TOTAL QUALITY	0.2537
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.8403
TEST SECTION PRESSURE (LBF/IN ²)	83.8000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	21.7600
DENSITY OF TEST AIR (LBM/FT ³)	0.4880	AVERAGE LINEAR WATER VELOCITY	2.6386
AIR MASS VELOCITY (LBM/SEC-IN ²)	0.0620	WATER MASS VELOCITY (LRM/SEC-IN ²)	0.1823
INTEGRATED AIR MASS VELOCITY (LRM/SEC-IN ²)	0.0283	INTEGRATED WATER MASS VELOCITY (LRM/SEC-IN ²)	0.7272
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.5427	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-2.9886
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1110	0.2120	0.3130	0.4250
R(I)/(D)	0.0556	0.2467	0.4711	0.6956	0.9444
IMPACT PRESSURE (PSIA)	0.0502	0.0407	0.0486	0.0564	0.0549
ACTUAL ISO SETTING OF MANO	-0.2500	-0.5385	-0.9032	-0.6111	-0.5714
ISO AIR MASS VEL (LBM/SEC-IN ²)	0.0234	0.0569	0.0226	0.0188	0.0167
NONDIM AIR MASS VELOCITY	0.3778	0.9175	0.3652	0.3040	0.2698
ISO H ₂ O MASS VEL (LBM/SEC-IN ²)	0.4569	0.1350	0.6693	0.7024	0.7053
NONDIM H ₂ O MASS VELOCITY	2.5061	0.7407	3.6713	3.8527	3.8686
LINEAR VEL AIR (FT/SEC)	9.487	17.647	13.801	10.867	9.869
NONDIM LINEAR AIR VELOCITY	0.4360	0.8110	0.6342	0.4994	0.4535
LINEAR VEL WATER (FT/SEC)	3.891	6.343	3.002	3.328	3.266
NONDIM LINEAR H ₂ O VELOCITY	1.4745	2.4040	1.1378	1.2614	1.2376
LOCAL QUALITY	0.0487	0.2963	0.0327	0.0261	0.0232
NONDIMENSIONAL QUALITY	0.1922	1.1680	0.1289	0.1029	0.0913
LOCAL VOID FRACTION	0.7281	0.9507	0.4839	0.5114	0.5000
LOCAL SLIP RATIO	2.438	2.782	4.597	3.265	3.022

START OF CASE NO. 48 102066

1930.

TEST NUMBER 95

PROBE NUMBER 2

ANGULAR POSITION (DEGREES) 45.0

WALL TO WALL DISTANCE (INCHES)	0.3250	AVERAGE TOTAL QUALITY	0.2477
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.8403
TEST SECTION PRESSURE (LBF/IN2)	83.6000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	21.9294
DENSITY OF TEST AIR (LBM/FT3)	0.4852	AVERAGE LINEAR WATER VELOCITY	2.7289
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0621	WATER MASS VELOCITY (LBM/SEC-IN2)	0.1885
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.0206	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.3711
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.6677	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-0.9684
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1160	0.2240	0.3250
R(I)/(D)	0.0769	0.3569	0.6892	1.0000
IMPACT PRESSURE (PSIA)	0.0440	0.0314	0.0440	0.0440
ACTUAL ISO SETTING OF MANO	-0.2857	-0.8000	0.	0.
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0204	0.0357	0.0127	0.0145
NONDIM AIR MASS VELOCITY	0.3282	0.5757	0.2041	0.2334
ISO H2O MASS VEL (LBM/SEC-IN2)	0.3512	0.3078	0.3400	0.4160
NONDIM H2O MASS VELOCITY	1.8626	1.6325	1.8035	2.2065
LINEAR VEL AIR (FT/SEC)	7.472	13.871	4.560	5.752
NONDIM LINEAR AIR VELOCITY	0.3407	0.6325	0.2080	0.2623
LINEAR VEL WATER (FT/SEC)	4.269	3.030	4.494	3.816
NONDIM LINEAR H2O VELOCITY	1.5644	1.1102	1.6469	1.3983
LOCAL QUALITY	0.0549	0.1041	0.0359	0.0337
NONDIMENSIONAL QUALITY	0.2214	0.4200	0.1451	0.1359
LOCAL VOID FRACTION	0.8095	0.7648	0.8248	0.7476
LOCAL SLIP RATIO	1.750	4.578	1.015	1.507

START OF CASE NO. 49 102066

1930.

TEST NUMBER 95

PROBE NUMBER 2

ANGULAR POSITION (DEGREES) 90.0

WALL TO WALL DISTANCE (INCHES)	0.3310	AVERAGE TOTAL QUALITY	0.2489
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.8403
TEST SECTION PRESSURE (LBF/IN2)	85.2000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	21.7765
DENSITY OF TEST AIR (LBM/FT3)	0.4913	AVERAGE LINEAR WATER VELOCITY	2.7263
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0624	WATER MASS VELOCITY (LBM/SEC-IN2)	0.1884
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.0416	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.5345
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	0.3333	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-1.8377
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.0850	0.1620	0.2360	0.3060
R(I)/(D)	0.0755	0.2568	0.4894	0.7130	0.9245
IMPACT PRESSURE (PSIA)	0.0534	0.0424	0.0534	0.0549	0.0565
ACTUAL ISO SETTING OF MANO	-1.1176	-0.8889	-0.5882	-0.6286	-0.5000
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0400	0.0531	0.0356	0.0344	0.0393
NONDIM AIR MASS VELOCITY	0.6401	0.8505	0.5698	0.5512	0.6295
ISO H2O MASS VEL (LBM/SEC-IN2)	0.6754	0.3719	0.5614	0.5247	0.3979
NONDIM H2O MASS VELOCITY	3.5855	1.9745	2.9801	2.7857	2.1122
LINEAR VEL AIR (FT/SEC)	24.629	21.859	16.932	15.115	14.510
NONDIM LINEAR AIR VELOCITY	1.1310	1.0038	0.7775	0.6941	0.6663
LINEAR VEL WATER (FT/SEC)	2.981	2.989	3.383	3.651	4.468
NONDIM LINEAR H2O VELOCITY	1.0936	1.0965	1.2409	1.3391	1.6389
LOCAL QUALITY	0.0559	0.1249	0.0596	0.0615	0.0899
NONDIMENSIONAL QUALITY	0.2244	0.5019	0.2394	0.2472	0.3611
LOCAL VOID FRACTION	0.4756	0.7120	0.6158	0.6672	0.7939
LOCAL SLIP RATIO	8.261	7.313	5.005	4.140	3.248

START OF CASE NO. 50 102066

1930.

TEST NUMBER 95

PROBE NUMBER 2

ANGULAR POSITION (DEGREES) 225.0

WALL TO WALL DISTANCE (INCHES)	0.3250	AVERAGE TOTAL QUALITY	0.2501
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.8403
TEST SECTION PRESSURE (LBF/IN2)	83.8000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	21.6156
DENSITY OF TEST AIR (LBM/FT3)	0.4889	AVERAGE LINEAR WATER VELOCITY	2.6759
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0617	WATER MASS VELOCITY (LBM/SEC-IN2)	0.1849
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.0806	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.3352
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.3077	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-0.8129
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1160	0.2240	0.3250
R(I)/(D)	0.0769	0.3569	0.6892	1.0000
IMPACT PRESSURE (PSIA)	0.1506	0.1161	0.1130	0.1255
ACTUAL ISO SETTING OF MANO ,	-0.0833	-0.1081	0.	0.
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0301	0.0795	0.0948	0.0947
NONDIM AIR MASS VELOCITY	0.4885	1.2886	1.5372	1.5359
ISO H2O MASS VEL (LBM/SEC-IN2)	0.8794	0.2255	0.0756	0.0733
NONDIM H2O MASS VELOCITY	4.7563	1.2195	0.4087	0.3966
LINEAR VEL AIR (FT/SEC)	13.022	24.406	28.080	28.025
NONDIM LINEAR AIR VELOCITY	0.6024	1.1291	1.2991	1.2965
LINEAR VEL WATER (FT/SEC)	6.389	12.730	30.731	37.210
NONDIM LINEAR H2O VELOCITY	2.3877	4.7574	11.4841	13.9055
LOCAL QUALITY	0.0331	0.2606	0.5564	0.5636
NONDIMENSIONAL QUALITY	0.1324	1.0419	2.2247	2.2534
LOCAL VOID FRACTION	0.6814	0.9590	0.9943	0.9954
LOCAL SLIP RATIO	2.038	1.917	0.914	0.753

START OF CASE NO. 51 102066

1930.

TEST NUMBER 95

PROBE NUMBER 2

ANGULAR POSITION (DEGREES) 315.0

WALL TO WALL DISTANCE (INCHES)	0.3130	AVERAGE TOTAL QUALITY	0.2534
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.8403
TEST SECTION PRESSURE (LBF/IN ²)	81.4000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	22.2143
DENSITY OF TEST AIR (LBM/FT ³)	0.4752	AVERAGE LINEAR WATER VELOCITY	2.6272
AIR MASS VELOCITY (LBM/SEC-IN ²)	0.0616	WATER MASS VELOCITY (LBM/SEC-IN ²)	0.1815
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN ²)	0.0692	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN ²)	0.3076
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.1235	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-0.6945
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1110	0.2110	0.3130
R(I)/(D)	0.0799	0.3546	0.6741	1.0000
IMPACT PRESSURE (PSIA)	0.0754	0.0628	0.0628	0.0566
ACTUAL ISO SETTING OF MANO	-0.3333	-0.4000	-0.3000	-0.3333
ISO AIR MASS VEL (LBM/SEC-IN ²)	0.0332	0.0686	0.0790	0.0752
NONDIM AIR MASS VELOCITY	0.5385	1.1131	1.2831	1.2213
ISO H ₂ O MASS VEL (LBM/SEC-IN ²)	0.7348	0.2268	0.0906	0.1673
NONDIM H ₂ O MASS VELOCITY	4.0481	1.2495	0.4993	0.9218
LINEAR VEL AIR (FT/SEC)	17.717	22.754	24.379	24.386
NONDIM LINEAR AIR VELOCITY	0.7975	1.0243	1.0974	1.0978
LINEAR VEL WATER (FT/SEC)	3.932	6.045	11.983	5.950
NONDIM LINEAR H ₂ O VELOCITY	1.4967	2.3011	4.5612	2.2649
LOCAL QUALITY	0.0432	0.2321	0.4658	0.3102
NONDIMENSIONAL QUALITY	0.1705	0.9162	1.8385	1.2241
LOCAL VOID FRACTION	0.5674	0.9131	0.9825	0.9349
LOCAL SLIP RATIO	4.506	3.764	2.034	4.098

START OF CASE NO. 52 102066

1930.

TEST NUMBER 95

PROBE NUMBER 3

ANGULAR POSITION (DEGREES) 0.

WALL TO WALL DISTANCE (INCHES)	0.4810	AVERAGE TOTAL QUALITY	0.2526
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.8403
TEST SECTION PRESSURE (LBF/IN2)	83.8000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	21.7690
DENSITY OF TEST AIR (LBM/FT3)	0.4884	AVERAGE LINEAR WATER VELOCITY	2.6572
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0620	WATER MASS VELOCITY (LBM/SEC-IN2)	0.1836
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.0872	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	1.1306
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.4052	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-5.1582
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1250	0.2360	0.3460	0.4560
R(I)/(D)	0.0520	0.2599	0.4906	0.7193	0.9480
IMPACT PRESSURE (PSIA)	0.1882	0.1380	0.1255	0.1757	0.2007
ACTUAL ISO SETTING OF MANO	-0.4000	-0.4091	-0.4000	-0.4286	-0.3750
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0415	0.1204	0.1271	0.0444	0.0423
NONDIM AIR MASS VELOCITY	0.6694	1.9402	2.0479	0.7157	0.6816
ISO H2O MASS VEL (LBM/SEC-IN2)	1.3609	0.2541	0.1943	1.2846	1.3602
NONDIM H2O MASS VELOCITY	7.4124	1.3839	1.0584	6.9971	7.4087
LINEAR VEL AIR (FT/SEC)	26.551	37.866	39.489	27.539	25.602
NONDIM LINEAR AIR VELOCITY	1.2197	1.7395	1.8140	1.2651	1.1761
LINEAR VEL WATER (FT/SEC)	5.847	9.375	8.758	5.669	6.139
NONDIM LINEAR H2O VELOCITY	2.2004	3.5280	3.2959	2.1334	2.3102
LOCAL QUALITY	0.0296	0.3215	0.3954	0.0334	0.0302
NONDIMENSIONAL QUALITY	0.1172	1.2728	1.5653	0.1323	0.1194
LOCAL VOID FRACTION	0.4612	0.9373	0.9486	0.4754	0.4870
LOCAL SLIP RATIO	4.541	4.039	4.509	4.858	4.171

START OF CASE NO. 53 102066

1930.

TEST NUMBER 95

PROBE NUMBER 3

ANGULAR POSITION (DEGREES) 22.5

WALL TO WALL DISTANCE (INCHES)	0.4560	AVERAGE TOTAL QUALITY	0.2511
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.8403
TEST SECTION PRESSURE (LBF/IN2)	83.8000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	21.5174
DENSITY OF TEST AIR (LBM/FT3)	0.4871	AVERAGE LINEAR WATER VELOCITY	2.6408
AIR MASS VELOCITY (LBM/SEC-IN2)	0.0612	WATER MASS VELOCITY (LBM/SEC-IN2)	0.1825
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN2)	0.1091	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN2)	0.5868
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-0.7840	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-2.2159
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1670	0.3120	0.4560
R(I)/(D)	0.0548	0.3662	0.6842	1.0000
IMPACT PRESSURE (PSIA)	0.1883	0.1412	0.1506	0.1569
ACTUAL ISO SETTING OF MANO	-0.3000	-0.1778	-0.1667	-0.2000
ISO AIR MASS VEL (LBM/SEC-IN2)	0.0411	0.1163	0.1210	0.1067
NONDIM AIR MASS VELOCITY	0.6716	1.9019	1.9780	1.7442
ISO H2O MASS VEL (LBM/SEC-IN2)	1.3103	0.1619	0.1348	0.2749
NONDIM H2O MASS VELOCITY	7.1813	0.8871	0.7388	1.5064
LINEAR VEL AIR (FT/SEC)	24.739	35.217	36.330	33.216
NONDIM LINEAR AIR VELOCITY	1.1497	1.6367	1.6884	1.5437
LINEAR VEL WATER (FT/SEC)	5.958	15.919	20.079	12.582
NONDIM LINEAR H2O VELOCITY	2.2562	6.0279	7.6034	4.7644
LOCAL QUALITY	0.0304	0.4182	0.4730	0.2796
NONDIMENSIONAL QUALITY	0.1211	1.6657	1.8840	1.1137
LOCAL VOID FRACTION	0.4909	0.9765	0.9845	0.9494
LOCAL SLIP RATIO	4.152	2.212	1.809	2.640

START OF CASE NO 54 102066

1930.

TEST NUMBER 95

PROBE NUMBER 3

ANGULAR POSITION (DEGREES) 45.0

WALL TO WALL DISTANCE (INCHES)	0.4700	AVERAGE TOTAL QUALITY	0.2530
FLOW AREA OF TEST SECTION (INCHES)	10.9500	AVERAGE VOID FRACTION (QUICK CLOSING VALVES)	0.8403
TEST SECTION PRESSURE (LBF/IN ²)	82.8000	AVERAGE LINEAR AIR VELOCITY (FT/SEC)	21.8300
DENSITY OF TEST AIR (LBM/FT ³)	0.4804	AVERAGE LINEAR WATER VELOCITY	2.6156
AIR MASS VELOCITY (LBM/SEC-IN ²)	0.0612	WATER MASS VELOCITY (LBM/SEC-IN ²)	0.1807
INTEGRATED AIR MASS VELOCITY (LBM/SEC-IN ²)	0.1425	INTEGRATED WATER MASS VELOCITY (LBM/SEC-IN ²)	0.5432
ERROR IN AIRFLOW (INTEGRATED TO TRUE)	-1.3278	ERROR IN WATERFLOW (INTEGRATED TO TRUE)	-2.0060
APPROX. ISOKINETIC SETTING OF MANOMETER	-0.2000		

RADIUS TO CL OF PROBE (IN)	0.0250	0.1680	0.3180	0.4700
R(I)/(D)	0.0532	0.3574	0.6766	1.0000
IMPACT PRESSURE (PSIA)	0.1945	0.1569	0.1632	0.1632
ACTUAL ISO SETTING OF MANO	-0.3871	-0.3200	-0.3846	-0.3846
ISO AIR MASS VEL (LBM/SEC-IN ²)	0.0450	0.1388	0.1605	0.1658
NONDIM AIR MASS VELOCITY	0.7359	2.2679	2.6235	2.7090
ISO H2O MASS VEL (LBM/SEC-IN ²)	1.3291	0.2052	0.0973	0.0723
NONDIM H2O MASS VELOCITY	7.3548	1.1355	0.5382	0.4002
LINEAR VEL AIR (FT/SEC)	27.575	43.521	48.891	50.230
NONDIM LINEAR AIR VELOCITY	1.2632	1.9936	2.2396	2.3010
LINEAR VEL WATER (FT/SEC)	6.028	10.774	14.358	15.685
NONDIM LINEAR H2O VELOCITY	2.3047	4.1193	5.4892	5.9968
LOCAL QUALITY	0.0328	0.4035	0.6228	0.6962
NONDIMENSIONAL QUALITY	0.1296	1.5949	2.4618	2.7523
LOCAL VOID FRACTION	0.4896	0.9559	0.9843	0.9893
LOCAL SLIP RATIO	4.574	4.039	3.405	3.202

APPENDIX B

WADR—A DATA REDUCTION COMPUTER CODE FOR CALCULATION OF
PRESSURE DROP, VOID FRACTION, AND FLOW CONDITIONS

It is the purpose of this code to calculate the frictional pressure drop, average void fraction, average quality, average slip ratio, nondimensional pressure drop parameters (of the Lockhart-Martinelli formulation), and other pertinent parameters for the air-water loops located in Building R Tower at General Electric, San Jose. WADR is written in FORTRAN IV and is on file at the Computer and Data Processing Department at General Electric, San Jose.

The important calculating equations are as follows.

B.1 AIR FLOW RATE

- a. When rotometer is employed:

$$W_A \left(\frac{\text{lb}}{\text{sec}} \right) = \frac{Q_{\text{ROTO}} [0.0752]}{60} \sqrt{\left(1 + \frac{P_A}{14.7} \right) \left(\frac{530}{T_A + 460} \right)},$$

where Q_{ROTO} is obtained from built-in rotometer calibration. Required inputs are ROTO, P_A , T_A .

- b. When orifice plate is employed ($\text{NTR} = \text{C}$):

$$W_A \left(\frac{\text{lb}}{\text{sec}} \right) = B \sqrt{\left(\frac{P_A + 14.7}{T_A + 460} \right)} \sqrt{\frac{\text{Sgm } 62.4}{1728} |\Delta h_i|},$$

where B is orifice calibration coefficient. Sgm is manometer fluid specific gravity (calculated as function of manometer temperature from built-in relations given by Meriam), Δh_i is manometer deflection in inches.

B.2 WATER FLOW RATE

$$W_W \left(\frac{\text{lb}}{\text{sec}} \right) = C \sqrt{|\Delta h_i|},$$

where C is water flow orifice constant, Δh_i manometer deflection (separate determinations of water flow introduced on the rod or on the tube in the annulus may be made).

B.3 $W_{\text{total}} = W_A + W_W$

B.4 Quality: $X = W_A / W_T$

B.5 Void Fraction $\bar{\alpha} = 1 - \text{VL} / \text{VOL}$

where VL is water collected in the volume (VOL) between the quick-closing valves.

B.6 AVERAGE DENSITY IN TEST SECTION

$$\bar{\rho} = (1 - \bar{\alpha}) \rho_w + \bar{\alpha} \rho_{\text{air}},$$

$$\rho_w = \text{water density} = 62.3 \text{ lb/ft}^3,$$

$$\rho_{\text{air}} = (\text{lb/ft}^2) = (0.0752) \left[\frac{528}{T_R + 460} \right] \left[\frac{P_R}{14.7} \right],$$

where T_R = temperature ($^{\circ}\text{F}$) at reference point,

P_R = pressure (psia) at reference point. Reference point is usually taken at midpoint of test section.

B.7 PRESSURE DROP RELATIONS

$$a. \quad \Delta P_i = (0.0361) \left[\Delta h_i (\text{sgm}-1) + \Delta X_i \right],$$

where i refers to i^{th} manometer, connected at ΔX_i ;

Δh_i deflection of i^{th} manometer (inches) (left-right); and

ΔX_i position of i^{th} manometer pressure tap with respect to reference elevation (inches).

b. The slope of the ΔP_i versus ΔX_i curve is fitted with a straight line over a specified interval of ΔX_i with a least-squares fit; i. e., $\Delta P_i = S_p \Delta X_i + B$, and S_p is total pressure gradient.

c. Frictional pressure gradient (S_F)

$$S_F = S_p - \bar{\rho}/1728.$$

B.8 TOTAL MASS VELOCITY

$$G (\text{lb/h-ft}^2) = \frac{3600 W_T}{A_F},$$

where A_F is cross-sectional flow area in ft^2 .

B.9 SLIP RATIO

$$\eta = \left(\frac{X}{1-X} \right) \left(\frac{62.3}{\rho_{\text{air}}} \right) \frac{1 - \bar{\alpha}}{\bar{\alpha}}.$$

B. 10 LOCKHART-MARTINELLI PRESSURE DROP PARAMETERS

- a. Two-phase flow modulus

$$X_{LN} = \left(\frac{W_W}{W_A} \right)^{0.9} \left(\frac{\mu_W}{\mu_A} \right)^{0.1} \left(\frac{\rho_{air}}{\rho_W} \right)^{0.5}$$

- b. Pressure drop if air flowed alone

$$PDMG = (2.98 \times 10^{-3}) \left[\frac{W_A^{1.8} \mu_A^{0.2}}{\rho_A A_F^{1.8} d_n^{1.2}} \right]$$

- c. Pressure drop if liquid flowed alone

$$PDML = (2.98 \times 10^{-3}) \left[\frac{W_W^{1.8} \mu_W^{0.2}}{\rho_W A_F^{1.8} d_n^{1.2}} \right]$$

- d. Reynolds number—air

$$R_{EA} = \frac{W_A d_n}{A_F \mu_A}$$

- e. Reynolds number—water

$$R_{EW} = \frac{W_W d_n}{A_F \mu_W}$$

- f.
- $\phi_g^2 = S_F / PDMG$

- g.
- $\phi_L^2 = S_F / PDML$
- ,

where fluid properties (ρ_W , μ_W , μ_A) are tabulated in code as function of T_R .

d_h = hydraulic diameter (ft).

A single run takes approximately 0.005 minute. A summary of WADR results are listed in Table 2 in Section IV of this report.

NOMENCLATURE

A	Sample probe area (in. ²)
D _h	Hydraulic diameter
d	Sample probe inside diameter (inches)
f	Friction factor
g _c	$32.2 \left(\frac{\text{lb}_m - \text{ft}}{\text{sec}^2 - \text{lb}_f} \right)$
G	Mass velocity (lb/sec-in. ²)
L	Longitudinal length (feet)
P	Pressure (psi)
P*	$P_s - P_\infty / P_0 - P_\infty$
Q	Volumetric flow rate (cc/sec) or (ft ³ /sec)
r	Radial position (inches)
R	Tube radius (inches)
Re	Hydraulic diameter Reynolds number
T	Temperature (°F)
U _τ	$(\tau_w g_c / \rho)^{1/2}$
U ⁺	V/U _τ , dimensionless velocity
V	Actual (linear) velocity (ft/sec)
W _g	Gas flow rate (lb/sec)
W _ℓ	Liquid flow rate (lb/sec)
y	Distance away from wall (inches)
y ⁺	$\equiv \frac{y U_\tau}{12 \nu}$, dimensionless distance
Z	Longitudinal length (feet)

Greek Symbols

α	Gas volumetric void fraction
β	Nondimensional pressure drop $\left[\Delta P / \left(G_s^2 / 2 \rho g \right) \right]$
ΔH	Height difference
ΔP	Pressure difference
δ	Film thickness (inches)
η	Slip ratio = gas velocity/liquid velocity
θ	Angular position (degrees)
μ	Dynamic viscosity (lb _f -sec/ft ²)
ν	Kinematic viscosity (ft ² /sec)

ρ	Density (lb_m/ft^3)
τ	Shear stress (lb_f/ft^2)
x_L	$= \left[\frac{(dP/dz)_{\text{two phase}}}{(dP/dz)_{\text{liquid}}} \right]^{1/2}$, Lockhart-Martinelli parameter
x	Mass quality
x_{LM}	$= \left(\frac{W_g}{W_\ell} \right)^{0.9} \left(\frac{\mu_g}{\mu_\ell} \right)^{0.1} \left(\frac{\rho_\ell}{\rho_g} \right)^{0.5}$, Lockhart-Martinelli parameter

Subscripts

a	Air
I	Impact
m	Mean or homogeneous value
g	Gas
ℓ	Liquid
p	Probe
s	Sample line
t	Test section
o	Total; e.g., P_o is total pressure
w	Wall value; also denotes water
∞	At freestream conditions
homo	Refers to homogeneous method of data reduction
iso	Refers to isokinetic method of data reduction

Superscripts

$()^*$	Superficial or fictitious; e.g., G_g^* is $\frac{W_g}{A}$ or "velocity" based on probe area rather than true gas flow area
$(-)$	Spatial average over flow cross section
$(\bar{})$	Nondimensional; e.g., $\bar{r} = r/R$

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