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UCRL-52717

MEASUREMENTS, ERROR ANALYSES, AND CALCULATIONS OF WATER AND STEAM INDIVIDUAL MASS FLOW RATES, VELOCITIES, AND RELATED FLOW PARAMETERS OBTAINED FROM SINGLE-PHASE AND TWO-PHASE PROTOTYPE TESTS OF THE PKL INSTRUMENTED SPOOL PIECES FOR THE U. S. NRC-RSR 3-D PROGRAM

Werner Stein

September 10, 1979

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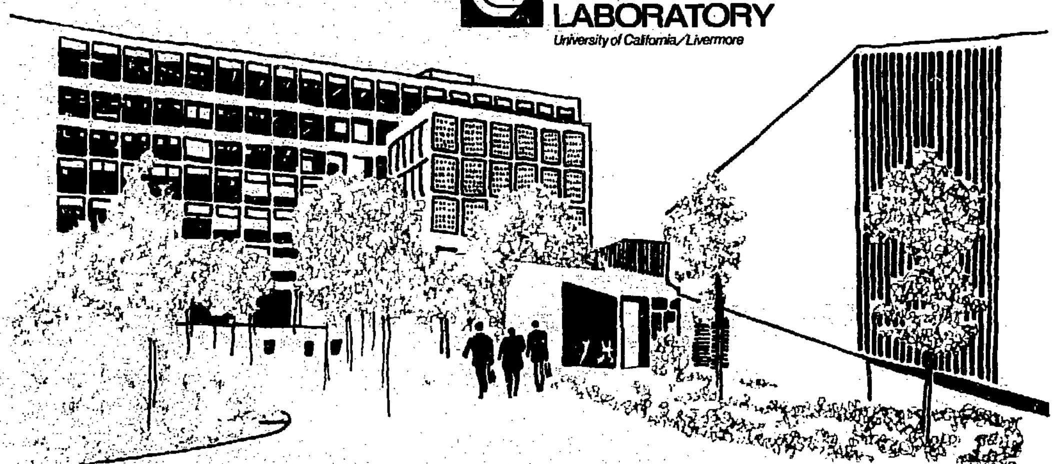

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ABSTRACT

The operation of the emergency core cooling system and its related steam-binding problems in pressurized water reactors are the subject of a cooperative study by the United States, Germany, and Japan. Lawrence Livermore Laboratory and EG&G, Inc., San Ramon Operations, are responsible for the design, hardware, and software of the 80.8-mm and 113-mm spool piece measurement systems for the German Primarkreislauf (PKL) Test Facility at Kraftwerk Union in Erlangen, West Germany. This work was done for the U. S. Nuclear Regulatory Commission, Division of Reactor Safety Research, under its 3-D Technical Support and Instrumentation Program.

Four PKL spool pieces each containing a flow turbine, drag screen, three-beam densitometer, and pressure and temperature probes were constructed and tested to measure single-phase and two-phase steam and water flow parameters. Individual phase velocities, mass flow rates, and densities were calculated from the analytical relationships presented. These calculated and measured parameters were compared to those parameters determined from the test facility instrumentation at Wyle Laboratories. Error analyses were performed, and individual test results were presented for both horizontal and vertical flows. The various flow regimes tested included annular mist, slug, froth, stratified wavy, and homogeneous flow of water or superheated steam.

INTRODUCTION

SPOOL PIECE MEASUREMENT SYSTEMS AND TESTING

The safe operation of nuclear power reactors has been the subject of extensive analyses by scientists and of increasing concern by the general public. The operation of the emergency core cooling system (ECCS) and the related steam-binding problems in pressurized water reactors (PWR's) is the subject of a joint cooperative German, Japanese, and United States steam-binding study. The German Primarkreislauf (PKL) Test Facility at Kraftwerk Union (KWU) in Erlangen, West Germany, was constructed to perform loss-of-coolant experiment (LOCE) reflood tests. In order to measure fluid flows during these reflood tests, instrumented pipe spools were developed to measure both single-phase and two-phase water and steam flows in the various coolant loop legs of the PKL reactor. Lawrence Livermore Laboratory and EG&G, Inc., San Ramon Operations, developed the spool piece measurement system* for the U. S. Nuclear Regulatory Commission, Division of Reactor Safety Research (NRC-RSR), under the 3-D Technical Support and Instrumentation Program.

A total of four spool pieces will be used in the PKL Test Facility. Each spool consists of a flanged pipe that is 830-mm long. Three of the spools have an inside diameter of 80.8 mm, and one spool has an inside diameter of 113 mm. The spools are designed for horizontal installation except for one of the 80.8-mm spools which is designed for vertical installation.

*In this report, the spool piece measurement system is also referred to as a spool piece or a spool.

Each spool contains the following instruments:

- Three-beam densitometer.
- Full-diameter flow turbine.
- Full-diameter drag screen or plate.
- Wall temperature probe.
- Fluid temperature probe.
- Absolute pressure probe.
- Differential pressure probe across the drag screen.

The vertical spool also contains a superheated-steam probe. Provisions have been made for the installation of a rod endoscope lens system to view flow conditions inside the spools. This system, however, is only for use during prototype testing and is not to be delivered to the PKL Test Facility.

A computer system is supplied with the four spools. Software routines have been developed to convert input signals to engineering units and to calculate the following flow parameters:

- Temperature.
- Pressure.
- Vapor and liquid velocities.
- Vapor and liquid densities.
- Void fraction.
- Liquid and vapor mass flow rates.

Prototypes of the spools were tested at a two-phase flow facility constructed at Wyle Laboratories, Norco, California. These tests included the following:

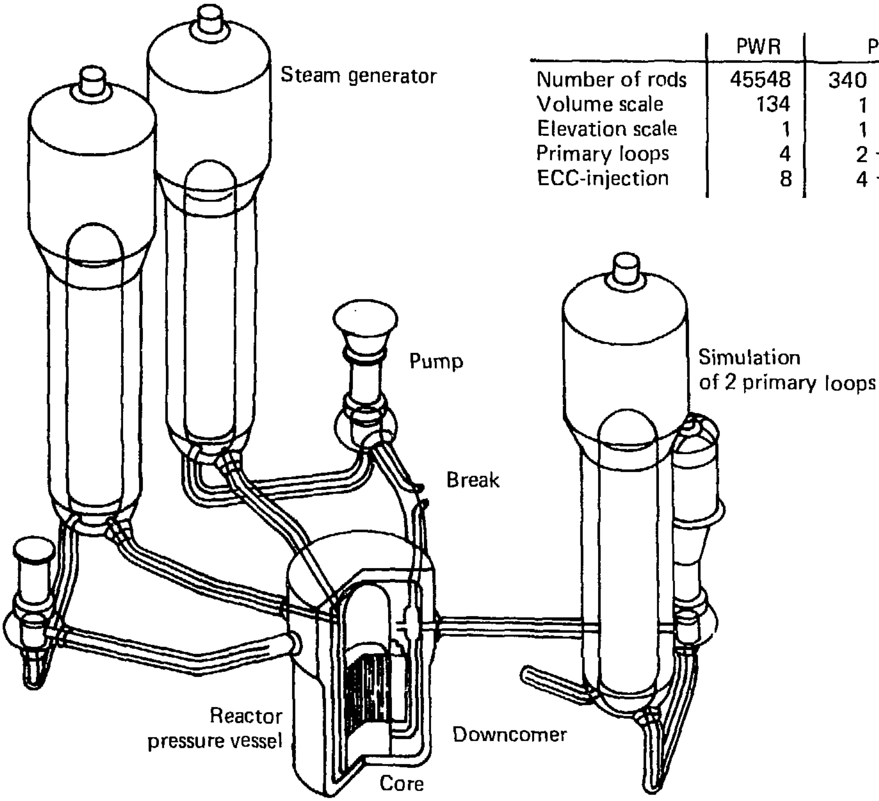
- Single-phase water-flow calibrations.
- Single-phase superheated-steam tests.
- Two-phase flow tests representative of slug, annular mist, froth, and stratified wavy flow conditions.

Testing in both vertical and horizontal flows was accomplished.

The Wyle Laboratories test facility was equipped with a data acquisition system (DAS) to measure steam and water flow parameters. The Wyle DAS also calculated mass and energy balances. A comparison was made of individual phase mass flow rates calculated by the PKL DAS and those determined by the Wyle Laboratories DAS. An error analysis of the data is presented in this report. Data is also presented for overall spool head loss for various tests and spool response to 40 cycles of limiting condition testing.

KWU PKL TEST FACILITY

The German PKL Test Facility at KWU in Erlangen, West Germany was developed to perform LOCE reflood tests. Figure 1 shows the PKL Test Facility modeling of a PWR system. As shown, the PKL reactor is full-scale in the vertical direction and is scaled down on a volume basis by a factor of 134. The reflood tests to be conducted involve coolant loop pipe breaks in the hot legs and also in the cold legs. Figure 2 shows a break in one of the three coolant loops of the PKL reactor. A schematic of the PKL Test Facility and the relative location of the four spool pieces are shown in Figure 3.



	PWR	PKL
Number of rods	45548	340
Volume scale	134	1
Elevation scale	1	1
Primary loops	4	2 + double
ECC-injection	8	4 + double

FIG. 1. PKL simulation of a four-loop pressurized water reactor (PWR).

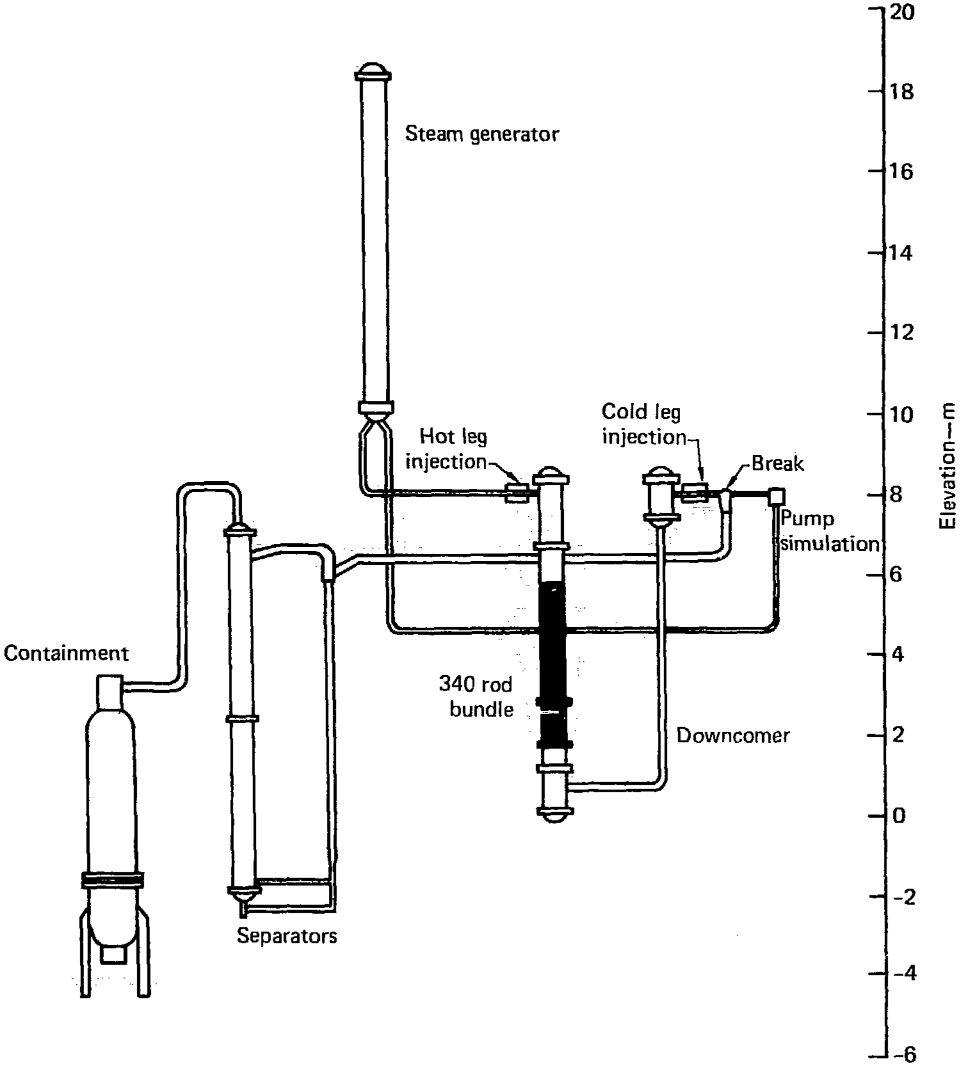


FIG. 2. Cold-leg break simulation in the PKL reactor.

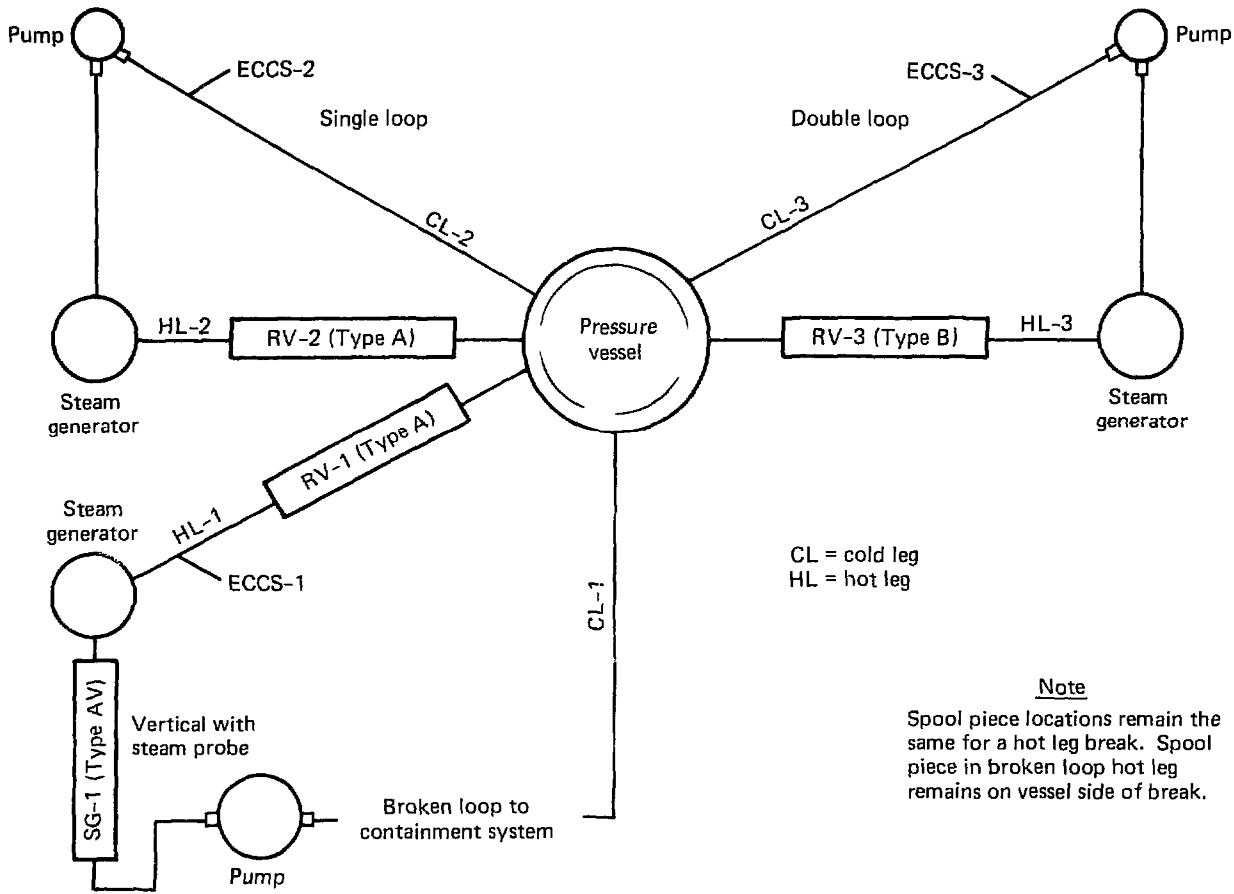


FIG. 3. PKL reflood test facility schematic (cold-leg break).

PKL SPOOL PIECE DESIGN AND INSTRUMENTATION

The four spools are designed to be mounted to mating flanges in the piping system of the PKL reactor coolant loops.

There are 11 channels of data to be recorded for the three horizontal spools, and there is an additional superheated-steam probe channel to be recorded for the vertical spool.

SPOOL PIECE PHYSICAL DESCRIPTION

The pertinent physical details for each of the spools are given in EG&G drawing nos. 137086, 137087, and 137088 (refer to Appendix A).

SPOOL PIECE INSTRUMENTATION

A description of the instrumentation used on the spool pieces is given below. For each system, accuracy of 1% of full scale is required, and a response time of 350 ms is required for a 10 to 90% response due to a step excitation.

Turbine Flowmeter

A whole-duct, bidirectional turbine flowmeter is used to measure volumetric flow in the spool piece. Passage of fluid through the instrument causes the nine-bladed rotor to turn at a rate proportional to the flow rate of the fluid. The rotation of the rotor is sensed by two magnetic pickup devices, and the direction of rotation is determined by the phase shift between these two devices. The main components of the flowmeter are a rotor, stainless-steel ball bearings, and flow straighteners attached to both ends of a stationary shaft. The range of operation is from 2 to 60 m/s.

Drag Screen System

A full pipe drag screen or plate is used to measure momentum flux in the spool piece. The drag screen is held in place by a three-pin suspension system. Screen deflections, under flow conditions, are sensed by three variable reluctance transducers. The sum of the three outputs is proportional to the momentum flux. The range of operation is from 70 to 7,200 $kg/m\text{-}s^2$.

Absolute and Differential Pressure Measurements

The fluid differential pressure is measured across the drag screen, and the absolute pressure is measured upstream of the drag screen. Both measurements are made using water-cooled, water-filled standoff tubes connecting the transducers to the spool piece. The absolute pressure transducer has a range of operation from 0 to 700 kPa. The differential pressure transducer has a range of operation from 0 to 7 kPa.

Wall, Fluid, and Steam Temperature Measurements

Probes consisting of chromel-alumel thermocouples and an ice-bath reference are used to measure the wall, fluid, and superheated-steam temperatures in the spool piece.

Densitometer System

The density of single-phase and two-phase flow is measured by a three-beam, low-energy (6-22 keV) x-ray densitometer. The chordal average density is determined by the amount of attenuation of the radiation beam by the fluid in the spool. The densitometer contains a single silicon-lithium-drifted, low-energy photon detector collimated to three sources through the beryllium windows of the spool piece. The radiation sources are Iron-55, Cadmium-109, and Americium-241. The density range of the measurement is from 0.7 to 1,000 kg/m^3. A densitometer statistical error analysis[1] is given in Table 1.

TABLE 1. Densitometer statistical error analysis.[1]

Density, kg/m^3	Required % error* of reading (a)	Required % error* of reading (b)		% error prototype test: 80.8-mm horizontal Fe^{55}	80.8-mm horizontal Cd^{109}	80.8-mm horizontal Am^{241}	80.8-mm vertical Fe^{55}	80.8-mm vertical Cd^{109}	80.8-mm vertical Am^{241}	113-mm Fe^{55}	113-mm Cd^{109}	113-mm Am^{241}
0.7	100.0			18.9	172.0	237.0	21.0	172.0	212.0	20.1	106.0	255.0
1.5	46.7			9.2	81.6	111.0	10.2	81.6	99.0	10.0	49.6	119.0
2	35.0			7.1	61.3	83.3	7.8	61.3	74.5	7.8	37.3	90.0
3	23.3			5.0	41.0	55.6	5.5	41.0	49.7	5.6	24.9	60.0
5	14.0			3.3	24.7	33.5	3.7	24.7	30.0	4.9	15.1	36.2
10	7.0			2.2	12.5	17.0	2.1	12.5	15.2	3.9	7.7	18.4
30	2.3			2.1	4.4	5.9	2.3	4.4	5.3	4.0	2.7	6.6
50	1.4			3.7	2.8	3.7	4.1	2.8	3.3	10.3	1.8	4.2
70	1.0	14.3	(143)	**	2.1	2.8	**	2.1	2.5	**	1.4	3.2
100		10.0	(100)		1.6	2.1		1.6	1.9		1.1	2.5
500		2.0	(20)		0.9	1.1		0.9	1.0		0.9	2.0
1000		1.0	(10)		1.6	1.8		1.6	1.6		2.6	5.7

*Required by PKL Functional Specification (MPR Associates, Inc., 1978); (a) 1% of full scale, 0.7 to 70 kg/m^3; (b) 1% of full scale, 70 to 1,000 kg/m^3 (10% of full scale acceptable).

**Compton effect (see Nuclear Science, vol. ns. 19, no. 3, June 1972).

PKL SPOOL PIECE DATA ACQUISITION SYSTEM

SYSTEM DESCRIPTION

The computer system used to monitor and control spool piece testing is an LSI-11 microprocessor system with 32,000 words of memory. The peripherals include the following:

- Line printer.
- CRT terminal (TTY).
- Cartridge tape recorder/reproducer.
- Analog-to-digital converter and multiplexer.
- Three floppy disc drives.

SOFTWARE

Computer programs were developed to allow the acquisition of 50 data channels and to provide the capabilities for:

- Acquiring and storing data on cartridge tape.
- Retrieving data from tape and performing analysis of the data.
- Real-time acquisition and analysis of data.

The analysis of data consists of converting the data signals to engineering units. This is accomplished primarily by a calibration table look-up scheme with straight-line interpolation between points. After conversion of the data to engineering units, calculations are made to determine the flow parameters.

ANALYTICAL RELATIONSHIPS

The major portion of the calculations involves converting the data signals into engineering units, and then using these engineering unit values to determine the phase velocities, mass flow rate, and void fraction.

Engineering Units Conversion

Engineering unit values for the following flow parameters are obtained from calibration tables with instrument voltage signals as input:

- Wall temperature (^{o}C).
- Fluid temperature (^{o}C).
- Steam temperature (^{o}C).
- Fluid absolute pressure (kPa).
- Differential pressure (kPa).
- Flow turbine velocity (m/s).
- Individual drag screen transducer force (N).

To determine velocity from the flow turbine, two calibration tables are available. One table is based on a water calibration and the other on an air calibration.

To determine momentum flux from the drag screen, calibration tables relating total force to momentum flux are available. The total force is determined by algebraically summing the force values from the three drag transducers. If one of the drag transducers is over-range, an alternate calculation for momentum flux is made. This calculation involves relating differential pressure across the drag screen to the momentum flux.

The density along each of the three beam paths is obtained from the voltage signal. The voltage signal is given by the following relationship:[2]

$$V = V_{off} + De^{-C\rho} \qquad (1)$$

where

V = voltage signal

V_{off} = offset voltage in system

D = calibration constant proportional to the radiation source intensity

C = attenuation calibration constant

ρ = average density along beam path.

Engineering unit values for density along each beam are obtained by inverting equation (1) to give:

$$\rho = \frac{1}{C} \ln\left(\frac{D}{V-V_{off}}\right) . \tag{2}$$

Flow Parameter Calculations

The individual phase parameters calculated include density, velocity, mass flow rate, void fraction, and average pipe cross-sectional density.

Density. The vapor density (ρ_S) and liquid density (ρ_W) are calculated from steam table routines with measured values of fluid temperature and pressure as input. The average cross-sectional density is calculated by fitting a density distribution model to the individual beam density measurements.[3]

Individual Phase Velocities[4] and Void Fraction. The average pipe cross-sectional density (ρ_f) of two-phase flow is given by:

$$\rho_f = \alpha\rho_S + (1-\alpha)\rho_W \tag{3}$$

where

α = void fraction

ρ_S = steam density

ρ_W = water density.

The void fraction is given by solving equation (3) for α:

$$\alpha = \frac{\rho_W - \rho_f}{\rho_W - \rho_S} \quad .$$

The mass flux (G_f) is given by:

$$G_f = \rho_f V_f = \alpha\rho_S V_S + (1-\alpha)\rho_W V_W \tag{4}$$

where

V_f = average velocity

V_S = vapor velocity

V_W = water velocity.

Solving equation (4) for V_f gives:

$$V_f = \frac{G_f}{\rho_f} = \frac{\alpha\rho_S V_S + (1-\alpha)\rho_W V_W}{\alpha\rho_S + (1-\alpha)\rho_W} \quad . \tag{5}$$

The momentum flux (I) is measured from the drag screen and is given by:

$$I = \alpha\rho_S V_S^2 + (1-\alpha)\rho_W V_W^2 \quad . \tag{6}$$

The turbine velocity (V_t) is calculated, based on the Rouhani model,[5] as:

$$V_t = \frac{I}{\rho_f V_f} = \frac{\alpha\rho_S V_S^2 + (1-\alpha)\rho_W V_W^2}{\alpha\rho_S V_S + (1-\alpha)\rho_W V_W} \quad . \tag{7}$$

The drag screen and turbine outputs above have been normalized by their calibration constants. Another form of this equation shows that the Rouhani model is a flowing quality weighted velocity as follows:

$$V_t = XV_S + (1-X)V_W \tag{8}$$

where

X = flowing quality.

Solving equations (6) and (7) simultaneously gives the following individual phase velocities:

$$V_S = V_f + \eta^{-1/2}\Delta V \tag{9}$$

$$V_W = V_f - \eta^{1/2}\Delta V \tag{10}$$

where

$$\eta = \left(\frac{\alpha}{1-\alpha}\right)\left(\frac{\rho_S}{\rho_W}\right) \tag{11}$$

$$\Delta V = \sqrt{V_f V_t - V_f^2} \tag{12}$$

$$V_f = \frac{I}{\rho_f V_t} \quad . \tag{13}$$

From an analysis of equations (5) and (7), the turbine velocity (V_t) is equal to or greater than the average fluid velocity (V_f). Therefore, from equation (13), the following is obtained:

$$\frac{I}{V_t^2} \leq \rho_f \tag{14}$$

and, in general, the following relationship holds true:

$$\rho_S \leq \frac{I}{V_t^2} \leq \rho_f \leq \rho_W \quad . \tag{15}$$

The relationship given by equation (15) is one of the tests used in the software to determine if the data is satisfactory for proceeding with the calculations. If the test is not found to hold true, then unity slip models are assumed. If the average density (ρ_f) is found not to satisfy the test

$$\rho_S \leq \rho_f \leq \rho_W \quad , \tag{16}$$

then the unity slip velocity (VUS) is assumed to equal the turbine velocity (V_t) and the density (ρ_f) is set equal to I/V_t^2. If equation (16) is satisfied but the following test,

$$\rho_S \leq \frac{I}{V_t^2} \leq \rho_f \quad , \tag{17}$$

is not satisfied, the VUS is calculated from:

$$VUS = \sqrt{\frac{I}{\rho_f}} \quad . \tag{18}$$

Mass Flow Rate. The calculations for mass flow rates for single-phase and two-phase water and steam flow conditions are presented below.

Single-Phase Water Flow Conditions. The mass flow rate (MW) for single-phase water flow conditions is calculated by the following relationship:

$$MW = A \times \rho_W \times V_W \tag{19}$$

where

A = pipe cross-sectional area

V_W = water velocity.

V_W is calculated from the relationship:

$$V_W = \sqrt{\frac{I}{\rho_W}} \quad . \tag{20}$$

Single-Phase Steam Flow Conditions. For single-phase steam flow conditions, the mass flow rate (MS) is calculated by the following relationship:

$$MS = A \times \rho_S \times V_S \tag{21}$$

where

V_S = turbine velocity reading based on an air calibration.

Two-Phase Flow Conditions. For the case of two-phase flow, the steam mass flow rates (MS) and the water mass flow rates (MW) are given by:

$$MS = A \times \alpha \times \rho_S \times V_S \tag{22}$$

and

$$MW = A \times (1-\alpha) \times \rho_W \times V_W \tag{23}$$

where V_S and V_W are obtained from equations (9) and (10), respectively.

Flow Charts. Flow charts for the calculation steps in the program and for the two-phase parameters are shown in Figures 4 and 5, respectively. A description of each of the numbered boxes shown in Figures 4 and 5 is given in Table 2. The various terms used in these flow charts are explained below:

- RV = spool identification. RV is an input option to allow selection of the spool data to be analyzed. RV = 1 represents the 80.8-mm horizontal spool, RV = 3 represents the 113-mm diameter spool, and RV = 4 represents the vertical 80.8-mm diameter spool.
- TS = superheated-steam temperature.
- TF = fluid temperature.

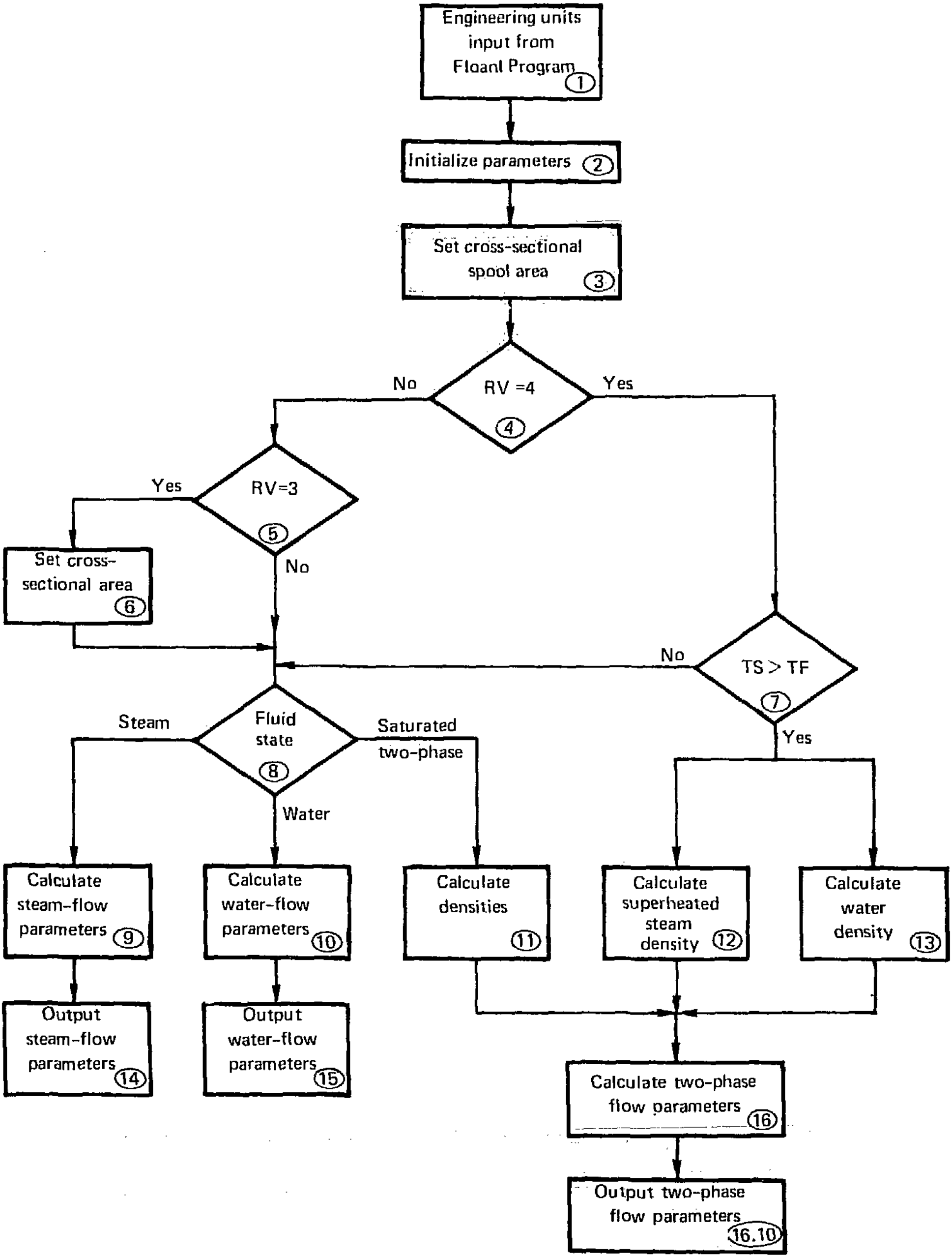


FIG. 4. Flow chart for fluid flow calculations.

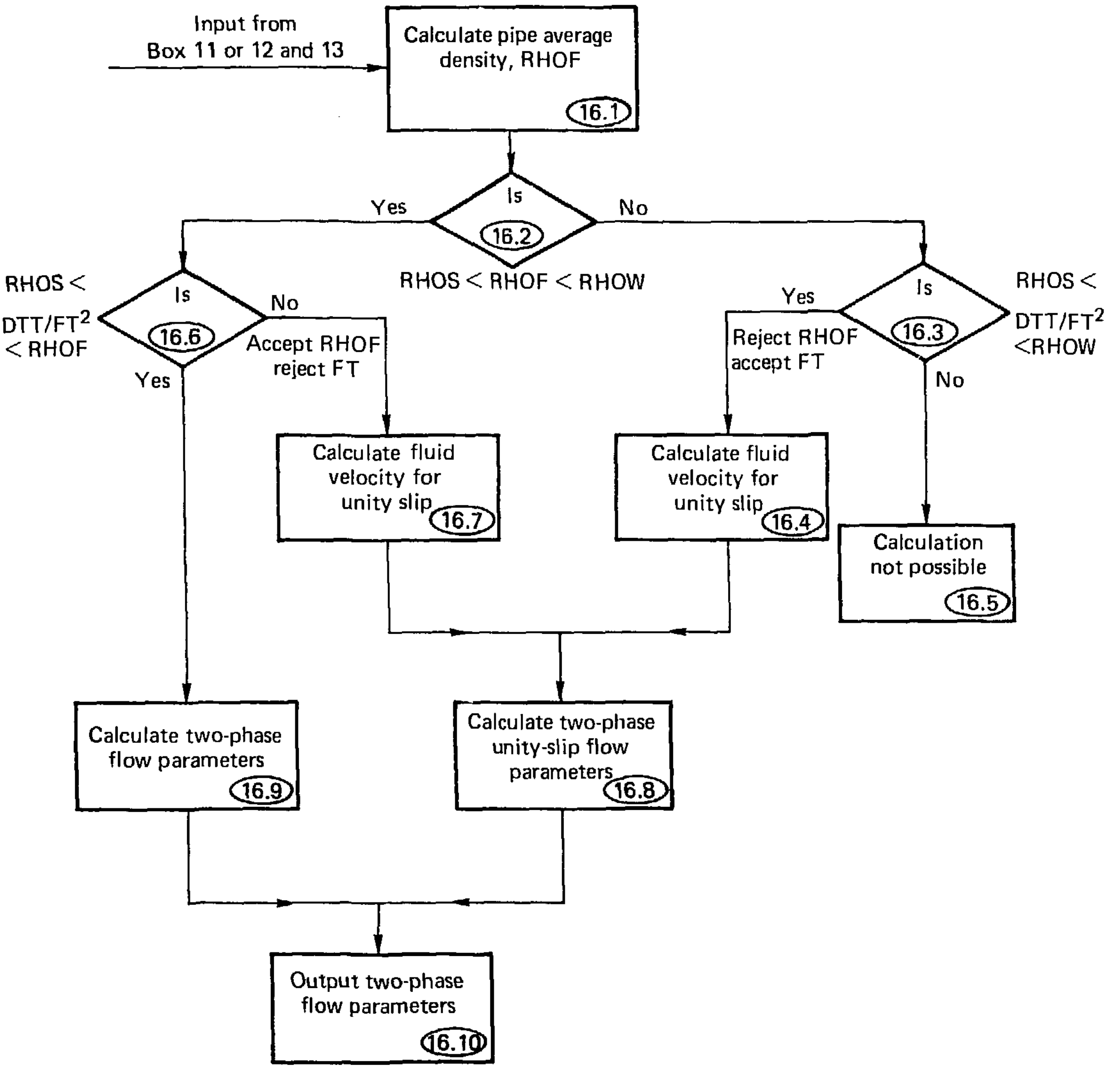


FIG. 5. Flow chart for two-phase parameter calculations.

- RHOF = average pipe cross-sectional density, ρ_f.
- RHOS = steam density, ρ_S.
- RHOW = water density, ρ_W.
- FT = turbine velocity.
- DTT = value of momentum flux (I) as given in equations (6) and (15).

TABLE 2. Description of numbered boxes in the program flow chart (FIG. 4) and the two-phase parameter flow chart (FIG. 5).

BOX NUMBER	DESCRIPTION
1	Program obtains engineering unit values for each of the instrument signals for a designated spool.
2	All flags and flow parameters are zeroed. Pressure and temperature readings are verified to be greater than zero. If either is less than zero, a return without calculation is made to the calling program.
3	Spool cross-sectional area is set for the 80.8-mm diameter spool.
4	A test is made to determine if the spool is no. 4. Spool no. four is spool SG-1 (80.8-mm diameter) which is installed in the vertical direction and contains a superheated-steam probe. If this test indicates that the spool is no. 4, then the calculations proceed to Box #7.
5 & 6	A test is performed to determine if the spool number to be analyzed equals three (113-mm diameter spool). If so, then the cross-sectional area of the spool is modified to reflect the 113-mm diameter spool in Box #6.

TABLE 2. Description of numbered boxes in the program flow chart (FIG. 4) and the two-phase parameter flow chart (FIG. 5). (Continued)

BOX NUMBER	DESCRIPTION
7	A test is made to determine if the superheat-temperature signal (TF) is greater than the fluid temperature by a specified value. This specified value is normally set equal to the sum of the expected full-scale error of the fluid temperature probe and the superheat-temperature probe.
8	A calculation is made to determine if the fluid in the spool is subcooled water, superheated steam, or fluid at saturated conditions. This is accomplished by obtaining the maximum and minimum saturation temperatures based on an absolute pressure reading that has been increased and decreased by the expected error of the pressure probe. These maximum and minimum saturation temperatures are then compared to the measured fluid temperature. If the maximum temperature is greater than the fluid temperature by an amount equal to the expected full-scale error of the fluid temperature probe, then the calculations proceed to Box #9 and the flow is flagged as "STM", indicating superheated steam. Conversely, if the minimum temperature is less than the fluid temperature minus the expected fluid temperature probe error, then the fluid is deemed subcooled water, flagged "WTR" in the output, and calculations proceed to Box #10. If the fluid pressure and temperature are close to saturation values, such that the fluid is not deemed superheated steam nor subcooled water, it is assumed to be saturated fluid and calculations proceed to Box #11.
9	Calculations of single-phase, superheated-steam flow parameters are made. Steam density (RHOS) is calculated. The velocity is set equal to the turbine velocity. The steam mass flow rate (MS) is calculated from equation (21).

TABLE 2. Description of numbered boxes in the program flow chart (FIG. 4) and the two-phase parameter flow chart (FIG. 5). (Continued)

BOX NUMBER	DESCRIPTION
10	Calculations of single-phase water flow are made. Density (RHOF) is determined. Water velocity (VUS) is calculated by equation (20). Mass flow is calculated by equation (19).
11	The saturated-steam temperature is determined by the measured pressure. Steam density is determined by the pressure readings and calculated saturation temperature. Water density is calculated from the fluid temperature readings.
12 & 13	The superheated-steam density is calculated from the fluid pressure and superheated steam-probe temperature. Water density is calculated from the fluid temperature readings.
14 & 15	The output of flow parameters is made.
16.1	The average density (RHOF) for two-phase flow is calculated. For the case of saturated water flow, tests are included to recalculate RHOF based on a weighted average of density readings from densitometer beam nos. 1 and 2. This is required because beam no. 3 is not capable of calculating densities above 70 kg/m^3. An option is also provided for the use of beam no. 3 alone to calculate average density (RHOF) when the readings from beam nos. 1 and 2 are below a minimum value.
16.2	A test is made to verify that the average density (RHOF) is between the steam and the water density.
16.3	A range check is made to determine if the turbine and drag screen readings are valid.

TABLE 2. Description of numbered boxes in the program flow chart (FIG. 4) and the two-phase parameter flow chart (FIG. 5). (Continued)

BOX NUMBER	DESCRIPTION
16.4	The average density (RHOF) value is rejected as being invalid, and density is calculated from the drag screen value of ρV^2 divided by the square of the flow turbine velocity. Steam and water velocities are set equal to the velocity determined from the flow turbine. A flag (USDR) is set to indicate a unity slip condition and that the densitometer readings are rejected.
16.5	No calculations are possible. A flag (NCAL) is set to reflect this.
16.6	A range check is made to determine if equation (17) is satisfied.
16.7	The velocity readings from the turbine are rejected, but the densitometer readings are accepted. Unity slip steam and water velocities are calculated from equation (18). A flag (USTR) is set in the output to identify the unity slip condition and to indicate that the turbine velocity readings are rejected.
16.8	The void fraction is calculated. Steam, water, and total mass flow rates are calculated from steam table-determined densities, void fraction, cross-sectional spool area, and unity slip flow velocities.
16.9	Calculations are made to determine individual phase velocities for saturated two-phase steam and water flows from equations (9) and (10).
16.10	The output of the flow parameters is made.

ERROR ANALYSIS

In order to assess the accuracy of the spool measurements of individual mass flow rates, an error analysis is performed on the data obtained from the prototype single-phase and two-phase flow tests. Data is taken during prototype tests for a period of two minutes at a rate of five data-channel scans per second. The individual mass flow rates are calculated for each scan, and their standard deviations (σ) are calculated from the following equation:

$$\sigma = \left\{ \frac{1}{n-1} \sum_{J=1}^{n} (Y-\bar{Y})_j^2 \right\}^{1/2} \quad (24)$$

where

$\bar{Y}$ = average of n values of Y
Y = calculated mass flow rate.

The average values of individual mass flow rates and their standard deviations are also available from the Wyle Laboratories test facility instrumentation. Using this data, a calculation of the percent difference between the mean results from the Wyle Laboratories test facility ($\bar{Y}_{Facility}$) and the PKL spool results ($\bar{Y}_{PKL}$) is made as follows:

$$\% \text{ Difference} = \left(\frac{\bar{Y}_{PKL} - \bar{Y}_{Facility}}{\bar{Y}_{Facility}} \right) \times 100 \quad (25)$$

A calculation is also made to determine the deviation (σ_R) between the flow rates calculated from the PKL spool piece (Y_{PKL}) and the mean flow values determined from the Wyle Laboratories test facility instrumentation. If all of the error is assumed to be random, then this calculation, shown below, would be the same as the standard deviation calculation. It is presented as an aid in analyzing the results and is calculated as shown below:

$$\sigma_1 = \left\{ \frac{1}{n-1} \sum_{J=1}^{n} (Y_{PKL} - \bar{Y}_{Facility})_J^2 \right\}^{1/2} \qquad (26)$$

$$\sigma_R = \sqrt{\sigma_1^2 - \sigma^2_{Facility}} \qquad (27)$$

where

$\sigma_{Facility}$ = standard deviation of of the Wyle Laboratories test facility determined flow rates.

WYLE LABORATORIES PKL PROTOTYPE SPOOL PIECE TEST FACILITY

A facility to test the PKL prototype spools was designed and constructed by Wyle Laboratories at their Norco, California, facility. This facility is capable of generating single-phase water flow, superheated-steam flow, and two-phase water and steam flow conditions for testing the horizontal and vertical PKL spools. The pertinent data and a diagram of the test facility are shown in Table 3 and Figure 6, respectively.

TABLE 3. General system characteristics of the Wyle Laboratories Test Facility.

CHARACTERISTIC	PARAMETER
Maximum operating pressure	150 psig
Horizontal distance from mixer to receiver	28 ft
Cold system activation	1 - 2 hr
Cooldown rate	2 - 3^{0}F/min
Mass balance performance	2 - 5%
Energy balance	<5%
Steam venturi metering range	0.012 - 6.0 lb/s
Water turbine metering range	2 - 325 gpm
Water venturi metering range	300 - 1000 gpm
Nominal water circulation pump capacity	400 gpm @ 170 ft (each)

Operation of the facility for testing involves the single-phase measurement of steam and of water upstream from a mixer. In the mixer, the steam and water flows are mixed and flow downstream to the PKL spool piece. Downstream of the PKL spool piece, the fluid flow is separated into the steam and water phases in the separator. Steam and water flow rates from the separator, as well as accumulations of water in the separator, are measured. Energy and mass balances are performed on the system using measured steam and water flows into and from the system to verify the performance of the facility for each prototype test.

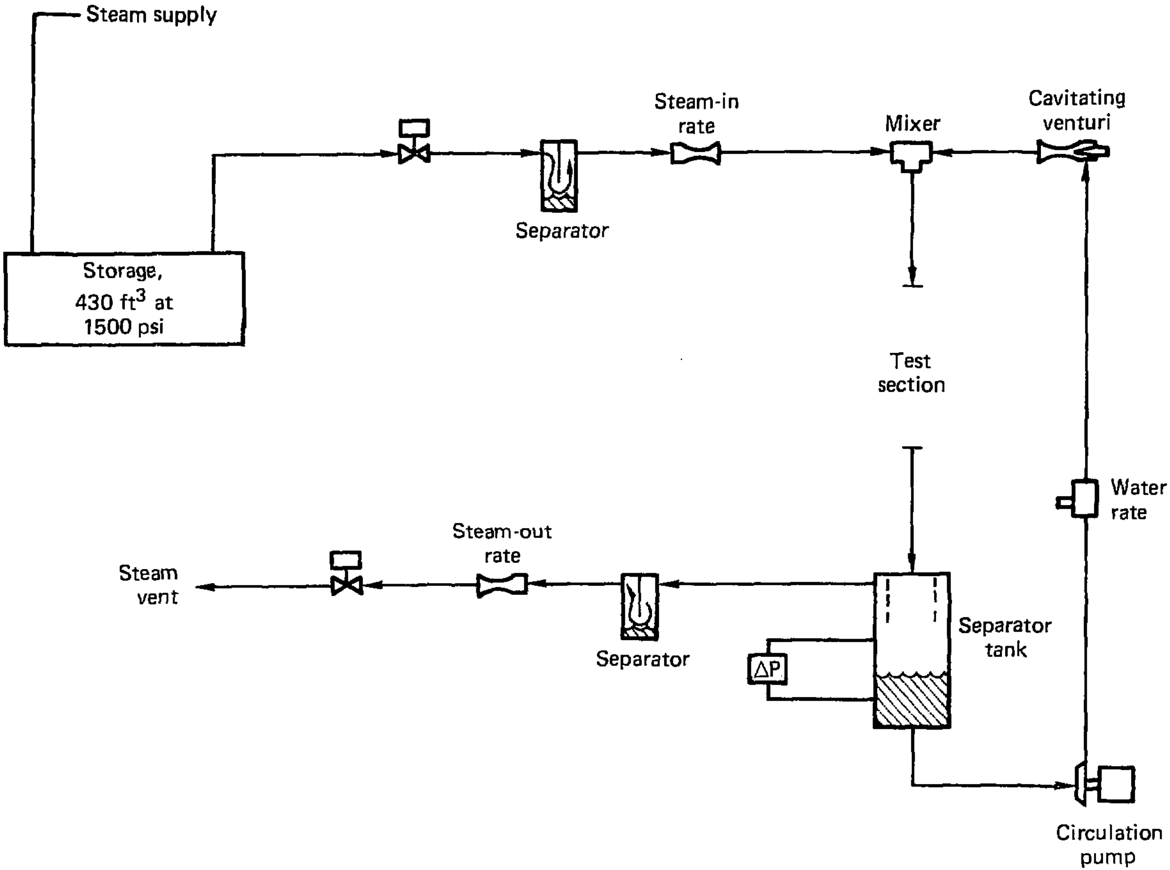


FIG. 6. Two-phase test facility flow diagram.

A computerized data acquisition system (DAS) performs the calculations. The DAS acquires data over a period of two minutes. It determines the average values of temperature, pressure, and phase mass flow rates. It also determines the results of mass and energy balance calculations for every ten seconds of the two-minute tests. At the conclusion of the test, a linear regression analysis is performed on the temperature, pressure, and mass flow rate data.

The instrumentation installed in this facility is traceable to standards maintained by the U. S. National Bureau of Standards.

INTRODUCTION

The three prototype spools tested at the Wyle Laboratories test facility include the following:

- 80.8-mm diameter horizontal spool (designated spool no. 1).
- 113-mm diameter horizontal spool (designated spool no. 3).
- 80.8-mm diameter vertical spool (designated spool no. 4).

The fourth spool (spool no. 2) was not tested since it is essentially identical to spool no. 1.

Prototype testing involves testing the spools with the flow in the forward direction and also with the flow in the reverse direction. Changing the flow direction is accomplished by physically turning the spool around in the piping system. Various tests are repeated several times, on different days, and at essentially identical flow conditions to determine repeatability. Spool nos. 1 and 3 are tested under horizontal flow conditions, and spool no. 4 is tested under vertical flow conditions.

Each of the spools is tested in single-phase water flow, single-phase superheated steam (approximately 10 to 40^{o}F superheat), and two-phase water and steam flows. For two-phase horizontal flow, the flow regimes during testing include slug flow, stratified wavy flow, and annular mist flow. For two-phase vertical flow, the flow regimes are slug flow, froth flow, and annular mist flow. The two-phase flow testing is done at saturation conditions and is conducted at three different fluid pressures, i.e., 620, 414, and 207 kPa (90, 60, and 30 psia, respectively). In addition to the above testing, spool nos. 1 and 3 are cycled 40 times between a zero flow condition and a momentum flux condition of 14,400 kg/m-s^2 to verify their operation without degradation of performance under these conditions.

In the organization of the test results, the prototype spool tests are each assigned a test number, beginning with no. 1 and ending with no. 302. Table 4 gives the number of the test, the number of the spool tested, the direction of flow (forward or reverse) during testing, the flow regime during the testing, and any pertinent comments. In the results presented, a positive mass flow rate indicates flow in the forward direction and a negative mass flow rate indicates flow in the reverse direction. Forward flow is defined as flow from the drag screen in the direction of the flow turbine. For the case of vertical flow, forward direction implies downward flow from the drag screen toward the flow turbine. Computer printouts of the test results are given in Appendices B and C.

CALIBRATIONS

Temperature, Pressure, and Differential Pressure

Calibration data relating the instrument electrical signal to engineering unit values of temperature were obtained from vendor data.

Velocity

Calibration data relating the turbine flowmeter electrical signal to water velocity were obtained from vendor data. An alternate calibration was obtained from water flow tests performed at the Wyle Laboratories test facility.

Calibration data relating the instrument electrical signal to air velocity were obtained from vendor data and were used in determining turbine velocity in all steam-flow and two-phase flow tests.

Momentum Flux

Calibration tests of the drag screen system using water were conducted on a ballistic calibrator at Flow Technology, Inc. in Phoenix, Arizona. These calibrations yielded data relating total drag force (the sum of the three drag

TABLE 4. Identification of the PKL prototype spool piece tests conducted by Wyle Laboratories.

Test no.	Spool no.	Flow direction	Fluid	Flow regime	Comments
1-32	1	Forward	Water	1Ø	1Ø = single phase
33	1	Forward	Water	1Ø	Limiting conditions, 40 cycle
36	1	Forward	Wtr & Stm	Slug	
37	1	Forward	Wtr & Stm	Ann.	
38	1	Forward	Steam	1Ø	
41	1	Forward	Wtr & Stm	Slug	
42	1	Forward	Wtr & Stm	Ann.	
43	1	Forward	Wtr & Stm	Ann.	
44	1	Forward	Wtr & Stm	Wave	
45	1	Forward	Wtr & Stm	Ann.	
46	1	Forward	Wtr & Stm	Ann.	
47	1	Forward	Steam	1Ø	
48	1	Forward	Steam	1Ø	
54	1	Forward	Wtr & Stm	Ann.	
55	1	Forward	Wtr & Stm	Ann.	
56	1	Forward	Wtr & Stm	Slug	
57	1	Forward	Wtr & Stm	Slug	
58	1	Forward	Wtr & Stm	Ann.	
59	1	Forward	Wtr & Stm	Slug	
60	1	Forward	Wtr & Stm	Wave	
61	1	Forward	Steam	1Ø	
62	1	Forward	Steam	1Ø	
63	1	Forward	Steam	1Ø	
64	1	Forward	Steam	1Ø	
69	1	Reverse	Wtr & Stm	Ann.	
70	1	Reverse	Wtr & Stm	Ann.	
71	1	Reverse	Steam	1Ø	
72	1	Reverse	Steam	1Ø	
73	1	Reverse	Steam	1Ø	

TABLE 4. Identification of the PKL prototype spool piece tests conducted by Wyle Laboratories. (Continued)

Test no.	Spool no.	Flow direction	Fluid	Flow regime	Comments
74	1	Reverse	Wtr & Stm	Wave	
75	1	Reverse	Wtr & Stm	Slug	
78	1	Reverse	Wtr & Stm	Wave	
79	1	Reverse	Wtr & Stm	Slug	
80	1	Reverse	Wtr & Stm	Ann.	
81	1	Reverse	Wtr & Stm	Ann.	
82	1	Reverse	Wtr & Stm	Ann.	
83	1	Reverse	Wtr & Stm	Ann.	
84	1	Reverse	Wtr & Stm	Slug	
85	1	Reverse	Wtr & Stm	Wave	
88	1	Reverse	Steam	1Ø	
89	1	Reverse	Steam	1Ø	
90	1	Reverse	Steam	1Ø	
91	1	Reverse	Wtr & Stm	Ann.	
92	1	Reverse	Wtr & Stm	Ann.	
93	1	Reverse	Wtr & Stm	Ann.	
94	1	Reverse	Wtr & Stm	Slug	
97	1	Reverse	Steam	1Ø	
98	1	Reverse	Wtr & Stm	Ann.	
99	1	Reverse	Wtr & Stm	Slug	
103-121	3	Reverse	Water	1Ø	
124-142	3	Forward	Water	1Ø	
143	3	Forward	Water	1Ø	Limiting conditions, 40 cycle
146	3	Forward	Wtr & Stm	Slug	
147	3	Forward	Wtr & Stm	Ann.	
148	3	Forward	Steam	1Ø	
152	3	Forward	Wtr & Stm	Ann.	
153	3	Forward	Wtr & Stm	Ann.	
154	3	Forward	Wtr & Stm	Ann.	

TABLE 4. Identification of the PKL prototype spool piece tests conducted by Wyle Laboratories. (Continued)

Test no.	Spool no.	Flow direction	Fluid	Flow regime	Comments
155	3	Forward	Wtr & Stm	Slug	
156	3	Forward	Wtr & Stm	Wave	
157	3	Forward	Steam	1Ø	
158	3	Forward	Wtr & Stm	Ann.	
159	3	Forward	Wtr & Stm	Ann.	
161	3	Forward	Wtr & Stm	Slug	
162	3	Forward	Wtr & Stm	Ann.	
163	3	Forward	Wtr & Stm	Ann.	
164	3	Forward	Wtr & Stm	Slug	
170	3	Forward	Wtr & Stm	Slug	
171	3	Forward	Wtr & Stm	Ann.	
172	3	Forward	Steam	1Ø	
175	3	Reverse	Wtr & Stm	Ann.	
176	3	Reverse	Wtr & Stm	Ann.	
177	3	Reverse	Wtr & Stm	Wave	
178	3	Reverse	Wtr & Stm	Slug	
179	3	Reverse	Wtr & Stm	Wave	
180	3	Reverse	Wtr & Stm	Ann.	
181	3	Reverse	Wtr & Stm	Ann.	
182	3	Reverse	Wtr & Stm	Slug	
183	3	Reverse	Steam	1Ø	
188	3	Reverse	Wtr & Stm	Wave	
189	3	Reverse	Wtr & Stm	Ann.	
190	3	Reverse	Wtr & Stm	Slug	
191	3	Reverse	Wtr & Stm	Ann.	
192	3	Reverse	Wtr & Stm	Slug	
193	3	Reverse	Wtr & Stm	Ann.	
194	3	Reverse	Steam	1Ø	
233-244	4	Forward	Water	1Ø	

TABLE 4. Identification of the PKL prototype spool piece tests conducted by Wyle Laboratories. (Continued)

Test no.	Spool no.	Flow direction	Fluid	Flow regime	Comments
245	4	Forward	Wtr & Stm	Ann.	
246	4	Forward	Wtr & Stm	Ann.	
247	4	Forward	Wtr & Stm	Froth	
248	4	Forward	Wtr & Stm	Froth	
249	4	Forward	Wtr & Stm	Ann.	
250	4	Forward	Wtr & Stm	Ann.	
251	4	Forward	Wtr & Stm	Slug	
252	4	Forward	Steam	1Ø	
258	4	Forward	Wtr & Stm	Froth	
259	4	Forward	Wtr & Stm	Froth	
260	4	Forward	Wtr & Stm	Slug	
261	4	Forward	Wtr & Stm	Froth	
262	4	Forward	Wtr & Stm	Ann.	
263	4	Forward	Wtr & Stm	Ann.	
264	4	Forward	Steam	1Ø	
267-278	4	Reverse	Water	1Ø	
282	4	Reverse	Wtr & Stm	Ann.	
283	4	Reverse	Wtr & Stm	Ann.	
284	4	Reverse	Wtr & Stm	Froth	
285	4	Reverse	Wtr & Stm	Froth	
286	4	Reverse	Wtr & Stm	Slug	
287	4	Reverse	Wtr & Stm	Ann.	
288	4	Reverse	Wtr & Stm	Ann.	
289	4	Reverse	Wtr & Stm	Slug	
290	4	Reverse	Wtr & Stm	Froth	
291	4	Reverse	Wtr & Stm	Ann.	
292	4	Reverse	Wtr & Stm	Ann.	
293	4	Reverse	Steam	1Ø	
298	4	Reverse	Wtr & Stm	Froth	
299	4	Reverse	Wtr & Stm	Froth	
300	4	Reverse	Steam	1Ø	

transducer forces) and differential pressure drag to momentum flux. These calibrations were repeated at the Wyle Laboratories test facility. The results from these tests provided the calibration tables for all the steam flow and two-phase flow calculations.

Densitometer Beam Average Density

Calibration tests using the three-beam densitometer were conducted at the Wyle Laboratories test facility. The calibrations involved obtaining voltage readings at known densities of water and steam. By using data collected from at least two calibration points, the constants C and D in equation (1) can be calculated. To ensure accurate values for these two sensitive constants, voltage readings for each calibration test need to be taken many times and then averaged. Also, in addition to the points at the extremes of the beam operating range, two or three calibration points within the range are necessary to check and modify the constants in order to obtain a proper fit to the data.

SINGLE-PHASE WATER TESTS

The three PKL spools were tested under varying all-water flow rates. Test results including comparisons to the Wyle Laboratories test facility flow rates are given in Table 5. The PKL results include an average velocity determined from the flow turbine, and an average momentum flux value determined from the three drag screen transducers. In each case, the calibration curves were obtained from tests conducted at Flow Technology, Inc. using a ballistic calibrator. The differential pressure drop across the drag screen and the calculations of percent error between the Wyle Laboratories and PKL results are also given in Table 5.

The purpose of these water tests was primarily to provide a means of verifying the satisfactory operation of the turbine and drag screen instruments and also to use the data as an alternate means of obtaining calibration data. The allowable tolerance on velocity measurements is $\pm$0.6m/s; at 2.69 m/s, this tolerance is 22% of the reading. The test results show that the accuracy of the measurements generally meets this requirement.

TABLE 5. PKL prototype spool water-flow test results.

Test no.	Spool no.	Velocity, m/s Wyle	PKL turbine	% Diff.	Momentum flux, kg/m-s^2 Wyle	PKL	% Diff.	ΔPressure, kPa
1	1	3.80	3.83	0.8	14,296.0	---	---	3.08
2	1	3.29	3.33	1.2	10,746.0	---	---	2.26
3	1	2.69	2.75	2.2	7,164.0	7,131.0	-0.5	1.52
4	1	2.43	2.48	2.1	5,870.0	5,792.0	-1.3	1.23
5	1	2.15	2.18	1.4	4,577.0	4,507.0	-1.5	0.96
6	1	1.82	1.85	1.6	3,283.0	3,233.0	-1.5	0.68
7	1	1.42	1.46	2.8	1,990.0	1,625.0	-18.3	0.41
8	1	0.834	0.872	4.6	691.0	748.0	8.2	0.14
9	1	0.759	0.830	9.4	571.0	600.0	5.1	0.11
10	1	0.671	0.693	3.3	446.0	428.0	-4.0	0.078
11	1	0.591	0.576	-2.5	345.0	338.0	-2.0	0.040
12	1	0.461	0.459	-0.4	113.0	218.0	92.9	0.018
13	1	0.279	0.292	4.7	76.8	108.0	40.6	---
14	1	0.222	0.161	-27.5	48.6	91.0	87.2	---
19	1	-0.222	-0.126	-43.2	-48.6	-58.5	20.4	---
20	1	-0.277	-0.228	-17.7	-76.0	-87.6	15.3	---
21	1	-0.461	-0.347	-24.7	-113.0	-189.0	67.3	---
22	1	-0.587	-0.526	-10.4	-345.0	-397.0	15.1	---
23	1	-0.671	-0.614	-8.5	-446.0	-514.0	15.2	-0.022
24	1	-0.759	-0.735	-3.2	-571.0	-647.0	13.3	-0.043
25	1	-0.838	-0.826	-1.4	-697.0	-799.0	14.6	-0.063
26	1	-1.42	-1.39	-2.1	-1,990.0	-2,111.0	6.1	-0.22
27	1	-1.82	-1.78	-2.2	-3,284.0	-3,451.0	5.1	-0.37
28	1	-2.15	-2.11	-1.9	-4,577.0	-4,812.0	5.1	-0.58
29	1	-2.43	-2.32	-4.5	-5,871.0	-6,164.0	5.0	-0.76
30	1	-2.69	-2.67	-0.7	-7,164.0	-7,611.0	6.2	-0.92
31	1	-3.29	-3.29	0.0	-10,746.0	---	---	-1.34
32	1	-3.80	-3.78	-0.5	-14,328.0	---	---	-1.83
103	3	-0.147	-0.133	-11.6	---	---	---	---

TABLE 5. PKL prototype spool water-flow test results. (Continued)

Test no.	Spool no.	Velocity, m/s			Momentum flux, $kg/m\text{-}s^2$			ΔPressure, kPa
		Wyle	PKL turbine	% Diff.	Wyle	PKL	% Diff.	
104	3	-0.188	-0.178	-5.3	---	---	---	---
105	3	-0.222	-0.207	-6.8	-48.9	-122.0	149.0	---
106	3	-0.251	-0.296	17.9	-62.8	-149.0	137.0	---
107	3	-0.278	-0.302	1.4	-76.6	-158.0	106.0	---
108	3	-0.269	-0.272	1.1	-71.6	-184.0	157.0	---
109	3	-0.445	-0.456	2.5	-106.0	-287.0	171.0	---
110	3	-0.570	-0.565	-0.9	-320.0	-395.0	23.4	---
111	3	-0.671	-0.662	-1.3	-446.0	-492.0	10.3	---
112	3	-0.759	-0.734	-3.3	-571.0	-598.0	4.7	---
113	3	-0.838	-0.836	-0.2	-697.0	-693.0	-0.6	---
114	3	-1.42	-1.43	0.7	-1,990.0	-1,902.0	-4.4	-0.397
115	3	-1.82	-1.83	0.5	-3,284.0	-3,079.0	-6.2	-0.687
116	3	-2.15	-2.22	3.3	-4,577.0	-4,209.0	-8.0	-0.978
117	3	-2.43	-2.49	2.4	-5,870.0	-5,278.0	-10.1	-1.24
119	3	-2.69	-2.77	3.0	-7,164.0	-6,661.0	-7.0	-1.66
120	3	-3.29	-3.35	1.9	-10,746.0	---	---	-2.43
121	3	-3.80	-3.86	1.6	-14,328.0	---	---	-3.27
124	3	0.088	0.072	-18.2	7.6	---	---	---
125	3	0.147	0.132	-10.2	21.2	---	---	---
126	3	0.188	0.179	-5.9	35.1	---	---	---
127	3	0.222	0.226	1.7	48.9	---	---	---
128	3	0.251	0.256	2.0	62.8	---	---	---
130	3	0.269	0.268	-0.4	72.0	---	---	---
131	3	0.445	0.451	1.3	106.0	146.0	37.7	---
132	3	0.570	0.590	3.5	322.0	263.0	-18.3	0.057
133	3	0.671	0.664	-1.0	448.0	386.0	-13.8	0.085
134	3	0.759	0.775	2.1	574.0	514.0	-10.5	0.114
135	3	0.838	0.827	-1.3	697.0	652.0	-6.5	0.146
136	3	1.42	1.38	-2.8	1,990.0	1,984.0	-0.3	0.47

TABLE 5. PKL prototype spool water-flow test results. (Continued)

Test no.	Spool no.	Velocity, m/s			Momentum flux, kg/m-s^2			ΔPressure, kPa
		Wyle	PKL turbine	% Diff.	Wyle	PKL	% Diff.	
137	3	1.82	1.79	-1.6	3,284.0	3,195.0	-2.7	0.80
138	3	2.15	2.24	4.2	4,577.0	4,844.0	5.8	1.32
139	3	2.43	2.51	3.3	5,870.0	6,090.0	3.8	1.66
140	3	2.69	2.75	2.2	7,164.0	7,217.0	0.7	1.98
141	3	3.29	3.38	3.3	10,746.0	---	---	3.03
142	3	3.80	3.87	1.8	14,328.0	---	---	4.07
233	4	3.80	3.74	-1.6	14,328.0	---	---	2.74
234	4	3.29	3.24	-1.5	10,746.0	---	---	2.05
235	4	2.69	2.65	-1.5	7,164.0	7,159.0	-0.1	1.36
236	4	2.43	2.38	-2.1	5,870.0	5,810.0	-1.0	1.12
237	4	2.15	2.10	-2.3	4,577.0	4,510.0	-1.5	0.87
238	4	1.82	1.78	-2.2	3,284.0	3,295.0	0.3	0.63
239	4	1.42	1.38	-2.8	1,990.0	2,006.0	0.8	0.38
240	4	0.838	0.811	-3.2	697.0	766.0	9.9	0.12
241	4	0.570	0.550	-3.5	320.0	398.0	24.4	0.055
243	4	0.278	0.261	-6.1	76.6	143.0	86.0	---
244	4	0.147	0.108	-26.5	21.2	76.0	256.0	---
267	4	-3.80	-3.81	0.3	-14,328.0	---	---	-2.39
268	4	-3.29	-3.32	0.9	-10,746.0	---	---	-1.78
269	4	-2.69	-2.71	0.7	-7,164.0	-7,408.0	4.4	-1.16
270	4	-2.43	-2.41	-0.8	-5,870.0	-6,079.0	3.6	-0.93
271	4	-2.15	-2.17	0.9	-4,577.0	-4,788.0	4.6	-0.72
272	4	-1.82	-1.83	0.5	-3,284.0	-3,470.0	5.7	-0.52
273	4	-1.42	-1.44	1.4	-1,990.0	-2,186.0	9.8	-0.31
274	4	-0.838	-0.854	1.9	-697.0	-854.0	22.5	-0.11
275	4	-0.570	-0.603	5.8	-320.0	-457.0	42.8	---
277	4	-0.278	-0.320	15.1	-76.6	-207.0	169.0	---
278	4	-0.147	-0.136	-7.5	---	---	---	---

The accuracy requirements of the momentum flux measurements are 1% of the full-scale flux value of 7,200 kg/m-s^2. This accuracy requirement is satisfied for the three spools for all of the forward flow conditions. For reverse flow tests at full-scale momentum flux conditions, the spool-measured fluxes differ from the Wyle-determined fluxes by 6.2%, -7.0%, and 4.4% for spool nos. 1, 3, and 4, respectively.

SINGLE-PHASE SUPERHEATED STEAM TESTS

Each of the three spools was tested. The test results data for the single-phase flow of superheated steam are given in Appendix B. The mass flow in each case was calculated by equation (21).

Upon inspection of the percent-difference results between the Wyle Laboratories test facility mass flow rates and the PKL Test Facility calculated mass flow rates, certain trends in the data appear as follows:

- The accuracy expressed in percent difference is generally good.
- For spool nos. 3 and 4, the mass flow rates in the forward direction appear to be more accurate than those in the reverse direction.
- The PKL Test Facility mass flow rates, in general, are greater than the Wyle Laboratories test facility values.

In the calculation of mass flow rates, a certain percentage error is expected. Pressure reading accuracies and turbine velocity reading accuracies of 1% of full scale of 700 kPa and 60 m/s, respectively, are expected. In the Wyle Laboratories test facility measurements, accuracies of the same order are expected. Based on these accuracies, errors on the order of 2 to 4% are not unreasonable, and much of the data appears to fall within this range.

Calibration tables for determining turbine velocity were obtained for air flow conditions on a ballistic calibrator. Improvements in the calibrations may be possible using a more steady-flow calibration facility.

TWO-PHASE WATER AND STEAM TESTS

Each of the spools was tested in two-phase water and steam flow. The test results are given in Appendix C.

Inspection of the data indicates that the total mass flow rate accuracy is good. Total mass flow rates are more accurate at the higher values of momentum flux. In comparing the accuracy of the individual phase mass flow rates, the larger of the two is generally much more accurate, particularly for the slug flow regime tests.

OVERALL SPOOL HEAD LOSS

Measurements of overall spool head loss during single-phase water and steam flow tests were made for the prototype spools. A comparison is made between the calculated head loss obtained from the measured values of overall pressure drop and density, and the velocity head of the water or steam. A ratio of the head loss divided by the velocity head is made. Table 6 gives the results for these calculations.

The relationship for calculating velocity head (VH) is given by:

$$VH = \frac{V^2}{2g} \tag{28}$$

where

g = gravity

V = fluid velocity.

The relationship for calculating head loss (HL) from the measured data is given by:

$$HL = \frac{\Delta P}{\rho g} \tag{29}$$

TABLE 6. Overall spool head loss during single-phase water and steam flow tests.

Test no.	Spool no.	ΔPressure, kPa	Density, kg/m^3	Velocity, m/s	No. of Velocity Heads
9	1	0.27	995.0	0.759	0.94
10	1	0.2	995.0	0.671	0.89
11	1	0.15	995.0	0.591	0.86
12	1	0.1	995.0	0.461	0.95
13	1	0.045	995.0	0.279	1.16
14	1	0.03	995.0	0.222	1.23
15	1	0.02	995.0	0.148	1.84
16	1	0.005	995.0	0.090	1.24
18	1	0.01	995.0	0.148	0.92
19	1	0.02	995.0	0.222	0.82
20	1	0.03	995.0	0.277	0.79
21	1	0.06	995.0	0.461	0.57
22	1	0.13	995.0	0.587	0.76
23	1	0.18	995.0	0.671	0.81
24	1	0.23	995.0	0.759	0.80
25	1	0.29	995.0	0.838	0.83
26	1	0.82	995.0	1.42	0.82
27	1	1.33	995.0	1.82	0.81
28	1	1.85	995.0	2.15	0.81
29	1	2.45	995.0	2.43	0.84
30	1	2.99	995.0	2.69	0.83
31	1	5.22	995.0	3.29	0.97
32	1	5.90	995.0	3.80	0.82
47	1	0.917	3.2	32.2	0.55
48	1	2.750	2.2	56.2	0.79
61	1	3.221	2.2	56.5	0.92
63	1	0.11	2.1	8.78	1.4
64	1	0.655	1.1	39.8	0.75
71	1	0.412	2.2	17.9	1.2
72	1	2.796	2.1	57.0	0.82
73	1	0.052	2.2	7.05	0.95

TABLE 6. Overall spool head loss during single-phase water and steam flow tests. (Continued)

Test no.	Spool no.	Δ Pressure, kPa	Density, kg/m^3	Velocity, m/s	No. of Velocity Heads
88	1	0.637	1.2	36.8	0.79
89	1	2.911	2.2	56.7	0.82
90	1	0.942	3.2	28.8	0.71
119	3	2.28	995.0	2.69	0.63
120	3	3.22	995.0	3.29	0.60
121	3	4.42	995.0	3.80	0.62
125	3	0.005	995.0	0.147	0.47
126	3	0.01	995.0	0.188	0.57
127	3	0.012	995.0	0.222	0.49
128	3	0.023	995.0	0.251	0.74
130	3	0.018	995.0	0.269	0.50
131	3	0.072	995.0	0.445	0.73
132	3	0.120	995.0	0.570	0.74
133	3	0.175	995.0	0.671	0.78
134	3	0.228	995.0	0.759	0.80
135	3	0.277	995.0	0.838	0.79
136	3	0.687	995.0	1.42	0.69
137	3	1.132	995.0	1.82	0.69
138	3	2.078	995.0	2.15	0.91
139	3	2.690	995.0	2.43	0.92
140	3	3.230	995.0	2.69	0.90
141	3	4.757	995.0	3.29	0.89
142	3	6.457	995.0	3.80	0.90
148	3	2.540	2.2	54.40	0.78
157	3	2.939	2.2	54.3	0.91
172	3	3.008	2.2	55.0	0.91
183	3	2.018	2.2	56.8	0.57
194	3	2.300	2.2	57.2	0.64

where

ρ = fluid density

$\Delta\rho$ = spool overall pressure drop.

Dividing equation (29) by equation (28) gives the number of velocity heads pressure loss. From an inspection of the test results in Table 6, it is noted that the number of velocity heads for the majority of the tests is below a value of 1.0.

40-CYCLE LIMITING CONDITION SURVIVAL TESTS

Spool nos. 1 and 3 were tested for 40 cycles between a zero-water flow rate and a water flow rate corresponding to a momentum flux condition of 14,400 $kg/m\text{-}s^2$. For each cycle, engineering unit data were obtained at zero-water flow and at the limiting momentum flux condition. Results of the tests show no observable degradation of performance of the spool instruments.

SUMMARY AND CONCLUSIONS

Three PKL instrumented prototype spools were tested in single-phase water, single-phase superheated steam, and two-phase steam and water flows. For single-phase water flow tests, turbine velocity measurements are within the allowable tolerance limit and show good agreement with the Wyle facility measurements. Drag screen measurements of momentum flux in the forward-flow direction are generally within tolerance. In the reverse-flow direction, measured momentum flux accuracies are not as good as in the forward-flow direction and generally exceed allowable tolerance limits.

For single-phase superheated steam flow tests, measurements of steam mass flow rates appear very good. In analyzing the accuracy of the data, it is generally expected that accuracies decrease for lower velocity flows. The accuracies for reverse-flow tests on spool no. 4 do not appear to be as good as on the other two spools tested.

In two-phase flows, the accuracy of measured total mass flow rate is good. In analyzing the accuracies of the measured flows, consideration must be given to the accuracy requirements of the instruments. In general, accuracies decrease with decreases in momentum flux and velocity.

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(1) R. F. Smellie, PKL Instrumented Spool Piece Final Design Review, EG&G, Inc., San Ramon Operations, MES-014, Tab 2, p. 35 (April 1979).

(2) G. D. Lassahn, Loft Experimental Measurements Uncertainties Analyses. Volume 16: Loft Three-Beam Gamma Densitometer System, Tree-NUREG-1089 (February 1978).

(3) G. D. Lassahn, Loft Three-Beam Densitometer Data Interpretation, Tree-NUREG-1111 (October 1977).

(4) Calculations developed by J. Colson, INEL, Idaho Falls, Idaho; private communication W. Stein/J. Colson (January 1978).

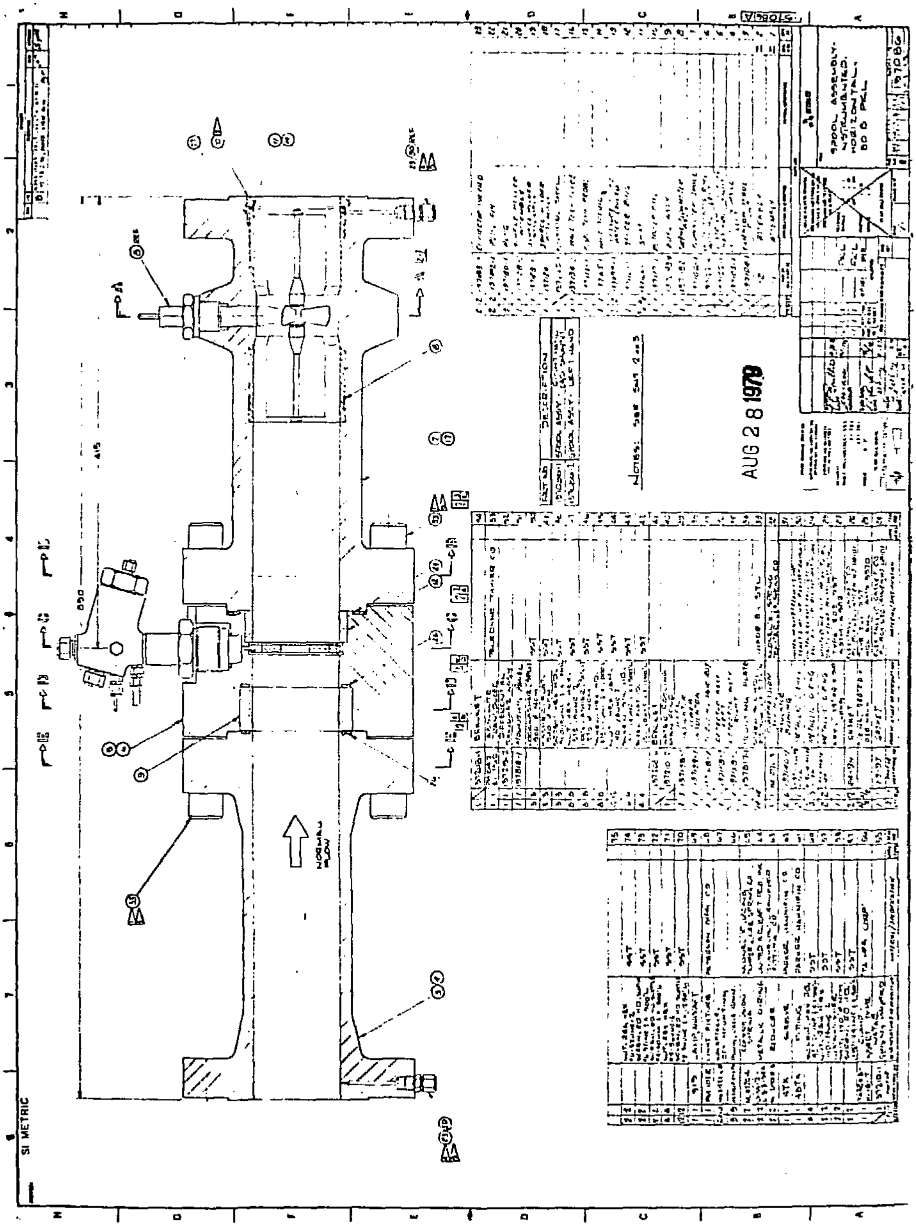
(5) H. Estranda, Jr., and J. D. Sheppard, Some Aspects of Interpreting Two-Phase Flow Measurements in Instrumented Piping Spool Pieces, NUREG-0280 (June 1977).

LMS/amr(EG&G/SRO)

APPENDIX A

PKL SPOOL PIECE DRAWINGS

(EG&G DRAWING NOS. 137086, 137087, AND 137088)



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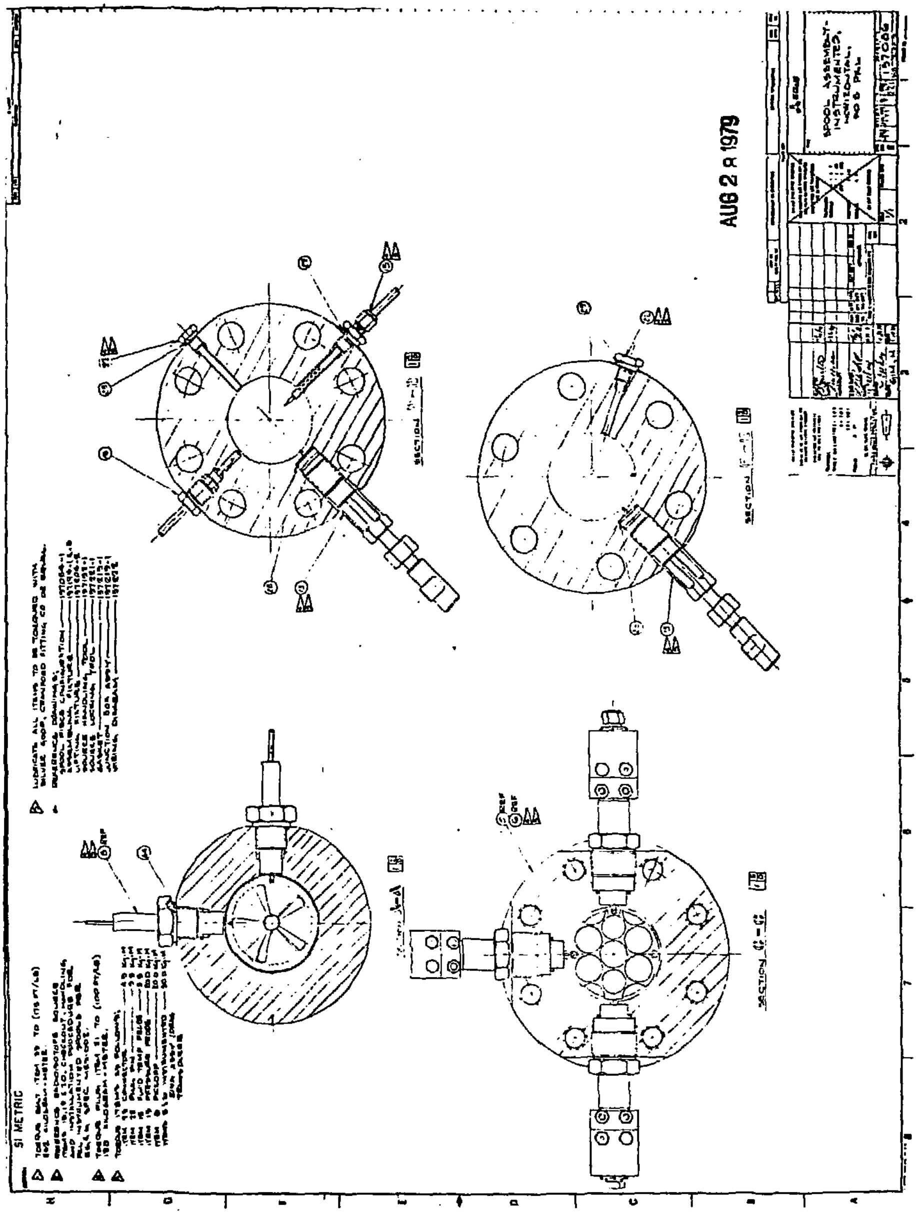
NORMAL FLOW
AUG 2 8 1979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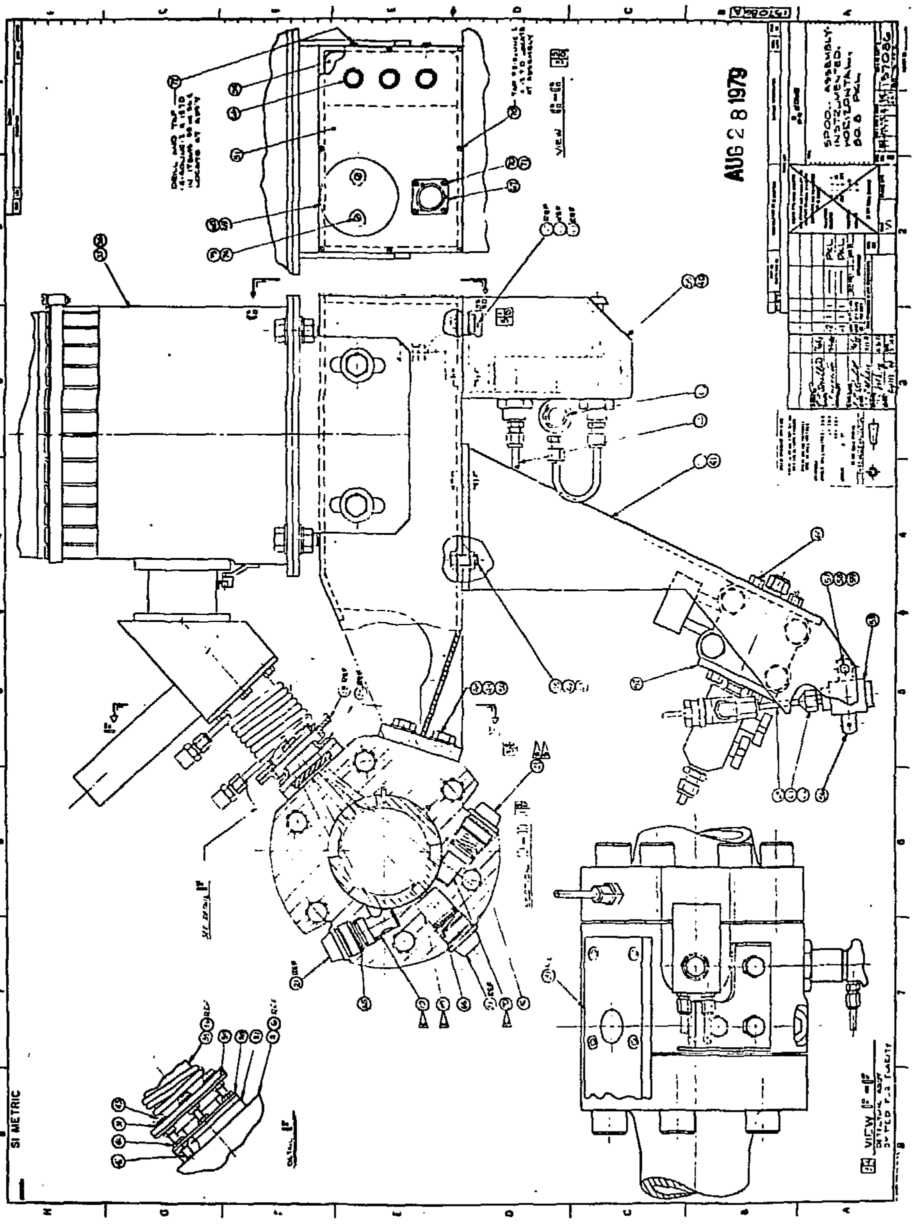
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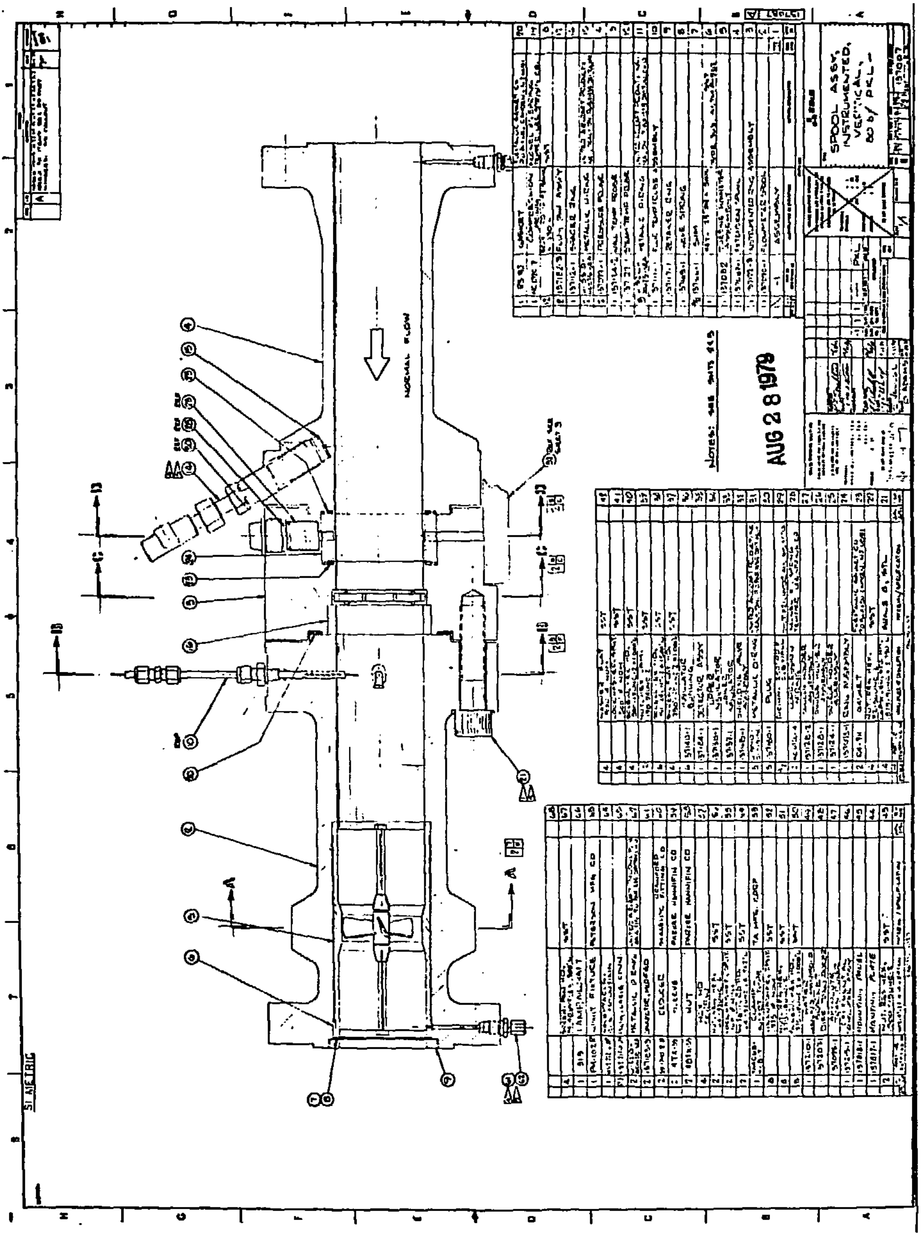
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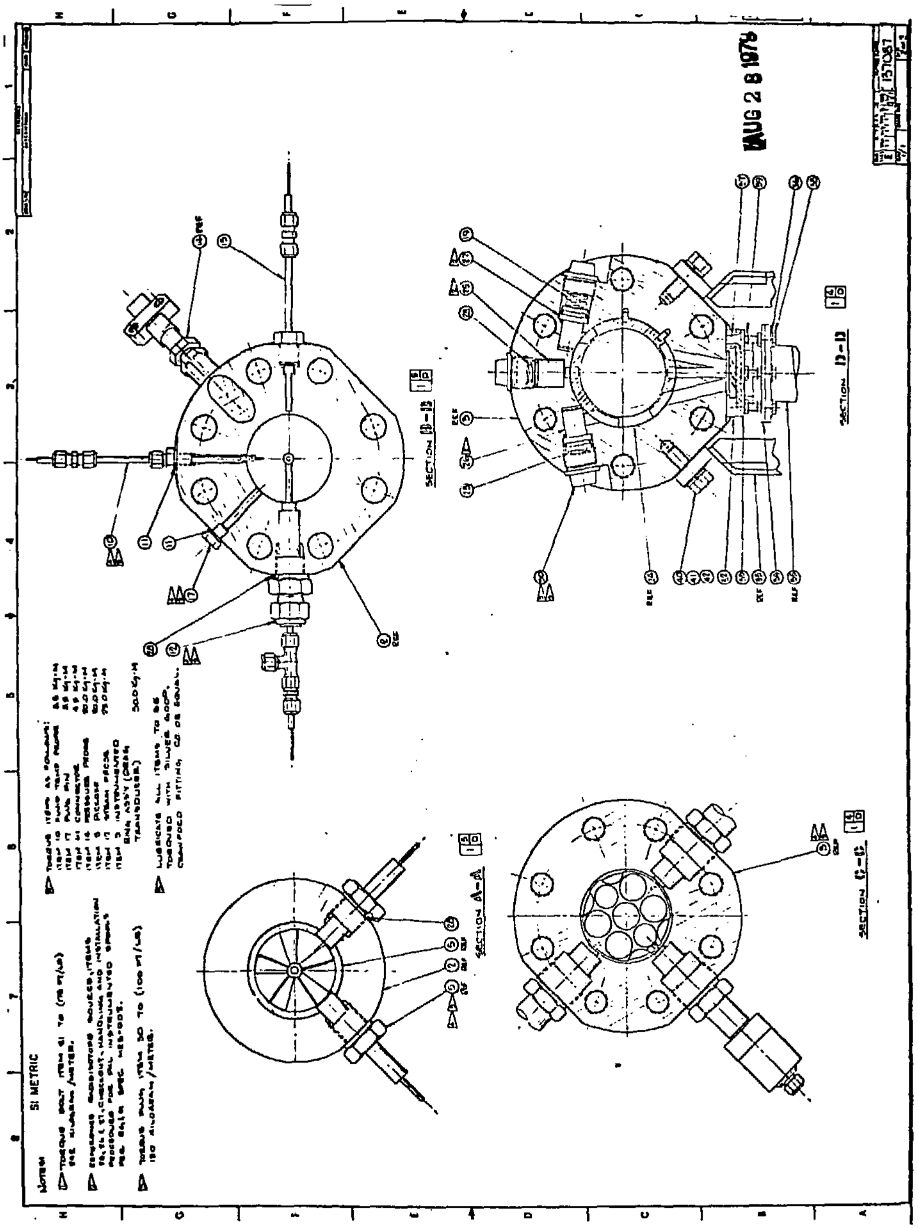
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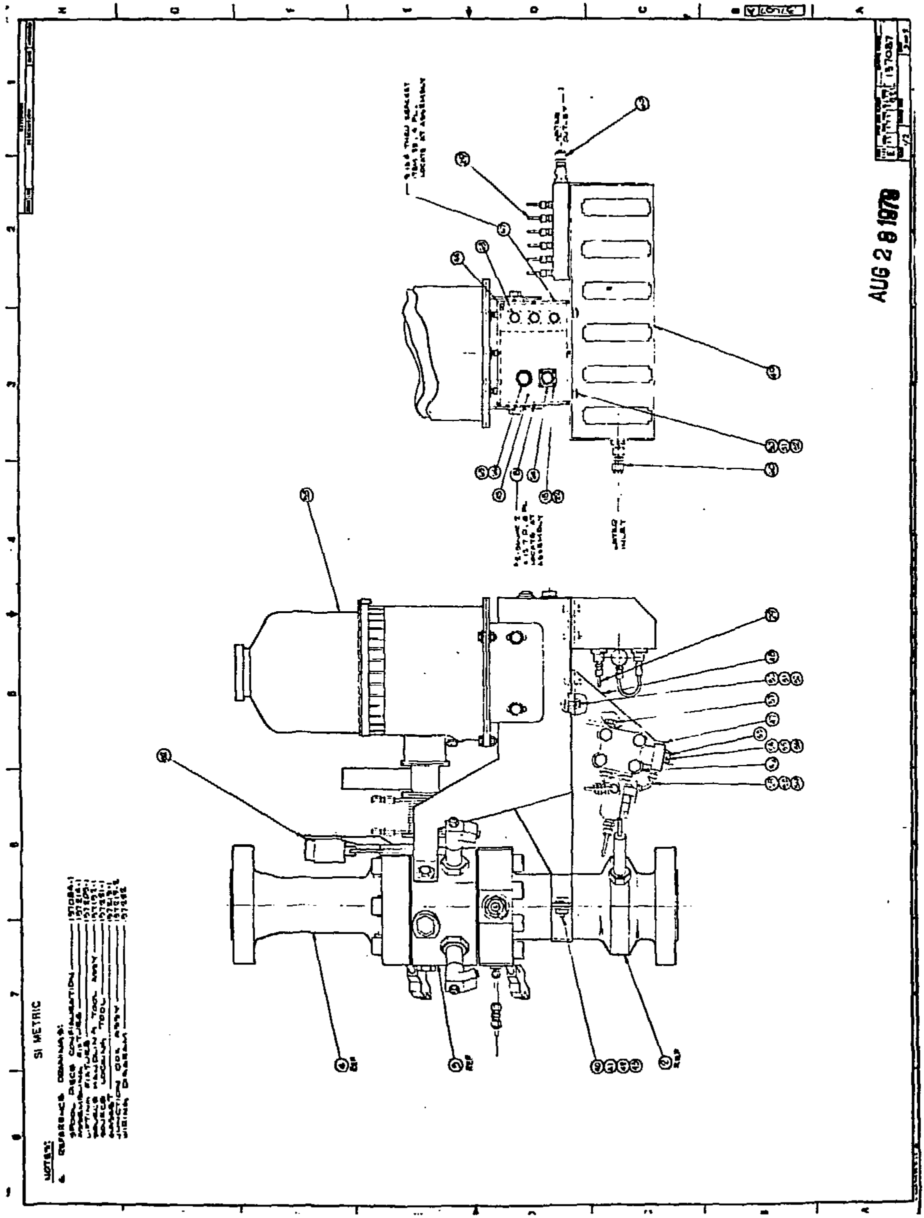
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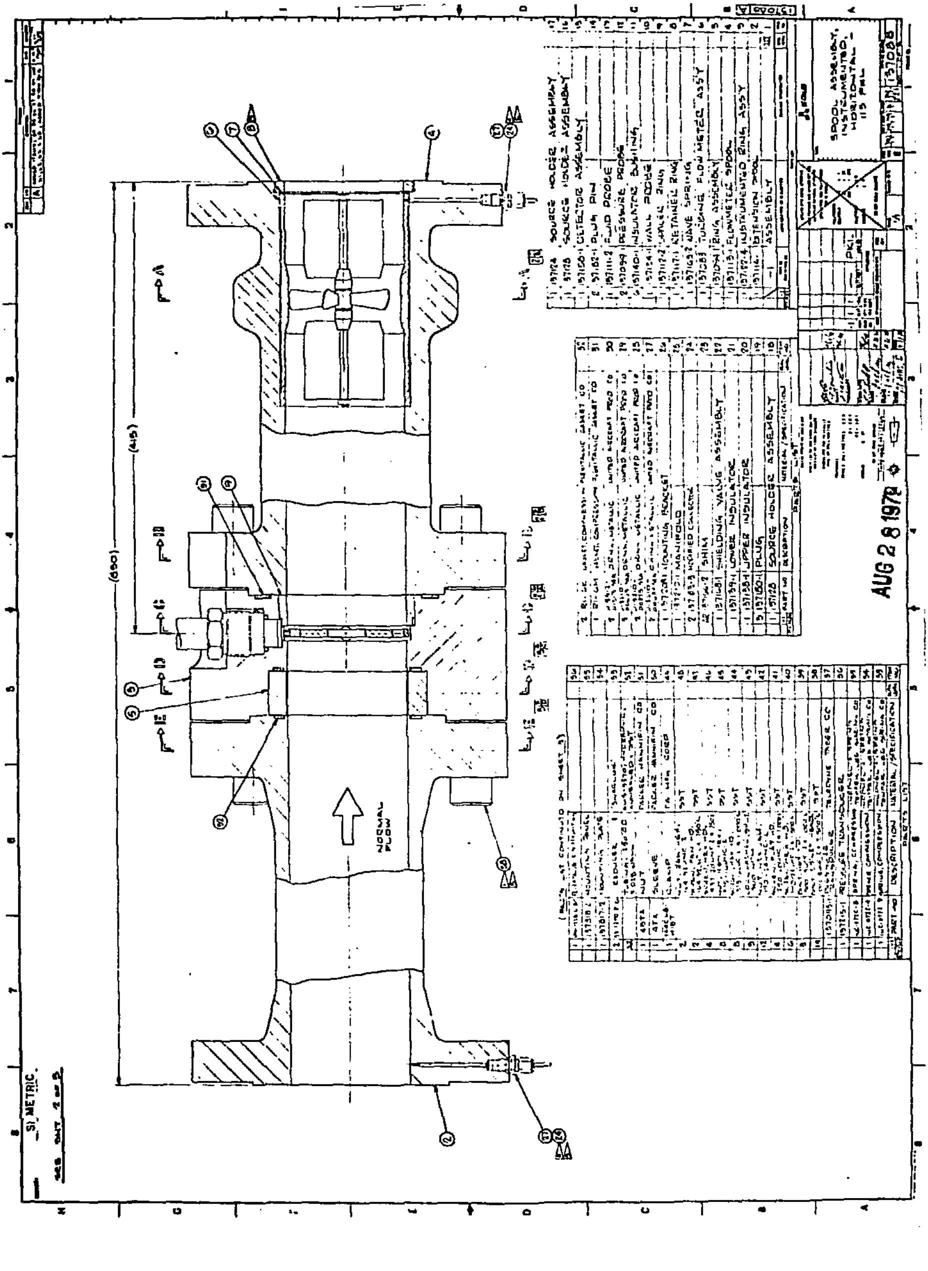
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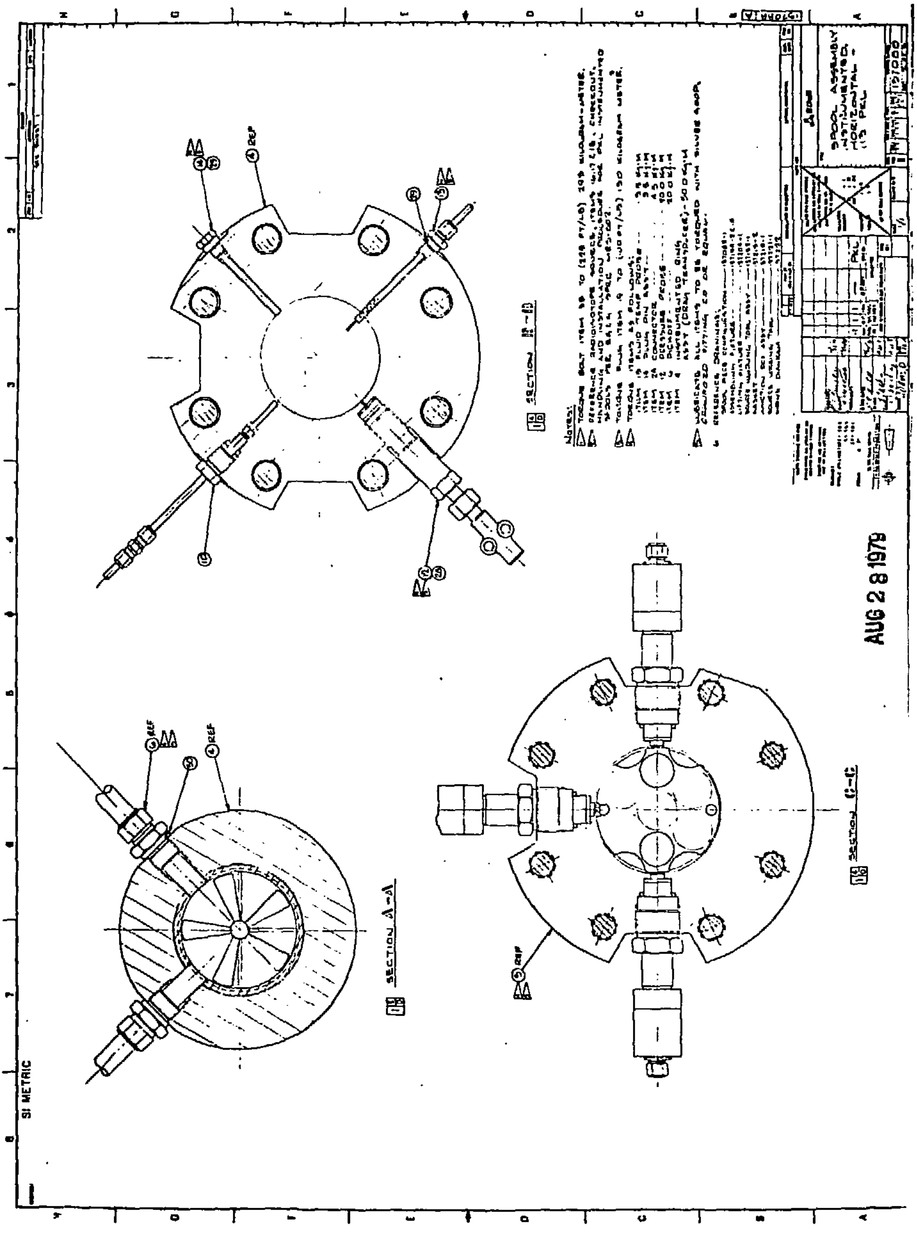
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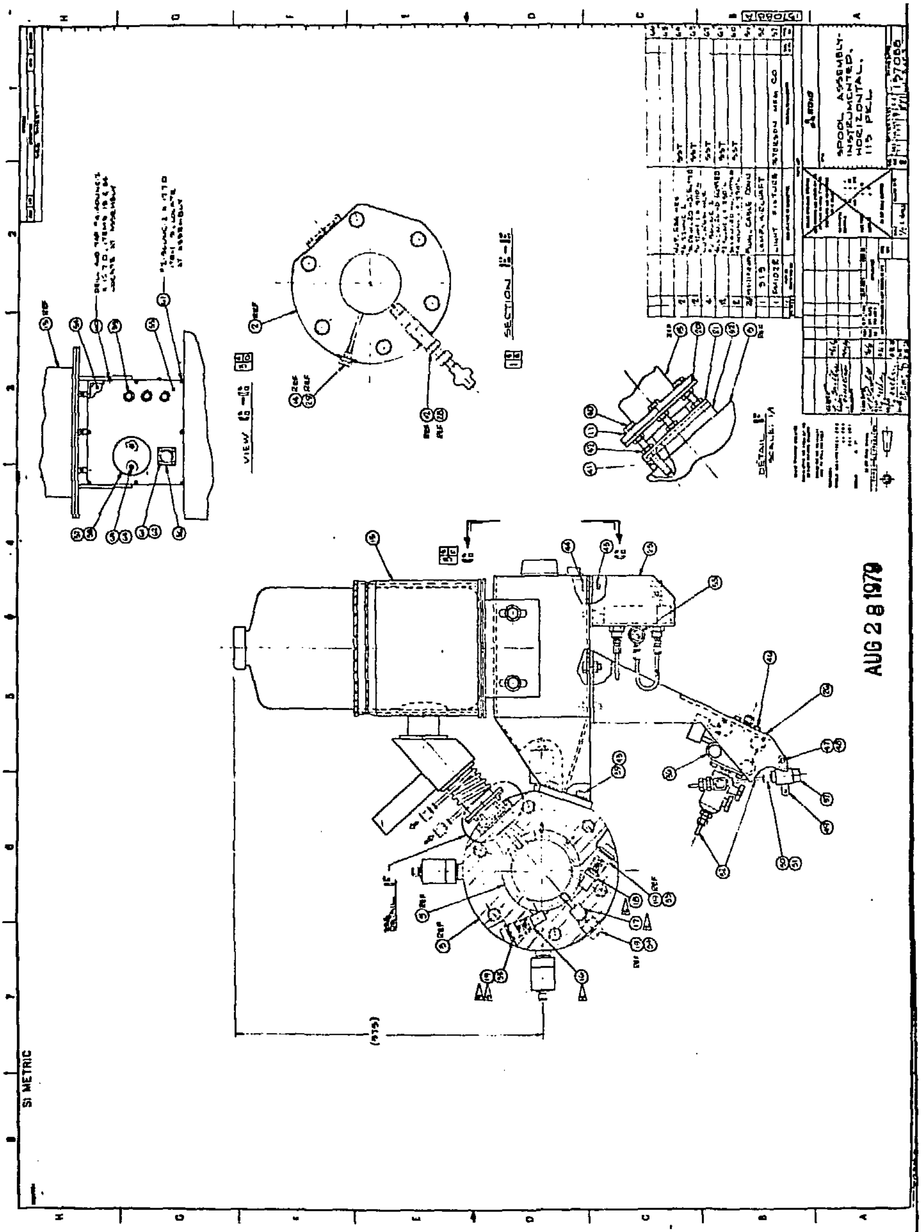
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VIEW
SECTION
DETAIL
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APPENDIX B

PKL SPOOL PIECE TEST RESULTS FROM SINGLE-PHASE SUPERHEATED-STEAM TESTS

APPENDIX B

The data presented in this appendix give the test results for the single-phase superheated-steam flow tests and compare these results to the Wyle Laboratory test facility measured results.

The test numbers applicable to each of the three spools tested are given below:

Spool No.	Test No.
1	38-97
3	148-194
4	252-300

A test number is indicated for each test and the data is presented with the printouts in the following format:

- First row: Average steam flow data is given to the right of the heading "STEAM FLOW =" with numerical values given in the "WYLE" AND "PKL" columns. In the same row, a percent difference calculated by equation (25) is given for these values under the column "% DIFF", and a deviation calculated by equation (27) is given for steam flow rate under column "DEVIATION".
- Second row: Data is given on standard deviations associated with the Wyle and PKL steam flow rates, respectively, and is calculated using equation (24).
- Third and fourth rows: Similar data as for the above two rows is presented for water flows.

- Fifth row: Data is given on the total flow which is a sum of the steam and water flow rates already given. A percent difference between the total Wyle and PKL flow is given in the "% DIFF" column and is calculated by equation (25).
- To the right of the above data, under the general heading of "AVERAGE PKL TEST PARAMETERS", are given the average values for the engineering unit data obtained from each of the instrument channels. Identification for each of the abbreviations is given below:

TF = fluid temperature.

TW = wall temperature.

TS = superheated-steam temperature (applicable only to spool no. 4).

DF1,DF2,DF3 = drag screen transducer force for transducer nos. 1, 2, and 3.

GD1,GD2,GD3 = density along beam nos. 1, 2, and 3 of the densitometer.

PA = fluid absolute pressure.

PD = drag screen differential pressure.

FT = turbine velocity.

DTT = drag screen momentum flux.

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
38	STEAM FLOW =	0.604	0.614	1.68	0.0107	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.003			-----	------	-------	PA(KPA)= 391.8
	WATER FLOW =	0.000	0.000	0.00	0.0000	TF=160.3	DF1= 3.131	GD1= 3.9	PD(KPA)= 1.232
	STD DEV =	0.000	0.000			TW=150.1	DF2= 3.201	GD2= 2.9	FT(M/S)= 56.47
	TOTAL FLOW =	0.604	0.614	1.68		TS= 0.0	DF3= 0.019	GD3= 2.0	DTT(KG/M-S)= 6567.2

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
47	STEAM FLOW =	0.490	0.530	8.22	0.0413	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.003	0.005			-----	------	-------	PA(KPA)= 608.6
	WATER FLOW =	0.000	0.000	0.00	0.0000	TF=170.7	DF1= 1.586	GD1= 5.0	PD(KPA)= 0.657
	STD DEV =	0.000	0.000			TW=162.7	DF2= 1.633	GD2= 3.9	FT(M/S)= 32.20
	TOTAL FLOW =	0.490	0.530	8.22		TS= 0.0	DF3=-0.006	GD3= 3.1	DTT(KG/M-S)= 3359.7

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
48	STEAM FLOW =	0.607	0.632	4.19	0.0260	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.002	0.002			-----	------	-------	PA(KPA)= 405.9
	WATER FLOW =	0.000	0.000	0.00	0.0000	TF=160.8	DF1= 3.293	GD1= 4.2	PD(KPA)= 1.310
	STD DEV =	0.000	0.000			TW=153.0	DF2= 3.375	GD2= 3.1	FT(M/S)= 56.24
	TOTAL FLOW =	0.607	0.632	4.19		TS= 0.0	DF3= 0.001	GD3= 2.1	DTT(KG/M-S)= 6895.1

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
61	STEAM FLOW =	0.609	0.626	2.75	0.0173	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.002	0.003			-----	------	-------	PA(KPA)= 399.5
	WATER FLOW =	0.000	0.000	0.00	0.0000	TF=156.5	DF1= 3.244	GD1= 3.5	PD(KPA)= 1.332
	STD DEV =	0.000	0.000			TW=147.8	DF2= 3.328	GD2= 3.5	FT(M/S)= 56.48
	TOTAL FLOW =	0.609	0.626	2.75		TS= 0.0	DF3= 0.021	GD3= 2.1	DTT(KG/M-S)= 6817.3

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
62	STEAM FLOW =	0.205	0.203	-1.01	0.0033	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.003			-----	------	-------	PA(KPA)= 401.9
	WATER FLOW =	0.000	0.000	0.00	0.0000	TF=152.9	DF1= 0.338	GD1= 4.1	PD(KPA)= 0.182
	STD DEV =	0.000	0.000			TW=145.2	DF2= 0.354	GD2= 3.7	FT(M/S)= 18.22
	TOTAL FLOW =	0.205	0.203	-1.01		TS= 0.0	DF3=-0.007	GD3= 2.2	DTT(KG/M-S)= 760.8

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
63	STEAM FLOW =	0.097	0.095	-2.23	0.0022	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.003	0.003			-----	------	-------	PA(KPA)= 388.9
	WATER FLOW =	0.000	0.000	0.00	0.0000	TF=149.4	DF1= 0.081	GD1= 6.9	PD(KPA)= 0.067
	STD DEV =	0.000	0.000			TW=143.9	DF2= 0.087	GD2= 3.9	FT(M/S)= 8.78
	TOTAL FLOW =	0.097	0.095	-2.23		TS= 0.0	DF3=-0.003	GD3= 2.9	DTT(KG/M-S)= 205.4

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
64	STEAM FLOW =	0.211	0.223	5.74	0.0123	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.001			-----	------	-------	PA(KPA)= 193.4
	WATER FLOW =	0.000	0.000	0.00	0.0000	TF=149.9	DF1= 0.786	GD1= 2.7	PD(KPA)= 0.350
	STD DEV =	0.000	0.000			TW=126.8	DF2= 0.698	GD2= 2.7	FT(M/S)= 39.76
	TOTAL FLOW =	0.211	0.223	5.74		TS= 0.0	DF3=-0.287	GD3= 1.1	DTT(KG/M-S)= 1285.5

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
71	STEAM FLOW =	-0.204	-0.204	0.23	0.0022	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.002			-----	------	-------	PA(KPA)= 412.0
	WATER FLOW =	0.000	0.000	0.00	0.0000	TF=153.2	DF1=-0.335	GD1= 3.9	PD(KPA)=-0.169
	STD DEV =	0.000	0.000			TW=146.6	DF2=-0.355	GD2= 4.1	FT(M/S)=-17.93
	TOTAL FLOW =	-0.204	-0.204	0.23		TS= 0.0	DF3=-0.022	GD3= 2.9	DTT(KG/M-S)= -787.2

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
72	STEAM FLOW =	-0.608	-0.626	3.02	0.0195	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.002	0.006			-----	------	-------	PA(KPA)= 395.9
	WATER FLOW =	0.000	0.000	0.00	0.0000	TF=161.0	DF1=-3.215	GD1= 3.9	PD(KPA)=-1.162
	STD DEV =	0.000	0.000			TW=150.0	DF2=-3.204	GD2= 3.9	FT(M/S)=-57.03
	TOTAL FLOW =	-0.608	-0.626	3.02		TS= 0.0	DF3=-0.129	GD3= 2.5	DTT(KG/M-S)=-7215.7

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
73	STEAM FLOW =	-0.102	-0.078	-23.17	0.0240	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.002	0.001			-----	------	-------	PA(KPA)= 401.0
	WATER FLOW =	0.000	0.000	0.00	0.0000	TF=150.0	DF1=-0.058	GD1= 14.1	PD(KPA)=-0.010
	STD DEV =	0.000	0.000			TW=145.4	DF2=-0.079	GD2= 4.2	FT(M/S)= -7.05
	TOTAL FLOW =	-0.102	-0.078	-23.17		TS= 0.0	DF3=-0.015	GD3= 3.4	DTT(KG/M-S)= -206.1

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
88	STEAM FLOW =	-0.212	-0.221	4.29	0.0089	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.003	0.002			-----	------	-------	PA(KPA)= 207.8
	WATER FLOW =	0.000	0.000	0.00	0.0000	TF=138.9	DF1=-0.725	GD1= 3.4	PD(KPA)=-0.265
	STD DEV =	0.000	0.000			TW=123.2	DF2=-0.753	GD2= 4.3	FT(M/S)=-36.84
	TOTAL FLOW =	-0.212	-0.221	4.29		TS= 0.0	DF3=-0.045	GD3= 1.1	DTT(KG/M-S)=-1722.4

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
89	STEAM FLOW =	-0.610	-0.640	4.89	0.0304	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.002	0.002			-----	------	-------	PA(KPA)= 407.2
	WATER FLOW =	0.000	0.000	0.00	0.0000	TF=159.2	DF1=-3.331	GD1= 4.3	PD(KPA)=-1.164
	STD DEV =	0.000	0.000			TW=145.1	DF2=-3.321	GD2= 4.6	FT(M/S)=-56.73
	TOTAL FLOW =	-0.610	-0.640	4.89		TS= 0.0	DF3=-0.064	GD3= 2.0	DTT(KG/M-S)=-7390.2

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
90	STEAM FLOW =	-0.462	-0.477	3.34	0.0163	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.002	0.005			-----	------	-------	PA(KPA)= 612.7
	WATER FLOW =	0.000	0.000	0.00	0.0000	TF=171.8	DF1=-1.250	GD1= 5.4	PD(KPA)=-0.441
	STD DEV =	0.000	0.000			TW=162.7	DF2=-1.260	GD2= 5.3	FT(M/S)=-28.81
	TOTAL FLOW =	-0.462	-0.477	3.34		TS= 0.0	DF3=-0.049	GD3= 2.9	DTT(KG/M-S)=-2905.9

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
97	STEAM FLOW =	-0.607	-0.618	1.82	0.0114	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.002			-----	------	-------	PA(KPA)= 405.7
	WATER FLOW =	0.000	0.000	0.00	0.0000	TF=161.5	DF1=-3.097	GD1= 3.6	PD(KPA)=-1.137
	STD DEV =	0.000	0.000			TW=147.3	DF2=-3.053	GD2= 4.9	FT(M/S)=-54.99
	TOTAL FLOW =	-0.607	-0.618	1.82		TS= 0.0	DF3=-0.063	GD3= 1.9	DTT(KG/M-S)=-6866.6

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
148	STEAM FLOW =	1.138	1.191	4.65	0.0537	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.007	0.004			-----	------	-------	PA(KPA)= 404.1
	WATER FLOW =	0.000	0.000	0.00	0.0000	TF=162.7	DF1= 6.182	GD1= 0.0	PD(KPA)= 2.183
	STD DEV =	0.000	0.000			TW=144.1	DF2= 6.278	GD2= 0.0	FT(M/S)= 54.38
	TOTAL FLOW =	1.138	1.191	4.65		TS= 0.0	DF3= 0.269	GD3= 1.2	DTT(KG/M-S)= 6273.0

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
157	STEAM FLOW =	1.174	1.212	3.25	0.0387	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.007	0.005			-----	------	-------	PA(KPA)= 412.4
	WATER FLOW =	0.000	0.000	0.00	0.0000	TF=158.0	DF1= 6.401	GD1= 3.0	PD(KPA)= 1.744
	STD DEV =	0.000	0.000			TW=144.8	DF2= 6.492	GD2= 1.2	FT(M/S)= 54.29
	TOTAL FLOW =	1.174	1.212	3.25		TS= 0.0	DF3= 0.218	GD3= 1.9	DTT(KG/M-S)= 6452.3

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
172	STEAM FLOW =	1.157	1.205	4.16	0.0481	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.009	0.004			-----	------	-------	PA(KPA)= 404.6
	WATER FLOW =	0.000	0.000	0.00	0.0000	TF=160.0	DF1= 6.372	GD1= 3.2	PD(KPA)= 1.822
	STD DEV =	0.000	0.000			TW=144.0	DF2= 6.453	GD2= 1.2	FT(M/S)= 54.97
	TOTAL FLOW =	1.157	1.205	4.16		TS= 0.0	DF3= 0.245	GD3= 1.9	DTT(KG/M-S)= 6433.3

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
183	STEAM FLOW =	-1.161	-1.246	7.33	0.0875	DEG C	NEWTON.	KG/M**3	
	STD DEV =	0.003	0.011			-----	------	-------	PA(KPA)= 404.7
	WATER FLOW =	0.000	0.000	0.00	0.0000	TF=163.9	DF1=-6.265	GD1= 1.5	PD(KPA)=-1.570
	STD DEV =	0.000	0.000			TW=146.8	DF2=-6.088	GD2= 1.4	FT(M/S)=-56.81
	TOTAL FLOW =	-1.161	-1.246	7.33		TS= 0.0	DF3=-0.241	GD3= 1.9	DTT(KG/M-S)=-6952.1

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
194	STEAM FLOW =	-1.175	-1.258	7.08	0.0850	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.003	0.005			-----	------	-------	PA(KPA)= 406.0
	WATER FLOW =	0.000	0.000	0.00	0.0000	TF=161.6	DF1=-6.303	GD1= 1.9	PD(KPA)=-1.377
	STD DEV =	0.000	0.000			TW=144.0	DF2=-6.180	GD2= 2.4	FT(M/S)=-57.20
	TOTAL FLOW =	-1.175	-1.258	7.08		TS= 0.0	DF3=-0.222	GD3= 2.0	DTT(KG/M-S)=-7004.4

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
252	STEAM FLOW =	0.609	0.616	1.23	0.0068	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.004	0.002			-----	------	-------	PA(KPA)= 418.7
	WATER FLOW =	0.000	0.000	0.00	0.0000	TF=159.0	DF1= 3.369	GD1= 2.1	PD(KPA)= 3.487
	STD DEV =	0.000	0.000			TW=142.8	DF2= 3.332	GD2= 2.0	FT(M/S)= 53.24
	TOTAL FLOW =	0.609	0.616	1.23		TS=157.5	DF3= 0.037	GD3= 1.9	DTT(KG/M-S)= 6965.8

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
264	STEAM FLOW =	0.611	0.621	1.64	0.0103	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.003	0.003			-----	------	-------	PA(KPA)= 415.5
	WATER FLOW =	0.000	0.000	0.00	0.0000	TF=160.5	DF1= 3.412	GD1= 2.5	PD(KPA)= 2.953
	STD DEV =	0.000	0.000			TW=142.6	DF2= 3.370	GD2= 2.3	FT(M/S)= 54.03
	TOTAL FLOW =	0.611	0.621	1.64		TS=159.2	DF3= 0.038	GD3= 1.7	DTT(KG/M-S)= 7048.4

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
293	STEAM FLOW =	-0.613	-0.701	14.35	0.0897	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.003	0.001			-----	------	-------	PA(KPA)= 422.4
	WATER FLOW =	0.000	0.000	0.00	0.0000	TF=160.5	DF1=-3.170	GD1= 2.2	PD(KPA)= 0.463
	STD DEV =	0.000	0.000			TW= -0.0	DF2=-3.050	GD2= 3.2	FT(M/S)=-60.04
	TOTAL FLOW =	-0.613	-0.701	14.35		TS=161.8	DF3=-0.026	GD3= 1.8	DTT(KG/M-S)=-6949.5

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
300	STEAM FLOW =	-0.617	-0.701	13.65	0.0859	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.003	0.001			-----	------	-------	PA(KPA)= 422.8
	WATER FLOW =	0.000	0.000	0.00	0.0000	TF=158.3	DF1=-3.148	GD1= 2.7	PD(KPA)= 0.457
	STD DEV =	0.000	0.000			TW= 0.0	DF2=-3.063	GD2= 4.9	FT(M/S)=-60.02
	TOTAL FLOW =	-0.617	-0.701	13.65		TS=159.8	DF3=-0.016	GD3= 1.8	DTT(KG/M-S)=-6930.5

APPENDIX C

PKL SPOOL PIECE TEST RESULTS FROM TWO-PHASE WATER AND STEAM FLOW TESTS

APPENDIX C

The data presented in this appendix give the test results for the two-phase water and steam flow tests and compare the results to the Wyle Laboratory test facility measured results.

The test numbers applicable to each of the three spools tested are given below:

Spool No.	Test No.
1	36-99
2	146-193
3	245-299

A test number is indicated for each test and the data is presented with the printouts in the following format:

- First row: Average steam flow data is given to the right of the heading "STEAM FLOW =" with numerical values given in the "WYLE" AND "PKL" columns. In the same row, a percent difference calculated by equation (25) is given for these values under the column "% DIFF", and a deviation calculated by equation (27) is given for steam flow rate under column "DEVIATION".
- Second row: Data is given on standard deviations associated with the Wyle and PKL steam flow rates, respectively, and is calculated using equation (24).
- Third and fourth rows: Similar data as for the above two rows is presented for water flows.
- Fifth row: Data is given on the total flow which is a sum of the steam and water flow rates already given. A percent difference between the total Wyle and PKL flow is given in the "% DIFF" column and is calculated by equation (25).

- To the right of the above data, under the general heading of "AVERAGE PKL TEST PARAMETERS", are given the average values for the engineering unit data obtained from each of the instrument channels. Identification for each of the abbreviations is given below:

  TF = fluid temperature.

  TW = wall temperature.

  TS = superheated-steam temperature (applicable only to spool no. 4).

  DF1,DF2,DF3 = drag screen transducer force for transducer nos. 1, 2, and 3.

  GD1,GD2,GD3 = density along beam nos. 1, 2, and 3 of the densitometer.

  PA = fluid absolute pressure.

  PD = drag screen differential pressure.

  FT = turbine velocity.

  DTT = drag screen momentum flux.

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
36	STEAM FLOW =	0.071	0.131	84.67	0.0851	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.059			-----	------	-------	PA(KPA)= 414.2
	WATER FLOW =	4.280	3.808	-11.04	1.3351	TF=146.0	DF1= 1.429	GD1= 547.3	PD(KPA)= 0.790
	STD DEV =	0.004	1.245			TW=146.5	DF2= 1.432	GD2= 244.1	FT(M/S)= 3.19
	TOTAL FLOW =	4.351	3.939	-9.48		TS= 0.0	DF3=-0.442	GD3= 7.0	DTT(KG/M-S)= 2534.7

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
37	STEAM FLOW =	0.592	0.621	4.88	0.0296	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.002	0.003			-----	------	-------	PA(KPA)= 415.9
	WATER FLOW =	0.212	0.135	-36.28	0.0786	TF=145.7	DF1= 3.251	GD1= 10.3	PD(KPA)= 1.492
	STD DEV =	0.000	0.004			TW=147.4	DF2= 3.270	GD2= 3.7	FT(M/S)= 45.64
	TOTAL FLOW =	0.804	0.756	-5.97		TS= 0.0	DF3=-0.013	GD3= 5.5	DTT(KG/M-S)= 6729.6

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
41	STEAM FLOW =	0.069	0.158	128.31	0.0964	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.002	0.031			-----	------	-------	PA(KPA)= 400.9
	WATER FLOW =	4.266	3.499	-17.99	1.2842	TF=143.0	DF1= 1.387	GD1= 566.5	PD(KPA)= 0.737
	STD DEV =	0.007	1.010			TW=144.0	DF2= 1.372	GD2= 221.6	FT(M/S)= 3.18
	TOTAL FLOW =	4.335	3.656	-15.66		TS= 0.0	DF3=-0.593	GD3= 6.8	DTT(KG/M-S)= 2276.7

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
42	STEAM FLOW =	0.592	0.627	5.97	0.0363	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.002	0.003			-----	------	-------	PA(KPA)= 398.0
	WATER FLOW =	0.219	0.158	-27.85	0.0626	TF=143.3	DF1= 3.507	GD1= 10.1	PD(KPA)= 1.592
	STD DEV =	0.003	0.004			TW=145.3	DF2= 3.556	GD2= 3.7	FT(M/S)= 47.11
	TOTAL FLOW =	0.811	0.785	-3.17		TS= 0.0	DF3=-0.076	GD3= 5.0	DTT(KG/M-S)= 7214.9

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
43	STEAM FLOW =	0.351	0.457	30.30	0.1089	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.002	0.004			-----	------	-------	PA(KPA)= 392.4
	WATER FLOW =	0.674	0.905	34.32	0.2389	TF=142.9	DF1= 2.436	GD1= 104.2	PD(KPA)= 1.159
	STD DEV =	0.002	0.032			TW=144.5	DF2= 2.501	GD2= 5.6	FT(M/S)= 18.30
	TOTAL FLOW =	1.025	1.363	32.95		TS= 0.0	DF3=-0.225	GD3= 5.5	DTT(KG/M-S)= 4862.4

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
44	STEAM FLOW =	0.047	0.041	-12.15	0.0070	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.004			-----	------	-------	PA(KPA)= 402.2
	WATER FLOW =	0.155	0.093	-39.74	0.0687	TF=143.7	DF1= 0.035	GD1= 283.5	PD(KPA)= 0.050
	STD DEV =	0.001	0.026			TW=145.0	DF2= 0.005	GD2= 5.0	FT(M/S)= 1.44
	TOTAL FLOW =	0.202	0.135	-33.32		TS= 0.0	DF3=-0.010	GD3= 6.4	DTT(KG/M-S)= 37.6

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
45	STEAM FLOW =	0.254	0.259	1.79	0.0055	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.003			-----	------	-------	PA(KPA)= 620.8
	WATER FLOW =	0.300	0.373	24.44	0.0804	TF=160.9	DF1= 0.462	GD1= 143.4	PD(KPA)= 0.255
	STD DEV =	0.006	0.028			TW=161.2	DF2= 0.463	GD2= 4.5	FT(M/S)= 7.60
	TOTAL FLOW =	0.554	0.632	14.06		TS= 0.0	DF3=-0.069	GD3= 3.9	DTT(KG/M-S)= 934.9

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
46	STEAM FLOW =	0.714	0.750	5.10	0.0381	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.004	0.003			-----	------	-------	PA(KPA)= 613.3
	WATER FLOW =	0.218	0.166	-24.03	0.0552	TF=159.8	DF1= 3.337	GD1= 11.6	PD(KPA)= 1.518
	STD DEV =	0.001	0.005			TW=161.6	DF2= 3.376	GD2= 5.3	FT(M/S)= 38.57
	TOTAL FLOW =	0.932	0.916	-1.71		TS= 0.0	DF3=-0.049	GD3= 6.1	DTT(KG/M-S)= 6890.7

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
54	STEAM FLOW =	0.089	0.095	6.22	0.0057	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.001			-----	------	-------	PA(KPA)= 197.6
	WATER FLOW =	0.293	0.399	36.34	0.1101	TF=120.3	DF1= 0.187	GD1= 206.2	PD(KPA)= 0.102
	STD DEV =	0.000	0.018			TW=121.4	DF2= 0.194	GD2= 4.0	FT(M/S)= 4.28
	TOTAL FLOW =	0.382	0.494	29.32		TS= 0.0	DF3=-0.041	GD3= 2.9	DTT(KG/M-S)= 411.8

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
55	STEAM FLOW =	0.360	0.444	23.41	0.0859	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.005	0.001			-----	------	-------	PA(KPA)= 199.4
	WATER FLOW =	0.295	0.239	-18.83	0.0569	TF=119.8	DF1= 3.269	GD1= 13.9	PD(KPA)= 1.579
	STD DEV =	0.001	0.003			TW=121.6	DF2= 3.607	GD2= 3.9	FT(M/S)= 52.94
	TOTAL FLOW =	0.655	0.684	4.36		TS= 0.0	DF3=-0.048	GD3= 4.6	DTT(KG/M-S)= 7056.9

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
56	STEAM FLOW =	0.056	0.126	125.82	0.0728	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.012			-----	------	-------	PA(KPA)= 196.7
	WATER FLOW =	3.100	2.525	-18.56	1.0343	TF=120.0	DF1= 1.115	GD1= 540.2	PD(KPA)= 0.620
	STD DEV =	0.006	0.851			TW=120.8	DF2= 1.089	GD2= 199.1	FT(M/S)= 3.32
	TOTAL FLOW =	3.156	2.651	-15.99		TS= 0.0	DF3=-0.585	GD3= 5.5	DTT(KG/M-S)= 1717.3

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
57	STEAM FLOW =	0.072	0.149	106.33	0.0968	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.057			-----	------	-------	PA(KPA)= 409.4
	WATER FLOW =	4.304	3.848	-10.59	1.2567	TF=145.1	DF1= 1.531	GD1= 591.8	PD(KPA)= 0.869
	STD DEV =	0.007	1.167			TW=145.1	DF2= 1.525	GD2= 248.1	FT(M/S)= 3.20
	TOTAL FLOW =	4.376	3.997	-8.67		TS= 0.0	DF3=-0.619	GD3= 6.9	DTT(KG/M-S)= 2552.7

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
58	STEAM FLOW =	0.579	0.615	6.27	0.0371	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.002			-----	------	-------	PA(KPA)= 391.9
	WATER FLOW =	0.216	0.154	-28.74	0.0635	TP=143.0	DF1= 3.392	GD1= 10.2	PD(KPA)= 1.589
	STD DEV =	0.001	0.004			TW=144.6	DF2= 3.454	GD2= 4.2	FT(M/S)= 46.84
	TOTAL FLOW =	0.795	0.769	-3.24		TS= 0.0	DF3=-0.048	GD3= 5.0	DTT(KG/M-S)= 7027.0

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
59	STEAM FLOW =	0.155	0.265	71.26	0.1129	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.006			-----	------	-------	PA(KPA)= 603.9
	WATER FLOW =	2.865	2.626	-8.36	0.5506	TF=160.1	DF1= 1.327	GD1= 491.4	PD(KPA)= 0.771
	STD DEV =	0.000	0.493			TW=159.7	DF2= 1.318	GD2= 173.1	FT(M/S)= 3.92
	TOTAL FLOW =	3.020	2.891	-4.27		TS= 0.0	DF3=-0.549	GD3= 8.5	DTT(KG/M-S)= 2205.2

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
60	STEAM FLOW =	0.065	0.082	26.01	0.0177	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.003	0.005			-----	------	-------	PA(KPA)= 617.3
	WATER FLOW =	0.428	0.536	25.13	0.1251	TF=160.6	DF1= 0.065	GD1= 406.2	PD(KPA)= 0.046
	STD DEV =	0.001	0.060			TW=160.8	DF2= 0.064	GD2= 84.9	FT(M/S)= 1.28
	TOTAL FLOW =	0.493	0.617	25.25		TS= 0.0	DF3=-0.005	GD3= 4.7	DTT(KG/M-S)= 154.1

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
69	STEAM FLOW =	-0.584	-0.625	6.99	0.0418	DEG C	NEWTON.	KG/M**3	
	STD DEV =	0.002	0.004			-----	------	-------	PA(KPA)= 406.4
	WATER FLOW =	-0.168	-0.176	4.51	0.0091	TF=144.8	DF1=-3.265	GD1= 5.0	PD(KPA)=-1.343
	STD DEV =	0.001	0.005			TW=145.7	DF2=-3.268	GD2= 5.0	FT(M/S)=-45.69
	TOTAL FLOW =	-0.752	-0.800	6.43		TS= 0.0	DF3= 0.065	GD3= 7.0	DTT(KG/M-S)=-7132.0

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
70	STEAM FLOW =	-0.350	-0.200	-42.76	0.1527	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.003	0.003			-----	------	-------	PA(KPA)= 409.0
	WATER FLOW =	-0.694	-1.389	100.17	0.7099	TF=145.2	DF1=-2.497	GD1= 21.5	PD(KPA)=-1.373
	STD DEV =	0.002	0.024			TW=145.8	DF2=-2.390	GD2- 10.4	FT(M/S)=-15.97
	TOTAL FLOW =	-1.044	-1.590	52.25		TS= 0.0	DF3=-0.100	GD3= 19.8	DTT(KG/M-S)=-5575.1

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
74	STEAM FLOW =	-0.044	-0.026	-40.74	0.0188	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.000	0.004			-----	------	-------	PA(KPA)= 404.6
	WATER FLOW =	-0.142	-0.128	-9.80	0.0288	TF=145.9	DF1=-0.013	GD1= 27.0	PD(KPA)= 0.029
	STD DEV =	0.001	0.025			TW=145.4	DF2=-0.038	GD2= 4.7	FT(M/S)= -0.07
	TOTAL FLOW =	-0.186	-0.154	-17.12		TS= 0.0	DF3=-0.013	GD3= 7.3	DTT(KG/M-S)= -71.0

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
75	STEAM FLOW =	-0.073	-0.073	-0.65	0.0530	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.002	0.053			-----	------	-------	PA(KPA)= 411.9
	WATER FLOW =	-4.320	-4.763	10.25	0.9971	TF=145.7	DF1=-1.733	GD1= 449.5	PD(KPA)=-0.956
	STD DEV =	0.002	0.889			TW=146.0	DF2=-1.726	GD2= 288.3	FT(M/S)= -3.22
	TOTAL FLOW =	-4.393	-4.835	10.07		TS= 0.0	DF3= 0.566	GD3= 26.6	DTT(KG/M-S)=-3271.5

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
78	STEAM FLOW =	-0.060	-0.087	44.51	0.0273	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.002			-----	------	-------	PA(KPA)= 629.5
	WATER FLOW =	-0.444	-0.617	38.85	0.1795	TF=161.3	DF1=-0.067	GD1= 370.9	PD(KPA)= 0.034
	STD DEV =	0.001	0.035			TW=161.7	DF2=-0.087	GD2= 121.7	FT(M/S)= -1.37
	TOTAL FLOW =	-0.504	-0.703	39.53		TS= 0.0	DF3= 0.017	GD3= 4.1	DTT(KG/M-S)= -187.7

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
79	STEAM FLOW =	-0.161	-0.226	40.19	0.0684	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.018			-----	------	-------	PA(KPA)= 625.7
	WATER FLOW =	-2.916	-3.634	24.63	0.7773	TF=161.2	DF1=-1.639	GD1= 300.5	PD(KPA)=-0.796
	STD DEV =	0.005	0.259			TW=161.4	DF2=-1.544	GD2= 222.6	FT(M/S)= -4.05
	TOTAL FLOW =	-3.077	-3.860	25.44		TS= 0.0	DF3= 0.501	GD3= 22.4	DTT(KG/M-S)=-3045.5

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
80	STEAM FLOW =	-0.253	-0.240	-5.18	0.0274	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.002	0.024			-----	------	-------	PA(KPA)= 622.4
	WATER FLOW =	-0.289	-0.491	69.95	0.2229	TF=160.8	DF1=-0.513	GD1= 56.6	PD(KPA)=-0.268
	STD DEV =	0.004	0.030			TW=161.4	DF2=-0.522	GD2= 10.3	FT(M/S)= -8.39
	TOTAL FLOW =	-0.542	-0.731	34.88		TS= 0.0	DF3=-0.028	GD3= 17.3	DTT(KG/M-S)=-1192.8

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
81	STEAM FLOW =	-0.718	-0.737	2.70	0.0208	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.003	0.007			-----	------	-------	PA(KPA)= 612.8
	WATER FLOW =	-0.160	-0.192	20.09	0.0435	TF=160.3	DF1=-3.123	GD1= 6.8	PD(KPA)=-1.251
	STD DEV =	0.001	0.029			TW=160.7	DF2=-3.124	GD2= 5.7	FT(M/S)=-37.82
	TOTAL FLOW =	-0.878	-0.930	5.87		TS= 0.0	DF3= 0.048	GD3= 7.0	DTT(KG/M-S)=-6852.8

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
82	STEAM FLOW =	-0.370	-0.489	32.08	0.1212	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.002	0.005			-----	------	-------	PA(KPA)= 200.2
	WATER FLOW =	-0.297	-0.329	10.79	0.0389	TF=120.6	DF1=-4.381	GD1= 5.3	PD(KPA)=-1.660
	STD DEV =	0.002	0.021			TW=121.6	DF2=-4.010	GD2= 6.0	FT(M/S)=-56.05
	TOTAL FLOW =	-0.667	-0.818	22.60		TS= 0.0	DF3= 0.187	GD3= 6.8	DTT(KG/M-S)=-8934.9

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
83	STEAM FLOW =	-0.092	-0.093	1.17	0.0332	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.033			-----	------	-------	PA(KPA)= 198.0
	WATER FLOW =	-0.299	-0.594	98.59	0.3513	TF=119.9	DF1=-0.362	GD1= 118.1	PD(KPA)=-0.104
	STD DEV =	0.001	0.181			TW=121.3	DF2=-0.329	GD2= 12.7	FT(M/S)= -5.44
	TOTAL FLOW =	-0.391	-0.687	75.67		TS= 0.0	DF3= 0.059	GD3= 9.0	DTT(KG/M-S)= -696.5

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
84	STEAM FLOW =	-0.054	-0.131	141.86	0.1037	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.068			-----	------	-------	PA(KPA)= 198.9
	WATER FLOW =	-3.032	-2.806	-7.45	1.1865	TF=120.4	DF1=-1.256	GD1= 281.2	PD(KPA)=-0.645
	STD DEV =	0.006	1.164			TW=121.4	DF2=-1.201	GD2= 281.0	FT(M/S)= -4.18
	TOTAL FLOW =	-3.086	-2.937	-4.83		TS= 0.0	DF3= 0.449	GD3= 10.8	DTT(KG/M-S)=-2279.2

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
85	STEAM FLOW =	-0.022	-0.056	154.51	0.0357	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.000	0.004			-----	------	-------	PA(KPA)= 200.9
	WATER FLOW =	-0.302	-0.286	-5.41	0.1324	TF=120.5	DF1=-0.043	GD1= 368.7	PD(KPA)= 0.017
	STD DEV =	0.001	0.131			TW=121.7	DF2=-0.056	GD2= 92.9	FT(M/S)= -2.54
	TOTAL FLOW =	-0.324	-0.342	5.45		TS= 0.0	DF3=-0.016	GD3= 3.9	DTT(KG/M-S)= -151.2

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PKL PROTOTYPE SPOOL TEST RESULTS
TEST NO. UNITS (KG/S)     WYLE     PKL    % DIFF  DEVIATION              AVERAGE PKL TEST PARAMETERS
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  91    STEAM FLOW =  -0.581  -0.628    8.16    0.0484     DEG C      NEWTON.    KG/M**3

          STD DEV =    0.003   0.004                       -----      ------     -------  PA(KPA)= 409.1

        WATER FLOW =  -0.218  -0.253   16.14    0.0365  TF=145.0 DF1=-3.533 GD1=    5.9  PD(KPA)=-1.385

          STD DEV =    0.002   0.007                    TW=146.1 DF2=-3.422 GD2=    5.8  FT(M/S)=-43.17

        TOTAL FLOW =  -0.799  -0.882   10.33            TS=  0.0 DF3= 0.208 GD3=    7.4  DTT(KG/M-S)=-7422.4
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PKL PROTOTYPE SPOOL TEST RESULTS
TEST NO. UNITS (KG/S)     WYLE     PKL    % DIFF  DEVIATION              AVERAGE PKL TEST PARAMETERS
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  92    STEAM FLOW =  -0.351  -0.190  -45.86    0.1642     DEG C      NEWTON     KG/M**3

          STD DEV =    0.005   0.003                       -----      ------     -------  PA(KPA)= 407.3

        WATER FLOW =  -0.691  -1.333   92.94    0.6559  TF=144.9 DF1=-2.288 GD1=   23.1  PD(KPA)=-1.245

          STD DEV =    0.001   0.022                    TW=145.9 DF2=-2.171 GD2=   10.6  FT(M/S)=-14.40

        TOTAL FLOW =  -1.042  -1.523   46.19            TS=  0.0 DF3=-0.085 GD3=   18.4  DTT(KG/M-S)=-5037.8
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PKL PROTOTYPE SPOOL TEST RESULTS
TEST NO. UNITS (KG/S)     WYLE     PKL    % DIFF  DEVIATION              AVERAGE PKL TEST PARAMETERS
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  93    STEAM FLOW =  -0.589  -0.628    6.59    0.0399     DEG C      NEWTON     KG/M**3

          STD DEV =    0.001   0.004                       -----      ------     -------  PA(KPA)= 409.4

        WATER FLOW =  -0.174  -0.208   19.59    0.0355  TF=144.9 DF1=-3.385 GD1=    5.4  PD(KPA)=-1.324

          STD DEV =    0.001   0.007                    TW=145.9 DF2=-3.323 GD2=    5.0  FT(M/S)=-44.71

        TOTAL FLOW =  -0.763  -0.836    9.56            TS=  0.0 DF3= 0.038 GD3=    6.5  DTT(KG/M-S)=-7289.6
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PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
94	STEAM FLOW =	-0.070	-0.088	25.11	0.0240	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.014			-----	------	-------	PA(KPA)= 403.5
	WATER FLOW =	-4.270	-4.461	4.47	0.2860	TF=144.6	DF1=-1.508	GD1= 483.2	PD(KPA)=-0.788
	STD DEV =	0.003	0.191			TW=145.3	DF2=-1.540	GD2= 280.0	FT(M/S)= -3.11
	TOTAL FLOW =	-4.340	-4.548	4.80		TS= 0.0	DF3= 0.619	GD3= 25.9	DTT(KG/M-S)=-2758.6

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
98	STEAM FLOW =	-0.589	-0.631	7.20	0.0434	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.002	0.004			-----	------	-------	PA(KPA)= 404.1
	WATER FLOW =	-0.172	-0.198	15.02	0.0273	TF=144.6	DF1=-3.427	GD1= 5.4	PD(KPA)=-1.407
	STD DEV =	0.002	0.007			TW=144.4	DF2=-3.396	GD2= 5.4	FT(M/S)=-45.76
	TOTAL FLOW =	-0.761	-0.829	8.97		TS= 0.0	DF3= 0.097	GD3= 6.2	DTT(KG/M-S)=-7400.8

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
99	STEAM FLOW =	-0.070	-0.125	78.98	0.0623	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.002	0.018			-----	------	-------	PA(KPA)= 399.9
	WATER FLOW =	-4.368	-4.017	-8.02	0.4474	TF=144.3	DF1=-1.460	GD1= 445.1	PD(KPA)=-0.803
	STD DEV =	0.006	0.238			TW=143.8	DF2=-1.415	GD2= 279.4	FT(M/S)= -3.14
	TOTAL FLOW =	-4.438	-4.143	-6.65		TS= 0.0	DF3= 0.643	GD3= 25.7	DTT(KG/M-S)=-2533.8

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
146	STEAM FLOW =	0.140	0.351	150.93	0.2157	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.003			-----	------	-------	PA(KPA)= 414.8
	WATER FLOW =	8.330	5.854	-29.73	2.5317	TF=146.1	DF1= 2.098	GD1= 744.4	PD(KPA)= 0.869
	STD DEV =	0.005	0.147			TW= 30.2	DF2= 2.327	GD2= 379.2	FT(M/S)= 2.95
	TOTAL FLOW =	8.470	6.205	-26.74		TS= 0.0	DF3=-0.953	GD3= 5.8	DTT(KG/M-S)= 1826.0

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
147	STEAM FLOW =	1.098	0.969	-11.73	0.1236	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.045	0.005			-----	------	-------	PA(KPA)= 411.8
	WATER FLOW =	0.340	0.221	-34.94	0.1219	TF=145.5	DF1= 4.841	GD1= 0.0	PD(KPA)= 1.562
	STD DEV =	0.005	0.014			TW=142.8	DF2= 5.318	GD2= 0.0	FT(M/S)= 43.50
	TOTAL FLOW =	1.438	1.190	-17.21		TS= 0.0	DF3= 0.212	GD3= 3.6	DTT(KG/M-S)= 5164.0

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
152	STEAM FLOW =	0.513	0.507	-1.16	0.0000	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.021	0.003			-----	------	-------	PA(KPA)= 629.3
	WATER FLOW =	0.582	0.687	18.03	0.1128	TF=161.9	DF1= 0.802	GD1= 169.6	PD(KPA)= 0.249
	STD DEV =	0.002	0.036			TW=157.3	DF2= 0.924	GD2= 2.6	FT(M/S)= 7.60
	TOTAL FLOW =	1.095	1.194	9.04		TS= 0.0	DF3=-0.015	GD3= 3.7	DTT(KG/M-S)= 903.7

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
153	STEAM FLOW =	0.516	0.510	-1.18	0.0000	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.022	0.006			-----	------	-------	PA(KPA)= 630.2
	WATER FLOW =	0.595	0.698	17.26	0.1106	TF=161.9	DF1= 0.818	GD1= 170.8	PD(KPA)= 0.251
	STD DEV =	0.004	0.036			TW=158.1	DF2= 0.940	GD2= 2.5	FT(M/S)= 7.60
	TOTAL FLOW =	1.111	1.208	8.70		TS= 0.0	DF3=-0.026	GD3= 3.7	DTT(KG/M-S)= 914.3

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
154	STEAM FLOW =	1.438	1.359	-5.52	0.0562	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.059	0.008			-----	------	-------	PA(KPA)= 627.7
	WATER FLOW =	0.327	0.081	-75.27	0.2513	TF=161.6	DF1= 5.415	GD1= 11.1	PD(KPA)= 1.698
	STD DEV =	0.001	0.007			TW=158.7	DF2= 5.686	GD2= 3.5	FT(M/S)= 38.94
	TOTAL FLOW =	1.765	1.439	-18.45		TS= 0.0	DF3= 0.174	GD3= 5.4	DTT(KG/M-S)= 5589.2

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
155	STEAM FLOW =	0.296	0.488	64.81	0.1960	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.003	0.010			-----	------	-------	PA(KPA)= 629.3
	WATER FLOW =	5.462	3.799	-30.45	1.7214	TF=161.8	DF1= 1.731	GD1= 528.3	PD(KPA)= 0.643
	STD DEV =	0.002	0.287			TW=159.1	DF2= 1.984	GD2= 129.0	FT(M/S)= 3.66
	TOTAL FLOW =	5.758	4.287	-25.55		TS= 0.0	DF3=-0.754	GD3= 7.0	DTT(KG/M-S)= 1564.0

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
156	STEAM FLOW =	0.120	0.093	-22.68	0.0288	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.003	0.008			-----	------	-------	PA(KPA)= 630.0
	WATER FLOW =	0.834	0.479	-42.57	0.3749	TF=161.9	DF1=-0.026	GD1= 596.2	PD(KPA)= 0.007
	STD DEV =	0.006	0.097			TW=159.3	DF2= 0.075	GD2= 225.0	FT(M/S)= 0.84
	TOTAL FLOW =	0.954	0.572	-40.06		TS= 0.0	DF3= 0.042	GD3= 4.0	DTT(KG/M-S)= 48.0

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
158	STEAM FLOW =	0.699	0.791	13.23	0.0919	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.023	0.009			-----	------	-------	PA(KPA)= 416.0
	WATER FLOW =	1.350	1.118	-17.19	0.2433	TF=146.1	DF1= 3.695	GD1= 80.0	PD(KPA)= 0.979
	STD DEV =	0.001	0.056			TW=143.3	DF2= 3.838	GD2= 4.7	FT(M/S)= 17.77
	TOTAL FLOW =	2.049	1.909	-6.81		TS= 0.0	DF3=-0.891	GD3= 3.9	DTT(KG/M-S)= 3382.7

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
159	STEAM FLOW =	1.094	1.066	-2.53	0.0000	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.045	0.005			-----	------	-------	PA(KPA)= 402.2
	WATER FLOW =	0.332	0.118	-64.36	0.2182	TF=144.6	DF1= 5.028	GD1= 10.4	PD(KPA)= 1.611
	STD DEV =	0.001	0.008			TW=142.3	DF2= 5.412	GD2= 2.7	FT(M/S)= 44.52
	TOTAL FLOW =	1.426	1.185	-16.92		TS= 0.0	DF3= 0.132	GD3= 4.4	DTT(KG/M-S)= 5259.0

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
161	STEAM FLOW =	0.137	0.362	164.51	0.2301	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.002	0.004			-----	- ---	-------	PA(KPA)= 411.0
	WATER FLOW =	8.261	5.870	-28.94	2.4458	TF=145.4	DF1= 2.313	GD1= 701.2	PD(KPA)= 0.936
	STD DEV =	0.004	0.162			TW=143.0	DF2= 2.426	GD2= 403.5	FT(M/S)= 3.06
	TOTAL FLOW =	8.398	6.232	-25.79		TS= 0.0	DF3=-1.115	GD3= 6.9	DTT(KG/M-S)= 1900.9

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
162	STEAM FLOW =	0.703	0.779	10.77	0.0775	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.006			-----	------	-------	PA(KPA)= 197.2
	WATER FLOW =	0.595	0.332	-44.27	0.2693	TF=120.2	DF1= 5.564	GD1= 13.3	PD(KPA)= 1.691
	STD DEV =	0.002	0.015			TW=119.5	DF2= 6.268	GD2= 1.7	FT(M/S)= 51.13
	TOTAL FLOW =	1.298	1.110	-14.46		TS= 0.0	DF3=-0.404	GD3= 3.4	DTT(KG/M-S)= 5661.0

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
163	STEAM FLOW =	0.181	0.164	-9.57	0.0177	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.002			-----	------	-------	PA[illegible]= 195.7
	WATER FLOW =	0.590	0.551	-6.63	0.0444	TF=120.2	DF1= 0.246	GD1= 22[illegible].6	PD(KPA)= 0.072
	STD DEV =	0.001	0.0[illegible]			TW=118.6	DF2= 0.384	GD2= 0.8	FT(M/S)= 4.21
	TOTAL FLOW =	0.771	0.715	-7.32		TS= 0.0	DF3=-0.063	GD3= 2.0	DTT(KG/M-S)= 299.7

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
164	STEAM FLOW =	0.106	0.230	117.34	0.1271	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.006			-----	------	-------	PA(KPA)= 194.[illegible]
	WATER FLOW =	5.823	4.362	-25.09	1.5523	TF=119.9	DF1= 1.554	GD1= 638.3	PD(KPA)= 0.601
	STD DEV =	0.004	0.431			TW=113.0	DF2= 1.754	GD2= 229.2	FT(M/S)= 2.36
	TOTAL FLOW =	5.929	4.592	-22.55		TS= 0.0	DF3=-0.827	GD3= 4.8	DTT(KG/M-S)= 13[illegible]

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
170	STEAM FLOW =	0.141	0.352	149.35	0.2149	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.003			-----	------	-------	PA(KPA)= 414.
	WATER FLOW =	8.273	5.915	-28.50	2.4108	TF=146.1	DF1= 2.168	GD1= 734.3	PD(KPA)= 0.88[illegible]
	STD DEV =	0.006	0.140			TW=142.1	DF2= [illegible].347	GD2= [illegible]8.4	FT(M/S)= 2.[illegible]
	TOTAL FLOW =	8.414	6.267	-25.52		TS= 0.0	DF3=-0.999	GD3= 6.5	DTT(KG/M-S)= [illegible]

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
171	STEAM FLOW =	1.110	1.077	-2.95	0.0000	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.045	0.007			-----	------	-------	PA(KPA)= 410.[illegible]
	WATER FLOW =	0.343	0.124	-64.15	0.2261	TF=[illegible]	DF1= 5.033	GD1= 10.2	PD(KPA)= 1.607
	STD DEV =	0.001	0.011			TW=14[illegible].7	DF2= 5.393	GD2= 2.5	FT(M/S)= 44.0[illegible]
	TOTAL FLOW =	1.455	1.201	-17.46		TS= 0.0	DF3= 0.170	GD3= 4.4	DTT(KG/M-S)= 5[illegible]

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
175	STEAM FLOW =	-1.102	-1.128	2.40	0.0000	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.045	0.004			-----	------	-------	PA(KPA)= 399.3
	WATER FLOW =	-0.341	-0.231	-32.13	0.1121	TF=144.7	DF1=-5.384	GD1= 7.5	PD(KPA)=-1.581
	STD DEV =	0.001	0.007			TW=141.0	DF2=-5.155	GD2= 2.4	FT(M/S)=-44.36
	TOTAL FLOW =	-1.443	-1.360	-5.76		TS= 0.0	DF3=-0.193	GD3= 4.7	DTT(KG/M-S)=-6082.3

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
176	STEAM FLOW =	-0.689	-0.743	7.84	0.0718	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.002	0.046			-----	------	-------	PA(KPA)= 401.7
	WATER FLOW =	-1.331	-1.882	41.37	0.5982	TF=145.0	DF1=-4.771	GD1= 36.0	PD(KPA)=-1.564
	STD DEV =	0.002	0.205			TW=141.7	DF2=-3.948	GD2= 7.7	FT(M/S)=-17.47
	TOTAL FLOW =	-2.020	-2.625	29.93		TS= 0.0	DF3= 0.631	GD3= 16.7	DTT(KG/M-S)=-4564.7

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
177	STEAM FLOW =	-0.081	-0.075	-7.42	0.0063	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.002			-----	------	-------	PA(KPA)= 404.8
	WATER FLOW =	-0.298	-0.463	55.22	0.1733	TF=145.1	DF1=-0.168	GD1= 397.4	PD(KPA)= 0.008
	STD DEV =	0.001	0.043			TW=142.2	DF2=-0.088	GD2= 69.3	FT(M/S)= -0.81
	TOTAL FLOW =	-0.379	-0.538	41.83		TS= 0.0	DF3= 0.001	GD3= 3.3	DTT(KG/M-S)= -43.3

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
178	STEAM FLOW =	-0.143	-0.320	123.56	0.1804	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.006			-----	------	-------	PA(KPA)= 403.0
	WATER FLOW =	-8.400	-7.471	-11.05	0.9740	TF=145.4	DF1=-2.545	GD1= 670.9	PD(KPA)=-1.072
	STD DEV =	0.007	0.225			TW=141.8	DF2=-2.435	GD2= 376.6	FT(M/S)= -2.83
	TOTAL FLOW =	-8.543	-7.791	-8.80		TS= 0.0	DF3= 1.046	GD3= 15.6	DTT(KG/M-S)=-2196.1

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
179	STEAM FLOW =	-0.124	-0.089	-28.38	0.0359	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.003	0.003			-----	------	-------	PA(KPA)= 620.7
	WATER FLOW =	-0.823	-0.469	-43.07	0.3626	TF=161.4	DF1=-0.203	GD1= 572.7	PD(KPA)= 0.075
	STD DEV =	0.003	0.026			TW=158.1	DF2=-0.117	GD2= 201.7	FT(M/S)= -0.79
	TOTAL FLOW =	-0.947	-0.557	-41.14		TS= 0.0	DF3= 0.064	GD3= 4.1	DTT(KG/M-S)= -43.6

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
180	STEAM FLOW =	-1.392	-1.390	-0.13	0.0000	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.057	0.007			-----	------	-------	PA(KPA)= 609.9
	WATER FLOW =	-0.317	-0.190	-40.20	0.1308	TF=160.7	DF1=-5.435	GD1= 8.7	PD(KPA)=-1.573
	STD DEV =	0.001	0.014			TW=157.5	DF2=-5.226	GD2= 3.9	FT(M/S)=-38.90
	TOTAL FLOW =	-1.709	-1.580	-7.56		TS= 0.0	DF3=-0.169	GD3= 5.1	DTT(KG/M-S)=-6127.7

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
181	STEAM FLOW =	-0.510	-0.489	-4.08	0.0344	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.006	0.028			-----	------	-------	PA(KPA)= 618.0
	WATER FLOW =	-0.595	-1.303	118.92	0.7377	TF=161.1	DF1=-1.344	GD1= 38.6	PD(KPA)=-0.481
	STD DEV =	0.002	0.151			TW=159.1	DF2=-1.137	GD2= 8.1	FT(M/S)= -7.75
	TOTAL FLOW =	-1.105	-1.792	62.15		TS= 0.0	DF3=-0.010	GD3= 44.3	DTT(KG/M-S)=-1381.6

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
182	STEAM FLOW =	-0.312	-0.504	61.63	0.1964	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.003	0.008			-----	------	--------	PA(KPA)= 615.4
	WATER FLOW =	-5.537	-5.497	-0.73	0.2139	TF=161.4	DF1=-2.816	GD1= 384.0	PD(KPA)=-0.826
	STD DEV =	0.006	0.210			TW=158.1	DF2=-2.510	GD2= 157.0	FT(M/S)= -4.14
	TOTAL FLOW =	-5.849	-6.001	2.60		TS= 0.0	DF3= 0.388	GD3= 8.7	DTT(KG/M-S)=-2474.2

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
188	STEAM FLOW =	-0.043	-0.034	-21.91	0.0101	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.003			-----	------	-------	PA(KPA)= 199.7
	WATER FLOW =	-0.599	-0.577	-3.61	0.0719	TF=121.1	DF1=-0.076	GD1= 592.6	PD(KPA)=-0.022
	STD DEV =	0.001	0.068			TW=118.1	DF2=-0.084	GD2= 235.5	FT(M/S)= -0.42
	TOTAL FLOW =	-0.642	-0.611	-4.83		TS= 0.0	DF3= 0.009	GD3= 2.6	DTT(KG/M-S)= -25.6

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
189	STEAM FLOW =	-0.179	-0.155	-13.20	0.0261	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.000	0.010			-----	------	-------	PA(KPA)= 199.7
	WATER FLOW =	-0.600	-1.258	109.66	0.6740	TF=121.1	DF1=-0.658	GD1= 112.9	PD(KPA)=-0.202
	STD DEV =	0.002	0.057			TW=118.4	DF2=-0.545	GD2= 28.0	FT(M/S)= -3.92
	TOTAL FLOW =	-0.779	-1.413	81.43		TS= 0.0	DF3= 0.131	GD3= 4.7	DTT(KG/M-S)= -552.4

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
190	STEAM FLOW =	-0.106	-0.200	88.55	0.0959	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.003			-----	------	-------	PA(KPA)= 200.2
	WATER FLOW =	-5.752	-5.083	-11.63	0.7181	TF=121.4	DF1=-1.515	GD1= 587.6	PD(KPA)=-0.647
	STD DEV =	0.005	0.222			TW=119.3	DF2=-1.500	GD2= 315.1	FT(M/S)= -2.46
	TOTAL FLOW =	-5.858	-5.283	-9.82		TS= 0.0	DF3= 0.675	GD3= 9.4	DTT(KG/M-S)=-1295.7

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
191	STEAM FLOW =	-0.710	-0.822	15.81	0.1149	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.009			-----	------	-------	PA(KPA)= 199.7
	WATER FLOW =	-0.602	-0.489	-18.83	0.1197	TF=121.2	DF1=-6.069	GD1= 7.3	PD(KPA)=-1.811
	STD DEV =	0.001	0.031			TW=119.4	DF2=-5.586	GD2= 3.7	FT(M/S)=-49.81
	TOTAL FLOW =	-1.312	-1.311	-0.09		TS= 0.0	DF3= 0.008	GD3= 6.2	DTT(KG/M-S)=-6509.3

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
192	STEAM FLOW =	-0.136	-0.302	121.91	0.1693	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.002	0.005			-----	------	-------	PA(KPA)= 414.2
	WATER FLOW =	-8.286	-7.134	-13.90	1.2082	TF=146.3	DF1=-2.217	GD1= 698.9	PD(KPA)=-0.971
	STD DEV =	0.007	0.278			TW=142.6	DF2=-2.198	GD2= 395.0	FT(M/S)= -2.62
	TOTAL FLOW =	-8.422	-7.436	-11.71		TS= 0.0	DF3= 0.940	GD3= 15.4	DTT(KG/M-S)=-1940.0

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
193	STEAM FLOW =	-1.127	-1.153	2.34	0.0000	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.046	0.004			-----	------	-------	PA(KPA)= 407.3
	WATER FLOW =	-0.344	-0.207	-39.76	0.1397	TF=145.5	DF1=-5.459	GD1= 6.5	PD(KPA)=-1.631
	STD DEV =	0.001	0.006			TW=142.8	DF2=-5.308	GD2= 3.9	FT(M/S)=-45.62
	TOTAL FLOW =	-1.471	-1.361	-7.50		TS= 0.0	DF3=-0.195	GD3= 4.5	DTT(KG/M-S)=-6189.5

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
245	STEAM FLOW =	0.354	0.417	17.67	0.0628	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.002			-----	------	-------	PA(KPA)= 206.7
	WATER FLOW =	0.299	0.228	-23.89	0.0726	TF=122.2	DF1= 2.913	GD1= 14.1	PD(KPA)= 3.487
	STD DEV =	0.000	0.011			TW=118.9	DF2= 2.862	GD2= 5.1	FT(M/S)= 47.32
	TOTAL FLOW =	0.653	0.644	-1.36		TS=121.9	DF3=-0.028	GD3= 11.2	DTT(KG/M-S)= 5942.8

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
246	STEAM FLOW =	0.186	0.264	42.17	0.0799	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.000	0.012			-----	------	-------	PA(KPA)= 201.8
	WATER FLOW =	0.657	0.696	5.89	0.0889	TF=121.4	DF1= 1.590	GD1= 34.2	PD(KPA)= 2.599
	STD DEV =	0.000	0.080			TW=118.6	DF2= 1.478	GD2= 16.3	FT(M/S)= 17.10
	TOTAL FLOW =	0.843	0.960	13.90		TS=122.0	DF3=-0.016	GD3= 23.4	DTT(KG/M-S)= 3191.3

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
247	STEAM FLOW =	0.075	0.123	64.47	0.0497	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.002	0.003			-----	------	-------	PA(KPA)= 207.5
	WATER FLOW =	0.299	0.372	24.52	0.0810	TF=122.1	DF1= 0.374	GD1= 39.8	PD(KPA)= 1.774
	STD DEV =	0.002	0.030			TW=119.3	DF2= 0.291	GD2= 14.9	FT(M/S)= 7.42
	TOTAL FLOW =	0.374	0.496	32.53		TS=123.2	DF3=-0.025	GD3= 25.4	DTT(KG/M-S)= 716.7

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
248	STEAM FLOW =	0.070	0.067	-3.57	0.0121	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.012			-----	------	-------	PA(KPA)= 425.3
	WATER FLOW =	1.480	1.817	22.75	0.5744	TF=146.5	DF1= 1.152	GD1= 93.9	PD(KPA)= 1.974
	STD DEV =	0.013	0.460			TW=143.9	DF2= 1.053	GD2= 46.6	FT(M/S)= 3.99
	TOTAL FLOW =	1.550	1.884	21.56		TS=147.1	DF3=-0.131	GD3= 41.9	DTT(KG/M-S)= 2183.4

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
249	STEAM FLOW =	0.354	0.518	46.21	0.1670	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.003	0.005			-----	------	-------	PA(KPA)= 421.2
	WATER FLOW =	0.662	0.568	-14.16	0.1076	TF=146.3	DF1= 2.538	GD1= 25.1	PD(KPA)= 3.318
	STD DEV =	0.004	0.049			TW=143.4	DF2= 2.548	GD2= 12.3	FT(M/S)= 24.92
	TOTAL FLOW =	1.016	1.086	6.87		TS=146.1	DF3= 0.019	GD3= 22.4	DTT(KG/M-S)= 5273.4

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
250	STEAM FLOW =	0.581	0.607	4.46	0.0266	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.002	0.004			-----	------	-------	PA(KPA)= 414.4
	WATER FLOW =	0.166	0.116	-30.11	0.0515	TF=145.8	DF1= 3.109	GD1= 8.0	PD(KPA)= 3.350
	STD DEV =	0.001	0.007			TW=142.6	DF2= 3.064	GD2= 3.5	FT(M/S)= 45.54
	TOTAL FLOW =	0.747	0.723	-3.22		TS=144.6	DF3= 0.036	GD3= 7.6	DTT(KG/M-S)= 6419.8

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
251	STEAM FLOW =	0.025	0.057	127.36	0.0325	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.002			-----	------	-------	PA(KPA)= 424.2
	WATER FLOW =	7.359	5.893	-19.92	1.5086	TF=146.5	DF1= 3.527	GD1= 221.9	PD(KPA)= 2.070
	STD DEV =	0.005	0.195			TW=143.5	DF2= 3.156	GD2= 228.1	FT(M/S)= 3.72
	TOTAL FLOW =	7.384	5.950	-19.42		TS=146.8	DF3= 0.167	GD3= 44.3	DTT(KG/M-S)= 7075.6

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
258	STEAM FLOW =	0.074	0.118	59.68	0.0451	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.002			-----	------	-------	PA(KPA)= 209.8
	WATER FLOW =	0.297	0.403	35.75	0.1147	TF=122.5	DF1= 0.369	GD1= 39.5	PD(KPA)= 1.779
	STD DEV =	0.001	0.038			TW=119.8	DF2= 0.289	GD2= 14.6	FT(M/S)= 6.97
	TOTAL FLOW =	0.371	0.521	40.52		TS=123.8	DF3=-0.026	GD3= 25.3	DTT(KG/M-S)= 708.2

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
259	STEAM FLOW =	0.071	0.059	-17.60	0.0153	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.009			-----	------	-------	PA(KPA)= 422.9
	WATER FLOW =	1.488	1.569	5.43	0.4555	TF=146.2	DF1= 0.919	GD1= 95.5	PD(KPA)= 2.048
	STD DEV =	0.002	0.448			TW=143.4	DF2= 0.833	GD2= 42.3	FT(M/S)= 3.40
	TOTAL FLOW =	1.559	1.627	4.38		TS=146.9	DF3=-0.128	GD3= 40.9	DTT(KG/M-S)= 1723.3

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
260	STEAM FLOW =	0.035	0.079	126.40	0.0458	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.008			-----	------	-------	PA(KPA)= 638.9
	WATER FLOW =	1.423	1.576	10.76	0.4111	TF=161.8	DF1= 0.853	GD1= 100.6	PD(KPA)= 1.644
	STD DEV =	0.003	0.380			TW=158.4	DF2= 0.811	GD2= 52.3	FT(M/S)= 1.86
	TOTAL FLOW =	1.458	1.655	13.54		TS=163.2	DF3=-0.138	GD3= 39.7	DTT(KG/M-S)= 1620.9

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
261	STEAM FLOW =	0.104	0.094	-9.28	0.0157	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.002	0.012			-----	------	-------	PA(KPA)= 637.4
	WATER FLOW =	1.488	1.879	26.26	0.5797	TF=161.8	DF1= 1.234	GD1= 100.1	PD(KPA)= 1.938
	STD DEV =	0.003	0.421			TW=158.1	DF2= 1.091	GD2= 49.1	FT(M/S)= 3.97
	TOTAL FLOW =	1.592	1.973	23.93		TS=162.1	DF3=-0.118	GD3= 42.9	DTT(KG/M-S)= 2321.8

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
262	STEAM FLOW =	0.367	0.538	46.54	0.1745	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.004	0.008			-----	------	-------	PA(KPA)= 628.0
	WATER FLOW =	1.037	0.929	-10.44	0.1617	TF=161.4	DF1= 2.320	GD1= 51.4	PD(KPA)= 3.071
	STD DEV =	0.002	0.118			TW=157.1	DF2= 2.150	GD2= 24.4	FT(M/S)= 15.78
	TOTAL FLOW =	1.404	1.467	4.46		TS=161.2	DF3=-0.111	GD3= 27.0	DTT(KG/M-S)= 4504.6

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
263	STEAM FLOW =	0.724	0.735	1.57	0.0000	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.030	0.005			-----	------	-------	PA(KPA)= 629.9
	WATER FLOW =	0.166	0.104	-37.16	0.0632	TF=161.7	DF1= 3.059	GD1= 9.3	PD(KPA)= 3.273
	STD DEV =	0.001	0.006			TW=156.9	DF2= 3.017	GD2= 4.8	FT(M/S)= 38.66
	TOTAL FLOW =	0.890	0.840	-5.65		TS=160.5	DF3= 0.047	GD3= 8.4	DTT(KG/M-S)= 6331.7

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
282	STEAM FLOW =	-0.359	-0.437	21.83	0.0807	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.011			-----	------	-------	PA(KPA)= 203.8
	WATER FLOW =	-0.301	-0.333	10.52	0.0615	TF=121.9	DF1=-3.347	GD1= 6.2	PD(KPA)=-0.003
	STD DEV =	0.002	0.052			TW= -0.0	DF2=-3.339	GD2= 5.9	FT(M/S)=-47.48
	TOTAL FLOW =	-0.660	-0.770	16.67		TS=123.2	DF3= 0.291	GD3= 6.5	DTT(KG/M-S)=-7107.0

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
283	STEAM FLOW =	-0.180	-0.217	20.36	0.0431	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.004	0.022			-----	------	-------	PA(KPA)= 206.6
	WATER FLOW =	-0.687	-1.044	52.03	0.3907	TF=121.7	DF1=-1.738	GD1= 23.3	PD(KPA)= 0.728
	STD DEV =	0.002	0.140			TW= -0.0	DF2=-1.854	GD2= 16.5	FT(M/S)=-15.31
	TOTAL FLOW =	-0.867	-1.261	45.46		TS=122.8	DF3= 0.240	GD3= 21.5	DTT(KG/M-S)=-3754.6

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
284	STEAM FLOW =	-0.071	-0.105	47.36	0.0347	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.005			-----	------	-------	PA(KPA)= 209.3
	WATER FLOW =	-0.303	-0.253	-16.61	0.0895	TF=122.2	DF1=-0.174	GD1= 114.7	PD(KPA)= 1.312
	STD DEV =	0.001	0.073			TW= 0.0	DF2=-0.287	GD2= 63.7	FT(M/S)= -6.16
	TOTAL FLOW =	-0.374	-0.357	-4.46		TS=123.2	DF3= 0.016	GD3= 44.3	DTT(KG/M-S)= -420.3

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
285	STEAM FLOW =	-0.071	-0.055	-22.87	0.0391	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.035			-----	------	-------	PA(KPA)= 426.2
	WATER FLOW =	-1.554	-1.827	17.60	0.5284	TF=146.5	DF1=-0.475	GD1= 195.6	PD(KPA)= 1.025
	STD DEV =	0.003	0.449			TW= -0.0	DF2=-0.593	GD2= 129.2	FT(M/S)= -2.74
	TOTAL FLOW =	-1.625	-1.882	15.83		TS=147.4	DF3= 0.014	GD3= 44.3	DTT(KG/M-S)=-1117.4

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
286	STEAM FLOW =	-0.024	-0.033	37.73	0.0094	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.002			-----	------	-------	PA(KPA)= 420.9
	WATER FLOW =	-7.326	-6.777	-7.49	0.6356	TF=146.2	DF1=-2.557	GD1= 401.9	PD(KPA)=-0.579
	STD DEV =	0.001	0.300			TW= -0.0	DF2=-2.463	GD2= 322.9	FT(M/S)= -2.99
	TOTAL FLOW =	-7.350	-6.810	-7.35		TS=148.5	DF3=-0.031	GD3= 44.3	DTT(KG/M-S)=-5681.9

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
287	STEAM FLOW =	-0.355	-0.449	26.56	0.1132	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.002	0.060			-----	------	-------	PA(KPA)= 432.7
	WATER FLOW =	-0.684	-0.861	25.84	0.2402	TF=146.9	DF1=-2.500	GD1= 18.6	PD(KPA)= 0.277
	STD DEV =	0.001	0.159			TW= -0.0	DF2=-2.621	GD2= 14.5	FT(M/S)=-21.56
	TOTAL FLOW =	-1.039	-1.310	26.09		TS=148.5	DF3= 0.252	GD3= 15.6	DTT(KG/M-S)=-5480.3

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
288	STEAM FLOW =	-0.587	-0.618	5.24	0.0324	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.002	0.008			-----	------	-------	PA(KPA)= 422.3
	WATER FLOW =	-0.168	-0.089	-47.19	0.0915	TF=146.0	DF1=-2.972	GD1= 5.0	PD(KPA)= 0.263
	STD DEV =	0.001	0.043			TW= -0.1	DF2=-2.900	GD2= 6.1	FT(M/S)=-47.44
	TOTAL FLOW =	-0.755	-0.706	-6.43		TS=146.8	DF3= 0.034	GD3= 5.6	DTT(KG/M-S)=-6521.9

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
289	STEAM FLOW =	-0.033	-0.019	-42.37	0.0144	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.003			-----	------	-------	PA(KPA)= 644.0
	WATER FLOW =	-1.476	-2.038	38.09	0.6563	TF=162.1	DF1=-0.246	GD1= 404.5	PD(KPA)= 0.779
	STD DEV =	0.005	0.321			TW= 0.0	DF2=-0.370	GD2= 252.6	FT(M/S)= -1.24
	TOTAL FLOW =	-1.509	-2.057	36.33		TS=163.9	DF3=-0.009	GD3= 44.3	DTT(KG/M-S)= -625.0

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
290	STEAM FLOW =	-0.106	-0.086	-18.80	0.0540	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.050			-----	------	-------	PA(KPA)= 641.1
	WATER FLOW =	-1.458	-1.775	21.73	0.5470	TF=161.9	DF1=-0.595	GD1= 152.5	PD(KPA)= 1.076
	STD DEV =	0.003	0.441			TW= 0.0	DF2=-0.691	GD2= 99.4	FT(M/S)= -3.29
	TOTAL FLOW =	-1.564	-1.861	18.98		TS=163.2	DF3= 0.003	GD3= 43.9	DTT(KG/M-S)=-1380.2

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
291	STEAM FLOW =	-0.371	-0.496	33.82	0.1339	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.002	0.039			-----	------	-------	PA(KPA)= 638.6
	WATER FLOW =	-1.042	-1.401	34.42	0.3942	TF=161.7	DF1=-2.959	GD1= 29.0	PD(KPA)= 0.026
	STD DEV =	0.004	0.146			TW= -0.0	DF2=-2.849	GD2= 24.4	FT(M/S)=-16.93
	TOTAL FLOW =	-1.413	-1.897	34.26		TS=163.2	DF3= 0.215	GD3= 23.3	DTT(KG/M-S)=-6261.7

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
292	STEAM FLOW =	-0.710	-0.729	2.65	0.0712	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.002	0.069			-----	------	-------	PA(KPA)= 643.3
	WATER FLOW =	-0.157	-0.073	-53.35	0.1735	TF=162.1	DF1=-2.907	GD1= 5.8	PD(KPA)= 0.336
	STD DEV =	0.001	0.151			TW= -0.3	DF2=-2.854	GD2= 6.6	FT(M/S)=-42.55
	TOTAL FLOW =	-0.867	-0.802	-7.49		TS=162.8	DF3= 0.055	GD3= 6.5	DTT(KG/M-S)=-6383.0

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
298	STEAM FLOW =	-0.076	-0.116	52.53	0.0412	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.001	0.006			-----	------	-------	PA(KPA)= 211.8
	WATER FLOW =	-0.309	-0.279	-9.71	0.0771	TF=122.8	DF1=-0.207	GD1= 93.8	PD(KPA)= 1.320
	STD DEV =	0.002	0.071			TW= 0.0	DF2=-0.335	GD2= 58.8	FT(M/S)= -6.74
	TOTAL FLOW =	-0.385	-0.395	2.53		TS=123.6	DF3= 0.018	GD3= 43.0	DTT(KG/M-S)= -511.1

PKL PROTOTYPE SPOOL TEST RESULTS

TEST NO.	UNITS (KG/S)	WYLE	PKL	% DIFF	DEVIATION	AVERAGE PKL TEST PARAMETERS			
299	STEAM FLOW =	-0.072	-0.038	-47.28	0.0348	DEG C	NEWTON	KG/M**3	
	STD DEV =	0.004	0.004			-----	------	-------	PA(KPA)= 414.5
	WATER FLOW =	-1.448	-2.022	39.61	0.6344	TF=145.5	DF1=-0.655	GD1= 149.6	PD(KPA)= 1.004
	STD DEV =	0.004	0.244			TW= 0.0	DF2=-0.755	GD2= 112.1	FT(M/S)= -3.13
	TOTAL FLOW =	-1.520	-2.060	35.50		TS=146.7	DF3= 0.014	GD3= 43.7	DTT(KG/M-S)=-1510.2