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FINAL REPORT (U)

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EXECUTIVE SUMMARY OF THE ANNULAR FLOW DISTRIBUTION PROGRAM

Power limits for the Mark 22 reactor assembly must be calculated for the Emergency Cooling System (ECS) phase of a design-basis, double-ended guillotine break Loss of Coolant Accident (DEGB-LOCA, hereafter referred to as LOCA). Air-water two-phase flow is expected during the ECS phase, under most of the postulated LOCA scenarios. The power limits calculation is currently performed using a computational tool, the FLOWTRAN-TF code [1]. FLOWTRAN-TF requires empirical information on the distribution of liquid flow among the annular channels of the assembly. The following report documents the Annular Flow Distribution (AFD) experiment, a two-year experimental program which was initiated to provide these data.

In 1988, WSRC contracted Babcock and Wilcox (B&W) to measure annular flow distributions under a broad range of assembly boundary conditions. The project was intended to supersede previous annular flow distribution experiments by providing: (i) wider ranges of test variables; (ii) a screening study to identify additional relevant test variables; (iii) a stricter standard of Quality Assurance documentation; and (iv) higher data confidence, by using an improved simulation of the outlet region of the assembly. As described below, the experimental method used to obtain flow distribution also yielded detailed hydraulic data for the Mark 22 assembly. The scope of the experiment was thus broadened from the original annular flow distribution measurements to include ECS-LOCA pressure, airflow, and plenum level data for the Mark 22 assembly as well. Portions of this additional database have been used in FLOWTRAN-TF benchmarking [2].

Because the equilibrium assembly boundary conditions for the limiting LOCA scenario were not well-established at the time testing was initiated, the test variable ranges were set as broadly as practicable. The range of assembly flows tested makes the database usable for the analysis of long-term cooling (down to 3 gpm) and of the transition from single-phase to two-phase flow (up to 110 gpm). The range of pressure boundary conditions covers most of the LOCA scenarios, including the plenum inlet break with AC motors on (PIAC) which is now considered to be the most limiting.

The most straightforward method of measuring flow distribution is by collection of annular channel outflows. This approach necessitates alteration of the prototypical outlet geometry, in which these flows mix together prior to discharge. WSRC concerns about the effect of such alteration on two-phase flow distributions led to the choice of method used in the current experiment. This method, referred to as "hydraulic similarity," uses the following strategy:

- Employ a test assembly outlet in which prototypicality is maintained as much as possible, except for the requisite separation of annular outflows.
- Maintain prototypical annulus backpressures in the test assembly during testing.
- Monitor the level of "success" in reproducing prototypical assembly hydraulics in the test assembly.

The reason for maintaining prototypical backpressures is as follows: Specified assembly boundary conditions include plenum pressure, assembly flowrate, and assembly backpressure; the latter is set by the reactor tank level. Each set of boundary conditions is associated with a pressure at the exit of each annulus. This annulus exit pressure can be set independently of the particular outlet geometry. Maintaining annulus exit pressures thus ensures the appropriate annulus boundary conditions, regardless of outlet geometry. Barring upstream communication of downstream effects, this should produce an exact simulation of the prototypical hydraulics.

The desire to control and monitor the prototypicality of the test assembly hydraulics prompted the WSRC decision to run two assemblies in parallel, one prototypical in outlet geometry (the reference assembly) and one altered to enable flow distribution measurement (the test assembly). Annulus back pressures in the test assembly were controlled to be equal to those of the reference assembly; pressures at equivalent locations in the two assemblies were compared, as were assembly airflows. Detailed hydraulic data for a prototypical assembly were thus acquired as a "by-product" of the chosen experimental method.

A proof-of-principle test phase was first conducted, to verify the experimental method over the range of test conditions. The monitoring process revealed some differences in hydraulic behavior between the two assemblies under certain boundary conditions. Several types of sensitivity tests were performed to assess the significance of the observed differences [3]. Because these differences appeared to be associated with, at best, second order perturbations of liquid flow distribution [4], the program was completed utilizing the hydraulic similarity method described above.

An interim report issued to WSRC by B&W [3] discusses the construction of the test loop and the first part of the test program, in particular the proof-of-principle test phase. The present, final report is self-standing, but concentrates on discussion of the later phases of testing. The entire experimental database is contained in the appendices to the present report. In addition to this hard-copy documentation of the time-averaged measurements, all raw data were stored electronically and transmitted to WSRC. These electronic data files will be installed on the archival system of WSRC's Heat Transfer Laboratory.

In addition to proof-of-principle testing, the test phases included: (i) a screening phase, to assess the significance of several variables thought to have impact on flow distribution, and (ii) a parametric test phase, used to develop flow fraction correlations in terms of those variables established during the screening phase as being significant. In accordance with the expanded scope of the experiment, the significance of variables was assessed not only for their impact on annular flow distribution, but also on total assembly airflow, air flow distribution, and plenum level.

Statistical experimental design methods were used to develop the test matrices for both of these test phases. For screening, such methods yield the minimum number of tests required to support statistically valid assessments of variable significance. For the parametric test phase, the methods ensure that the test matrix is balanced. Two advantages of a balanced matrix are: (i) the relative magnitudes of empirical correlation coefficients are representative of the relative influence of the test variables, thus providing physical insight; and (ii) the number of test points needed to achieve advantage (i) is minimized.

Empirical correlations of liquid flow distribution data were a desired product of the AFD project. The correlations developed as part of this project are presented herein. The data are correlated as a fraction of total assembly liquid flow down a given annulus. Subsequent to the decision to develop these correlations, the FLOWTRAN-TF code was structured in terms of channel void distribution, rather than in terms of liquid flow distribution. To implement the latter approach, AFD flow distribution data were used to estimate channel inlet void fractions; these esti-

mated void fractions were then correlated for use in FLOWTRAN-TF [1]. The FLOWTRAN-TF model thus depends not only on the experimental flow distribution data, but also on the method of estimating channel void fractions from liquid flow distribution. The adequacy of this approach is discussed in reference [2].

At the present time, there is no plan to implement the experimental liquid flow fraction correlations presented herein into FLOWTRAN-TF. The experimental data are independent of a choice of two-phase model, however, so correlations of the liquid flow fractions themselves are still desirable for analytical use. Therefore, the correlation of the experimental data was pursued to completion.

Analysis of the AFD facility flow distribution data is contained in reference [4]. This analysis includes a detailed evaluation of the observed dissimilarities in hydraulic behavior between test and reference assemblies, and an evaluation of the current AFD data against that of previous flow distribution experiments. Reference [4] also discusses scoping tests made in the AFD facility which were important in providing insight into hydraulic similarity issues. Some of these test results are not discussed in reference [3] or the present report, but were documented by letter to WSRC [5, 6].

Plenum level and assembly airflow data are also discussed in reference [4]. Assembly airflow data from the reference assembly appear to disagree with that of experiments conducted at WSRC, though the differences (1 scfm or less) are much smaller than those between the current FLOWTRAN-TF predictions and either database [2]. The issue is not resolved as of this writing. It is discussed at greater length in reference [7], which also presents the intended path forward for resolution.

Annulus hydraulic data from the test assembly are useful in analyzing the hydraulics of single annuli. The three annuli, isolated at the exit, effectively constitute three single-annulus experiments which cover the prototypic range of annular diameters and hydraulic diameters. In reference [8], these data are compared to those of the Void Rig [9], a single-annulus experiment which was used extensively in developing the FLOWTRAN-TF code. The AFD annulus hydraulic data are then used in reference [8] to model the hydraulics of a ribbed annulus in air-water downflow.

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Sensitivity tests were performed to examine the effects of gas expansion within the fuel assembly, the effects of pressure gradients near the fuel assembly inlet, and the effects of reactor tank water level on flow distribution. Air flow tests were conducted to measure the total assembly air flow for the Mark-22 fuel assembly for a range of assembly water flow and assembly pressure drop conditions.

Screening tests were performed to evaluate the need to include several variables in the final empirical correlations for annular flow distribution. The screening variables included BFI type, fluid properties, and air leakage past the inlet plenum piston ring. Tests showed these variables to be insignificant, and they were dropped from the final test phase, parametric testing.

Extensive testing was performed to characterize the dependence of flow distribution on total assembly water flow and overall assembly pressure drop in the parametric testing phase. Best-fit correlations for annular flow distribution were developed from this data, and are presented in this report.

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Attachment

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FINAL REPORT

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INTRODUCTION

This report documents the Babcock and Wilcox (B&W) Annular Flow Distribution testing for the Savannah River Laboratory (SRL). The objective of the Annular Flow Distribution Test Program is to characterize the flow distribution between annular coolant channels for the Mark-22 fuel assembly with the bottom fitting insert (BFI) in place. Flow rate measurements for each annular channel were obtained by establishing "hydraulic similarity" between an instrumented fuel assembly with the BFI removed and a "reference" fuel assembly with the BFI installed. Empirical correlations of annular flow rates were generated for a range of boundary conditions.

In November, 1988, the facility design and fabrication tasks were initiated. The facility, shown schematically in Figure 1.1, together with modifications to the fuel assemblies was designed to provide the following range of test conditions:

- total liquid flow rates from 10 to 120 gpm,
- liquid and air inlet temperature from 70 F to 135 F,
- inlet plenum pressures from -5 to +5 psig,
- tank bottom pressures from 1.5 to 5.0 feet of water,
- inlet plenum flow regimes of dispersed and stratified flow,
- piston ring (inlet plenum to reactor tank) leak simulation,
- auxiliary orifice plate hole number from 18 to 54, and
- auxiliary orifice plate hole diameter from 0.172 to 0.281 inches.

In September, 1989, the test facility was operational and the testing task was initiated. The test program consisted of five phases:

- a proof of principle test phase,
- a sensitivity test phase,
- an air flow test phase,
- a screening test phase,
- and the parametric testing phase.

All phases of testing were based on hydraulic similarity and utilize the parallel fuel assembly arrangement. The objective of the proof of principle test phase was to verify the ability to establish hydraulic similarity for parallel fuel assemblies over the required range of test conditions. An Interim Report (Reference 1) was issued in March, 1990 and documents the proof of principle test phase. The sensitivity test phase examined the effects of asymmetric water injection into the inlet plenum, the effects of testing with a low tank level, and examined the effect of gas injection near the bottom of the fuel assembly. Air flow tests were performed to investigate differences between data generated in the Annular Flow Distribution Test Facility and WSKF data. The screening tests were included to determine if any of several variables have significant influence on annular flow splits. The variables examined include BFI geometry, fluid temperature and properties, and air leakage past the fuel assembly piston ring. Finally, the parametric test phase data has been used to define best-fit empirical correlations over the applicable range of flow conditions.

The following sections of this report provide a discussion of the measurement technique, description and results of the individual test phases, the annular flow correlations, measurement uncertainty, and the format of the engineering data files transmitted to WSRC. All reduced data are provided in the appendices.

Figure 1.1 Annular Flow Distribution Test Facility

In the Annular Flow Distribution project, similar Mark-22 fuel assemblies were installed in parallel in a facility capable of providing boundary conditions expected for the emergency cooling system (ECS) phase of a loss of coolant accident (LOCA). Fluid conditions during this phase of the transient were a two-component mixture of air-water. Parameters which influence the coolant flow distribution may include any of the following:

- total fuel assembly coolant flow,
- fluid property variations,
- inlet plenum pressure and flow regime,
- auxiliary orifice plate hole diameter and number,
- fuel assembly piston ring air leakage,
- bottom fitting geometry, and
- tank bottom pressure (outlet head).

B&W proposed 6 experimental concepts for characterizing annular flow distribution for SRL fuel assemblies with prototypical bottom fitting hardware installed. Mixing of the parallel annular streams in the bottom fitting hardware greatly complicates the measurement of flow distribution. The concepts for characterizing the annular flow distribution, as originally presented, are summarized in Reference 1. B&W assessed the development potential for each measurement concept. Considerations included the technical risks associated with development of a concept into a measurement technique, qualitative projections for best and worst case measurement uncertainty, projected test program expense, and development time required for implementation. Based on this assessment, B&W determined that the hydraulic similarity concept for annular flow measurement has the best potential for successful development. The principle of hydraulic similarity for the two parallel fuel assemblies is described below. The test facility hardware including the air and water supply systems, and instrumentation are also detailed.

2.1 Hydraulic Similarity Approach

Annular flow distribution measurements for the prototypical Mark-22 fuel assemblies are desired for the expected ECS-phase hydraulic conditions. Flow rate measurements for each annular channel were obtained by establishing "hydraulic similarity" between two fuel assemblies; the "reference" assembly having the BFI in place, and the "test" assembly with the BFI removed. Figure 2.1 identifies the relevant hardware features for the hydraulic similarity concept. With the BFI removed from the test assembly, the flow exiting each of the annuli can be measured. Hydraulic similarity between the two Mark-22 fuel assemblies is considered to be established if total liquid and air flows agree within tolerance, and pressure gradients are equivalent from plenum to tank bottom and from inlet to outlet for each annular channel. Individual channel flow rates were measured for the test fuel assembly and assumed to be representative of the BFI-equipped fuel assembly if hydraulic similarity is confirmed by the measurements.

The following is the general procedure, based on hydraulic similarity, for obtaining annular flow measurements for the BFI-equipped fuel assembly:

1. Establish equal liquid flow rates to each inlet plenum supplying the parallel fuel assemblies.
2. Establish tank bottom and inlet plenum pressures for the reference fuel assembly. Adjust the outlet tank water level to achieve the required tank bottom pressure. Adjust total plenum air flow or vacuum to achieve the required plenum pressure.
3. Establish a nominal plenum pressure match for the test fuel assembly by adjusting plenum air flow or vacuum.
4. Match channel outlet pressures for the parallel fuel assemblies by adjusting each test fuel assembly channel air/water separator water level to increase or decrease the channel backpressure.
5. Repeat Steps 3 and 4 as required to establish a match between fuel assemblies for channel differential pressures and plenum air flows.
6. Verify hydraulic similarity by comparison of total fuel assembly air flows, and comparison of corresponding channel flow patterns as indicated by axial channel pressure profiles.

The verification requirement for similar flow patterns in corresponding channels is based on calculations which indicate that a transition from annular to slug flow may occur for some Mark-22 assembly channels near 40 gpm total assembly flow. If the flow patterns are different for corresponding channels in the parallel fuel assemblies, an inlet to outlet pressure difference match may not be sufficient to guarantee equal channel flows. The degree to which these pressure profiles must agree is measurement uncertainty at best.

2.2 Test Apparatus

For the Annular Flow Distribution Test, two Savannah River Plant Mark-22 fuel assemblies were installed in parallel. One assembly is installed with plant-typical BFI hardware, and the other with the BFI replaced by a transition which preserves flow segregation beyond the channel exits. Parallel flow paths were as similar as practical. In this section, the air and water supply circuits as well as the collection and return systems are described. The list of Annular Flow Distribution Test Facility drawings is provided in Table 2.1. The test apparatus discussion below is the same as that presented in the Interim Report (Reference 1), with the exception that the air-supply system was subsequently enhanced to provide air inlet temperatures up to 135°F.

2.2.1 Water Supply System

A schematic of the Annular Flow Distribution Test Facility forced circulation system is presented in Figure 2.2 (also, see Reference 2). The forced circulation system is a closed-loop configuration to permit continuous testing. The system is capable of providing up to 120 gpm to each of two parallel fuel assemblies. A closed-loop configuration is also prerequisite for the screening tests in which heated water was used. For all test points, water chemistry is controlled to avoid possible impact on test data. Water chemistry checks for conductivity, pH, oxygen concentration, total suspended solids, and total organic carbon (TOC) were routinely performed in accordance with controlled test procedures.

For most tests, the process fluid is high purity water at ambient conditions (70°F). A heat exchanger is used to offset heat input from the forced circulation pump and from ambient. Warm (135°F) water is available for screening tests by heating the inventory stored in the large 1700-gallon reservoir. "On/Off" heater control is used to maintain approximately constant fluid temperature due to continuous pump heat input and the large thermal mass contained in the reservoir. Test fluids are saturated with air. Air saturation is achieved in the 1700-gallon reservoir by injecting return water above the tank water level to facilitate mixing of air and water. The air concentration in the water is monitored during testing.

Feedback control maintains constant water flow rates to each fuel assembly inlet plenum based on Coriolis-type mass flowmeters. Remaining boundary system controls were manual, including plenum air (pressure), tank bottom pressure, and channel outlet pressure.

The two fuel assembly inlet plenums were identical in design (Reference 3, 4). The 22-inch diameter plenums were constructed with Plexiglas lids to allow observation of inlet flows. The remainder of the plenum is constructed of aluminum. The plenum serves to uniformly distribute flow from three inlet pipes to the fuel assembly test section. Positioned in the 8.75-inch high plenum and surrounding the central fuel assembly on a prototypic 7-inch pitch were six "dummy" permanent sleeve housings with outside diameter of 5.25 inches. The three 2.90-inch diameter inlet flow nozzles were equally spaced on 120-degree centers around the circumference of the plenum. The inlet flow impinges on three of the six dummy assemblies before redistributing to enter the center fuel assembly. The three inlet flow slots of the fuel assembly test section were aligned with the neighboring "dummy" housings, thus replicating the plant geometry. The inlet plenums were equipped with relief valves set at 10 psig.

For the stratified "air over water" inlet plenum condition, air enters the inlet plenum through the 3 inlet flow nozzles. To support testing with dispersed air/water flow, the aluminum base of each inlet plenum contains a series of 1/8-inch diameter holes directly in front of the fuel assembly inlet slots so that air may be supplied from the "subplenum" chamber, thus providing a dispersed or bubbly flow pattern in the plenum water pool. This feature of the inlet plenums was not used in any of the test phases described in this report.

The tops of the fuel assemblies (Reference 5) were sealed with an aluminum plug (sealed by O-ring groove) to allow for quick change of auxiliary orifice plates without fuel assembly disassembly. The plugs were machined to provide a flow boundary inside the fuel assembly typical of the plant plugs. "Standpipes" were installed on both inlet plenums to aid in matching reference and test fuel assembly inlet plenum pressures for tests with positive pressure.

Fluid flow is downward through the parallel fuel assemblies. Each of the fuel assemblies has the capability to include air leakage into the inlet plenum from below through the plant-typical piston ring which seals the inlet plenum from the reactor tank. In the Annular Flow Distribution Facility, the piston rings have been omitted, and replaced by an isolation valve and metering circuit. The effect of piston ring air leakage was examined as part of the screening test phase.

Reference fuel assembly (includes BFI) flow discharges into an outlet tank (References 6, 7). The tank is used for backpressure control as well as phase separation. Manual adjustment of the spillover elevation for the liquid outlet line allows continuous control of water level and establishes the required "tank bottom" pressure for the reference fuel assembly. Liquid flow exits the tank at the bottom of the outer cylinder and returns to the 1700 gallon supply reservoir. Air flow exits at the top through an air flowmeter. The outlet tank includes 4 viewports to allow visual observation of the flow exiting the BFI. The bottom of the outlet tank can be removed to gain access to the reference assembly BFI. The reference fuel assembly BFI is removable, and can be interchanged between K/C-type, and P/L-type bottom fittings. The monitor pin (Reference 8) is also simulated. As in the plant, the monitor pin is a flow path for the K/C-type BFI only.

The transition piece (Reference 9) at the channel outlet for the test fuel assembly maintains separate channel flows to individual air/water separation (Reference 10) and collection equipment. The flow exits the test fuel assembly transition piece (described in Section 2.2.2) and is routed to the air/water separators (References 7, 10, 11) and the collection and return system shown in Figure 2.3. The air/water separators for the test fuel assembly were used for backpressure control as well as phase separation. Phase separation was visually confirmed in the latter stage of the test program when a transparent length of outlet hose was installed. Manual adjustment of spillover elevations for liquid outlet lines allows continuous control of separator levels and establishes the required channel outlet backpressures for the test fuel assembly. Individual channel liquid flows were routed to collection tanks (low and high capacity available for each separator) to determine annular flow distribution. The flows for the 3 primary Mark-22 flow channels (channels 2, 3, and 4) were continuously routed through the collection tanks during setup and data acquisition so that no influence on backpressure is observed when liquid collection begins. The flows for channels 1 and 5 were dumped to drain. Individual air flow measurements were made at the top of each separator.

2.2.2 Test Fuel Assembly Transition Piece

The test fuel assembly transition piece, Figure 2.4, at the channel outlet for the test fuel assembly maintains separate channel flows to individual air/water separation and collection equipment. The stainless steel transition piece uses close-tolerance lap joints for the connection to the test fuel assembly. Fuel assembly channel walls (Reference 12) were machined to provide adequate mating surfaces. The transition piece is held in place by threaded rods through the base plate of the transition piece and a plate clamped onto the test fuel assembly just above the lowest pressure tap plane. All 5 Mark-22 flow channels were segregated in the transition piece. The transition piece was designed to simulate both a 36-hole K/C-type BFI, and an 80-hole P/L-type BFI. Thin-walled shims were used to block shell holes when simulating the 36-hole K/C-type BFI. A different set of thin-walled shims were used to block a simulated flow path at the monitor pin location when simulating the 80-hole P/L-type BFI. Neither of these sets of shims were used for tests after the proof of principle test phase so that individual channel pressure drop was reduced, permitting a larger range of boundary conditions to be tested.

In the fuel assembly, the channel flow areas are:

Channel 2 -- 1.74 in^2 (35.0% of the active flow area)
Channel 3 -- 2.14 in^2 (43.1% of the active flow area)
Channel 4 -- 1.09 in^2 (21.9% of the active flow area)

The "active flow area" for the Mark-22 fuel assembly is the combined area for Channels 2, 3, and 4 (or 4.97 in^2). The transition piece simulates the area expansion from the flow channels (4.97 in^2) to the BFI flow area (6.89 in^2). The individual flow channels are expanded such that the active flow area ratios were preserved, with the additional constraint that the flow channel width not be less than the channel width in the fuel assembly. The flow areas in the transition piece were:

	<u>Ideal</u> (in^2)	<u>As Built</u> (in^2)
Channel 2	2.4	2.65
Channel 3	2.97	3.04
Channel 4	1.51	1.56

The shell hole size and location were preserved in the transition piece for each of the 3 primary Mark-22 flow channels, thus forcing the two-phase mixture down to the BFI-typical elevation before exiting the fuel assembly. The total flow area through the shell holes is split among the 3 flow channels based on relative active flow area ratios defined earlier. Just as in the reference fuel assembly, once flow has exited through the BFI shell flow holes, it is not likely to return to the fuel assembly.

BFI pressure plates were also simulated in the transition piece. The pressure plate total flow area is distributed among channels 2, 3, and 4 based on relative flow areas in the fuel assembly. The pressure plate hole areas were preserved to limit the size of air bubbles moving downward through the transition piece. It should be noted that the pressure plates in channel 3 were removed from the transition piece prior to the start of proof of principle testing to reduce the pressure drop in channel 3 so that a broader range of test conditions could be achieved. Likewise, the pressure plates in channel 4 were removed following the proof of principle tests.

Flow exits the transition piece channels through the shell holes or the monitor pin flow area (K/C BFI only) and enters the "riser" annulus prior to exiting the transition piece through 1 of 4 symmetrically located 1-inch inside diameter tubes. The riser annulus areas were 7.94 in², 6.16 in², and 2.59 in² for channels 2, 3, and 4, respectively. The 4 exit paths for each channel slope gradually upward toward the air/water separator where they were combined just prior to the separator inlet.

2.2.3 Air Supply System

Auxiliary air, Figure 2.5a, and vacuum, Figure 2.6, systems (also, see Reference 2) were designed to achieve plenum pressures between -5 and +5 psig. Positive pressures were achieved by increasing air flow to the inlet plenum (see Reference 13 for the inlet plenum supply piping configuration). Air system capacity is approximately 150 SCFM per fuel assembly, sufficient to support continued testing following "blowthrough". To support screening tests at elevated temperature, the supply air can be heated to approximately 185F. For heated-air flows above approximately 20 SCFM, the heat exchanger of Figure 2.5a is used. To supply heated air at flow rates less than 20 SCFM, the circuit shown in Figure 2.5b is used. This system uses a smaller heat exchanger with water coolant supplied from the 1700-gallon reservoir. The heated-air supply could also be directed to the piston ring leak site.

Plenum air is drawn from the atmosphere, through filtration and metering equipment, for test points with specified plenum static pressures between -5 and about 0 psig. For specified plenum pressures above 0 psig, a forced air supply is required. To minimize the risk of altering fuel assembly surface properties by introducing contaminants, an "oil-less" blower and filtration system is used to supply air to the fuel assemblies. The system includes a water-cooled heat exchanger with automatic control to reduce the temperature of supplied air from approximately 260F to nominal test conditions of 70F. The system also includes inlet filtration to protect the blower from airborne particulates, outlet filtration to protect the fuel assemblies and the air flowmeters in the event of blower seal failure, and an outlet silencer for personnel protection. A two-speed blower motor is used to improve controllability over a large range in flows, and minimize operating costs.

Negative plenum pressures were achieved passively as a function of fuel assembly liquid flow. Increased plenum vacuums were achieved using a single vacuum pump and vacuum breaker control valve shown in Figure 2.6. Auxiliary air and vacuum systems were not operated simultaneously, although air flow and vacuum conditions naturally occur for some test points.

In the plant, a piston ring on the universal sleeve housing, at the level of the inlet plenum bottom, is intended to seal water leaks between the plenum and the blanket gas below the plenum. It does not provide a good seal against gas leaks into the plenum. When the plenum is in a vacuum, gas can pass upward, between the slotted permanent sleeve and the universal sleeve housing holes, and thence into the assembly. The effects of this gas leakage were evaluated in the screening test phase of the AFD testing. The AFD facility piston ring leakage system is included in the low-range, heated air supply circuit schematic of Figure 2.5b. In the AFD facility, the piston ring has not been installed. Air is injected just below the piston ring location through a single pipe and flows upward into the inlet plenum for tests with negative plenum pressure. The air flow is controlled by adjusting the resistance in the inlet path using a hand valve. Measurements of piston ring leak air flow rate and temperature are made.

2.2.4 Instrumentation

The locations for test facility instrumentation routed to the data acquisition system are shown in Figure 2.7. Table 2.2 defines this instrument set. The database variable names are composed of three parts. The first two characters identify the component, as follows:

AS	Air supply system
RP	Inlet plenum for the reference fuel assembly
TP	Inlet plenum for the test fuel assembly
T1	Test fuel assembly, flow channel 1 (outer target to USH)
T2	Test fuel assembly, flow channel 2 (outer fuel to outer target)
T3	Test fuel assembly, flow channel 3 (inner fuel to outer fuel)
T4	Test fuel assembly, flow channel 4 (inner target to inner fuel)
T5	Test fuel assembly, flow channel 5 (inside inner target)
R1	Reference fuel assembly, flow channel 1 (outer target to USH)
R2	Reference fuel assembly, flow channel 2 (outer fuel to outer target)
R3	Reference fuel assembly, flow channel 3 (inner fuel to outer fuel)
R4	Reference fuel assembly, flow channel 4 (inner target to inner fuel)
R5	Reference fuel assembly, flow channel 5 (inside inner target)
RT	Reference fuel assembly outlet tank

Characters 3 and 4 designate the type of measurement or derived quantity, as follows:

DP	Differential pressure
GM	Gas flowmeter
GP	Gage pressure
LC	Load cells
MM	MicroMotion flowmeter
TC	Fluid thermocouple

The final two characters designate the individual measurement.

A total of 75 instrument channels were recorded in the database, including; 2 ranges for total liquid flow to each fuel assembly, inlet air flow to each plenum (2 or 3 ranges for later tests) and "piston ring" air flow for each fuel assembly, 3 channel outlet air flows (2 ranges for later tests) for the test fuel assembly, and total outlet air flow for the reference fuel assembly (2 ranges for later tests), differential and static pressures for each plenum, 15 channel static pressure measurements for the reference fuel assembly, 18 channel static pressure measurements for the test fuel assembly, additional static pressures above and below each fuel assembly auxiliary orifice plate elevation, and at tank bottom for the reference assembly, a total of 3 inlet fluid temperatures, and 2 load cell ranges for each of 3 channel liquid flows. Calibrations for all instruments are traceable to the National Institute of Standards and Technology.

Total liquid flow rates for each fuel assembly were made using Coriolis-type mass flowmeters (manufactured by Micromotion) upstream of plenum air injection points. These meters were preferred due to accuracy and reliability (B&W experience) considerations. Two meter ranges were used to minimize uncertainty. The mass flow indications were converted to volumetric flow units (gpm) assuming a user specified water density (generally 62.25 lbm/ft³). All air flow measurements were made using low pressure drop, constant-temperature thermal sensors (manufactured by Kurz or Omega). The thermal sensors provide mass flow output directly, and provide adequate measurement response times of approximately 1 second (Kurz) or 0.1 second (Omega).

Channel outlet water flow rates were derived from load cell collected mass. Two load cell ranges (manufactured by Toledo Scale) were used for each channel flow and collection times were adequate to reduce measurement uncertainty to $\pm 1\%$ of the channel flow rate. Characterization tests were performed for the load cells to show adequate dynamic performance over the desired flow range (Reference 14).

Plenum liquid levels were measured using differential pressure transmitters (manufactured by Rosemount or Bailey). These units were selected for reliability and accuracy considerations. The plenum level is reported in units of inches from the bottom of the plenum using a user specified water density (typically 62.25 lbm/ft³) for conversion. Plexiglas lids and "dummy" tubes at the inlet plenums enable visual measurements of plenum water level. These hand-recorded plenum levels were compared with the data base values as a measurement consistency check for tests performed after the proof of principle test phase.

Static pressure was recorded for each plenum using gage pressure transmitters (manufactured by Sensotec). These transmitters were selected based on considerations of measurement response, accuracy, and reliability. The transmitters were used over the range from -5 to +10 psig.

The pressure gradient across the fuel assembly annular channels (channels 2, 3, and 4 only) was measured using a combination of gage pressure (manufactured by Sensotec) and differential pressure transmitters (manufactured by Rosemount or Bailey). Individual subchannels were tapped at 6 elevations for each annulus in each fuel assembly. A piezometric tap configuration (Reference 15), with 4 penetrations per tap, was used at all locations along the fuel assembly channel length. Channel inlet static pressures were measured directly for the test fuel assembly and inferred from differential pressure measurements between corresponding channels for the reference fuel assembly. Static pressure measurements at the remaining 5 elevations within the annular channels of each fuel assembly were measured directly using gage pressure transmitters and 1/8-inch diameter pressure taps. At the lowest channel measurement elevation, a differential pressure measurement was also made between corresponding channels in the reference and test assemblies. These measurements aided in accurately balancing test assembly channel outlet pressures with those in the reference assembly. Since these differential pressure measurements were redundant with a pair of gage pressure measurements, they also served as a check on the adequacy of differencing the gage pressure measurements at the other elevations. Based on examination of the redundant measurement comparisons for the parametric test phase, it is acceptable to difference the gage pressure measurements at the other elevations.

Static pressure measurements above and below each fuel assembly orifice plate utilized gage pressure transmitters with a single, 1/4-inch diameter tap. Tank bottom static pressure was recorded for the reference fuel assembly using a pressure tap off the bottom of the outlet tank.

Inlet air and water temperatures were recorded using 1/16-inch diameter, ungrounded junction. Type E thermocouples (manufactured by Marlin). A water temperature measurement was located just upstream of each inlet plenum (Figure 2.2). The air supply temperature was located at the end of the common supply piping for the fuel assemblies (Figure 2.5a). Thermocouple transmitters (manufactured by Omega) were included in the circuitry to boost the thermocouple input to the data acquisition system from the millivolt range up into the volt range. All instrument signals to the data acquisition system were in the 0 - 3 volt range.

The data acquisition system for the Annular Flow Distribution Test utilized an existing B&W PDP 11/23 (manufactured by Digital Equipment Corporation) computer with an HP3852A (manufactured by Hewlett-Packard) scanning voltmeter. The B&W STARS-RSX data acquisition software was used for on-line data monitoring and collection. The system features also include software for checking out the HP3852A voltmeter, acquiring transmitter "zero" values, and updating the database. The system was capable of sampling all instruments at 5 second intervals. The software was enhanced for the Annular Flow Distribution test to provide "high-speed" data recording capability. The data acquisition system was capable of sampling and storing raw instrument data for up to 80 instruments as often as 1 scan every 0.2 seconds for a test duration of up to 15 minutes. Data was written to a 40 megabyte Winchester hard disk. Raw test data was transferred via a local network connection to other B&W computers for off-line data reduction, analysis, data qualification, and archival.

In addition to instruments connected to the data acquisition system, the facility included several instruments for channels 1 and 5 that were not connected to the data acquisition system. Indications from these instruments were recorded in the test logs. A single pressure tap was installed at the lowest instrument plane for channels 1 and 5 in both fuel assemblies. The differential pressure between assemblies for these channels was measured by a calibrated differential pressure meter (manufactured by Barton). The separator levels for the test fuel assembly were generally adjusted just as for channels 2, 3, and 4, until the differential pressure between assemblies near the channel exit was near zero. Uncalibrated air flowrators (manufactured by Fisher-Porter) were installed at the top of the separators (2 ranges for each separator) for indications of channel 1 and 5 air flow.

Table 2.1
Drawing List

<u>Drawing Number</u>	<u>Sheet Number</u>	<u>Title</u>
13460-B	1	Overall Panel Layout
	2	Annunciator Controls
	3	Forced Circulation & Blower
	4	Weigh Tank Load Cell Readout
	5	Weigh Tank Load Cell Terminals
	6	Kurz Electronics Mounting
	7	Kurz Electronics Mounting
	8	Micro Motion Electronics Mounting
	9	Micro Motion Electronics Mounting
	10	Flow Rate Indicator
	11	Thermocouple Transmitters
	12	Relay Mounting
	13	Outlet Mounting
	14	Instrument Power Supply Enclosure Layout Panel
	15	Instrument Power Supply Panel Drilling
	16	Bay 19 600 Amp Motor Control Center Layout Panel
13461-B	1	480 V Power Motor Control Center
	2	480 V Power Motor Control Center
	3	120 V Power Circuit Breaker Panel
	4	Air Blower Controls
	5	Forced Circulation Controls
	6	Forced Circulation Controls
	7	Forced Circulation & Heater Controls
	8	Annunciator
	9	Annunciator
	10	Annunciator
	11	Transmitter Power Supply Termination - Typical Connections
	12	Power Supply Termination Panel (Section 1)
	13	Power Supply Termination Panel (Section 2)
	14	Power Supply Termination Panel (Section 3)
	15	Power Supply Termination Panel (Section 3)
	16	Weigh Tank Load Cell
	17	Weigh Tank Load Cell Readout
	18	Weigh Scale Load Cell Cables
	19	Thermocouple Transmitters
	20	Micro Motion Flowmeters
	21	Micro Motion Flowmeters
	22	Micro Motion Readout
	23	Kurz Air Flowmeters
	24	Kurz Air Flowmeters
	25	Hewlett-Packard Data Acquisition System

Table 2.1 (cont'd.)

Drawing List

<u>Drawing Number</u>	<u>Sheet Number</u>	<u>Title</u>
13461-B	26	Wire Number Chart
	27	Cable Number Chart
13338-E		Flow Schematic for Water, Air, and Vacuum Systems
13339-E		Water Air Separator Assembly and Details
13340-E		BFI Backpressure Tank
13341-E		BFI Backpressure Tank Details
13343-E		Inlet Plenum
13347-E		Inlet Plenum Details
13348-E		Inlet Plenum Supply Piping
13463-D		Channels 1 and 5 Air/Water Separator
13344-E		Fuel Bundle Pressure Tap Locations
13345-E		Enhanced Outlet Transition Piece Assembly
13349-E		Enhanced Outlet Transition Piece Details
13433-E		Upper Fuel Sleeve and Bundle Modifications
13437-E		Bundle Cutting Detail
13438-E		Enhanced Outlet Transition Piece Details
13439-E	C	Enhanced Outlet Transition Piece Detail,
13462-D		Split Clamp Details
13466-E		Support Steel and Arrangement
13467-E		Support Steel Details
14052-D		Schematic for Air Supply System

Table 2.2
Database Variable (VTAB) Measurement Definitions

<u>VTAB</u>	<u>Description</u>
ASTC01	INLET PLENUM COMMON AIR TEMPERATURE
TPTC01	TEST INLET PLENUM LIQUID TEMPERATURE
RPTC01	REFERENCE INLET PLENUM LIQUID TEMPERATURE
TPMM02	LIQUID HIGH FLOW RATE TEST PLENUM
RPMM02	LIQUID HIGH FLOW RATE REFERENCE PLENUM
TPMM01	LIQUID LOW FLOW RATE TEST PLENUM
RPMM01	LIQUID LOW FLOW RATE REFERENCE PLENUM
TPGM01	AIR MASS RATE, TEST INLET PLENUM
TPGM02	AIR MASS RATE, TEST PLENUM PISTON RING LEAK
RPGM01	AIR MASS RATE, REFERENCE INLET PLENUM
RPGM02	AIR MASS RATE, REFERENCE PLENUM PISTON RING LEAK
RTGM01	AIR MASS RATE, REFERENCE ASSEMBLY OUTLET
T2GM01	AIR MASS RATE, CHANNEL 2 SEPARATOR
T3GM01	AIR MASS RATE, CHANNEL 3 SEPARATOR
T4GM01	AIR MASS RATE, CHANNEL 4 SEPARATOR
TPGM03	AIR MASS RATE, TEST INLET PLENUM, LOW RANGE
RPGM03	AIR MASS RATE, REFERENCE INLET PLENUM, LOW RANGE
T2GM02	AIR MASS RATE, CHANNEL 2 SEPARATOR, LOW RANGE
T3GM02	AIR MASS RATE, CHANNEL 3 SEPARATOR, LOW RANGE
T4GM02	AIR MASS RATE, CHANNEL 4 SEPARATOR, LOW RANGE
RTGM02	AIR MASS RATE, REFERENCE OUTLET, LOW RANGE
RPGP01	PRESSURE, TOP OF REFERENCE INLET PLENUM, 230.4 inches
RPGP02	PRESSURE, REFERENCE ASSEMBLY, ABOVE ORIFICE, 198.2 inches
RPGP03	PRESSURE, REFERENCE ASSEMBLY, BELOW ORIFICE, 194.7 inches
TPGP01	PRESSURE, TOP OF TEST INLET PLENUM, 230.4 inches
TPGP02	PRESSURE, TEST ASSEMBLY ABOVE ORIFICE, 198.2 inches
TPGP03	PRESSURE, TEST ASSEMBLY BELOW ORIFICE, 194.7 inches
T2GP01	PRESSURE, CHANNEL 2, TEST ASS'Y., 162.7 inches
T3GP01	PRESSURE, CHAN. 3, TEST ASS'Y., 162.3 inches
T4GP01	PRESSURE, CHAN. 4, TEST ASS'Y., 161.9 inches
T2GP02	PRESSURE, CHAN. 2, TEST ASS'Y., 131.2 inches
T3GP02	PRESSURE, CHAN. 3, TEST ASS'Y., 130.8 inches
T4GP02	PRESSURE, CHAN. 4, TEST ASS'Y., 130.4 inches
T2GP03	PRESSURE, CHAN. 2, TEST ASS'Y., 99.7 inches
T3GP03	PRESSURE, CHAN. 3, TEST ASS'Y., 99.3 inches
T4GP03	PRESSURE, CHAN. 4, TEST ASS'Y., 98.9 inches
T2GP04	PRESSURE, CHAN. 2, TEST ASS'Y., 68.2 inches
T3GP04	PRESSURE, CHAN. 3, TEST ASS'Y., 67.8 inches
T4GP04	PRESSURE, CHAN. 4, TEST ASS'Y., 67.4 inches
T2GP05	PRESSURE, CHAN. 2, TEST ASS'Y., 36.7 inches
T3GP05	PRESSURE, CHAN. 3, TEST ASS'Y., 36.3 inches

Table 2.2 (cont'd.)
Database Variable (VTAB) Measurement Definitions

<u>VTAB</u>	<u>Description</u>
T4GP05	PRESSURE, CHAN. 4, TEST ASS'Y., 35.9 inches
T2GP06	PRESSURE, CHAN. 2, TEST ASS'Y., 5.2 inches
T3GP06	PRESSURE, CHAN. 3, TEST ASS'Y., 4.8 inches
T4GP06	PRESSURE, CHAN. 4, TEST ASS'Y., 4.4 inches
R2GP02	PRESSURE, CHAN. 2, REFERENCE ASS'Y., 131.2 inches
R3GP02	PRESSURE, CHAN. 3, REFERENCE ASS'Y., 130.8 inches
R4GP02	PRESSURE, CHAN. 4, REFERENCE ASS'Y., 130.4 inches
R2GP03	PRESSURE, CHAN. 2, REFERENCE ASS'Y., 99.7 inches
R3GP03	PRESSURE, CHAN. 3, REFERENCE ASS'Y., 99.3 inches
R4GP03	PRESSURE, CHAN. 4, REFERENCE ASS'Y., 98.9 inches
R2GP04	PRESSURE, CHAN. 2, REFERENCE ASS'Y., 68.2 inches
R3GP04	PRESSURE, CHAN. 3, REFERENCE ASS'Y., 67.8 inches
R4GP04	PRESSURE, CHAN. 4, REFERENCE ASS'Y., 67.4 inches
R2GP05	PRESSURE, CHAN. 2, REFERENCE ASS'Y., 36.7 inches
R3GP05	PRESSURE, CHAN. 3, REFERENCE ASS'Y., 36.3 inches
R4GP05	PRESSURE, CHAN. 4, REFERENCE ASS'Y., 35.9 inches
R2GP06	PRESSURE, CHAN. 2, REFERENCE ASS'Y., 5.2 inches
R3GP06	PRESSURE, CHAN. 3, REFERENCE ASS'Y., 4.8 inches
R4GP06	PRESSURE, CHAN. 4, REFERENCE ASS'Y., 4.4 inches
RTGP01	PRESSURE, TANK BOTTOM FOR REFERENCE ASSEMBLY
T2LC01	LIQ. MASS, LOW RANGE CHAN. 2 SEPARATOR
T2LC02	LIQ. MASS, HIGH RANGE CHAN. 2 SEPARATOR
T3LC01	LIQ. MASS, LOW RANGE CHAN. 3 SEPARATOR
T3LC02	LIQ. MASS, HIGH RANGE CHAN. 3 SEPARATOR
T4LC01	LIQ. MASS, LOW RANGE CHAN. 4 SEPARATOR
T4LC02	LIQ. MASS, HIGH RANGE CHAN. 4 SEPARATOR
R2DP01	DP TEST/REFER. ASS'Y. CHAN. 2, 162.7 inches
R3DP01	DP TEST/REFER. ASS'Y. CHAN. 3, 162.3 inches
R4DP01	DP TEST/REFER. ASS'Y. CHAN. 4, 161.9 inches
R2DP02	DP TEST/REFER. ASS'Y. CHAN. 2, 5.2 inches
R3DP02	DP TEST/REFER. ASS'Y. CHAN. 3, 4.8 inches
R4DP02	DP TEST/REFER. ASS'Y. CHAN. 4, 4.4 inches
RPLV01	LEVEL, REFERENCE INLET PLENUM
TPLV01	LEVEL, TEST INLET PLENUM

Note: The instrument elevations were referenced to the bottom of the fuel subassembly bottom fitting (see Reference 15)

Figure 2.1 Hydraulic Similarity Concept

Figure 2.2 Forced Circulation System

Figure 2.3 Collection and Return System

Figure 2.4 Transition Piece Test Fuel Assembly

Figure 2.5a. Air Supply System

Figure 2.5b. Low-Range, Heated-Air Supply Circuit

Figure 2.6 Vacuum System

Figure 2.7 Data Acquisition System Instrumentation

3.0 TEST PHASES

Five phases of testing were performed as part of the Annular Flow Distribution Test Program. These include:

- proof of principle testing,
- sensitivity testing,
- air flow testing,
- screening testing, and
- parametric testing.

The following sections describe each of the five phases including the test phase objective, loop and/or instrumentation modifications, test matrix, and test results.

Data summaries for each of the five test phases are provided in Appendix A for all qualified tests. For each test, the data includes a summary of boundary conditions, test results, and pressure measurements for both assemblies. The values reported are time-averaged for the duration of each steady-state test (typically about 5 minutes.)

The summary sheet boundary conditions include total assembly water and air flow rates, water and air inlet temperatures, the inlet plenum pressure, and tank bottom pressure. Test assembly air/water separator levels (referenced to tank bottom) are also provided. The channel flow splits are determined from the rate of change in load cell readings for the collection period. The water flow splits are reported in percent of the total assembly inlet water flow as measured by the Micromotion mass flowmeters. The air flows are reported in units of standard cubic feet per minute (SCFM). The individual channel air flows are also reported in percent of the summation of individual channel (1 through 5) air flows. The plenum levels and barometric pressure are listed for information.

Pressure comparisons between the reference and test assemblies can be made using the information provided on the pressure profile summary sheet provided in Appendix A for each test. This summary sheet also includes the 2-sigma (95% confidence level) fluctuation values for each of the pressure measurements (column labeled "Two Std Deviation".)

Data quality is controlled through performance of the following tasks which are detailed in the individual test procedures (Appendix C).

- on-line measurement system checks bracketing each test, including
 - data acquisition system voltmeter check,
 - visual inspection of pressure measurement process tubing to assure the absence of trapped air,
 - acquisition of new transmitter "zero" values to verify calibration stability and to detect instrument problems,
 - pressure transmitter performance check at atmospheric pressure,
 - load cell performance check at 50 or 150 lbm, and
 - water chemistry checks for conductivity, pH, oxygen, total organic carbon, and total suspended solids.
- on-line, pre-data storage checks, including

- verifying all instrument readings are within the calibrated range,
 - verifying the consistency of the measurements where possible,
- off-line test setup and measurement system checks (using average values from recorded data set), including
 - boundary conditions established within specifications, and
 - verifying the consistency of the measurements where possible.

The data qualification check summaries identifying measurement or test condition deviations, along with the impact on the test data, are included in Appendix B, Data Quality Summaries.

3.1 Proof of Principle Testing

Proof of principle tests were performed to confirm the ability to establish hydraulic similarity for parallel Mark-22 fuel assemblies over the required range of test conditions, and to confirm reproducibility of test points. The proof of principle test phase is the subject of the Interim Report (Reference 1). The reader is referred to the Interim Report for a complete discussion of the results of the proof of principle testing. A complete list of tests performed in the proof of principle test phase is given in Table 3.1 and is briefly described below under "Test Conditions". Test results for only those proof of principle tests performed after the Interim Report will be discussed here, including the "alternate matching criterion tests" and the "annulus-to-annulus leakage check".

The proof of principle testing was performed in accordance with B&W Technical Procedure ARC-TP-897, "Annular Flow Distribution Test -- Proof of Principle Testing". The air and water inlet temperatures were approximately 70F for all tests. The auxiliary orifice sleeves were not installed for these tests. Flow channels 1 and 5 were treated as individual flow channels for all proof of principle tests.

A 36-shell hole, K/C-type BFI was installed in the reference fuel assembly for all proof of principle tests. The test fuel assembly transition piece was designed to model a 36-shell hole, K/C-type BFI or an 80-shell hole, P/L-type BFI. For the K/C-type BFI only, a flow path is available at the base of the BFI (through the monitor pin). To simulate the 36-shell hole, K/C-type BFI with flow through the monitor pin, the "tall", thin-walled, shell hole blocking shims were installed. To model an 80-shell hole, P/L-type BFI, the "tall" shims were replaced with "short" shims. The short shims block none of the shell holes, but do block the monitor pin flow path. The 80-hole, P/L-type BFI simulation was not used for the proof of principle tests. The 36-hole, K/C-type BFI was used for many tests, but this simulation resulted in an undesired limitation in the pressure control for the test assembly (flow channel 4 in particular). For a particular set of boundary conditions, excessive pressure drop through the transition piece precluded lowering the test assembly channel separator level enough to allow a match in exit pressure with the corresponding reference assembly channel. In an attempt to achieve an acceptable channel exit pressure match for a larger range of boundary

conditions, all shims were removed from the transition piece, thereby reducing the flow resistance and strictly simulating neither BFI. This configuration, referred to as the "shims out" configuration, combines the shell hole flow area of the 80-shell hole P/L-type BFI and the monitor pin flow area of the 36-shell hole K/C-type BFI. The status of the transition piece model was a variable between tests and is indicated in Table 3.1. Some tests were repeated with and without transition piece shell hole blocking shims installed. These tests indicated no significant change in the test assembly pressure profiles or flow splits.

3.1.1 Test Conditions

The test condition matrix for the proof of principle testing is presented in Table 3.1. Tests 897001 through 897098 are the subject of the Interim Report, Reference 1. Tests 897001 through 897035 were baseline tests covering total assembly flows from 10 to 40 gpm, reference assembly backpressures from 2 to 5 feet, and plenum pressures from -6.4 to +5 psig. In an effort to reduce the pressure drop in the test assembly transition piece, the shell hole blocking shims were removed from the transition piece, and the scaling for BFI type was sacrificed. Tests 897038 through 897052 were now achieved with the reduced transition piece pressure drop. Tests 897053 through 897058 were performed to support a code benchmarking effort at the Savannah River Laboratory. Some desired data points at assembly flows of 24 and 40 gpm could not be achieved due to excessive transition piece pressure drop even with the shims removed. Those test points were modified by increasing the reference assembly backpressure by 6 to 12 inches, tests 897059 through 897064. Additional code benchmarking tests were performed at assembly flows of 30 and 60 gpm (tests 897065 through 897071).

Tests 897072 through 897080 were performed with shims removed as part of the repeatability series. The "tall" shims were re-installed and additional repeatability tests were performed, tests 897081 through 897087. Tests 897090 and 897091 were performed to examine water flow hysteresis (controlled water flow). Channel pressure profiles and flow rates were compared for a test point (897090) approached by decreasing water flow (normal procedure), and a test point (897091) approached by increasing water flow. Likewise, air flow hysteresis (controlled air flow) was examined in tests 897092 through 897098. Tests 897092 through 897095 were obtained by increasing air flows (normal procedure), while tests 897096 through 897098 were achieved by decreasing air flow. For these water and air flow hysteresis tests, the pressure profiles and annular flow splits did not vary significantly.

As described in the Interim Report, the proof of principle tests revealed potentially significant questions regarding the achievement of hydraulic similarity between the test and reference fuel assemblies. In particular, differing total air flows were measured between assemblies, and channel pressure profiles did not always agree. The "alternate matching criterion tests", tests 897115 through 897140, were performed to determine if channel exit phenomenon was responsible for the observed pressure profile differences. For these tests, rather than adjusting the test assembly channel outlet pressures to agree with those of the reference assembly, the match was forced at higher elevations within the fuel assembly. The tests listed in Table 3.1 as "alternate matching criterion tests, Baseline points" were performed in the usual way, namely, matching test and reference assembly

channel exit pressures (GP06's). These tests also serve as repeats of earlier proof of principle tests. The tests listed in Table 3.1 as "alternate matching criterion tests, highest elevation match" each correspond to one of the "baseline" tests, but test assembly individual channel backpressures were adjusted to force a pressure match between the reference and test assemblies at higher elevations (either GP03, GP04, or GP05 elevations).

The alternate matching criterion tests did not significantly improve agreement for reference and test assembly pressure profiles, air flows, nor did they significantly affect water flow splits. These tests indicated that the channel exit characteristics are not the cause of observed differences between the reference and test assemblies. The decision was made to continue testing using the original scheme, namely, matching channel exit pressures.

3.1.2 Annulus-to-Annulus Leakage Check

The annulus-to-annulus leakage check was performed to verify that the observed deviations in pressure profiles for the proof of principle tests were not experimentally induced by passage of air from one annulus to another via small gaps between flow channels due to the pressure tap penetrations. Based on fabrication method checks for the pressure taps, the maximum hole diameter is expected to be 0.134 inches, and the tube diameter is 0.127 inches. Only the reference assembly was tested for this phase. The annulus-to-annulus leakage check was performed in accordance with ARC-TP-959 "Annular Flow Distribution Test -- Annulus to Annulus Leakage Check."

To perform this test, the reference assembly backpressure tank was sealed off to maintain a water level above the top of the channels. The reference assembly was open to atmosphere at the inlet plenum for this testing. To perform this test, the piezometric ring for R2GP04 (channel 2, 62.8 inches) was disconnected and bottled air was connected. The water level in the reference assembly was established above the channel inlets in an attempt to avoid recirculation of air and water in the assembly channels. Air was then injected into the assembly through the R2GP04 connection at a rate resulting in the local pressure at the next highest pressure tap elevation (R2GP03 -- channel 2, 99.7 inches) to exceed the pressure in the neighboring channel by approximately 0.5 psid. Data was recorded for about 1 minute during the air injection period. Pressure profile changes in the neighboring channels were used to infer air leakage rates across the channel boundaries. The procedure was repeated for air injection into channel 3 and finally channel 4.

These tests proved inconclusive due to communication between channels at the inlet and outlet plane. To be successful, the channels should be isolated at the channel bottom. This would allow one to relate the change in channel pressure profile to the passage of air through the annular gaps in channel boundaries.

In a different test, a single-phase liquid annulus-to-annulus leakage check was performed on both the test and reference assemblies. This test was performed for scoping purposes only, and any data recorded is for information only. For this test, the channel 3 exit for the reference and test fuel assemblies was plugged to provide a seal for water pressures up to several psi. Water was injected into channel 3 only at a rate sufficient to maintain a water level (relative to the bottom of the fuel sub-assembly just as pressure tap elevations are defined) at various elevations within the channel length. All water leakage from channel 3 (and into the neighboring channels) was attributed to the penetrations in channel boundaries at the pressure tap elevations.

For a constant channel 3 water level, the leakage out of channel 3 was monitored by measuring the water flow into channel 3, using a flow rotameter. By repeating this procedure for various water levels in channel 3, the leakage through the pressure tap holes at various elevations could be estimated. Results for the lower 4 pressure tap elevations are shown in Table 3.2 for the case where the pressure difference across the channel boundaries is approximately 1.1 psid. The results indicate that measurable leakage exists at both the reference and test assembly channel 3 boundary. Also, data suggests that leakage rates are similar for the test and reference assemblies. Although not measured independently, leakage flow was observed into both channels 2 and 4 for each assembly.

Table 3.1
Proof of Principle Test Matrix

<u>Test Number</u>	<u>Total Water Flow (gpm)</u>	<u>Backpressure (ft of H₂O)</u>	<u>Inlet Plenum Pres. (psig)</u>	<u>Assembly Pres. Drop (psid)</u>	<u>Shims¹ Status</u>
[baseline data]					
897001	40.0	5.0 (2.17 psig)	-5.3 (no air) ²	-7.5	In
897002	40.0	5.0 (2.17 psig)	0.00	-2.2	In
897004	40.0	5.0 (2.17 psig)	2.00	-0.1	In
897006	40.0	5.0 (2.17 psig)	5.00	2.9	In
897007	40.0	2.0 (0.87 psig)	-6.4 (no air)	-7.4	In
897013	40.0	2.0 (0.87 psig)	5.00	4.2	In
897015	24.0	2.0 (0.87 psig)	-4.4	-5.2	In
897019	24.0	2.0 (0.87 psig)	2.00	1.2	In
897020	10.0	5.0 (2.17 psig)	-1.4 (no air)	-3.5	In
897021	10.0	5.0 (2.17 psig)	0.00	-2.2	In
897022	10.0	5.0 (2.17 psig)	2.00	-0.1	In
897024	10.0	5.0 (2.17 psig)	4.00	2.0	In
897027	24.0	2.0 (0.87 psig)	-6.0 (no air)	-7.0	In
897028	10.0	2.0 (0.87 psig)	-1.5 (no air)	-2.4	In
897033	10.0	2.0 (0.87 psig)	0.00	-0.9	In
897034	10.0	2.0 (0.87 psig)	2.00	1.2	In
897035	10.0	2.0 (0.87 psig)	3.00	2.2	In
897036	10.0	2.0 (0.87 psig)	-3.00	-3.9	In
897037	10.0	5.0 (2.17 psig)	-3.00	-5.2	In
897038	40.0	5.0 (2.17 psig)	0.00	-2.2	Out
897039	24.0	2.0 (0.87 psig)	2.00	1.2	Out
897040	10.0	2.0 (0.87 psig)	0.00	-0.9	Out
897046	40.0	2.0 (0.87 psig)	-5.00	-6.1	Out
897050	40.0	2.0 (0.87 psig)	2.00	1.2	Out
897051	10.0	2.0 (0.87 psig)	0.00	-0.9	Out
897052	10.0	5.0 (2.17 psig)	0.00	-2.2	Out
897059	24.0	2.5 (1.08 psig)	-3.00	-4.1	Out
897060	24.0	2.5 (1.08 psig)	-2.00	-3.1	Out
897061	24.0	2.5 (1.08 psig)	0.00	-1.1	Out
897062	40.0	2.5 (1.08 psig)	-2.00	-3.1	Out
897064	40.0	3.0 (1.30 psig)	0.00	-1.4	Out
[code benchmarking data]					
897053	40.0	2.5 (1.08 psig)	-1.1	-2.1	Out
897054	24.0	5.0 (2.17 psig)	0.00	-2.2	Out
897055	80.0	4.0 (1.73 psig)	0.00	-1.8	Out
897057	80.0	2.5 (1.08 psig)	-1.1	-2.2	Out
897058	80.0	2.0 (0.87 psig)	0.00	-0.8	Out
897065	30.0	5.0 (2.17 psig)	0.00	-2.2	Out
897066	30.0	3.0 (1.30 psig)	0.00	-1.3	Out
897067	30.0	3.0 (1.30 psig)	-0.86	-2.2	Out
897069	60.0	4.5 (1.95 psig)	0.00	-2.0	Out
897070	60.0	3.0 (1.30 psig)	0.00	-1.3	Out
897071	60.0	2.5 (1.08 psig)	-0.86	-1.9	Out

Table 3.1 (cont'd.)
Proof of Principle Test Matrix

<u>Test Number</u>	<u>Total Water Flow (gpm)</u>	<u>Backpressure (ft of H2O)</u>	<u>Inlet Plenum Pres. (psig)</u>	<u>Assembly Pres. Drop (psid)</u>	<u>Shims¹ Status</u>
[repeatability tests]					
897072	80.0	2.5 (1.08 psig)	-1.1	-2.3	Out
897073	60.0	3.0 (1.30 psig)	0.00	-1.3	Out
897074	40.0	5.0 (2.17 psig)	0.00	-2.2	Out
897075	40.0	3.0 (1.30 psig)	-1.1	-2.4	Out
897076	40.0	3.0 (1.30 psig)	0.00	-1.4	Out
897077	24.0	5.0 (2.17 psig)	0.00	-2.2	Out
897078	24.0	3.0 (1.30 psig)	0.00	-1.3	Out
897079	24.0	2.5 (1.08 psig)	-2.00	-3.2	Out
897080	15.0	3.0 (1.30 psig)	0.00	-1.3	Out
897081	40.0	5.0 (2.17 psig)	0.00	-2.2	In
897082	24.0	5.0 (2.17 psig)	0.00	-2.2	In
897084	24.0	3.0 (1.30 psig)	0.00	-1.3	In
897086	24.0	2.0 (0.87 psig)	2.00	1.1	In
897087	15.0	3.0 (1.30 psig)	0.00	-1.3	In
[water flow hysteresis tests]					
897090	24.0	3.3 (1.45 psig)	0.00	-1.5	In
897091	24.0	3.3 (1.45 psig)	0.00	-1.5	In
[air flow hysteresis tests]					
897092	24.0	3.3 (1.45 psig)	-1.00	-2.5	In
897094	24.0	3.3 (1.45 psig)	0.00	-1.5	In
897096	24.0	3.3 (1.45 psig)	+1.00	-0.5	In
897098	24.0	3.3 (1.45 psig)	+1.00	-0.4	In
897097	24.0	3.3 (1.45 psig)	0.00	-1.5	In
897098	24.0	3.3 (1.45 psig)	-1.00	-2.4	In
[alternate matching criterion tests, BASELINE points]					
897115	10.0	5.0 (2.17 psig)	0.00	-2.2	Out
897118	24.0	5.0 (2.17 psig)	0.00	-2.2	Out
897121	40.0	3.0 (1.30 psig)	-1.10	-2.5	Out
897125	24.0	3.0 (1.30 psig)	0.00	-1.4	Out
897128	24.0	2.5 (1.08 psig)	-2.00	-3.1	Out
897133	40.0	5.0 (2.17 psig)	0.00	-2.3	Out
897135	40.0	2.5 (1.08 psig)	-1.10	-2.1	Out
897139	80.0	4.0 (1.73 psig)	0.00	-1.8	Out
897140	24.0	3.3 (1.45 psig)	+1.00	-0.4	Out
[alternate matching criterion tests, highest elevation match]					
897116	like 897115, but match GP05 pressures				
897119	like 897118, but match GP05 pressures				
897123	like 897121, but match GP04 pressures				
897127	like 897125, but match GP04 pressures				
897131	like 897128, but match GP03 pressures				
897137	like 897135, but match GP04 pressures				

Table 3.1 (cont'd.)

¹"Shim Status" refers to the installation status of the test fuel assembly transition piece shell-hole blocking shims. A 36-hole, K/C-type bottom fitting insert is modeled when the shims were "in", and an 80-hole, P/L-type BFI shell hole area combined with the K/C-type monitor pin flow area is modeled when the shims are "out". The reference fuel assembly BFI was a 36-hole K/C-type for all tests.

²For tests with inlet plenum pressures labeled "no air", the indicated vacuum pressure resulted naturally without air injection or use of the vacuum pump.

Table 3.2
Channel 3 Water Leakage Results

Pressure Across Channel Boundary: 1.1 psid

	Pressure Tap Plane			
	GP06 5"*	GP05 36"*	GP04 67"*	GP03 128"*
	(gpm)	(gpm)	(gpm)	(gpm)
Test ** Assembly	0.183	0.181	0.156	0.156
Reference ** Assembly	0.133	0.194	0.149	0.149

*Elevations are relative to the bottom of the fuel subassembly (Reference 15).

**Only GP06 values are direct measurements, others are calculated based on information from incremental increases in water level.

3.2 Sensitivity Testing

Three types of tests were performed for the sensitivity testing phase, including:

- lower-end, air injection testing,
- asymmetric water flow injection testing,
- low-tank level testing,

These sensitivity tests were performed in accordance to technical procedure ARC-TP-955, "Annular Flow Distribution Test -- Sensitivity Testing."

3.2.1 Air Injection Sensitivity Testing

The air injection sensitivity testing was performed to evaluate the effect of lower-end air injection on the Mark-22 fuel assembly flow distribution. Such a gas injection can be considered a simulation of the increase in channel void fraction due to heating.

Test assembly conditions for proof of principle tests 897072 and 897140 were replicated. For each of these tests, air was injected through the existing channel 2 penetration ports located near the top of the transition piece. Data sets were recorded for successively higher air injection rates. The low-range air meter (Omega) on the channel 4 separator, T4GM02, was temporarily plumbed to monitor the air injection into the transition piece. The transition piece shell-hole blocking shims were removed for these tests.

Table 3.3 lists the test conditions that were evaluated for the air injection sensitivity testing. These tests demonstrated that air injected near the bottom of the assembly is swept out the bottom for these particular test conditions. Based on the channel outlet air flow measurements, the air did not flow upward.

Table 3.3
Air Injection Sensitivity Test Matrix

<u>Test Number</u>	<u>Water Flow (gpm)</u>	<u>Backpressure (ft of H2O)</u>	<u>Inlet Plenum Pressure (psig)</u>	<u>Air Injection (scfm)</u>	<u>Repeat of Test Number</u>
955001	24	3.3	1	0	897140
955002*	24	3.3	1	0.3	
955004*	24	3.3	1	0.9	
955005*	24	3.3	1	1.3	
955006	24	3.3	1	1.5	
955007*	24	3.3	1	2.2**	
955008	80	2.5	-1.1	0	897072
955009*	80	2.5	-1.1	0.2	
955010*	80	2.5	-1.1	0.4	
955011*	80	2.5	-1.1	0.6	
955012	80	2.5	-1.1	1.5	
955013*	80	2.5	-1.1	2.2**	

*This test has not undergone full data qualification and is not included in Appendix A.

**The 2.2 scfm air injection is only an estimate because the injection air flowmeter (0-1.5 scfm) was over-ranged.

3.2.2 Asymmetric Water Injection Tests

The asymmetric water injection sensitivity testing was performed to observe the impact on the annular flow distributions caused by a pressure gradient at the inlet to the fuel assembly. To do this, all plenum air and water flow was injected into the north facing inlet nozzle and the remaining two nozzles were plumbed together to form the bypass line. The bypass line included a water flow rotameter for flow indication, and a hand valve to control the bypass flow. The test assembly bypass flow was returned to the 1700-gallon forced circulation system reservoir. The reference assembly bypass flow was collected for mass flow measurement, then returned to the 1700-gallon reservoir.

Table 3.4 lists the test conditions evaluated in the asymmetric sensitivity testing. With the exception of test 955017, these tests showed that for the levels of bypass flow achieved, there was no significant effect of the asymmetric inlet water flow on water flow distribution within the assembly, nor on assembly air flow. The results for the comparison of 955017 with 897140 are not as clear, given the large variability in results for this test condition (identified later in Section 5.2.)

Table 3.4
Asymmetric Water Injection Test Matrix

<u>Test</u> <u>Number</u>	<u>Water</u> <u>Flow</u> <u>(gpm)</u>	<u>Backpressure</u> <u>(ft. of H₂O)</u>	<u>Inlet Plenum</u> <u>Pressure</u> <u>(psig)</u>	<u>Bypass</u> <u>Flow</u> <u>(gpm)</u>	<u>Similar to</u> <u>Test Number</u>
955014	24	5.0	0	11	897077
955015	30	5.0	0	15	897065
955016	40	5.0	0	30	897038
955017	24	3.3	1	11	897140

3.2.3 Low-Tank Level Sensitivity Testing

At the outset of the Annular Flow Distribution Test Program, a matrix of inlet and outlet pressures was specified for testing. The test matrix could be reduced if it were appropriate to combine the two variables into one, namely overall assembly pressure drop. A number of proof of principle tests were specified to achieve the same overall assembly pressure drop with different combinations of inlet and outlet pressure. These proof of principle tests seemed to support combining the two variables. The low-tank level sensitivity tests were performed to further examine the validity of testing various levels of overall assembly pressure drop, rather than individual inlet and outlet pressure combinations, under conditions where mixture levels inside the assembly fall below channel exits. To perform this testing, the channel 4 pressure plates were removed from the transition piece so that lower tank levels could be tested.

Table 3.5 lists the test conditions evaluated for the low-tank level sensitivity testing. Table 3.6 is a comparison of test results for each of the low-tank level tests and the associated test having the same overall assembly pressure drop but with different tank levels. The comparison of 897006 with 955022, and 955021 with 955024 indicate that water flow split does not vary significantly with tank level. The comparison of 897140 with 955023 seems to indicate a dependence of flow splits on tank level, but as shown in Section 5 on repeatability, there appears to be a large variability in test results for this set of test conditions independent of tank level.

One consistent trend for the low-tank level test comparisons is that the total assembly air flows generally increased with decreasing tank level (for the same overall assembly pressure drop). As a result, 6 new tests were specified in the air flow testing procedure (ARC-TP-965) for comparison with parametric tests. These tests allow further characterization of the dependence of total assembly air flow on the tank level.

Table 3.5
Low-Tank Level Sensitivity Test Matrix

<u>Test Number</u>	<u>Test Date</u>	<u>Water Flow (gpm)</u>	<u>Tank Level or Backpressure (ft of H₂O)</u>	<u>Inlet Plenum Pressure (psig)</u>	<u>Comments</u>
955018	5/08/90	24	5.0	0	Repeat of 897054
955020	5/09/90	24	1.5	1.2	
955021	5/09/90	50	1.5	0.3	Compare to 955024
955022	5/10/90	40	1.5	3.5	Compare to 897006
955023	5/10/90	24	1.5	0.2	Compare to 897140
955024	5/10/90	50	5.0	1.8	Compare to 955021

Table 3.6
Low-Tank Level Test Comparisons

<u>Conditions</u> (water flow, pressure drop)		<u>Tank Level (ft)</u>	<u>Water Flow Splits</u> <u>Ch 2 Ch 3 Ch 4</u> (%) (%) (%)			<u>Air Flows</u> <u>Test Ref.</u> (scfm) (scfm)		<u>Plenum Levels</u> <u>Test Ref.</u> (in) (in)	
24 gpm, -0.45 psid									
897140	02/05/90	3.3	22.5	34.4	42.0	3.18	0.47	4.5	4.5
955023	05/10/90	1.5	32.7	27.2	39.0	2.21	0.63	3.9	4.0
40 gpm, +2.95 psid									
897006	10/27/89	5.0	47.0	18.4	29.1	54.7	55.8	5.4	5.3
955022	05/10/90	1.5	44.4	20.7	30.9	46.5	48.2	5.3	5.2
50 gpm, -0.35 psid									
955021	05/09/90	1.5	18.4	48.2	32.2	3.86	4.68	6.7	6.5
955024	05/10/90	5.0	18.5	49.2	31.1	4.21	5.47	6.6	6.5

3.3 Air Flow Testing

In the air flow testing phase, tests were conducted to measure the total assembly air flow for the Mark-22 fuel assembly for a range of assembly water flows and assembly pressure drops. These tests were performed using only the reference fuel assembly. The air flow testing was performed in accordance with ARC-TP-965 "Annular Flow Distribution Test -- Air Flow Testing".

Table 3.7 lists the test conditions evaluated for the air flow testing. The purpose for each test and the results are described in the following paragraphs. Tests 965001 through 965006 were repeats of earlier tests in the Annular Flow Distribution (AFD) Test Facility, but the 36-hole K/C bottom fitting insert was replaced with the 80-hole P/L type. These tests showed no significant difference in AFD data for the 80-hole P/L and 36-hole K/C bottom fitting inserts.

Tests 965007 through 965020 were performed to examine the air flow differences between the AFD facility and similar WSRC test rig data. These tests showed that the differences in assembly air flow remain for comparable AFD and WSRC data.

Tests 965021 through 965024 were repeats of four screening tests, but with an enhanced reference assembly air outlet flowmeter. The outlet air flow measurements provided greater confidence in the repeat tests. Tests 965025 through 965028 were proof of principle test repeats requested by WSRC to support the WSRC code analysis. In particular, additional confidence in total assembly air flow and inlet plenum level measurements was desired. These tests reinforced earlier proof of principle test measurements of total assembly air flow and inlet plenum level.

Tests 965034 through 965039 were repeats of six parametric tests having a total assembly pressure drop of -0.23 psid, but with a different outlet tank water level and inlet plenum pressure combination. These tests were added as a result of the low tank level test data analysis described earlier. These tests showed small air flow differences from comparable parametric tests. Tests 965034 through 965039 also indicated a questionable outlet air flow measurement using T3GM01. A different air flowmeter was installed to measure outlet air flow, T4GM01, and 2 tests were repeated as 965040 (repeat of 965038) and 965041 (repeat of 965037). These repeat tests showed that the outlet meter for tests 965034 through 965039 was indeed performing outside of specifications, however, the inlet flow measurement for those tests was an accurate indication of total assembly air flow.

Table 3.7
Air Flow Test Conditions

Test Number	Test Point	BFI Type	Water Flow (gpm)	Plenum Pressure (psig)	Tank Level (ft)	Comments
965001	1	P/L	24	0.0	3.3	Repeat of 897090
965002	2	P/L	24	1.0	3.3	Repeat of 897140
965003	3	P/L	24	0.0	5.0	Repeat of 897118
965004	4	P/L	30	0.0	5.0	Repeat of 897065
965005	6	P/L	40	0.0	5.0	Repeat of 897133
965006	5	P/L	40	0.0	3.0	Repeat of 897064
965007	9	P/L	40.7	-0.22	2.5	
965008	7	P/L	20.2	-0.04	2.5	
965009	8	P/L	30.4	-0.30	2.5	
965010	13	P/L	20.4	-0.03	4.5	
965011	14	P/L	26.4	-0.08	4.4	
965012	16	P/L	41.3	-0.03	4.3	
965013	15	P/L	31.1	-0.14	4.4	
965014	17	P/L	60.3	-0.08	4.1	
965015	18	P/L	69.6	-0.05	4.0	
965016	9a	P/L	40.7	-0.22	2.5	*
965017	10	P/L	52.7	-0.19	2.4	
965018	11	P/L	62.2	-0.15	2.3	
965019	12	P/L	70.0	-0.13	2.3	
965020	9b	P/L	40.7	-0.22	2.5	**
965021	21	P/L	20.0	-2.00	5.0	Repeat of 958014
965022	22	P/L	60.0	-2.00	5.0	Repeat of 958015
965023	19	P/L	20.0	-2.00	5.0	Repeat of 958006
965024	20	P/L	60.0	-2.00	5.0	Repeat of 958013
965025	23	K/C	40.0	2.00	5.0	Repeat of 897004
965026	24	K/C	40.0	5.00	5.0	Repeat of 897006
965027	25	K/C	40.0	2.00	2.0	Repeat of 897050
965028	26	K/C	40.0	5.00	2.0	Repeat of 897013
965034	32	K/C	70.0	1.94	5.0	Compare 964049
965035	31	K/C	59.0	1.94	5.0	Compare 964043
965036	30	K/C	48.0	1.94	5.0	Compare 964038
965037	29	K/C	37.0	1.94	5.0	Compare 964034
965038	28	K/C	26.0	1.94	5.0	Compare 964031
965039	27	K/C	15.0	1.94	5.0	Compare 964052
965040		K/C	26.0	1.94	5.0	Repeat of 965038 ***
965041		K/C	37.0	1.94	5.0	Repeat of 965034 ***

* -- Like Test Point 9 (965007) but inject air at the vacuum line connection rather than normal inlet of 3 nozzles.

** -- Like Test Point 9 (965007) but removed split ring on monitor pin allowing atypically large flow path through the monitor pin for the P/L BFI.

*** -- T4GM01 was used as the outlet air flowmeter instead of T3GM01.

3.4 Screening Tests

In the screening phase of testing, tests were conducted to determine the significance of several variables on the annular flow distribution for the Mark-22 fuel assembly. The screening variables included:

- the bottom fitting insert type,
- the fluid temperature (or properties), and
- piston ring air leakage.

Testing was performed in accordance with ARC-TP-958 "Annular Flow Distribution Test -- Screening Testing." The screening test data was examined for significance of the above variables using the SAS software (Reference 16) running on a Digital Equipment Corporation VAX 11/785 computer (operating system was VMS Version 4.7).

For the screening tests, the only loop modifications (relative to the proof of principle testing) occurred when testing different bottom fitting inserts. Two types of bottom fitting inserts (BFIs) were tested; the K/C-type (36-shell hole type used in the proof of principle testing) and the P/L type. When the K/C type bottom fitting insert is used, a flow path is present in the monitor pin. For P/L testing, the monitor pin flow path is blocked. For testing with either insert, the test assembly transition piece shims were not installed.

Table 3.8 lists the 41 test conditions evaluated in the screening tests. These test conditions were evaluated to determine their effect on the following response variables:

- water flow splits for the flow channels,
- inlet plenum water level,
- total assembly air flow, and
- air flow splits for the flow channels.

Initially, the screening matrix consisted of only test points 1 through 28. After analyzing the results, the decision was made to test intermediate values of total assembly water flow and overall assembly pressure drop to identify significant interactions between the screening variables and flow, and the screening variables and assembly pressure drop. Test points 29 through 40 were added to the test matrix.

The SAS software was used to evaluate the significance of the 3 screening variables. Data for test conditions and response variables was input, and separate analyses were performed for each screening variable. The regression method of statistical analysis was used to determine the significance of the bottom fitting type, temperature, and piston ring leak on the response variables. This method used the measured values of the test conditions in the analysis. The analysis (Reference 17) was carried out looking specifically for the following:

- linear effects of bottom fitting insert type, fluid properties (temperature), and piston ring leakage,

- linear and quadratic interaction between flow and bottom fitting insert type, between flow and piston ring leakage, and between flow and fluid properties,
- linear and quadratic interaction between assembly pressure drop and bottom fitting insert type, and between assembly pressure drop and fluid properties, and
- linear interaction between assembly pressure drop and piston ring leakage effects.

The analysis assumed no interaction between bottom fitting insert type, fluid properties, and piston ring leak effects. A 5% level was used as the basis for accepting or rejecting the hypothesis that a test variable had no significant effect on a test result. The results of the analysis were that none of the screening variables had a significant effect on the test results, and there was no significant interaction between flow or assembly pressure drop and the three screening variables. As expected, there were significant linear and in some cases quadratic effects of flow and pressure drop on the response variables.

The regression analysis indicated that the effects of the screening variables (bottom fitting insert type, piston ring leakage, and fluid properties) are not significant for response variables of channel water flow split, inlet plenum water level, total assembly air flow, and channel air flow split. The screening variables were dropped from consideration for the parametric test phase, leaving only total assembly water flow and assembly pressure drop variables to be evaluated for the annular flow split empirical correlations.

Table 3.8
Screening Test Conditions

<u>Test Number</u>	<u>Test Point</u>	<u>BFI Type</u>	<u>Fluid Temp. (°F)</u>	<u>Piston Leakage (SCFM)</u>	<u>Water Flow (gpm)</u>	<u>Plenum Pressure (psig)</u>	<u>Tank Level (ft)</u>	<u>Ass'y Pressure Drop (psid)</u>
958002	3	K/C	70	0.0	20	-2.0	5.0	-4.2
958003	5	K/C	70	0.0	20	2.0	1.5	1.3
958004	4	K/C	70	0.0	60	-2.0	5.0	-4.2
958005	6	K/C	70	0.0	60	2.0	1.5	1.3
958006	1	K/C	70	2.0	20	-2.0	5.0	-4.2
958007	11	K/C	135	0.0	20	2.0	1.5	1.3
958008	9	K/C	135	0.0	20	-2.0	5.0	-4.2
958009	7	K/C	135	2.0	20	-2.0	5.0	-4.2
958011	8	K/C	135	2.0	60	-2.0	5.0	-4.2
958012	12	K/C	135	0.0	60	2.0	1.5	1.3
958013	2	K/C	70	2.0	60	-2.0	5.0	-4.2
958014	13	P/L	70	2.0	20	-2.0	5.0	-4.2
958015	14	P/L	70	2.0	60	-2.0	5.0	-4.2
958016	15	P/L	70	0.0	20	-2.0	5.0	-4.2
958017	16	P/L	70	0.0	60	-2.0	5.0	-4.2
958018	17	P/L	70	0.0	20	2.0	1.5	1.3
958019	18	P/L	70	0.0	60	2.0	1.5	1.3
958020	23	P/L	135	0.0	20	2.0	1.5	1.3
958021	24	P/L	135	0.0	60	2.0	1.5	1.3
958022	19	P/L	135	2.0	20	-2.0	5.0	-4.2
958023	20	P/L	135	2.0	60	-2.0	5.0	-4.2
958024	21	P/L	135	0.0	20	-2.0	5.0	-4.2
958025	22	P/L	135	0.0	60	-2.0	5.0	-4.2
958026	25 (1)	K/C	70	2.0	20	-2.0	5.0	-4.2
958027	26 (2)	K/C	135	0.0	60	2.0	1.5	1.3
958028	10	K/C	135	0.0	60	-2.0	5.0	-4.2
958029	28 (3)	P/L	135	2.0	60	-2.0	5.0	-4.2
958030	27 (4)	P/L	70	0.0	20	2.0	1.5	1.3
958031	29A	K/C	70	0.0	37	-2.0	5.0	-4.2
958032	38	K/C	70	2.0	37	-2.0	5.0	-4.2
958033	39	K/C	70	2.0	37	-0.5	3.0	-1.8
958034	40	K/C	70	2.0	60	-0.5	3.0	-1.8
958035	29	P/L	70	0.0	37	-2.0	5.0	-4.2
958036	30	P/L	70	0.0	37	-0.5	3.0	-1.8
958037	31	P/L	70	0.0	60	-0.5	3.0	-1.8
958038	32	P/L	135	2.0	37	-2.0	5.0	-4.2
958039	33	P/L	135	2.0	37	-0.5	3.0	-1.8
958040	34	P/L	135	2.0	60	-0.5	3.0	-1.8
958041	35	K/C	135	0.0	37	-2.0	5.0	-4.2
958042	36	K/C	135	0.0	37	-0.5	3.0	-1.8
958043	37	K/C	135	0.0	60	-0.5	3.0	-1.8

Notes: (1) Repeat of 958006.
(2) Repeat of 958011.
(3) Repeat of 958013.
(4) Repeat of 958018.

3.5 Parametric Testing

Parametric testing was performed to fully characterize and evaluate the annular flow distribution in the Mark-22 fuel assembly, with the goal of developing best-estimate empirical correlations for the annular flow distribution. Testing was performed in accordance with ARC-TP-964 "Annular Flow Distribution Test -- Parametric Testing." Reduced data for the parametric tests are provided in Appendix A.

The screening testing demonstrated that the temperature, piston ring leak, and the bottom fitting insert type had no significant effect on flow response variables. Thus, they were fixed for the parametric testing. The results of the "low-tank level" tests indicated that overall assembly pressure drop is the relevant variable, and it is not necessary to consider its components separately (namely, inlet plenum pressure and tank bottom pressure or tank level).

For the parametric testing, the nominal temperature was fixed at 70°F and the piston ring leakage system was isolated. In addition, all parametric testing was performed with the 36-shell hole K/C bottom fitting insert type in the reference assembly. No shims were installed in the test assembly transition piece for any of the parametric tests. Auxiliary orifice sleeves were not installed in either fuel assembly. For parametric tests, the piston ring leak air flowmeters were relocated to provide an intermediate range for inlet air flow measurement into each assembly.

Total assembly water flow and overall assembly pressure drop were tested extensively in the parametric test phase. The range of most interest is classified as the "design" range. The test matrix was established to examine this range in detail (48 tests). As shown in Table 3.9, six levels of assembly flow and 8 levels of assembly pressure drop were selected for the design test range. Additional tests were identified for the "extended" range testing, to extend the range of flow testing to a minimum of 3 gpm and a maximum of approximately 110 gpm. The extended range testing included assembly pressure drop values up to 43 psid. Finally, tests termed "transition points" were identified in the design range to provide more detail for near-zero pressure drop conditions. A facility benchmark test (repeat of proof of principle test 897054) was repeated weekly during the parametric phase to monitor consistency in the facility during parametric tests.

Table 3.10 is a complete listing of the test conditions for the parametric testing. A total of 62 tests were performed in the design range (tests 964001 to 964062), including repeat points. A total of 16 extended range data points (964063 to 964078), 3 repeats (964079 to 964081) and 12 transition points (964082 to 964093) were also obtained.

Examination of the test data in Appendix A shows that the parametric test data demonstrated trends similar to the proof of principle test data with regard to the achievement of hydraulic similarity. Test and reference assembly pressure profiles, and air flows did not always agree within measurement uncertainties for tests with air flows less than approximately 2 SCFM.

An unusually pronounced difference in reference and test assembly pressure profiles was observed for 3 tests at 59 gpm water flow, and the lowest values of pressure drop tested (less than -3 psid). Based on pressure profiles for these tests (964022, 964023, and 964085), the test assembly channel 2 appeared to be nearly voided for much of the upper channel length. By contrast, the reference assembly channel 2 profile showed a gradual change in pressure along the channel length. The test assembly measured flow splits for these tests indicated a very sharp discontinuity from tests at the same water flow but with pressure drop above -2.6 psid. Due to the fact that these tests were at an extreme boundary condition in the matrix, additional testing effort to explore this discontinuity was not deemed cost effective. Because the test assembly does not appear to be representative of the reference assembly for these tests, they were excluded from the correlation database.

The parametric test data was input into the SAS code and correlations were developed for annular flow splits. These correlations are described in Section 4.0.

Table 3.9
Parametric Design Range Test Conditions

Variable	Levels		
Assembly Flow	15.0 gpm		
	26.0 gpm		
	37.0 gpm		
(6 levels)	48.0 gpm		
	59.0 gpm		
	70.0 gpm		
		Plenum Pressure	Tank Level
Assembly Pressure Drop	-4.17 psid	-2.0 psig	5.0 ft
	-3.38 psid	-1.5 psig	4.4 ft
	-2.59 psid	-1.0 psig	3.7 ft
	-1.80 psid	-0.5 psig	3.0 ft
(8 levels)	-1.02 psid	0.0 psig	2.4 ft
	-0.23 psid	+0.42 psig	1.5 ft
	+0.56 psid	+1.3 psig	1.7 ft
	+1.35 psid	+2.0 psig	1.5 ft

Table 3.10
Parametric Test Matrix

<u>TEST NUMBER</u>	<u>TEST POINT</u>	<u>WATER FLOW (GPM)</u>	<u>PLENUM PRESSURE (PSIG)</u>	<u>ASSEMBLY DP (PSID)</u>	<u>BACKPRESSURE or TANK LEVEL (FT)</u>
964001	*	24	0.0	-2.16	5.0
964002	1	15	-2.0	-4.17	5.0
964003	12	26	-0.5	-1.80	3.0
964004	13	26	-1.0	-1.02	2.4
964005	18	37	-1.5	-3.38	4.4
964006	27	48	-1.0	-2.59	3.7
964007	35	59	-1.0	-2.59	3.7
964008	42	70	-1.5	-3.38	4.4
964009	11	26	-1.0	-2.59	3.7
964010	*	24	0.0	-2.16	5.0
964011	17	37	-2.0	-4.17	5.0
964012	28	48	-0.5	-1.80	3.0
964013	41	70	-2.0	-4.17	5.0
964014	2	15	-1.5	-3.38	4.4
964015	9	26	-2.0	-4.17	5.0
964016	10	26	-1.5	-3.38	4.4
964017	*	24	0.0	-2.16	5.0
964018	19	37	-1.0	-2.59	3.7
964019	20	37	-0.5	-1.80	3.0
964020	21	37	0.0	-1.02	2.4
964021	25	48	-2.0	-4.17	5.0
964022	33	59	-2.0	-4.17	5.0
964023	34	59	-1.5	-3.38	4.4
964024	26	48	-1.5	-3.38	4.4
964025	3	15	-1.0	-2.59	3.7
964026	*	24	0.0	-2.16	5.0
964027	4	15	-0.5	-1.80	3.0
964028	5	15	0.0	-1.02	2.4
964029	43	70	-1.0	-2.59	3.7
964030	44	70	-0.5	-1.80	3.0
964031	14	26	0.4	-0.23	1.5
964032	15	26	1.3	0.56	1.7
964033	16	26	2.0	1.35	1.5
964034	22	37	0.4	-0.23	1.5
964035	23	37	1.3	0.56	1.7
964036	24	37	2.0	1.35	1.5
964037	29	48	0.0	-1.02	2.4
964038	30	48	0.4	-0.23	1.5
964039	31	48	1.3	0.56	1.7
964040	32	48	2.0	1.35	1.5

Table 3.10 (cont'd.)
Parametric Test Matrix

<u>TEST NUMBER</u>	<u>TEST POINT</u>	<u>WATER FLOW (GPM)</u>	<u>PLENUM PRESSURE (PSIG)</u>	<u>ASSEMBLY DP (PSID)</u>	<u>BACKPRESSURE or TANK LEVEL (FT)</u>
964041	36	59	-0.5	-1.80	3.0
964042	37	59	0.0	-1.02	2.4
964043	38	59	0.4	-0.23	1.5
964044	39A	59	0.4	-0.32	1.7
964045	39	59	1.3	0.56	1.7
964046	40	59	2.0	1.35	1.5
964047	*	24	0.0	-2.16	5.0
964048	45	70	0.0	-1.02	2.4
964049	46	70	0.4	-0.23	1.5
964050	47	70	1.3	0.56	1.7
964051	48	70	2.0	1.35	1.5
964052	6	15	0.4	-0.23	1.5
964053	7	15	1.3	0.56	1.7
964054	8	15	2.0	1.35	1.5
964055	52	37	-0.5	-1.80	3.0
964056	53	48	0.0	-1.02	2.4
964057	54	59	-1.0	-2.59	3.7
964058	55	70	-2.0	-4.17	5.0
964059	49	15	-2.0	-4.17	5.0
964060	50	15	2.0	1.35	1.5
964061	56	70	2.0	1.35	1.5
964062	51	26	0.4	-0.23	1.5

[extended range points]

964063	64	26	3.7	3.00	1.5
964064	65	70	3.7	3.00	1.5
964065	60	9	-2.0	-4.17	5.0
964066	61	9	-0.5	-1.80	3.0
964067	62	9	0.4	-0.23	1.5
964068	63	9	2.0	1.35	1.5
964069	*	24	0.0	-2.16	5.0
964070	73	110	-1.3	-2.00	1.5
964071	74	107	3.7	3.00	1.5
964072	66	95	-1.3	-3.45	5.0
964073	67	95	-0.5	-1.80	3.0
964074	57	3	-0.5	-1.80	3.0
964075	68	95	0.4	-0.23	1.5
964076	69	95	2.0	1.35	1.5
964077	58	3	0.4	-0.23	1.5
964078	59	3	1.3	0.56	1.7

Table 3.10 (cont'd.)
Parametric Test Matrix

<u>TEST</u> <u>NUMBER</u>	<u>TEST</u> <u>POINT</u>	<u>WATER</u> <u>FLOW</u> <u>(GPM)</u>	<u>PLENUM</u> <u>PRESSURE</u> <u>(PSIG)</u>	<u>ASSEMBLY</u> <u>DP</u> <u>(PSID)</u>	<u>BACKPRESSURE</u> <u>or TANK LEVEL</u> <u>(FT)</u>
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[reproducibility at low pressure drop]

964079	75	40	2.0	-0.17	5.0
964080	76	10	0.0	-0.87	2.0
964081	77	24	1.0	-0.43	3.3

[transition points]

964082	78	37	0.4	-0.60	2.3
964083	79	37	1.0	0.20	1.9
964084	80	43	0.4	-0.23	1.5
964085	81	59	-1.3	-3.00	4.0
964086	*	24	0.0	-2.16	5.0
964087	86	48	0.4	-0.60	2.3
964088	87	48	1.0	0.20	1.9
964089	84	26	0.4	-0.60	2.3
964090	82	15	0.4	-0.60	2.3
964091	*	24	0.0	-2.16	5.0
964092	83	15	1.0	0.20	1.9
964093	85	26	1.0	0.20	1.9

* -- Repeat of proof of principle test 897054 serving as a facility benchmark test.

4.0 EMPIRICAL ANNULAR FLOW DISTRIBUTION CORRELATIONS

The parametric test phase data was input to the SAS software (Reference 16) running on a Digital Equipment Corporation VAX 11/785 (operating system VMS Version 4.7). Equations characterizing the annular flow distribution for the Mark-22 fuel assembly were developed (Reference 18). The empirical equations are of the general quadratic form:

$$\text{Channel Flow Split (\%)} = A0 + A1*(Q) + A2*(DP) + A3*(Q)^2 + A4*(DP)^2 + A5*(Q)*(DP).$$

where Q (gpm) is the test assembly total water flow, and DP (psid) is the overall assembly pressure drop. Readings from water flow instruments TPMM01 (low range) or TPMM02 (high range) were used. The overall assembly pressure drop was computed as the difference in TPGP01 (test assembly inlet plenum pressure) and RTGP01 (reference assembly tank bottom pressure). The channel flow splits were computed by dividing the individual channel flows (based on load cell data) by the total inlet water flow. The final form of the equations may differ to a slight extent. The terms in the equation that were found to be insignificant for a particular correlation were deleted.

The standard deviation of the differences between the observed and calculated flow split values was used as a measure of the goodness of fit of the equation to the data. A small standard deviation obtained for a correlation indicates a good fit; whereas, a large standard deviation indicates a poor fit. On a statistical basis, approximately 68% of the differences between the observed and calculated flow split values will be within one standard deviation. Approximately 95% of the differences will be within two standard deviations.

The data submitted for flow split correlation included test results covering the "design" range and "extended" test range. The design range for the assembly water flow is 15 to 70 gpm, and for overall assembly pressure drop is -4.17 to 1.35 psid. The overall flow was then extended in the tests to 3 gpm on the low end and approximately 110 gpm on the high end. The pressure drop was extended only on the high end to +3 psid.

The correlation database did not include all 93 parametric tests. The weekly repeat facility benchmark tests (tests 964001, 964010, 964017, 964026, 964047, 964069, 964086, and 964091) were excluded. Also, as described in Section 3.5, the database excluded 3 tests at 59 gpm water flow and large, negative pressure drop (tests 964022, 964023, and 965085). Based on the observed pressure profiles for these 3 tests, the test assembly results were not considered representative of the reference assembly, and they were not included in the correlation database.

The equations derived for the three flow channels including the design and extended range test points are shown in Table 4.1. Also shown are the standard deviations for the individual correlations. These values appear to be somewhat high and it was surmised that improvements in the correlations could be obtained by considering the design and extended ranges separately. Consequently, equations were derived for 4 regions. The four regions are defined in Table 4.2. The equations obtained for the design range are shown in Table 4.3. In addition to deriving the full quadratic equations, stepwise regression techniques were applied to eliminate any terms in the equation that are insignificant. In the design range, all the terms were found to be significantly correlated with the flow split for channels 2 and 3. In the channel 4 correlation, the term $(Q)^2$ was found to be insignificant and was deleted. Note, the standard deviations for the design range are considerably lower than the values obtained for the combined data (Table 4.1). Correlations for the remaining 3 regions are provided in Tables 4.4, 4.5, and 4.6. In deriving the correlations for these 3 remaining regions, the neighboring data from the design range region was used to provide continuity between the regions.

Comparisons of the parametric phase test data and the resulting correlations are shown in Figures 4.1 through 4.12. For each of the 4 regions, response surfaces with constant flow split value contours representing the correlations are shown along with the measured flow split values for each flow channel. The approximate 95% confidence values (estimated as two times the standard deviation) are also shown in each figure.

Table 4.7 presents comparisons for non-parametric phase test data (data that was not used to generate the correlations) with the values predicted by the correlations. The correlations for each of the 4 regions were used to generate Table 4.7. Comparisons are made for proof of principle test data, low-tank level test data, and screening test data. Comparisons for screening tests (test numbers beginning with 958) at approximately 60 gpm and pressure drop at approximately -4.2 psid are not included. As described in Section 3.5, this particular boundary condition was excluded from the correlation database because test assembly behavior was not considered representative of the reference assembly.

Table 4.1
Correlation Coefficients for Combined Data

Region: All Regions Combined

<u>Coefficients</u>	<u>Channel 2</u>	<u>Channel 3</u>	<u>Channel 4</u>
A0	59.436722	-1.078830	36.380661
A1	-1.078300	1.109962	0.065124
A2	5.838656	-3.448940	-3.200310
A3	0.007027	-0.005716	-0.001854
A4	0.744631	-0.417590	-0.411754
A5	-0.064964	0.022041	0.050559
Standard Deviation	3.33	3.39	3.25

Table 4.2
Correlation Boundaries

<u>Region</u>	<u>Description</u>	<u>Flow Range</u> <u>(gpm)</u>	<u>Pressure Drop Range</u> <u>(psid)</u>
A	Design Range	$15 < Q \leq 70$	$-4.2 < DP < 1.4$
B	Lower Flow Extended Range	$Q \leq 15$	$-4.2 < DP < 1.4$
C	Upper Flow Extended Range	$Q > 70$	$DP \geq -3.38$
D	Upper Pressure Drop Extended Range	$15 < Q \leq 70$	$DP \geq 1.4$

Table 4.3
Correlation Coefficients for Design Range

Region: A
 $15 < Q(\text{gpm}) \leq 70, \quad -4.2 < DP(\text{psid}) < 1.4$

<u>Coefficients</u>	<u>Channel 2</u>	<u>Channel 3</u>	<u>Channel 4</u>
A0	59.985698	-9.234970	43.856728
A1	-1.065140	1.367497	-0.187927
A2	9.481205	-7.053670	-3.111300
A3	0.006552	-0.007363	---
A4	1.407109	-1.011050	-0.474579
A5	-0.092150	0.047105	0.051004
Standard Deviation	1.95	2.28	1.76

Table 4.4
Correlation Coefficients for Lower Flow Extended Range

Region: B

$Q(\text{gpm}) \leq 15, \quad -4.2 < DP(\text{psid}) < 1.4$

<u>Coefficients</u>	<u>Channel 2</u>	<u>Channel 3</u>	<u>Channel 4</u>
A0	59.445717	9.589308	22.853289
A1	-1.065490	----	1.746475
A2	----	1.720288	-4.673230
A3	----	0.015444	-0.040669
A4	0.665489	----	-0.965507
A5	0.313805	-0.198235	----
Standard Deviation	2.83	2.37	1.94

Table 4.5
Correlation Coefficients for Upper Flow Extended Range

Region: C

$Q(\text{gpm}) > 70, \quad DP(\text{psid}) \geq -3.38$

<u>Coefficients</u>	<u>Channel 2</u>	<u>Channel 3</u>	<u>Channel 4</u>
A0	11.799216	44.540097	61.292814
A1	0.111601	0.078212	-0.638824
A2	6.719091	-8.607860	1.723251
A3	----	----	0.002602
A4	0.518556	-0.566273	-0.043109
A5	-0.077977	0.088484	-0.010906
Standard Deviation	1.90	1.87	0.50

Table 4.6
Correlation Coefficients for Upper Pressure Drop Extended Range

Region: D

$15 < Q(\text{gpm}) \leq 70, \quad DP(\text{psid}) \geq 1.4$

<u>Coefficients</u>	<u>Channel 2</u>	<u>Channel 3</u>	<u>Channel 4</u>
A0	57.833466	8.043258	28.083222
A1	-0.509858	0.305477	0.426113
A2	----	----	-2.935040
A3	----	0.004094	-0.005717
A4	0.619172	----	----
A5	----	-0.054958	0.051082
Standard Deviation	1.25	0.93	0.34

Table 4.7
Comparisons for Non-Parametric Tests

TEST NUMBER	FLOW (GPM)	REGION	DP (PSID)	----- Channel 2 -----			----- Channel 3 -----			----- Channel 4 -----		
				Pred (%)	Act (%)	Diff (%)	Pred (%)	Act (%)	Diff (%)	Pred (%)	Act (%)	Diff (%)
897001	39.93	N/A	-7.48	N/A	28.30	N/A	N/A	48.90	N/A	N/A	22.10	N/A
897002	40.36	A	-2.22	21.81	20.40	1.4	40.42	40.80	-0.4	36.27	36.50	-0.2
897004	39.79	A	-0.08	27.54	30.20	-2.7	33.91	30.20	3.7	36.46	37.30	-0.8
897006	40.09	D	2.89	42.56	47.00	-4.4	20.50	18.40	2.1	33.41	29.10	4.3
897007	40.62	N/A	-7.37	N/A	27.60	N/A	N/A	51.10	N/A	N/A	22.80	N/A
897013	39.93	D	4.19	48.33	45.60	2.7	17.58	19.80	-2.2	32.23	30.10	2.1
897015	24.49	N/A	-5.21	N/A	36.80	N/A	N/A	41.30	N/A	N/A	19.60	N/A
897019	23.98	A	1.22	49.14	50.20	-1.1	10.62	15.70	-5.1	36.35	30.80	5.6
897020	9.80	B	-3.51	46.40	44.10	2.3	11.85	10.10	1.8	40.58	42.40	-1.8
897021	10.01	B	-2.16	45.10	42.90	2.2	11.71	12.10	-0.4	41.85	41.50	0.4
897022	10.25	B	-0.09	48.24	50.10	-1.9	11.24	6.60	4.6	36.90	38.60	-1.7
897024	10.22	N/A	1.96	N/A	47.50	N/A	N/A	14.40	N/A	N/A	30.30	N/A
897027	24.08	N/A	-6.96	N/A	31.30	N/A	N/A	43.00	N/A	N/A	25.00	N/A
897028	9.68	B	-2.37	45.67	42.90	2.8	11.51	12.70	-1.2	41.60	40.80	0.8
897033	10.01	B	-0.89	46.52	41.00	5.5	11.37	18.30	-6.9	39.65	37.10	2.5
897034	8.94	B	1.22	54.33	47.90	6.4	10.76	14.20	-3.4	28.08	30.90	-2.8
897035	9.97	N/A	2.20	N/A	47.40	N/A	N/A	15.50	N/A	N/A	30.50	N/A
897036	9.92	B	-3.87	46.79	41.60	5.2	12.06	18.40	-6.3	39.81	35.20	4.6
897037	10.16	N/A	-5.17	N/A	43.60	N/A	N/A	14.40	N/A	N/A	37.70	N/A
897038	40.24	A	-2.22	21.85	20.00	1.9	40.34	42.10	-1.8	36.31	36.50	-0.2
897039	23.90	A	1.16	48.64	49.70	-1.1	10.98	15.30	-4.3	36.52	30.60	5.9
897040	10.01	B	-0.90	46.50	39.00	7.5	11.37	7.00	4.4	39.68	49.70	-10.0
897046	40.10	N/A	-6.06	N/A	5.40	N/A	N/A	63.80	N/A	N/A	29.70	N/A
897050	40.01	A	1.16	36.43	37.70	-1.3	26.37	26.90	-0.5	34.47	32.00	2.5
897051	10.04	B	-0.90	46.45	36.10	10.4	11.39	7.20	4.2	39.71	52.70	-13.0
897052	9.97	B	-2.18	45.16	49.70	-4.5	11.68	8.10	3.6	41.82	38.20	3.6
897053	39.88	A	-2.14	21.95	25.80	-3.9	40.04	38.60	1.4	36.49	33.80	2.7
897054	24.52	A	-2.19	28.74	27.20	1.5	27.93	31.00	-3.1	41.05	39.80	1.2
897055	80.87	C	-1.81	21.77	22.70	-0.9	51.64	50.30	1.3	24.99	24.60	0.4
897057	79.50	C	-2.16	21.96	24.30	-2.3	51.52	50.40	1.1	24.91	24.70	0.2
897058	79.50	C	-0.84	20.60	20.70	-0.1	51.68	53.00	-1.3	26.21	25.80	0.4
897059	23.51	A	-4.09	32.17	28.10	4.1	26.26	30.80	-4.5	39.33	38.20	1.1
897060	23.48	A	-3.09	29.41	27.50	1.9	27.54	31.40	-3.9	40.83	39.50	1.3
897061	24.01	A	-1.10	31.89	27.20	4.7	24.65	30.30	-5.6	40.85	41.00	-0.2
897062	40.19	A	-3.09	23.34	26.60	-3.3	40.12	39.60	0.5	35.05	32.40	2.7
897064	39.96	A	-1.36	22.60	19.00	3.6	38.82	42.00	-3.2	36.93	37.40	-0.5
897065	30.28	A	-2.20	25.83	21.20	4.6	32.90	37.80	-4.9	39.32	39.30	0.0
897066	30.37	A	-1.32	27.30	21.00	6.3	31.17	36.80	-5.6	39.39	39.80	-0.4
897067	30.29	A	-2.19	25.83	20.20	5.6	32.90	38.50	-5.6	39.32	39.30	0.0
897069	59.86	A	-1.97	17.36	18.80	-1.4	50.66	51.70	-1.0	30.88	29.10	1.8
897070	60.27	A	-1.31	16.86	17.60	-0.7	50.23	52.90	-2.7	31.76	29.60	2.2
897071	60.43	A	-1.87	17.15	16.60	0.5	50.84	53.10	-2.3	30.90	29.50	1.4
897072	78.68	C	-2.25	21.90	24.60	-2.7	51.53	50.20	1.3	24.97	24.50	0.5
897073	59.47	A	-1.30	16.99	16.60	0.4	49.86	51.10	-1.2	31.99	31.10	0.9
897074	40.15	A	-2.20	21.88	19.00	2.9	40.26	42.60	-2.3	36.36	36.70	-0.3
897075	39.69	A	-2.40	22.16	26.40	-4.2	40.06	38.40	1.7	36.28	33.90	2.4

Table 4.7 (cont'd.)

TEST NUMBER	FLOW (GPM)	REGION	DP (PSID)	----- Channel 2 -----			----- Channel 3 -----			----- Channel 4 -----		
				Pred (%)	Act (%)	Diff (%)	Pred. (%)	Act. (%)	Diff (%)	Pred. (%)	Act. (%)	Diff (%)
897076	39.52	A	-1.37	22.76	18.90	3.9	38.53	41.10	-2.6	37.04	36.70	0.3
897077	24.23	A	-2.20	28.89	28.70	0.2	27.68	30.40	-2.7	41.13	38.70	2.4
897078	24.17	A	-1.33	30.90	29.50	1.4	25.61	28.20	-2.6	40.98	40.40	0.6
897079	24.14	A	-3.18	29.24	29.70	-0.5	28.08	28.10	0.0	40.50	40.40	0.1
897080	14.86	B	-1.32	38.62	39.70	-1.1	14.61	13.90	0.7	44.31	43.40	0.9
897081	40.76	A	-2.21	21.68	19.20	2.5	40.68	42.50	-1.8	36.16	37.20	-1.0
897082	24.40	A	-2.19	28.81	27.40	1.4	27.82	32.20	-4.4	41.08	38.70	2.4
897084	24.36	A	-1.33	30.80	28.10	2.7	25.77	30.60	-4.8	40.93	40.00	0.9
897086	23.86	A	1.09	47.89	50.90	-3.0	11.56	13.50	-1.9	36.75	32.30	4.4
897087	15.05	A	-1.33	37.16	40.60	-3.4	16.33	15.40	0.9	43.31	42.60	0.7
897090	23.78	A	-1.51	30.56	32.00	-1.4	25.78	26.00	-0.2	41.17	39.20	2.0
897091	23.56	A	-1.51	30.70	32.70	-2.0	25.56	26.60	-1.0	41.23	40.30	0.9
897092	24.10	A	-2.48	28.77	29.50	-0.7	27.91	29.80	-1.9	41.07	39.50	1.6
897094	23.91	A	-1.51	30.48	31.00	-0.5	25.90	27.20	-1.3	41.14	39.90	1.2
897095	23.81	A	-0.49	35.13	41.00	-5.9	21.79	19.80	2.0	40.19	37.30	2.9
897096	23.61	A	-0.42	35.68	41.80	-6.1	21.26	20.00	1.3	40.14	37.50	2.6
897097	23.74	A	-1.53	30.53	32.20	-1.7	25.79	26.40	-0.6	41.19	39.90	1.3
897098	23.69	A	-2.44	29.00	30.80	-1.8	27.49	29.30	-1.8	41.23	39.00	2.2
897115	9.93	B	-2.18	45.24	42.30	2.9	11.65	16.90	-5.2	41.78	36.80	5.0
897116	9.93	B	-2.18	45.24	41.80	3.4	11.65	17.50	-5.9	41.78	37.80	4.0
897118	24.45	A	-2.22	28.74	29.70	-1.0	27.92	26.50	1.4	41.06	41.30	-0.2
897119	24.47	A	-2.22	28.74	29.40	-0.7	27.94	26.40	1.5	41.06	41.40	-0.3
897121	39.87	A	-2.49	22.19	19.70	2.5	40.20	42.30	-2.1	36.11	36.70	-0.6
897123	39.81	A	-2.46	22.19	18.10	4.1	40.15	43.40	-3.2	36.16	36.30	-0.1
897125	23.85	A	-1.38	30.93	29.60	1.3	25.45	26.70	-1.2	41.09	42.00	-0.9
897127	23.82	A	-1.38	30.95	28.40	2.5	25.43	25.30	0.1	41.10	42.80	-1.7
897128	23.88	A	-3.12	29.27	29.20	0.1	27.88	27.60	0.3	40.65	40.40	0.3
897131	23.88	A	-3.11	29.26	26.70	2.6	27.88	29.20	-1.3	40.66	40.70	0.0
897133	39.87	A	-2.29	22.01	19.60	2.4	40.13	41.70	-1.6	36.35	36.70	-0.4
897135	39.83	A	-2.12	21.96	20.20	1.8	39.99	41.40	-1.4	36.53	37.20	-0.7
897137	39.90	A	-2.16	21.95	18.50	3.4	40.06	42.30	-2.2	36.47	37.10	-0.6
897139	79.59	C	-1.79	21.42	22.80	-1.4	51.76	51.20	0.6	25.27	25.30	0.0
897140	23.79	A	-0.41	35.58	22.90	12.7	21.42	34.40	-13.0	40.09	42.00	-1.9
955001	24.31	A	-0.43	35.14	33.50	1.6	21.98	25.80	-3.8	40.00	37.50	2.5
955006	24.35	A	-0.40	35.25	33.70	1.5	21.91	25.10	-3.2	39.96	38.50	1.5
955008	78.80	C	-2.23	21.88	24.10	-2.2	51.54	50.80	0.7	24.98	24.70	0.3
955012	80.48	C	-2.10	22.13	23.70	-1.6	51.46	49.00	2.5	24.78	24.60	0.2
955014	34.94	A	-2.21	23.80	25.00	-1.2	36.57	35.40	1.2	37.91	38.10	-0.2
955015	44.84	A	-2.22	20.46	20.40	0.1	43.26	39.00	4.3	34.93	39.50	-4.6
955016	70.24	C	-2.27	19.49	19.80	-0.3	52.55	43.00	9.5	26.86	36.40	-9.5
955017	35.46	A	-0.38	28.29	32.90	-4.6	31.91	26.70	5.2	37.62	38.80	-1.2
955018	23.89	A	-2.22	29.05	24.40	4.7	27.41	35.70	-8.3	41.23	37.70	3.5
955020	24.00	A	0.53	42.47	44.40	-1.9	15.90	18.30	-2.4	38.21	33.10	5.1
955021	50.46	A	-0.36	21.38	18.40	3.0	42.56	48.20	-5.6	34.51	32.20	2.3
955022	40.28	D	2.84	42.30	44.40	-2.1	20.69	20.70	0.0	33.48	30.90	2.6
955023	23.91	A	-0.45	35.31	32.70	2.6	21.69	27.20	-5.5	40.11	39.00	1.1

Table 4.7 (cont'd.)

TEST NUMBER	FLOW (GPM)	REGION	DP (PSID)	----- Channel 2 -----			----- Channel 3 -----			----- Channel 4 -----		
				Pred (%)	Act (%)	Diff (%)	Pred. (%)	Act. (%)	Diff (%)	Pred. (%)	Act. (%)	Diff (%)
955024	49.98	A	-0.38	21.47	18.50	3.0	42.36	49.20	-6.8	34.61	31.10	3.5
958002	19.74	A	-4.17	34.05	31.60	2.4	22.83	32.40	-9.6	40.66	35.10	5.6
958003	19.80	A	1.40	54.88	52.80	2.1	4.45	10.90	-6.4	36.28	29.80	6.5
958004	59.54	N/A	-4.18	N/A	2.90	N/A	N/A	65.90	N/A	N/A	30.70	N/A
958005	58.85	A	1.34	27.97	25.40	2.6	38.18	42.20	-4.0	31.80	31.30	0.5
958006	20.10	A	-4.17	33.89	31.10	2.8	23.16	27.40	-4.2	40.52	38.70	1.8
958007	19.79	D	1.43	49.00	50.50	-1.5	14.14	13.30	0.8	31.54	31.90	-0.4
958008	20.19	A	-4.20	33.94	35.00	-1.1	23.18	23.80	-0.6	40.44	39.60	0.8
958009	20.44	A	-4.11	33.50	35.10	-1.6	23.59	23.00	0.6	40.50	40.00	0.5
958011	59.96	N/A	-4.15	N/A	4.30	N/A	N/A	64.80	N/A	N/A	31.09	N/A
958012	60.04	D	1.47	28.57	31.30	-2.7	36.28	31.70	4.6	33.25	34.30	-1.0
958013	59.89	N/A	-4.20	N/A	3.70	N/A	N/A	66.30	N/A	N/A	31.00	N/A
958014	20.29	A	-4.18	33.84	31.90	1.9	23.30	25.80	-2.5	40.43	41.40	-1.0
958015	59.83	N/A	-4.16	N/A	2.50	N/A	N/A	66.40	N/A	N/A	31.00	N/A
958016	20.02	A	-4.20	34.05	33.70	0.4	23.01	25.20	-2.2	40.49	39.80	0.7
958017	59.99	N/A	-4.25	N/A	3.40	N/A	N/A	64.30	N/A	N/A	31.00	N/A
958018	20.03	A	1.36	54.28	53.40	0.9	5.01	11.90	-6.9	36.37	31.00	5.4
958019	59.75	A	1.39	28.01	27.10	0.9	38.31	38.00	0.3	31.62	32.70	-1.1
958020	20.29	A	1.35	53.92	50.10	3.8	5.40	12.50	-7.1	36.37	31.90	4.5
958021	59.83	D	1.40	28.55	31.20	-2.7	36.37	30.80	5.6	33.28	34.70	-1.4
958022	20.53	A	-4.14	33.65	34.70	-1.1	23.44	23.30	0.1	40.50	39.10	1.4
958023	59.83	N/A	-4.16	N/A	4.20	N/A	N/A	62.70	N/A	N/A	31.60	N/A
958024	20.17	A	-4.16	33.80	34.30	-0.5	23.25	23.20	0.0	40.52	39.50	1.0
958025	60.08	N/A	-4.21	N/A	3.70	N/A	N/A	64.00	N/A	N/A	31.10	N/A
958026	20.29	A	-4.17	33.82	31.70	2.1	23.32	23.90	-0.6	40.44	41.70	-1.3
958027	59.41	A	1.35	27.83	31.00	-3.2	38.41	32.20	6.2	31.71	35.20	-3.5
958028	59.53	N/A	-4.23	N/A	3.80	N/A	N/A	63.40	N/A	N/A	31.70	N/A
958029	59.77	N/A	-4.11	N/A	4.10	N/A	N/A	60.30	N/A	N/A	32.00	N/A
958030	19.89	A	1.35	54.26	50.30	4.0	4.97	12.10	-7.1	36.43	32.00	4.4
958031	37.60	A	-4.22	28.88	27.30	1.6	36.05	39.40	-3.3	33.37	30.90	2.5
958032	37.13	A	-4.23	29.01	25.20	3.8	35.74	42.70	-7.0	33.54	29.70	3.8
958033	37.04	A	-1.77	23.19	20.10	3.1	37.54	38.20	-0.7	37.57	41.10	-3.5
958034	60.44	A	-1.78	17.05	18.80	-1.8	50.80	49.10	1.7	31.04	30.60	0.4
958035	36.92	A	-4.18	26.77	27.30	-1.5	35.76	39.70	-3.9	33.76	31.50	2.3
958036	36.84	A	-1.77	23.28	21.60	1.7	37.39	37.40	0.0	37.63	39.40	-1.8
958037	59.64	A	-1.83	17.18	19.20	-2.0	50.51	48.70	1.8	31.19	30.60	0.6
958038	37.25	A	-4.19	28.74	25.40	3.3	35.55	40.10	-4.1	33.61	32.80	0.8
958039	36.89	A	-1.81	23.21	23.40	-0.2	37.51	34.60	2.9	37.59	39.80	-2.2
958040	59.68	A	-1.76	17.11	18.40	-1.3	50.49	47.60	2.9	31.29	31.90	-0.6
958041	37.00	A	-4.19	28.80	25.20	3.6	35.79	39.50	-3.7	33.70	33.30	0.4
958042	37.26	A	-1.85	23.02	23.30	-0.3	37.84	34.90	2.9	37.47	40.20	-2.7
958043	59.60	A	-1.83	17.19	19.40	-2.2	50.50	48.80	1.7	31.20	31.90	-0.7

Channel 2 Flow Fraction

15 < Flow < 70 gpm, -4.2 < DP < 1.4 psid

Figure 4.1 Comparison of Data and Region A, Channel 2 Correlation

Channel 3 Flow Fraction

15 < Flow < 70 gpm, -4.2 < DP < 1.4 psid

Figure 4.2 Comparison of Data and Region A, Channel 3 Correlation

Channel 4 Flow Fraction

$15 < \text{Flow} < 70 \text{ gpm}$, $-4.2 < DP < 1.4 \text{ psid}$

Figure 4.3 Comparison of Data and Region A, Channel 4 Correlation

Channel 2 Flow Fraction

Flow < 15 gpm, -4.2 < DP < 1.4 psid

Figure 4.4 Comparison of Data and Region B, Channel 2 Correlation

Channel 3 Flow Fraction

Flow < 15 gpm, -4.2 < DP < 1.4 psid

Figure 4.5 Comparison of Data and Region B, Channel 3 Correlation

Channel 4 Flow Fraction

Flow < 15 gpm, -4.2 < DP < 1.4 psid

Figure 4.6 Comparison of Data and Region B, Channel 4 Correlation

Channel 2 Flow Fraction

Flow > 70 gpm, DP > -3.38 psid

Figure 4.7 Comparison of Data and Region C, Channel 2 Correlation

Channel 3 Flow Fraction

Flow > 70 gpm, DP > -3.38 psid

Figure 4.8 Comparison of Data and Region C, Channel 3 Correlation

Channel 4 Flow Fraction

Flow > 70 gpm, DP > -3.38 psid

Figure 4.9 Comparison of Data and Region C, Channel 4 Correlation

Channel 2 Flow Fraction

$15 < \text{Flow} < 70 \text{ gpm}, DP > 1.4 \text{ psid}$

Figure 4.10 Comparison of Data and Region D, Channel 2 Correlation

Channel 3 Flow Fraction

15 < Flow < 70 gpm, DP > 1.4 psid

Figure 4.11 Comparison of Data and Region D, Channel 3 Correlation

Channel 4 Flow Fraction

$15 < \text{Flow} < 70 \text{ gpm}, DP > 1.4 \text{ psid}$

Figure 4.12 Comparison of Data and Region D, Channel 4 Correlation

MEASUREMENT UNCERTAINTY

The measurement system for a typical instrument configuration is illustrated in Figure 5.1. Associated with this measurement system are numerous components, each of which has characteristic error components that contribute to the overall uncertainty for the individual instrument measurements. The error sources can be categorized into three major areas for the purpose of uncertainty analysis. These areas are:

Calibration Errors: Those errors that occur in the calibration hierarchy between the National Institute of Standards and Technology (NIST) and the measurement of the instrument.

Data Acquisition Errors: Those errors present in the hardware associated with the measurement system including the instrument, signal conditioning electronics, data acquisition system, and computer.

Data Reduction Errors: Those errors in the conversion process that translate the raw data value, acquired through the measurement system, to the engineering data value. Such errors are inherent in curve fits, assumed data reduction equations, and computer resolution.

Uncertainty models were developed for each of the measurement systems. The models are applicable to steady or quasi-steady conditions and therefore need not consider dynamic response characteristics of the measurement systems. The basis for the uncertainty analyses is described in References 19, 20, and 21. The uncertainty models were developed at 95% confidence and typically consisted only of contributions from random error components. The uncertainty interval is defined as the algebraic sum of the bias and random error components, with the bias and random error terms calculated as the root-sum-square of all the individual components at 95% confidence levels.

5.1

Uncertainty Values

Measurement uncertainties for the Annular Flow Distribution Test database variables are identified in Table 5.1. Uncertainties for temperature, pressure, and differential pressure measurement do not vary significantly over the range of interest and are represented as constants. The uncertainty in total assembly water flow, air flow, and inlet plenum level measurements can vary significantly with reading or time interval (in the case of hardware problems), and are presented in tabular form for each test in Table 5.2 (total assembly water flow), Table 5.3 (reference assembly air flow), Table 5.4 (test assembly air flow), and Table 5.5 (inlet plenum level). Signal fluctuation values (2-standard deviation) are identified in these tables for comparison with measured values and uncertainties. The values reported in Tables 5.2, 5.3, and 5.4 are taken from the lowest-ranged instrument available where multiple meters are monitoring the parameter of interest.

Individual test assembly channel water flow rates (used in the calculation of the channel flow splits) are based on collection of mass for a period of time. Time plots of the appropriate load cell mass indications were made for the collection time interval in each test. The slope of the time tracing was used to compute the water flow rate for the channel. The water collection time interval largely determines the flow rate uncertainty, however, the mass versus time signal was typically observed to be linear, and so the calculated flow was not very sensitive to the collection time. The channel water flow rate uncertainties are estimated to be $\pm 1\%$ of the flow rate value. Confidence in these measurements was gained by comparing the inlet water flow measurement with the sum of the 5 individual channel outlet flow measurements. The results of these measurement consistency checks are included in Appendix B, Data Quality Summaries. Due to a data acquisition system problem for test 958003, the uncertainty for channel 3 is increased to $\pm 3.5\%$ of channel flow, and for the remaining 4 flow channels the uncertainty is $\pm 2\%$ of channel flow.

Prior to the parametric test phase, a problem with the high-range air flow measurements (Kurz-manufactured units) was identified. Air flow continuity checks on the test assembly did not meet expectations for some test conditions. The observed air flow discrepancies were attributed to a combination of out-of-specification meter performance and meter installation characteristics. Through performance checks of the meters, it was concluded that the unobstructed pipe length upstream of the air flowmeters needed to be increased. The hardware changes were made prior to use in the parametric test phase. The measurement uncertainties (presented in Tables 5.3 and 5.4) for the other test phases are increased to account for the measurement problem (including installation effects and any out-of-specification post-test calibration results). Both lower and upper limit uncertainties are presented in Tables 5.3 and 5.4 because the uncertainty is not symmetric about the measurement value for many tests.

Inlet plenum water level measurements were also effected by various conditions for tests prior to the parametric test phase. The uncertainties presented in Table 5.5 reflect various sources of measurement error throughout the course of the test program including voiding in the measurement process line (due to the technique for approaching test conditions or evaporation), and removal of debris collected in several universal sleeve housing flow holes at the inlet plenum.

5.2 Repeatability Comparisons

Tables 5.6 through 5.8 present data for several sets of boundary conditions that were repeated throughout the course of the Annular Flow Distribution Test Program. Comparisons of the repeated tests provide information regarding the reproducibility of the test data. Tests at 24 gpm water flow, 0 psig plenum pressure, and 60-inch backpressure (Table 5.6) served as a check on the facility during the parametric tests. Test 955018 appears to be significantly different from the remainder of the group. If test 955018 is neglected, the water flow splits for all 3 channels are in good agreement, and they fall within the 95% confidence band for the correlation predicted values. Air flows also appear to repeat well. The inlet plenum water levels prior to test 847118 are believed to be effected by the presence of "debris" in the universal sleeve housing flow holes at the inlet plenum,

resulting in a higher than expected plenum water level. Also, the levels prior to test 955018 are believed to be effected by voiding in the measurement line tubing resulting in an erroneously high water level indication. The voiding was due to relatively large vacuum conditions experienced at the plenums during the approach to test conditions.

Table 5.7 identifies results for tests run at 24 gpm water flow, +1 psig plenum pressure, and 40-inch backpressure. Finally, Table 5.8 identifies tests run at 40 gpm water flow, 0 psig plenum pressure, and 60-inch backpressure.

Table 5.1
Database Variable (VTAB) Measurement Definitions and Uncertainties

<u>VTAB</u>	<u>Description</u>	<u>Uncertainty</u>
ASTC01	INLET PLENUM COMMON AIR TEMPERATURE	$\pm 1.9F$
TPTC01	TEST INLET PLENUM LIQUID TEMPERATURE	$\pm 1.9F$
RPTC01	REFERENCE INLET PLENUM LIQUID TEMPERATURE	$\pm 1.9F$
TPMM02	LIQUID HIGH FLOW RATE TEST PLENUM	Table 5.2
RPMM02	LIQUID HIGH FLOW RATE REFERENCE PLENUM	Table 5.2
TPMM01	LIQUID LOW FLOW RATE TEST PLENUM	Table 5.2
RPMM01	LIQUID LOW FLOW RATE REFERENCE PLENUM	Table 5.2
TPGM01	AIR MASS RATE, TEST INLET PLENUM	Table 5.4
TPGM02	AIR MASS RATE, TEST PLENUM PISTON RING LEAK	Table 5.4
RPGM01	AIR MASS RATE, REFERENCE INLET PLENUM	Table 5.3
RPGM02	AIR MASS RATE, REFERENCE PLENUM PISTON RING LEAK	Table 5.3
RTGM01	AIR MASS RATE, REFERENCE ASSEMBLY OUTLET	Table 5.3
T2GM01	AIR MASS RATE, CHANNEL 2 SEPARATOR	Table 5.4
T3GM01	AIR MASS RATE, CHANNEL 3 SEPARATOR	Table 5.4
T4GM01	AIR MASS RATE, CHANNEL 4 SEPARATOR	Table 5.4
TPGM03	AIR MASS RATE, TEST INLET PLENUM, LOW RANGE	Table 5.4
RPGM03	AIR MASS RATE, REFERENCE INLET PLENUM, LOW RANGE	Table 5.3
T2GM02	AIR MASS RATE, CHANNEL 2 SEPARATOR, LOW RANGE	Table 5.4
T3GM02	AIR MASS RATE, CHANNEL 3 SEPARATOR, LOW RANGE	Table 5.4
T4GM02	AIR MASS RATE, CHANNEL 4 SEPARATOR, LOW RANGE	Table 5.4
RTGM02	AIR MASS RATE, REFERENCE OUTLET, LOW RANGE	Table 5.3
RPGP01	PRESSURE, TOP OF REFERENCE INLET PLENUM, 230.4 in	± 0.042 psig
RPGP02	PRESSURE, REF. ASSEMBLY, ABOVE ORIFICE, 198.2 in	± 0.042 psig
RPGP03	PRESSURE, REF. ASSEMBLY, BELOW ORIFICE, 194.7 in	± 0.042 psig
TPGP01	PRESSURE, TOP OF TEST INLET PLENUM, 230.4 inches	± 0.042 psig
TPGP02	PRESSURE, TEST ASSEMBLY ABOVE ORIFICE, 198.2 in	± 0.042 psig
TPGP03	PRESSURE, TEST ASSEMBLY BELOW ORIFICE, 194.7 in	± 0.042 psig
T2GP01	PRESSURE, CHANNEL 2, TEST ASS'Y., 162.7 inches	± 0.042 psig
T3GP01	PRESSURE, CHAN. 3, TEST ASS'Y., 162.3 inches	± 0.042 psig
T4GP01	PRESSURE, CHAN. 4, TEST ASS'Y., 161.9 inches	± 0.042 psig
T2GP02	PRESSURE, CHAN. 2, TEST ASS'Y., 131.2 inches	± 0.042 psig
T3GP02	PRESSURE, CHAN. 3, TEST ASS'Y., 130.8 inches	± 0.042 psig
T4GP02	PRESSURE, CHAN. 4, TEST ASS'Y., 130.4 inches	± 0.042 psig
T2GP03	PRESSURE, CHAN. 2, TEST ASS'Y., 99.7 inches	± 0.042 psig
T3GP03	PRESSURE, CHAN. 3, TEST ASS'Y., 99.3 inches	± 0.042 psig
T4GP03	PRESSURE, CHAN. 4, TEST ASS'Y., 98.9 inches	± 0.042 psig
T2GP04	PRESSURE, CHAN. 2, TEST ASS'Y., 68.2 inches	± 0.042 psig
T3GP04	PRESSURE, CHAN. 3, TEST ASS'Y., 67.8 inches	± 0.042 psig
T4GP04	PRESSURE, CHAN. 4, TEST ASS'Y., 67.4 inches	± 0.042 psig
T2GP05	PRESSURE, CHAN. 2, TEST ASS'Y., 36.7 inches	± 0.042 psig
T3GP05	PRESSURE, CHAN. 3, TEST ASS'Y., 36.3 inches	± 0.042 psig

Table 5.1 (cont'd.)
Database Variable (VTAB) Measurement Definitions and Uncertainties

<u>VTAB</u>	<u>Description</u>	<u>Uncertainty</u>
T4GP05	PRESSURE, CHAN. 4, TEST ASS'Y., 35.9 inches	± 0.042 psig
T2GP06	PRESSURE, CHAN. 2, TEST ASS'Y., 5.2 inches	± 0.042 psig
T3GP06	PRESSURE, CHAN. 3, TEST ASS'Y., 4.8 inches	± 0.042 psig
T4GP06	PRESSURE, CHAN. 4, TEST ASS'Y., 4.4 inches	± 0.042 psig
R2GP02	PRESSURE, CHAN. 2, REFERENCE ASS'Y., 131.2 inches	± 0.042 psig
R3GP02	PRESSURE, CHAN. 3, REFERENCE ASS'Y., 130.8 inches	± 0.042 psig
R4GP02	PRESSURE, CHAN. 4, REFERENCE ASS'Y., 130.4 inches	± 0.042 psig
R2GP03	PRESSURE, CHAN. 2, REFERENCE ASS'Y., 99.7 inches	± 0.042 psig
R3GP03	PRESSURE, CHAN. 3, REFERENCE ASS'Y., 99.3 inches	± 0.042 psig
R4GP03	PRESSURE, CHAN. 4, REFERENCE ASS'Y., 98.9 inches	± 0.042 psig
R2GP04	PRESSURE, CHAN. 2, REFERENCE ASS'Y., 68.2 inches	± 0.042 psig
R3GP04	PRESSURE, CHAN. 3, REFERENCE ASS'Y., 67.8 inches	± 0.042 psig
R4GP04	PRESSURE, CHAN. 4, REFERENCE ASS'Y., 67.4 inches	± 0.042 psig
R2GP05	PRESSURE, CHAN. 2, REFERENCE ASS'Y., 36.7 inches	± 0.042 psig
R3GP05	PRESSURE, CHAN. 3, REFERENCE ASS'Y., 36.3 inches	± 0.042 psig
R4GP05	PRESSURE, CHAN. 4, REFERENCE ASS'Y., 35.9 inches	± 0.042 psig
R2GP06	PRESSURE, CHAN. 2, REFERENCE ASS'Y., 5.2 inches	± 0.042 psig
R3GP06	PRESSURE, CHAN. 3, REFERENCE ASS'Y., 4.8 inches	± 0.042 psig
R4GP06	PRESSURE, CHAN. 4, REFERENCE ASS'Y., 4.4 inches	± 0.042 psig
RTGP01	PRESSURE, TANK BOTTOM FOR REFERENCE ASSEMBLY	± 0.042 psig
T2LC01	LIQ. MASS, LOW RANGE CHAN. 2 SEPARATOR	± 0.2 lbm
T2LC02	LIQ. MASS, HIGH RANGE CHAN. 2 SEPARATOR	± 2.0 lbm
T3LC01	LIQ. MASS, LOW RANGE CHAN. 3 SEPARATOR	± 0.2 lbm
T3LC02	LIQ. MASS, HIGH RANGE CHAN. 3 SEPARATOR	± 2.0 lbm
T4LC01	LIQ. MASS, LOW RANGE CHAN. 4 SEPARATOR	± 0.2 lbm
T4LC02	LIQ. MASS, HIGH RANGE CHAN. 4 SEPARATOR	± 2.0 lbm
R2DP01	DP TEST/REFER. ASS'Y. CHAN. 2, 162.7 inches	± 0.0051 psid
R3DP01	DP TEST/REFER. ASS'Y. CHAN. 3, 162.3 inches	± 0.0051 psid
R4DP01	DP TEST/REFER. ASS'Y. CHAN. 4, 161.9 inches	± 0.0051 psid
R2DP02	DP TEST/REFER. ASS'Y. CHAN. 2, 5.2 inches	± 0.0051 psid
R3DP02	DP TEST/REFER. ASS'Y. CHAN. 3, 4.8 inches	± 0.0051 psid
R4DP02	DP TEST/REFER. ASS'Y. CHAN. 4, 4.4 inches	± 0.0051 psid
RPLV01	LEVEL, REFERENCE INLET PLENUM	Table 5.5
TPLV01	LEVEL, TEST INLET PLENUM	Table 5.5

Note: The instrument elevations were referenced to the bottom of the fuel subassembly bottom fitting (see Reference 15).

Table 5.2
Test and Reference Assembly Total Water Flow Values and Uncertainties

TEST NUMBER	TEST DATE/TIME	----- TEST ASSY WATER FLOW -----				----- REF ASSY WATER FLOW -----			
		VTAB	VALUE (GPM)	FLUCT. (GPM)	UNC (GPM)	VTAB	VALUE (GPM)	FLUCT. (GPM)	UNC (GPM)
897001	27-OCT-89, 14:30	TPMM01	39.93	0.35	0.17	RPMM01	39.47	0.47	0.13
897002	27-OCT-89, 16:54	TPMM01	40.36	0.47	0.18	RPMM01	40.42	0.52	0.14
897004	27-OCT-89, 22:00	TPMM01	39.79	0.42	0.17	RPMM01	39.60	0.49	0.13
897006	28-OCT-89, 00:01	TPMM01	40.09	0.33	0.17	RPMM01	39.65	0.52	0.13
897007	30-OCT-89, 15:30	TPMM01	40.62	0.51	0.18	RPMM01	40.11	0.49	0.13
897013	31-OCT-89, 02:34	TPMM01	39.93	0.42	0.17	RPMM01	40.25	0.63	0.14
897015	31-OCT-89, 21:33	TPMM01	24.49	0.20	0.11	RPMM01	24.09	0.45	0.09
897019	01-NOV-89, 17:58	TPMM01	23.98	0.18	0.11	RPMM01	24.04	0.23	0.09
897020	03-NOV-89, 07:22	TPMM01	9.80	0.10	0.06	RPMM01	9.74	0.09	0.05
897021	03-NOV-89, 09:48	TPMM01	10.01	0.08	0.06	RPMM01	10.05	0.08	0.05
897022	03-NOV-89, 12:42	TPMM01	10.25	0.10	0.06	RPMM01	10.21	0.09	0.05
897024	03-NOV-89, 14:40	TPMM01	10.22	0.08	0.06	RPMM01	10.12	0.08	0.05
897027	01-NOV-89, 21:42	TPMM01	24.08	0.20	0.11	RPMM01	24.11	0.23	0.09
897028	04-NOV-89, 06:45	TPMM01	9.68	0.09	0.06	RPMM01	9.52	0.07	0.05
897033	04-NOV-89, 13:25	TPMM01	10.01	0.09	0.06	RPMM01	10.27	0.09	0.05
897034	04-NOV-89, 17:34	TPMM01	8.94	1.19	0.05	RPMM01	9.98	0.08	0.05
897035	04-NOV-89, 19:19	TPMM01	9.97	0.09	0.06	RPMM01	10.27	0.09	0.05
897036	04-NOV-89, 22:04	TPMM01	9.92	0.08	0.06	RPMM01	9.96	0.07	0.05
897037	04-NOV-89, 23:48	TPMM01	10.16	0.08	0.06	RPMM01	10.42	0.07	0.05
897038	06-NOV-89, 08:05	TPMM01	40.24	0.44	0.17	RPMM01	39.88	0.63	0.13
897039	06-NOV-89, 14:47	TPMM01	23.90	0.20	0.11	RPMM01	24.01	0.27	0.09
897040	06-NOV-89, 19:53	TPMM01	10.01	0.11	0.06	RPMM01	10.20	0.11	0.05
897046	07-NOV-89, 11:25	TPMM01	40.10	0.39	0.17	RPMM01	40.56	0.50	0.14
897050	07-NOV-89, 20:24	TPMM01	40.01	0.45	0.17	RPMM01	39.52	0.57	0.13
897051	08-NOV-89, 02:16	TPMM01	10.04	0.10	0.06	RPMM01	10.29	0.09	0.05
897052	08-NOV-89, 06:15	TPMM01	9.97	0.09	0.06	RPMM01	9.87	0.08	0.05
897053	08-NOV-89, 10:20	TPMM01	39.88	0.40	0.17	RPMM01	40.29	0.63	0.14
897054	08-NOV-89, 12:52	TPMM01	24.52	0.22	0.11	RPMM01	24.85	0.61	0.09
897055	08-NOV-89, 18:41	TPMM02	80.87	0.94	0.21	RPMM02	80.94	3.10	0.21
897057	08-NOV-89, 23:24	TPMM02	79.50	1.12	0.20	RPMM02	78.16	2.92	0.20
897058	09-NOV-89, 02:35	TPMM02	79.50	1.02	0.20	RPMM02	80.05	3.07	0.21
897059	09-NOV-89, 07:05	TPMM01	23.51	0.19	0.11	RPMM01	24.13	0.57	0.09
897060	09-NOV-89, 09:35	TPMM01	23.48	0.18	0.11	RPMM01	24.14	0.65	0.09
897061	09-NOV-89, 11:20	TPMM01	24.01	0.16	0.11	RPMM01	24.01	0.69	0.09
897062	09-NOV-89, 14:08	TPMM01	40.19	0.36	0.17	RPMM01	39.17	0.51	0.13
897064	09-NOV-89, 18:57	TPMM01	39.96	0.44	0.17	RPMM01	40.04	0.60	0.13
897065	09-NOV-89, 20:43	TPMM01	30.28	0.37	0.14	RPMM01	29.87	0.44	0.10
897066	09-NOV-89, 22:22	TPMM01	30.37	0.26	0.14	RPMM01	30.05	0.40	0.11
897067	10-NOV-89, 01:54	TPMM01	30.29	0.30	0.14	RPMM01	29.95	0.42	0.10
897069	10-NOV-89, 09:11	TPMM02	59.86	1.35	0.17	RPMM02	59.05	3.06	0.16
897070	10-NOV-89, 11:25	TPMM02	60.27	1.22	0.17	RPMM02	58.53	2.73	0.16
897071	10-NOV-89, 16:04	TPMM02	60.43	1.27	0.17	RPMM02	59.18	2.49	0.16
897072	20-NOV-89, 11:23	TPMM02	78.68	0.87	0.20	RPMM02	79.66	3.07	0.20
897073	20-NOV-89, 13:35	TPMM02	59.47	1.29	0.17	RPMM02	60.14	3.59	0.17
897074	20-NOV-89, 16:06	TPMM02	40.15	0.55	0.13	RPMM02	39.52	1.59	0.13
897075	21-NOV-89, 10:42	TPMM02	39.69	0.54	0.13	RPMM02	39.72	1.20	0.13

Table 5.2 (cont'd.)

TEST NUMBER	TEST DATE/TIME	----- TEST ASSY WATER FLOW -----				----- REF ASSY WATER FLOW -----			
		VTAB	VALUE (GPM)	FLUCT. (GPM)	UNC (GPM)	VTAB	VALUE (GPM)	FLUCT. (GPM)	UNC (GPM)
897076	21-NOV-89, 12:26	TPMM02	39.52	0.68	0.13	RPMM02	39.22	1.30	0.13
897077	21-NOV-89, 14:05	TPMM01	24.23	0.38	0.11	RPMM01	23.81	0.65	0.09
897078	21-NOV-89, 15:38	TPMM01	24.17	0.30	0.11	RPMM01	23.87	0.70	0.09
897079	22-NOV-89, 12:08	TPMM01	24.14	0.29	0.11	RPMM01	24.65	0.62	0.09
897080	22-NOV-89, 14:31	TPMM01	14.86	0.17	0.08	RPMM01	15.39	0.17	0.06
897081	27-NOV-89, 14:43	TPMM01	40.76	0.85	0.18	RPMM01	40.88	0.75	0.14
897082	28-NOV-89, 12:23	TPMM01	24.40	0.37	0.11	RPMM01	24.13	0.55	0.09
897084	28-NOV-89, 14:41	TPMM01	24.36	0.33	0.11	RPMM01	24.62	0.60	0.09
897086	29-NOV-89, 08:05	TPMM01	23.86	0.33	0.11	RPMM01	24.25	0.37	0.09
897087	29-NOV-89, 10:08	TPMM01	15.05	0.16	0.08	RPMM01	15.26	0.16	0.06
897090	05-DEC-89, 13:53	TPMM01	23.78	0.32	0.11	RPMM01	24.03	0.37	0.09
897091	05-DEC-89, 15:24	TPMM01	23.56	0.36	0.11	RPMM01	23.38	0.74	0.09
897092	06-DEC-89, 09:36	TPMM01	24.10	0.37	0.11	RPMM01	24.19	0.39	0.09
897094	06-DEC-89, 11:14	TPMM01	23.91	0.31	0.11	RPMM01	23.86	0.32	0.09
897095	06-DEC-89, 13:42	TPMM01	23.81	0.32	0.11	RPMM01	23.79	0.33	0.09
897096	06-DEC-89, 15:48	TPMM01	23.61	0.30	0.11	RPMM01	23.73	0.28	0.09
897097	06-DEC-89, 16:54	TPMM01	23.74	0.28	0.11	RPMM01	23.80	0.27	0.09
897098	06-DEC-89, 18:30	TPMM01	23.69	0.37	0.11	RPMM01	23.88	0.31	0.09
897115	30-JAN-90, 15:31	TPMM01	9.93	0.26	0.06	RPMM01	9.99	0.39	0.05
897116	30-JAN-90, 16:14	TPMM01	9.93	0.20	0.06	RPMM01	9.98	0.40	0.05
897118	31-JAN-90, 13:31	TPMM01	24.45	0.42	0.11	RPMM01	24.51	0.74	0.09
897119	31-JAN-90, 14:57	TPMM01	24.47	0.42	0.11	RPMM01	24.50	0.63	0.09
897121	01-FEB-90, 11:52	TPMM01	39.87	0.97	0.17	RPMM01	39.87	0.75	0.13
897123	01-FEB-90, 14:08	TPMM01	39.81	0.95	0.17	RPMM01	39.85	0.75	0.13
897125	01-FEB-90, 18:01	TPMM01	23.85	0.46	0.11	RPMM01	23.87	0.77	0.09
897127	01-FEB-90, 20:30	TPMM01	23.82	0.49	0.11	RPMM01	23.89	0.83	0.09
897128	01-FEB-90, 11:48	TPMM01	23.88	0.45	0.11	RPMM01	23.89	0.52	0.09
897131	03-FEB-90, 15:04	TPMM01	23.88	0.54	0.11	RPMM01	23.92	0.41	0.09
897133	03-FEB-90, 18:48	TPMM01	39.87	0.90	0.17	RPMM01	40.48	0.84	0.14
897135	04-FEB-90, 14:56	TPMM01	39.83	0.99	0.17	RPMM01	39.88	0.92	0.13
897137	04-FEB-90, 17:10	TPMM01	39.90	1.03	0.17	RPMM01	39.91	0.81	0.13
897139	05-FEB-90, 13:07	TPMM02	79.59	0.74	0.20	RPMM02	80.97	3.62	0.21
897140	05-FEB-90, 18:02	TPMM01	23.79	0.53	0.11	RPMM01	23.95	0.35	0.09
955001	28-MAR-90, 13:12	TPMM01	24.31	0.52	0.11	N/A	N/A	N/A	0.06
955006	28-MAR-90, 18:30	TPMM01	24.35	0.65	0.11	N/A	N/A	N/A	0.06
955008	29-MAR-90, 10:34	TPMM02	78.80	1.04	0.20	N/A	N/A	N/A	0.06
955012	29-MAR-90, 15:06	TPMM02	80.48	0.91	0.21	N/A	N/A	N/A	0.06
955014	07-APR-90, 13:03	TPMM01	34.94 (2)	0.53	0.15	RPMM01	34.93 (2)	0.50	0.12
955015	07-APR-90, 15:28	TPMM01	44.84 (2)	0.73	0.19	RPMM01	45.17 (2)	0.97	0.15
955016	08-APR-90, 13:12	TPMM02	70.24 (2)	1.24	0.19	RPMM02	70.39 (2)	3.87	0.19
955017	08-APR-90, 16:58	TPMM01	35.46 (2)	0.59	0.16	RPMM01	34.93 (2)	0.51	0.12
955018	08-MAY-90, 14:51	TPMM01	23.89	0.31	0.11	RPMM01	24.10	0.53	0.09
955020	09-MAY-90, 13:05	TPMM01	24.00	0.29	0.11	RPMM01	23.78	0.30	0.09
955021	09-MAY-90, 17:45	TPMM02	50.46	0.68	0.15	RPMM02	49.69	2.22	0.15
955022	10-MAY-90, 11:18	TPMM01	40.28	0.64	0.17	RPMM01	40.33	0.62	0.14

Table 5.2 (cont'd.)

TEST NUMBER	TEST DATE/TIME	----- TEST ASSY WATER FLOW -----				----- REF ASSY WATER FLOW -----			
		VTAB	VALUE (GPM)	FLUCT. (GPM)	UNC (GPM)	VTAB	VALUE (GPM)	FLUCT. (GPM)	UNC (GPM)
955023	10-MAY-90, 14:40	TPMM01	23.91	0.31	0.11	RPMM01	23.70	0.55	0.09
955024	10-MAY-90, 19:54	TPMM02	49.98	0.81	0.15	RPMM02	50.43	3.07	0.15
958002	15-MAY-90, 14:29	TPMM01	19.74	0.25	0.09	RPMM01	19.84	0.23	0.08
958003	15-MAY-90, 18:16	TPMM01	19.80	0.22	0.09	RPMM01	19.85	0.22	0.08
958004	15-MAY-90, 12:28	TPMM02	59.54	1.18	0.17	RPMM02	58.68	3.88	0.16
958005	16-MAY-90, 16:02	TPMM02	58.85	1.61	0.16	RPMM02	58.00	4.05	0.16
958006	18-MAY-90, 15:09	TPMM01	20.10	0.26	0.10	RPMM01	19.91	0.16	0.08
958007	21-MAY-90, 19:32	TPMM01	19.79	0.22	0.09	RPMM01	19.86	0.21	0.08
958008	22-MAY-90, 17:01	TPMM01	20.19	0.29	0.10	RPMM01	20.04	0.22	0.08
958009	23-MAY-90, 15:49	TPMM01	20.44	0.25	0.10	RPMM01	20.47	0.35	0.08
958011	24-MAY-90, 14:42	TPMM02	59.96	0.52	0.17	RPMM02	60.14	0.38	0.19
958012	24-MAY-90, 21:49	TPMM02	60.04	0.65	0.17	RPMM02	59.90	0.39	0.19
958013	26-MAY-90, 15:59	TPMM02	59.89	0.78	0.17	RPMM02	59.77	0.37	0.19
958014	29-MAY-90, 10:57	TPMM01	20.29	0.23	0.10	RPMM01	20.39	0.18	0.08
958015	29-MAY-90, 14:46	TPMM02	59.83	0.78	0.17	RPMM02	60.15	0.43	0.19
958016	29-MAY-90, 17:39	TPMM01	20.02	0.22	0.10	RPMM01	20.08	0.27	0.08
958017	30-MAY-90, 10:39	TPMM02	59.99	0.79	0.17	RPMM02	59.92	0.32	0.19
958018	30-MAY-90, 15:18	TPMM01	20.03	0.25	0.10	RPMM01	20.25	0.19	0.08
958019	31-MAY-90, 10:30	TPMM02	59.75	1.30	0.17	RPMM02	59.96	0.33	0.19
958020	01-JUN-90, 11:49	TPMM01	20.29	0.26	0.10	RPMM01	20.33	0.32	0.08
958021	01-JUN-90, 17:04	TPMM02	59.83	0.74	0.17	RPMM02	60.17	0.49	0.19
958022	02-JUN-90, 14:26	TPMM01	20.33	0.19	0.10	RPMM01	20.08	0.32	0.08
958023	02-JUN-90, 19:10	TPMM02	59.83	0.50	0.17	RPMM02	60.30	0.49	0.20
958024	03-JUN-90, 14:48	TPMM01	20.17	0.21	0.10	RPMM01	20.22	0.18	0.08
958025	03-JUN-90, 22:21	TPMM02	60.08	0.60	0.17	RPMM02	60.15	0.50	0.19
958026	04-JUN-90, 15:53	TPMM01	20.29	0.26	0.10	RPMM01	20.21	0.25	0.08
958027	05-JUN-90, 12:12	TPMM02	59.41	0.62	0.17	RPMM02	60.07	0.42	0.19
958028	06-JUN-90, 16:04	TPMM02	59.53	0.58	0.17	RPMM02	59.70	0.43	0.19
958029	08-JUN-90, 14:27	TPMM02	59.77	0.72	0.17	RPMM02	60.07	0.45	0.19
958030	08-JUN-90, 22:18	TPMM01	19.89	0.27	0.09	RPMM01	19.82	0.19	0.08
958031	09-JUL-90, 12:02	TPMM01	37.60	0.71	0.16	RPMM01	36.74	0.46	0.12
958032	09-JUL-90, 17:17	TPMM01	37.13	0.81	0.16	RPMM01	36.75	0.44	0.12
958033	09-JUL-90, 23:21	TPMM01	37.04	0.74	0.16	RPMM01	36.60	0.46	0.12
958034	10-JUL-90, 02:52	TPMM02	60.44	1.12	0.17	RPMM02	59.87	0.34	0.19
958035	10-JUL-90, 22:42	TPMM01	36.92	0.80	0.16	RPMM01	37.48	0.45	0.13
958036	11-JUL-90, 01:43	TPMM01	36.84	0.81	0.16	RPMM01	36.97	0.45	0.13
958037	11-JUL-90, 04:23	TPMM02	59.64	1.01	0.17	RPMM02	60.48	0.32	0.20
958038	11-JUL-90, 15:34	TPMM01	37.25	0.53	0.16	RPMM01	37.24	0.59	0.13
958039	11-JUL-90, 21:13	TPMM01	36.89	0.67	0.16	RPMM01	37.02	0.62	0.13
958040	12-JUL-90, 00:29	TPMM02	59.68	0.51	0.17	RPMM02	59.59	0.40	0.19
958041	12-JUL-90, 14:26	TPMM01	37.00	0.46	0.16	RPMM01	36.77	0.60	0.12
958042	12-JUL-90, 17:42	TPMM01	37.26	0.59	0.16	RPMM01	37.32	0.61	0.13
958043	12-JUL-90, 20:34	TPMM02	59.60	0.88	0.17	RPMM02	59.98	0.47	0.19
964001	16-JUL-90, 11:30	TPMM01	23.85	0.39	0.11	RPMM01	23.92	0.26	0.09

Table 5.2 (cont'd.)

TEST NUMBER	TEST DATE/TIME	----- TEST ASSY WATER FLOW -----				----- REF ASSY WATER FLOW -----			
		VTAB	VALUE (GPM)	FLUCT. (GPM)	UNC (GPM)	VTAB	VALUE (GPM)	FLUCT. (GPM)	UNC (GPM)
964002	16-JUL-90, 16:06	TPMM01	15.12	0.21	0.08	RPMM01	14.98	0.10	0.06
964003	17-JUL-90, 10:44	TPMM01	26.48	0.44	0.12	RPMM01	26.17	0.34	0.09
964004	17-JUL-90, 13:50	TPMM01	26.19	0.46	0.12	RPMM01	25.95	0.30	0.09
964005	18-JUL-90, 12:05	TPMM01	37.27	0.74	0.16	RPMM01	37.24	0.47	0.13
964006	18-JUL-90, 14:47	TPMM01	47.96	1.04	0.21	RPMM01	47.59	0.94	0.16
964007	19-JUL-90, 10:34	TPMM02	59.13	0.87	0.16	RPMM02	59.51	0.29	0.19
964008	19-JUL-90, 13:38	TPMM02	70.89	1.08	0.19	RPMM02	70.37	0.45	0.23
964009	20-JUL-90, 15:20	TPMM01	26.47	0.44	0.12	RPMM01	26.54	0.52	0.09
964010	23-JUL-90, 14:24	TPMM01	24.33	0.45	0.11	RPMM01	24.29	0.44	0.09
964011	24-JUL-90, 11:32	TPMM01	36.60	0.79	0.16	RPMM01	37.30	0.52	0.13
964012	24-JUL-90, 15:19	TPMM01	47.79	1.20	0.20	RPMM01	48.43	0.84	0.16
964013	25-JUL-90, 14:06	TPMM02	69.26	0.88	0.18	RPMM02	69.88	0.40	0.22
964014	26-JUL-90, 11:51	TPMM01	15.18	0.17	0.08	RPMM01	15.08	0.13	0.06
964015	27-JUL-90, 11:44	TPMM01	25.83	0.46	0.12	RPMM01	25.84	0.33	0.09
964016	27-JUL-90, 14:18	TPMM01	25.83	0.39	0.12	RPMM01	25.83	0.34	0.09
964017	30-JUL-90, 09:51	TPMM01	24.16	0.36	0.11	RPMM01	23.77	0.22	0.09
964018	30-JUL-90, 12:35	TPMM01	37.01	0.79	0.16	RPMM01	37.22	0.50	0.13
964019	30-JUL-90, 16:15	TPMM01	36.98	0.78	0.16	RPMM01	37.30	0.47	0.13
964020	30-JUL-90, 18:39	TPMM01	37.15	0.82	0.16	RPMM01	37.11	0.52	0.13
964021	30-JUL-90, 23:00	TPMM01	47.66	1.07	0.20	RPMM01	48.11	0.94	0.16
964022	31-JUL-90, 10:47	TPMM02	59.47	0.81	0.17	RPMM02	58.69	0.38	0.19
964023	31-JUL-90, 13:56	TPMM02	58.78	0.85	0.16	RPMM02	58.81	0.29	0.19
964024	31-JUL-90, 17:38	TPMM01	47.67	1.11	0.20	RPMM01	47.92	1.03	0.16
964025	31-JUL-90, 21:44	TPMM01	12.99	9.97	0.07	RPMM01	12.85	9.87	0.06
964026	06-AUG-90, 09:56	TPMM01	23.84	0.37	0.11	RPMM01	24.13	0.46	0.09
964027	06-AUG-90, 14:35	TPMM01	14.97	0.15	0.08	RPMM01	15.49	0.15	0.06
964028	06-AUG-90, 17:22	TPMM01	14.85	0.14	0.08	RPMM01	14.86	0.13	0.06
964029	06-AUG-90, 20:19	TPMM02	70.19	0.92	0.19	RPMM02	70.12	0.42	0.22
964030	06-AUG-90, 22:49	TPMM02	69.58	1.04	0.18	RPMM02	70.01	0.49	0.22
964031	09-AUG-90, 12:24	TPMM01	25.72	0.39	0.12	RPMM01	25.97	0.53	0.09
964032	09-AUG-90, 17:04	TPMM01	25.86	0.42	0.12	RPMM01	26.14	0.58	0.09
964033	09-AUG-90, 19:43	TPMM01	25.98	0.43	0.12	RPMM01	25.81	0.56	0.09
964034	09-AUG-90, 22:05	TPMM01	36.73	0.70	0.16	RPMM01	36.89	0.52	0.13
964035	10-AUG-90, 00:07	TPMM01	37.20	0.80	0.16	RPMM01	36.84	0.51	0.13
964036	10-AUG-90, 02:21	TPMM01	36.54	0.80	0.16	RPMM01	36.56	0.58	0.12
964037	10-AUG-90, 11:37	TPMM01	47.99	1.16	0.21	RPMM01	48.31	1.11	0.16
964038	10-AUG-90, 16:23	TPMM01	47.78	1.18	0.20	RPMM01	47.69	1.02	0.16
964039	10-AUG-90, 18:53	TPMM01	47.53	1.30	0.20	RPMM01	47.61	1.07	0.16
964040	10-AUG-90, 20:55	TPMM01	47.94	1.17	0.21	RPMM01	47.85	1.00	0.16
964041	11-AUG-90, 10:46	TPMM02	58.94	0.91	0.16	RPMM02	58.95	0.37	0.19
964042	11-AUG-90, 12:36	TPMM02	58.46	1.11	0.16	RPMM02	58.43	0.37	0.19
964043	11-AUG-90, 14:39	TPMM02	59.12	1.21	0.16	RPMM02	59.22	0.33	0.19
964044	13-AUG-90, 00:34	TPMM02	58.54	1.18	0.16	RPMM02	58.74	0.39	0.19
964045	13-AUG-90, 01:41	TPMM02	59.16	1.25	0.16	RPMM02	59.29	0.28	0.19
964046	13-AUG-90, 04:41	TPMM02	58.63	1.51	0.16	RPMM02	59.01	0.33	0.19
964047	13-AUG-90, 06:35	TPMM01	24.01	0.38	0.11	RPMM01	23.55	0.25	0.09

Table 5.2 (cont'd.)

TEST NUMBER	TEST DATE/TIME	----- TEST ASSY WATER FLOW -----				----- REF ASSY WATER FLOW -----			
		VTAB	VALUE (GPM)	FLUCT. (GPM)	UNC (GPM)	VTAB	VALUE (GPM)	FLUCT. (GPM)	UNC (GPM)
964048	13-AUG-90, 11:59	TPMM01	69.70	1.21	0.29	RPMM02	69.31	0.40	0.22
964049	14-AUG-90, 00:12	TPMM02	70.39	1.28	0.19	RPMM02	70.00	0.52	0.22
964050	14-AUG-90, 02:02	TPMM02	70.03	1.47	0.19	RPMM02	69.55	0.41	0.22
964051	14-AUG-90, 03:50	TPMM02	70.73	1.65	0.19	RPMM02	69.95	0.42	0.22
964052	14-AUG-90, 07:52	TPMM01	14.66	0.16	0.07	RPMM01	15.16	0.14	0.06
964053	14-AUG-90, 12:29	TPMM01	15.02	0.18	0.08	RPMM01	14.70	0.13	0.06
964054	14-AUG-90, 15:49	TPMM01	14.88	0.20	0.08	RPMM01	14.69	0.14	0.06
964055	14-AUG-90, 22:54	TPMM01	37.23	0.65	0.16	RPMM01	37.03	0.48	0.13
964056	15-AUG-90, 00:42	TPMM01	47.68	1.14	0.20	RPMM01	48.44	1.16	0.16
964057	15-AUG-90, 02:43	TPMM02	59.23	0.88	0.17	RPMM02	59.04	0.30	0.19
964058	15-AUG-90, 05:13	TPMM02	69.65	0.95	0.18	RPMM02	70.17	0.35	0.22
964059	15-AUG-90, 10:33	TPMM01	15.33	0.20	0.08	RPMM01	15.29	0.11	0.06
964060	15-AUG-90, 14:12	TPMM01	15.04	0.23	0.08	RPMM01	14.96	0.14	0.06
964061	15-AUG-90, 23:56	TPMM02	70.80	1.15	0.19	RPMM02	69.88	0.33	0.22
964062	16-AUG-90, 02:36	TPMM01	26.34	0.42	0.12	RPMM01	26.16	0.36	0.09
964063	17-AUG-90, 00:24	TPMM01	26.13	0.43	0.12	RPMM01	26.12	0.58	0.09
964064	17-AUG-90, 02:33	TPMM02	69.75	1.13	0.19	RPMM02	70.35	0.39	0.23
964065	17-AUG-90, 10:02	TPMM01	8.85	0.11	0.05	RPMM01	9.12	0.09	0.05
964066	20-AUG-90, 04:24	TPMM01	9.12	0.12	0.05	RPMM01	9.12	0.10	0.05
964067	20-AUG-90, 08:48	TPMM01	9.18	0.12	0.05	RPMM01	9.09	0.12	0.05
964068	20-AUG-90, 13:18	TPMM01	8.93	0.08	0.05	RPMM01	8.90	0.09	0.04
964069	20-AUG-90, 14:57	TPMM01	23.92	0.37	0.11	RPMM01	23.87	0.28	0.09
964070	21-AUG-90, 04:36	TPMM02	109.84	0.84	0.26	RPMM02	108.99 (1)	0.86	0.26
964071	21-AUG-90, 08:38	TPMM02	107.71	0.73	0.26	RPMM02	106.64 (1)	0.69	0.25
964072	21-AUG-90, 12:11	TPMM02	94.59	0.84	0.23	RPMM02	95.62 (1)	0.57	0.24
964073	21-AUG-90, 14:41	TPMM02	94.84	0.77	0.23	RPMM02	95.25 (1)	0.53	0.24
964074	21-AUG-90, 23:42	TPMM01	2.95	0.07	0.03	RPMM01	2.90	0.07	0.03
964075	22-AUG-90, 13:23	TPMM02	93.75	0.64	0.23	RPMM02	94.07 (1)	0.61	0.23
964076	22-AUG-90, 16:06	TPMM02	95.15	1.02	0.23	RPMM02	95.39 (1)	0.62	0.23
964077	22-AUG-90, 19:07	TPMM01	2.95	0.07	0.03	RPMM01	2.92	0.06	0.03
964078	22-AUG-90, 23:36	TPMM01	2.96	0.07	0.03	RPMM01	2.91	0.06	0.03
964079	23-AUG-90, 10:18	TPMM01	40.13	0.88	0.17	RPMM01	39.78	0.68	0.13
964080	23-AUG-90, 13:02	TPMM01	9.99	0.10	0.06	RPMM01	10.28	0.10	0.06
964081	23-AUG-90, 15:37	TPMM01	24.12	0.30	0.11	RPMM01	23.79	0.27	0.09
964082	23-AUG-90, 19:03	TPMM01	37.10	0.72	0.16	RPMM01	37.30	0.49	0.13
964083	23-AUG-90, 22:10	TPMM01	36.76	0.80	0.16	RPMM01	36.87	0.55	0.13
964084	24-AUG-90, 10:23	TPMM01	42.88	0.93	0.19	RPMM01	42.99	0.79	0.14
964085	24-AUG-90, 13:47	TPMM02	59.14	0.82	0.16	RPMM02	59.37	0.29	0.19
964086	27-AUG-90, 10:13	TPMM01	24.10	0.37	0.11	RPMM01	23.86	0.29	0.09
964087	31-AUG-90, 11:14	TPMM01	47.59	0.90	0.20	RPMM01	48.00	0.97	0.16
964088	31-AUG-90, 14:00	TPMM01	47.12	1.10	0.20	RPMM01	47.51	0.96	0.16
964089	04-SEP-90, 10:27	TPMM01	26.37	0.42	0.12	RPMM01	25.90	0.34	0.09
964090	04-SEP-90, 14:06	TPMM01	15.07	0.23	0.06	RPMM01	15.23	0.13	0.06
964091	05-SEP-90, 09:10	TPMM01	24.01	0.39	0.11	RPMM01	24.08	0.25	0.09
964092	05-SEP-90, 12:39	TPMM01	14.95	0.21	0.08	RPMM01	14.68	0.16	0.06
964093	05-SEP-90, 15:07	TPMM01	26.12	0.38	0.12	RPMM01	25.45	0.34	0.09

Table 5.2 (cont'd.)

TEST NUMBER	TEST DATE/TIME	----- TEST ASSY WATER FLOW -----				----- REF ASSY WATER FLOW -----			
		VTAB	VALUE (GPM)	FLUCT. (GPM)	UNC (GPM)	VTAB	VALUE (GPM)	FLUCT. (GPM)	UNC (GPM)
965001	25-JUN-90, 13:35	N/A	N/A	N/A	N/A	RPMM01	24.21	0.23	0.09
965002	25-JUN-90, 14:39	N/A	N/A	N/A	N/A	RPMM01	24.10	0.26	0.09
965003	26-JUN-90, 08:15	N/A	N/A	N/A	N/A	RPMM01	23.92	0.76	0.09
965004	26-JUN-90, 10:09	N/A	N/A	N/A	N/A	RPMM01	30.13	0.47	0.11
965005	26-JUN-90, 12:03	N/A	N/A	N/A	N/A	RPMM01	39.77	0.60	0.13
965006	26-JUN-90, 13:52	N/A	N/A	N/A	N/A	RPMM01	39.91	0.63	0.13
965007	26-JUN-90, 15:28	N/A	N/A	N/A	N/A	RPMM01	40.92	0.60	0.14
965008	27-JUN-90, 09:02	N/A	N/A	N/A	N/A	RPMM01	20.38	0.19	0.08
965009	27-JUN-90, 10:49	N/A	N/A	N/A	N/A	RPMM01	30.24	0.45	0.11
965010	27-JUN-90, 15:03	N/A	N/A	N/A	N/A	RPMM01	20.52	0.26	0.08
965011	28-JUN-90, 08:58	N/A	N/A	N/A	N/A	RPMM01	26.71	0.63	0.10
965012	28-JUN-90, 10:47	N/A	N/A	N/A	N/A	RPMM01	41.02	0.68	0.14
965013	28-JUN-90, 13:05	N/A	N/A	N/A	N/A	RPMM01	31.19	0.39	0.11
965014	28-JUN-90, 15:51	N/A	N/A	N/A	N/A	RPMM02	60.46	0.38	0.20
965015	28-JUN-90, 19:12	N/A	N/A	N/A	N/A	RPMM02	69.60	0.49	0.22
965016	29-JUN-90, 09:52	N/A	N/A	N/A	N/A	RPMM01	40.85	0.62	0.14
965017	29-JUN-90, 13:28	N/A	N/A	N/A	N/A	RPMM01	52.45	1.04	0.17
965018	29-JUN-90, 15:04	N/A	N/A	N/A	N/A	RPMM02	62.39	0.36	0.20
965019	29-JUN-90, 16:17	N/A	N/A	N/A	N/A	RPMM02	70.19	0.49	0.22
965020	30-JUN-90, 10:59	N/A	N/A	N/A	N/A	RPMM01	40.48	0.57	0.14
965021	02-JUL-90, 11:12	N/A	N/A	N/A	N/A	RPMM01	20.39	0.24	0.08
965022	03-JUL-90, 08:48	N/A	N/A	N/A	N/A	RPMM02	60.00	0.30	0.19
965023	03-JUL-90, 10:24	N/A	N/A	N/A	N/A	RPMM01	20.10	0.15	0.08
965024	02-JUL-90, 12:55	N/A	N/A	N/A	N/A	RPMM02	59.97	0.30	0.19
965025	21-JUL-90, 10:30	N/A	N/A	N/A	N/A	RPMM01	40.20	0.66	0.14
965026	21-JUL-90, 11:35	N/A	N/A	N/A	N/A	RPMM01	39.88	0.62	0.13
965027	21-JUL-90, 11:35	N/A	N/A	N/A	N/A	RPMM01	40.26	0.67	0.14
965027	21-JUL-90, 13:30	N/A	N/A	N/A	N/A	RPMM01	39.87	0.62	0.13
965028	21-JUL-90, 14:24	N/A	N/A	N/A	N/A	RPMM01	39.87	0.62	0.13
965034	16-AUG-90, 06:54	N/A	N/A	N/A	N/A	RPMM02	70.72	0.46	0.23
965035	16-AUG-90, 09:36	N/A	N/A	N/A	N/A	RPMM02	59.13	0.38	0.19
965036	16-AUG-90, 12:00	N/A	N/A	N/A	N/A	RPMM01	47.38	0.82	0.16
965037	16-AUG-90, 13:07	N/A	N/A	N/A	N/A	RPMM01	36.31	0.48	0.12
965038	16-AUG-90, 14:24	N/A	N/A	N/A	N/A	RPMM01	25.62	0.27	0.09
965039	16-AUG-90, 15:40	N/A	N/A	N/A	N/A	RPMM01	14.79	0.13	0.06
965040	28-AUG-90, 09:44	N/A	N/A	N/A	N/A	RPMM01	25.66	0.28	0.09
965041	28-AUG-90, 11:31	N/A	N/A	N/A	N/A	RPMM01	36.68	0.56	0.12

NOTES

- (1) Indicated value is the sum of both the low and high range meters (RPMM01 + RPMM02). Fluctuation and uncertainty are calculated as root-sum-square values from each meter.
- (2) Measurement is for total water flow injected into plenum. For this test, a portion of that flow bypassed the fuel assembly

Table 5.3
Reference Assembly Inlet and Outlet Air Flow Values and Uncertainties

TEST NUMBER	TEST DATE/TIME	----- Reference Assembly Inlet -----					----- Reference Assembly Outlet -----				
		VTAB	VALUE (SCFM)	FLUCT (SCFM)	----- UNC -----		VTAB	VALUE (SCFM)	FLUCT (SCFM)	----- UNC -----	
					LOWER (SCFM)	UPPER (SCFM)				LOWER (SCFM)	UPPER (SCFM)
897001	27-OCT-89, 14:30	RPGM01	0.00	0.00	-0.75	0.75	RTGM01	0.00	0.00	-0.75	0.75
897002	27-OCT-89, 16:54	RPGM01	0.60	0.07	-0.76	0.76	RTGM01	0.38	0.09	-0.76	0.76
897004	27-OCT-89, 22:00	RPGM01	7.21	0.09	-1.98	0.89	RTGM01	6.99	0.24	-0.89	0.89
897006	28-OCT-89, 00:01	RPGM01	55.81	0.23	-10.24	1.87	RTGM01	55.61	0.32	-7.98	1.86
897007	30-OCT-89, 15:30	RPGM01	0.00	0.00	-0.75	0.75	RTGM01	0.00	0.00	-0.75	0.75
897013	31-OCT-89, 02:34	RPGM01	67.90	0.32	-12.29	2.11	RTGM01	68.47	0.38	-9.65	2.12
897015	31-OCT-89, 21:33	RPGM01	0.00	0.00	-0.75	0.75	RTGM01	0.00	0.00	-0.75	0.75
897019	01-NOV-89, 17:58	RPGM01	51.54	0.18	-9.51	1.78	RTGM01	51.49	0.27	-7.44	1.78
897020	03-NOV-89, 07:22	RPGM01	0.00	0.00	-0.75	0.75	RTGM01	0.00	0.00	-0.75	0.75
897021	03-NOV-89, 09:48	RPGM01	0.03	0.07	-0.75	0.75	RTGM01	0.00	0.09	-0.75	0.75
897022	03-NOV-89, 12:42	RPGM01	36.01	0.17	-6.87	1.47	RTGM01	35.48	0.20	-5.36	1.46
897024	03-NOV-89, 14:40	RPGM01	124.58	0.70	-21.93	3.24	RTGM01	124.41	0.56	-16.92	3.24
897027	01-NOV-89, 21:42	RPGM01	0.00	0.00	-0.75	0.75	RTGM01	0.00	0.00	-0.75	0.75
897028	04-NOV-89, 06:45	RPGM01	0.00	0.00	-0.75	0.75	RTGM01	0.00	0.00	-0.75	0.75
897033	04-NOV-89, 13:25	RPGM01	0.00	0.07	-0.75	0.75	RTGM01	0.22	0.12	-0.75	0.75
897034	04-NOV-89, 17:34	RPGM01	95.97	0.48	-17.06	2.67	RTGM01	97.15	0.40	-13.38	2.69
897035	04-NOV-89, 19:19	RPGM01	126.13	0.91	-22.19	3.27	RTGM01	127.63	0.63	-17.34	3.30
897036	04-NOV-89, 22:04	N/A	N/A	(4) N/A	N/A	N/A	RTGM01	0.00	0.00	-0.75	0.75
897037	04-NOV-89, 23:48	N/A	N/A	(4) N/A	N/A	N/A	RTGM01	0.00	0.00	-0.75	0.75
897038	06-NOV-89, 08:05	RPGM01	0.51	0.12	-0.76	0.76	RTGM01	0.46	0.15	-0.76	0.76
897039	06-NOV-89, 14:47	RPGM01	50.91	0.21	-9.41	1.77	RTGM01	50.95	0.29	-7.37	1.77
897040	06-NOV-89, 19:53	RPGM01	0.03	0.07	-0.75	0.75	RTGM01	0.11	0.09	-0.75	0.75
897046	07-NOV-89, 11:25	RPGM01	0.00	0.00	-0.75	0.75	RTGM01	0.00	0.00	-0.75	0.75
897050	07-NOV-89, 20:24	RPGM01	26.11	0.14	-5.19	1.27	RTGM01	25.59	0.24	-4.08	1.26
897051	08-NOV-89, 02:16	RPGM01	0.01	0.08	-0.75	0.75	RTGM01	0.08	0.10	-0.75	0.75
897052	08-NOV-89, 06:15	RPGM01	0.01	0.07	-0.75	0.75	RTGM01	0.01	0.10	-0.75	0.75
897053	08-NOV-89, 10:20	RPGM01	0.48	0.08	-0.76	0.76	RTGM01	0.41	0.10	-0.76	0.76
897054	08-NOV-89, 12:52	RPGM01	0.19	0.08	-0.75	0.75	RTGM01	0.06	0.10	-0.75	0.75
897055	08-NOV-89, 18:41	RPGM01	1.35	0.07	-0.78	0.78	RTGM01	1.05	0.15	-0.77	0.77
897057	08-NOV-89, 23:24	RPGM01	0.99	0.07	-0.77	0.77	RTGM01	0.72	0.14	-0.76	0.76
897058	09-NOV-89, 02:35	RPGM01	1.94	0.07	-0.79	0.79	RTGM01	1.73	0.18	-0.78	0.78
897059	09-NOV-89, 07:05	RPGM01	0.03	0.08	-0.75	0.75	RTGM01	0.08	0.09	-0.75	0.75
897060	09-NOV-89, 09:35	RPGM01	0.07	0.07	-0.75	0.75	RTGM01	0.11	0.15	-0.75	0.75
897061	09-NOV-89, 11:20	RPGM01	0.32	0.08	-0.76	0.76	RTGM01	0.38	0.15	-0.76	0.76
897062	09-NOV-89, 14:08	RPGM01	0.28	0.07	-0.76	0.76	RTGM01	0.37	0.11	-0.76	0.76
897064	09-NOV-89, 18:57	RPGM01	0.87	0.08	-0.77	0.77	RTGM01	0.75	0.10	-0.77	0.77
897065	09-NOV-89, 20:43	RPGM01	0.30	0.08	-0.76	0.76	RTGM01	0.25	0.12	-0.76	0.76
897066	09-NOV-89, 22:22	RPGM01	0.42	0.08	-0.76	0.76	RTGM01	0.40	0.14	-0.76	0.76
897067	10-NOV-89, 01:54	RPGM01	0.19	0.07	-0.75	0.75	RTGM01	0.27	0.10	-0.76	0.76
897069	10-NOV-89, 09:11	RPGM01	1.38	0.08	-0.78	0.78	RTGM01	1.06	0.11	-0.77	0.77
897070	10-NOV-89, 11:25	RPGM01	2.12	0.08	-0.79	0.79	RTGM01	1.82	0.13	-0.79	0.79
897071	10-NOV-89, 16:04	RPGM01	1.37	0.07	-0.78	0.78	RTGM01	1.00	0.17	-0.77	0.77
897072	20-NOV-89, 11:23	RPGM01	0.89	0.07	-0.77	0.77	RTGM01	0.82	0.25	-0.77	0.77
897073	20-NOV-89, 13:35	RPGM01	2.03	0.08	-0.79	0.79	RTGM01	1.98	0.27	-0.79	0.79
897074	20-NOV-89, 16:06	RPGM01	0.50	0.09	-0.76	0.76	RTGM01	0.46	0.12	-0.76	0.76
897075	21-NOV-89, 10:42	RPGM01	0.28	0.07	-0.76	0.76	RTGM01	0.17	0.10	-0.75	0.75

Table 5.3 (cont'd.)

TEST NUMBER	TEST DATE/TIME	Reference Assembly Inlet					Reference Assembly Outlet				
		VTAB	VALUE (SCFM)	FLUCT (SCFM)	UNC		VTAB	VALUE (SCFM)	FLUCT (SCFM)	UNC	
					LOWER (SCFM)	UPPER (SCFM)				LOWER (SCFM)	UPPER (SCFM)
897076	21-NOV-89, 12:26	RPGM01	0.75	0.17	-0.77	0.77	RTGM01	0.51	0.11	-0.76	0.76
897077	21-NOV-89, 14:05	RPGM01	0.30	0.07	-0.76	0.76	RTGM01	0.12	0.08	-0.75	0.75
897078	21-NOV-89, 15:38	RPGM01	0.19	0.08	-0.75	0.75	RTGM01	0.12	0.16	-0.75	0.75
897079	22-NOV-89, 12:08	RPGM01	0.00	0.07	-0.75	0.75	RTGM01	0.06	0.11	-0.75	0.75
897080	22-NOV-89, 14:31	RPGM01	0.01	0.08	-0.75	0.75	RTGM01	0.12	0.13	-0.75	0.75
897081	27-NOV-89, 14:43	RPGM01	0.53	0.13	-0.76	0.76	RTGM01	0.35	0.14	-0.76	0.76
897082	28-NOV-89, 12:23	RPGM01	0.13	0.08	-0.75	0.75	RTGM01	0.17	0.17	-0.75	0.75
897084	28-NOV-89, 14:41	RPGM01	0.24	0.08	-0.75	0.75	RTGM01	0.33	0.14	-0.76	0.76
897086	29-NOV-89, 08:05	RPGM01	51.45	0.25	-9.50	1.78	RTGM01	51.79	0.25	-7.48	1.79
897087	29-NOV-89, 10:08	RPGM01	0.12	0.08	-0.75	0.75	RTGM01	0.02	0.11	-0.75	0.75
897090	05-DEC-89, 13:53	RPGM03	0.17 (2)	N/A	-0.07	0.07	RTGM01	0.11	0.13	-0.75	0.75
897091	05-DEC-89, 15:24	RPGM03	0.16 (2)	N/A	-0.07	0.07	RTGM01	0.18	0.14	-0.75	0.75
897092	06-DEC-89, 09:36	RPGM03	0.10 (2)	N/A	-0.07	0.07	RTGM01	0.00	0.11	-0.75	0.75
897094	06-DEC-89, 11:14	RPGM03	0.19 (2)	N/A	-0.07	0.07	RTGM01	0.13	0.13	-0.75	0.75
897095	06-DEC-89, 13:42	RPGM03	0.30 (2)	N/A	-0.07	0.07	RTGM01	0.32	0.17	-0.76	0.76
897096	06-DEC-89, 15:48	RPGM03	0.46 (2)	N/A	-0.07	0.07	RTGM01	0.39	0.12	-0.76	0.76
897097	06-DEC-89, 16:54	RPGM03	0.17 (2)	N/A	-0.07	0.07	RTGM01	0.10	0.16	-0.75	0.75
897098	06-DEC-89, 18:30	RPGM03	0.10 (2)	N/A	-0.07	0.07	RTGM01	0.00	0.12	-0.75	0.75
897115	30-JAN-90, 15:31	RPGM03	0.03	0.04	-0.07	0.07	RTGM01	0.00	0.07	-0.75	0.75
897116	30-JAN-90, 16:14	RPGM03	0.04	0.04	-0.07	0.07	RTGM01	0.00	0.07	-0.75	0.75
897118	31-JAN-90, 13:31	RPGM03	0.13	0.12	-0.07	0.07	RTGM01	0.04	0.13	-0.75	0.75
897119	31-JAN-90, 14:57	RPGM03	0.13	0.10	-0.07	0.07	RTGM01	0.07	0.13	-0.75	0.75
897121	01-FEB-90, 11:52	RPGM03	0.29	0.01	-0.07	0.07	RTGM01	0.26	0.12	-0.76	0.76
897123	01-FEB-90, 14:08	RPGM03	0.29	0.01	-0.07	0.07	RTGM01	0.27	0.11	-0.76	0.76
897125	01-FEB-90, 18:01	RPGM03	0.17	0.12	-0.07	0.07	RTGM01	0.21	0.16	-0.75	0.75
897127	01-FEB-90, 20:30	RPGM03	0.17	0.13	-0.07	0.07	RTGM01	0.21	0.15	-0.75	0.75
897128	01-FEB-90, 11:48	RPGM03	0.05	0.00	-0.07	0.07	RTGM01	0.15	0.11	-0.75	0.75
897131	03-FEB-90, 15:04	RPGM03	0.05	0.01	-0.07	0.07	RTGM01	0.13	0.12	-0.75	0.75
897133	03-FEB-90, 18:48	RPGM03	0.38	0.22	-0.07	0.07	RTGM01	0.49	0.12	-0.76	0.76
897135	04-FEB-90, 14:56	RPGM03	0.32	0.01	-0.07	0.07	RTGM01	0.29	0.12	-0.76	0.76
897137	04-FEB-90, 17:10	RPGM03	0.32	0.01	-0.07	0.07	RTGM01	0.28	0.11	-0.76	0.76
897139	05-FEB-90, 13:07	RPGM03	1.08	0.02	-0.07	0.07	RTGM01	1.08	0.39	-0.77	0.77
897140	05-FEB-90, 18:02	RPGM01	0.47	0.07	-0.76	0.76	RTGM01	0.49	0.12	-0.76	0.76
955001	28-MAR-90, 13:12	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
955006	28-MAR-90, 18:30	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
955008	29-MAR-90, 10:34	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
955012	29-MAR-90, 15:06	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
955014	07-APR-90, 13:03	RPGM03	0.15	0.10	-0.07	0.07	RTGM01	0.18	0.11	-0.75	0.75
955015	07-APR-90, 15:28	RPGM03	0.26	0.17	-0.07	0.07	RTGM01	0.41	0.18	-0.76	0.76
955016	08-APR-90, 13:12	RPGM03	0.58	0.20	-0.07	0.07	RTGM01	0.65	0.14	-0.76	0.76
955017	08-APR-90, 16:58	RPGM01	2.37	0.07	-0.80	0.80	RTGM01	2.39	0.15	-0.80	0.80
955018	08-MAY-90, 14:51	RPGM03	0.16	0.11	-0.07	0.07	RTGM01	0.22	0.09	-0.75	0.75
955020	09-MAY-90, 13:05	RPGM01	36.52	0.21	-6.96	1.48	RTGM01	37.14	0.21	-5.58	1.49
955021	09-MAY-90, 17:45	RPGM01	4.68	0.08	-0.84	0.84	RTGM01	4.79	0.11	-0.85	0.85
955022	10-MAY-90, 11:18	RPGM01	48.18	0.20	-8.94	1.71	RTGM01	48.74	0.35	-7.09	1.72

Table 5.3 (cont'd.)

TEST NUMBER	TEST DATE/TIME	VTAB	----- Reference Assembly Inlet -----				----- Reference Assembly Outlet -----				
			VALUE (SCFM)	FLUCT (SCFM)	----- UNC -----		VTAB	VALUE (SCFM)	FLUCT (SCFM)	----- UNC -----	
					LOWER (SCFM)	UPPER (SCFM)				LOWER (SCFM)	UPPER (SCFM)
955023	10-MAY-90, 14:40	RPGM03	0.63	0.00	-0.07	0.07	RTGM01	0.62	0.08	-0.76	0.76
955024	10-MAY-90, 19:54	RPGM01	5.47	0.11	-1.68	0.86	RTGM01	5.57	0.18	-0.86	0.86
958002	15-MAY-90, 14:29	RPGM03	0.04	0.00	-0.07	0.07	RTGM01	0.00	0.08	-0.75	0.75
958003	15-MAY-90, 18:16	RPGM01	67.22	0.27	-12.18	2.09	RTGM01	68.13	0.32	-9.61	2.11
958004	15-MAY-90, 12:28	RPGM03	0.40	0.01	-0.07	0.07	RTGM01	0.41	0.12	-0.76	0.76
958005	16-MAY-90, 16:02	RPGM01	13.27	0.10	-3.01	1.02	RTGM01	12.43	0.22	-2.37	1.00
958006	18-MAY-90, 15:09	RPGM02	1.95 (1)	0.05	-0.19	0.16	RTGM01	0.01	0.08	-0.75	0.75
958007	21-MAY-90, 19:32	RPGM01	51.87	0.27	-9.57	1.79	RTGM01	66.53 (3)	1.37	(3)	(3)
958008	22-MAY-90, 17:01	RPGM02	0.05	0.01	-0.13	0.13	RTGM01	0.00	0.08	-0.75	0.75
958009	23-MAY-90, 15:49	RPGM02	1.93 (1)	0.07	-0.19	0.16	RTGM01	0.05	0.11	-0.75	0.75
958011	24-MAY-90, 14:42	RPGM02	1.95 (1)	0.04	-0.19	0.16	RTGM01	0.09	0.19	-0.75	0.75
958012	24-MAY-90, 21:49	RPGM02	8.79	0.15	0.89	1.62	RTGM01	12.43 (3)	0.21	(3)	(3)
958013	26-MAY-90, 15:59	RPGM02	1.99 (1)	0.04	-0.19	0.16	RTGM01	0.25	0.13	-0.76	0.76
958014	29-MAY-90, 10:57	RPGM02	1.95 (1)	0.04	-0.19	0.16	RTGM01	0.04	0.08	-0.75	0.75
958015	29-MAY-90, 14:46	RPGM02	1.95 (1)	0.04	-0.19	0.16	RTGM01	0.33	0.14	-0.76	0.76
958016	29-MAY-90, 17:39	RPGM03	0.01	0.00	-0.07	0.07	RTGM01	0.03	0.08	-0.75	0.75
958017	30-MAY-90, 10:39	RPGM01	0.40	0.08	-0.76	0.76	RTGM01	0.32	0.14	-0.76	0.76
958018	30-MAY-90, 15:18	RPGM01	68.59	0.35	-12.41	2.12	RTGM01	70.25	0.36	-9.88	2.16
958019	31-MAY-90, 10:30	RPGM01	12.82	0.13	-2.93	1.01	RTGM01	13.05	0.24	-2.45	1.01
958020	01-JUN-90, 11:49	RPGM03	52.95	0.33	-0.07	0.07	RTGM01	66.25 (3)	5.37	(3)	(3)
958021	01-JUN-90, 17:04	RPGM02	8.64	0.11	0.87	1.59	RTGM01	13.12 (3)	0.50	(3)	(3)
958022	02-JUN-90, 14:26	RPGM02	2.02 (1)	0.10	-0.20	0.17	RTGM01	0.00	0.11	-0.75	0.75
958023	02-JUN-90, 19:10	RPGM02	1.95 (1)	0.12	-0.19	0.16	RTGM01	0.00	0.13	-0.75	0.75
958024	03-JUN-90, 14:48	RPGM02	0.01	0.01	-0.13	0.13	RTGM01	0.03	0.10	-0.75	0.75
958025	03-JUN-90, 22:21	RPGM02	0.22	0.01	-0.13	0.13	RTGM01	0.15	0.16	-0.75	0.75
958026	04-JUN-90, 15:53	RPGM02	1.94 (1)	0.04	-0.19	0.16	RTGM01	0.00	0.07	-0.75	0.75
958027	05-JUN-90, 12:12	RPGM02	8.45	0.14	0.85	1.56	RTGM01	12.94 (3)	0.29	(3)	(3)
958028	06-JUN-90, 16:04	RPGM02	0.10	0.01	-0.13	0.13	RTGM01	0.00	0.10	-0.75	0.75
958029	08-JUN-90, 14:27	RPGM02	1.92 (1)	0.12	-0.19	0.16	RTGM01	0.00	0.15	-0.75	0.75
958030	08-JUN-90, 22:18	RPGM01	69.23	0.26	-12.52	2.13	RTGM01	70.22	0.27	-9.88	2.15
958031	09-JUL-90, 12:02	RPGM03	0.13	0.01	-0.07	0.07	RTGM02	0.13	0.12	-0.07	0.07
958032	09-JUL-90, 17:17	RPGM02	2.01 (1)	0.05	-0.20	0.17	RTGM02	0.14	0.11	-0.07	0.07
958033	09-JUL-90, 23:21	RPGM02	1.89 (1)	0.04	-0.19	0.16	RTGM02	0.39	0.11	-0.07	0.07
958034	10-JUL-90, 02:52	RPGM02	1.91 (1)	0.04	-0.19	0.16	RTGM02	1.30	0.04	-0.07	0.07
958035	10-JUL-90, 22:42	RPGM03	0.15	0.01	-0.07	0.07	RTGM02	0.13	0.12	-0.07	0.07
958036	11-JUL-90, 01:43	RPGM03	0.36	0.03	-0.07	0.07	RTGM02	0.36	0.08	-0.07	0.07
958037	11-JUL-90, 04:23	RPGM03	1.32	0.04	-0.07	0.07	RTGM02	1.31	0.04	-0.07	0.07
958038	11-JUL-90, 15:34	RPGM02	1.92 (1)	0.08	-0.19	0.16	RTGM02	0.07	0.08	-0.07	0.07
958039	11-JUL-90, 21:13	RPGM02	1.97 (1)	0.11	-0.19	0.16	RTGM02	0.20	0.08	-0.07	0.07
958040	12-JUL-90, 00:29	RPGM02	2.03 (1)	0.09	-0.20	0.17	RTGM02	1.19	0.30	-0.07	0.07
958041	12-JUL-90, 14:26	RPGM02	0.25	0.02	-0.13	0.13	RTGM02	0.07	0.09	-0.07	0.07
958042	12-JUL-90, 17:42	RPGM02	0.19	0.01	-0.13	0.13	RTGM02	0.20	0.06	-0.07	0.07
958043	12-JUL-90, 20:34	RPGM02	0.76	0.04	-0.15	0.14	RTGM02	1.00	0.15	-0.07	0.07
964001	16-JUL-90, 11:30	RPGM03	0.12	0.10	-0.07	0.07	RTGM02	0.13	0.09	-0.07	0.07

Table 5.3 (cont'd.)

TEST NUMBER	TEST DATE/TIME	----- Reference Assembly Inlet -----					----- Reference Assembly Outlet -----				
		VTAB	VALUE (SCFM)	FLUCT (SCFM)	----- UNC -----		VTAB	VALUE (SCFM)	FLUCT (SCFM)	----- UNC -----	
					LOWER (SCFM)	UPPER (SCFM)				LOWER (SCFM)	UPPER (SCFM)
964002	16-JUL-90 16:06	RPGM03	0.00	0.00	-0.07	0.07	RTGM02	0.03	0.02	-0.07	0.07
964003	17-JUL-90, 10:44	RPGM03	0.16	0.01	-0.07	0.07	RTGM02	0.18	0.05	-0.07	0.07
964004	17-JUL-90, 13:50	RPGM03	0.28	0.01	-0.07	0.07	RTGM02	0.28	0.04	-0.07	0.07
964005	18-JUL-90, 12:05	RPGM03	0.19	0.01	-0.07	0.07	RTGM02	0.21	0.08	-0.07	0.07
964006	18-JUL-90, 14:47	RPGM03	0.58	0.02	-0.07	0.07	RTGM02	0.59	0.09	-0.07	0.07
964007	19-JUL-90, 10:34	RPGM03	0.80	0.01	-0.07	0.07	RTGM02	0.77	0.07	-0.07	0.07
964008	19-JUL-90, 13:38	RPGM03	0.49	0.01	-0.07	0.07	RTGM02	0.48	0.09	-0.07	0.07
964009	20-JUL-90, 15:20	RPGM03	0.11	0.01	-0.07	0.07	RTGM02	0.14	0.07	-0.07	0.07
964010	23-JUL-90, 14:24	RPGM03	0.13	0.10	-0.07	0.07	RTGM02	0.12	0.09	-0.07	0.07
964011	24-JUL-90, 11:32	RPGM03	0.14	0.01	-0.07	0.07	RTGM02	0.15	0.12	-0.07	0.07
964012	24-JUL-90, 15:19	RPGM03	1.06	0.02	-0.07	0.07	RTGM02	1.08	0.07	-0.07	0.07
964013	25-JUL-90, 14:06	RPGM03	0.26	0.00	-0.07	0.07	RTGM02	0.29	0.11	-0.07	0.07
964014	26-JUL-90, 11:51	RPGM03	0.00	0.00	-0.07	0.07	RTGM02	0.03	0.03	-0.07	0.07
964015	27-JUL-90, 11:44	RPGM03	0.04	0.00	-0.07	0.07	RTGM02	0.05	0.05	-0.07	0.07
964016	27-JUL-90, 14:18	RPGM03	0.06	0.01	-0.07	0.07	RTGM02	0.08	0.07	-0.07	0.07
964017	30-JUL-90, 09:51	RPGM03	0.13	0.11	-0.07	0.07	RTGM02	0.13	0.08	-0.07	0.07
964018	30-JUL-90, 12:35	RPGM03	0.27	0.01	-0.07	0.07	RTGM02	0.29	0.07	-0.07	0.07
964019	30-JUL-90, 16:15	RPGM03	0.42	0.02	-0.07	0.07	RTGM02	0.42	0.06	-0.07	0.07
964020	30-JUL-90, 18:39	RPGM03	1.20	0.02	-0.07	0.07	RTGM02	1.20	0.04	-0.07	0.07
964021	30-JUL-90, 23:00	RPGM03	0.26	0.01	-0.07	0.07	RTGM02	0.24	0.11	-0.07	0.07
964022	31-JUL-90, 10:47	RPGM03	0.28	0.01	-0.07	0.07	RTGM02	0.29	0.11	-0.07	0.07
964023	31-JUL-90, 13:56	RPGM03	0.45	0.01	-0.07	0.07	RTGM02	0.47	0.10	-0.07	0.07
964024	31-JUL-90, 17:38	RPGM03	0.35	0.01	-0.07	0.07	RTGM02	0.37	0.08	-0.07	0.07
964025	31-JUL-90, 21:44	RPGM03	0.01	0.01	-0.07	0.07	RTGM02	0.04	0.03	-0.07	0.07
964026	06-AUG-90, 09:56	RPGM03	0.12	0.10	-0.07	0.07	RTGM02	0.12	0.08	-0.07	0.07
964027	06-AUG-90, 14:35	RPGM03	0.02	0.00	-0.07	0.07	RTGM02	0.04	0.04	-0.07	0.07
964028	06-AUG-90, 17:22	RPGM03	0.09	0.08	-0.07	0.07	RTGM02	0.04	0.04	-0.07	0.07
964029	06-AUG-90, 20:19	RPGM03	0.67	0.01	-0.07	0.07	RTGM02	0.68	0.10	-0.07	0.07
964030	06-AUG-90, 22:49	RPGM03	1.09	0.05	-0.07	0.07	RTGM02	1.10	0.06	-0.07	0.07
964031	09-AUG-90, 12:24	RPGM02	3.99	0.07	-0.20	0.76	RTGM01	4.07	0.11	-0.83	0.83
964032	09-AUG-90, 17:04	RPGM01	34.67	0.13	-1.44	1.44	RTGM01	34.21	0.22	-1.43	1.43
964033	09-AUG-90, 19:43	RPGM01	52.67	0.18	-3.91	1.80	RTGM01	52.45	0.27	-1.80	1.80
964034	09-AUG-90, 22:05	RPGM02	3.89	0.05	-0.20	0.75	RTGM01	3.96	0.14	-0.83	0.83
964035	10-AUG-90, 00:07	RPGM02	18.51	0.24	-0.50	3.09	RTGM01	19.25	0.23	-1.13	1.13
964036	10-AUG-90, 02:21	RPGM01	33.31	0.13	-1.42	1.42	RTGM01	32.73	0.25	-1.40	1.40
964037	10-AUG-90, 11:37	RPGM02	2.22	0.13	-0.17	0.48	RTGM01	2.10	0.17	-0.79	0.79
964038	10-AUG-90, 16:23	RPGM02	4.58	0.04	-0.22	0.86	RTGM01	4.48	0.20	-0.84	0.84
964039	10-AUG-90, 18:53	RPGM02	10.98	0.15	-0.34	1.88	RTGM01	10.92	0.19	-0.97	0.97
964040	10-AUG-90, 20:55	RPGM02	18.69	0.31	-0.50	3.12	RTGM01	19.50	0.28	-1.14	1.14
964041	11-AUG-90, 10:46	RPGM03	1.29	0.04	-0.07	0.07	RTGM02	1.29	0.04	-0.07	0.07
964042	11-AUG-90, 12:36	RPGM02	2.15	0.12	-0.17	0.47	RTGM01	2.01	0.19	-0.79	0.79
964043	11-AUG-90, 14:39	RPGM02	4.29	0.04	-0.21	0.81	RTGM01	4.13	0.15	-0.83	0.83
964044	13-AUG-90, 00:34	RPGM02	3.84	0.04	-0.20	0.74	RTGM01	3.78	0.14	-0.83	0.83
964045	13-AUG-90, 01:41	RPGM02	8.18	0.07	-0.29	1.43	RTGM01	7.72	0.18	-0.90	0.90
964046	13-AUG-90, 04:41	RPGM02	11.61	0.19	-0.36	1.98	RTGM01	11.77	0.19	-0.99	0.99
964047	13-AUG-90, 06:35	RPGM03	0.14	0.12	-0.07	0.07	RTGM02	0.14	0.08	-0.07	0.07

Table 5.3 (cont'd.)

TEST NUMBER	TEST DATE TIME	Reference Assembly Inlet					Reference Assembly Outlet				
		VTAB	VALUE (SCFM)	FLUCT (SCFM)	UNC		VTAB	VALUE (SCFM)	FLUCT (SCFM)	UNC	
					LOWER (SCFM)	UPPER (SCFM)				LOWER (SCFM)	UPPER (SCFM)
964048	13-AUG-90, 11:59	RPGM02	2.00	0.03	-0.16	0.16	RTGM01	1.85	0.12	-0.79	0.79
964049	14-AUG-90, 00:12	RPGM02	2.95	0.05	-0.18	0.60	RTGM01	3.00	0.13	-0.81	0.81
964050	14-AUG-90, 02:02	RPGM02	5.84	0.04	-0.24	1.06	RTGM01	5.70	0.19	-0.86	0.86
964051	14-AUG-90, 03:50	RPGM02	8.79	0.12	-0.30	1.53	RTGM01	8.40	0.24	-0.92	0.92
964052	14-AUG-90, 07:52	RPGM02	13.11	0.21	-0.39	2.22	RTGM01	13.29	0.16	-1.02	1.02
964053	14-AUG-90, 12:29	RPGM01	58.83	0.23	-4.28	1.93	RTGM01	59.32	0.31	-1.94	1.94
964054	14-AUG-90, 15:49	RPGM01	77.10	0.37	-5.38	2.29	RTGM01	78.82	0.40	-2.33	2.33
964055	14-AUG-90, 22:54	RPGM03	0.44	0.02	-0.07	0.07	RTGM02	0.42	0.06	-0.07	0.07
964056	15-AUG-90, 00:42	RPGM02	2.29	0.11	-0.17	0.49	RTGM01	2.30	0.15	-0.80	0.80
964057	15-AUG-90, 02:43	RPGM03	0.80	0.01	-0.07	0.07	RTGM02	0.77	0.07	-0.07	0.07
964058	15-AUG-90, 05:13	RPGM03	0.32	0.01	-0.07	0.07	RTGM02	0.30	0.13	-0.07	0.07
964059	15-AUG-90, 10:33	RPGM03	0.00	0.00	-0.07	0.07	RTGM02	0.03	0.03	-0.07	0.07
964060	15-AUG-90, 14:12	RPGM01	75.95	0.29	-5.31	2.27	RTGM01	77.72	0.47	-2.30	2.30
964061	15-AUG-90, 23:56	RPGM02	8.50	0.07	-0.30	1.49	RTGM01	8.19	0.16	-0.91	0.91
964062	16-AUG-90, 02:36	RPGM02	4.45	0.10	-0.21	0.84	RTGM01	4.49	0.14	-0.84	0.84
964063	17-AUG-90, 00:24	RPGM01	80.62	0.43	-5.59	2.36	RTGM01	82.76	0.40	-2.41	2.41
964064	17-AUG-90, 02:33	RPGM02	15.32	0.15	-0.43	2.58	RTGM01	15.55	0.24	-1.06	1.06
964065	17-AUG-90, 10:02	RPGM03	0.00	0.00	-0.07	0.07	RTGM02	0.02	0.00	-0.07	0.07
964066	20-AUG-90, 04:24	RPGM03	0.00	0.00	-0.07	0.07	RTGM02	0.02	0.03	-0.07	0.07
964067	20-AUG-90, 08:48	RPGM02	19.77	0.18	-0.52	3.29	RTGM01	20.74	0.16	-1.16	1.16
964068	20-AUG-90, 13:18	RPGM01	96.95	0.31	-6.57	2.69	RTGM01	99.34	0.37	-2.74	2.74
964069	20-AUG-90, 14:57	RPGM03	0.12	0.10	-0.07	0.07	RTGM02	0.25	0.01	-0.07	0.07
964070	21-AUG-90, 04:36	RPGM03	0.00	0.00	-0.07	0.07	RTGM02	0.07	0.08	-0.07	0.07
964071	21-AUG-90, 08:38	RPGM02	5.19	0.05	-0.23	0.96	RTGM01	4.74	0.22	-0.84	0.84
964072	21-AUG-90, 12:11	RPGM03	0.00	0.00	-0.07	0.07	RTGM02	0.07	0.07	-0.07	0.07
964073	21-AUG-90, 14:41	RPGM03	0.79	0.03	-0.07	0.07	RTGM02	0.82	0.05	-0.07	0.07
964074	21-AUG-90, 23:42	N/A	N/A (4)	N/A	N/A	N/A	RTGM02	0.01	0.01	-0.07	0.07
964075	22-AUG-90, 13:23	RPGM02	1.75	0.03	-0.16	0.16	RTGM01	1.44	0.15	-0.78	0.78
964076	22-AUG-90, 16:06	RPGM02	3.44	0.05	-0.19	0.67	RTGM01	3.43	0.14	-0.82	0.82
964077	22-AUG-90, 19:07	RPGM01	35.86	0.11	-1.47	1.47	RTGM01	35.34	0.15	-1.46	1.46
964078	22-AUG-90, 23:36	RPGM01	103.26	0.26	-6.95	2.82	RTGM01	105.73	0.22	-2.86	2.86
964079	23-AUG-90, 10:18	RPGM02	5.33	0.07	-0.23	0.98	RTGM01	5.41	0.17	-0.86	0.86
964080	23-AUG-90, 13:02	RPGM03	0.06	0.05	-0.07	0.07	RTGM02	0.03	2.00	-0.07	0.07
964081	23-AUG-90, 15:37	RPGM03	0.77	0.00	-0.07	0.07	RTGM02	0.78	0.02	-0.07	0.07
964082	23-AUG-90, 19:03	RPGM02	2.21	0.03	-0.17	0.48	RTGM01	2.15	0.14	-0.79	0.79
964083	23-AUG-90, 22:10	RPGM02	12.78	0.14	-0.38	2.17	RTGM01	12.97	0.19	-1.01	1.01
964084	24-AUG-90, 10:23	RPGM02	4.35	0.04	-0.21	0.82	RTGM01	4.32	0.14	-0.84	0.84
964085	24-AUG-90, 13:47	RPGM03	0.60	0.01	-0.07	0.07	RTGM02	0.60	0.10	-0.07	0.07
964086	27-AUG-90, 10:13	RPGM03	0.13	0.09	-0.07	0.07	RTGM02	0.12	0.08	-0.07	0.07
964087	31-AUG-90, 11:14	RPGM02	3.45	0.03	-0.19	0.68	RTGM01	3.65	0.12	-0.82	0.82
964088	31-AUG-90, 14:00	RPGM02	8.09	0.08	-0.29	1.42	RTGM01	8.00	0.15	-0.91	0.91
964089	04-SEP-90, 10:27	RPGM03	0.36	0.01	-0.07	0.07	RTGM02	0.35	0.04	-0.07	0.07
964090	04-SEP-90, 14:06	RPGM03	0.04	0.00	-0.07	0.07	RTGM02	0.05	0.04	-0.07	0.07
964091	05-SEP-90, 09:10	RPGM03	0.13	0.11	-0.07	0.07	RTGM02	0.13	0.08	-0.07	0.07
964092	05-SEP-90, 12:39	RPGM01	42.11	0.16	-3.28	1.59	RTGM01	41.85	0.23	-1.59	1.59
964093	05-SEP-90, 15:07	RPGM02	23.36	0.35	-0.59	3.86	RTGM01	24.61	0.27	-1.24	1.24

Table 5.3 (cont'd.)

TEST NUMBER	TEST DATE-TIME	----- Reference Assembly Inlet -----					----- Reference Assembly Outlet -----				
		VTAB	VALUE (SCFM)	FLUCT (SCFM)	----- UNC -----		VTAB	VALUE (SCFM)	FLUCT (SCFM)	----- UNC -----	
					LOWER (SCFM)	UPPER (SCFM)				LOWER (SCFM)	UPPER (SCFM)
965001	25-JUN-90, 13:35	RPGM03	0.17	0.12	-0.07	0.07	TPGM03	0.16	0.09	-0.07	0.07
965002	25-JUN-90, 14:39	RPGM03	0.38	0.01	-0.07	0.07	TPGM03	0.39	0.04	-0.07	0.07
965003	26-JUN-90, 08:15	RPGM03	0.11	0.10	-0.07	0.07	TPGM03	0.10	0.09	-0.07	0.07
965004	26-JUN-90, 10:09	RPGM03	0.18	0.12	-0.07	0.07	TPGM03	0.19	0.09	-0.07	0.07
965005	26-JUN-90, 12:03	RPGM03	0.42	0.21	-0.07	0.07	TPGM03	0.43	0.11	-0.07	0.07
965006	26-JUN-90, 13:52	RPGM03	1.03	0.26	-0.07	0.07	TPGM03	1.02	0.11	-0.07	0.07
965007	26-JUN-90, 15:28	RPGM03	1.40	0.16	-0.07	0.07	TPGM03	1.38	0.10	-0.07	0.07
965008	27-JUN-90, 09:02	RPGM03	0.10	0.02	-0.07	0.07	TPGM03	0.10	0.09	-0.07	0.07
965009	27-JUN-90, 10:49	RPGM03	0.25	0.01	-0.07	0.07	TPGM03	0.27	0.06	-0.07	0.07
965010	27-JUN-90, 15:03	RPGM03	0.07	0.02	-0.07	0.07	TPGM03	0.07	0.08	-0.07	0.07
965011	28-JUN-90, 08:58	RPGM03	0.14	0.02	-0.07	0.07	TPGM03	0.16	0.09	-0.07	0.07
965012	28-JUN-90, 10:47	RPGM03	0.45	0.04	-0.07	0.07	TPGM03	0.45	0.07	-0.07	0.07
965013	28-JUN-90, 13:05	RPGM03	0.19	0.02	-0.07	0.07	TPGM03	0.23	0.07	-0.07	0.07
965014	28-JUN-90, 15:51	RPGM03	1.35	0.01	-0.07	0.07	TPGM03	1.35	0.08	-0.07	0.07
965015	28-JUN-90, 19:12	RPGM03	1.28	0.01	-0.07	0.07	TPGM03	1.29	0.05	-0.07	0.07
965016	29-JUN-90, 09:52	RPGM03	1.32	0.03	-0.07	0.07	TPGM03	1.32	0.05	-0.07	0.07
965017	29-JUN-90, 13:28	RPGM01	2.30	0.07	-0.80	0.80	T4GM01	1.86	0.02	-0.11	0.11
965018	29-JUN-90, 15:04	RPGM01	2.38	0.08	-0.80	0.80	T4GM01	1.98	0.02	-0.11	0.11
965019	29-JUN-90, 16:17	RPGM01	2.20	0.08	-0.79	0.79	T4GM01	1.74	0.04	-0.11	0.11
965020	30-JUN-90, 10:59	RPGM03	1.33	0.17	-0.07	0.07	TPGM03	1.29	0.07	-0.07	0.07
965021	02-JUL-90, 11:12	RPGM02	2.01 (1)	0.05	-0.20	0.17	TPGM03	0.02	0.04	-0.07	0.07
965022	03-JUL-90, 08:48	RPGM02	2.01 (1)	0.04	-0.20	0.17	TPGM03	0.27	0.15	-0.07	0.07
965023	03-JUL-90, 10:24	RPGM02	2.03 (1)	0.05	-0.20	0.17	TPGM03	0.02	0.04	-0.07	0.07
965024	02-JUL-90, 12:55	RPGM02	1.98 (1)	0.05	-0.19	0.16	TPGM03	0.23	0.16	-0.07	0.07
965025	21-JUL-90, 10:30	RPGM01	6.79	0.10	-1.90	0.89	RTGM01	6.71	0.18	-0.88	0.88
965026	21-JUL-90, 11:35	RPGM01	57.73	1.27	-10.56	1.90	RTGM01	55.60	0.46	-7.98	1.86
965027	21-JUL-90, 13:30	RPGM01	25.87	0.54	-5.15	1.27	RTGM01	25.14	0.30	-4.02	1.25
965028	21-JUL-90, 14:24	RPGM01	72.96	1.78	-13.15	2.21	RTGM01	71.34	0.64	-10.02	2.18
965034	16-AUG-90, 06:54	RPGM02	3.10	0.07	-0.19	0.62	T3GM01	2.82	0.04	-0.18	0.58
965035	16-AUG-90, 09:36	RPGM02	4.59	0.06	-0.22	0.86	T3GM01	4.14	0.15	-0.21	0.79
965036	16-AUG-90, 12:00	RPGM02	5.25	0.10	-0.23	0.97	T3GM01	4.70	0.16	-0.22	0.88
965037	16-AUG-90, 13:07	RPGM02	4.61	0.06	-0.22	0.86	T3GM01	4.07	0.10	-0.21	0.78
965038	16-AUG-90, 14:24	RPGM02	5.53	0.07	-0.24	1.01	T3GM01	4.94	0.07	-0.22	0.91
965039	16-AUG-90, 15:40	RPGM02	13.19	0.11	-0.39	2.24	T3GM01	12.57	0.14	-0.38	0.38
965040	28-AUG-90, 09:44	RPGM02	4.90	0.04	-0.22	0.91	T4GM01	4.83	0.06	-0.17	0.17
965041	28-AUG-90, 11:31	RPGM02	4.82	0.06	-0.22	0.90	T4GM01	4.77	0.10	-0.17	0.17

NOTES

- (1) Piston ring leakage system on. Vacuum system active
- (2) Air flow measurement obtained from additional low range air meter read through integrating digital multi-meter (non-DAS)
- (3) Outlet air meters not reliable due to moisture content of air flow. No estimate of measurement uncertainty is available
- (4) Air inlets isolated and vacuum system active

Table 6.4

Test Assembly Inlet and Outlet Air Flow Values and Uncertainties

TEST NUMBER	TEST DATE/TIME	VTAB	VALUE (SCFM)	Channel 2 Outlet			Channel 3 Outlet			Channel 4 Outlet		
				FLUCT (SCFM)	LOWER (SCFM)	UPPER (SCFM)	FLUCT (SCFM)	LOWER (SCFM)	UPPER (SCFM)	FLUCT (SCFM)	LOWER (SCFM)	UPPER (SCFM)
09-001	21 OCT 88 14:30	TPQM01	0.00	0.00	-0.75	0.75	TPQM01	0.00	0.13	TPQM01	0.01	0.08
09-002	21 OCT 88 16:54	TPQM01	0.78	0.10	-0.77	0.77	TPQM01	0.14	0.15	TPQM01	0.44	0.08
09-003	21 OCT 88 17:00	TPQM01	7.19	0.14	-0.86	0.86	TPQM01	2.90	0.14	TPQM01	0.44	0.08
09-004	21 OCT 88 22:00	TPQM01	24.66	0.64	-0.46	0.46	TPQM01	4.91	0.37	TPQM01	4.13	0.16
09-005	21 OCT 88 15:30	TPQM01	0.00	0.00	-0.75	0.75	TPQM01	0.01	0.01	TPQM01	0.00	0.08
09-006	21 OCT 88 02:34	TPQM01	87.73	0.72	-0.73	0.73	TPQM01	8.85	0.26	TPQM01	5.38	0.12
09-007	21 OCT 88 21:33	TPQM01	0.00	0.00	-0.75	0.75	TPQM01	0.13	0.13	TPQM01	0.05	0.08
09-008	21 NOV 88 07:22	TPQM01	54.80	0.44	-0.30	0.30	TPQM01	5.48	0.26	TPQM01	4.13	0.16
09-009	21 NOV 88 09:48	TPQM01	0.04	0.05	-0.75	0.75	TPQM01	0.02	0.02	TPQM01	0.05	0.08
09-010	21 NOV 88 14:40	TPQM01	123.21	1.50	-1.00	1.00	TPQM01	17.55	0.33	TPQM01	13.09	0.14
09-011	21 NOV 88 17:42	TPQM01	0.00	0.00	-0.75	0.75	TPQM01	0.03	0.03	TPQM01	0.01	0.08
09-012	21 NOV 88 19:25	TPQM01	0.09	0.06	-0.75	0.75	TPQM01	0.03	0.03	TPQM01	0.04	0.08
09-013	21 NOV 88 17:34	TPQM01	91.50	1.11	-1.05	1.05	TPQM01	11.96	0.36	TPQM01	10.03	0.28
09-014	21 NOV 88 19:19	TPQM01	126.50	1.50	-1.00	1.00	TPQM01	17.36	0.27	TPQM01	13.85	0.35
09-015	21 NOV 88 22:04	TPQM01	0.00	0.00	-0.75	0.75	TPQM01	0.02	0.02	TPQM01	0.03	0.08
09-016	21 NOV 88 23:48	TPQM01	0.00	0.00	-0.75	0.75	TPQM01	0.01	0.01	TPQM01	0.04	0.08
09-017	21 NOV 88 06:05	TPQM01	53.14	0.45	-0.78	0.78	TPQM01	5.31	0.21	TPQM01	4.42	0.16
09-018	21 NOV 88 14:47	TPQM01	0.30	0.12	-0.78	0.78	TPQM01	0.03	0.03	TPQM01	0.04	0.08
09-019	21 NOV 88 11:25	TPQM01	0.03	0.05	-0.75	0.75	TPQM01	0.00	0.01	TPQM01	0.02	0.08
09-020	21 NOV 88 20:24	TPQM01	23.53	0.20	-0.44	0.44	TPQM01	3.80	0.10	TPQM01	2.16	0.12
09-021	21 NOV 88 02:18	TPQM01	0.34	0.12	-0.78	0.78	TPQM01	0.04	0.04	TPQM01	0.54	0.09
09-022	21 NOV 88 06:15	TPQM01	0.01	0.05	-0.75	0.75	TPQM01	0.02	0.02	TPQM01	0.13	0.08
09-023	21 NOV 88 10:20	TPQM01	0.57	0.05	-0.78	0.78	TPQM01	0.23	0.07	TPQM01	0.48	0.08
09-024	21 NOV 88 12:52	TPQM01	0.30	0.07	-0.78	0.78	TPQM01	0.09	0.03	TPQM01	0.43	0.08
09-025	21 NOV 88 16:41	TPQM01	0.68	0.08	-0.77	0.77	TPQM01	0.36	0.10	TPQM01	0.20	0.08
09-026	21 NOV 88 23:24	TPQM01	0.73	0.05	-0.76	0.76	TPQM01	0.46	0.08	TPQM01	0.18	0.08
09-027	21 NOV 88 02:36	TPQM01	1.80	0.07	-0.79	0.79	TPQM01	0.82	0.08	TPQM01	0.32	0.08
09-028	21 NOV 88 07:05	TPQM01	0.09	0.05	-0.75	0.75	TPQM01	0.03	0.03	TPQM01	0.14	0.08
09-029	21 NOV 88 09:36	TPQM01	0.16	0.05	-0.75	0.75	TPQM01	0.03	0.04	TPQM01	0.25	0.08
09-030	21 NOV 88 11:20	TPQM01	0.04	0.08	-0.78	0.78	TPQM01	0.11	0.08	TPQM01	0.84	0.09
09-031	21 NOV 88 14:08	TPQM01	0.42	0.05	-0.78	0.78	TPQM01	0.16	0.08	TPQM01	0.34	0.08
09-032	21 NOV 88 18:57	TPQM01	1.19	0.06	-0.77	0.77	TPQM01	0.14	0.08	TPQM01	0.83	0.09
09-033	21 NOV 88 20:43	TPQM01	0.44	0.06	-0.78	0.78	TPQM01	0.07	0.05	TPQM01	0.53	0.09
09-034	21 NOV 88 22:22	TPQM01	0.68	0.10	-0.78	0.78	TPQM01	0.10	0.05	TPQM01	0.77	0.09
09-035	21 NOV 88 01:54	TPQM01	0.40	0.05	-0.78	0.78	TPQM01	0.05	0.12	TPQM01	0.48	0.08
09-036	21 NOV 88 09:11	TPQM01	1.34	0.06	-0.78	0.78	TPQM01	0.24	0.15	TPQM01	0.35	0.08
09-037	21 NOV 88 11:26	TPQM01	1.86	0.06	-0.79	0.79	TPQM01	0.29	0.15	TPQM01	0.42	0.08
09-038	21 NOV 88 16:04	TPQM01	1.18	0.04	-0.77	0.77	TPQM01	0.18	0.10	TPQM01	0.34	0.08

Table 5.4 (cont'd.)

Test Assembly Inter Air Flow										Channel 2 Output				Channel 3 Output				Channel 4 Output				
TEST NUMBER	TEST DATE/TIME	VTAB	VALUE (SCFM)	UNC		UNC		VTAB	VALUE (SCFM)	FLUCT (SCFM)	UNC		VTAB	VALUE (SCFM)	FLUCT (SCFM)	UNC		VTAB	VALUE (SCFM)	FLUCT (SCFM)	UNC	
				LOWER (SCFM)	UPPER (SCFM)	LOWER (SCFM)	UPPER (SCFM)				LOWER (SCFM)	UPPER (SCFM)				LOWER (SCFM)	UPPER (SCFM)				LOWER (SCFM)	UPPER (SCFM)
R97012	20 NOV 89 11:23	TPGM01	0.54	0.05	0.76	0.76	TPGM01	0.41	0.08	0.18	0.13	TPGM01	0.48	0.08	0.15	0.13	T4GM01	0.16	0.01	0.08	0.06	
R97013	20 NOV 89 13:35	TPGM01	1.79	0.03	-0.79	0.76	TPGM01	0.27	0.10	0.15	0.13	TPGM01	1.32	0.55	-0.20	0.15	T4GM01	0.42	0.02	-0.08	0.04	
R97014	20 NOV 89 16:08	TPGM01	0.55	0.12	-0.76	0.76	TPGM01	0.12	0.05	-0.13	0.13	TPGM01	0.47	0.13	-0.15	0.13	T4GM01	0.44	0.03	-0.08	0.06	
R97015	20 NOV 89 10:42	TPGM01	0.50	0.05	-0.76	0.76	TPGM01	0.22	0.07	-0.14	0.13	TPGM01	0.41	0.14	-0.15	0.13	T4GM01	0.44	0.03	-0.04	0.04	
R97016	20 NOV 89 12:26	TPGM01	1.11	0.30	-0.77	0.77	TPGM01	0.15	0.05	-0.14	0.13	TPGM01	0.68	0.16	-0.17	0.14	T4GM01	0.63	0.02	-0.09	0.06	
R97017	20 NOV 89 14:05	TPGM01	0.30	0.07	-0.76	0.76	TPGM01	0.09	0.04	-0.13	0.13	TPGM01	0.15	0.09	-0.13	0.13	T4GM01	0.43	0.06	-0.08	0.06	
R97018	20 NOV 89 13:08	TPGM01	0.52	0.06	-0.76	0.76	TPGM01	0.12	0.04	-0.13	0.13	TPGM01	0.09	0.05	-0.13	0.13	T4GM01	0.77	0.04	-0.09	0.06	
R97019	20 NOV 89 12:06	TPGM01	0.09	0.05	-0.75	0.75	TPGM01	0.05	0.04	-0.13	0.13	TPGM01	0.09	0.06	-0.13	0.13	T4GM01	0.26	0.04	-0.08	0.06	
R97020	20 NOV 89 14:31	TPGM01	0.18	0.12	-0.75	0.75	TPGM01	0.04	0.04	-0.13	0.13	TPGM01	0.01	0.02	-0.13	0.13	T4GM01	0.36	0.13	-0.08	0.06	
R97021	20 NOV 89 14:43	TPGM01	0.64	0.15	-0.76	0.76	TPGM01	0.13	0.05	-0.14	0.13	TPGM01	0.41	0.12	-0.15	0.13	T4GM01	0.43	0.03	-0.08	0.06	
R97022	20 NOV 89 12:23	TPGM01	0.24	0.08	-0.75	0.75	TPGM01	0.08	0.05	-0.13	0.13	TPGM01	0.13	0.09	-0.13	0.13	T4GM01	0.40	0.07	-0.08	0.06	
R97023	20 NOV 89 14:41	TPGM01	0.47	0.06	-0.76	0.76	TPGM01	0.10	0.04	0.13	0.13	TPGM01	0.09	0.06	-0.13	0.13	T4GM01	0.74	0.04	-0.04	0.09	
R97024	20 NOV 89 08:05	TPGM01	51.87	0.39	-0.81	1.79	TPGM01	4.86	0.23	-0.51	0.22	N/A	43.37	N/A	(1)	1.81	T4GM01	3.65	0.14	-0.15	0.15	
R97025	20 NOV 89 10:08	TPGM01	0.23	0.12	-0.75	0.75	TPGM01	0.06	0.03	-0.13	0.13	TPGM01	0.03	0.03	-0.13	0.13	T4GM01	0.43	0.15	-0.08	0.06	
R97026	05 DEC 89 13:53	TPGM03	0.72	(2)	N/A	0.07	TPGM02	0.10	(2)	N/A	0.07	TPGM02	0.07	N/A	(2)	0.07	T4GM01	0.60	0.04	-0.09	0.06	
R97027	05 DEC 89 15:24	TPGM03	0.71	(2)	N/A	0.07	TPGM02	0.11	(2)	N/A	-0.07	TPGM02	0.01	N/A	(2)	0.07	T4GM01	0.61	0.05	-0.09	0.06	
R97028	06 DEC 89 09:26	TPGM03	0.35	(2)	N/A	0.07	TPGM02	0.08	(2)	N/A	0.07	TPGM02	0.07	N/A	(2)	0.07	T4GM01	0.31	0.04	-0.09	0.06	
R97029	06 DEC 89 11:14	TPGM03	0.68	(2)	N/A	0.07	TPGM02	0.11	(2)	N/A	-0.07	TPGM02	0.09	N/A	(2)	0.07	T4GM01	0.62	0.05	-0.08	0.06	
R97030	06 DEC 89 13:42	TPGM01	3.16	0.07	-0.81	0.81	TPGM01	1.73	0.08	-0.26	0.16	TPGM02	0.08	N/A	(2)	0.07	T4GM01	1.67	0.05	-0.11	0.11	
R97031	06 DEC 89 15:48	TPGM01	3.25	0.07	-0.82	0.82	TPGM01	1.79	0.08	-0.27	0.16	TPGM02	0.08	N/A	(2)	0.07	T4GM01	1.71	0.07	-0.11	0.11	
R97032	06 DEC 89 16:54	TPGM03	0.68	(2)	N/A	0.07	TPGM02	0.10	(2)	N/A	-0.07	TPGM02	0.06	N/A	(2)	0.07	T4GM01	0.60	0.07	-0.09	0.06	
R97033	06 DEC 89 18:30	TPGM03	0.34	(2)	N/A	0.07	TPGM02	0.02	(2)	N/A	0.07	TPGM02	0.06	N/A	(2)	0.07	T4GM01	0.28	0.04	-0.08	0.06	
R97034	30 JAN 89 15:31	TPGM03	0.03	0.03	-0.07	0.07	TPGM02	0.02	0.02	-0.07	0.07	TPGM02	0.02	0.02	0.03	0.07	T4GM01	0.03	0.02	-0.08	0.06	
R97035	30 JAN 89 16:14	TPGM03	0.53	0.06	-0.07	0.07	TPGM02	0.04	0.04	-0.07	0.07	TPGM02	0.03	0.03	0.03	0.07	T4GM01	0.48	0.03	-0.08	0.06	
R97036	31 JAN 89 13:31	TPGM03	0.52	0.06	-0.07	0.07	TPGM02	0.04	0.07	-0.07	0.07	TPGM02	0.03	0.03	0.03	0.07	T4GM01	0.48	0.04	-0.06	0.06	
R97037	31 JAN 89 14:57	TPGM03	0.47	0.01	-0.07	0.07	TPGM02	0.06	0.03	-0.07	0.07	TPGM02	0.28	0.24	-0.07	0.07	T4GM01	0.36	0.03	-0.08	0.06	
R97038	01 FEB 89 11:52	TPGM03	0.47	0.01	-0.07	0.07	TPGM02	0.05	0.06	-0.07	0.07	TPGM02	0.30	0.25	-0.07	0.07	T4GM01	0.36	0.02	-0.08	0.06	
R97039	01 FEB 89 14:06	TPGM03	0.47	0.01	-0.07	0.07	TPGM02	0.03	0.03	-0.07	0.07	TPGM02	0.04	0.05	-0.07	0.07	T4GM01	0.71	0.03	-0.09	0.09	
R97040	01 FEB 89 18:01	TPGM03	0.81	0.06	-0.07	0.07	TPGM02	0.07	0.08	-0.07	0.07	TPGM02	0.03	0.03	0.03	0.07	T4GM01	0.75	0.02	-0.09	0.09	
R97041	01 FEB 89 20:30	TPGM03	0.80	0.07	-0.07	0.07	TPGM02	0.03	0.03	-0.07	0.07	TPGM02	0.03	0.03	0.03	0.07	T4GM01	0.75	0.03	-0.08	0.06	
R97042	01 FEB 89 11:48	TPGM03	0.29	0.00	-0.07	0.07	TPGM02	0.02	0.02	-0.07	0.07	TPGM02	0.03	0.04	-0.07	0.07	T4GM01	0.29	0.03	-0.08	0.06	
R97043	01 FEB 89 15:04	TPGM03	0.30	0.00	-0.07	0.07	TPGM02	0.02	0.02	-0.07	0.07	TPGM02	0.03	0.04	-0.07	0.07	T4GM01	0.43	0.03	-0.08	0.06	
R97044	03 FEB 89 18:48	TPGM03	0.66	0.18	-0.07	0.07	TPGM02	0.07	0.08	-0.07	0.07	TPGM02	0.37	0.24	-0.07	0.07	T4GM01	0.36	0.02	-0.08	0.06	
R97045	04 FEB 89 14:56	TPGM03	0.89	0.02	-0.07	0.07	TPGM02	0.07	0.10	-0.07	0.07	TPGM02	0.30	0.27	-0.07	0.07	T4GM01	0.37	0.03	-0.08	0.06	
R97046	04 FEB 89 17:10	TPGM03	0.67	0.02	-0.07	0.07	TPGM02	0.05	0.07	-0.07	0.07	TPGM02	0.30	0.25	-0.07	0.07	T4GM01	0.37	0.03	-0.08	0.06	
R97047	04 FEB 89 13:07	TPGM03	1.20	0.01	-0.07	0.07	TPGM02	0.45	0.07	-0.07	0.07	TPGM02	0.60	0.11	-0.07	0.07	T4GM01	0.21	0.02	-0.08	0.06	
R97048	04 FEB 89 16:02	TPGM01	3.18	0.06	-0.81	0.81	TPGM02	1.42	0.01	-0.07	0.07	TPGM02	0.05	0.06	-0.07	0.07	T4GM01	1.66	0.02	-0.11	0.11	
R97049	26 MAR 89 13:12	TPGM01	3.21	0.06	-0.81	0.81	TPGM01	1.74	0.07	-0.26	0.16	TPGM01	0.11	0.04	-0.13	0.13	T4GM01	1.70	0.05	-0.11	0.11	
R97050	26 MAR 89 18:30	TPGM01	1.25	(3)	-0.82	0.82	TPGM01	3.05	0.09	-0.37	0.19	TPGM01	0.12	0.05	-0.13	0.13	T4GM01	1.73	0.06	-0.11	0.11	
R97051	26 MAR 89 10:34	TPGM01	1.02	0.01	-0.07	0.07	TPGM02	0.40	0.06	-0.07	0.07	TPGM02	0.52	0.07	-0.07	0.07	T4GM01	0.19	0.02	-0.08	0.06	
R97052	26 MAR 89 15:06	TPGM03	0.99	(4)	-0.83	0.83	TPGM02	0.01	0.02	-0.07	0.07	TPGM02	0.53	0.06	-0.07	0.07	T4GM01	0.18	0.02	-0.08	0.06	

Table 5.4 (continued.)

TEST NUMBER	TEST DATE TIME	Channel 1 Output				Channel 2 Output				Channel 3 Output				Channel 4 Output			
		UNC		UNC		UNC		UNC		UNC		UNC		UNC		UNC	
		FLUCT (SCFM)	LOWER (SCFM)	UPPER (SCFM)	VTAB (SCFM)	VALUE (SCFM)	FLUCT (SCFM)	LOWER (SCFM)	UPPER (SCFM)	VTAB (SCFM)	VALUE (SCFM)	FLUCT (SCFM)	LOWER (SCFM)	UPPER (SCFM)	VTAB (SCFM)	VALUE (SCFM)	FLUCT (SCFM)
958014	01 APR 90 13:03	0.52	0.12	0.07	TPGM02	0.01	0.04	-0.07	0.07	TPGM02	0.06	0.06	-0.07	0.07	T4GM01	0.47	0.06
958015	01 APR 90 15:28	0.46	0.11	0.07	TPGM02	0.04	0.03	-0.07	0.07	TPGM02	0.14	0.12	-0.07	0.07	T4GM01	0.55	0.09
958016	06 APR 90 13:12	0.92	0.18	-0.07	TPGM02	0.07	0.08	-0.07	0.07	TPGM02	0.45	0.24	-0.07	0.07	T4GM01	0.44	0.09
958017	06 APR 90 16:58	2.85	0.07	-0.81	TPGM01	1.26	0.10	-0.07	0.07	TPGM02	0.08	0.07	-0.07	0.07	T4GM01	1.80	0.11
958018	06 MAY 90 14:51	0.52	0.06	-0.07	TPGM02	0.04	0.04	-0.07	0.07	TPGM02	0.06	0.07	-0.07	0.07	T4GM01	0.46	0.08
958019	06 MAY 90 13:05	30.73	0.37	5.33	TPGM01	4.06	0.11	0.45	0.21	TPGM01	19.27	0.28	0.65	2.44	T4GM01	2.86	0.13
958020	06 MAY 90 17:45	3.86	0.07	-0.83	TPGM02	0.75	0.15	-0.07	0.07	TPGM01	2.43	0.58	-0.27	0.17	T4GM01	0.70	0.09
958021	13 MAY 90 11:18	46.50	0.45	7.26	TPGM01	5.44	0.21	-0.23	0.23	N/A	35.00 (1)	N/A	-7.27	1.70	T4GM01	3.82	0.15
958022	13 MAY 90 14:40	2.21	0.09	-0.79	TPGM02	0.90	0.08	-0.07	0.07	TPGM02	0.06	0.07	-0.07	0.07	T4GM01	1.44	0.10
958023	13 MAY 90 19:54	4.21	0.23	-0.83	TPGM02	0.71	0.22	0.07	0.07	TPGM01	2.57	0.14	-0.28	0.18	T4GM01	0.91	0.09
958024	15 MAY 90 14:29	0.00	0.01	-0.07	TPGM02	0.19	0.18	-0.07	0.07	TPGM02	0.04	0.05	-0.07	0.07	T4GM01	0.06	0.08
958025	15 MAY 90 18:16	69.93	0.73	10.12	TPGM01	6.26	0.27	-0.25	0.25	N/A	53.80 (1)	N/A	-10.12	2.11	T4GM01	5.28	0.18
958026	15 MAY 90 12:28	0.28	0.01	-0.07	TPGM02	0.12	0.10	-0.07	0.07	TPGM02	0.20	0.16	-0.07	0.07	T4GM01	0.04	0.08
958027	16 MAY 90 16:02	12.45	0.14	-2.48	TPGM01	3.70	0.07	-0.42	0.20	TPGM01	5.99	0.91	-0.48	0.24	T4GM01	1.20	0.10
958028	16 MAY 90 15:09	1.96	0.05	-0.26	TPGM02	0.20	0.18	-0.07	0.07	TPGM02	0.03	0.05	-0.07	0.07	T4GM01	0.10	0.08
958029	21 MAY 90 19:32	52.14	0.41	-8.05	TPGM01	6.92 (6)	0.21 (6)	-0.07	0.07	N/A	38.05 (1.6)	N/A	(6)	(6)	T4GM01	5.27 (6)	(6)
958030	22 MAY 90 17:01	0.02	0.01	-0.13	TPGM02	0.03	0.03	-0.07	0.07	TPGM02	0.03	0.04	-0.07	0.07	T4GM01	0.07	0.08
958031	23 MAY 90 15:49	1.90 (5)	0.08	-0.26	TPGM02	0.02	0.03	-0.07	0.07	TPGM02	0.03	0.04	-0.07	0.07	T4GM01	0.06	0.08
958032	23 MAY 90 14:42	2.03 (5)	0.04	-0.27	TPGM02	0.02	0.02	-0.07	0.07	TPGM02	0.36	0.53	-0.07	0.07	T4GM01	0.02	0.08
958033	24 MAY 90 21:49	8.34	0.13	0.21	TPGM01	3.13 (6)	0.15 (6)	-0.07	0.07	TPGM01	8.00 (6)	0.28	(6)	(6)	T4GM01	1.06 (6)	(6)
958034	24 MAY 90 15:59	2.01 (5)	0.05	-0.27	TPGM02	0.01	0.01	-0.07	0.07	TPGM02	0.25	0.46	-0.07	0.07	T4GM01	0.03	0.08
958035	24 MAY 90 10:57	1.93 (5)	0.05	-0.26	TPGM02	0.02	0.02	-0.07	0.07	TPGM02	0.02	0.04	-0.07	0.07	T4GM01	0.10	0.08
958036	28 MAY 90 14:46	1.97 (5)	0.05	-0.26	TPGM02	0.03	0.03	-0.07	0.07	TPGM02	0.16	0.22	-0.07	0.07	T4GM01	0.03	0.08
958037	30 MAY 90 17:39	0.10	0.00	-0.07	TPGM02	0.03	0.03	-0.07	0.07	TPGM02	0.15	0.28	-0.07	0.07	T4GM01	0.10	0.08
958038	30 MAY 90 10:39	0.22	0.01	-0.07	TPGM02	0.01	0.01	-0.07	0.07	TPGM02	0.03	0.04	-0.07	0.07	T4GM01	0.03	0.08
958039	30 MAY 90 15:18	86.72	0.86	-10.09	TPGM01	6.35	0.19	-0.25	0.25	N/A	53.19 (1)	N/A	-10.09	2.10	T4GM01	5.74	0.18
958040	31 MAY 90 10:30	12.94	0.14	-2.56	TPGM01	3.67	0.07	-0.42	0.20	TPGM01	6.23	0.19	-0.50	0.25	T4GM01	1.16	0.10
958041	01 JUN 90 11:49	51.12	0.46	-7.91	TPGM01	6.87 (6)	0.54 (6)	-0.07	0.07	N/A	37.86 (1.6)	N/A	(6)	(6)	T4GM01	5.10 (6)	(6)
958042	01 JUN 90 17:04	8.30	0.12	0.21	TPGM01	3.14 (6)	0.37 (6)	-0.07	0.07	TPGM01	8.15 (6)	0.22	(6)	(6)	T4GM01	1.10 (6)	(6)
958043	01 JUN 90 14:26	1.94 (5)	0.11	-0.26	TPGM02	0.03	0.03	-0.07	0.07	TPGM02	0.04	0.05	-0.07	0.07	T4GM01	0.06	0.08
958044	02 JUN 90 19:10	1.96 (5)	0.09	-0.26	TPGM02	0.02	0.02	-0.07	0.07	TPGM02	0.24	0.42	-0.07	0.07	T4GM01	0.04	0.08
958045	02 JUN 90 14:48	0.06	0.01	-0.13	TPGM02	0.02	0.02	-0.07	0.07	TPGM02	0.03	0.05	-0.07	0.07	T4GM01	0.06	0.08
958046	03 JUN 90 22:21	0.15	0.01	-0.14	TPGM02	0.01	0.01	-0.07	0.07	TPGM02	0.18	0.36	-0.07	0.07	T4GM01	0.03	0.08
958047	04 JUN 90 15:53	1.94 (5)	0.04	-0.26	TPGM02	0.01	0.02	-0.07	0.07	TPGM02	0.02	0.03	-0.07	0.07	T4GM01	0.12	0.08
958048	05 JUN 90 12:12	7.97	0.12	0.19	TPGM01	3.01 (6)	0.13 (6)	-0.07	0.07	TPGM01	7.59 (6)	0.23	(6)	(6)	T4GM01	1.05 (6)	(6)
958049	06 JUN 90 16:04	0.15	0.01	-0.14	TPGM02	0.01	0.01	-0.07	0.07	TPGM02	0.21	0.35	-0.07	0.07	T4GM01	0.03	0.08
958050	06 JUN 90 14:27	1.96 (5)	0.12	-0.26	TPGM02	0.03	0.02	-0.07	0.07	TPGM02	0.16	0.19	-0.07	0.07	T4GM01	0.04	0.08
958051	06 JUN 90 22:18	69.04	1.80	-10.41	TPGM01	6.76	0.30	-0.26	0.26	N/A	55.35 (1)	N/A	-10.41	2.15	T4GM01	5.18	0.18
958052	09 JUL 90 12:02	0.40	0.01	-0.07	TPGM02	0.06	0.11	-0.07	0.07	TPGM02	0.13	0.15	-0.07	0.07	T4GM02	0.18	0.07
958053	09 JUL 90 17:17	2.00 (5)	0.04	-0.26	TPGM02	0.08	0.10	-0.07	0.07	TPGM02	0.15	0.17	-0.07	0.07	T4GM02	0.14	0.07
958054	09 JUL 90 23:21	1.93 (5)	0.05	-0.26	TPGM02	0.08	0.07	-0.07	0.07	TPGM02	0.22	0.17	-0.07	0.07	T4GM02	0.58	0.07

Table 5.4 (cont'd.)

Test Assembly Inlet Air Flow										Channel 2 Outlet				Channel 3 Outlet				Channel 4 Outlet			
TEST NUMBER	TEST DATE TIME	VTAB	VALUE (SCFM)	FLUCT (SCFM) (SOEM)	LOWER (SCFM)	UPPER (SCFM)	VTAB	VALUE (SCFM)	FLUCT (SCFM) (SOEM)	LOWER (SCFM)	UPPER (SCFM)	VTAB	VALUE (SCFM)	FLUCT (SCFM) (SOEM)	LOWER (SCFM)	UPPER (SCFM)	VTAB	VALUE (SCFM)	FLUCT (SCFM) (SOEM)	LOWER (SCFM)	UPPER (SCFM)
94A014	10 JUL 90 20:52	TPGM02	1.95 (5)	0.04	-0.26	0.16	T2GM02	0.34	0.15	-0.07	0.07	T2GM02	1.19	0.83	-0.07	0.07	T4GM02	0.35	0.06	-0.07	0.07
94A015	10 JUL 90 22:42	TPGM03	0.41	0.01	-0.07	0.07	T2GM02	0.09	0.08	0.07	0.07	T2GM02	0.14	0.13	-0.07	0.07	T4GM02	0.20	0.05	-0.07	0.07
94A016	11 JUL 90 01:43	TPGM03	0.81	0.04	-0.07	0.07	T2GM02	0.10	0.08	0.07	0.07	T2GM02	0.20	0.16	-0.07	0.07	T4GM02	0.50	0.04	-0.07	0.07
94A017	11 JUL 90 04:23	TPGM03	1.55	0.06	-0.07	0.07	T2GM02	0.29	0.18	-0.07	0.07	T2GM02	1.11	0.88	-0.07	0.07	T4GM02	0.37	0.05	-0.07	0.07
94A018	11 JUL 90 14:34	TPGM02	1.97 (5)	0.08	-0.26	0.16	T2GM02	0.06	0.07	-0.07	0.07	T2GM02	0.10	0.11	-0.07	0.07	T4GM02	0.12	0.08	-0.07	0.07
94A019	11 JUL 90 21:13	TPGM02	1.99 (5)	0.09	-0.26	0.16	T2GM02	0.07	0.07	-0.07	0.07	T2GM02	0.13	0.12	-0.07	0.07	T4GM02	0.53	0.05	-0.07	0.07
94A020	12 JUL 90 06:29	TPGM02	2.04 (5)	0.08	-0.27	0.17	T2GM02	0.16	0.17	0.07	0.07	T2GM02	0.87	0.86	-0.07	0.07	T4GM02	0.34	0.06	-0.07	0.07
94A021	12 JUL 90 14:26	TPGM02	0.32	0.02	-0.15	0.13	T2GM02	0.06	0.05	0.07	0.07	T2GM02	0.11	0.10	-0.07	0.07	T4GM02	0.12	0.07	-0.07	0.07
94A022	12 JUL 90 17:42	TPGM02	0.60	0.04	-0.17	0.14	T2GM02	0.04	0.07	-0.07	0.07	T2GM02	0.13	0.11	-0.07	0.07	T4GM02	0.46	0.05	-0.07	0.07
94A023	12 JUL 90 20:34	TPGM02	1.14	0.05	-0.20	0.15	T2GM02	0.15	0.15	-0.07	0.07	T2GM02	0.69	0.67	-0.07	0.07	T4GM02	0.30	0.06	-0.07	0.07
94A024	16 JUL 90 11:30	TPGM01	0.54	0.06	-0.07	0.07	T2GM02	0.07	0.06	-0.07	0.07	T2GM02	0.05	0.06	-0.07	0.07	T4GM02	0.50	0.06	-0.07	0.07
94A025	16 JUL 90 16:08	TPGM03	0.71	0.00	-0.07	0.07	T2GM02	0.02	0.02	-0.07	0.07	T2GM02	0.03	0.05	-0.07	0.07	T4GM02	0.04	0.04	-0.07	0.07
94A026	17 JUL 90 10:44	TPGM03	0.31	0.01	-0.07	0.07	T2GM02	0.04	0.08	-0.07	0.07	T2GM02	0.06	0.06	-0.07	0.07	T4GM02	0.56	0.05	-0.07	0.07
94A027	17 JUL 90 13:50	TPGM03	1.30	0.02	-0.07	0.07	T2GM02	0.27	0.16	-0.07	0.07	T2GM02	0.07	0.07	-0.07	0.07	T4GM02	1.01	0.04	-0.07	0.07
94A028	18 JUL 90 12:05	TPGM03	0.52	0.01	-0.07	0.07	T2GM02	0.09	0.06	-0.07	0.07	T2GM02	0.18	0.16	-0.07	0.07	T4GM02	0.30	0.06	-0.07	0.07
94A029	18 JUL 90 14:47	TPGM03	0.99	0.04	-0.07	0.07	T2GM02	0.21	-0.17	-0.07	0.07	T2GM02	0.49	0.21	-0.07	0.07	T4GM02	0.35	0.08	-0.07	0.07
94A030	19 JUL 90 10:34	TPGM03	1.01	0.04	-0.07	0.07	T2GM02	0.23	0.21	-0.07	0.07	T2GM02	0.33	0.53	-0.07	0.07	T4GM02	0.23	0.05	-0.07	0.07
94A031	19 JUL 90 13:38	TPGM03	0.65	0.01	-0.07	0.07	T2GM02	0.27	0.13	-0.07	0.07	T2GM02	0.29	0.22	-0.07	0.07	T4GM02	0.11	0.02	-0.07	0.07
94A032	20 JUL 90 15:20	TPGM03	0.46	0.01	-0.07	0.07	T2GM02	0.08	0.05	-0.07	0.07	T2GM02	0.05	0.05	-0.07	0.07	T4GM02	0.41	0.06	-0.07	0.07
94A033	23 JUL 90 14:24	TPGM03	0.54	0.07	-0.07	0.07	T2GM02	0.08	0.06	-0.07	0.07	T2GM02	0.04	0.05	-0.07	0.07	T4GM02	0.49	0.06	-0.07	0.07
94A034	24 JUL 90 11:30	TPGM03	0.34	0.02	-0.07	0.07	T2GM02	0.21	0.19	-0.07	0.07	T2GM02	0.14	0.14	-0.07	0.07	T4GM02	0.19	0.04	-0.07	0.07
94A035	24 JUL 90 15:19	TPGM03	1.29	0.02	-0.07	0.07	T2GM02	0.12	0.04	-0.07	0.07	T2GM02	0.82	0.20	-0.07	0.07	T4GM02	0.49	0.08	-0.07	0.07
94A036	25 JUL 90 14:36	TPGM03	0.35	0.01	-0.07	0.07	T2GM02	0.02	0.02	-0.07	0.07	T2GM02	0.37	0.72	-0.07	0.07	T4GM02	0.04	0.05	-0.07	0.07
94A037	26 JUL 90 11:51	TPGM03	0.05	0.00	-0.07	0.07	T2GM02	0.02	0.02	-0.07	0.07	T2GM02	0.02	0.04	-0.07	0.07	T4GM02	0.08	0.06	-0.07	0.07
94A038	27 JUL 90 11:44	TPGM03	0.17	0.00	-0.07	0.07	T2GM02	0.03	0.03	-0.07	0.07	T2GM02	0.03	0.04	-0.07	0.07	T4GM02	0.14	0.04	-0.07	0.07
94A039	27 JUL 90 14:18	TPGM03	0.30	0.00	-0.07	0.07	T2GM02	0.04	0.04	-0.07	0.07	T2GM02	0.04	0.04	-0.07	0.07	T4GM02	0.23	0.05	-0.07	0.07
94A040	30 JUL 90 09:51	TPGM03	0.52	0.07	-0.07	0.07	T2GM02	0.05	0.05	-0.07	0.07	T2GM02	0.05	0.08	-0.07	0.07	T4GM02	0.52	0.06	-0.07	0.07
94A041	30 JUL 90 12:35	TPGM03	0.69	0.02	-0.07	0.07	T2GM02	0.12	0.11	-0.07	0.07	T2GM02	0.17	0.16	-0.07	0.07	T4GM02	0.51	0.08	-0.07	0.07
94A042	30 JUL 90 16:15	TPGM03	0.84	0.04	-0.07	0.07	T2GM02	0.08	0.09	-0.07	0.07	T2GM02	0.22	0.18	-0.07	0.07	T4GM02	0.83	0.05	-0.07	0.07
94A043	30 JUL 90 18:30	TPGM03	1.21	0.03	-0.07	0.07	T2GM02	0.15	0.12	-0.07	0.07	T2GM02	0.27	0.23	-0.07	0.07	T4GM02	0.83	0.05	-0.07	0.07
94A044	30 JUL 90 23:00	TPGM03	0.53	0.00	-0.07	0.07	T2GM02	0.14	0.17	-0.07	0.07	T2GM02	0.25	0.20	-0.07	0.07	T4GM02	0.18	0.06	-0.07	0.07
94A045	31 JUL 90 10:47	TPGM03	0.18	0.00	-0.07	0.07	T2GM02	0.01	0.01	-0.07	0.07	T2GM02	0.18	0.13	-0.07	0.07	T4GM02	0.02	0.03	-0.07	0.07
94A046	31 JUL 90 13:56	TPGM03	0.34	0.01	-0.07	0.07	T2GM02	0.02	0.02	-0.07	0.07	T2GM02	0.28	0.17	-0.07	0.07	T4GM02	0.08	0.04	-0.07	0.07
94A047	31 JUL 90 17:38	TPGM03	0.68	0.02	-0.07	0.07	T2GM02	0.16	0.17	-0.07	0.07	T2GM02	0.33	0.17	-0.07	0.07	T4GM02	0.29	0.06	-0.07	0.07
94A048	31 JUL 90 21:44	TPGM03	0.08	0.01	-0.07	0.07	T2GM02	0.02	0.02	-0.07	0.07	T2GM02	0.02	0.04	-0.07	0.07	T4GM02	0.09	0.06	-0.07	0.07
94A049	06 AUG 90 09:56	TPGM03	0.54	0.07	-0.07	0.07	T2GM02	0.07	0.06	-0.07	0.07	T2GM02	0.05	0.05	-0.07	0.07	T4GM02	0.51	0.07	-0.07	0.07
94A050	06 AUG 90 14:35	TPGM03	0.25	0.01	-0.07	0.07	T2GM02	0.03	0.03	-0.07	0.07	T2GM02	0.03	0.04	-0.07	0.07	T4GM02	0.23	0.12	-0.07	0.07
94A051	06 AUG 90 17:22	TPGM03	0.73	0.07	-0.07	0.07	T2GM02	0.04	0.04	-0.07	0.07	T2GM02	0.03	0.04	-0.07	0.07	T4GM02	0.74	0.08	-0.07	0.07
94A052	06 AUG 90 20:19	TPGM03	0.85	0.02	-0.07	0.07	T2GM02	0.31	0.12	-0.07	0.07	T2GM02	0.45	0.16	-0.07	0.07	T4GM02	0.15	0.04	-0.07	0.07
94A053	06 AUG 90 22:49	TPGM03	1.31	0.08	-0.07	0.07	T2GM02	0.34	0.19	-0.07	0.07	T2GM02	0.89	0.20	-0.07	0.07	T4GM02	0.28	0.05	-0.07	0.07
94A054	06 AUG 90 12:24	TPGM02	6.87	0.06	-0.26	0.40	T2GM01	2.53	0.10	-0.18	0.18	T2GM01	1.76	0.10	-0.16	0.41	T4GM01	1.78	0.03	-0.32	0.11

Table 5.4 (cont'd.)

Test Assembly Inter Air Flow										Channel 2 Outlet					Channel 3 Outlet					Channel 4 Outlet						
TEST NUMBER	TEST DATE/TIME	VTAB	VALUE (SCFM)	FLUCT (SCFM)	LOWER (SCFM)	UPPER (SCFM)	UNC					VTAB	VALUE (SCFM)	FLUCT (SCFM)	LOWER (SCFM)	UPPER (SCFM)	UNC					VTAB	VALUE (SCFM)	FLUCT (SCFM)	LOWER (SCFM)	UPPER (SCFM)
							VTAB	VALUE (SCFM)	FLUCT (SCFM)	LOWER (SCFM)	UPPER (SCFM)						VTAB	VALUE (SCFM)	FLUCT (SCFM)	LOWER (SCFM)	UPPER (SCFM)					
964032	09 AUG 90, 17:04	TPGM01	30.20	0.14	-1.35	1.35	T2GM01	4.26	0.12	-0.21	0.21	T3GM01	21.70	0.32	-0.56	0.56	T4GM01	2.51	0.06	-0.43	0.13					
964033	09 AUG 90, 19:43	TPGM01	47.72	0.23	-1.70	1.70	TPGM01	5.62	0.19	-0.24	0.24	N/A	36.89 (1)	N/A	-1.82	1.72	T4GM01	3.81	0.12	-0.81	0.15					
964034	09 AUG 90, 22:05	TPGM02	4.85	0.11	-0.22	0.32	T2GM01	1.99	0.05	-0.16	0.16	T3GM01	1.50	0.05	-0.15	0.15	T4GM02	1.29	0.02	-0.07	0.07					
964035	10 AUG 90, 00:07	TPGM02	18.33	0.23	-0.49	0.86	T2GM01	3.48	0.10	-0.18	0.18	T3GM01	12.04	0.28	-0.37	0.37	T4GM01	1.80	0.03	-0.33	0.11					
964036	10 AUG 90, 02:21	TPGM01	28.19	0.14	-1.31	1.31	T2GM01	4.50	0.17	-0.21	0.21	T3GM01	19.04	0.35	-0.51	0.51	T4GM01	2.37	0.04	-0.41	0.12					
964037	10 AUG 90, 11:27	TPGM02	2.31	0.14	-0.17	0.22	T2GM02	0.24	0.16	-0.07	0.07	T3GM02	1.39	0.05	-0.07	0.07	T4GM02	0.65	0.06	-0.07	0.07					
964038	10 AUG 90, 16:23	TPGM02	4.14	0.09	-0.21	0.29	T2GM02	0.85	0.17	-0.07	0.07	T3GM01	2.16	0.16	-0.17	0.17	T4GM02	0.91	0.03	-0.07	0.07					
964039	10 AUG 90, 18:53	TPGM02	11.05	0.14	-0.35	0.57	T2GM01	3.15	0.09	-0.19	0.19	T3GM01	5.98	0.15	-0.24	0.24	T4GM02	1.26	0.04	-0.07	0.07					
964040	10 AUG 90, 20:55	TPGM02	18.27	0.36	-0.49	0.86	T2GM01	3.99	0.14	-0.20	0.20	T3GM01	11.38	0.32	-0.35	0.35	T4GM01	1.70	0.05	-0.31	0.11					
964041	11 AUG 90, 10:46	TPGM02	1.63	0.09	-0.16	0.19	T2GM02	0.30	0.20	-0.07	0.07	T3GM02	0.85	0.64	-0.07	0.07	T4GM02	0.39	0.05	-0.07	0.07					
964042	11 AUG 90, 12:36	TPGM02	2.39	0.21	-0.17	0.22	T2GM02	0.44	0.19	-0.07	0.07	T3GM01	1.32	0.83	-0.15	0.15	T4GM02	0.52	0.04	-0.07	0.07					
964043	11 AUG 90, 14:39	TPGM02	3.97	0.10	-0.20	0.28	T2GM02	0.99	0.18	-0.07	0.07	T3GM01	1.78	0.76	-0.16	0.16	T4GM02	0.96	0.04	-0.07	0.07					
964044	13 AUG 90, 00:34	TPGM02	3.67	0.07	-0.20	0.27	T2GM01	0.94	0.21	-0.14	0.14	T3GM01	1.76	0.76	-0.16	0.16	T4GM02	0.68	0.03	-0.07	0.07					
964045	13 AUG 90, 01:41	TPGM02	7.85	0.10	-0.26	0.44	T2GM01	2.57	0.06	-0.18	0.18	T3GM01	3.85	0.40	-0.20	0.20	T4GM02	0.90	0.04	-0.07	0.07					
964046	13 AUG 90, 04:41	TPGM02	12.13	0.17	-0.37	0.61	T2GM01	3.58	0.08	-0.20	0.20	T3GM01	6.54	0.15	-0.26	0.26	T4GM02	1.20	0.02	-0.07	0.07					
964047	13 AUG 90, 06:35	TPGM03	0.54	0.08	-0.07	0.07	TPGM02	0.05	0.05	-0.07	0.07	T3GM02	0.05	0.05	-0.07	0.07	T4GM02	0.48	0.06	-0.07	0.07					
964048	13 AUG 90, 11:59	TPGM02	2.33	0.06	-0.17	0.22	TPGM02	0.54	0.20	-0.07	0.07	T3GM02	1.35	0.08	-0.07	0.07	T4GM02	0.39	0.04	-0.07	0.07					
964049	14 AUG 90, 00:12	TPGM02	3.28	0.08	-0.19	0.26	T2GM01	1.10	0.23	-0.15	0.15	T3GM01	1.82	0.90	-0.16	0.16	T4GM02	0.50	0.03	-0.07	0.07					
964050	14 AUG 90, 02:02	TPGM02	5.37	0.07	-0.23	0.34	T2GM01	1.69	0.09	-0.18	0.18	T3GM01	2.80	0.48	-0.18	0.18	T4GM02	0.64	0.02	-0.07	0.07					
964051	14 AUG 90, 03:50	TPGM02	8.95	0.14	-0.30	0.48	T2GM01	3.15	0.08	-0.19	0.19	T3GM01	3.92	0.54	-0.20	0.20	T4GM02	0.83	0.03	-0.07	0.07					
964052	14 AUG 90, 07:52	TPGM02	14.99	0.24	-0.42	0.72	T2GM01	2.72	0.16	-0.18	0.18	T3GM01	9.36	0.26	-0.31	0.31	T4GM01	2.12	0.06	-0.37	0.12					
964053	14 AUG 90, 12:29	TPGM01	51.78	0.22	-1.79	1.79	TPGM01	5.71	0.21	-0.24	0.24	N/A	40.99 (1)	N/A	-1.81	1.81	T4GM01	4.07	0.27	-0.16	0.16					
964054	14 AUG 90, 15:49	TPGM01	72.92	0.42	-2.21	2.21	TPGM01	9.15	0.28	-0.31	0.31	N/A	54.04 (1)	N/A	-2.24	2.24	T4GM01	7.53	0.17	-0.23	0.23					
964055	14 AUG 90, 22:54	TPGM03	0.87	0.07	-0.07	0.07	TPGM02	0.08	0.09	-0.07	0.07	T3GM02	0.28	0.22	-0.07	0.07	T4GM02	0.59	0.07	-0.07	0.07					
964056	15 AUG 90, 00:42	TPGM02	2.43	0.12	-0.17	0.22	T2GM02	0.29	0.17	-0.07	0.07	T3GM02	1.40	0.04	-0.07	0.07	T4GM02	0.67	0.05	-0.07	0.07					
964057	15 AUG 90, 02:43	TPGM03	0.98	0.04	-0.07	0.07	TPGM02	0.16	0.22	-0.07	0.07	T3GM02	0.73	0.90	-0.07	0.07	T4GM02	0.24	0.08	-0.07	0.07					
964058	15 AUG 90, 05:13	TPGM03	0.42	0.01	-0.07	0.07	TPGM02	0.13	0.04	-0.07	0.07	T3GM02	0.28	0.61	-0.07	0.07	T4GM02	0.05	0.02	-0.07	0.07					
964059	15 AUG 90, 10:33	TPGM03	0.03	0.00	-0.07	0.07	TPGM02	0.01	0.02	-0.07	0.07	T3GM02	0.03	0.05	-0.07	0.07	T4GM02	0.05	0.04	-0.07	0.07					
964060	15 AUG 90, 14:12	TPGM01	73.32	0.38	-2.22	2.22	TPGM01	9.11	0.28	-0.31	0.31	N/A	54.61 (1)	N/A	-2.25	2.25	T4GM01	7.60	0.16	-0.23	0.23					
964061	15 AUG 90, 23:58	TPGM02	8.56	0.13	-0.30	0.47	T2GM01	3.01	0.08	-0.19	0.19	T3GM01	3.73	0.53	-0.20	0.20	T4GM02	0.83	0.02	-0.07	0.07					
964062	16 AUG 90, 02:36	TPGM02	6.24	0.05	-0.25	0.37	TPGM01	2.53	0.10	-0.18	0.18	T3GM01	1.50	0.11	-0.16	0.16	T4GM01	1.77	0.02	-0.32	0.11					
964063	17 AUG 90, 00:24	TPGM01	75.52	0.40	-2.26	2.26	T2GM01	8.53	0.33	-0.30	0.30	N/A	58.18 (1)	N/A	-2.29	2.29	T4GM01	6.80	0.21	-0.21	0.21					
964064	17 AUG 90, 02:33	TPGM02	16.11	0.25	-0.45	0.77	TPGM01	4.64	0.15	-0.22	0.22	T3GM01	9.00	0.92	-0.30	0.30	T4GM01	1.40	0.04	-0.27	0.10					
964065	17 AUG 90, 10:02	TPGM03	0.00	0.00	-0.07	0.07	TPGM02	0.02	0.02	-0.07	0.07	T3GM02	0.01	0.02	-0.07	0.07	T4GM02	0.02	0.02	-0.07	0.07					
964066	20 AUG 90, 04:24	TPGM03	0.00	0.01	-0.07	0.07	TPGM02	0.02	0.03	-0.07	0.07	T3GM02	0.01	0.02	-0.07	0.07	T4GM02	0.05	0.04	-0.07	0.07					
964067	20 AUG 90, 06:46	TPGM02	19.74	0.28	-0.52	0.91	TPGM01	3.39	0.12	-0.19	0.19	T3GM01	13.19	0.21	-0.39	0.39	T4GM01	2.42	0.10	-0.41	0.12					
964068	20 AUG 90, 13:18	TPGM01	92.91	0.42	-2.81	2.81	TPGM01	13.87	0.24	-0.40	0.40	N/A	65.61 (1)	N/A	-2.19	3.21	T4GM01	11.47	0.22	-0.30	0.30					
964069	20 AUG 90, 14:57	TPGM03	0.52	0.07	-0.07	0.07	TPGM02	0.04	0.04	-0.07	0.07	T3GM02	0.04	0.05	-0.07	0.07	T4GM02	0.47	0.07	-0.07	0.07					
964070	21 AUG 90, 04:36	TPGM03	0.00	0.00	-0.07	0.07	TPGM02	0.06	0.08	-0.07	0.07	T3GM02	0.06	0.07	-0.07	0.07	T4GM02	0.02	0.02	-0.07	0.07					
964071	21 AUG 90, 06:38	TPGM02	5.16	0.07	-0.23	0.33	TPGM01	2.31	0.11	-0.17	0.17	T3GM02	1.73	0.07	-0.07	0.07	T4GM02	0.52	0.02	-0.07	0.07					
964072	21 AUG 90, 12:11	TPGM03	0.00	0.00	-0.07	0.07	TPGM02	0.02	0.02	-0.07	0.07	T3GM02	0.05	0.07	-0.07	0.07	T4GM02	0.01	0.01	-0.07	0.07					
964073	21 AUG 90, 14:41	TPGM03	0.75	0.02	-0.07	0.07	TPGM02	0.25	0.06	-0.07	0.07	T3GM02	0.45	0.06	-0.07	0.07	T4GM02	0.10	0.03	-0.07	0.07					

Table 5.4 (continued)

TEST NUMBER	TEST DATE/TIME	Test Assembly Inlet Air Flow					Channel 2 Outlet					Channel 3 Outlet					Channel 4 Outlet				
		VTAB	VALUE (SCFM)	FLUCT (SCFM)	UNC	VTAB	VALUE (SCFM)	FLUCT (SCFM)	UNC	VTAB	VALUE (SCFM)	FLUCT (SCFM)	UNC	VTAB	VALUE (SCFM)	FLUCT (SCFM)	UNC	VTAB	VALUE (SCFM)	FLUCT (SCFM)	UNC
964074	21 AUG 90 23:42	N/A	0.00 (7)	N/A	N/A	N/A	0.00	0.00	0.07	0.07	T3GM02	0.00	0.00	0.07	T3GM02	0.00	0.00	0.07	T4GM02	0.00	0.07
964075	22 AUG 90 13:23	TPGM02	2.01	0.06	-0.17	0.21	T2GM02	0.78	0.04	-0.07	0.07	T3GM02	0.89	0.06	-0.07	0.07	T4GM02	0.27	0.02	-0.07	0.07
964076	22 AUG 90 16:06	TPGM02	3.58	0.08	-0.20	0.27	T2GM01	1.80	0.08	-0.16	0.18	T3GM01	1.46	0.10	-0.15	0.15	T4GM02	0.44	0.02	-0.07	0.07
964077	22 AUG 90 19:07	TPGM01	36.20	0.15	1.47	1.47	T2GM01	6.54	0.49	-0.26	0.26	T3GM01	19.94	0.48	-0.52	0.52	T4GM01	6.91	0.29	-0.21	0.21
964078	22 AUG 90 23:36	TPGM01	101.45	0.39	2.78	2.78	T2GM01	17.60	0.73	-0.48	0.83	N/A (8)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
964079	23 AUG 90 10:18	TPGM02	6.25	0.06	-0.25	0.37	T2GM01	1.81	0.12	-0.16	0.16	T3GM01	2.22	0.13	-0.17	0.48	T4GM01	1.41	0.03	-0.27	0.10
964080	23 AUG 90 13:02	TPGM03	0.05	0.06	-0.07	0.07	T2GM02	1.04	0.04	-0.07	0.07	T3GM02	0.02	0.04	-0.07	0.07	T4GM02	0.07	0.08	-0.07	0.07
964081	23 AUG 90 15:37	TPGM02	2.54	0.09	-0.18	0.23	T2GM02	0.62	0.20	-0.07	0.07	T3GM02	0.07	0.25	-0.07	0.07	T4GM02	0.99	0.04	-0.07	0.07
964082	23 AUG 90 19:03	TPGM02	12.78	0.17	-0.38	0.84	T2GM01	2.97	0.14	-0.18	0.18	T3GM01	7.65	0.21	-0.28	1.35	T4GM01	1.50	0.10	-0.29	0.11
964083	23 AUG 90 22:10	TPGM02	2.03	0.05	-0.17	0.21	T2GM02	0.91	0.16	-0.07	0.07	T3GM01	1.87	0.19	-0.16	0.42	T4GM02	1.08	0.02	-0.07	0.07
964084	24 AUG 90 10:23	TPGM02	4.07	0.07	-0.21	0.26	T2GM02	0.04	0.05	-0.07	0.07	T3GM02	0.43	0.12	-0.07	0.07	T4GM02	0.12	0.04	-0.07	0.07
964085	24 AUG 90 13:47	TPGM03	9.51	0.01	-0.07	0.07	T2GM02	0.03	0.03	-0.07	0.07	T3GM02	0.04	0.04	-0.07	0.07	T4GM02	0.47	0.07	-0.07	0.07
964086	27 AUG 90 10:13	TPGM03	0.51	0.07	-0.07	0.07	T2GM02	0.04	0.05	-0.07	0.07	T3GM02	0.04	0.18	-0.21	0.28	T4GM02	0.83	0.05	-0.07	0.07
964087	31 AUG 90 11:14	TPGM02	3.27	0.05	-0.19	0.26	T2GM02	0.49	0.17	-0.07	0.07	T3GM01	2.03	0.07	-0.36	0.51	T4GM02	1.16	0.03	-0.07	0.07
964088	31 AUG 90 14:00	TPGM02	8.80	0.11	-0.30	0.47	T2GM01	2.54	0.07	-0.18	0.18	T3GM01	4.72	0.07	-0.07	0.07	T4GM02	1.33	0.05	-0.07	0.07
964089	04 SEP 90 10:27	TPGM02	2.31	0.05	-0.17	0.22	T2GM02	0.91	0.12	-0.07	0.07	T3GM02	0.07	0.06	-0.07	0.07	T4GM02	1.36	0.06	-0.07	0.07
964090	04 SEP 90 14:08	TPGM02	1.83	0.04	-0.16	0.19	T2GM02	0.33	0.14	-0.07	0.07	T3GM02	0.04	0.05	-0.07	0.07	T4GM02	0.46	0.07	-0.07	0.07
964091	05 SEP 90 06:10	TPGM03	0.50	0.06	-0.07	0.07	T2GM02	0.04	0.04	-0.07	0.07	T3GM02	0.04	0.05	-0.07	0.07	T4GM02	2.92	0.08	-0.48	0.13
964092	05 SEP 90 12:30	TPGM01	42.50	0.18	-1.80	1.80	T2GM01	4.50	0.11	-0.21	0.21	N/A (1)	N/A	N/A	-1.68	1.62	T4GM01	2.92	0.08	-0.48	0.13
964093	05 SEP 90 15:07	TPGM02	21.37	0.29	-0.55	0.88	T2GM01	3.56	0.09	-0.20	0.20	T3GM01	14.89	0.27	-0.42	0.42	T4GM01	2.11	0.03	-0.37	0.12

NOTES

- (1) Channel 3 air flow meter over-ranged. Value was obtained by summing the individual channels and subtracting from the total assembly flow rate. Uncertainty values were obtained from the root-sum-square of the individual meter uncertainty values
- (2) Air flow measurements obtained through additional low range air meters read through integrating digital voltmeter (non-DAS)
- (3) Air injected at bottom, measured by T4GM02 = 1.516 scfm
- (4) Air injected at bottom, measured by T4GM02 = 1.506 scfm
- (5) Piston ring leakage system on. Vacuum system active.
- (6) Outlet air meters not reliable due to moisture content of air flow. No estimate of measurement uncertainty is available
- (7) Air inlets isolated and vacuum system active.
- (8) Channels 3 and 4 air flow meters were over-ranged

TABLE 5.5
Test and Reference Assembly Inlet Plenum
Water Level Values and Uncertainties

TEST NUMBER	TEST DATE/TIME	----- Reference Plenum Level -----				----- Test Plenum Level -----			
		VTAB	VALUE ("H ₂ O)	FLUCT ("H ₂ O)	UNC "H ₂ O	VTAB	VALUE "H ₂ O	FLUCT "H ₂ O	UNC "H ₂ O
897001	27-OCT-89, 14:30	RPLV01	6.15	0.01	(1)	TPLV01	6.30	0.02	(1)
897002	27-OCT-89, 16:54	RPLV01	5.89	0.02	(1)	TPLV01	5.93	0.02	(1)
897004	27-OCT-89, 22:00	RPLV01	5.79	0.02	(1)	TPLV01	5.84	0.02	(1)
897006	28-OCT-89, 00:01	RPLV01	5.31	0.03	(1)	TPLV01	5.35	0.03	(1)
897007	30-OCT-89, 15:30	RPLV01	6.16	0.01	(1)	TPLV01	6.31	0.01	(1)
897013	31-OCT-89, 02:34	RPLV01	5.17	0.05	(1)	TPLV01	5.30	0.05	(1)
897015	31-OCT-89, 21:33	RPLV01	4.32	0.02	(1)	TPLV01	4.55	0.01	(1)
897019	01-NOV-89, 17:58	RPLV01	4.31	0.01	(1)	TPLV01	4.36	0.01	(1)
897020	03-NOV-89, 07:22	RPLV01	3.00	0.01	(1)	TPLV01	2.89	0.01	(1)
897021	03-NOV-89, 09:48	RPLV01	3.10	0.01	(1)	TPLV01	2.96	0.02	(1)
897022	03-NOV-89, 12:42	RPLV01	3.16	0.01	(1)	TPLV01	3.07	0.02	(1)
897024	03-NOV-89, 14:40	RPLV01	2.77	0.01	(1)	TPLV01	2.74	0.02	(1)
897027	01-NOV-89, 21:42	RPLV01	4.39	0.01	(1)	TPLV01	4.40	0.02	(1)
897028	04-NOV-89, 06:45	RPLV01	2.89	0.01	(1)	TPLV01	2.87	0.01	(1)
897033	04-NOV-89, 13:25	RPLV01	3.10	0.01	(1)	TPLV01	2.98	0.02	(1)
897034	04-NOV-89, 17:34	RPLV01	2.85	0.01	(1)	TPLV01	2.82	0.01	(1)
897035	04-NOV-89, 19:19	RPLV01	2.81	0.01	(1)	TPLV01	2.77	0.01	(1)
897036	04-NOV-89, 22:04	RPLV01	2.97	0.01	(1)	TPLV01	2.79	0.02	(1)
897037	04-NOV-89, 23:48	RPLV01	3.06	0.01	(1)	TPLV01	2.90	0.01	(1)
897038	06-NOV-89, 08:05	RPLV01	6.35	0.03	(1)	TPLV01	6.45	0.02	(1)
897039	06-NOV-89, 14:47	RPLV01	4.77	0.01	(1)	TPLV01	4.64	0.02	(1)
897040	06-NOV-89, 19:53	RPLV01	3.17	0.01	(1)	TPLV01	2.87	0.01	(1)
897046	07-NOV-89, 11:25	RPLV01	6.19	0.02	(1)	TPLV01	6.35	0.02	(1)
897050	07-NOV-89, 20:24	RPLV01	5.79	0.06	(1)	TPLV01	5.86	0.03	(1)
897051	08-NOV-89, 02:16	RPLV01	3.27	0.01	(1)	TPLV01	3.03	0.01	(1)
897052	08-NOV-89, 06:15	RPLV01	3.11	0.01	(1)	TPLV01	2.99	0.01	(1)
897053	08-NOV-89, 10:20	RPLV01	6.52	0.02	(1)	TPLV01	6.45	0.02	(1)
897054	08-NOV-89, 12:52	RPLV01	4.95	0.01	(1)	TPLV01	4.89	0.02	(1)
897055	08-NOV-89, 18:41	RPLV01	8.38	0.05	(1)	TPLV01	8.43	0.06	(1)
897057	08-NOV-89, 23:24	RPLV01	8.39	0.05	(1)	TPLV01	8.43	0.06	(1)
897058	09-NOV-89, 02:35	RPLV01	8.37	0.04	(1)	TPLV01	8.43	0.06	(1)
897059	09-NOV-89, 07:05	RPLV01	4.39	0.02	(1)	TPLV01	4.30	0.01	(1)
897060	09-NOV-89, 09:35	RPLV01	4.45	0.02	(1)	TPLV01	4.31	0.01	(1)
897061	09-NOV-89, 11:20	RPLV01	4.75	0.01	(1)	TPLV01	4.66	0.01	(1)
897062	09-NOV-89, 14:08	RPLV01	6.43	0.02	(1)	TPLV01	6.43	0.01	(1)
897064	09-NOV-89, 18:57	RPLV01	6.66	0.03	(1)	TPLV01	6.50	0.02	(1)
897065	09-NOV-89, 20:43	RPLV01	5.63	0.01	(1)	TPLV01	5.48	0.03	(1)
897066	09-NOV-89, 22:22	RPLV01	5.71	0.01	(1)	TPLV01	5.43	0.02	(1)
897067	10-NOV-89, 01:54	RPLV01	5.67	0.02	(1)	TPLV01	5.50	0.03	(1)
897069	10-NOV-89, 09:11	RPLV01	7.77	0.03	(1)	TPLV01	7.73	0.06	(1)
897070	10-NOV-89, 11:25	RPLV01	7.67	0.05	(1)	TPLV01	7.77	0.04	(1)
897071	10-NOV-89, 16:04	RPLV01	7.77	0.05	(1)	TPLV01	7.80	0.05	(1)
897072	20-NOV-89, 11:23	RPLV01	8.39	0.04	(1)	TPLV01	8.45	0.05	(1)
897073	20-NOV-89, 13:35	RPLV01	7.86	0.05	(1)	TPLV01	7.75	0.06	(1)
897074	20-NOV-89, 16:06	RPLV01	6.58	0.01	(1)	TPLV01	6.68	0.02	(1)
897075	21-NOV-89, 10:42	RPLV01	6.12	0.01	(1)	TPLV01	6.08	0.02	(1)

Table 5.5 (cont'd.)

TEST NUMBER	TEST DATE/TIME	----- Reference Plenum Level -----				----- Test Plenum Level -----			
		VTAB	VALUE ("H2O)	FLUCT ("H2O)	UNC "H2O	VTAB	VALUE "H2O	FLUCT "H2O	UNC "H2O
897076	21-NOV-89, 12:26	RPLV01	6.32	0.02	(1)	TPLV01	6.43	0.03	(1)
897077	21-NOV-89, 14:05	RPLV01	4.64	0.01	(1)	TPLV01	4.91	0.02	(1)
897078	21-NOV-89, 15:38	RPLV01	4.79	0.01	(1)	TPLV01	4.86	0.02	(1)
897079	22-NOV-89, 12:08	RPLV01	4.62	0.01	(1)	TPLV01	4.49	0.01	(1)
897080	22-NOV-89, 14:31	RPLV01	3.85	0.01	(1)	TPLV01	3.83	0.01	(1)
897081	27-NOV-89, 14:43	RPLV01	6.64	0.03	(1)	TPLV01	6.51	0.02	(1)
897082	28-NOV-89, 12:23	RPLV01	4.85	0.02	(1)	TPLV01	4.87	0.01	(1)
897084	28-NOV-89, 14:41	RPLV01	4.95	0.01	(1)	TPLV01	4.97	0.01	(1)
897086	29-NOV-89, 08:05	RPLV01	4.60	0.01	(1)	TPLV01	4.71	0.02	(1)
897087	29-NOV-89, 10:08	RPLV01	3.74	0.01	(1)	TPLV01	3.77	0.02	(1)
897090	05-DEC-89, 13:53	RPLV01	4.80	0.03	(1)	TPLV01	4.80	0.02	(1)
897091	05-DEC-89, 15:24	RPLV01	4.74	0.02	(1)	TPLV01	4.78	0.02	(1)
897092	06-DEC-89, 09:36	RPLV01	4.69	0.02	(1)	TPLV01	4.72	0.02	(1)
897094	06-DEC-89, 11:14	RPLV01	4.75	0.01	(1)	TPLV01	4.78	0.02	(1)
897095	06-DEC-89, 13:42	RPLV01	4.78	0.02	(1)	TPLV01	4.81	0.02	(1)
897096	06-DEC-89, 15:48	RPLV01	4.78	0.01	(1)	TPLV01	4.85	0.02	(1)
897097	06-DEC-89, 16:54	RPLV01	4.72	0.01	(1)	TPLV01	4.81	0.02	(1)
897098	06-DEC-89, 18:30	RPLV01	4.68	0.02	(1)	TPLV01	4.70	0.02	(1)
897115	30-JAN-90, 15:31	RPLV01	2.70	0.01	(2)	TPLV01	2.62	0.01	(2)
897116	30-JAN-90, 16:14	RPLV01	2.69	0.01	(2)	TPLV01	2.60	0.01	(2)
897118	31-JAN-90, 13:31	RPLV01	4.50	0.02	(2)	TPLV01	4.47	0.01	(2)
897119	31-JAN-90, 14:57	RPLV01	4.52	0.01	(2)	TPLV01	4.49	0.01	(2)
897121	01-FEB-90, 11:52	RPLV01	6.25	0.02	(2)	TPLV01	5.93	0.03	(2)
897123	01-FEB-90, 14:08	RPLV01	6.21	0.02	(2)	TPLV01	5.75	0.02	(2)
897125	01-FEB-90, 18:01	RPLV01	4.45	0.01	(2)	TPLV01	4.42	0.01	(2)
897127	01-FEB-90, 20:30	RPLV01	4.49	0.02	(2)	TPLV01	4.46	0.02	(2)
897128	01-FEB-90, 11:48	RPLV01	4.41	0.01	(2)	TPLV01	4.36	0.02	(2)
897131	03-FEB-90, 15:04	RPLV01	4.44	0.01	(2)	TPLV01	4.41	0.02	(2)
897133	03-FEB-90, 18:48	RPLV01	6.14	0.02	(2)	TPLV01	6.07	0.02	(2)
897135	04-FEB-90, 14:56	RPLV01	6.05	0.02	(2)	TPLV01	6.03	0.03	(2)
897137	04-FEB-90, 17:10	RPLV01	6.05	0.02	(2)	TPLV01	6.05	0.03	(2)
897139	05-FEB-90, 13:07	RPLV01	8.38	0.05	(2)	TPLV01	8.39	0.05	(2)
897140	05-FEB-90, 18:02	RPLV01	4.53	0.01	(2)	TPLV01	4.51	0.02	(2)
955001	28-MAR-90, 13:12	RPLV01	N/A	N/A	N/A	TPLV01	4.51	0.02	(2)
955006	28-MAR-90, 18:30	RPLV01	N/A	N/A	N/A	TPLV01	4.50	0.02	(2)
955008	29-MAR-90, 10:34	RPLV01	N/A	N/A	N/A	TPLV01	8.39	0.06	(2)
955012	29-MAR-90, 15:06	RPLV01	N/A	N/A	N/A	TPLV01	8.38	0.06	(2)
955014	07-APR-90, 13:03	RPLV01	4.05	0.05	(2)	TPLV01	4.34	0.04	(2)
955015	07-APR-90, 15:28	RPLV01	4.75	0.05	(2)	TPLV01	4.93	0.05	(2)
955016	08-APR-90, 13:12	RPLV01	5.67	0.13	(2)	TPLV01	5.68	0.10	(2)
955017	08-APR-90, 16:58	RPLV01	4.35	0.05	(2)	TPLV01	4.47	0.05	(2)
955018	08-MAY-90, 14:51	RPLV01	4.10	0.02	0.20	TPLV01	4.06	0.01	0.20
955020	09-MAY-90, 13:05	RPLV01	4.08	0.03	0.20	TPLV01	3.88	0.02	0.20
955021	09-MAY-90, 17:45	RPLV01	6.52	0.02	0.20	TPLV01	6.67	0.04	0.20
955022	10-MAY-90, 11:18	RPLV01	5.20	0.02	0.20	TPLV01	5.33	0.03	0.20

Table 5.5 (cont'd.)

TEST NUMBER	TEST DATE/TIME	----- Reference Plenum Level -----				----- Test Plenum Level -----			
		VTAB	VALUE (*H ₂ O)	FLUCT (*H ₂ O)	UNC *H ₂ O	VTAB	VALUE *H ₂ O	FLUCT *H ₂ O	UNC *H ₂ O
955023	10-MAY-90, 14:40	RPLV01	3.97	0.01	0.20	TPLV01	3.93	0.02	0.20
955024	10-MAY-90, 19:54	RPLV01	6.49	0.02	0.20	TPLV01	6.62	0.03	0.20
958002	15-MAY-90, 14:29	RPLV01	3.62	0.02	0.20	TPLV01	3.55	0.02	0.20
958003	15-MAY-90, 18:16	RPLV01	3.35	0.01	0.20	TPLV01	3.19	0.01	0.20
958004	15-MAY-90, 12:28	RPLV01	7.31	0.02	0.20	TPLV01	7.57	0.06	0.20
958005	16-MAY-90, 16:02	RPLV01	7.16	0.07	0.20	TPLV01	7.19	0.06	0.20
958006	18-MAY-90, 15:09	RPLV01	3.65	0.01	0.20	TPLV01	3.67	0.02	0.20
958007	21-MAY-90, 19:32	RPLV01	3.79 (3)	0.03 (3)	(3)	TPLV01	3.81 (3)	0.04 (3)	(3)
958008	22-MAY-90, 17:01	RPLV01	3.66	0.01	0.20	TPLV01	3.66	0.02	0.20
958009	23-MAY-90, 15:49	RPLV01	3.75	0.01	0.20	TPLV01	3.74	0.02	0.20
958011	24-MAY-90, 14:42	RPLV01	7.60	0.02	0.20	TPLV01	7.50	0.03	0.20
958012	24-MAY-90, 21:49	RPLV01	7.62 (4)	0.03 (4)	(4)	TPLV01	7.57 (4)	0.03 (4)	(4)
958013	26-MAY-90, 15:59	RPLV01	7.48	0.02	0.20	TPLV01	7.42	0.03	0.20
958014	29-MAY-90, 10:57	RPLV01	3.74	0.01	0.20	TPLV01	3.68	0.02	0.20
958015	29-MAY-90, 14:46	RPLV01	7.50	0.02	0.20	TPLV01	7.41	0.03	0.20
958016	29-MAY-90, 17:39	RPLV01	3.64	0.01	0.20	TPLV01	3.62	0.02	0.20
958017	30-MAY-90, 10:39	RPLV01	7.44	0.02	0.20	TPLV01	7.41	0.03	0.20
958018	30-MAY-90, 15:18	RPLV01	3.62	0.03	0.20	TPLV01	3.56	0.03	0.20
958019	31-MAY-90, 10:30	RPLV01	7.26	0.09	0.20	TPLV01	7.19	0.05	0.20
958020	01-JUN-90, 11:49	RPLV01	3.72 (5)	0.05 (5)	(5)	TPLV01	3.70 (5)	0.07 (5)	(5)
958021	01-JUN-90, 17:04	RPLV01	7.52 (6)	0.08 (6)	(6)	TPLV01	7.80 (6)	0.03 (6)	(6)
958022	02-JUN-90, 14:26	RPLV01	3.73	0.01	0.20	TPLV01	3.72	0.02	0.20
958023	02-JUN-90, 19:10	RPLV01	7.59	0.02	0.20	TPLV01	7.49	0.03	0.20
958024	03-JUN-90, 14:48	RPLV01	3.67	0.01	0.20	TPLV01	3.67	0.02	0.20
958025	03-JUN-90, 22:21	RPLV01	7.47	0.02	0.20	TPLV01	7.44	0.04	0.20
958026	04-JUN-90, 15:53	RPLV01	3.73	0.01	0.20	TPLV01	3.69	0.02	0.20
958027	05-JUN-90, 12:12	RPLV01	7.39	0.03	0.20	TPLV01	7.49	0.03	0.20
958028	06-JUN-90, 16:04	RPLV01	7.48	0.03	0.20	TPLV01	7.51	0.04	0.20
958029	08-JUN-90, 14:27	RPLV01	7.57	0.02	0.20	TPLV01	7.57	0.04	0.20
958030	08-JUN-90, 22:18	RPLV01	3.22	0.03	0.20	TPLV01	3.33	0.06	0.20
958031	09-JUL-90, 12:02	RPLV01	5.42	0.02	0.20	TPLV01	5.52	0.03	0.20
958032	09-JUL-90, 17:17	RPLV01	5.48	0.01	0.20	TPLV01	5.53	0.02	0.20
958033	09-JUL-90, 23:21	RPLV01	5.44	0.02	0.20	TPLV01	5.49	0.03	0.20
958034	10-JUL-90, 02:52	RPLV01	7.47	0.03	0.20	TPLV01	7.48	0.04	0.20
958035	10-JUL-90, 22:42	RPLV01	5.46	0.02	0.20	TPLV01	5.43	0.02	0.20
958036	11-JUL-90, 01:43	RPLV01	5.44	0.01	0.20	TPLV01	5.43	0.03	0.20
958037	11-JUL-90, 04:23	RPLV01	7.49	0.02	0.20	TPLV01	7.42	0.05	0.20
958038	11-JUL-90, 15:34	RPLV01	5.62	0.01	0.20	TPLV01	5.60	0.02	0.20
958039	11-JUL-90, 21:13	RPLV01	5.59	0.02	0.20	TPLV01	5.62	0.02	0.20
958040	12-JUL-90, 00:29	RPLV01	7.72	0.03	0.20	TPLV01	7.65	0.03	0.20
958041	12-JUL-90, 14:26	RPLV01	5.44	0.01	0.20	TPLV01	5.56	0.02	0.20
958042	12-JUL-90, 17:42	RPLV01	5.51	0.01	0.20	TPLV01	5.65	0.02	0.20
958043	12-JUL-90, 20:34	RPLV01	7.77	0.02	0.20	TPLV01	7.65	0.06	0.20
964001	16-JUL-90, 11:30	RPLV01	4.06	0.01	0.20	TPLV01	4.10	0.03	0.20

Table 5.5 (cont'd.)

TEST NUMBER	TEST DATE/TIME	----- Reference Plenum Level -----				----- Test Plenum Level -----			
		VTAB	VALUE ("H ₂ O)	FLUCT ("H ₂ O)	UNC "H ₂ O	VTAB	VALUE "H ₂ O	FLUCT "H ₂ O	UNC "H ₂ O
964002	16-JUL-90, 16:06	RPLV01	3.04	0.02	0.20	TPLV01	3.08	0.03	0.20
964003	17-JUL-90, 10:44	RPLV01	4.33	0.02	0.20	TPLV01	4.38	0.04	0.20
964004	17-JUL-90, 13:50	RPLV01	4.31	0.01	0.20	TPLV01	4.35	0.02	0.20
964005	18-JUL-90, 12:05	RPLV01	5.45	0.02	0.20	TPLV01	5.43	0.02	0.20
964006	18-JUL-90, 14:47	RPLV01	6.40	0.02	0.20	TPLV01	6.45	0.02	0.20
964007	19-JUL-90, 10:34	RPLV01	7.44	0.02	0.20	TPLV01	7.39	0.03	0.20
964008	19-JUL-90, 13:38	RPLV01	8.32	0.03	0.20	TPLV01	8.20	0.05	0.20
964009	20-JUL-90, 15:20	RPLV01	4.38	0.02	0.20	TPLV01	4.39	0.03	0.20
964010	23-JUL-90, 14:24	RPLV01	4.15	0.02	0.20	TPLV01	4.24	0.03	0.20
964011	24-JUL-90, 11:32	RPLV01	5.45	0.01	0.20	TPLV01	5.42	0.02	0.20
964012	24-JUL-90, 15:19	RPLV01	6.50	0.02	0.20	TPLV01	6.52	0.04	0.20
964013	25-JUL-90, 14:06	RPLV01	8.28	0.03	0.20	TPLV01	8.12	0.06	0.20
964014	26-JUL-90, 11:51	RPLV01	3.04	0.01	0.20	TPLV01	3.08	0.02	0.20
964015	27-JUL-90, 11:44	RPLV01	4.37	0.02	0.20	TPLV01	4.38	0.03	0.20
964016	27-JUL-90, 14:18	RPLV01	4.29	0.01	0.20	TPLV01	4.29	0.03	0.20
964017	30-JUL-90, 09:51	RPLV01	4.06	0.01	0.20	TPLV01	4.10	0.02	0.20
964018	30-JUL-90, 12:35	RPLV01	5.43	0.03	0.20	TPLV01	5.38	0.03	0.20
964019	30-JUL-90, 16:15	RPLV01	5.47	0.02	0.20	TPLV01	5.43	0.02	0.20
964020	30-JUL-90, 18:39	RPLV01	5.46	0.03	0.20	TPLV01	5.45	0.05	0.20
964021	30-JUL-90, 23:00	RPLV01	6.44	0.02	0.20	TPLV01	6.44	0.02	0.20
964022	31-JUL-90, 10:47	RPLV01	7.33	0.03	0.20	TPLV01	7.37	0.05	0.20
964023	31-JUL-90, 13:56	RPLV01	7.34	0.02	0.20	TPLV01	7.34	0.05	0.20
964024	31-JUL-90, 17:38	RPLV01	6.43	0.02	0.20	TPLV01	6.42	0.02	0.20
964025	31-JUL-90, 21:44	RPLV01	2.99	0.01	0.20	TPLV01	3.03	0.04	0.20
964026	06-AUG-90, 09:56	RPLV01	4.10	0.02	0.20	TPLV01	4.07	0.02	0.20
964027	06-AUG-90, 14:35	RPLV01	3.10	0.02	0.20	TPLV01	3.05	0.04	0.20
964028	06-AUG-90, 17:22	RPLV01	3.01	0.01	0.20	TPLV01	3.04	0.02	0.20
964029	06-AUG-90, 20:19	RPLV01	8.28	0.03	0.20	TPLV01	8.16	0.04	0.20
964030	06-AUG-90, 22:49	RPLV01	8.24	0.05	0.20	TPLV01	8.12	0.06	0.20
964031	09-AUG-90, 12:24	RPLV01	4.39	0.01	0.20	TPLV01	4.36	0.03	0.20
964032	09-AUG-90, 17:04	RPLV01	4.35	0.06	0.20	TPLV01	4.41	0.04	0.20
964033	09-AUG-90, 19:43	RPLV01	4.06	0.04	0.20	TPLV01	4.18	0.03	0.20
964034	09-AUG-90, 22:05	RPLV01	5.44	0.02	0.20	TPLV01	5.48	0.03	0.20
964035	10-AUG-90, 00:07	RPLV01	5.35	0.05	0.20	TPLV01	5.39	0.03	0.20
964036	10-AUG-90, 02:21	RPLV01	4.99	0.02	0.20	TPLV01	5.25	0.03	0.20
964037	10-AUG-90, 11:37	RPLV01	6.50	0.03	0.20	TPLV01	6.50	0.04	0.20
964038	10-AUG-90, 16:23	RPLV01	6.51	0.03	0.20	TPLV01	6.45	0.03	0.20
964039	10-AUG-90, 18:53	RPLV01	6.36	0.05	0.20	TPLV01	6.41	0.04	0.20
964040	10-AUG-90, 20:55	RPLV01	6.27	0.03	0.20	TPLV01	6.25	0.03	0.20
964041	11-AUG-90, 10:46	RPLV01	7.37	0.03	0.20	TPLV01	7.32	0.05	0.20
964042	11-AUG-90, 12:36	RPLV01	7.39	0.08	0.20	TPLV01	7.28	0.06	0.20
964043	11-AUG-90, 14:39	RPLV01	7.39	0.06	0.20	TPLV01	7.37	0.07	0.20
964044	13-AUG-90, 00:34	RPLV01	7.36	0.08	0.20	TPLV01	7.31	0.08	0.20
964045	13-AUG-90, 01:41	RPLV01	7.33	0.07	0.20	TPLV01	7.32	0.05	0.20
964046	13-AUG-90, 04:41	RPLV01	7.23	0.07	0.20	TPLV01	7.16	0.05	0.20
964047	13-AUG-90, 06:35	RPLV01	4.04	0.01	0.20	TPLV01	4.12	0.02	0.20

Table 5.5 (cont'd.)

TEST NUMBER	TEST DATE/TIME	----- Reference Plenum Level -----				----- Test Plenum Level -----			
		VTAB	VALUE ("H2O)	FLUCT ("H2O)	UNC "H2O	VTAB	VALUE "H2O	FLUCT "H2O	UNC "H2O
964048	13-AUG-90, 11:59	RPLV01	8.13	0.04	0.20	TPLV01	8.08	0.06	0.20
964049	14-AUG-90, 00:12	RPLV01	8.12	0.05	0.20	TPLV01	8.07	0.06	0.20
964050	14-AUG-90, 02:02	RPLV01	7.97	0.06	0.20	TPLV01	7.98	0.06	0.20
964051	14-AUG-90, 03:50	RPLV01	7.89	0.06	0.20	TPLV01	7.87	0.06	0.20
964052	14-AUG-90, 07:52	RPLV01	3.25	0.03	0.20	TPLV01	2.95	0.02	0.20
964053	14-AUG-90, 12:29	RPLV01	2.69	0.04	0.20	TPLV01	2.81	0.09	0.20
964054	14-AUG-90, 15:49	RPLV01	2.68	0.11	0.20	TPLV01	2.81	0.10	0.20
964055	14-AUG-90, 22:54	RPLV01	5.47	0.01	0.20	TPLV01	5.47	0.04	0.20
964056	15-AUG-90, 00:42	RPLV01	6.60	0.02	0.20	TPLV01	6.49	0.03	0.20
964057	15-AUG-90, 02:43	RPLV01	7.44	0.02	0.20	TPLV01	7.38	0.04	0.20
964058	15-AUG-90, 05:13	RPLV01	8.31	0.03	0.20	TPLV01	8.13	0.05	0.20
964059	15-AUG-90, 10:33	RPLV01	3.10	0.01	0.20	TPLV01	3.18	0.02	0.20
964060	15-AUG-90, 14:12	RPLV01	2.82	0.09	0.20	TPLV01	2.79	0.12	0.20
964061	15-AUG-90, 23:56	RPLV01	7.90	0.07	0.20	TPLV01	7.90	0.06	0.20
964062	16-AUG-90, 02:36	RPLV01	4.48	0.02	0.20	TPLV01	4.46	0.03	0.20
964063	17-AUG-90, 00:24	RPLV01	3.93	0.03	0.20	TPLV01	3.97	0.02	0.20
964064	17-AUG-90, 02:33	RPLV01	7.68	0.05	0.20	TPLV01	7.60	0.06	0.20
964065	17-AUG-90, 10:02	RPLV01	2.21	0.02	0.20	TPLV01	2.26	0.06	0.20
964066	20-AUG-90, 04:24	RPLV01	2.26	0.01	0.20	TPLV01	2.30	0.03	0.20
964067	20-AUG-90, 08:48	RPLV01	2.26	0.02	0.20	TPLV01	2.34	0.02	0.20
964068	20-AUG-90, 13:18	RPLV01	1.86	0.05	0.20	TPLV01	1.94	0.05	0.20
964069	20-AUG-90, 14:57	RPLV01	4.14	0.02	0.20	TPLV01	4.19	0.03	0.20
964070	21-AUG-90, 04:36	RPLV01	FULL (7)	N/A	0.20	TPLV01	FULL (7)	N/A	0.20
964071	21-AUG-90, 08:38	RPLV01	8.31	0.11	0.20	TPLV01	8.26	0.09	0.20
964072	21-AUG-90, 12:11	RPLV01	FULL (7)	N/A	0.20	TPLV01	FULL (7)	N/A	0.20
964073	21-AUG-90, 14:41	RPLV01	8.43 (8)	0.06	0.20	TPLV01	8.30 (8)	0.07	0.20
964074	21-AUG-90, 23:42	RPLV01	1.10	0.01	0.20	TPLV01	1.17	0.02	0.20
964075	22-AUG-90, 13:23	RPLV01	8.41 (8)	0.06	0.20	TPLV01	8.30 (8)	0.06	0.20
964076	22-AUG-90, 16:06	RPLV01	8.33 (8)	0.05	0.20	TPLV01	8.26 (8)	0.07	0.20
964077	22-AUG-90, 19:07	RPLV01	1.09	0.04	0.20	TPLV01	1.14	0.04	0.20
964078	22-AUG-90, 23:36	RPLV01	0.98 (9)	0.02	(9)	TPLV01	1.03 (9)	0.03	(9)
964079	23-AUG-90, 10:18	RPLV01	5.75	0.03	0.20	TPLV01	5.89	0.04	0.20
964080	23-AUG-90, 13:02	RPLV01	2.43	0.01	0.20	TPLV01	2.50	0.02	0.20
964081	23-AUG-90, 15:37	RPLV01	4.11	0.01	0.20	TPLV01	4.26	0.02	0.20
964082	23-AUG-90, 19:03	RPLV01	5.53	0.02	0.20	TPLV01	5.58	0.03	0.20
964083	23-AUG-90, 22:10	RPLV01	5.40	0.02	0.20	TPLV01	5.50	0.03	0.20
964084	24-AUG-90, 10:23	RPLV01	6.01	0.03	0.20	TPLV01	6.13	0.04	0.20
964085	24-AUG-90, 13:47	RPLV01	7.41	0.02	0.20	TPLV01	7.47	0.05	0.20
964086	27-AUG-90, 10:13	RPLV01	4.10	0.02	0.20	TPLV01	4.20	0.04	0.20
964087	31-AUG-90, 11:14	RPLV01	6.51	0.03	0.20	TPLV01	6.56	0.03	0.20
964088	31-AUG-90, 14:00	RPLV01	6.46	0.03	0.20	TPLV01	6.33	0.03	0.20
964089	04-SEP-90, 10:27	RPLV01	4.36	0.02	0.20	TPLV01	4.41	0.02	0.20
964090	04-SEP-90, 14:06	RPLV01	3.15	0.02	0.20	TPLV01	3.17	0.04	0.20
964091	05-SEP-90, 09:10	RPLV01	4.08	0.01	0.20	TPLV01	4.14	0.02	0.20
964092	05-SEP-90, 12:39	RPLV01	2.83	0.02	0.20	TPLV01	2.91	0.03	0.20
964093	05-SEP-90, 15:07	RPLV01	4.19	0.01	0.20	TPLV01	4.33	0.02	0.20

Table 5.5 (cont'd.)

TEST NUMBER	TEST DATE TIME	----- Reference Plenum Level -----				----- Test Plenum Level -----			
		VTAB	VALUE (*H ₂ O)	FLUCT (*H ₂ O)	UNC *H ₂ O	VTAB	VALUE *H ₂ O	FLUCT *H ₂ O	UNC *H ₂ O
965001	25-JUN-90, 13:35	RPLV01	4.19	0.01	0.20	TPLV01	N/A	N/A	N/A
965002	25-JUN-90, 14:39	RPLV01	4.35	0.01	0.20	TPLV01	N/A	N/A	N/A
965003	26-JUN-90, 08:15	RPLV01	4.08	0.01	0.20	TPLV01	N/A	N/A	N/A
965004	26-JUN-90, 10:09	RPLV01	4.70	0.01	0.20	TPLV01	N/A	N/A	N/A
965005	26-JUN-90, 12:03	RPLV01	5.72	0.02	0.20	TPLV01	N/A	N/A	N/A
965006	26-JUN-90, 13:52	RPLV01	5.78	0.02	0.20	TPLV01	N/A	N/A	N/A
965007	26-JUN-90, 15:28	RPLV01	5.83	0.01	0.20	TPLV01	N/A	N/A	N/A
965008	27-JUN-90, 09:02	RPLV01	3.71	0.01	0.20	TPLV01	N/A	N/A	N/A
965009	27-JUN-90, 10:49	RPLV01	4.81	0.01	0.20	TPLV01	N/A	N/A	N/A
965010	27-JUN-90, 15:03	RPLV01	3.74	0.02	0.20	TPLV01	N/A	N/A	N/A
965011	28-JUN-90, 08:58	RPLV01	4.40	0.01	0.20	TPLV01	N/A	N/A	N/A
965012	28-JUN-90, 10:47	RPLV01	5.82	0.02	0.20	TPLV01	N/A	N/A	N/A
965013	28-JUN-90, 13:05	RPLV01	4.86	0.01	0.20	TPLV01	N/A	N/A	N/A
965014	28-JUN-90, 15:51	RPLV01	7.49	0.03	0.20	TPLV01	N/A	N/A	N/A
965015	28-JUN-90, 19:12	RPLV01	8.22	0.04	0.20	TPLV01	N/A	N/A	N/A
965016	29-JUN-90, 09:52	RPLV01	5.78	0.02	0.20	TPLV01	N/A	N/A	N/A
965017	29-JUN-90, 13:28	RPLV01	6.82	0.03	0.20	TPLV01	N/A	N/A	N/A
965018	29-JUN-90, 15:04	RPLV01	7.65	0.03	0.20	TPLV01	N/A	N/A	N/A
965019	29-JUN-90, 16:17	RPLV01	8.21	0.03	0.20	TPLV01	N/A	N/A	N/A
965020	30-JUN-90, 10:59	RPLV01	5.77	0.02	0.20	TPLV01	N/A	N/A	N/A
965021	02-JUL-90, 11:12	RPLV01	3.73	0.01	0.20	TPLV01	N/A	N/A	N/A
965022	03-JUL-90, 08:48	RPLV01	7.50	0.02	0.20	TPLV01	N/A	N/A	N/A
965023	03-JUL-90, 10:24	RPLV01	3.71	0.01	0.20	TPLV01	N/A	N/A	N/A
965024	02-JUL-90, 12:55	RPLV01	7.48	0.02	0.20	TPLV01	N/A	N/A	N/A
965025	21-JUL-90, 10:30	RPLV01	5.72	0.03	0.20	TPLV01	N/A	N/A	N/A
965026	21-JUL-90, 11:35	RPLV01	5.19	0.03	0.20	TPLV01	N/A	N/A	N/A
965027	21-JUL-90, 13:30	RPLV01	5.68	0.10	0.20	TPLV01	N/A	N/A	N/A
965028	21-JUL-90, 14:24	RPLV01	4.96	0.02	0.20	TPLV01	N/A	N/A	N/A
965034	16-AUG-90, 06:54	RPLV01	8.14	0.04	0.20	TPLV01	N/A	N/A	N/A
965035	16-AUG-90, 09:36	RPLV01	7.43	0.05	0.20	TPLV01	N/A	N/A	N/A
965036	16-AUG-90, 12:00	RPLV01	6.39	0.02	0.20	TPLV01	N/A	N/A	N/A
965037	16-AUG-90, 13:07	RPLV01	5.39	0.01	0.20	TPLV01	N/A	N/A	N/A
965038	16-AUG-90, 14:24	RPLV01	4.37	0.01	0.20	TPLV01	N/A	N/A	N/A
965039	16-AUG-90, 15:40	RPLV01	3.08	0.02	0.20	TPLV01	N/A	N/A	N/A
965040	28-AUG-90, 09:44	RPLV01	4.33	0.01	0.20	TPLV01	N/A	N/A	N/A
965041	28-AUG-90, 11:31	RPLV01	5.44	0.02	0.20	TPLV01	N/A	N/A	N/A

NOTES

- (1) The uncertainty is estimated to be ±0.55 inches (±0.20 inches). Level indication may be affected by voiding in the process tubing during test setup. Also, the plenum level may have been affected by debris collecting in the USH lower holes. It is estimated that the debris may have resulted in an increase in plenum level of up to 0.5 inches. Although this is not truly a measurement error, the uncertainty estimate has been increased to aid in comparisons with other data.

Table 5.5 (cont'd.)

TEST NUMBER	TEST DATE TIME	----- Reference Plenum Level -----				----- Test Plenum Level -----			
		VTAB	VALUE (*H ₂ O)	FLUCT (*H ₂ O)	UNC *H ₂ O	VTAB	VALUE *H ₂ O	FLUCT *H ₂ O	UNC *H ₂ O

- (2) The measurement uncertainty is estimated to be -0.70 inches/+0.20 inches. This estimate reflects the fact that the indication may have been affected by voiding in the measurement process tubing during test setup.
- (3) Hand measured reference and test assembly plenum levels are 3.31 in and 3.38 in, respectively. The measurement uncertainty is estimated to be -0.50 inches/+0.20 inches.
- (4) Hand measured reference and test assembly plenum levels are 7.25 in and 7.31 in, respectively. The measurement uncertainty is estimated to be -0.50 inches/+0.20 inches.
- (5) Hand measured reference and test assembly plenum levels are 3.38 in and 3.44 in, respectively. The measurement uncertainty is estimated to be -0.50 inches/+0.20 inches.
- (6) Hand measured reference and test assembly plenum levels are 7.25 in each. The measurement uncertainty is estimated to be -0.60 inches/+0.20 inches.
- (7) Reference and test assembly plenum levels were above measurement range which is approximately 8.5 inches.
- (8) Hand data shows plenum levels fluctuating between 8.5 in and full (8.75 in).
- (9) Hand measured reference and test assembly plenum levels are 0.69 in and 0.75 in, respectively. The measurement uncertainty is estimated to be -0.40 inches/+0.20 inches.

Table 5.6
Comparison for Tests at 24 gpm, Low Pressure Drop

Conditions : Water Flow = 24 gpm
Plenum Pressure = 0 psig
Backpressure = 60 inches
Pressure Drop = -2.2 psid

Test Number	Test Date	Water Flow Splits			Air Flows		Plenum Levels	
		Ch 2 (%)	Ch 3 (%)	Ch 4 (%)	Test (scfm)	Reference (scfm)	Test (in)	Reference (in)
897014	11/08/89	27.2	31.0	39.8	0.30	0.19	4.89	4.95
897037	11/21/89	28.7	30.4	38.7	0.30	0.12	4.90	4.60
897187	11/26/89	27.4	32.2	38.7	0.24	0.13	4.90	4.80
897118	01/31/90	29.7	26.5	41.3	0.53	0.13	4.50	4.50
897018	08/18/90	24.4	35.7	37.7	0.52	0.16	4.06	4.10
904117	07/16/90	31.9	25.2	40.2	0.54	0.12	4.10	4.00
904110	07/23/90	32.1	24.4	41.1	0.54	0.13	4.24	4.15
904117	07/30/90	30.2	27.4	39.9	0.52	0.13	4.10	4.00
904110	08/06/90	32.7	24.1	41.3	0.54	0.12	4.07	4.10
904047	08/13/90	29.6	28.4	39.6	0.54	0.14	4.12	4.04
904109	08/20/90	29.5	27.9	40.3	0.52	0.12	4.19	4.14
904100	08/27/90	29.7	28.3	40.4	0.51	0.13	4.20	4.10
904101	09/05/90	29.1	28.5	40.5	0.50	0.13	4.14	4.00

Table 5.7
Comparison for Tests at 24 gpm, Near Zero Pressure Drop

Conditions : Water Flow = 24 gpm
Plenum Pressure = +1 psig
Backpressure = 40 inches
Pressure Drop = -0.5 psid

Test Number	Test Date	<u>Water Flow Splits</u>			<u>Air Flows</u>		<u>Plenum Levels</u>	
		Ch 2 (<u>g</u>)	Ch 3 (<u>g</u>)	Ch 4 (<u>g</u>)	Test (<u>scfm</u>)	Reference (<u>scfm</u>)	Test (<u>in</u>)	Reference (<u>in</u>)
897095	12/06/89	41.0	19.8	37.3	3.16	0.30	4.80	4.80
897096	12/06/89	41.8	20.0	37.5	3.25	0.46	4.80	4.80
897140	02/05/90	22.9	34.4	42.0	3.18	0.47	4.50	4.50
955001	03/28/90	30.5	25.8	37.5	3.20	----	4.51	----
955017	04/08/90	32.9	26.7	38.8	2.85	2.37	4.47	4.35
964081	08/23/90	34.4	23.2	40.9	2.54	0.77	4.26	4.11

Table 5.8
Comparison for Tests at 40 gpm, Low Pressure Drop

Conditions _: Water Flow = 40 gpm
Plenum Pressure = 0 psig
Backpressure = 60 inches
Pressure Drop = -2.2 psid

Test Number	Test Date	<u>Water Flow Splits</u>			<u>Air Flows</u>		<u>Plenum Levels</u>	
		Ch 2	Ch 3	Ch 4	Test	Reference	Test	Reference
		(t)	(t)	(t)	(scfm)	(scfm)	(in)	(in)
897002	10/27/89	24.4	40.8	36.5	0.80	0.60	5.93	5.89
897038	11/06/89	20.0	42.1	36.5	0.62	0.51	6.40	6.40
897074	11/20/89	19.0	42.6	36.7	0.55	0.50	6.70	6.60
897081	11/27/89	19.2	42.5	37.2	0.64	0.53	6.50	6.50
897133	02/03/90	19.6	41.7	36.7	0.86	0.52	6.10	6.10
955016	04/08/90	19.8	43.0	36.4	0.92	0.58	5.68	5.67
965005	06/26/90	----	----	----	----	0.42	----	5.72

Figure 5.1 Measurement System for a Typical Instrument

ENGINEERING DATA FILES

For each test performed in the Annular Flow Distribution Facility, steady-state boundary conditions were established, then raw voltage information was stored to a computer file for each instrument for a period of several minutes. Scans of data are typically 5 seconds apart. For approximately 40 seconds, "high-speed" data was active wherein scans of data are approximately 0.2 seconds apart. An engineering units data file results for each test, and has been transmitted to WSRC. The purpose of this section is to describe the contents of the engineering units data file.

Test data is acquired on the data acquisition system described in Section 2. For each test, a raw data file is created, containing all instrument and derived quantity information (including voltmeter channels, calibration and data reduction constants, etc.), and raw voltage readings for each instrument, for each time scan. The engineering units data file is created off-line, using certified data reduction software and the raw data file as input. The data reduction software allows all or a portion of the scans in the raw data file to be "converted" to engineering units and included in the engineering data file. The engineering data file is further processed in two ways:

- compute the average value (as well as other statistical quantities) using each reading in the engineering data file, and
- strip out the data for individual instruments or derived quantities to generate "trend" plots.

The average values for the instruments are used in the summaries presented in Appendix A. The trend plots are used to evaluate instrument performance, as well as to evaluate steady-state conditions.

Figure 6.1 illustrates a portion of the engineering file which contains all the reduced data for a given test. The numbers at the right hand side (1 to 10) are not part of the file but are included to aid in describing the format of the file.

The first line, "P 23-AUG-90 13:01:42.47" includes a letter indicating the type of field followed by the date and time that the data save was initiated. The second line, "964080 82 370 370" includes the filename, the number of scanned instruments (VTABs), the total number of scans that are included in the engineering data file, and the total number of scans in the raw data file. The third line contains field type and the date and time. The fourth line contains a title indicating the date and time the instrument data base was created. The fifth line indicates the beginning of the VTAB list. Line six is the beginning of the VTAB list of 82 VTABs in this example. This list corresponds to the reduced data for the individual scans. That is, the 38th vtab (T3GP04) corresponds to the 38th value indicated under each scan (see line 9). Line seven is the beginning of the reduced data for the first scan (obtained at 13:02:03.90 hours). Line eight indicates the reduced data for the first eight VTABs for the first scan. Line 9 is the reduced data for VTABs 33 through 40. The value that is circled (0.016) corresponds to the 38th VTAB, which is shown in the VTAB list as T3GP04. Line ten is the date and time stamp for the next data scan, which was obtained five seconds later than the first. For the 964080.E00 file, a total of 370 scans were obtained.

Table 6.1
Example Engineering Data File

P 23-AUG-90 13:01:42.47
964080 82 370 370
T 23-AUG-90 13:01:42.47
VTABLE CREATED: 28-JUL-90 12:58:50
D 23-AUG-90 13:01:42.47

--- 1
--- 2
--- 3
--- 4
--- 5
--- 6

1 ASTC01 DEG F	2 TPTC01 DEG F	3 RPTC01 DEG F	4 TPMM02 GPM
5 RPMM02 GPM	6 TPMM01 GPM	7 RPMM01 GPM	8 TPGM01 SCFM
9 TPGM02 SCFM	10 RPGM01 SCFM	11 RPGM02 SCFM	12 RTGM02 SCFM
13 RTGM01 SCFM	14 T2GM01 SCFM	15 T3GM01 SCFM	16 T4GM01 SCFM
17 TPGM03 SCFM	18 RPGM03 SCFM	19 T2GM02 SCFM	20 T3GM02 SCFM
21 T4GM02 SCFM	22 RPGP01 PSIG	23 RPGP02 PSIG	24 RPGP03 PSIG
25 TPGP01 PSIG	26 TPGP02 PSIG	27 TPGP03 PSIG	28 T2GP01 PSIG
29 T3GP01 PSIG	30 T4GP01 PSIG	31 T2GP02 PSIG	32 T3GP02 PSIG
33 T4GP02 PSIG	34 T2GP03 PSIG	35 T3GP03 PSIG	36 T4GP03 PSIG
37 T2GP04 PSIG	38 T3GP04 PSIG	39 T4GP04 PSIG	40 T2GP05 PSIG
41 T3GP05 PSIG	42 T4GP05 PSIG	43 T2GP06 PSIG	44 T3GP06 PSIG
45 T4GP06 PSIG	46 R2GP06 PSIG	47 R3GP06 PSIG	48 R4GP06 PSIG
49 R2GP02 PSIG	50 R3GP02 PSIG	51 R4GP02 PSIG	52 R2GP03 PSIG
53 R3GP03 PSIG	54 R4GP03 PSIG	55 R2GP04 PSIG	56 R3GP04 PSIG
57 R4GP04 PSIG	58 R2GP05 PSIG	59 R3GP05 PSIG	60 R4GP05 PSIG
61 RTGP01 PSIG	62 T2LC01 LBM	63 T2LC02 LBM	64 T3LC01 LBM
65 T3LC02 LBM	66 T4LC01 LBM	67 T4LC02 LBM	68 R2DP01 PSI
69 R3DP01 PSI	70 R4DP01 PSI	71 R2DP02 PSI	72 R3DP02 PSI
73 R4DP02 PSI	74 RPLV01 IN-H2O	75 TPLV01 IN-H2O	76 TPMM22 LBM/HR
77 RPMM22 LBM/HR	78 TPMM21 LBM/HR	79 RPMM21 LBM/HR	80 T2LC30 LBM/HR
81 T3LC30 LBM/HR	82 T4LC30 LBM/HR		

V 23-AUG-90 13:02:03.90

69.1920	70.8114	70.8658	-0.02163	0.10994	10.0311	10.2835	-0.0371	---	7
-0.007	-0.3586	0.084	0.0102	-0.4012	-0.086	-0.065	-0.002	---	8
0.0135	0.0524	0.0473	0.0305	0.0482	-0.009	0.006	0.026		
-0.012	0.021	0.015	0.013	0.024	0.022	0.033	0.010		
0.064	0.040	0.022	0.122	0.055	0.016	0.187	0.093	---	9
0.016	0.262	0.202	0.231	0.359	0.225	0.245	0.326		
0.033	0.016	0.029	0.055	0.009	0.081	0.054	0.010		
0.143	0.056	0.018	0.244	0.871	14.2195	117.8567	11.3556		
103.9092	13.3222	122.5309	-0.0010	-0.0017	-0.0027	0.0194	0.0138		
-0.0126	2.4190	2.4739	0.0	54.9	5008.5	5134.5	0.00		
0.00	0.00								

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69.2228	70.8370	70.9067	-0.06488	0.06896	9.8899	10.2624	-0.0227	---	10
0.016	-0.2974	0.040	0.0212	-0.4460	-0.078	-0.043	0.038		
0.0581	0.0403	0.0237	0.0475	0.0879	-0.010	0.004	0.025		
-0.011	0.023	0.017	0.016	0.026	0.020	0.029	0.013		
0.094	0.046	0.025	0.153	0.057	0.019	0.176	0.081		
0.019	0.236	0.225	0.232	0.282	0.240	0.255	0.328		
0.028	0.017	0.062	0.067	0.010	0.109	0.082	0.012		
0.178	0.093	0.020	0.228	0.871	14.2195	117.8567	11.3556		
103.9592	13.3122	122.5808	-0.0002	-0.0015	-0.0012	0.0060	0.0010		
-0.0092	2.4220	2.4699	0.0	34.4	4938.0	5124.0	0.00		
36.06	28.80								

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7.0 QUALITY ASSURANCE PROGRAM

The B&W Research and Development Division quality policies are established by a Quality Assurance Manual and are further implemented by Administrative Procedures. For the Annular Flow Distribution Test, the project leader and quality administrator developed a quality assurance plan (QA Plan 88009) which identified the verification activities to be applied for the project based on the end use of the data and customer requirements. The Quality Assurance Plan was approved by the customer.

B&W Quality Assurance performed surveillances for the proof of principle, screening, and parametric test phases to ensure compliance with the requirements of the QA Plan, and thereby ensure compliance with customer quality assurance requirements. At the completion of the program, the final audit was performed by B&W Quality Assurance. All data collected for the project and included in Appendix A including proof of principle tests, sensitivity tests, air flow tests, screening tests, and parametric tests are considered "Final". This status indicates successful completion of the quality assurance process, as identified by the statement of the Quality Assurance Manager, given below.

To the best of my knowledge and belief, this project was conducted in accordance with the requirements of Quality Assurance Plan 88009 Revision 0 dated December 30, 1988.

George W. Roberts
Manager of Quality Assurance

8.0 REFERENCES

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To	A. L. KIELPINSKI - WESTINGHOUSE SAVANNAH RIVER COMPANY	
From	M. T. CHILDERTON - NUCLEAR STEAM SYSTEMS & COMPONENTS SECTION, ARC	
Cust.	WESTINGHOUSE SAVANNAH RIVER COMPANY	File No. RDD:90:4558-05-01:02
Subj.	ANNULAR FLOW DISTRIBUTION PROJECT FINAL REPORT	Date OCTOBER 31, 1990
This letter to cover one customer and one subject only		

SUMMARY

This report documents the Babcock and Wilcox (B&W) Annular Flow Distribution testing for the Savannah River Laboratory (SRL). The objective of this 2-year program was to characterize the flow distribution between annular coolant channels for the Mark-22 fuel assembly with the bottom fitting insert (BFI) in place. A description of the facility is provided, as well as a discussion of each of the 5 principle test phases. Empirical correlations of annular flow rates are presented for the tested range of fuel assembly boundary conditions.

Flow rate measurements for each annular channel were obtained by establishing "hydraulic similarity" between an instrumented fuel assembly with the BFI removed and a "reference" fuel assembly with the BFI installed. Proof of principle tests were performed to confirm the ability to establish hydraulic similarity for parallel Mark-22 fuel assemblies over the required range of test conditions, and to confirm reproducibility of test points. This test phase is the subject of the Interim Report (RDD:90:4558-05-01:01) issued in March, 1990.

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