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ORNL Rod-Bundle Heat-Transfer Test Data

Volume 3. Thermal-Hydraulic Test
Facility Experimental Data Report
for Test 3.06.6B—Transient
Film Boiling in Upflow

C. B. Mullins
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ORNL ROD BUNDLE HEAT TRANSFER TEST DATA

**VOLUME 3. THERMAL-HYDRAULIC TEST FACILITY EXPERIMENTAL
DATA REPORT FOR TEST 3.06.6B - TRANSIENT
FILM BOILING IN UPFLOW**

C. B. Mullins	S. S. Gould
D. K. Felde	D. G. Morris
A. G. Sutton	J. J. Robinson

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ORNL ROD BUNDLE HEAT TRANSFER TEST DATA

VOLUME 3. THERMAL-HYDRAULIC TEST FACILITY EXPERIMENTAL DATA REPORT FOR TEST 3.06.6B - TRANSIENT FILM BOILING IN UPFLOW

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ABSTRACT

Reduced instrument responses are presented for Thermal-Hydraulic Test Facility (THTF) Test 3.06.6B. This test was conducted by members of the Oak Ridge National Laboratory Pressurized-Water-Reactor (PWR) Blowdown Heat Transfer (BDHT) Separate-Effects Program on August 29, 1980. The objective of the program was to investigate heat transfer phenomena believed to occur in PWR's during accidents, including small and large break loss-of-coolant accidents.

Test 3.06.6B was conducted to obtain transient film boiling data in rod bundle geometry under reactor accident-type conditions. The primary purpose of this report is to make the reduced instrument responses for THTF Test 3.06.6B available. Included in the report are uncertainties in the instrument responses, calculated mass flows, and calculated rod powers.

1. INTRODUCTION

The Oak Ridge National Laboratory (ORNL) Pressurized-Water-Reactor (PWR) Blowdown Heat Transfer (BDHT) program is studying several aspects of heat transfer thought to occur in accident situations in PWR's, including dispersed flow film boiling. The study involves experimental as well as analytical efforts. The purpose of this report is to present reduced instrument responses obtained during Test 3.06.6B in the Thermal-Hydraulic Test Facility (THTF).

An analysis of Test 3.06.6B data is presented in Ref. 1.

2. THERMAL-HYDRAULIC TEST FACILITY DESCRIPTION

The THTF is a heavily instrumented nonnuclear pressurized-water loop (Fig. 1) containing 64 full-length rods (of which 60 are electrically heated) arranged in an 8 x 8 bundle. Rod diameter and pitch are typical of a PWR with 17 x 17 fuel assemblies. Figure 2 is a schematic of the THTF rod bundle cross section. Figure 3 shows a simplified cross section of a typical fuel rod simulator (FRS). Note that for axial levels A, B, C, D, E, F, and G (when a rod has thermocouples), there are three individual thermocouples spaced azimuthally around the rod. Other axial levels (e.g., F1, F2) have just one thermocouple per rod when a rod has a thermocouple at that level. The axial and radial power profile of the THTF bundle is flat. The axial locations of FRS thermocouples are shown schematically in Fig. 4. The heated length of the bundle is 3.66 m (12 ft), and there are six spacer grids in the heated length.

Figure 5 is a simplified diagram of the THTF included to help the reader visualize the facility. In the steady-state mode, fluid flows from the pump through the horizontal inlet (SHI) and vertical inlet (SVI) spool pieces, respectively. From the vertical inlet (SVI) spool piece, fluid enters the external downcomer (BI1) spool piece and then flows into the test section lower plenum. Fluid flows from the lower plenum through the heated length of the bundle, into the test section upper plenum, through the outlet spool pieces (BO1, SVD, SHD), into the main heat exchangers, and back to the inlet of the pump. The test section steady-state conditions prior to transient initiation are shown in Table 1.

Figure 6 is a more detailed diagram showing the location of pressure and differential pressure instrumentation for Test 3.06.6B. Figure 7 is a detailed diagram of the entire THTF piping system and its associated instrumentation. For a more detailed description of the THTF the reader is referred to Ref. 2.

The transient was initiated by breaking the outlet rupture disk assembly. The outlet break area was $3.135 \times 10^{-4} \text{ m}^2$ (0.003375 ft^2). A 6.35×10^{-2} -cm diam (0.25-in.) orifice was placed in the pressurizer surge line for this experiment to reduce the possibility of a flow reversal during the transient. A discussion of the transient phenomenology is given in Appendix A.

Table 1. Test section steady-state conditions

Outlet temperature	610 K (638°F)
Inlet temperature	545 K (521°F)
Average pressure	14.9 MN/m ² (2167 psi)
Mass flow	5.99 kg/s (13.2 lb _m /s)
Bundle power	~2.27 MW

Fig. 1. THTF system with instrumented spool pieces labeled.

Fig. 2. Identification of THTF heater rods, subchannel location, and inactive rods in THTF heater bundle.

Fig. 3. Cross section of a typical FRS.

Fig. 4. Axial location of spacer grid and FRS thermocouples.

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Fig. 5. Diagram of THTF.

Fig. 7. THTF instrumentation diagram.

Fig. 6. Positions of differential pressure and pressure instrumentation for THTF Test 3.06.6B

3. DATA PRESENTATION

The recorded instrument responses for THTF Test 3.03.6B are shown graphically on the microfiche in the back of this report. Three types of tables have been constructed to assist the reader in using the data. Table 2 lists instrumentation in terms of instrument function, type, and location. Included in Table 2 are headings and subheadings that refer to instrument function, type, and location; a brief description of each instrument; and an instrument application number (IAN). The IAN is a unique identifier that is associated with each instrument. The following example illustrates the format used in Table 2.

Example

BUNDLE TEMPERATURE	<u>Heading denoting function</u>
SHEATH THERMOCOUPLE	<u>Heading denoting type</u>
LEVEL A	<u>Subheading denoting location</u>
Instrument application	
<u>number</u>	<u>Instrument description</u>
TE-306-AA	SHEATH THERMOCOUPLE, ROD 6, LEVEL A

Table 3 lists instruments in the order they are shown graphically on the microfiche in the back of this report. Included in this table are the figure number, the IAN, the instrument description, the instrument range, and comments on the functionability of the instrument. There are four types of comments associated with Table 3. "Out of service" means the instrument was not expected to operate during the test. "Failed instrument" means the instrument was expected to function but failed to function properly. "Questionable" implies that the instrument could be functioning properly but that the data from such an instrument could be faulty. "Spurious spike" means the data as shown are considered accurate except where an out-of-character spike occurs.

Table 4 lists instruments alphabetically in terms of the IAN. Included in Table 4 are the the IAN, the corresponding figure number, and the instrument type code. The instrument type code is discussed in Appendix D. Table 4 coordinates the information in Tables 2 and 3. One can look up an instrument by function using Table 2; then, by using the IAN and Table 4, the associated figure number can be determined. Table 3 can be used to check the instrument status.

Table 5 is a presentation of the nomenclature used in designating thermocouples. This table together with Figs. 2 and 4 will allow the reader to locate thermocouples in the THTF test section.

The reduced instrument responses presented in this report were recorded by a computer-controlled digital data acquisition system (CCDAS). Further information on this system can be found in Ref. 2.

Graphical results and a discussion of the calculation of mass flux at various THTF spool pieces are included in Appendix B. Appendix C includes a graphical presentation of rod power for THTF Test 3.06.6B. Appendix D is devoted to discussion and calculation of uncertainties for THTF instrumentation. Appendix E provides data interpretation from the three-beam densitometer.

Fig. (continued)

Table 2

SENSOR	DESCRIPTION
BUNDLE TEMPERATURE	
SHEATH THERMOCOUPLES	
LEVEL A	
TE-306AA	SHEATH THERMOCOUPLE, ROD 6, LEVEL A, ANGLE A
TE-311AA	SHEATH THERMOCOUPLE, ROD 11, LEVEL A, ANGLE A
TE-323AA	SHEATH THERMOCOUPLE, ROD 23, LEVEL A
TE-325CA	SHEATH THERMOCOUPLE, ROD 25, LEVEL A
TE-327BA	SHEATH THERMOCOUPLE, ROD 27, LEVEL A
TE-340CA	SHEATH THERMOCOUPLE, ROD 40, LEVEL A
TE-343BA	SHEATH THERMOCOUPLE, ROD 43, LEVEL A
TE-355AA	SHEATH THERMOCOUPLE, ROD 55, LEVEL A
TE-357BA	SHEATH THERMOCOUPLE, ROD 57, LEVEL A
LEVEL B	
TE-302AB	SHEATH THERMOCOUPLE, ROD 2, LEVEL B
TE-306AB	SHEATH THERMOCOUPLE, ROD 6, LEVEL B
TE-308CB	SHEATH THERMOCOUPLE, ROD 8, LEVEL B
TE-309CB	SHEATH THERMOCOUPLE, ROD 9, LEVEL B
TE-311AB	SHEATH THERMOCOUPLE, ROD 11, LEVEL B, ANGLE A
TE-312CB	SHEATH THERMOCOUPLE, ROD 12, LEVEL B
TE-324AB	SHEATH THERMOCOUPLE, ROD 24, LEVEL B, ANGLE A
TE-325CB	SHEATH THERMOCOUPLE, ROD 25, LEVEL B
TE-326BB	SHEATH THERMOCOUPLE, ROD 26, LEVEL B
TE-327CB	SHEATH THERMOCOUPLE, ROD 27, LEVEL B
TE-329CB	SHEATH THERMOCOUPLE, ROD 29, LEVEL B
TE-330CB	SHEATH THERMOCOUPLE, ROD 30, LEVEL B
TE-335BB	SHEATH THERMOCOUPLE, ROD 35, LEVEL B
TE-339BB	SHEATH THERMOCOUPLE, ROD 39, LEVEL B
TE-340CB	SHEATH THERMOCOUPLE, ROD 40, LEVEL B
TE-341AB	SHEATH THERMOCOUPLE, ROD 41, LEVEL B
TE-343BB	SHEATH THERMOCOUPLE, ROD 43, LEVEL B
TE-344CB	SHEATH THERMOCOUPLE, ROD 44, LEVEL B
TE-349CB	SHEATH THERMOCOUPLE, ROD 49, LEVEL B
TE-351AB	SHEATH THERMOCOUPLE, ROD 51, LEVEL B
TE-355CB	SHEATH THERMOCOUPLE, ROD 55, LEVEL B
TE-357CB	SHEATH THERMOCOUPLE, ROD 57, LEVEL B
TE-361AB	SHEATH THERMOCOUPLE, ROD 61, LEVEL B
TE-362LB	SHEATH THERMOCOUPLE, ROD 62, LEVEL B, ANGLE B
TE-363CB	SHEATH THERMOCOUPLE, ROD 63, LEVEL B
LEVEL C	
TE-302BC	SHEATH THERMOCOUPLE, ROD 2, LEVEL C
TE-304AC	SHEATH THERMOCOUPLE, ROD 4, LEVEL C

Table 2 (continued)

SENSOR	DESCRIPTION
BUNDLE TEMPERATURE (CONT.)	
SHEATH THERMOCOUPLES (CONT.)	
LEVEL C (CONT.)	
TE-307AC	SHEATH THERMOCOUPLE, ROD 7, LEVEL C
TE-308BC	SHEATH THERMOCOUPLE, ROD 8, LEVEL C
TE-309AC	SHEATH THERMOCOUPLE, ROD 9, LEVEL C
TE-310CC	SHEATH THERMOCOUPLE, ROD 10, LEVEL C
TE-311CC	SHEATH THERMOCOUPLE, ROD 11, LEVEL C
TE-312BC	SHEATH THERMOCOUPLE, ROD 12, LEVEL C
TE-313BC	SHEATH THERMOCOUPLE, ROD 13, LEVEL C
TE-315AC	SHEATH THERMOCOUPLE, ROD 15, LEVEL C, ANGLE A
TE-323BC	SHEATH THERMOCOUPLE, ROD 23, LEVEL C
TE-324AC	SHEATH THERMOCOUPLE, ROD 24, LEVEL C
TE-325BC	SHEATH THERMOCOUPLE, ROD 25, LEVEL C
TE-325CC	SHEATH THERMOCOUPLE, ROD 25, LEVEL C
TE-326AC	SHEATH THERMOCOUPLE, ROD 26, LEVEL C
TE-327AC	SHEATH THERMOCOUPLE, ROD 27, LEVEL C
TE-327CC	SHEATH THERMOCOUPLE, ROD 27, LEVEL C
TE-328AC	SHEATH THERMOCOUPLE, ROD 28, LEVEL C, ANGLE A
TE-328CC	SHEATH THERMOCOUPLE, ROD 28, LEVEL C
TE-329AC	SHEATH THERMOCOUPLE, ROD 29, LEVEL C, ANGLE A
TE-329BC	SHEATH THERMOCOUPLE, ROD 29, LEVEL C
TE-330AC	SHEATH THERMOCOUPLE, ROD 30, LEVEL C, ANGLE A
TE-333AC	SHEATH THERMOCOUPLE, ROD 33, LEVEL C, ANGLE A
TE-339AC	SHEATH THERMOCOUPLE, ROD 39, LEVEL C
TE-340BC	SHEATH THERMOCOUPLE, ROD 40, LEVEL C
TE-343BC	SHEATH THERMOCOUPLE, ROD 43, LEVEL C
TE-344CC	SHEATH THERMOCOUPLE, ROD 44, LEVEL C
TE-349CC	SHEATH THERMOCOUPLE, ROD 49, LEVEL C
TE-351BC	SHEATH THERMOCOUPLE, ROD 51, LEVEL C
TE-353CC	SHEATH THERMOCOUPLE, ROD 53, LEVEL C
TE-355BC	SHEATH THERMOCOUPLE, ROD 55, LEVEL C, ANGLE B
TE-357AC	SHEATH THERMOCOUPLE, ROD 57, LEVEL C, ANGLE A
TE-357BC	SHEATH THERMOCOUPLE, ROD 57, LEVEL C
TE-359CC	SHEATH THERMOCOUPLE, ROD 59, LEVEL C
TE-361AC	SHEATH THERMOCOUPLE, ROD 61, LEVEL C
TE-362AC	SHEATH THERMOCOUPLE, ROD 62, LEVEL C, ANGLE A
TE-363BC	SHEATH THERMOCOUPLE, ROD 63, LEVEL C
LEVEL U	
TE-305BU	SHEATH THERMOCOUPLE, ROD 5, LEVEL U
TE-352AU	SHEATH THERMOCOUPLE, ROD 52, LEVEL U
TE-352BU	SHEATH THERMOCOUPLE, ROD 52, LEVEL U
TE-352CU	SHEATH THERMOCOUPLE, ROD 52, LEVEL U
TE-356BU	SHEATH THERMOCOUPLE, ROD 56, LEVEL U, ANGLE B
LEVEL H	
TE-305BH	SHEATH THERMOCOUPLE, ROD 5, LEVEL H

Table 2 (continued)

SENSOR	DESCRIPTION
BUNDLE TEMPERATURE (CONT.)	
SHEATH THERMOCOUPLES (CONT.)	
LEVEL H (CONT.)	
TE-348AH	SHEATH THERMOCOUPLE, ROD 48, LEVEL H, ANGLE A
TE-352AH	SHEATH THERMOCOUPLE, ROD 52, LEVEL H
TE-352BH	SHEATH THERMOCOUPLE, ROD 52, LEVEL H
TE-352CH	SHEATH THERMOCOUPLE, ROD 52, LEVEL H
TE-356CH	SHEATH THERMOCOUPLE, ROD 56, LEVEL H, ANGLE C
LEVEL S	
TE-305AS	SHEATH THERMOCOUPLE, ROD 6, LEVEL S, ANGLE A
TE-352AS	SHEATH THERMOCOUPLE, ROD 52, LEVEL S
TE-352BS	SHEATH THERMOCOUPLE, ROD 52, LEVEL S
TE-352CS	SHEATH THERMOCOUPLE, ROD 52, LEVEL S
TE-356BS	SHEATH THERMOCOUPLE, ROD 56, LEVEL S ANGLE B
LEVEL Y	
TE-305CY	SHEATH THERMOCOUPLE, ROD 5, LEVEL Y
TE-348AY	SHEATH THERMOCOUPLE, ROD 48, LEVEL Y, ANGLE A
TE-352AY	SHEATH THERMOCOUPLE, ROD 52, LEVEL Y
TE-352BY	SHEATH THERMOCOUPLE, ROD 52, LEVEL Y
TE-352CY	SHEATH THERMOCOUPLE, ROD 52, LEVEL Y
TE-356AY	SHEATH THERMOCOUPLE, ROD 56, LEVEL Y, ANGLE A
LEVEL D	
TE-302AD	SHEATH THERMOCOUPLE, ROD 2, LEVEL D, ANGLE A
TE-303CD	SHEATH THERMOCOUPLE, ROD 3, LEVEL D
TE-304AD	SHEATH THERMOCOUPLE, ROD 4, LEVEL D
TE-308AD	SHEATH THERMOCOUPLE, ROD 8, LEVEL D, ANGLE A
TE-308CD	SHEATH THERMOCOUPLE, ROD 8, LEVEL D, ANGLE C
TE-309CD	SHEATH THERMOCOUPLE, ROD 9, LEVEL D
TE-310BD	SHEATH THERMOCOUPLE, ROD 10, LEVEL D
TE-310CD	SHEATH THERMOCOUPLE, ROD 10, LEVEL D
TE-312CD	SHEATH THERMOCOUPLE, ROD 12, LEVEL D
TE-313CD	SHEATH THERMOCOUPLE, ROD 13, LEVEL D
TE-315AD	SHEATH THERMOCOUPLE, ROD 15, LEVEL D ANGLE A
TE-315BD	SHEATH THERMOCOUPLE, ROD 15, LEVEL D, ANGLE B
TE-316AD	SHEATH THERMOCOUPLE, ROD 16, LEVEL D
TE-318BD	SHEATH THERMOCOUPLE, ROD 18, LEVEL D, ANGLE B
TE-318CD	SHEATH THERMOCOUPLE, ROD 18, LEVEL D, ANGLE C
TE-320AD	SHEATH THERMOCOUPLE, ROD 20, LEVEL D
TE-320BD	SHEATH THERMOCOUPLE, ROD 20, LEVEL D
TE-320CD	SHEATH THERMOCOUPLE, ROD 20, LEVEL D
TE-324BD	SHEATH THERMOCOUPLE, ROD 24, LEVEL D
TE-325BD	SHEATH THERMOCOUPLE, ROD 25, LEVEL D, ANGLE B
TE-325CD	SHEATH THERMOCOUPLE, ROD 25, LEVEL D
TE-326AD	SHEATH THERMOCOUPLE, ROD 26, LEVEL D, ANGLE A
TE-326BD	SHEATH THERMOCOUPLE, ROD 26, LEVEL D, ANGLE B

Table 2 (continued)

SENSOR	DESCRIPTION
BUNDLE TEMPERATURE (CONT.)	
SHEATH THERMOCOUPLES (CONT.)	
LEVEL D (CONT.)	
TE-326CD	SHEATH THERMOCOUPLE, ROD 26, LEVEL D, ANGLE C
TE-327AD	SHEATH THERMOCOUPLE, ROD 27, LEVEL D, ANGLE A
TE-327BD	SHEATH THERMOCOUPLE, ROD 27, LEVEL D, ANGLE B
TE-327CD	SHEATH THERMOCOUPLE, ROD 27, LEVEL D
TE-328AD	SHEATH THERMOCOUPLE, ROD 28, LEVEL D
TE-328BD	SHEATH THERMOCOUPLE, ROD 28, LEVEL D
TE-328CD	SHEATH THERMOCOUPLE, ROD 28, LEVEL D
TE-329AD	SHEATH THERMOCOUPLE, ROD 29, LEVEL D
TE-329BD	SHEATH THERMOCOUPLE, ROD 29, LEVEL D
TE-329CD	SHEATH THERMOCOUPLE, ROD 29, LEVEL D
TE-330AD	SHEATH THERMOCOUPLE, ROD 30, LEVEL D, ANGLE A
TE-331CD	SHEATH THERMOCOUPLE, ROD 31, LEVEL D
TE-332CD	SHEATH THERMOCOUPLE, ROD 32, LEVEL D
TE-333AD	SHEATH THERMOCOUPLE, ROD 33, LEVEL D
TE-335BD	SHEATH THERMOCOUPLE, ROD 35, LEVEL D, ANGLE B
TE-339BD	SHEATH THERMOCOUPLE, ROD 39, LEVEL D
TE-340BD	SHEATH THERMOCOUPLE, ROD 40, LEVEL D
TE-342BD	SHEATH THERMOCOUPLE, ROD 42, LEVEL D
TE-343AD	SHEATH THERMOCOUPLE, ROD 43, LEVEL D, ANGLE A
TE-343BD	SHEATH THERMOCOUPLE, ROD 43, LEVEL D
TE-344CD	SHEATH THERMOCOUPLE, ROD 44, LEVEL D
TE-345AD	SHEATH THERMOCOUPLE, ROD 45, LEVEL D, ANGLE A
TE-345BD	SHEATH THERMOCOUPLE, ROD 45, LEVEL D
TE-349CD	SHEATH THERMOCOUPLE, ROD 49, LEVEL D
TE-351BD	SHEATH THERMOCOUPLE, ROD 51, LEVEL D
TE-355CD	SHEATH THERMOCOUPLE, ROD 55, LEVEL D
TE-357BD	SHEATH THERMOCOUPLE, ROD 57, LEVEL D, ANGLE B
TE-357CD	SHEATH THERMOCOUPLE, ROD 57, LEVEL D
TE-358AD	SHEATH THERMOCOUPLE, ROD 58, LEVEL D, ANGLE A
TE-358CD	SHEATH THERMOCOUPLE, ROD 58, LEVEL D
TE-359AD	SHEATH THERMOCOUPLE, ROD 59, LEVEL D
TE-361AD	SHEATH THERMOCOUPLE, ROD 61, LEVEL D
TE-362AD	SHEATH THERMOCOUPLE, ROD 62, LEVEL D, ANGLE A
TE-364AD	SHEATH THERMOCOUPLE, ROD 64, LEVEL D
TE-364BD	SHEATH THERMOCOUPLE, ROD 64, LEVEL D
TE-364CD	SHEATH THERMOCOUPLE, ROD 64, LEVEL D
LEVEL E	
TE-302AE	SHEATH THERMOCOUPLE, ROD 2, LEVEL E
TE-303BE	SHEATH THERMOCOUPLE, ROD 3, LEVEL E
TE-303CE	SHEATH THERMOCOUPLE, ROD 03, LEVEL E
TE-304BE	SHEATH THERMOCOUPLE, ROD 4, LEVEL E
TE-307BE	SHEATH THERMOCOUPLE, ROD 7, LEVEL E, ANGLE B
TE-307CE	SHEATH THERMOCOUPLE, ROD 7, LEVEL E
TE-310BE	SHEATH THERMOCOUPLE, ROD 10, LEVEL E

Table 2 (continued)

SENSOR	DESCRIPTION
BUNDLE TEMPERATURE (CONT.)	
SHEATH THERMOCOUPLES (CONT.)	
LEVEL E (CONT.)	
TE-312AE	SHEATH THERMOCOUPLE, ROD 12, LEVEL E, ANGLE A
TE-313AE	SHEATH THERMOCOUPLE, ROD 13, LEVEL E, ANGLE A
TE-313CE	SHEATH THERMOCOUPLE, ROD 13, LEVEL E
TE-315BE	SHEATH THERMOCOUPLE, ROD 15, LEVEL E, ANGLE B
TE-315CE	SHEATH THERMOCOUPLE, ROD 15, LEVEL E, ANGLE C
TE-316BE	SHEATH THERMOCOUPLE, ROD 16, LEVEL E, ANGLE B
TE-316CE	SHEATH THERMOCOUPLE, ROD 16, LEVEL E
TE-318AE	SHEATH THERMOCOUPLE, ROD 18, LEVEL E, ANGLE A
TE-318BE	SHEATH THERMOCOUPLE, ROD 18, LEVEL E
TE-318CE	SHEATH THERMOCOUPLE, ROD 18, LEVEL E, ANGLE C
TE-320AE	SHEATH THERMOCOUPLE, ROD 20, LEVEL E
TE-320BE	SHEATH THERMOCOUPLE, ROD 20, LEVEL E, ANGLE B
TE-320CE	SHEATH THERMOCOUPLE, ROD 20, LEVEL E
TE-324AE	SHEATH THERMOCOUPLE, ROD 24, LEVEL E, ANGLE A
TE-324CE	SHEATH THERMOCOUPLE, ROD 24, LEVEL E
TE-326AE	SHEATH THERMOCOUPLE, ROD 26, LEVEL E, ANGLE A
TE-326BE	SHEATH THERMOCOUPLE, ROD 26, LEVEL E, ANGLE B
TE-326CE	SHEATH THERMOCOUPLE, ROD 26, LEVEL E
TE-328AE	SHEATH THERMOCOUPLE, ROD 28, LEVEL E
TE-328CE	SHEATH THERMOCOUPLE, ROD 28, LEVEL E
TE-329AE	SHEATH THERMOCOUPLE, ROD 29, LEVEL E
TE-329BE	SHEATH THERMOCOUPLE, ROD 29, LEVEL E
TE-329CE	SHEATH THERMOCOUPLE, ROD 29, LEVEL E
TE-330AE	SHEATH THERMOCOUPLE, ROD 30, LEVEL E, ANGLE A
TE-330BE	SHEATH THERMOCOUPLE, ROD 30, LEVEL E, ANGLE B
TE-331CE	SHEATH THERMOCOUPLE, ROD 31, LEVEL E
TE-332AE	SHEATH THERMOCOUPLE, ROD 32, LEVEL E, ANGLE A
TE-332CE	SHEATH THERMOCOUPLE, ROD 32, LEVEL E
TE-333AE	SHEATH THERMOCOUPLE, ROD 33, LEVEL E, ANGLE A
TE-333BE	SHEATH THERMOCOUPLE, ROD 33, LEVEL E, ANGLE B
TE-333CE	SHEATH THERMOCOUPLE, ROD 33, LEVEL E
TE-335BE	SHEATH THERMOCOUPLE, ROD 35, LEVEL E
TE-342BE	SHEATH THERMOCOUPLE, ROD 42, LEVEL E
TE-344AE	SHEATH THERMOCOUPLE, ROD 44, LEVEL E, ANGLE A
TE-344CE	SHEATH THERMOCOUPLE, ROD 44, LEVEL E
TE-345AE	SHEATH THERMOCOUPLE, ROD 45, LEVEL E
TE-345BE	SHEATH THERMOCOUPLE, ROD 45, LEVEL E
TE-349AE	SHEATH THERMOCOUPLE, ROD 49, LEVEL E, ANGLE A
TE-349BE	SHEATH THERMOCOUPLE, ROD 49, LEVEL E, ANGLE B
TE-349CE	SHEATH THERMOCOUPLE, ROD 49, LEVEL E
TE-351AE	SHEATH THERMOCOUPLE, ROD 51, LEVEL E, ANGLE A
TE-351BE	SHEATH THERMOCOUPLE, ROD 51, LEVEL E, ANGLE B
TE-353AE	SHEATH THERMOCOUPLE, ROD 53, LEVEL E
TE-353BE	SHEATH THERMOCOUPLE, ROD 53, LEVEL E, ANGLE B
TE-358AE	SHEATH THERMOCOUPLE, ROD 58, LEVEL E, ANGLE A

Table 2 (continued)

SENSOR	DESCRIPTION
BUNDLE TEMPERATURE (CONT.)	
SHEATH THERMOCOUPLES (CONT.)	
LEVEL E (CONT.)	
TE-358BE	SHEATH THERMOCOUPLE, ROD 58, LEVEL E
TE-359AE	SHEATH THERMOCOUPLE, ROD 59, LEVEL E
TE-359BE	SHEATH THERMOCOUPLE, ROD 59, LEVEL E, ANGLE B
TE-359CE	SHEATH THERMOCOUPLE, ROD 59, LEVEL E
TE-361AE	SHEATH THERMOCOUPLE, ROD 61, LEVEL E, ANGLE A
TE-361BE	SHEATH THERMOCOUPLE, ROD 61, LEVEL E, ANGLE B
TE-361CE	SHEATH THERMOCOUPLE, ROD 61, LEVEL E
TE-362CE	SHEATH THERMOCOUPLE, ROD 62, LEVEL E, ANGLE C
TE-363AE	SHEATH THERMOCOUPLE, ROD 63, LEVEL E, ANGLE A
TE-363BE	SHEATH THERMOCOUPLE, ROD 63, LEVEL E
TE-364AE	SHEATH THERMOCOUPLE, ROD 64, LEVEL E, ANGLE A
TE-364BE	SHEATH THERMOCOUPLE, ROD 64, LEVEL E
TE-338E8	SHEATH THERMOCOUPLE, ROD 38, LEVEL E, SUPER LEVEL 8
TE-338E7	SHEATH THERMOCOUPLE, ROD 38, LEVEL E, SUPER LEVEL 7
TE-354E6	SHEATH THERMOCOUPLE, ROD 54, LEVEL E, SUPER LEVEL 6
TE-337E7	SHEATH THERMOCOUPLE, ROD 37, LEVEL E, SUPER LEVEL 7
TE-337E3	SHEATH THERMOCOUPLE, ROD 37, LEVEL E, SUPER LEVEL 3
TE-338E3	SHEATH THERMOCOUPLE, ROD 38, LEVEL E, SUPER LEVEL 3
TE-354E3	SHEATH THERMOCOUPLE, ROD 54, LEVEL E, SUPER LEVEL 3
TE-338E1	SHEATH THERMOCOUPLE, ROD 38, LEVEL E, SUPER LEVEL 1
TE-337E8	SHEATH THERMOCOUPLE, ROD 37, LEVEL E, SUPER LEVEL 8
TE-314E8	SHEATH THERMOCOUPLE, ROD 14, LEVEL E, SUPER LEVEL 8
TE-314E7	SHEATH THERMOCOUPLE, ROD 14, LEVEL E, SUPER LEVEL 7
TE-314E3	SHEATH THERMOCOUPLE, ROD 14, LEVEL E, SUPER LEVEL 3
TE-314E1	SHEATH THERMOCOUPLE, ROD 14, LEVEL E, SUPER LEVEL 1
TE-354E2	SHEATH THERMOCOUPLE, ROD 54, LEVEL E, SUPER LEVEL 2
TE-301E3	SHEATH THERMOCOUPLE, ROD 01, LEVEL E, SUPER LEVEL 3
TE-321E3	SHEATH THERMOCOUPLE, ROD 21, LEVEL E, SUPER LEVEL 3
TE-301E8	SHEATH THERMOCOUPLE, ROD 01, LEVEL E, SUPER LEVEL 8
TE-360E3	SHEATH THERMOCOUPLE, ROD 60, LEVEL E, SUPER LEVEL 3
TE-360E2	SHEATH THERMOCOUPLE, ROD 60, LEVEL E, SUPER LEVEL 2
TE-334E8	SHEATH THERMOCOUPLE, ROD 34, LEVEL E, SUPER LEVEL 8
TE-334E7	SHEATH THERMOCOUPLE, ROD 34, LEVEL E, SUPER LEVEL 7
TE-334E3	SHEATH THERMOCOUPLE, ROD 34, LEVEL E, SUPER LEVEL 3
TE-350E7	SHEATH THERMOCOUPLE, ROD 50, LEVEL E, SUPER LEVEL 7
TE-350E3	SHEATH THERMOCOUPLE, ROD 50, LEVEL E, SUPER LEVEL 3
TE-350E1	SHEATH THERMOCOUPLE, ROD 50, LEVEL E, SUPER LEVEL 1
TE-360E6	SHEATH THERMOCOUPLE, ROD 60, LEVEL E, SUPER LEVEL 6
TE-317E3	SHEATH THERMOCOUPLE, ROD 17, LEVEL E, SUPER LEVEL 3
TE-321E6	SHEATH THERMOCOUPLE, ROD 21, LEVEL E, SUPER LEVEL 6
TE-301E1	SHEATH THERMOCOUPLE, ROD 01, LEVEL E, SUPER LEVEL 1
TE-321E2	SHEATH THERMOCOUPLE, ROD 21, LEVEL E, SUPER LEVEL 2
TE-301E7	SHEATH THERMOCOUPLE, ROD 01, LEVEL E, SUPER LEVEL 7

LEVEL F

Table 2 (continued)

SENSOR	DESCRIPTION
BUNDLE TEMPERATURE (CONT.)	
SHEATH THERMOCOUPLES (CONT.)	
LEVEL F (CONT.)	
TE-301AF	SHEATH THERMOCOUPLE, ROD 01, LEVEL F, ANGLE A
TE-303BF	SHEATH THERMOCOUPLE, ROD 3, LEVEL F
TE-304AF	SHEATH THERMOCOUPLE, ROD 4, LEVEL F, ANGLE A
TE-307AF	SHEATH THERMOCOUPLE, ROD 7, LEVEL F
TE-307BF	SHEATH THERMOCOUPLE, ROD 7, LEVEL F, ANGLE B
TE-310AF	SHEATH THERMOCOUPLE, ROD 10, LEVEL F
TE-310BF	SHEATH THERMOCOUPLE, ROD 10, LEVEL F, ANGLE B
TE-310CF	SHEATH THERMOCOUPLE, ROD 10, LEVEL F, ANGLE C
TE-313BF	SHEATH THERMOCOUPLE, ROD 13, LEVEL F
TE-313CF	SHEATH THERMOCOUPLE, ROD 13, LEVEL F, ANGLE C
TE-314AF	SHEATH THERMOCOUPLE, ROD 14, LEVEL F, ANGLE A
TE-315AF	SHEATH THERMOCOUPLE, ROD 15, LEVEL F, ANGLE A
TE-316BF	SHEATH THERMOCOUPLE, ROD 16, LEVEL F
TE-317AF	SHEATH THERMOCOUPLE, ROD 17, LEVEL F, ANGLE A
TE-318AF	SHEATH THERMOCOUPLE, ROD 18, LEVEL F
TE-318CF	SHEATH THERMOCOUPLE, ROD 18, LEVEL F, ANGLE C
TE-320AF	SHEATH THERMOCOUPLE, ROD 20, LEVEL F
TE-320BF	SHEATH THERMOCOUPLE, ROD 20, LEVEL F
TE-320CF	SHEATH THERMOCOUPLE, ROD 20, LEVEL F
TE-321AF	SHEATH THERMOCOUPLE, ROD 21, LEVEL F, ANGLE A
TE-328AF	SHEATH THERMOCOUPLE, ROD 28, LEVEL F
TE-328BF	SHEATH THERMOCOUPLE, ROD 28, LEVEL F
TE-328CF	SHEATH THERMOCOUPLE, ROD 28, LEVEL F
TE-331BF	SHEATH THERMOCOUPLE, ROD 31, LEVEL F, ANGLE B
TE-331CF	SHEATH THERMOCOUPLE, ROD 31, LEVEL F
TE-332CF	SHEATH THERMOCOUPLE, ROD 32, LEVEL F
TE-334AF	SHEATH THERMOCOUPLE, ROD 34, LEVEL F, ANGLE A
TE-337AF	SHEATH THERMOCOUPLE, ROD 37, LEVEL F, ANGLE A
TE-338AF	SHEATH THERMOCOUPLE, ROD 38, LEVEL F, ANGLE A
TE-342BF	SHEATH THERMOCOUPLE, ROD 42, LEVEL F
TE-345AF	SHEATH THERMOCOUPLE, ROD 45, LEVEL F
TE-345BF	SHEATH THERMOCOUPLE, ROD 45, LEVEL F
TE-345CF	SHEATH THERMOCOUPLE, ROD 45, LEVEL F
TE-347CF	SHEATH THERMOCOUPLE, ROD 47, LEVEL F, ANGLE C
TE-353BF	SHEATH THERMOCOUPLE, ROD 59, LEVEL F, ANGLE B
TE-354AF	SHEATH THERMOCOUPLE, ROD 54, LEVEL F, ANGLE A
TE-358BF	SHEATH THERMOCOUPLE, ROD 58, LEVEL F, ANGLE A
TE-359AF	SHEATH THERMOCOUPLE, ROD 59, LEVEL F, ANGLE A
TE-359BF	SHEATH THERMOCOUPLE, ROD 59, LEVEL F, ANGLE B
TE-359CF	SHEATH THERMOCOUPLE, ROD 59, LEVEL F
TE-360AF	SHEATH THERMOCOUPLE, ROD 60, LEVEL F, ANGLE A
TE-364AF	SHEATH THERMOCOUPLE, ROD 64, LEVEL F
TE-364BF	SHEATH THERMOCOUPLE, ROD 64, LEVEL F
TE-364CF	SHEATH THERMOCOUPLE, ROD 64, LEVEL F
TE-354F8	SHEATH THERMOCOUPLE, ROD 54, LEVEL F, SUPER LEVEL 8

Table 2 (continued)

SENSOR	DESCRIPTION
BUNDLE TEMPERATURE (CONT.)	
SHEATH THERMOCOUPLES (CONT.)	
LEVEL F (CONT.)	
TE-354F7	SHEATH THERMOCOUPLE, ROD 54, LEVEL F, SUPER LEVEL 7
TE-354F6	SHEATH THERMOCOUPLE, ROD 54, LEVEL F, SUPER LEVEL 6
TE-354F5	SHEATH THERMOCOUPLE, ROD 54, LEVEL F, SUPER LEVEL 5
TE-354F1	SHEATH THERMOCOUPLE, ROD 54, LEVEL F, SUPER LEVEL 1
TE-338F1	SHEATH THERMOCOUPLE, ROD 38, LEVEL F, SUPER LEVEL 1
TE-337F8	SHEATH THERMOCOUPLE, ROD 37, LEVEL F, SUPER LEVEL 8
TE-337F7	SHEATH THERMOCOUPLE, ROD 37, LEVEL F, SUPER LEVEL 7
TE-337F6	SHEATH THERMOCOUPLE, ROD 37, LEVEL F, SUPER LEVEL 6
TE-334F6	SHEATH THERMOCOUPLE, ROD 34, LEVEL F, SUPER LEVEL 6
TE-334F3	SHEATH THERMOCOUPLE, ROD 34, LEVEL F, SUPER LEVEL 3
TE-360F6	SHEATH THERMOCOUPLE, ROD 60, LEVEL F, SUPER LEVEL 6
TE-360F5	SHEATH THERMOCOUPLE, ROD 60, LEVEL F, SUPER LEVEL 5
TE-360F4	SHEATH THERMOCOUPLE, ROD 60, LEVEL F, SUPER LEVEL 4
TE-338F2	SHEATH THERMOCOUPLE, ROD 38, LEVEL F, SUPER LEVEL 2
TE-338F6	SHEATH THERMOCOUPLE, ROD 38, LEVEL F, SUPER LEVEL 6
TE-338F7	SHEATH THERMOCOUPLE, ROD 38, LEVEL F, SUPER LEVEL 7
TE-350F6	SHEATH THERMOCOUPLE, ROD 50, LEVEL F, SUPER LEVEL 6
TE-350F2	SHEATH THERMOCOUPLE, ROD 50, LEVEL F, SUPER LEVEL 2
TE-350F1	SHEATH THERMOCOUPLE, ROD 50, LEVEL F, SUPER LEVEL 1
TE-321F7	SHEATH THERMOCOUPLE, ROD 21, LEVEL F, SUPER LEVEL 7
TE-321F6	SHEATH THERMOCOUPLE, ROD 21, LEVEL F, SUPER LEVEL 6
TE-321F4	SHEATH THERMOCOUPLE, ROD 21, LEVEL F, SUPER LEVEL 4
TE-321F3	SHEATH THERMOCOUPLE, ROD 21, LEVEL F, SUPER LEVEL 3
TE-314F2	SHEATH THERMOCOUPLE, ROD 14, LEVEL F, SUPER LEVEL 2
TE-314F8	SHEATH THERMOCOUPLE, ROD 14, LEVEL F, SUPER LEVEL 8
TE-314F7	SHEATH THERMOCOUPLE, ROD 14, LEVEL F, SUPER LEVEL 7
TE-317F2	SHEATH THERMOCOUPLE, ROD 17, LEVEL F, SUPER LEVEL 2
TE-317F8	SHEATH THERMOCOUPLE, ROD 17, LEVEL F, SUPER LEVEL 8
TE-317F7	SHEATH THERMOCOUPLE, ROD 17, LEVEL F, SUPER LEVEL 7
TE-317F6	SHEATH THERMOCOUPLE, ROD 17, LEVEL F, SUPER LEVEL 6
TE-317F3	SHEATH THERMOCOUPLE, ROD 17, LEVEL F, SUPER LEVEL 3
TE-301F1	SHEATH THERMOCOUPLE, ROD 01, LEVEL F, SUPER LEVEL 1
TE-301F6	SHEATH THERMOCOUPLE, ROD 01, LEVEL F, SUPER LEVEL 6
TE-301F3	SHEATH THERMOCOUPLE, ROD 01, LEVEL F, SUPER LEVEL 3
TE-301F2	SHEATH THERMOCOUPLE, ROD 01, LEVEL F, SUPER LEVEL 2
TE-354F4	SHEATH THERMOCOUPLE, ROD 54, LEVEL F, SUPER LEVEL 4
TE-354F3	SHEATH THERMOCOUPLE, ROD 54, LEVEL F, SUPER LEVEL 3
TE-334F8	SHEATH THERMOCOUPLE, ROD 34, LEVEL F, SUPER LEVEL 8
TE-334F2	SHEATH THERMOCOUPLE, ROD 34, LEVEL F, SUPER LEVEL 2
TE-334F1	SHEATH THERMOCOUPLE, ROD 34, LEVEL F, SUPER LEVEL 1
TE-360F8	SHEATH THERMOCOUPLE, ROD 60, LEVEL F, SUPER LEVEL 8
TE-360F7	SHEATH THERMOCOUPLE, ROD 60, LEVEL F, SUPER LEVEL 7
TE-360F3	SHEATH THERMOCOUPLE, ROD 60, LEVEL F, SUPER LEVEL 3
TE-350F8	SHEATH THERMOCOUPLE, ROD 50, LEVEL F, SUPER LEVEL 8
TE-321F1	SHEATH THERMOCOUPLE, ROD 21, LEVEL F, SUPER LEVEL 1

Table 2 (continued)

SENSOR	DESCRIPTION						
BUNDLE TEMPERATURE (CONT.)							
SHEATH THERMOCOUPLES (CONT.)							
LEVEL F (CONT.)							
TE-350F7	SHEATH	THERMOCOUPLE,	ROD 50,	LEVEL F,	SUPER	LEVEL	7
TE-350F3	SHEATH	THERMOCOUPLE,	ROD 50,	LEVEL F,	SUPER	LEVEL	3
TE-337F1	SHEATH	THERMOCOUPLE,	ROD 37,	LEVEL F,	SUPER	LEVEL	1
TE-314F6	SHEATH	THERMOCOUPLE,	ROD 14,	LEVEL F,	SUPER	LEVEL	6
TE-314F3	SHEATH	THERMOCOUPLE,	ROD 14,	LEVEL F,	SUPER	LEVEL	3
TE-338F8	SHEATH	THERMOCOUPLE,	ROD 38,	LEVEL F,	SUPER	LEVEL	8
TE-317F1	SHEATH	THERMOCOUPLE,	ROD 17,	LEVEL F,	SUPER	LEVEL	1
TE-321F8	SHEATH	THERMOCOUPLE,	ROD 21,	LEVEL F,	SUPER	LEVEL	8
TE-321F5	SHEATH	THERMOCOUPLE,	ROD 21,	LEVEL F,	SUPER	LEVEL	5
TE-301F7	SHEATH	THERMOCOUPLE,	ROD 01,	LEVEL F,	SUPER	LEVEL	7
TE-301F8	SHEATH	THERMOCOUPLE,	ROD 01,	LEVEL F,	SUPER	LEVEL	8
TE-334F7	SHEATH	THERMOCOUPLE,	ROD 34,	LEVEL F,	SUPER	LEVEL	7
TE-338F3	SHEATH	THERMOCOUPLE,	ROD 38,	LEVEL F,	SUPER	LEVEL	3
LEVEL G							
TE-301AG	SHEATH	THERMOCOUPLE,	ROD 01,	LEVEL G,	ANGLE A		
TE-303CG	SHEATH	THERMOCOUPLE,	ROD 3,	LEVEL G,			
TE-314AG	SHEATH	THERMOCOUPLE,	ROD 14,	LEVEL G,	ANGLE A		
TE-316BG	SHEATH	THERMOCOUPLE,	ROD 16,	LEVEL G,	ANGLE B		
TE-316CG	SHEATH	THERMOCOUPLE,	ROD 16,	LEVEL G,			
TE-317AG	SHEATH	THERMOCOUPLE,	ROD 17,	LEVEL G,	ANGLE A		
TE-318AG	SHEATH	THERMOCOUPLE,	ROD 18,	LEVEL G,	ANGLE A		
TE-318BG	SHEATH	THERMOCOUPLE,	ROD 18,	LEVEL G,			
TE-318CG	SHEATH	THERMOCOUPLE,	ROD 18,	LEVEL G,	ANGLE C		
TE-320AG	SHEATH	THERMOCOUPLE,	ROD 20,	LEVEL G,			
TE-320BG	SHEATH	THERMOCOUPLE,	ROD 20,	LEVEL G,	ANGLE B		
TE-320CG	SHEATH	THERMOCOUPLE,	ROD 20,	LEVEL G,			
TE-321AG	SHEATH	THERMOCOUPLE,	ROD 21,	LEVEL G,	ANGLE A		
TE-332CG	SHEATH	THERMOCOUPLE,	ROD 32,	LEVEL G,			
TE-334AG	SHEATH	THERMOCOUPLE,	ROD 34,	LEVEL G,	ANGLE A		
TE-337AG	SHEATH	THERMOCOUPLE,	ROD 37,	LEVEL G,	ANGLE A		
TE-338AG	SHEATH	THERMOCOUPLE,	ROD 38,	LEVEL G,	ANGLE A		
TE-342AG	SHEATH	THERMOCOUPLE,	ROD 42,	LEVEL G,			
TE-342BG	SHEATH	THERMOCOUPLE,	ROD 42,	LEVEL G,	ANGLE B		
TE-342CG	SHEATH	THERMOCOUPLE,	ROD 42,	LEVEL G,			
TE-345AG	SHEATH	THERMOCOUPLE,	ROD 45,	LEVEL G,			
TE-345BG	SHEATH	THERMOCOUPLE,	ROD 45,	LEVEL G,			
TE-345CG	SHEATH	THERMOCOUPLE,	ROD 45,	LEVEL G,			
TE-347CG	SHEATH	THERMOCOUPLE,	ROD 47,	LEVEL G,			
TE-350AG	SHEATH	THERMOCOUPLE,	ROD 50,	LEVEL G,	ANGLE A		
TE-354AG	SHEATH	THERMOCOUPLE,	ROD 54,	LEVEL G,	ANGLE A		
TE-358CG	SHEATH	THERMOCOUPLE,	ROD 58,	LEVEL G,			
TE-360AG	SHEATH	THERMOCOUPLE,	ROD 60,	LEVEL G,	ANGLE A		
TE-364AG	SHEATH	THERMOCOUPLE,	ROD 64,	LEVEL G,			
TE-364CG	SHEATH	THERMOCOUPLE,	ROD 64,	LEVEL G,			

Table 2 (continued)

SENSOR	DESCRIPTION
BUNDLE TEMPERATURE (CONT.)	
SHEATH THERMOCOUPLES (CONT.)	
LEVEL J	
TE-361CJ	SHEATH THERMOCOUPLE, ROD 61, LEVEL J
TE-361BJ	SHEATH THERMOCOUPLE, ROD 61, LEVEL J
MIDDLE THERMOCOUPLES	
LEVEL A	
TE-306MA	MIDDLE THERMOCOUPLE, ROD 6, LEVEL A
TE-311MA	MIDDLE THERMOCOUPLE, ROD 11, LEVEL A
TE-325MA	MIDDLE THERMOCOUPLE, ROD 25, LEVEL A
TE-340MA	MIDDLE THERMOCOUPLE, ROD 40, LEVEL A
TE-341MA	MIDDLE THERMOCOUPLE, ROD 41, LEVEL A
TE-355MA	MIDDLE THERMOCOUPLE, ROD 55, LEVEL A
TE-357MA	MIDDLE THERMOCOUPLE, ROD 57, LEVEL A
LEVEL B	
TE-302MB	MIDDLE THERMOCOUPLE, ROD 2, LEVEL B
TE-308MB	MIDDLE THERMOCOUPLE, ROD 8, LEVEL B
TE-309MB	MIDDLE THERMOCOUPLE, ROD 9, LEVEL B
TE-312MB	MIDDLE THERMOCOUPLE, ROD 12, LEVEL B
TE-325MB	MIDDLE THERMOCOUPLE, ROD 25, LEVEL B
TE-327MB	MIDDLE THERMOCOUPLE, ROD 27, LEVEL B
TE-329MB	MIDDLE THERMOCOUPLE, ROD 29, LEVEL B
TE-330MB	MIDDLE THERMOCOUPLE, ROD 30, LEVEL B
TE-335MB	MIDDLE THERMOCOUPLE, ROD 35, LEVEL B
TE-339MB	MIDDLE THERMOCOUPLE, ROD 39, LEVEL B
TE-340MB	MIDDLE THERMOCOUPLE, ROD 40, LEVEL B
TE-341MB	MIDDLE THERMOCOUPLE, ROD 41, LEVEL B
TE-344MB	MIDDLE THERMOCOUPLE, ROD 44, LEVEL B
TE-349MB	MIDDLE THERMOCOUPLE, ROD 49, LEVEL B
TE-355MB	MIDDLE THERMOCOUPLE, ROD 55, LEVEL B
TE-357MB	MIDDLE THERMOCOUPLE, ROD 57, LEVEL B
TE-361MB	MIDDLE THERMOCOUPLE, ROD 61, LEVEL B
TE-363MB	MIDDLE THERMOCOUPLE, ROD 63, LEVEL B
LEVEL C	
TE-302MC	MIDDLE THERMOCOUPLE, ROD 2, LEVEL C
TE-304MC	MIDDLE THERMOCOUPLE, ROD 4, LEVEL C
TE-306MC	MIDDLE THERMOCOUPLE, ROD 6, LEVEL C
TE-307MC	MIDDLE THERMOCOUPLE, ROD 7, LEVEL C
TE-308MC	MIDDLE THERMOCOUPLE, ROD 8, LEVEL C
TE-309MC	MIDDLE THERMOCOUPLE, ROD 9, LEVEL C
TE-310MC	MIDDLE THERMOCOUPLE, ROD 10, LEVEL C
TE-311MC	MIDDLE THERMOCOUPLE, ROD 11, LEVEL C
TE-312MC	MIDDLE THERMOCOUPLE, ROD 12, LEVEL C

Table 2 (continued)

SENSOR	DESCRIPTION			

BUNDLE TEMPERATURE (CONT.)				
MIDDLE THERMOCOUPLES (CONT.)				
LEVEL C (CONT.)				
TE-315MC	MIDDLE THERMOCOUPLE,	ROD 15,	LEVEL C	
TE-324MC	MIDDLE THERMOCOUPLE,	ROD 24,	LEVEL C	
TE-325MC	MIDDLE THERMOCOUPLE,	ROD 25,	LEVEL C	
TE-326MC	MIDDLE THERMOCOUPLE,	ROD 26,	LEVEL C	
TE-328MC	MIDDLE THERMOCOUPLE,	ROD 28,	LEVEL C	
TE-329MC	MIDDLE THERMOCOUPLE,	ROD 29,	LEVEL C	
TE-330MC	MIDDLE THERMOCOUPLE,	ROD 30,	LEVEL C	
TE-333MC	MIDDLE THERMOCOUPLE,	ROD 33,	LEVEL C	
TE-335MC	MIDDLE THERMOCOUPLE,	ROD 35,	LEVEL C	
TE-339MC	MIDDLE THERMOCOUPLE,	ROD 39,	LEVEL C	
TE-340MC	MIDDLE THERMOCOUPLE,	ROD 40,	LEVEL C	
TE-341MC	MIDDLE THERMOCOUPLE,	ROD 41,	LEVEL C	
TE-344MC	MIDDLE THERMOCOUPLE,	ROD 44,	LEVEL C	
TE-349MC	MIDDLE THERMOCOUPLE,	ROD 49,	LEVEL C	
TE-351MC	MIDDLE THERMOCOUPLE,	ROD 51,	LEVEL C	
TE-353MC	MIDDLE THERMOCOUPLE,	ROD 53,	LEVEL C	
TE-355MC	MIDDLE THERMOCOUPLE,	ROD 55,	LEVEL C	
TE-357MC	MIDDLE THERMOCOUPLE,	ROD 57,	LEVEL C	
TE-359MC	MIDDLE THERMOCOUPLE,	ROD 59,	LEVEL C	
TE-361MC	MIDDLE THERMOCOUPLE,	ROD 61,	LEVEL C	
TE-363MC	MIDDLE THERMOCOUPLE,	ROD 63,	LEVEL C	
LEVEL U				
TE-305MU	MIDDLE THERMOCOUPLE,	ROD 5,	LEVEL U	
TE-348MU	MIDDLE THERMOCOUPLE,	ROD 48,	LEVEL U	
TE-352MU	MIDDLE THERMOCOUPLE,	ROD 52,	LEVEL U	
LEVEL H				
TE-305MH	MIDDLE THERMOCOUPLE,	ROD 5,	LEVEL H	
TE-348MH	MIDDLE THERMOCOUPLE,	ROD 48,	LEVEL H	
TE-352MH	MIDDLE THERMOCOUPLE,	ROD 52,	LEVEL H	
TE-356MH	MIDDLE THERMOCOUPLE,	ROD 56,	LEVEL H	
LEVEL S				
TE-305MS	MIDDLE THERMOCOUPLE,	ROD 5,	LEVEL S	
TE-348MS	MIDDLE THERMOCOUPLE,	ROD 48,	LEVEL S	
TE-352MS	MIDDLE THERMOCOUPLE,	ROD 52,	LEVEL S	
TE-356MS	MIDDLE THERMOCOUPLE,	ROD 56,	LEVEL S	
LEVEL Y				
TE-305MY	MIDDLE THERMOCOUPLE,	ROD 5,	LEVEL Y	
TE-348MY	MIDDLE THERMOCOUPLE,	ROD 48,	LEVEL Y	
TE-352MY	MIDDLE THERMOCOUPLE,	ROD 52,	LEVEL Y	
LEVEL D				

Table 2 (continued)

SENSOR	DESCRIPTION
BUNDLE TEMPERATURE (CONT.)	
MIDDLE THERMOCOUPLES (CONT.)	
LEVEL D (CONT.)	
TE-302MD	MIDDLE THERMOCOUPLE, ROD 2, LEVEL D
TE-303MD	MIDDLE THERMOCOUPLE, ROD 3, LEVEL D
TE-304MD	MIDDLE THERMOCOUPLE, ROD 4, LEVEL D
TE-306MD	MIDDLE THERMOCOUPLE, ROD 6, LEVEL D
TE-307MD	MIDDLE THERMOCOUPLE, ROD 7, LEVEL D
TE-308MD	MIDDLE THERMOCOUPLE, ROD 8, LEVEL D
TE-310MD	MIDDLE THERMOCOUPLE, ROD 10, LEVEL D
TE-311MD	MIDDLE THERMOCOUPLE, ROD 11, LEVEL D
TE-312MD	MIDDLE THERMOCOUPLE, ROD 12, LEVEL D
TE-315MD	MIDDLE THERMOCOUPLE, ROD 15, LEVEL D
TE-316MD	MIDDLE THERMOCOUPLE, ROD 16, LEVEL D
TE-318MD	MIDDLE THERMOCOUPLE, ROD 18, LEVEL D
TE-320MD	MIDDLE THERMOCOUPLE, ROD 20, LEVEL D
TE-324MD	MIDDLE THERMOCOUPLE, ROD 24, LEVEL D
TE-325MD	MIDDLE THERMOCOUPLE, ROD 25, LEVEL D
TE-326MD	MIDDLE THERMOCOUPLE, ROD 26, LEVEL D
TE-328MD	MIDDLE THERMOCOUPLE, ROD 28, LEVEL D
TE-329MD	MIDDLE THERMOCOUPLE, ROD 29, LEVEL D
TE-332MD	MIDDLE THERMOCOUPLE, ROD 32, LEVEL D
TE-335MD	MIDDLE THERMOCOUPLE, ROD 35, LEVEL D
TE-339MD	MIDDLE THERMOCOUPLE, ROD 39, LEVEL D
TE-341MD	MIDDLE THERMOCOUPLE, ROD 41, LEVEL D
TE-345MD	MIDDLE THERMOCOUPLE, ROD 45, LEVEL D
TE-347MD	MIDDLE THERMOCOUPLE, ROD 47, LEVEL D
TE-349MD	MIDDLE THERMOCOUPLE, ROD 49, LEVEL D
TE-353MD	MIDDLE THERMOCOUPLE, ROD 53, LEVEL D
TE-355MD	MIDDLE THERMOCOUPLE, ROD 55, LEVEL D
TE-357MD	MIDDLE THERMOCOUPLE, ROD 57, LEVEL D
TE-358MD	MIDDLE THERMOCOUPLE, ROD 58, LEVEL D
TE-361MD	MIDDLE THERMOCOUPLE, ROD 61, LEVEL D
TE-363MD	MIDDLE THERMOCOUPLE, ROD 63, LEVEL D
TE-364MD	MIDDLE THERMOCOUPLE, ROD 64, LEVEL D
LEVEL E	
TE-303ME	MIDDLE THERMOCOUPLE, ROD 3, LEVEL E
TE-304ME	MIDDLE THERMOCOUPLE, ROD 4, LEVEL E
TE-307ME	MIDDLE THERMOCOUPLE, ROD 7, LEVEL E
TE-310ME	MIDDLE THERMOCOUPLE, ROD 10, LEVEL E
TE-312ME	MIDDLE THERMOCOUPLE, ROD 12, LEVEL E
TE-315ME	MIDDLE THERMOCOUPLE, ROD 15, LEVEL E
TE-316ME	MIDDLE THERMOCOUPLE, ROD 16, LEVEL E
TE-318ME	MIDDLE THERMOCOUPLE, ROD 18, LEVEL E
TE-324ME	MIDDLE THERMOCOUPLE, ROD 24, LEVEL E
TE-326ME	MIDDLE THERMOCOUPLE, ROD 26, LEVEL E
TE-328ME	MIDDLE THERMOCOUPLE, ROD 28, LEVEL E

Table 2 (continued)

SENSOR	DESCRIPTION
BUNDLE TEMPERATURE (CONT.)	
MIDDLE THERMOCOUPLES (CONT.)	
LEVEL E (CONT.)	
1E-329ME	MIDDLE THERMOCOUPLE, ROD 29, LEVEL E
1E-330ME	MIDDLE THERMOCOUPLE, ROD 30, LEVEL E
TE-332ME	MIDDLE THERMOCOUPLE, ROD 32, LEVEL E
TE-335ME	MIDDLE THERMOCOUPLE, ROD 35, LEVEL E
TE-339ME	MIDDLE THERMOCOUPLE, ROD 39, LEVEL E
TE-344ME	MIDDLE THERMOCOUPLE, ROD 44, LEVEL E
TE-345ME	MIDDLE THERMOCOUPLE, ROD 45, LEVEL E
TE-347ME	MIDDLE THERMOCOUPLE, ROD 47, LEVEL E
TE-349ME	MIDDLE THERMOCOUPLE, ROD 49, LEVEL E
TE-353ME	MIDDLE THERMOCOUPLE, ROD 53, LEVEL E
TE-358ME	MIDDLE THERMOCOUPLE, ROD 58, LEVEL E
TE-359ME	MIDDLE THERMOCOUPLE, ROD 59, LEVEL E
TE-363ME	MIDDLE THERMOCOUPLE, ROD 63, LEVEL E
TE-317M6	MIDDLE THERMOCOUPLE, ROD 17, LEVEL F, SUPER LEVEL 6
TE-321M3	MIDDLE THERMOCOUPLE, ROD 21, LEVEL F, SUPER LEVEL 3
TE-321M1	MIDDLE THERMOCOUPLE, ROD 21, LEVEL F, SUPER LEVEL 1
TE-337M7	MIDDLE THERMOCOUPLE, ROD 37, LEVEL F, SUPER LEVEL 7
TE-337M6	MIDDLE THERMOCOUPLE, ROD 37, LEVEL F, SUPER LEVEL 6
TE-338M8	MIDDLE THERMOCOUPLE, ROD 38, LEVEL F, SUPER LEVEL 8
TE-338M2	MIDDLE THERMOCOUPLE, ROD 38, LEVEL F, SUPER LEVEL 2
TE-354M6	MIDDLE THERMOCOUPLE, ROD 54, LEVEL F, SUPER LEVEL 6
TE-354M5	MIDDLE THERMOCOUPLE, ROD 54, LEVEL F, SUPER LEVEL 5
TE-360M3	MIDDLE THERMOCOUPLE, ROD 60, LEVEL F, SUPER LEVEL 3
TE-314M8	MIDDLE THERMOCOUPLE, ROD 14, LEVEL F, SUPER LEVEL 8
TE-314M2	MIDDLE THERMOCOUPLE, ROD 14, LEVEL F, SUPER LEVEL 2
TE-301M2	MIDDLE THERMOCOUPLE, ROD 1, LEVEL F, SUPER LEVEL 2
TE-317M7	MIDDLE THERMOCOUPLE, ROD 17, LEVEL F, SUPER LEVEL 7
TE-334M6	MIDDLE THERMOCOUPLE, ROD 34, LEVEL F, SUPER LEVEL 6
TE-350M7	MIDDLE THERMOCOUPLE, ROD 50, LEVEL F, SUPER LEVEL 7
TE-350M6	MIDDLE THERMOCOUPLE, ROD 50, LEVEL F, SUPER LEVEL 6
LEVEL F	
TE-301MF	MIDDLE THERMOCOUPLE, ROD 1, LEVEL F
TE-303MF	MIDDLE THERMOCOUPLE, ROD 3, LEVEL F
TE-304MF	MIDDLE THERMOCOUPLE, ROD 4, LEVEL F
TE-307MF	MIDDLE THERMOCOUPLE, ROD 7, LEVEL F
TE-314MF	MIDDLE THERMOCOUPLE, ROD 14, LEVEL F
TE-315MF	MIDDLE THERMOCOUPLE, ROD 15, LEVEL F
TE-316MF	MIDDLE THERMOCOUPLE, ROD 16, LEVEL F
TE-317MF	MIDDLE THERMOCOUPLE, ROD 17, LEVEL F
TE-318MF	MIDDLE THERMOCOUPLE, ROD 18, LEVEL F
TE-321MF	MIDDLE THERMOCOUPLE, ROD 21, LEVEL F
TE-328MF	MIDDLE THERMOCOUPLE, ROD 28, LEVEL F
TE-331MF	MIDDLE THERMOCOUPLE, ROD 31, LEVEL F
TE-334MF	MIDDLE THERMOCOUPLE, ROD 34, LEVEL F

Table 2 (continued)

SENSOR	DESCRIPTION
BUNDLE TEMPERATURE (CONT.)	
MIDDLE THERMOCOUPLES (CONT.)	
LEVEL F (CONT.)	
TE-337MF	MIDDLE THERMOCOUPLE, ROD 37, LEVEL F
TE-338MF	MIDDLE THERMOCOUPLE, ROD 38, LEVEL F
TE-347MF	MIDDLE THERMOCOUPLE, ROD 47, LEVEL F
TE-350MF	MIDDLE THERMOCOUPLE, ROD 50, LEVEL F
TE-354MF	MIDDLE THERMOCOUPLE, ROD 54, LEVEL F
TE-358MF	MIDDLE THERMOCOUPLE, ROD 58, LEVEL F
TE-359MF	MIDDLE THERMOCOUPLE, ROD 59, LEVEL F
TE-360MF	MIDDLE THERMOCOUPLE, ROD 60, LEVEL F
TE-364MF	MIDDLE THERMOCOUPLE, ROD 64, LEVEL F
TE-301M8	MIDDLE THERMOCOUPLE, ROD 1, LEVEL F, SUPER LEVEL 8
LEVEL G	
TE-301MG	MIDDLE THERMOCOUPLE, ROD 1, LEVEL G
TE-303MG	MIDDLE THERMOCOUPLE, ROD 3, LEVEL G
TE-314MG	MIDDLE THERMOCOUPLE, ROD 14, LEVEL G
TE-316MG	MIDDLE THERMOCOUPLE, ROD 16, LEVEL G
TE-317MG	MIDDLE THERMOCOUPLE, ROD 17, LEVEL G
TE-320MG	MIDDLE THERMOCOUPLE, ROD 20, LEVEL G
TE-321MG	MIDDLE THERMOCOUPLE, ROD 21, LEVEL G
TE-332MG	MIDDLE THERMOCOUPLE, ROD 32, LEVEL G
TE-337MG	MIDDLE THERMOCOUPLE, ROD 37, LEVEL G
TE-338MG	MIDDLE THERMOCOUPLE, ROD 38, LEVEL G
TE-345MG	MIDDLE THERMOCOUPLE, ROD 45, LEVEL G
TE-347MG	MIDDLE THERMOCOUPLE, ROD 47, LEVEL G
TE-354MG	MIDDLE THERMOCOUPLE, ROD 54, LEVEL G
TE-358MG	MIDDLE THERMOCOUPLE, ROD 58, LEVEL G
TE-360MG	MIDDLE THERMOCOUPLE, ROD 60, LEVEL G
TE-364MG	MIDDLE THERMOCOUPLE, ROD 64, LEVEL G
SHROUD BOX THERMOCOUPLES	
LEVEL A	
TE-181W	SHROUD BOX THERMOCOUPLE, LEVEL A WEST SIDE
LEVEL B	
TE-182E	SHROUD BOX THERMOCOUPLE, LEVEL B EAST SIDE
LEVEL C	
TE-183N	SHROUD BOX THERMOCOUPLE, LEVEL C NORTH SIDE
TE-183W	SHROUD BOX THERMOCOUPLE, LEVEL C WEST SIDE
LEVEL D	
TE-184E	SHROUD BOX THERMOCOUPLE, LEVEL D EAST SIDE
TE-184S	SHROUD BOX THERMOCOUPLE, LEVEL D SOUTH SIDE

Table 2 (continued)

SENSOR	DESCRIPTION
BUNDLE TEMPERATURE (CONT.)	
SHROUD BOX THERMOCOUPLES (CONT.)	
LEVEL E	
TE-185W	SHROUD BOX THERMOCOUPLE, LEVEL E WEST SIDE
LEVEL F	
TE-186S	SHROUD BOX THERMOCOUPLE, LEVEL F SOUTH SIDE
LEVEL G	
TE-187N	SHROUD BOX THERMOCOUPLE, LEVEL G NORTH SIDE
TE-187W	SHROUD BOX THERMOCOUPLE, LEVEL G WEST SIDE
TE-186E	SHROUD BOX THERMOCOUPLE, LEVEL G EAST SIDE
LEVEL 0	
TE-270AE	SHROUD BOX THERMOCOUPLE, LEVEL 0, PENETRATION A, SIDE EAST
TE-270BE	SHROUD BOX THERMOCOUPLE, LEVEL 0, PENETRATION B, SIDE EAST
LEVEL 1	
TE-271AE	SHROUD BOX THERMOCOUPLE, LEVEL 1, PENETRATION A, SIDE EAST
TE-271BE	SHROUD BOX THERMOCOUPLE, LEVEL 1, PENETRATION B, SIDE EAST
LEVEL 2	
TE-272AE	SHROUD BOX THERMOCOUPLE, LEVEL 2, PENETRATION A, SIDE EAST
TE-272BE	SHROUD BOX THERMOCOUPLE, LEVEL 2, PENETRATION B, SIDE EAST
TE-272AS	SHROUD BOX THERMOCOUPLE, LEVEL 2, PENETRATION A, SIDE SOUTH
TE-272BS	SHROUD BOX THERMOCOUPLE, LEVEL 2, PENETRATION B, SIDE SOUTH
LEVEL 3	
TE-273AE	SHROUD BOX THERMOCOUPLE, LEVEL 3, PENETRATION A, SIDE EAST
TE-273BE	SHROUD BOX THERMOCOUPLE, LEVEL 3, PENETRATION B, SIDE EAST
LEVEL 5	
TE-275AE	SHROUD BOX THERMOCOUPLE, LEVEL 5, PENETRATION A, SIDE EAST
TE-275BE	SHROUD BOX THERMOCOUPLE, LEVEL 5, PENETRATION B, SIDE EAST
TE-275AS	SHROUD BOX THERMOCOUPLE, LEVEL 5, PENETRATION A, SIDE SOUTH
TE-275BS	SHROUD BOX THERMOCOUPLE, LEVEL 5, PENETRATION B, SIDE SOUTH
LEVEL 6	
TE-276AE	SHROUD BOX THERMOCOUPLE, LEVEL 6, PENETRATION A, SIDE EAST
TE-276BE	SHROUD BOX THERMOCOUPLE, LEVEL 6, PENETRATION B, SIDE EAST
LEVEL 7	
TE-277AE	SHROUD BOX THERMOCOUPLE, LEVEL 7, PENETRATION A, SIDE EAST
TE-277BE	SHROUD BOX THERMOCOUPLE, LEVEL 7, PENETRATION B, SIDE EAST
LEVEL 8	
TE-278AE	SHROUD BOX THERMOCOUPLE, LEVEL 8, PENETRATION A, SIDE EAST

Table 2 (continued)

SENSOR	DESCRIPTION
BUNDLE TEMPERATURE (CONT.)	
SHROUD BOX THERMOCOUPLES (CONT.)	
LEVEL 8 (CONT.)	
TE-278BE	SHROUD BOX THERMOCOUPLE, LEVEL 8, PENETRATION B, SIDE EAST
LEVEL 9	
TE-279AE	SHROUD BOX THERMOCOUPLE, LEVEL 9, PENETRATION A, SIDE EAST
TE-279BE	SHROUD BOX THERMOCOUPLE, LEVEL 9, PENETRATION B, SIDE EAST
TE-279AS	SHROUD BOX THERMOCOUPLE, LEVEL 9, PENETRATION A, SIDE SOUTH
TE-279BS	SHROUD BOX THERMOCOUPLE, LEVEL 9, PENETRATION B, SIDE SOUTH
THERMOCOUPLE ARRAY ROD	
LEVEL D	
TE-188AD	ARRAY ROD THERMOCOUPLE GRID NUMBER 19 SUBCHANNEL 21 LEVEL D
TE-189AD	ARRAY ROD THERMOCOUPLE GRID NUMBER 22 SUBCHANNEL 25 LEVEL D
TE-189BD	ARRAY ROD THERMOCOUPLE GRID NUMBER 22 SUBCHANNEL 33 LEVEL D
LEVEL E	
TE-188AE	ARRAY ROD THERMOCOUPLE GRID NUMBER 19 SUBCHANNEL 21 LEVEL E
TE-188BE	ARRAY ROD THERMOCOUPLE GRID NUMBER 19 SUBCHANNEL 31 LEVEL E
TE-189AE	ARRAY ROD THERMOCOUPLE GRID NUMBER 22 SUBCHANNEL 25 LEVEL E
TE-189BE	ARRAY ROD THERMOCOUPLE GRID NUMBER 22 SUBCHANNEL 33 LEVEL E
LEVEL F	
TE-188AF	ARRAY ROD THERMOCOUPLE GRID NUMBER 19 SUBCHANNEL 21 LEVEL F
TE-188BF	ARRAY ROD THERMOCOUPLE GRID NUMBER 19 SUBCHANNEL 31 LEVEL F
TE-189AF	ARRAY ROD THERMOCOUPLE GRID NUMBER 22 SUBCHANNEL 25 LEVEL F
TE-189BF	ARRAY ROD THERMOCOUPLE GRID NUMBER 22 SUBCHANNEL 33 LEVEL F
LEVEL G	
TE-188AG	ARRAY ROD THERMOCOUPLE GRID NUMBER 19 SUBCHANNEL 21 LEVEL G
TE-188BG	ARRAY ROD THERMOCOUPLE GRID NUMBER 19 SUBCHANNEL 31 LEVEL G
TE-189AG	ARRAY ROD THERMOCOUPLE GRID NUMBER 22 SUBCHANNEL 25 LEVEL G
TE-189BG	ARRAY ROD THERMOCOUPLE GRID NUMBER 22 SUBCHANNEL 33 LEVEL G
SPACER GRID THERMOCOUPLES	
GRID NO. 2	
TE-291A	SPACER GRID NUMBER 2 THERMOCOUPLE SUBCHANNEL 32
TE-291B	SPACER GRID NUMBER 2 THERMOCOUPLE SUBCHANNEL 43
TE-291C	SPACER GRID NUMBER 2 THERMOCOUPLE SUBCHANNEL 57
TE-291D	SPACER GRID NUMBER 2 THERMOCOUPLE SUBCHANNEL 70
GRID NO. 3	
TE-292A	SPACER GRID NUMBER 3 THERMOCOUPLE SUBCHANNEL 32
TE-292B	SPACER GRID NUMBER 3 THERMOCOUPLE SUBCHANNEL 43
TE-292D	SPACER GRID NUMBER 3 THERMOCOUPLE SUBCHANNEL 70

Table 2 (continued)

SENSOR	DESCRIPTION				
BUNDLE TEMPERATURE (CONT.)					
SPACER GRID THERMOCOUPLES (CONT.)					
GRID NO. 4					
TE-293A	SPACER	GRID	NUMBER	4	THERMOCOUPLE SUBCHANNEL 32
TE-293B	SPACER	GRID	NUMBER	4	THERMOCOUPLE SUBCHANNEL 43
TE-293C	SPACER	GRID	NUMBER	4	THERMOCOUPLE SUBCHANNEL 57
TE-293D	SPACER	GRID	NUMBER	4	THERMOCOUPLE SUBCHANNEL 70
TE-293E	SPACER	GRID	NUMBER	4	THERMOCOUPLE SUBCHANNEL 17
TE-293F	SPACER	GRID	NUMBER	4	THERMOCOUPLE SUBCHANNEL 38
GRID NO. 5					
TE-294B	SPACER	GRID	NUMBER	5	THERMOCOUPLE SUBCHANNEL 43
TE-294D	SPACER	GRID	NUMBER	5	THERMOCOUPLE SUBCHANNEL 70
TE-294E	SPACER	GRID	NUMBER	5	THERMOCOUPLE SUBCHANNEL 17
TE-294F	SPACER	GRID	NUMBER	5	THERMOCOUPLE SUBCHANNEL 38
GRID NO. 6					
TE-295A	SPACER	GRID	NUMBER	6	THERMOCOUPLE SUBCHANNEL 32
TE-295B	SPACER	GRID	NUMBER	6	THERMOCOUPLE SUBCHANNEL 43
TE-295C	SPACER	GRID	NUMBER	6	THERMOCOUPLE SUBCHANNEL 57
TE-295D	SPACER	GRID	NUMBER	6	THERMOCOUPLE SUBCHANNEL 70
GRID NO. 7					
TE-296B	SPACER	GRID	NUMBER	7	THERMOCOUPLE SUBCHANNEL 43
TE-296D	SPACER	GRID	NUMBER	7	THERMOCOUPLE SUBCHANNEL 70
SUBCHANNEL THERMOCOUPLES					
TE-1201	SUBCHANNEL	NUMBER	1	THERMOCOUPLE	
TE-1205	SUBCHANNEL	NUMBER	5	THERMOCOUPLE	
TE-1207	SUBCHANNEL	NUMBER	7	THERMOCOUPLE	
TE-1209	SUBCHANNEL	NUMBER	9	THERMOCOUPLE	
TE-1211	SUBCHANNEL	NUMBER	11	THERMOCOUPLE	
TE-1213	SUBCHANNEL	NUMBER	13	THERMOCOUPLE	
TE-1214	SUBCHANNEL	NUMBER	14	THERMOCOUPLE	
TE-1216	SUBCHANNEL	NUMBER	16	THERMOCOUPLE	
TE-1217	SUBCHANNEL	NUMBER	17	THERMOCOUPLE	
TE-1219	SUBCHANNEL	NUMBER	19	THERMOCOUPLE	
TE-1220	SUBCHANNEL	NUMBER	20	THERMOCOUPLE	
TE-1221	SUBCHANNEL	NUMBER	21	THERMOCOUPLE	
TE-1223	SUBCHANNEL	NUMBER	23	THERMOCOUPLE	
TE-1225	SUBCHANNEL	NUMBER	25	THERMOCOUPLE	
TE-1226	SUBCHANNEL	NUMBER	26	THERMOCOUPLE	
TE-1227	SUBCHANNEL	NUMBER	27	THERMOCOUPLE	
TE-1229	SUBCHANNEL	NUMBER	29	THERMOCOUPLE	
TE-1230	SUBCHANNEL	NUMBER	30	THERMOCOUPLE	
TE-1231	SUBCHANNEL	NUMBER	31	THERMOCOUPLE	
TE-1232	SUBCHANNEL	NUMBER	32	THERMOCOUPLE	

Table 2 (continued)

SENSOR	DESCRIPTION
BUNDLE TEMPERATURE (CONT.)	
SUBCHANNEL THERMOCOUPLES (CONT.)	
TE-1234	SUBCHANNEL NUMBER 34 THERMOCOUPLE
TE-1235	SUBCHANNEL NUMBER 35 THERMOCOUPLE
TE-1237	SUBCHANNEL NUMBER 37 THERMOCOUPLE
TE-1238	SUBCHANNEL NUMBER 38 THERMOCOUPLE
TE-1239	SUBCHANNEL NUMBER 39 THERMOCOUPLE
TE-1240	SUBCHANNEL NUMBER 40 THERMOCOUPLE
TE-1241	SUBCHANNEL NUMBER 41 THERMOCOUPLE
TE-1242	SUBCHANNEL NUMBER 42 THERMOCOUPLE
TE-1244	SUBCHANNEL NUMBER 44 THERMOCOUPLE
TE-1245	SUBCHANNEL NUMBER 45 THERMOCOUPLE
TE-1247	SUBCHANNEL NUMBER 47 THERMOCOUPLE
TE-1248	SUBCHANNEL NUMBER 48 THERMOCOUPLE
TE-1249	SUBCHANNEL NUMBER 49 THERMOCOUPLE
TE-1250	SUBCHANNEL NUMBER 50 THERMOCOUPLE
TE-1251	SUBCHANNEL NUMBER 51 THERMOCOUPLE
TE-1252	SUBCHANNEL NUMBER 52 THERMOCOUPLE
TE-1255	SUBCHANNEL NUMBER 55 THERMOCOUPLE
TE-1256	SUBCHANNEL NUMBER 56 THERMOCOUPLE
TE-1258	SUBCHANNEL NUMBER 58 THERMOCOUPLE
TE-1259	SUBCHANNEL NUMBER 59 THERMOCOUPLE
TE-1260	SUBCHANNEL NUMBER 60 THERMOCOUPLE
TE-1261	SUBCHANNEL NUMBER 61 THERMOCOUPLE
TE-1263	SUBCHANNEL NUMBER 63 THERMOCOUPLE
TE-1265	SUBCHANNEL NUMBER 65 THERMOCOUPLE
TE-1266	SUBCHANNEL NUMBER 66 THERMOCOUPLE
TE-1268	SUBCHANNEL NUMBER 68 THERMOCOUPLE
TE-1269	SUBCHANNEL NUMBER 69 THERMOCOUPLE
TE-1270	SUBCHANNEL NUMBER 70 THERMOCOUPLE
TE-1271	SUBCHANNEL NUMBER 71 THERMOCOUPLE
TE-1273	SUBCHANNEL NUMBER 73 THERMOCOUPLE
TE-1275	SUBCHANNEL NUMBER 75 THERMOCOUPLE
TE-1277	SUBCHANNEL NUMBER 77 THERMOCOUPLE
TE-1279	SUBCHANNEL NUMBER 79 THERMOCOUPLE
TE-1281	SUBCHANNEL NUMBER 81 THERMOCOUPLE
SPOOL PIECE INSTRUMENTS	
TEMPERATURE	
TE-172	VERTICAL INLET SPOOL TEMPERATURE
TE-208	BUNDLE OUTLET SPOOL TEMPERATURE
TE-24	HORIZONTAL INLET SPOOL TEMPERATURE
TE-222	VERTICAL OUTLET SPOOL TEMPERATURE
TE-40	HORIZONTAL OUTLET SPOOL TEMPERATURE
PRESSURE	

Table 2 (continued)

SENSOR	DESCRIPTION
SPOOL PIECE INSTRUMENTS (CONT.)	
PRESSURE (CONT.)	
PE-26	HORIZONTAL INLET SPOOL TRANSIENT PRESSURE
PE-42	HORIZONTAL OUTLET SPOOL TRANSIENT PRESSURE
PE-174	VERTICAL INLET SPOOL TRANSIENT PRESSURE
PE-224	VERTICAL OUTLET SPOOL TRANSIENT PRESSURE
PE-209	BUNDLE OUTLET SPOOL TRANSIENT PRESSURE
PE-258	BUNDLE INLET UPPER SPOOL PRESSURE
PRESSURE DROP	
PDE-21	HORIZONTAL INLET SPOOL TRANSIENT DIFFERENTIAL PRESSURE
PDE-35	HORIZONTAL OUTLET SPOOL TRANSIENT DIFFERENTIAL PRESSURE
PDE-217	VERTICAL OUTLET SPOOL TRANSIENT DIFFERENTIAL PRESSURE
PDE-251	BUNDLE INLET SPOOL DIFFERENTIAL PRESSURE
VELOCITY	
FE-19	HORIZONTAL INLET SPOOL VELOCITY
FE-160	VERTICAL INLET SPOOL VELOCITY
FE-34	HORIZONTAL OUTLET SPOOL VELOCITY
FE-216	VERTICAL OUTLET SPOOL VELOCITY
MOMENTUM FLUX	
FMFE-22	HORIZONTAL INLET SPOOL DRAG DISC
FMFE-38	HORIZONTAL OUTLET SPOOL DRAG DISC
FMFE-170	VERTICAL INLET SPOOL DRAG DISC
FMFE-220	VERTICAL OUTLET SPOOL DRAG DISC
FMFE-206	BUNDLE OUTLET SPOOL DRAG DISC
FMFE-264	BUNDLE INLET LOWER SPOOL DRAG DISC
FLUID DENSITY	
DE-36	HORIZONTAL OUTLET SPOOL DENSITY
DE-168	VERTICAL INLET SPOOL DENSITY
DE-218	VERTICAL OUTLET SPOOL DENSITY
DE-204A	BUNDLE OUTLET SPOOL DENSITY
DE-204B	BUNDLE OUTLET SPOOL DENSITY
DE-204C	BUNDLE OUTLET SPOOL DENSITY
DE-20	BUNDLE INLET SPOOL DENSITY
TEST SECTION INSTRUMENTS	
TEMPERATURE	
TE-210A	TEST SECTION OUTLET LINE STEADY-STATE TEMPERATURE
TDE-28	DIFFERENTIAL TEMPERATURE TRANSMITTER
TE-48	BASE PRIMARY STEADY-STATE TEMPERATURE
TE-150	TEST SECTION BOTTOM FLANGE TEMPERATURE SIDE
TE-151	TEST SECTION BOTTOM FLANGE TEMPERATURE SIDE
TE-152	TEST SECTION BOTTOM FLANGE TEMPERATURE SIDE

Table 2 (continued)

SENSOR	DESCRIPTION
TEST SECTION INSTRUMENTS (CONT.)	
TEMPERATURE (CONT.)	
TE-29	INLET BLOWDOWN PLENUM TEMPERATURE
TE-45	OUTLET BLOWDOWN PLENUM TEMPERATURE
TE-25b	TEST SECTION INLET TEMPERATURE
TE-284	OLD DOWNCOMER PURGE LINE RETURN TEMPERATURE
TE-923	UPPER VOLUME PLUG TEMPERATURE
TE-924	LOWER VOLUME PLUG TEMPERATURE
TE-920	PURGE LINE RETURN TEMPERATURE
TE-921	INNER SEAL COOLANT SUPPLY TEMPERATURE
TE-922	INNER SEAL COOLANT SUPPLY TEMPERATURE
PRESSURE	
PE-156	TEST SECTION INLET TRANSIENT PRESSURE
PE-201	TEST SECTION OUTLET TRANSIENT PRESSURE
PE-16	DOWNSTREAM HCV 2 TRANSIENT PRESSURE
PE-27	INLET PLENUM TRANSIENT PRESSURE
PE-43	OUTLET PLENUM TRANSIENT PRESSURE
PE-427	OUTLET BD LINE TRANSIENT PRESSURE
PE-286	SHROUD PLENUM OUTLET PRESSURE
PE-32	TEST SECTION OUTLET STEADY-STATE PRESSURE
PRESSURE DROP	
PDE-180	SHROUD BOX DIFFERENTIAL PRESSURE LEVEL A TO B.
PDE-181	SHROUD BOX DIFFERENTIAL PRESSURE LEVEL B TO C
PDE-182	SHROUD BOX DIFFERENTIAL PRESSURE LEVEL C TO D
PDE-183	SHROUD BOX DIFFERENTIAL PRESSURE LEVEL D TO D/E
PDE-184	SHROUD BOX DIFFERENTIAL PRESSURE LEVEL D/E TO E
PDE-185	SHROUD BOX DIFFERENTIAL PRESSURE LEVEL E TO E/F
PDE-186	SHROUD BOX DIFFERENTIAL PRESSURE LEVEL E/F TO F
PDE-187	SHROUD BOX DIFFERENTIAL PRESSURE LEVEL F TO F/G
PDE-188	SHROUD BOX DIFFERENTIAL PRESSURE LEVEL F/G TO G
PDE-189	SHROUD BOX DIFFERENTIAL PRESSURE LEVEL G TO UPTAP
PDE-200	BUNDLE TRANSIENT DIFFERENTIAL PRESSURE
PDE-204	BUNDLE TRANSIENT DIFFERENTIAL PRESSURE
PDE-203	TEST SECTION TRANSIENT DIFFERENTIAL PRESSURE
PDE-30	TEST SECTION STEADY-STATE DIFFERENTIAL PRESSURE
PDL-271	SPLIT DOWNCOMER TRANSIENT DIFFERENTIAL PRESSURE
VELOCITY	
FE-232	INNER SEAL COOLANT VELOCITY
FE-202	BUNDLE OUTPUT LOWER VELOCITY
FE-260	BUNDLE INLET LOWER VELOCITY
FE-280	PURGE LINE RETURN VELOCITY
DENSITY	
DE-336U	INBUNDLE GAMMA DENSITOMETER, ROD 36, POSITION UPPER

Table 2 (continued)

SENSOR	DESCRIPTION
TEST SECTION INSTRUMENTS (CONT.)	
DENSITY (CONT.)	
DE-346L	INBUNDLE GAMMA DENSITOMETER, ROD 46, POSITION LOWER
ZE-336U	INBUNDLE GAMMA DENSITOMETER VERTICAL POSITIONING ON ROD 36
ZE-346L	INBUNDLE GAMMA DENSITOMETER VERTICAL POSITIONING ON ROD 46
VOLUMETRIC FLOW	
FE-18A	TEST SECTION INLET STEADY-STATE FLOW
FE-250	BUNDLE INLET VOLUMETRIC FLOW NUMBER 2
PRESSURIZER INSTRUMENTS	
TEMPERATURE	
TE-101	PRESSURIZER VAPOR STEADY-STATE TEMPERATURE
TE-1	PRESSURIZER VAPOR TEMPERATURE
TE-2	PRESSURIZER WATER TEMPERATURE
TE-116	PRESSURIZER EXIT SPOOL TEMPERATURE
PRESSURE	
PE-106	PRESSURIZER VAPOR TRANSIENT PRESSURE
PE-102	PRESSURIZER STEADY-STATE PRESSURE
PRESSURE DROP	
PDE-111	PRESSURIZER LINE SPOOL DIFFERENTIAL PRESSURE
LEVEL	
LE-100	PRESSURIZER LIQUID LEVEL INSTRUMENT
MOMENTUM FLUX	
FMFE-114	PZR LINE SPOOL DRAG DISC
VELOCITY	
FE-110	PZR LINE SPOOL VELOCITY
PRIMARY PUMP INSTRUMENTS	
PDE-78	PRIMARY PUMP TRANSIENT DIFFERENTIAL PRESSURE
FE-1A	PRIMARY PUMP FLOW
PE-76	PRIMARY PUMP SUCTION TRANSIENT PRESSURE
SE-72	PRIMARY PUMP SPEED
EWE-77A	PRIMARY PUMP POWER
PUMP BYPASS INSTRUMENTS	
PE-15	PUMP BYPASS SPOOL PRESSURE
PRESSURE SUPPRESSION SYSTEM INSTRUMENTS	
TE-408B	PRESSURE SUPPRESSION SYSTEM TANK SPRAY TEMPERATURE
TE-901	PRESSURE STEAM KILLER AIR VENT THERMOCOUPLE

Table 2 (continued)

SENSOR	DESCRIPTION
DEMINERALIZED WATER SYSTEM INSTRUMENTS	
PE-616	DEMINERALIZED WATER SUPPLY HEADER PRESSURE
TE-615	DEMINERALIZED WATER 6 IN HEADER STEADY-STATE TEMPERATURE
TE-520B	4 IN DEMINERALIZED WATER HEADER TEMPERATURE
HEAT EXCHANGER INSTRUMENTS	
PRIMARY SIDE	
TEMPERATURE	
TE-56	HEAT EXCHANGER D OUTLET TEMPERATURE
TE-57	HEAT EXCHANGER A SPOOL TEMPERATURE
TE-62	HEAT EXCHANGER B SPOOL TEMPERATURE
TE-67	HEAT EXCHANGER C SPOOL TEMPERATURE
TE-28B	MAIN HEAT EXCHANGER MIXING TEE STEADY-STATE TEMPERATURE
VELOCITY	
FE-51	HEAT EXCHANGER A SPOOL VELOCITY
FE-59	HEAT EXCHANGER B SPOOL VELOCITY
FE-64	HEAT EXCHANGER C SPOOL VELOCITY
PRESSURE	
PE-44	UPSTREAM MAIN HEAT EXCHANGER TRANSIENT PRESSURE
PE-58	HEAT EXCHANGER A SPOOL PRESSURE
PE-63	HEAT EXCHANGER B SPOOL PRESSURE
PE-68	HEAT EXCHANGER C SPOOL PRESSURE
PRESSURE DROP	
PDE-46	MAIN HEAT EXCHANGER BYPASS TRANSIENT DIFFERENTIAL PRESSURE
PDE-48	MAIN HEAT EXCHANGER STEADY-STATE DIFFERENTIAL PRESSURE
PDE-53	HEAT EXCHANGER A SPOOL DIFFERENTIAL PRESSURE
PDE-60	HEAT EXCHANGER B SPOOL DIFFERENTIAL PRESSURE
PDE-65	HEAT EXCHANGER C SPOOL DIFFERENTIAL PRESSURE
MOMENTUM FLUX	
FMFE-55	HEAT EXCHANGER A SPOOL DRAG DISC
FMFE-61	HEAT EXCHANGER B SPOOL DRAG DISC
FMFE-66	HEAT EXCHANGER C SPOOL DRAG DISC
SECONDARY SIDE	
TEMPERATURE	
TE-525	HEAT EXCHANGER A SECONDARY DISCHARGE STEADY-STATE TEMPERATURE
TE-627	HEAT EXCHANGER B SECONDARY DISCHARGE STEADY-STATE TEMPERATURE
TE-727	HEAT EXCHANGER C SECONDARY DISCHARGE STEADY-STATE TEMPERATURE

Table 2 (continued)

SENSOR	DESCRIPTION
HEAT EXCHANGER INSTRUMENTS (CONT.)	
SECONDARY SIDE (CONT.)	
TEMPERATURE (CONT.)	
TE-557	HEAT EXCHANGER D SECONDARY DISCHARGE STEADY-STATE TEMPERATURE
VOLUMETRIC FLOW	
FE-522	HEAT EXCHANGER A SECONDARY COOLING WATER FLOW
FE-620	HEAT EXCHANGER B SECONDARY COOLING WATER FLOW
FE-720	HEAT EXCHANGER C SECONDARY COOLING WATER FLOW
FE-550	HEAT EXCHANGER D SECONDARY COOLING WATER FLOW
PRESSURE	
PE-526	HEAT EXCHANGER A SECONDARY INLET PRESSURE
GENERATOR POWER	
GENERATOR VOLTAGE	
EEE-9	GENERATOR 9 VOLTAGE
EEE-10	GENERATOR 10 VOLTAGE
EEE-11	GENERATOR 11 VOLTAGE
EEE-12	GENERATOR 12 VOLTAGE
GENERATOR CURRENT	
EIE-9	GENERATOR 9 CURRENT
EIE-10	GENERATOR 10 CURRENT
EIE-11	GENERATOR 11 CURRENT
EIE-12	GENERATOR 12 CURRENT
HEATER ROD POWER	
HEATER CURRENT	
EIE-1301	ROD 01 HEATER CURRENT
EIE-1302	ROD 02 HEATER CURRENT
EIE-1303	ROD 03 HEATER CURRENT
EIE-1304	ROD 04 HEATER CURRENT
EIE-1305	ROD 05 HEATER CURRENT
EIE-1306	ROD 06 HEATER CURRENT
EIE-1307	ROD 07 HEATER CURRENT
EIE-1308	ROD 08 HEATER CURRENT
EIE-1309	ROD 09 HEATER CURRENT
EIE-1310	ROD 10 HEATER CURRENT
EIE-1311	ROD 11 HEATER CURRENT
EIE-1312	ROD 12 HEATER CURRENT
EIE-1313	ROD 13 HEATER CURRENT
EIE-1314	ROD 14 HEATER CURRENT
EIE-1315	ROD 15 HEATER CURRENT
EIE-1316	ROD 16 HEATER CURRENT
EIE-1317	ROD 17 HEATER CURRENT

Table 2 (continued)

SENSOR	DESCRIPTION
HEATER ROD POWER (CONT.)	
HEATER CURRENT (CONT.)	
EIE-1318	ROD 18 HEATER CURRENT
EIE-1320	ROD 20 HEATER CURRENT
EIE-1321	ROD 21 HEATER CURRENT
EIE-1323	ROD 23 HEATER CURRENT
EIE-1324	ROD 24 HEATER CURRENT
EIE-1325	ROD 25 HEATER CURRENT
EIE-1326	ROD 26 HEATER CURRENT
EIE-1327	ROD 27 HEATER CURRENT
EIE-1328	ROD 28 HEATER CURRENT
EIE-1329	ROD 29 HEATER CURRENT
EIE-1330	ROD 30 HEATER CURRENT
EIE-1331	ROD 31 HEATER CURRENT
EIE-1332	ROD 32 HEATER CURRENT
EIE-1333	ROD 33 HEATER CURRENT
EIE-1334	ROD 34 HEATER CURRENT
EIE-1335	ROD 35 HEATER CURRENT
EIE-1337	ROD 37 HEATER CURRENT
EIE-1338	ROD 38 HEATER CURRENT
EIE-1339	ROD 39 HEATER CURRENT
EIE-1340	ROD 40 HEATER CURRENT
EIE-1341	ROD 41 HEATER CURRENT
EIE-1342	ROD 42 HEATER CURRENT
EIE-1343	ROD 43 HEATER CURRENT
EIE-1344	ROD 44 HEATER CURRENT
EIE-1345	ROD 45 HEATER CURRENT
EIE-1347	ROD 47 HEATER CURRENT
EIE-1348	ROD 48 HEATER CURRENT
EIE-1349	ROD 49 HEATER CURRENT
EIE-1350	ROD 50 HEATER CURRENT
EIE-1351	ROD 51 HEATER CURRENT
EIE-1352	ROD 52 HEATER CURRENT
EIE-1353	ROD 53 HEATER CURRENT
EIE-1354	ROD 54 HEATER CURRENT
EIE-1355	ROD 55 HEATER CURRENT
EIE-1356	ROD 56 HEATER CURRENT
EIE-1357	ROD 57 HEATER CURRENT
EIE-1358	ROD 58 HEATER CURRENT
EIE-1359	ROD 59 HEATER CURRENT
EIE-1360	ROD 60 HEATER CURRENT
EIE-1361	ROD 61 HEATER CURRENT
EIE-1362	ROD 62 HEATER CURRENT
EIE-1363	ROD 63 HEATER CURRENT
EIE-1364	ROD 64 HEATER CURRENT
GENERAL INSTRUMENTATION (ELECTRICAL)	

Table 2 (continued)

SENSOR	DESCRIPTION
GENERAL INSTRUMENTATION (ELECTRICAL) (CONT.)	
BREAKWIRE DETECTORS	
XE-430B	INLET BREAKWIRE DETECTOR
XE-430A	OUTLET BREAKWIRE DETECTOR
RTD POWER	
EIE-1001B	RTD POWER SUPPLY CURRENT
DATA ACQUISITION CALIBRATION SIGNALS	
EEE-1026AZ	ZERO INPUT CHANNELS 0 TO 127
EEE-1026BZ	ZERO INPUT CHANNELS 128 TO 255
EEE-1026IZ	ZERO INPUT CHANNELS 1024 TO 1151
EEE-1026JZ	ZERO INPUT CHANNELS 1152 TO 1279
EEE-1026KZ	ZERO INPUT CHANNELS 1280 TO 1407
EEE-1026LZ	ZERO INPUT CHANNELS 1408 TO 1535
EEE-1026MZ	ZERO INPUT CHANNELS 1536 TO 1663
EEE-1026NZ	ZERO INPUT CHANNELS 1664 TO 1791
EEE-1026AC	CAL INPUT CHANNELS 0 TO 127
EEE-1026BC	CAL INPUT CHANNELS 128 TO 255
EEE-1026IC	CAL INPUT CHANNELS 1024 TO 1151
EEE-1026JC	CAL INPUT CHANNELS 1152 TO 1279
EEE-1026KC	CAL INPUT CHANNELS 1280 TO 1407
EEE-1026LC	CAL INPUT CHANNELS 1408 TO 1535
EEE-1026MC	CAL INPUT CHANNELS 1536 TO 1663
EEE-1026NC	CAL INPUT CHANNELS 1664 TO 1791
MISCELLANEOUS INSTRUMENTS	
TE-521	PURIFICATION COOLING OUTLET THERMOCOUPLE

Table 3. Thermal-Hydraulic Test Facility Test No. 3.06.6B

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
1	EEE-1026AZ	ZERO INPUT CHANNELS 0 TO 127	0 TO	40 MV	
2	EEE-1026AC	CALIBRATION INPUT CHANNELS 0 TO 127	0 TO	40 MV	
3	PDE-180	SHROUD BOX DIFFERENTIAL PRESSURE LEVEL A TO B	0 TO	25 INCHES	NEGATIVE VALUES OUT OF RANGE
4	PDE-181	SHROUD BOX DIFFERENTIAL PRESSURE LEVEL B TO C	0 TO	25 INCHES	NEGATIVE VALUES OUT OF RANGE
5	PDE-182	SHROUD BOX DIFFERENTIAL PRESSURE LEVEL C TO D	0 TO	25 INCHES	NEGATIVE VALUES OUT OF RANGE
6	PDE-183	SHROUD BOX DIFFERENTIAL PRESSURE LEVEL D TO D/E	0 TO	25 INCHES	NEGATIVE VALUES OUT OF RANGE
7	PDE-184	SHROUD BOX DIFFERENTIAL PRESSURE LEVEL D/E TO E	0 TO	25 INCHES	NEGATIVE VALUES OUT OF RANGE
8	PDE-185	SHROUD BOX DIFFERENTIAL PRESSURE LEVEL E TO E/F	0 TO	25 INCHES	NEGATIVE VALUES OUT OF RANGE
9	PE-26	HORIZONTAL INLET SPOOL TRANSIENT PRESSURE	0 TO	3000 PSIG	
10	PE-42	HORIZONTAL OUTLET SPOOL TRANSIENT PRESSURE	0 TO	3000 PSIG	
11	PE-44	UPSTREAM MAIN HEAT EXCHANGER TRANSIENT PRESSURE	0 TO	3000 PSIG	
12	PE-76	PRIMARY PUMP SUCTION TRANSIENT PRESSURE	0 TO	3000 PSIG	
13	PE-106	PRESSURIZER VAPOR TRANSIENT PRESSURE	0 TO	3000 PSIG	
14	PE-156	TEST SECTION INLET TRANSIENT PRESSURE	0 TO	3000 PSIG	
15	PE-201	TEST SECTION OUTLET TRANSIENT PRESSURE	0 TO	3000 PSIG	
16	PE-526	HEAT EXCHANGER A SECONDARY INLET PRESSURE	0 TO	350 PSIG	
17	PE-616	DEMINERALIZED WATER SUPPLY HEADER PRESSURE	0 TO	350 PSIG	
18	PDE-46	MAIN HEAT EXCHANGER BYPASS TRANSIENT DIFFERENTIAL PRESSURE	-200 TO	200 PSID	
19	PDE-78	PRIMARY PUMP TRANSIENT DIFFERENTIAL PRESSURE	-1000 TO	1000 PSID	
20	PDE-200	BUNDLE TRANSIENT DIFFERENTIAL PRESSURE	-50 TO	50 PSID	
21	FMFE-22	HORIZONTAL INLET SPOOL DRAG DISC	-250000 TO	250000 LB/FS2	OUT OF SERVICE
22	FMFE-38	HORIZONTAL OUTLET SPOOL DRAG DISC	-250000 TO	250000 LB/FS2	OUT OF SERVICE
23	FMFE-170	VERTICAL INLET SPOOL DRAG DISC	-250000 TO	250000 LB/FS2	OUT OF SERVICE

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE	COMMENTS
24	FMFE-220	VERTICAL OUTLET SPOOL DRAG DISC	-250000 TO 250000 LB/FS2	OUT OF SERVICE
25	FE-18A	TEST SECTION INLET STEADY-STATE FLOW	0 TO 700 GPM	QUESTIONABLE
26	PDE-21	HORIZONTAL INLET SPOOL TRANSIENT DIFFERENTIAL PRESSURE	-200 TO 200 PSID	
27	PDE-35	HORIZONTAL OUTLET SPOOL TRANSIENT DIFFERENTIAL PRESSURE	-200 TO 200 PSID	
28	PDE-217	VERTICAL OUTLET SPOOL TRANSIENT DIFFERENTIAL PRESSURE	-200 TO 200 PSID	
29	PE-174	VERTICAL INLET SPOOL TRANSIENT PRESSURE	0 TO 3000 PSIG	
30	PE-224	VERTICAL OUTLET SPOOL TRANSIENT PRESSURE	0 TO 3000 PSIG	
31	EIE-1339	ROD 39 HEATER CURRENT	0 TO 800 AMPS	
32	EIE-1331	ROD 31 HEATER CURRENT	0 TO 800 AMPS	
33	EIE-1314	ROD 14 HEATER CURRENT	0 TO 800 AMPS	
34	EIE-1313	ROD 13 HEATER CURRENT	0 TO 800 AMPS	
35	EIE-1308	ROD 08 HEATER CURRENT	0 TO 800 AMPS	
36	EIE-1306	ROD 06 HEATER CURRENT	0 TO 800 AMPS	
37	EIE-1312	ROD 12 HEATER CURRENT	0 TO 800 AMPS	
38	EIE-1307	ROD 07 HEATER CURRENT	0 TO 800 AMPS	
39	EIE-1321	ROD 21 HEATER CURRENT	0 TO 800 AMPS	
40	EIE-1316	ROD 16 HEATER CURRENT	0 TO 800 AMPS	
41	EIE-1324	ROD 24 HEATER CURRENT	0 TO 800 AMPS	
42	EIE-1362	ROD 62 HEATER CURRENT	0 TO 800 AMPS	
43	EIE-1361	ROD 61 HEATER CURRENT	0 TO 800 AMPS	
44	EIE-1364	ROD 64 HEATER CURRENT	0 TO 800 AMPS	
45	EIE-1363	ROD 63 HEATER CURRENT	0 TO 800 AMPS	
46	EIE-1347	ROD 47 HEATER CURRENT	0 TO 800 AMPS	
47	EIE-1338	ROD 38 HEATER CURRENT	0 TO 800 AMPS	
48	EIE-1332	ROD 32 HEATER CURRENT	0 TO 800 AMPS	

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
49	EIE-1340	ROD 40 HEATER CURRENT	0 TO	800 AMPS	
50	EIE-1348	ROD 48 HEATER CURRENT	0 TO	800 AMPS	
51	EIE-1355	ROD 55 HEATER CURRENT	0 TO	800 AMPS	
52	EIE-1354	ROD 54 HEATER CURRENT	0 TO	800 AMPS	
53	EIE-1345	ROD 45 HEATER CURRENT	0 TO	800 AMPS	
54	EIE-1349	ROD 49 HEATER CURRENT	0 TO	800 AMPS	
55	EIE-1325	ROD 25 HEATER CURRENT	0 TO	800 AMPS	
56	EIE-1335	ROD 35 HEATER CURRENT	0 TO	800 AMPS	
57	EIE-1309	ROD 09 HEATER CURRENT	0 TO	800 AMPS	
58	EIE-1317	ROD 17 HEATER CURRENT	0 TO	800 AMPS	
59	EIE-1328	ROD 28 HEATER CURRENT	0 TO	800 AMPS	
60	EIE-1301	ROD 01 HEATER CURRENT	0 TO	800 AMPS	
61	EIE-1318	ROD 18 HEATER CURRENT	0 TO	800 AMPS	
62	EIE-1334	ROD 34 HEATER CURRENT	0 TO	800 AMPS	
63	EIE-1326	ROD 26 HEATER CURRENT	0 TO	800 AMPS	
64	EIE-1333	ROD 33 HEATER CURRENT	0 TO	800 AMPS	
65	EIE-1350	ROD 50 HEATER CURRENT	0 TO	800 AMPS	
66	EIE-1344	ROD 44 HEATER CURRENT	0 TO	800 AMPS	
67	EIE-1343	ROD 43 HEATER CURRENT	0 TO	800 AMPS	
68	EIE-1352	ROD 52 HEATER CURRENT	0 TO	800 AMPS	
69	EIE-1351	ROD 51 HEATER CURRENT	0 TO	800 AMPS	
70	EIE-1320	ROD 20 HEATER CURRENT	0 TO	800 AMPS	
71	EIE-1303	ROD 03 HEATER CURRENT	0 TO	800 AMPS	
72	EIE-1305	ROD 05 HEATER CURRENT	0 TO	800 AMPS	
73	EIE-1311	ROD 11 HEATER CURRENT	0 TO	800 AMPS	

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE	COMMENTS
74	EIE-1357	ROD 57 HEATER CURRENT	0 TO 800 AMPS	
75	EIE-1358	ROD 58 HEATER CURRENT	0 TO 800 AMPS	
76	EIE-1359	ROD 59 HEATER CURRENT	0 TO 800 AMPS	
77	EIE-1353	ROD 53 HEATER CURRENT	0 TO 800 AMPS	
78	FMFE-206	BUNDLE OUTLET SPOOL DRAG DISC	-250000 TO 250000 LB/PS2	OUT OF SERVICE
79	SE-72	PRIMARY PUMP SPEED	100 TO 5400 RPM	
80	EIE-1315	ROD 15 HEATER CURRENT	0 TO 800 AMPS	
81	EIE-1330	ROD 30 HEATER CURRENT	0 TO 800 AMPS	
82	EIE-1323	ROD 23 HEATER CURRENT	0 TO 800 AMPS	
83	EIE-1329	ROD 29 HEATER CURRENT	0 TO 800 AMPS	
84	EIE-1356	ROD 56 HEATER CURRENT	0 TO 800 AMPS	
85	EIE-1337	ROD 37 HEATER CURRENT	0 TO 800 AMPS	
86	EIE-1360	ROD 60 HEATER CURRENT	0 TO 800 AMPS	
87	EIE-1327	ROD 27 HEATER CURRENT	0 TO 800 AMPS	
88	EIE-1341	ROD 41 HEATER CURRENT	0 TO 800 AMPS	
89	EIE-1342	ROD 42 HEATER CURRENT	0 TO 800 AMPS	
90	EIE-1302	ROD 02 HEATER CURRENT	0 TO 800 AMPS	
91	EIE-1310	ROD 10 HEATER CURRENT	0 TO 800 AMPS	
92	EIE-1304	ROD 04 HEATER CURRENT	0 TO 800 AMPS	
93	EIE-9	GENERATOR 9 CURRENT	0 TO 10000 AMPS	
94	EIE-10	GENERATOR 10 CURRENT	0 TO 10000 AMPS	
95	EIE-11	GENERATOR 11 CURRENT	0 TO 10000 AMPS	
96	EIE-12	GENERATOR 12 CURRENT	0 TO 10000 AMPS	
97	EEE-9	GENERATOR 9 VOLTAGE	0 TO 300 VOLTS	
98	EEE-10	GENERATOR 10 VOLTAGE	0 TO 300 VOLTS	

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
99	EEE-11	GENERATOR 11 VOLTAGE	0 TO	300 VOLTS	
100	EEE-12	GENERATOR 12 VOLTAGE	0 TO	300 VOLTS	
101	TE-210A	TEST SECTION OUTLET LINE STEADY-STATE TEMPERATURE	32 TO	800 DEGREES F	QUESTIONABLE
102	EIE-1001B	RTD POWER SUPPLY CURRENT	0 TO	2 MA	
103	TE-525	HEAT EXCHANGER A SECONDARY DISCHARGE STEADY-STATE TEMPERATURE	32 TO	800 DEGREES F	
104	TE-627	HEAT EXCHANGER B SECONDARY DISCHARGE STEADY-STATE TEMPERATURE	32 TO	800 DEGREES F	
105	PE-16	DOWNSTREAM HCV 2 TRANSIENT PRESSURE	0 TO	3000 PSIG	
106	PE-27	INLET PLENUM TRANSIENT PRESSURE	0 TO	3000 PSIG	
107	PE-43	OUTLET PLENUM TRANSIENT PRESSURE	0 TO	3000 PSIG	
108	EWE-77A	PRIMARY PUMP POWER	0 TO	750 KW	SPURIOUS SPIKE
109	FE-19	HORIZONTAL INLET SPOOL VELOCITY	-450 TO	450 GPM	SPURIOUS SPIKE-POWER CUTOFF
110	FE-166	VERTICAL INLET SPOOL VELOCITY	-450 TO	450 GPM	QUESTIONABLE - DEAD BAND
111	PE-427	OUTLET BLOWDOWN LINE TRANSIENT PRESSURE	0 TO	3000 PSIG	
112	FE-522	HEAT EXCHANGER A SECONDARY COOLING WATER FLOW	0 TO	150 GPM	
113	FE-550	HEAT EXCHANGER D SECONDARY COOLING WATER FLOW	0 TO	50 GPM	
114	FE-620	HEAT EXCHANGER B SECONDARY COOLING WATER FLOW	0 TO	150 GPM	
115	FE-720	HEAT EXCHANGER C SECONDARY COOLING WATER FLOW	0 TO	150 GPM	
116	EEE-1026BZ	ZERO INPUT CHANNELS 128 TO 255	0 TO	40 MV	
117	EEE-1026BC	CALIBRATION INPUT CHANNELS 128 TO 255	0 TO	40 MV	
118	PDE-186	SHROUD BOX DIFFERENTIAL PRESSURE LEVEL E/F TO F	0 TO	25 INCHES	NEGATIVE VALUES OUT OF RANGE
119	PDE-187	SHROUD BOX DIFFERENTIAL PRESSURE LEVEL F TO F/G	0 TO	25 INCHES	NEGATIVE VALUES OUT OF RANGE
120	PDE-188	SHROUD BOX DIFFERENTIAL PRESSURE LEVEL L/G TO G	0 TO	25 INCHES	NEGATIVE VALUES OUT OF RANGE
121	PDE-189	SHROUD BOX DIFFERENTIAL PRESSURE LEVEL G TO G/H	0 TO	25 INCHES	OUT OF SERVICE

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
122	FMFE-55	HEAT EXCHANGER A SPOOL DRAG DISC	-20000 TO	20000 LB/FS2	OUT OF SERVICE
123	FMFE-61	HEAT EXCHANGER B SPOOL DRAG DISC	-20000 TO	20000 LB/FS2	OUT OF SERVICE
124	FMFE-66	HEAT EXCHANGER C SPOOL DRAG DISC	-20000 TO	20000 LB/FS2	OUT OF SERVICE
125	FMFE-114	PRESSURIZER LINE SPOOL DRAG DISC	-20000 TO	20000 LB/FS2	OUT OF SERVICE
126	FMFE-264	BUNDLE INLET LOWER SPOOL DRAG DISC	-20000 TO	20000 LB/FS2	OUT OF SERVICE
127	PE-15	PUMP BYPASS SPOOL PRESSURE	0 TO	3000 PSIG	
128	PE-58	HEAT EXCHANGER A SPOOL PRESSURE	0 TO	3000 PSIG	
129	PE-63	HEAT EXCHANGER B SPOOL PRESSURE	0 TO	3000 PSIG	
130	PE-68	HEAT EXCHANGER C SPOOL PRESSURE	0 TO	3000 PSIG	
131	PE-209	BUNDLE OUTLET SPOOL TRANSIENT PRESSURE	0 TO	3000 PSIG	
132	PE-258	BUNDLE INLET UPPER SPOOL PRESSURE	0 TO	3000 PSIG	
133	PE-286	SHROUD PLENUM OUTLET PRESSURE	0 TO	3000 PSIG	
134	PDE-204	BUNDLE TRANSIENT DIFFERENTIAL PRESSURE	-166 TO	166 INCHES WATER	QUESTIONABLE
135	PDE-53	HEAT EXCHANGER A SPOOL DIFFERENTIAL PRESSURE	-50 TO	50 PSID	
136	PDE-60	HEAT EXCHANGER B SPOOL DIFFERENTIAL PRESSURE	-200 TO	200 PSID	
137	PDE-65	HEAT EXCHANGER C SPOOL DIFFERENTIAL PRESSURE	-50 TO	50 PSID	
138	PDE-111	PRESSURIZER LINE SPOOL DIFFERENTIAL PRESSURE	-50 TO	50 PSID	OUT OF SERVICE
139	PDE-203	TEST SECTION TRANSIENT DIFFERENTIAL PRESSURE	-50 TO	50 PSID	RINGING OBSERVED
140	PDE-251	BUNDLE INLET SPOOL DIFFERENTIAL PRESSURE	-50 TO	50 PSID	RINGING OBSERVED
141	FE-34	HORIZONTAL OUTLET SPOOL VELOCITY	-1800 TO	1800 GPM	QUESTIONABLE
142	FE-216	VERTICAL OUTLET SPOOL VELOCITY	-3600 TO	3600 GPM	
143	DE-36	HORIZONTAL OUTLET SPOOL DENSITY	0 TO	63 LB/CF	
144	DE-168	VERTICAL INLET SPOOL DENSITY	0 TO	63 LB/CF	
145	DE-218	VERTICAL OUTLET SPOOL DENSITY	0 TO	63 LB/CF	
146	XE-430B	INLET BREAKWIRE DETECTOR	0 TO	5 VOLTS	

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
147	XE-430A	OUTLET BREAKWIRE DETECTOR	0 TO	5 VOLTS	
148	FE-1A	PRIMARY PUMP FLOW	0 TO	800 GPM	
149	TDE-28	DIFFERENTIAL TEMPERATURE TRANSMITTER	-50 TO	50 DEGREES F	SPURIOUS SPIKES
150	PDE-30	TEST SECTION STEADY-STATE DIFFERENTIAL PRESSURE	0 TO	50 PSID	
151	PE-32	TEST SECTION OUTLET STEADY-STATE PRESSURE	500 TO	3951 PSIG	
152	PDE-48	MAIN HEAT EXCHANGER STEADY-STATE DIFFERENTIAL PRESSURE	0 TO	24 PSID	
153	LE-100	PRESSURIZER LIQUID LEVEL INSTRUMENT	0 TO	150 INCHES	
154	PE-102	PRESSURIZER STEADY-STATE PRESSURE	500 TO	2500 PSIG	
155	TE-727	HEAT EXCHANGER C SECONDARY DISCHARGE STEADY-STATE TEMPERATURE	32 TO	800 DEGREES F	
156	TE-557	HEAT EXCHANGER D SECONDARY DISCHARGE STEADY-STATE TEMPERATURE	32 TO	800 DEGREES F	SPURIOUS SPIKE
157	TE-28B	MAIN HEAT EXCHANGER MIXING TEE STEADY-STATE TEMPERATURE	32 TO	800 DEGREES F	SPURIOUS SPIKE
158	TE-4B	BASE PRIMARY STEADY-STATE TEMPERATURE	32 TO	800 DEGREES F	
159	TE-101	PRESSURIZER VAPOR STEADY-STATE TEMPERATURE	32 TO	800 DEGREES F	
160	TE-615	DEMINERALIZED WATER 6 INCH HEADER STEADY-STATE TEMPERATURE	32 TO	800 DEGREES F	
161	PDE-271	SPLIT DOWNCOMER TRANSIENT DIFFERENTIAL PRESSURE	-6 TO	6 PSID	NOISY
162	DE-204A	BUNDLE OUTLET SPOOL DENSITY	0 TO	63 LB/CF	SPURIOUS SPIKE
163	DE-204B	BUNDLE OUTLET SPOOL DENSITY	0 TO	63 LB/CF	SPURIOUS SPIKE
164	DE-204C	BUNDLE OUTLET SPOOL DENSITY	0 TO	63 LB/CF	SPURIOUS SPIKE
165	DE-336U	INBUNDLE GAMMA DENSITOMETER, ROD 36, UPPER	0 TO	63 LB/CF	QUESTIONABLE
166	DE-346L	INBUNDLE GAMMA DENSITOMETER, ROD 46, LOWER	0 TO	63 LB/CF	QUESTIONABLE
167	DE-336U	INBUNDLE GAMMA DENSITOMETER, ROD 36, VERTICAL	0 TO	155 INCHES	
168	DE-20	BUNDLE INLET SPOOL DENSITY	0 TO	63 LB/CF	
169	TE-172	VERTICAL INLET SPOOL TEMPERATURE	32 TO	1897 DEGREES F	SPURIOUS SPIKES

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
170	TE-208	BUNDLE OUTLET SPOOL TEMPERATURE	32 TO	1897 DEGREES F	
171	TE-3428E	SHEATH THERMOCOUPLE, ROD 42, LEVEL E	32 TO	1897 DEGREES F	SPURIOUS SPIKE
172	TE-351BD	SHEATH THERMOCOUPLE, ROD 51, LEVEL D	32 TO	1897 DEGREES F	SPURIOUS SPIKE
173	TE-1266	SUBCHANNEL NUMBER 66 THERMOCOUPLE	35 TO	1900 DEGREES F	
174	TE-1248	SUBCHANNEL NUMBER 48 THERMOCOUPLE	32 TO	1897 DEGREES F	
175	TE-1259	SUBCHANNEL NUMBER 59 THERMOCOUPLE	32 TO	1897 DEGREES F	
176	TE-1268	SUBCHANNEL NUMBER 68 THERMOCOUPLE	32 TO	1897 DEGREES F	
177	TE-1247	SUBCHANNEL NUMBER 47 THERMOCOUPLE	35 TO	1900 DEGREES F	
178	TE-1213	SUBCHANNEL THERMOCOUPLE, ROD NUMBER 13	32 TO	1897 DEGREES F	
179	TE-1235	SUBCHANNEL NUMBER 35 THERMOCOUPLE	32 TO	1897 DEGREES F	
180	FE-51	HEAT EXCHANGER A SPOOL VELOCITY	-57 TO	57 GPM	
181	FE-59	HEAT EXCHANGER B SPOOL VELOCITY	-57 TO	57 GPM	
182	FE-64	HEAT EXCHANGER C SPOOL VELOCITY	-57 TO	57 GPM	QUESTIONABLE
183	FE-232	INNER SEAL COOLANT VELOCITY	-10 TO	10 GPM	
184	FE-110	PRESSURIZER LINE SPOOL VELOCITY	-57 TO	57 GPM	
185	FE-202	BUNDLE OUTPUT LOWER VELOCITY	-3600 TO	3600 GPM	
186	FE-250	BUNDLE INLET VOLUMETRIC FLOW NUMBER 2	-450 TO	450 GPM	
187	FE-260	BUNDLE INLET LOWER VELOCITY	-450 TO	450 GPM	SPURIOUS SPIKE-POWER CUTOFF
188	FE-280	PURGE LINE RETURN VELOCITY	-60 TO	60 GPM	QUESTIONABLE
189	ZE-346L	INBUNDLE GAMMA DENSITOMETER VERTICAL POSITIONING ON ROD 46	0 TO	131 INCHES	
190	EEE-1026IZ	ZERO INPUT CHANNELS 1024 TO 1151	0 TO	40 MV	
191	EEE-1026IC	CALIBRATION INPUT CHANNELS 1024 TO 1151	0 TO	40 MV	
192	TE-270AE	SHROUD BOX THERMOCOUPLE, LEVEL 0, PENETRATION A, SIDE EAST	32 TO	1897 DEGREES F	
193	TE-270BE	SHROUD BOX THERMOCOUPLE, LEVEL 0, PENETRATION B, SIDE EAST	32 TO	1897 DEGREES F	

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
194	TE-271AE	SHROUD BOX THERMOCOUPLE, LEVEL 1, PENETRATION A, SIDE EAST	32 TO	1897 DEGREES F	
195	TE-271BE	SHROUD BOX THERMOCOUPLE, LEVEL 1, PENETRATION B, SIDE EAST	32 TO	1897 DEGREES F	
196	TE-272AE	SHROUD BOX THERMOCOUPLE, LEVEL 2, PENETRATION A, SIDE E	32 TO	1897 DEGREES F	FAILED INSTRUMENT
197	TE-272BE	SHROUD BOX THERMOCOUPLE, LEVEL 2, PENETRATION B, SIDE EAST	32 TO	1897 DEGREES F	
198	TE-329BC	SHEATH THERMOCOUPLE, ROD 29, LEVEL C	32 TO	1897 DEGREES F	
199	TE-329BD	SHEATH THERMOCOUPLE, ROD 29, LEVEL D	32 TO	1897 DEGREES F	
200	TE-329AE	SHEATH THERMOCOUPLE, ROD 29, LEVEL E	32 TO	1897 DEGREES F	
201	TE-354AG	SHEATH THERMOCOUPLE, ROD 54, LEVEL G, ANGLE A	32 TO	1897 DEGREES F	
202	TE-339BD	SHEATH THERMOCOUPLE, ROD 39, LEVEL D	32 TO	1897 DEGREES F	
203	TE-339BB	SHEATH THERMOCOUPLE, ROD 39, LEVEL B	32 TO	1897 DEGREES F	
204	TE-339AC	SHEATH THERMOCOUPLE, ROD 39, LEVEL C	32 TO	1897 DEGREES F	
205	TE-353BE	SHEATH THERMOCOUPLE, ROD 53, LEVEL E, ANGLE B	32 TO	1897 DEGREES F	
206	TE-338AF	SHEATH THERMOCOUPLE, ROD 38, LEVEL F, ANGLE A	32 TO	1897 DEGREES F	
207	TE-338E8	SHEATH THERMOCOUPLE, ROD 38, LEVEL E, SUPER LEVEL 8	32 TO	1897 DEGREES F	
208	TE-338E7	SHEATH THERMOCOUPLE, ROD 38, LEVEL E, SUPER LEVEL 7	32 TO	1897 DEGREES F	FAILED INSTRUMENT
209	TE-354F8	SHEATH THERMOCOUPLE, ROD 54, LEVEL F, SUPER LEVEL 8	32 TO	1897 DEGREES F	
210	TE-354F7	SHEATH THERMOCOUPLE, ROD 54, LEVEL F, SUPER LEVEL 7	32 TO	1897 DEGREES F	
211	TE-354F6	SHEATH THERMOCOUPLE, ROD 54, LEVEL F, SUPER LEVEL 6	32 TO	1897 DEGREES F	
212	TE-354F5	SHEATH THERMOCOUPLE, ROD 54, LEVEL F, SUPER LEVEL 5	32 TO	1897 DEGREES F	
213	TE-1234	SUBCHANNEL NUMBER 34 THERMOCOUPLE	32 TO	1897 DEGREES F	
214	TE-331CF	SHEATH THERMOCOUPLE, ROD 31, LEVEL F	32 TO	1897 DEGREES F	

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
215	TE-331CE	SHEATH THERMOCOUPLE, ROD 31, LEVEL E	32 TO	1897 DEGREES F	
216	TE-331CD	SHEATH THERMOCOUPLE, ROD 31, LEVEL D	32 TO	1897 DEGREES F	
217	TE-354F1	SHEATH THERMOCOUPLE, ROD 54, LEVEL F, SUPER LEVEL 1	32 TO	1897 DEGREES F	
218	TE-347CG	SHEATH THERMOCOUPLE	32 TO	1897 DEGREES F	
219	TE-345CF	SHEATH THERMOCOUPLE, ROD 45, LEVEL F	32 TO	1897 DEGREES F	FAILED INSTRUMENT
220	TE-345AG	SHEATH THERMOCOUPLE, ROD 45, LEVEL G	32 TO	1897 DEGREES F	
221	TE-1252	SUBCHANNEL NUMBER 52 THERMOCOUPLE	32 TO	1897 DEGREES F	
222	TE-361BE	SHEATH THERMOCOUPLE, ROD 61, LEVEL E, ANGLE B	32 TO	1897 DEGREES F	
223	TE-361AE	SHEATH THERMOCOUPLE, ROD 61, LEVEL E, ANGLE A	32 TO	1897 DEGREES F	
224	TE-354E6	SHEATH THERMOCOUPLE, ROD 54, LEVEL E, SUPER LEVEL 6	32 TO	1897 DEGREES F	
225	TE-340CB	SHEATH THERMOCOUPLE, ROD 40, LEVEL B	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
226	TE-340CA	SHEATH THERMOCOUPLE, ROD 40, LEVEL A	32 TO	1897 DEGREES F	
227	TE-340BD	SHEATH THERMOCOUPLE, ROD 40, LEVEL D	32 TO	1897 DEGREES F	
228	TE-340BC	SHEATH THERMOCOUPLE, ROD 40, LEVEL C	32 TO	1897 DEGREES F	
229	TE-338F1	SHEATH THERMOCOUPLE, ROD 38, LEVEL F, SUPER LEVEL 1	32 TO	1897 DEGREES F	
230	TE-330AC	SHEATH THERMOCOUPLE, ROD 30, LEVEL C, ANGLE A	32 TO	1897 DEGREES F	
231	TE-330AE	SHEATH THERMOCOUPLE, ROD 30, LEVEL E, ANGLE A	32 TO	1897 DEGREES F	
232	TE-330CB	SHEATH THERMOCOUPLE, ROD 30, LEVEL B	32 TO	1897 DEGREES F	
233	TE-1242	SUBCHANNEL NUMBER 42 THERMOCOUPLE	32 TO	1897 DEGREES F	
234	TE-1245	SUBCHANNEL NUMBER 45 THERMOCOUPLE	32 TO	1897 DEGREES F	
235	TE-1258	SUBCHANNEL NUMBER 58 THERMOCOUPLE	32 TO	1897 DEGREES F	
236	TE-1244	SUBCHANNEL NUMBER 44 THERMOCOUPLE	32 TO	1897 DEGREES F	
237	TE-1209	SUBCHANNEL NUMBER 9 THERMOCOUPLE	32 TO	1897 DEGREES F	
238	TE-1217	SUBCHANNEL NUMBER 17 THERMOCOUPLE	32 TO	1897 DEGREES F	

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
239	TE-1226	SUBCHANNEL NUMBER 26 THERMOCOUPLE	32 TO	1897 DEGREES F	
240	TE-1249	SUBCHANNEL NUMBER 49 THERMOCOUPLE	32 TO	1897 DEGREES F	
241	TE-1225	SUBCHANNEL NUMBER 25 THERMOCOUPLE	32 TO	1897 DEGREES F	
242	TE-353AE	SHEATH THERMOCOUPLE, ROD 53, LEVEL E	32 TO	1897 DEGREES F	
243	TE-1227	SUBCHANNEL NUMBER 27 THERMOCOUPLE	32 TO	1897 DEGREES F	
244	TE-353CC	SHEATH THERMOCOUPLE, ROD 53, LEVEL C	32 TO	1897 DEGREES F	
245	TE-361CE	SHEATH THERMOCOUPLE, ROD 61, LEVEL E	32 TO	1897 DEGREES F	
246	TE-361AB	SHEATH THERMOCOUPLE, ROD 61, LEVEL B	32 TO	1897 DEGREES F	
247	TE-361AC	SHEATH THERMOCOUPLE, ROD 61, LEVEL C	32 TO	1897 DEGREES F	
248	TE-361AD	SHEATH THERMOCOUPLE, ROD 61, LEVEL D	32 TO	1897 DEGREES F	QUESTIONABLE
249	TE-364AG	SHEATH THERMOCOUPLE, ROD 64, LEVEL G	32 TO	1897 DEGREES F	
250	TE-364BE	SHEATH THERMOCOUPLE, ROD 64, LEVEL E	32 TO	1897 DEGREES F	
251	TE-364AD	SHEATH THERMOCOUPLE, ROD 64, LEVEL D	32 TO	1897 DEGREES F	
252	TE-364BF	SHEATH THERMOCOUPLE, ROD 64, LEVEL F	32 TO	1897 DEGREES F	
253	TE-363BE	SHEATH THERMOCOUPLE, ROD 63, LEVEL E	32 TO	1897 DEGREES F	
254	TE-363BC	SHEATH THERMOCOUPLE, ROD 63, LEVEL C	32 TO	1897 DEGREES F	
255	TE-363CB	SHEATH THERMOCOUPLE, ROD 63, LEVEL B	32 TO	1897 DEGREES F	
256	TE-1263	SUBCHANNEL NUMBER 63 THERMOCOUPLE	32 TO	1897 DEGREES F	FAILED INSTRUMENT
257	TE-313CF	SHEATH THERMOCOUPLE, ROD 13, LEVEL F, ANGLE C	32 TO	1897 DEGREES F	
258	TE-348AH	SHEATH THERMOCOUPLE, ROD 48, LEVEL H, ANGLE A	32 TO	1897 DEGREES F	
259	TE-348AY	SHEATH THERMOCOUPLE, ROD 48, LEVEL Y, ANGLE A	32 TO	1897 DEGREES F	
260	TE-331BF	SHEATH THERMOCOUPLE, ROD 31, LEVEL F, ANGLE B	32 TO	1897 DEGREES F	
261	TE-355CB	SHEATH THERMOCOUPLE, ROD 55, LEVEL B	32 TO	1897 DEGREES F	SPURIOUS SPIKE
262	TE-355AA	SHEATH THERMOCOUPLE, ROD 55, LEVEL A	32 TO	1897 DEGREES F	SPURIOUS SPIKE
263	TE-362AC	SHEATH THERMOCOUPLE, ROD 62, LEVEL C, ANGLE A	32 TO	1897 DEGREES F	SPURIOUS SPIKE

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
264	TE-355BC	SHEATH THERMOCOUPLE, ROD 55, LEVEL C, ANGLE B	32 TO	1897 DEGREES F	SPURIOUS SPIKE
265	TE-356CH	SHEATH THERMOCOUPLE, ROD 56, LEVEL H, ANGLE C	32 TO	1897 DEGREES F	SPURIOUS SPIKE
266	TE-356BS	SHEATH THERMOCOUPLE, ROD 56, LEVEL S, ANGLE B	32 TO	1897 DEGREES F	
267	TE-356BU	SHEATH THERMOCOUPLE, ROD 56, LEVEL U, ANGLE B	32 TO	1897 DEGREES F	
268	TE-356AY	SHEATH THERMOCOUPLE, ROD 56, LEVEL Y, ANGLE A	32 TO	1897 DEGREES F	FAILED INSTRUMENT
269	TE-362CE	SHEATH THERMOCOUPLE, ROD 62, LEVEL E, ANGLE C	32 TO	1897 DEGREES F	
270	TE-362BB	SHEATH THERMOCOUPLE, ROD 62, LEVEL B, ANGLE B	32 TO	1897 DEGREES F	SPURIOUS SPIKE
271	TE-362AD	SHEATH THERMOCOUPLE, ROD 62, LEVEL D, ANGLE A	32 TO	1897 DEGREES F	
272	TE-337E7	SHEATH THERMOCOUPLE, ROD 37, LEVEL E, SUPER LEVEL 7	32 TO	1897 DEGREES F	
273	TE-337F8	SHEATH THERMOCOUPLE, ROD 37, LEVEL F, SUPER LEVEL 8	32 TO	1897 DEGREES F	
274	TE-337F7	SHEATH THERMOCOUPLE, ROD 37, LEVEL F, SUPER LEVEL 7	32 TO	1897 DEGREES F	
275	TE-337F6	SHEATH THERMOCOUPLE, ROD 37, LEVEL F, SUPER LEVEL 6	32 TO	1897 DEGREES F	
276	TE-334AG	SHEATH THERMOCOUPLE, ROD 34, LEVEL G, ANGLE A	32 TO	1897 DEGREES F	
277	TE-334F7	SHEATH THERMOCOUPLE, ROD 34, LEVEL 7, ANGLE F	32 TO	1897 DEGREES F	FAILED INSTRUMENT
278	TE-334F6	SHEATH THERMOCOUPLE, ROD 34, LEVEL F, SUPER LEVEL 6	32 TO	1897 DEGREES F	FAILED INSTRUMENT
279	TE-334F3	SHEATH THERMOCOUPLE, ROD 34, LEVEL F, SUPER LEVEL 3	32 TO	1897 DEGREES F	
280	TE-360F6	SHEATH THERMOCOUPLE, ROD 60, LEVEL F, SUPER LEVEL 6	32 TO	1897 DEGREES F	
281	TE-360F5	SHEATH THERMOCOUPLE, ROD 60, LEVEL F, SUPER LEVEL 5	32 TO	1897 DEGREES F	

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
282	TE-360F4	SHEATH THERMOCOUPLE, ROD 60, LEVEL F, SUPER LEVEL 4	32 TO	1897 DEGREES F	
283	TE-312BC	SHEATH THERMOCOUPLE, ROD 12, LEVEL C	32 TO	1897 DEGREES F	
284	TE-312AE	SHEATH THERMOCOUPLE, ROD 12, LEVEL E, ANGLE A	32 TO	1897 DEGREES F	
285	TE-312CB	SHEATH THERMOCOUPLE, ROD 12, LEVEL B	32 TO	1897 DEGREES F	
286	TE-349AE	SHEATH THERMOCOUPLE, ROD 49, LEVEL E, ANGLE A	32 TO	1897 DEGREES F	
287	TE-343BB	SHEATH THERMOCOUPLE, ROD 43, LEVEL B	32 TO	1897 DEGREES F	
288	TE-343BC	SHEATH THERMOCOUPLE, ROD 43, LEVEL C	32 TO	1897 DEGREES F	
289	TE-326AD	SHEATH THERMOCOUPLE, ROD 26, LEVEL D, ANGLE A	32 TO	1897 DEGREES F	
290	TE-343BA	SHEATH THERMOCOUPLE, ROD 43, LEVEL A	32 TO	1897 DEGREES F	FAILED INSTRUMENT
291	TE-327AC	SHEATH THERMOCOUPLE, ROD 27, LEVEL C	32 TO	1897 DEGREES F	
292	TE-338F2	SHEATH THERMOCOUPLE, ROD 38, LEVEL F, SUPER LEVEL 2	32 TO	1897 DEGREES F	
293	TE-337E3	SHEATH THERMOCOUPLE, ROD 37, LEVEL E, SUPER LEVEL 3	32 TO	1897 DEGREES F	
294	TE-341AB	SHEATH THERMOCOUPLE, ROD 41, LEVEL B	32 TO	1897 DEGREES F	
295	TE-342AG	SHEATH THERMOCOUPLE, ROD 42, LEVEL G	32 TO	1897 DEGREES F	
296	TE-343AD	SHEATH THERMOCOUPLE, ROD 43, LEVEL D, ANGLE A	32 TO	1897 DEGREES F	
297	TE-321MF	MIDDLE THERMOCOUPLE, ROD 21, LEVEL F	32 TO	1897 DEGREES F	
298	TE-342CG	SHEATH THERMOCOUPLE, ROD 42, LEVEL G	32 TO	1897 DEGREES F	
299	TE-308AD	SHEATH THERMOCOUPLE, ROD 8, LEVEL D, ANGLE A	35 TO	1900 DEGREES F	
300	TE-342BF	SHEATH THERMOCOUPLE, ROD 42, LEVEL F	32 TO	1897 DEGREES F	
301	TE-342BD	SHEATH THERMOCOUPLE, ROD 42, LEVEL D	32 TO	1897 DEGREES F	
302	TE-292b	SPACER GRID NUMBER 3 THERMOCOUPLE SUBCHANNEL 43	32 TO	1897 DEGREES F	FAILED INSTRUMENT
303	TE-292D	SPACER GRID NUMBER 3 THERMOCOUPLE SUBCHANNEL 70	32 TO	1897 DEGREES F	SPURIOUS SPIKE
304	TE-295B	SPACER GRID NUMBER 6 THERMOCOUPLE SUBCHANNEL 43	32 TO	1897 DEGREES F	

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
305	TE-295D	SPACER GRID NUMBER 6 THERMOCOUPLE SUBCHANNEL 70	32 TO	1897 DEGREES F	
306	TE-291D	SPACER GRID NUMBER 2 THERMOCOUPLE SUBCHANNEL 70	32 TO	1897 DEGREES F	
307	TE-294F	SPACER GRID NUMBER 5 THERMOCOUPLE SUBCHANNEL 38	32 TO	1897 DEGREES F	
308	TE-338F6	SHEATH THERMOCOUPLE, ROD 38, LEVEL F, SUPER LEVEL 6	32 TO	1897 DEGREES F	
309	TE-342BG	SHEATH THERMOCOUPLE, ROD 42, LEVEL G, ANGLE B	32 TO	1897 DEGREES F	
310	TE-330BE	SHEATH THERMOCOUPLE, ROD 30, LEVEL E, ANGLE B	32 TO	1897 DEGREES F	
311	TE-293A	SPACER GRID NUMBER 4 THERMOCOUPLE SUBCHANNEL 32	32 TO	1897 DEGREES F	FAILED INSTRUMENT
312	TE-295C	SPACER GRID NUMBER 6 THERMOCOUPLE SUBCHANNEL 57	32 TO	1897 DEGREES F	QUESTIONABLE
313	TE-295A	SPACER GRID NUMBER 6 THERMOCOUPLE SUBCHANNEL 32	32 TO	1897 DEGREES F	FAILED INSTRUMENT
314	EEE-1026JZ	ZERO INPUT CHANNELS 1152 TO 1279	0 TO	40 MV	
315	EEE-1026JC	CALIBRATION INPUT CHANNELS 1052 TO 1279	0 TO	40 MV	
316	TE-273AE	SHROUD BOX THERMOCOUPLE, LEVEL 3, PENETRATION A, SIDE EAST	32 TO	1897 DEGREES F	SPURIOUS SPIKE
317	TE-273BE	SHROUD BOX THERMOCOUPLE, LEVEL 3, PENETRATION B, SIDE EAST	32 TO	1897 DEGREES F	SPURIOUS SPIKE
318	TE-338F7	SHEATH THERMOCOUPLE, ROD 38, LEVEL F, SUPER LEVEL 7	32 TO	1897 DEGREES F	SPURIOUS SPIKE
319	TE-338F3	SHEATH THERMOCOUPLE, ROD 38, LEVEL 3, ANGLE F	32 TO	1897 DEGREES F	FAILED INSTRUMENT
320	TE-275AE	SHROUD BOX THERMOCOUPLE, LEVEL 5, PENETRATION A, SIDE EAST	32 TO	1897 DEGREES F	SPURIOUS SPIKE
321	TE-275BE	SHROUD BOX THERMOCOUPLE, LEVEL 5, PENETRATION B, SIDE EAST	32 TO	1897 DEGREES F	FAILED INSTRUMENT
322	TE-292A	SPACER GRID NUMBER 3 THERMOCOUPLE SUBCHANNEL 32	32 TO	1897 DEGREES F	SPURIOUS SPIKE
323	TE-291C	SPACER GRID NUMBER 2 THERMOCOUPLE SUBCHANNEL 57	32 TO	1897 DEGREES F	

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
324	TE-291B	SPACER GRID NUMBER 2 THERMOCOUPLE SUBCHANNEL 43	32 TO	1897 DEGREES F	QUESTIONABLE
325	TE-293F	SPACER GRID NUMBER 4 THERMOCOUPLE SUBCHANNEL 38	32 TO	1897 DEGREES F	
326	TE-181W	SHROUD BOX THERMOCOUPLE, LEVEL A WEST SIDE	32 TO	1897 DEGREES F	
327	TE-185W	SHROUD BOX THERMOCOUPLE, LEVEL E WEST SIDE	32 TO	1897 DEGREES F	FAILED INSTRUMENT
328	TE-291A	SPACER GRID NUMBER 2 THERMOCOUPLE SUBCHANNEL 32	32 TO	1897 DEGREES F	
329	TE-293C	SPACER GRID NUMBER 4 THERMOCOUPLE SUBCHANNEL 57	32 TO	1897 DEGREES F	
330	TE-294B	SPACER GRID NUMBER 5 THERMOCOUPLE SUBCHANNEL 43	32 TO	1897 DEGREES F	
331	TE-294E	SPACER GRID NUMBER 5 THERMOCOUPLE SUBCHANNEL 17	32 TO	1897 DEGREES F	QUESTIONABLE
332	TE-294D	SPACER GRID NUMBER 5 THERMOCOUPLE SUBCHANNEL 70	32 TO	1897 DEGREES F	
333	TE-293E	SPACER GRID NUMBER 4 THERMOCOUPLE SUBCHANNEL 17	32 TO	1897 DEGREES F	FAILED INSTRUMENT
334	TE-293D	SPACER GRID NUMBER 4 THERMOCOUPLE SUBCHANNEL 70	32 TO	1897 DEGREES F	
335	TE-293B	SPACER GRID NUMBER 4 THERMOCOUPLE SUBCHANNEL 43	32 TO	1897 DEGREES F	FAILED INSTRUMENT
336	TE-296B	SPACER GRID NUMBER 7 THERMOCOUPLE SUBCHANNEL 43	32 TO	1897 DEGREES F	
337	TE-296D	SPACER GRID NUMBER 7 THERMOCOUPLE SUBCHANNEL 70	32 TO	1897 DEGREES F	FAILED INSTRUMENT
338	TE-352AU	SHEATH THERMOCOUPLE, ROD 52, LEVEL U	32 TO	1897 DEGREES F	
339	TE-352BS	SHEATH THERMOCOUPLE, ROD 52, LEVEL S	32 TO	1897 DEGREES F	
340	TE-352CH	SHEATH THERMOCOUPLE, ROD 52, LEVEL H	32 TO	1897 DEGREES F	
341	TE-352CY	SHEATH THERMOCOUPLE, ROD 52, LEVEL Y	32 TO	1897 DEGREES F	
342	TE-350F6	SHEATH THERMOCOUPLE, ROD 50, LEVEL F, SUPER LEVEL 6	32 TO	1897 DEGREES F	

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
343	TE-349BE	SHEATH THERMOCOUPLE, ROD 49, LEVEL E, ANGLE B	32 TO	1897 DEGREES F	
344	TE-350F2	SHEATH THERMOCOUPLE, ROD 50, LEVEL F, SUPER LEVEL 2	32 TO	1897 DEGREES F	
345	TE-350F1	SHEATH THERMOCOUPLE, ROD 50, LEVEL F, SUPER LEVEL 1	32 TO	1897 DEGREES F	SPURIOUS SPIKE
346	TE-349CB	SHEATH THERMOCOUPLE, ROD 49, LEVEL B	32 TO	1897 DEGREES F	
347	TE-349CD	SHEATH THERMOCOUPLE, ROD 49, LEVEL D	32 TO	1897 DEGREES F	
348	TE-349CC	SHEATH THERMOCOUPLE, ROD 49, LEVEL C	32 TO	1897 DEGREES F	
349	TE-349CE	SHEATH THERMOCOUPLE, ROD 49, LEVEL E	32 TO	1897 DEGREES F	
350	TE-326CE	SHEATH THERMOCOUPLE, ROD 26, LEVEL E	32 TO	1897 DEGREES F	
351	TE-326AC	SHEATH THERMOCOUPLE, ROD 26, LEVEL C	32 TO	1897 DEGREES F	
352	TE-338E3	SHEATH THERMOCOUPLE, ROD 38, LEVEL E, SUPER LEVEL 3	32 TO	1897 DEGREES F	
353	TE-326BB	SHEATH THERMOCOUPLE, ROD 26, LEVEL B	32 TO	1897 DEGREES F	
354	TE-351BC	SHEATH THERMOCOUPLE, ROD 51, LEVEL C	32 TO	1897 DEGREES F	
355	TE-354E3	SHEATH THERMOCOUPLE, ROD 54, LEVEL E, SUPER LEVEL 3	32 TO	1897 DEGREES F	FAILED INSTRUMENT
356	TE-351AE	SHEATH THERMOCOUPLE, ROD 51, LEVEL E, ANGLE A	35 TO	1900 DEGREES F	
357	TE-351AB	SHEATH THERMOCOUPLE, ROD 51, LEVEL B	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
358	TE-1205	SUBCHANNEL NUMBER 5 THERMOCOUPLE	32 TO	1897 DEGREES F	
359	TE-1223	SUBCHANNEL NUMBER 23 THERMOCOUPLE	32 TO	1897 DEGREES F	
360	TE-1214	SUBCHANNEL NUMBER 14 THERMOCOUPLE	32 TO	1897 DEGREES F	
361	TE-1232	SUBCHANNEL NUMBER 32 THERMOCOUPLE	32 TO	1897 DEGREES F	
362	TE-1211	SUBCHANNEL NUMBER 11 THERMOCOUPLE	32 TO	1897 DEGREES F	
363	TE-1221	SUBCHANNEL NUMBER 21 THERMOCOUPLE	32 TO	1897 DEGREES F	
364	TE-1231	SUBCHANNEL NUMBER 31 THERMOCOUPLE	32 TO	1897 DEGREES F	
365	TE-1201	SUBCHANNEL NUMBER 1 THERMOCOUPLE	32 TO	1897 DEGREES F	

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
366	TE-1251	SUBCHANNEL NUMBER 51 THERMOCOUPLE	32 TO	1897 DEGREES F	
367	TE-329AC	SHEATH THERMOCOUPLE, ROD 29, LEVEL C, ANGLE A	35 TO	1900 DEGREES F	
368	TE-1273	SUBCHANNEL NUMBER 73 THERMOCOUPLE	32 TO	1897 DEGREES F	
369	TE-1265	SUBCHANNEL NUMBER 65 THERMOCOUPLE	32 TO	1897 DEGREES F	SPURIOUS SPIKE
370	TE-1256	SUBCHANNEL NUMBER 56 THERMOCOUPLE	32 TO	1897 DEGREES F	SPURIOUS SPIKE
371	TE-1240	SUBCHANNEL NUMBER 40 THERMOCOUPLE	32 TO	1897 DEGREES F	SPURIOUS SPIKE
372	TE-1230	SUBCHANNEL NUMBER 30 THERMOCOUPLE	32 TO	1897 DEGREES F	SPURIOUS SPIKE
373	TE-1237	SUBCHANNEL NUMBER 37 THERMOCOUPLE	32 TO	1897 DEGREES F	SPURIOUS SPIKE
374	TE-1238	SUBCHANNEL NUMBER 38 THERMOCOUPLE	32 TO	1897 DEGREES F	SPURIOUS SPIKE
375	TE-1239	SUBCHANNEL NUMBER 39 THERMOCOUPLE	32 TO	1897 DEGREES F	SPURIOUS SPIKE
376	TE-1260	SUBCHANNEL NUMBER 60 THERMOCOUPLE	32 TO	1897 DEGREES F	SPURIOUS SPIKE
377	TE-1270	SUBCHANNEL NUMBER 70 THERMOCOUPLE	32 TO	1897 DEGREES F	
378	TE-330AD	SHEATH THERMOCOUPLE, ROD 30, LEVEL D, ANGLE A	35 TO	1900 DEGREES F	
379	TE-1277	SUBCHANNEL NUMBER 77 THERMOCOUPLE	32 TO	1897 DEGREES F	
380	TE-1261	SUBCHANNEL NUMBER 61 THERMOCOUPLE	32 TO	1897 DEGREES F	
381	TE-1271	SUBCHANNEL NUMBER 71 THERMOCOUPLE	32 TO	1897 DEGREES F	
382	TE-1241	SUBCHANNEL NUMBER 41 THERMOCOUPLE	32 TO	1897 DEGREES F	
383	TE-1250	SUBCHANNEL NUMBER 50 THERMOCOUPLE	32 TO	1897 DEGREES F	
384	TE-345AD	SHEATH THERMOCOUPLE, ROD 45, LEVEL D, ANGLE A	35 TO	1900 DEGREES F	
385	TE-1281	SUBCHANNEL NUMBER 81 THERMOCOUPLE	32 TO	1897 DEGREES F	
386	TE-182E	SHROUD BOX THERMOCOUPLE, LEVEL B EAST SIDE	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
387	TE-187N	SHROUD BOX THERMOCOUPLE, LEVEL G NORTH SIDE	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
388	TE-183N	SHROUD BOX THERMOCOUPLE, LEVEL C NORTH SIDE	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
389	TE-184E	SHROUD BOX THERMOCOUPLE, LEVEL D	32 TO	1897 DEGREES F	SPURIOUS SPIKES-POWER CUTOFF

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
390	TE-150	TEST SECTION BOTTOM FLANGE TEMPERATURE SIDE	32 TO	1897 DEGREES F	SPURIOUS SPIKES-POWER CUTOFF
391	TE-151	TEST SECTION BOTTOM FLANGE TEMPERATURE SIDE	32 TO	1897 DEGREES F	SPURIOUS SPIKES-POWER CUTOFF
392	TE-152	TEST SECTION BOTTOM FLANGE TEMPERATURE SIDE	32 TO	1897 DEGREES F	SPURIOUS SPIKES-POWER CUTOFF
393	TE-1	PRESSURIZER VAPOR TEMPERATURE	32 TO	1897 DEGREES F	SPURIOUS SPIKES-POWER CUTOFF
394	TE-2	PRESSURIZER WATER TEMPERATURE	32 TO	1897 DEGREES F	SPURIOUS SPIKES-POWER CUTOFF
395	TE-116	PRESSURIZER EXIT SPOOL TEMPERATURE	32 TO	1897 DEGREES F	SPURIOUS SPIKES-POWER CUTOFF
396	TE-24	HORIZONTAL INLET SPOOL TEMPERATURE	32 TO	1897 DEGREES F	SPURIOUS SPIKES-POWER CUTOFF
397	TE-222	VERTICAL OUTLET SPOOL TEMPERATURE	32 TO	1897 DEGREES F	SPURIOUS SPIKES-POWER CUTOFF
398	TE-40	HORIZONTAL OUTLET SPOOL TEMPERATURE	32 TO	1897 DEGREES F	SPURIOUS SPIKES-POWER CUTOFF
399	TE-29	INLET BLOWDOWN PLENUM TEMPERATURE	32 TO	1897 DEGREES F	SPURIOUS SPIKES-POWER CUTOFF
400	TE-45	OUTLET BLOWDOWN PLENUM TEMPERATURE	32 TO	1897 DEGREES F	SPURIOUS SPIKES-POWER CUTOFF
401	TE-58	HEAT TRANSFER D OUTLET TEMPERATURE	32 TO	1897 DEGREES F	SPURIOUS SPIKES
402	TE-57	HEAT TRANSFER A SPOOL TEMPERATURE	32 TO	1897 DEGREES F	
403	TE-62	HEAT TRANSFER B SPOOL TEMPERATURE	32 TO	1897 DEGREES F	
404	TE-67	HEAT TRANSFER C SPOOL TEMPERATURE	32 TO	1897 DEGREES F	
405	TE-408B	PRESSURE SUPPRESSION SYSTEM TANK SPRAY TEMPERATURE	32 TO	1897 DEGREES F	
406	TE-520B	4 INCH DEMINERALIZED WATER HEADER TEMPERATURE	32 TO	1897 DEGREES F	
407	TE-521	PURIFICATION COOLING OUTLET THERMOCOUPLE	32 TO	1897 DEGREES F	
408	TE-901	PRESSURE STEAM KILLER AIR VENT THERMOCOUPLE	32 TO	1897 DEGREES F	
409	TE-256	TEST SECTION INLET TEMPERATURE	32 TO	1897 DEGREES F	
410	TE-284	OLD DOWNCOMER PURGE LINE RETURN TEMPERATURE	32 TO	1897 DEGREES F	
411	TE-313CD	SHEATH THERMOCOUPLE, ROD 13, LEVEL D	32 TO	1897 DEGREES F	
412	TE-313BC	SHEATH THERMOCOUPLE, ROD 13, LEVEL C	32 TO	1897 DEGREES F	
413	TE-313CE	SHEATH THERMOCOUPLE, ROD 13, LEVEL E	32 TO	1897 DEGREES F	
414	TE-313BF	SHEATH THERMOCOUPLE, ROD 13, LEVEL F	32 TO	1897 DEGREES F	SPURIOUS SPIKE

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
415	TE-323BC	SHEATH THERMOCOUPLE, ROD 23, LEVEL C	32 TO	1897 DEGREES F	
416	TE-1220	SUBCHANNEL NUMBER 20 THERMOCOUPLE	32 TO	1897 DEGREES F	
417	TE-1219	SUBCHANNEL NUMBER 19 THERMOCOUPLE	32 TO	1897 DEGREES F	
418	TE-J23AA	SHEATH THERMOCOUPLE, ROD 23, LEVEL A	32 TO	1897 DEGREES F	
419	TE-321F7	SHEATH THERMOCOUPLE, ROD 21, LEVEL F, SUPER LEVEL 7	32 TO	1897 DEGREES F	
420	TE-321F6	SHEATH THERMOCOUPLE, ROD 21, LEVEL F, SUPER LEVEL 6	32 TO	1897 DEGREES F	FAILED INSTRUMENT
421	TE-321F4	SHEATH THERMOCOUPLE, ROD 21, LEVEL F, SUPER LEVEL 4	32 TO	1897 DEGREES F	FAILED INSTRUMENT
422	TE-321F3	SHEATH THERMOCOUPLE, ROD 21, LEVEL F, SUPER LEVEL 3	32 TO	1897 DEGREES F	
423	TE-337AF	SHEATH THERMOCOUPLE, ROD 37, LEVEL F, ANGLE A	32 TO	1897 DEGREES F	
424	TE-327CB	SHEATH THERMOCOUPLE, ROD 27, LEVEL B	32 TO	1897 DEGREES F	
425	TE-326CD	SHEATH THERMOCOUPLE, ROD 26, LEVEL D, ANGLE C	32 TO	1897 DEGREES F	
426	TE-336E1	SHEATH THERMOCOUPLE, ROD 38, LEVEL E, SUPER LEVEL 1	32 TO	1897 DEGREES F	
427	TE-337E8	SHEATH THERMOCOUPLE, ROD 37, LEVEL E, SUPER LEVEL 8	32 TO	1897 DEGREES F	
428	TE-327CD	SHEATH THERMOCOUPLE, ROD 27, LEVEL D	32 TO	1897 DEGREES F	
429	TE-327CC	SHEATH THERMOCOUPLE, ROD 27, LEVEL C	32 TO	1897 DEGREES F	
430	TE-327BA	SHEATH THERMOCOUPLE, ROD 27, LEVEL A	32 TO	1897 DEGREES F	
431	EEE-1026KZ	ZERO INPUT CHANNELS 1280 TO 1407	0 TO	40 MV	
432	EEE-1026KC	CALIBRATION INPUT CHANNELS 1280 TO 1407	0 TO	40 MV	
433	TE-276AE	SHROUD BOX THERMOCOUPLE, LEVEL 6, PENETRATION A, SIDE EAST	32 TO	1897 DEGREES F	
434	TE-276BE	SHROUD BOX THERMOCOUPLE, LEVEL 6, PENETRATION B, SIDE EAST	32 TO	1897 DEGREES F	FAILED INSTRUMENT
435	TE-277AE	SHROUD BOX THERMOCOUPLE, LEVEL 7, PENETRATION A, SIDE EAST	32 TO	1897 DEGREES F	FAILED INSTRUMENT

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
436	TE-277BE	SHROUD BOX THERMOCOUPLE, LEVEL 7, PENETRATION B, SIDE EAST	32 TO	1897 DEGREES F	SPURIOUS SPIKE
437	TE-923	UPPER VOLUME PLUG TEMPERATURE	35 TO	1900 DEGREES F	QUESTIONABLE
438	TE-924	LOWER VOLUME PLUG TEMPERATURE	35 TO	1900 DEGREES F	QUESTIONABLE
439	TE-307AC	SHEATH THERMOCOUPLE, ROD 7, LEVEL C	32 TO	1897 DEGREES F	
440	TE-332CE	SHEATH THERMOCOUPLE, ROD 32, LEVEL E	32 TO	1897 DEGREES F	
441	TE-307AF	SHEATH THERMOCOUPLE, ROD 7, LEVEL F	32 TO	1897 DEGREES F	
442	TE-307CE	SHEATH THERMOCOUPLE, ROD 7, LEVEL E	32 TO	1897 DEGREES F	
443	TE-316BG	SHEATH THERMOCOUPLE, ROD 16, LEVEL G, ANGLE B	32 TO	1897 DEGREES F	
444	TE-332CF	SHEATH THERMOCOUPLE, ROD 32, LEVEL F	32 TO	1897 DEGREES F	
445	TE-332CD	SHEATH THERMOCOUPLE, ROD 32, LEVEL D	32 TO	1897 DEGREES F	
446	TE-318AG	SHEATH THERMOCOUPLE, ROD 18, LEVEL G, ANGLE A	32 TO	1897 DEGREES F	
447	TE-314F2	SHEATH THERMOCOUPLE, ROD 14, LEVEL F, SUPER LEVEL 2	32 TO	1897 DEGREES F	
448	TE-332CG	SHEATH THERMOCOUPLE, ROD 32, LEVEL G	32 TO	1897 DEGREES F	
449	TE-318AE	SHEATH THERMOCOUPLE, ROD 18, LEVEL E, ANGLE A	32 TO	1897 DEGREES F	QUESTIONABLE
450	TE-324AE	SHEATH THERMOCOUPLE, ROD 24, LEVEL E, ANGLE A	32 TO	1897 DEGREES F	
451	TE-305BU	SHEATH THERMOCOUPLE, ROD 5, LEVEL U	32 TO	1897 DEGREES F	
452	TE-305AS	SHEATH THERMOCOUPLE, ROD 6, LEVEL S, ANGLE A	32 TO	1897 DEGREES F	
453	TE-305BH	SHEATH THERMOCOUPLE, ROD 5, LEVEL H	32 TO	1897 DEGREES F	
454	TE-305CY	SHEATH THERMOCOUPLE, ROD 5, LEVEL Y	32 TO	1897 DEGREES F	
455	TE-189BG	ARRAY ROD THERMOCOUPLE GRID NUMBER 22 SUBCHANNEL 33 LEVEL G	32 TO	1897 DEGREES F	
456	TE-308CD	SHEATH THERMOCOUPLE, ROD 8, LEVEL D, ANGLE C	32 TO	1897 DEGREES F	
457	TE-188BE	ARRAY ROD THERMOCOUPLE GRID NUMBER 19 SUBCHANNEL 31 LEVEL E	32 TO	1897 DEGREES F	FAILED INSTRUMENT
458	TE-189BD	ARRAY ROD THERMOCOUPLE GRID NUMBER 22 SUBCHANNEL 33 LEVEL D	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
459	TE-189AG	ARRAY ROD THERMOCOUPLE GRID NUMBER 22 SUBCHANNEL 25 LEVEL G	32 TO	1897 DEGREES F	
460	TE-188AD	ARRAY ROD THERMOCOUPLE GRID NUMBER 19 SUBCHANNEL 21 LEVEL D	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
461	TE-189AE	ARRAY ROD THERMOCOUPLE GRID NUMBER 22 SUBCHANNEL 25 LEVEL E	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
462	TE-189AD	ARRAY ROD THERMOCOUPLE GRID NUMBER 22 SUBCHANNEL 25 LEVEL D	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
463	TE-189BE	ARRAY ROD THERMOCOUPLE GRID NUMBER 22 SUBCHANNEL 33 LEVEL E	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
464	TE-188AE	ARRAY ROD THERMOCOUPLE GRID NUMBER 19 SUBCHANNEL 21 LEVEL E	32 TO	1897 DEGREES F	
465	TE-188AF	ARRAY ROD THERMOCOUPLE GRID NUMBER 19 SUBCHANNEL 21 LEVEL F	32 TO	1897 DEGREES F	
466	TE-189BF	ARRAY ROD THERMOCOUPLE GRID NUMBER 22 SUBCHANNEL 33 LEVEL F	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
467	TE-188BF	ARRAY ROD THERMOCOUPLE GRID NUMBER 19 SUBCHANNEL 31 LEVEL F	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
468	TE-189AF	ARRAY ROD THERMOCOUPLE GRID NUMBER 22 SUBCHANNEL 25 LEVEL F	32 TO	1897 DEGREES F	
469	TE-188BG	ARRAY ROD THERMOCOUPLE GRID NUMBER 19 SUBCHANNEL 31 LEVEL G	32 TO	1897 DEGREES F	FAILED INSTRUMENT
470	TE-314F8	SHEATH THERMOCOUPLE, ROD 14, LEVEL F, SUPER LEVEL 8	32 TO	1897 DEGREES F	
471	TE-314F7	SHEATH THERMOCOUPLE, ROD 14, LEVEL F, SUPER LEVEL 7	32 TO	1897 DEGREES F	
472	TE-315CE	SHEATH THERMOCOUPLE, ROD 15, LEVEL E, ANGLE C	32 TO	1897 DEGREES F	
473	TE-314AF	SHEATH THERMOCOUPLE, ROD 14, LEVEL F, ANGLE A	32 TO	1897 DEGREES F	FAILED INSTRUMENT
474	TE-314E8	SHEATH THERMOCOUPLE, ROD 14, LEVEL E, SUPER LEVEL 8	32 TO	1897 DEGREES F	
475	TE-314E7	SHEATH THERMOCOUPLE, ROD 14, LEVEL E, SUPER LEVEL 7	32 TO	1897 DEGREES F	FAILED INSTRUMENT

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
476	TE-314E3	SHEATH THERMOCOUPLE, ROD 14, LEVEL E, SUPER LEVEL 3	32 TO	1897 DEGREES F	
477	TE-314E1	SHEATH THERMOCOUPLE, ROD 14, LEVEL E, SUPER LEVEL 1	32 TO	1897 DEGREES F	
478	TE-314MF	MIDDLE THERMOCOUPLE, ROD 14, LEVEL F	32 TO	1897 DEGREES F	QUESTIONABLE
479	TE-337AG	SHEATH THERMOCOUPLE, ROD 37, LEVEL G, ANGLE A	32 TO	1897 DEGREES F	
480	TE-364AE	SHEATH THERMOCOUPLE, ROD 64, LEVEL E, ANGLE A	32 TO	1897 DEGREES F	
481	TE-321MG	MIDDLE THERMOCOUPLE, ROD 21, LEVEL G	32 TO	1897 DEGREES F	FAILED INSTRUMENT
482	TE-315BE	SHEATH THERMOCOUPLE, ROD 15, LEVEL E, ANGLE B	32 TO	1897 DEGREES F	
483	TE-307BF	SHEATH THERMOCOUPLE, ROD 7, LEVEL F, ANGLE B	32 TO	1897 DEGREES F	
484	TE-315AD	SHEATH THERMOCOUPLE, ROD 15, LEVEL D ANGLE A	32 TO	1897 DEGREES F	FAILED INSTRUMENT
485	TE-307BE	SHEATH THERMOCOUPLE, ROD 7, LEVEL E, ANGLE B	32 TO	1897 DEGREES F	
486	TE-318CG	SHEATH THERMOCOUPLE, ROD 18, LEVEL G, ANGLE C	32 TO	1897 DEGREES F	
487	TE-306AA	SHEATH THERMOCOUPLE, ROD 6, LEVEL A, ANGLE A	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
488	TE-306AB	SHEATH THERMOCOUPLE, ROD 6, LEVEL B	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
489	TE-338AG	SHEATH THERMOCOUPLE, ROD 38, LEVEL G, ANGLE A	32 TO	1897 DEGREES F	
490	TE-308CB	SHEATH THERMOCOUPLE, ROD 8, LEVEL B	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
491	TE-354E2	SHEATH THERMOCOUPLE, ROD 54, LEVEL E, SUPER LEVEL 2	32 TO	1897 DEGREES F	
492	TE-308BC	SHEATH THERMOCOUPLE, ROD 8, LEVEL C	32 TO	1897 DEGREES F	
493	TE-316BF	SHEATH THERMOCOUPLE, ROD 16, LEVEL F	32 TO	1897 DEGREES F	
494	TE-316CE	SHEATH THERMOCOUPLE, ROD 16, LEVEL E	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
495	TE-316AD	SHEATH THERMOCOUPLE, ROD 16, LEVEL D	32 TO	1897 DEGREES F	
496	TE-316CG	SHEATH THERMOCOUPLE, ROD 16, LEVEL G	32 TO	1897 DEGREES F	
497	TE-324CE	SHEATH THERMOCOUPLE, ROD 24, LEVEL E	32 TO	1897 DEGREES F	
498	TE-321AF	SHEATH THERMOCOUPLE, ROD 21, LEVEL F, ANGLE A	32 TO	1897 DEGREES F	

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
499	TE-324AC	SHEATH THERMOCOUPLE, ROD 24, LEVEL C	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
500	TE-324BD	SHEATH THERMOCOUPLE, ROD 24, LEVEL D	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
501	TE-344CD	SHEATH THERMOCOUPLE, ROD 44, LEVEL D	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
502	TE-344CC	SHEATH THERMOCOUPLE, ROD 44, LEVEL C	32 TO	1897 DEGREES F	
503	TE-344CB	SHEATH THERMOCOUPLE, ROD 44, LEVEL B	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
504	TE-344CE	SHEATH THERMOCOUPLE, ROD 44, LEVEL E	32 TO	1897 DEGREES F	
505	TE-J17AG	SHEATH THERMOCOUPLE, ROD 17, LEVEL G, ANGLE A	32 TO	1897 DEGREES F	FAILED INSTRUMENT
506	TE-J35BB	SHEATH THERMOCOUPLE, ROD 35, LEVEL B	32 TO	1897 DEGREES F	FAILED INSTRUMENT
507	TE-317F2	SHEATH THERMOCOUPLE, ROD 17, LEVEL F, SUPER LEVEL 2	32 TO	1897 DEGREES F	
508	TE-J35BE	SHEATH THERMOCOUPLE, ROD 35, LEVEL E	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
509	TE-301E3	SHEATH THERMOCOUPLE, ROD 01, LEVEL E, SUPER LEVEL 3	32 TO	1897 DEGREES F	FAILED INSTRUMENT
510	TE-333CE	SHEATH THERMOCOUPLE, ROD 33, LEVEL E	32 TO	1897 DEGREES F	
511	TE-333AC	SHEATH THERMOCOUPLE, ROD 33, LEVEL C, ANGLE A	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
512	TE-333AD	SHEATH THERMOCOUPLE, ROD 33, LEVEL D	32 TO	1897 DEGREES F	QUESTIONABLE
513	TE-317F8	SHEATH THERMOCOUPLE, ROD 17, LEVEL F, SUPER LEVEL 8	32 TO	1897 DEGREES F	
514	TE-317F7	SHEATH THERMOCOUPLE, ROD 17, LEVEL F, SUPER LEVEL 7	32 TO	1897 DEGREES F	
515	TE-317F6	SHEATH THERMOCOUPLE, ROD 17, LEVEL F, SUPER LEVEL 6	32 TO	1897 DEGREES F	
516	TE-J17F3	SHEATH THERMOCOUPLE, ROD 17, LEVEL F, SUPER LEVEL 3	32 TO	1897 DEGREES F	
517	TE-1216	SUBCHANNEL NUMBER 16 THERMOCOUPLE	32 TO	1897 DEGREES F	
518	TE-359CE	SHEATH THERMOCOUPLE, ROD 59, LEVEL E	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
519	TE-328BD	SHEATH THERMOCOUPLE, ROD 28, LEVEL D	32 TO	1897 DEGREES F	
520	TE-328CF	SHEATH THERMOCOUPLE, ROD 28, LEVEL F	32 TO	1897 DEGREES F	

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
521	TE-320BG	SHEATH THERMOCOUPLE, ROD 20, LEVEL G ANGLE B	32 TO	1897 DEGREES F	
522	TE-320CG	SHEATH THERMOCOUPLE, ROD 20, LEVEL G	32 TO	1897 DEGREES F	
523	TE-320AD	SHEATH THERMOCOUPLE, ROD 20, LEVEL D	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
524	TE-320BF	SHEATH THERMOCOUPLE, ROD 20, LEVEL F	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
525	TE-301MB	MIDDLE THERMOCOUPLE, ROD 01, LEVEL F, SUPER LEVEL 8	32 TO	1897 DEGREES F	
526	TE-325CC	SHEATH THERMOCOUPLE, ROD 25, LEVEL C	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
527	TE-325CD	SHEATH THERMOCOUPLE, ROD 25, LEVEL D	32 TO	1897 DEGREES F	
528	TE-325CA	SHEATH THERMOCOUPLE, ROD 25, LEVEL A	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
529	TE-301MG	MIDDLE THERMOCOUPLE, ROD 01, LEVEL G	32 TO	1897 DEGREES F	
530	TE-318BG	SHEATH THERMOCOUPLE, ROD 18, LEVEL G	32 TO	1897 DEGREES F	
531	TE-318AF	SHEATH THERMOCOUPLE, ROD 18, LEVEL F	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
532	TE-318BE	SHEATH THERMOCOUPLE, ROD 18, LEVEL E	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
533	TE-359AE	SHEATH THERMOCOUPLE, ROD 59, LEVEL E	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
534	TE-359AD	SHEATH THERMOCOUPLE, ROD 59, LEVEL D	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
535	TE-359CF	SHEATH THERMOCOUPLE, ROD 59, LEVEL F	32 TO	1897 DEGREES F	
536	TE-359CC	SHEATH THERMOCOUPLE, ROD 59, LEVEL C	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
537	TE-358CD	SHEATH THERMOCOUPLE, ROD 58, LEVEL D	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
538	TE-358BE	SHEATH THERMOCOUPLE, ROD 58, LEVEL E	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
539	TE-358CG	SHEATH THERMOCOUPLE, ROD 58, LEVEL G	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
540	TE-309CD	SHEATH THERMOCOUPLE, ROD 9, LEVEL D	32 TO	1897 DEGREES F	
541	TE-309AC	SHEATH THERMOCOUPLE, ROD 9, LEVEL C	32 TO	1897 DEGREES F	
542	TE-311CC	SHEATH THERMOCOUPLE, ROD 11, LEVEL C	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
543	TE-321E3	SHEATH THERMOCOUPLE, ROD 21, LEVEL E, SUPER LEVEL 3	32 TO	1897 DEGREES F	FAILED INSTRUMENT
544	TE-311AB	SHEATH THERMOCOUPLE, ROD 11, LEVEL B, ANGLE A	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
545	TE-311AA	SHEATH THERMOCOUPLE, ROD 11, LEVEL A, ANGLE A	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
546	TE-301F1	SHEATH THERMOCOUPLE, ROD 01, LEVEL F, SUPER LEVEL 1	32 TO	1897 DEGREES F	
547	TE-357BC	SHEATH THERMOCOUPLE, ROD 57, LEVEL C	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
548	TE-301F6	SHEATH THERMOCOUPLE, ROD 01, LEVEL F, SUPER LEVEL 6	32 TO	1897 DEGREES F	
549	TE-301E8	SHEATH THERMOCOUPLE, ROD 01, LEVEL E, SUPER LEVEL 8	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
550	TE-304AF	SHEATH THERMOCOUPLE, ROD 4, LEVEL F, ANGLE A	32 TO	1897 DEGREES F	
551	TE-309CB	SHEATH THERMOCOUPLE, ROD 9, LEVEL B	32 TO	1897 DEGREES F	
552	TE-303CD	SHEATH THERMOCOUPLE, ROD 3, LEVEL D	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
553	TE-303BE	SHEATH THERMOCOUPLE, ROD 3, LEVEL E	32 TO	1897 DEGREES F	
554	TE-303CG	SHEATH THERMOCOUPLE, ROD 3, LEVEL G	32 TO	1897 DEGREES F	
555	TE-303BF	SHEATH THERMOCOUPLE, ROD 3, LEVEL F	32 TO	1897 DEGREES F	
556	EEE-1026LZ	ZERO INPUT CHANNELS 1408 TO 1535	0 TO	40 MV	
557	EEE-1026LC	CALIBRATION INPUT CHANNELS 1408 TO 1535	0 TO	40 MV	
558	TE-317MG	MIDDLE THERMOCOUPLE, ROD 17, LEVEL G	35 TO	1900 DEGREES F	
559	TE-317M6	MIDDLE THERMOCOUPLE, ROD 17, LEVEL F, SUPER LEVEL 6	35 TO	1900 DEGREES F	FAILED INSTRUMENT
560	TE-278AE	SHROUD BOX THERMOCOUPLE, LEVEL 8, PENETRATION A, SIDE EAST	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
561	TE-278BE	SHROUD BOX THERMOCOUPLE, LEVEL 8, PENETRATION B, SIDE EAST	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
562	TE-279AE	SHROUD BOX THERMOCOUPLE, LEVEL 9, PENETRATION A, SIDE EAST	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
563	TE-279BE	SHROUD BOX THERMOCOUPLE, LEVEL 9, PENETRATION B, SIDE EAST	32 TO	1897 DEGREES F	FAILED INSTRUMENT
564	TE-310CD	SHEATH THERMOCOUPLE, ROD 10, LEVEL D	32 TO	1897 DEGREES F	
565	TE-310AF	SHEATH THERMOCOUPLE, ROD 10, LEVEL F	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
566	TE-310CC	SHEATH THERMOCOUPLE, ROD 10, LEVEL C	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
567	TE-310BE	SHEATH THERMOCOUPLE, ROD 10, LEVEL E	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
568	TE-304BE	SHEATH THERMOCOUPLE, ROD 4, LEVEL E	32 TO	1897 DEGREES F	
569	TE-304AC	SHEATH THERMOCOUPLE, ROD 4, LEVEL C	32 TO	1897 DEGREES F	
570	TE-303CE	SHEATH THERMOCOUPLE, ROD 03, LEVEL E	32 TO	1897 DEGREES F	
571	TE-312CD	SHEATH THERMOCOUPLE, ROD 12, LEVEL D	32 TO	1897 DEGREES F	
572	TE-301F3	SHEATH THERMOCOUPLE, ROD 1, LEVEL F, SUPER LEVEL 3	32 TO	1897 DEGREES F	FAILED INSTRUMENT
573	TE-343BD	SHEATH THERMOCOUPLE, ROD 43, LEVEL D	32 TO	1897 DEGREES F	
574	TE-302AD	SHEATH THERMOCOUPLE, ROD 2, LEVEL D, ANGLE A	32 TO	1897 DEGREES F	
575	TE-302AB	SHEATH THERMOCOUPLE, ROD 2, LEVEL B	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
576	TE-302AE	SHEATH THERMOCOUPLE, ROD 2, LEVEL E	32 TO	1897 DEGREES F	
577	TE-302BC	SHEATH THERMOCOUPLE, ROD 2, LEVEL C	32 TO	1897 DEGREES F	
578	TE-310BF	SHEATH THERMOCOUPLE, ROD 10, LEVEL F, ANGLE B	32 TO	1897 DEGREES F	
579	TE-310CF	SHEATH THERMOCOUPLE, ROD 10, LEVEL F, ANGLE C	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
580	TE-334MF	MIDDLE THERMOCOUPLE, ROD 34, LEVEL F	32 TO	1897 DEGREES F	QUESTIONABLE
581	TE-301AF	SHEATH THERMOCOUPLE, ROD 1, LEVEL F, ANGLE A	32 TO	1897 DEGREES F	
582	TE-357BA	SHEATH THERMOCOUPLE, ROD 57, LEVEL A	32 TO	1897 DEGREES F	
583	TE-357CB	SHEATH THERMOCOUPLE, ROD 57, LEVEL B	32 TO	1897 DEGREES F	
584	TE-301F2	SHEATH THERMOCOUPLE, ROD 01, LEVEL F, SUPER LEVEL 2	32 TO	1897 DEGREES F	
585	TE-359AF	SHEATH THERMOCOUPLE, ROD 59, LEVEL F, ANGLE A	32 TO	1897 DEGREES F	
586	TE-357CD	SHEATH THERMOCOUPLE, ROD 57, LEVEL D	32 TO	1897 DEGREES F	
587	TE-359BF	SHEATH THERMOCOUPLE, ROD 59, LEVEL F, ANGLE B	32 TO	1897 DEGREES F	
588	TE-354F4	SHEATH THERMOCOUPLE, ROD 54, LEVEL F, SUPER LEVEL 4	32 TO	1897 DEGREES F	

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE	COMMENTS
589	TE-329CD	SHEATH THERMOCOUPLE, ROD 29, LEVEL D	32 TO 1897 DEGREES F	
590	TE-329CD	SHEATH THERMOCOUPLE, ROD 29, LEVEL B	32 TO 1897 DEGREES F	
591	TE-329CE	SHEATH THERMOCOUPLE, ROD 29, LEVEL E	32 TO 1897 DEGREES F	
592	TE-354FJ	SHEATH THERMOCOUPLE, ROD 54, LEVEL F, SUPER LEVEL 3	32 TO 1897 DEGREES F	
593	TE-329BE	SHEATH THERMOCOUPLE, ROD 29, LEVEL E	32 TO 1897 DEGREES F	
594	TE-329AD	SHEATH THERMOCOUPLE, ROD 29, LEVEL D	32 TO 1897 DEGREES F	
595	TE-347CF	SHEATH THERMOCOUPLE, ROD 47, LEVEL F, ANGLE C	32 TO 1897 DEGREES F	QUESTIONABLE
596	TE-345BD	SHEATH THERMOCOUPLE, ROD 45, LEVEL D	32 TO 1897 DEGREES F	
597	TE-345BF	SHEATH THERMOCOUPLE, ROD 45, LEVEL F	32 TO 1897 DEGREES F	
598	TE-345AE	SHEATH THERMOCOUPLE, ROD 45, LEVEL E	32 TO 1897 DEGREES F	
599	TE-345BE	SHEATH THERMOCOUPLE, ROD 45, LEVEL E	32 TO 1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
600	TE-345BG	SHEATH THERMOCOUPLE, ROD 45, LEVEL G	32 TO 1897 DEGREES F	
601	TE-345AF	SHEATH THERMOCOUPLE, ROD 45, LEVEL F	32 TO 1897 DEGREES F	
602	TE-345CG	SHEATH THERMOCOUPLE, ROD 45, LEVEL G	32 TO 1897 DEGREES F	
603	TE-361CJ	SHEATH THERMOCOUPLE, ROD 61, LEVEL J	32 TO 1897 DEGREES F	FAILED INSTRUMENT
604	TE-361BJ	SHEATH THERMOCOUPLE, ROD 61, LEVEL J	32 TO 1897 DEGREES F	FAILED INSTRUMENT
605	TE-364LD	SHEATH THERMOCOUPLE, ROD 64, LEVEL D	32 TO 1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
606	TE-353BF	SHEATH THERMOCOUPLE, ROD 59, LEVEL F, ANGLE B	32 TO 1897 DEGREES F	
607	TE-354AF	SHEATH THERMOCOUPLE, ROD 54, LEVEL F, ANGLE A	32 TO 1897 DEGREES F	
608	TE-364AF	SHEATH THERMOCOUPLE, ROD 64, LEVEL F	32 TO 1897 DEGREES F	
609	TE-313AE	SHEATH THERMOCOUPLE, ROD 13, LEVEL E, ANGLE A	32 TO 1897 DEGREES F	
610	TE-364CF	SHEATH THERMOCOUPLE, ROD 64, LEVEL F	32 TO 1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
611	TE-364CD	SHEATH THERMOCOUPLE, ROD 64, LEVEL D	32 TO 1897 DEGREES F	
612	TE-364CG	SHEATH THERMOCOUPLE, ROD 64, LEVEL G	32 TO 1897 DEGREES F	
613	TE-334F8	SHEATH THERMOCOUPLE, ROD 34, LEVEL F, SUPER LEVEL 8	32 TO 1897 DEGREES F	

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
614	TE-334F2	SHEATH THERMOCOUPLE, ROD 34, LEVEL F, SUPER LEVEL 2	32 TO	1897 DEGREES F	
615	TE-334F1	SHEATH THERMOCOUPLE, ROD 34, LEVEL F, SUPER LEVEL 1	32 TO	1897 DEGREES F	
616	TE-334AF	SHEATH THERMOCOUPLE, ROD 34, LEVEL F, ANGLE A	32 TO	1897 DEGREES F	
617	TE-360AG	SHEATH THERMOCOUPLE, ROD 60, LEVEL G, ANGLE A	32 TO	1897 DEGREES F	
618	TE-360E3	SHEATH THERMOCOUPLE, ROD 60, LEVEL E, SUPER LEVEL 3	32 TO	1897 DEGREES F	
619	TE-360E2	SHEATH THERMOCOUPLE, ROD 60, LEVEL E, SUPER LEVEL 2	32 TO	1897 DEGREES F	
620	TE-334E8	SHEATH THERMOCOUPLE, ROD 34, LEVEL E, SUPER LEVEL 8	32 TO	1897 DEGREES F	
621	TE-334E7	SHEATH THERMOCOUPLE, ROD 34, LEVEL E, SUPER LEVEL 7	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
622	TE-334E3	SHEATH THERMOCOUPLE, ROD 34, LEVEL E, SUPER LEVEL 3	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
623	TE-327AD	SHEATH THERMOCOUPLE, ROD 27, LEVEL D, ANGLE A	32 TO	1897 DEGREES F	
624	TE-360F8	SHEATH THERMOCOUPLE, ROD 60, LEVEL F, SUPER LEVEL 8	32 TO	1897 DEGREES F	
625	TE-360F7	SHEATH THERMOCOUPLE, ROD 60, LEVEL F, SUPER LEVEL 7	32 TO	1897 DEGREES F	
626	TE-360F3	SHEATH THERMOCOUPLE, ROD 60, LEVEL F, SUPER LEVEL 3	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
627	TE-184S	SHROUD BOX THERMOCOUPLE, LEVEL D SOUTH SIDE	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
628	TE-183W	SHROUD BOX THERMOCOUPLE, LEVEL C WEST SIDE	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
629	TE-187W	SHROUD BOX THERMOCOUPLE, LEVEL G WEST SIDE	32 TO	1897 DEGREES F	
630	TE-186S	SHROUD BOX THERMOCOUPLE, LEVEL F SOUTH SIDE	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
631	TE-352BU	SHEATH THERMOCOUPLE, ROD 52, LEVEL U	32 TO	1897 DEGREES F	
632	TE-352CU	SHEATH THERMOCOUPLE, ROD 52, LEVEL U	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
633	TE-352AS	SHEATH THERMOCOUPLE, ROD 52, LEVEL S	32 TO	1897 DEGREES F	
634	TE-352CS	SHEATH THERMOCOUPLE, ROD 52, LEVEL S	32 TO	1897 DEGREES F	
635	TE-352BH	SHEATH THERMOCOUPLE, ROD 52, LEVEL H	32 TO	1897 DEGREES F	
636	TE-352AH	SHEATH THERMOCOUPLE, ROD 52, LEVEL H	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
637	TE-352BY	SHEATH THERMOCOUPLE, ROD 52, LEVEL Y	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
638	TE-352AY	SHEATH THERMOCOUPLE, ROD 52, LEVEL Y	32 TO	1897 DEGREES F	
639	TE-350AG	SHEATH THERMOCOUPLE, ROD 50, LEVEL G	32 TO	1897 DEGREES F	
640	TE-350F8	SHEATH THERMOCOUPLE, ROD 50, LEVEL F, SUPER LEVEL 8	32 TO	1897 DEGREES F	
641	TE-326AE	SHEATH THERMOCOUPLE, ROD 26, LEVEL E, ANGLE A	32 TO	1897 DEGREES F	
642	TE-188AG	ARRAY ROD THERMOCOUPLE GRID NUMBER 19 SUBCHANNEL 21 LEVEL G	32 TO	1897 DEGREES F	QUESTIONABLE
643	TE-326BD	SHEATH THERMOCOUPLE, ROD 26, LEVEL D, ANGLE B	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
644	TE-350E7	SHEATH THERMOCOUPLE, ROD 50, LEVEL E, SUPER LEVEL 7	32 TO	1897 DEGREES F	
645	TE-350E3	SHEATH THERMOCOUPLE, ROD 50, LEVEL E, SUPER LEVEL 3	32 TO	1897 DEGREES F	
646	TE-350E1	SHEATH THERMOCOUPLE, ROD 50, LEVEL E, SUPER LEVEL 1	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
647	TE-321F1	SHEATH THERMOCOUPLE, ROD 21, LEVEL F, SUPER LEVEL 1	32 TO	1897 DEGREES F	
648	TE-1229	SUBCHANNEL NUMBER 29 THERMOCOUPLE	32 TO	1897 DEGREES F	
649	TE-326BE	SHEATH THERMOCOUPLE, ROD 26, LEVEL E, ANGLE B	32 TO	1897 DEGREES F	
650	TE-351BE	SHEATH THERMOCOUPLE, ROD 51, LEVEL E, ANGLE B	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
651	TE-186E	SHROUD BOX THERMOCOUPLE, LEVEL G EAST SIDE	32 TO	1897 DEGREES F	
652	TE-350F7	SHEATH THERMOCOUPLE, ROD 50, LEVEL F, SUPER LEVEL 7	32 TO	1897 DEGREES F	
653	TE-350F3	SHEATH THERMOCOUPLE, ROD 50, LEVEL F, SUPER LEVEL 3	32 TO	1897 DEGREES F	FAILED INSTRUMENT

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
654	TE-327BD	SHEATH THERMOCOUPLE, ROD 27, LEVEL D, ANGLE B	32 TO	1897 DEGREES F	
655	TE-360AF	SHEATH THERMOCOUPLE, ROD 60, LEVEL F, ANGLE A	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
656	TE-360E6	SHEATH THERMOCOUPLE, ROD 60, LEVEL E, SUPER LEVEL 6	32 TO	1897 DEGREES F	
657	TE-337F1	SHEATH THERMOCOUPLE, ROD 37, LEVEL F, SUPER LEVEL 1	32 TO	1897 DEGREES F	
658	TE-328CD	SHEATH THERMOCOUPLE, ROD 28, LEVEL D	32 TO	1897 DEGREES F	
659	TE-320CE	SHEATH THERMOCOUPLE, ROD 20, LEVEL E	32 TO	1897 DEGREES F	FAILED INSTRUMENT
660	TE-320BE	SHEATH THERMOCOUPLE, ROD 20, LEVEL E ANGLE B	32 TO	1897 DEGREES F	
661	TE-320AE	SHEATH THERMOCOUPLE, ROD 20, LEVEL E	32 TO	1897 DEGREES F	
662	TE-320CD	SHEATH THERMOCOUPLE, ROD 20, LEVEL D	32 TO	1897 DEGREES F	
663	TE-320CF	SHEATH THERMOCOUPLE, ROD 20, LEVEL F	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
664	TE-320AF	SHEATH THERMOCOUPLE, ROD 20, LEVEL F	32 TO	1897 DEGREES F	FAILED INSTRUMENT
665	TE-320BD	SHEATH THERMOCOUPLE, ROD 20, LEVEL D	32 TO	1897 DEGREES F	FAILED INSTRUMENT
666	TE-316BE	SHEATH THERMOCOUPLE, ROD 16, LEVEL E, ANGLE B	32 TO	1897 DEGREES F	
667	TE-355CD	SHEATH THERMOCOUPLE, ROD 55, LEVEL D	32 TO	1897 DEGREES F	
668	TE-314F6	SHEATH THERMOCOUPLE, ROD 14, LEVEL F, SUPER LEVEL 6	32 TO	1897 DEGREES F	FAILED INSTRUMENT
669	TE-314F3	SHEATH THERMOCOUPLE, ROD 14, LEVEL F, SUPER LEVEL 3	32 TO	1897 DEGREES F	
670	TE-344AE	SHEATH THERMOCOUPLE, ROD 44, LEVEL E, ANGLE A	32 TO	1897 DEGREES F	FAILED INSTRUMENT
671	TE-1207	SUBCHANNEL NUMBER 07 THERMOCOUPLE	32 TO	1897 DEGREES F	
672	TE-1255	SUBCHANNEL NUMBER 55 THERMOCOUPLE	32 TO	1897 DEGREES F	
673	TE-318CD	SHEATH THERMOCOUPLE, ROD 18, LEVEL D, ANGLE C	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
674	TE-320AG	SHEATH THERMOCOUPLE, ROD 20, LEVEL G	32 TO	1897 DEGREES F	FAILED INSTRUMENT
675	TE-317E3	SHEATH THERMOCOUPLE, ROD 17, LEVEL E, SUPER LEVEL 3	32 TO	1897 DEGREES F	

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
676	TE-321M3	MIDDLE THERMOCOUPLE, ROD 21, LEVEL F, SUPER LEVEL 3	32 TO	1897 DEGREES F	FAILED INSTRUMENT
677	TE-321M1	MIDDLE THERMOCOUPLE, ROD 21, LEVEL F, SUPER LEVEL 1	32 TO	1897 DEGREES F	
678	TE-325BC	SHEATH THERMOCOUPLE, ROD 25, LEVEL C	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
679	TE-J25CB	SHEATH THERMOCOUPLE, ROD 25, LEVEL B	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
680	TE-325BD	SHEATH THERMOCOUPLE, ROD 25, LEVEL D, ANGLE B	32 TO	1897 DEGREES F	
681	TE-J28AC	SHEATH THERMOCOUPLE, ROD 28, LEVEL C, ANGLE A	32 TO	1897 DEGREES F	
682	EEE-1026MZ	ZERO INPUT CHANNELS 1536 TO 1663	0 TO	40 MV	
683	EEE-1026MC	CALIBRATION INPUT CHANNELS 1536 TO 1663	0 TO	40 MV	
684	TE-272AS	SHROUD BOX THERMOCOUPLE, LEVEL 2, PENETRATION A, SIDE SOUTH	32 TO	1897 DEGREES F	
685	TE-272BS	SHROUD BOX THERMOCOUPLE, LEVEL 2, PENETRATION B, SIDE SOUTH	32 TO	1897 DEGREES F	
686	TE-275AS	SHROUD BOX THERMOCOUPLE, LEVEL 5, PENETRATION A, SIDE SOUTH	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
687	TE-275BS	SHROUD BOX THERMOCOUPLE, LEVEL 5, PENETRATION B, SIDE SOUTH	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
688	TE-279AS	SHROUD BOX THERMOCOUPLE, LEVEL 9, PENETRATION A, SIDE SOUTH	32 TO	1897 DEGREES F	
689	TE-279BS	SHROUD BOX THERMOCOUPLE, LEVEL 9, PENETRATION B, SIDE SOUTH	32 TO	1897 DEGREES F	FAILED INSTRUMENT
690	TE-337MG	MIDDLE THERMOCOUPLE, ROD 37, LEVEL G	35 TO	1900 DEGREES F	
691	TE-337M7	MIDDLE THERMOCOUPLE, ROD 37, LEVEL F, SUPER LEVEL 7	35 TO	1900 DEGREES F	
692	TE-337M6	MIDDLE THERMOCOUPLE, ROD 37, LEVEL F, SUPER LEVEL 6	35 TO	1900 DEGREES F	
693	TE-337MF	MIDDLE THERMOCOUPLE, ROD 37, LEVEL F	35 TO	1900 DEGREES F	
694	TE-345ME	MIDDLE THERMOCOUPLE, ROD 45, LEVEL E	35 TO	1900 DEGREES F	

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
695	TE-345MG	MIDDLE THERMOCOUPLE, ROD 45, LEVEL G	35 TO	1900 DEGREES F	
696	TE-345MD	MIDDLE THERMOCOUPLE, ROD 45, LEVEL D	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
697	TE-332AE	SHEATH THERMOCOUPLE, ROD 32, LEVEL F ANGLE A	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
698	TE-328MC	MIDDLE THERMOCOUPLE, ROD 28, LEVEL C	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
699	TE-328ME	MIDDLE THERMOCOUPLE, ROD 28, LEVEL E	35 TO	1900 DEGREES F	
700	TE-328MF	MIDDLE THERMOCOUPLE, ROD 28, LEVEL F	35 TO	1900 DEGREES F	
701	TE-328MD	MIDDLE THERMOCOUPLE, ROD 28, LEVEL D	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
702	TE-329ME	MIDDLE THERMOCOUPLE, ROD 29, LEVEL E	35 TO	1900 DEGREES F	
703	TE-329MC	MIDDLE THERMOCOUPLE, ROD 29, LEVEL C	35 TO	1900 DEGREES F	
704	TE-329MD	MIDDLE THERMOCOUPLE, ROD 29, LEVEL D	35 TO	1900 DEGREES F	
705	TE-329MB	MIDDLE THERMOCOUPLE, ROD 29, LEVEL B	35 TO	1900 DEGREES F	
706	TE-338MG	MIDDLE THERMOCOUPLE, ROD 38, LEVEL G	35 TO	1900 DEGREES F	
707	TE-338MB	MIDDLE THERMOCOUPLE, ROD 38, LEVEL F, SUPER LEVEL 8	35 TO	1900 DEGREES F	
708	TE-338M2	MIDDLE THERMOCOUPLE, ROD 38, LEVEL F, SUPER LEVEL 2	35 TO	1900 DEGREES F	FAILED INSTRUMENT
709	TE-338MF	MIDDLE THERMOCOUPLE, ROD 38, LEVEL F	35 TO	1900 DEGREES F	
710	TE-355MA	MIDDLE THERMOCOUPLE, ROD 55, LEVEL A	35 TO	1900 DEGREES F	QUESTIONABLE
711	TE-355MB	MIDDLE THERMOCOUPLE, ROD 55, LEVEL B	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
712	TE-355MC	MIDDLE THERMOCOUPLE, ROD 55, LEVEL C	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
713	TE-355MD	MIDDLE THERMOCOUPLE, ROD 55, LEVEL D	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
714	TE-344MC	MIDDLE THERMOCOUPLE, ROD 44, LEVEL C	35 TO	1900 DEGREES F	FAILED INSTRUMENT
715	TE-324AB	SHEATH THERMOCOUPLE, ROD 24, LEVEL B, ANGLE A	32 TO	1897 DEGREES F	QUESTIONABLE
716	TE-344MB	MIDDLE THERMOCOUPLE, ROD 44, LEVEL B	35 TO	1900 DEGREES F	FAILED INSTRUMENT
717	TE-344ME	MIDDLE THERMOCOUPLE, ROD 44, LEVEL E	35 TO	1900 DEGREES F	FAILED INSTRUMENT
718	TE-354MG	MIDDLE THERMOCOUPLE, ROD 54, LEVEL F	35 TO	1900 DEGREES F	FAILED INSTRUMENT

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
719	TE-354M6	MIDDLE THERMOCOUPLE, ROD 54, LEVEL F, SUPER LEVEL 6	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
720	TE-354M5	MIDDLE THERMOCOUPLE, ROD 54, LEVEL F, SUPER LEVEL 5	35 TO	1900 DEGREES F	FAILED INSTRUMENT
721	TE-354MF	MIDDLE THERMOCOUPLE, ROD 54, LEVEL F	35 TO	1900 DEGREES F	FAILED INSTRUMENT
722	TE-353MC	MIDDLE THERMOCOUPLE, ROD 53, LEVEL C	35 TO	1900 DEGREES F	FAILED INSTRUMENT
723	TE-353MD	MIDDLE THERMOCOUPLE, ROD 53, LEVEL D	35 TO	1900 DEGREES F	FAILED INSTRUMENT
724	TE-353ME	MIDDLE THERMOCOUPLE, ROD 53, LEVEL E	35 TO	1900 DEGREES F	FAILED INSTRUMENT
725	TE-360MG	MIDDLE THERMOCOUPLE, ROD 60, LEVEL G	35 TO	1900 DEGREES F	
726	TE-360M3	MIDDLE THERMOCOUPLE, ROD 60, LEVEL F, SUPER LEVEL 3	35 TO	1900 DEGREES F	
727	TE-315AF	SHEATH THERMOCOUPLE, ROD 15, LEVEL F, ANGLE A	35 TO	1900 DEGREES F	
728	TE-360MF	MIDDLE THERMOCOUPLE, ROD 60, LEVEL F	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
729	TE-361MC	MIDDLE THERMOCOUPLE, ROD 61, LEVEL C	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
730	TE-361MB	MIDDLE THERMOCOUPLE, ROD 61, LEVEL B	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
731	TE-361MD	MIDDLE THERMOCOUPLE, ROD 61, LEVEL D	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
732	TE-338F8	SHEATH THERMOCOUPLE, ROD 38, LEVEL F, SUPER LEVEL 8	35 TO	1900 DEGREES F	FAILED INSTRUMENT
733	TE-359ME	MIDDLE THERMOCOUPLE, ROD 59, LEVEL E	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
734	TE-359MF	MIDDLE THERMOCOUPLE, ROD 59, LEVEL F	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
735	TE-359MC	MIDDLE THERMOCOUPLE, ROD 59, LEVEL C	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
736	TE-315AC	SHEATH THERMOCOUPLE, ROD 15, LEVEL C, ANGLE A	35 TO	1900 DEGREES F	
737	TE-315BD	SHEATH THERMOCOUPLE, ROD 15, LEVEL D, ANGLE B	35 TO	1900 DEGREES F	
738	TE-317F1	SHEATH THERMOCOUPLE, ROD 17, LEVEL F, SUPER LEVEL 1	35 TO	1900 DEGREES F	
739	TE-317AF	SHEATH THERMOCOUPLE, ROD 17, LEVEL F, ANGLE A	35 TO	1900 DEGREES F	
740	TE-352MU	MIDDLE THERMOCOUPLE, ROD 52, LEVEL U	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
741	TE-352MS	MIDDLE THERMOCOUPLE, ROD 52, LEVEL S	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
742	TE-352MH	MIDDLE THERMOCOUPLE, ROD 52, LEVEL H	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
743	TE-352MY	MIDDLE THERMOCOUPLE, ROD 52, LEVEL Y	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
744	TE-339MD	MIDDLE THERMOCOUPLE, ROD 39, LEVEL D	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
745	TE-339ME	MIDDLE THERMOCOUPLE, ROD 39, LEVEL E	35 TO	1900 DEGREES F	
746	TE-339MC	MIDDLE THERMOCOUPLE, ROD 39, LEVEL C	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
747	TE-339MB	MIDDLE THERMOCOUPLE, ROD 39, LEVEL B	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
748	TE-330MC	MIDDLE THERMOCOUPLE, ROD 30, LEVEL C	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
749	TE-330MB	MIDDLE THERMOCOUPLE, ROD 30, LEVEL B	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
750	TE-321E6	SHEATH THERMOCOUPLE, ROD 21, LEVEL E, SUPER LEVEL 6	35 TO	1900 DEGREES F	FAILED INSTRUMENT
751	TE-330ME	MIDDLE THERMOCOUPLE, ROD 30, LEVEL E	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
752	TE-314MG	MIDDLE THERMOCOUPLE, ROD 14, LEVEL G	35 TO	1900 DEGREES F	
753	TE-314M8	MIDDLE THERMOCOUPLE, ROD 14, LEVEL F, SUPER LEVEL 8	35 TO	1900 DEGREES F	
754	TE-314M2	MIDDLE THERMOCOUPLE, ROD 14, LEVEL F, SUPER LEVEL 2	35 TO	1900 DEGREES F	
755	TE-321F8	SHEATH THERMOCOUPLE, ROD 21, LEVEL F, SUPER LEVEL 8	35 TO	1900 DEGREES F	
756	TE-314AG	SHEATH THERMOCOUPLE, ROD 14, LEVEL G, ANGLE A	32 TO	1897 DEGREES F	
757	TE-306MA	MIDDLE THERMOCOUPLE, ROD 6, LEVEL A	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
758	TE-306MD	MIDDLE THERMOCOUPLE, ROD 6, LEVEL D	35 TO	1900 DEGREES F	
759	TE-335BD	SHEATH THERMOCOUPLE, ROD 35, LEVEL D, ANGLE B	32 TO	1897 DEGREES F	
760	TE-306MC	MIDDLE THERMOCOUPLE, ROD 6, LEVEL C	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
761	TE-331MF	MIDDLE THERMOCOUPLE, ROD 31, LEVEL F	35 TO	1900 DEGREES F	
762	TE-920	PURGE LINE RETURN TEMPERATURE	35 TO	1900 DEGREES F	
763	TE-921	INNER SEAL COOLANT SUPPLY TEMPERATURE	35 TO	1900 DEGREES F	

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
764	TE-922	INNER SEAL COOLANT SUPPLY TEMPERATURE	35 TO	1900 DEGREES F	
765	TE-347MG	MIDDLE THERMOCOUPLE, ROD 47, LEVEL G	35 TO	1900 DEGREES F	
766	TE-347ME	MIDDLE THERMOCOUPLE, ROD 47, LEVEL E	35 TO	1900 DEGREES F	
767	TE-347MD	MIDDLE THERMOCOUPLE, ROD 47, LEVEL D	35 TO	1900 DEGREES F	
768	TE-347MF	MIDDLE THERMOCOUPLE, ROD 47, LEVEL F	35 TO	1900 DEGREES F	
769	TE-318CF	SHEATH THERMOCOUPLE, ROD 18, LEVEL F, ANGLE C	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
770	TE-315MC	MIDDLE THERMOCOUPLE, ROD 15, LEVEL C	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
771	TE-315ME	MIDDLE THERMOCOUPLE, ROD 15, LEVEL E	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
772	TE-315MD	MIDDLE THERMOCOUPLE, ROD 15, LEVEL D	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
773	TE-305AU	MIDDLE THERMOCOUPLE, ROD 5, LEVEL U	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
774	TE-305MS	MIDDLE THERMOCOUPLE, ROD 5, LEVEL S	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
775	TE-305MH	MIDDLE THERMOCOUPLE, ROD 5, LEVEL H	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
776	TE-305MY	MIDDLE THERMOCOUPLE, ROD 5, LEVEL Y	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
777	TE-307MF	MIDDLE THERMOCOUPLE, ROD 7, LEVEL F	35 TO	1900 DEGREES F	
778	TE-307ME	MIDDLE THERMOCOUPLE, ROD 7, LEVEL E	35 TO	1900 DEGREES F	
779	TE-307MC	MIDDLE THERMOCOUPLE, ROD 7, LEVEL C	35 TO	1900 DEGREES F	FAILED INSTRUMENT
780	TE-307MD	MIDDLE THERMOCOUPLE, ROD 7, LEVEL D	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
781	TE-321F5	SHEATH THERMOCOUPLE, ROD 21, LEVEL F, SUPER LEVEL 5	35 TO	1900 DEGREES F	
782	TE-340MC	MIDDLE THERMOCOUPLE, ROD 40, LEVEL C	35 TO	1900 DEGREES F	
783	TE-340MB	MIDDLE THERMOCOUPLE, ROD 40, LEVEL B	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
784	TE-340MA	MIDDLE THERMOCOUPLE, ROD 40, LEVEL A	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
785	TE-315MF	MIDDLE THERMOCOUPLE, ROD 15, LEVEL F	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
786	TE-356MS	MIDDLE THERMOCOUPLE, ROD 56, LEVEL S	35 TO	1900 DEGREES F	FAILED INSTRUMENT
787	TE-356MH	MIDDLE THERMOCOUPLE, ROD 56, LEVEL H	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
788	TE-317MF	MIDDLE THERMOCOUPLE, ROD 17, LEVEL F	35 TO	1900 DEGREES F	FAILED INSTRUMENT

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
789	TE-328AD	SHEATH THERMOCOUPLE, ROD 28, LEVEL D	32 TO	1897 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
790	TE-324ME	MIDDLE THERMOCOUPLE, ROD 24, LEVEL E	35 TO	1900 DEGREES F	SPURIOUS SPIKE
791	TE-324MC	MIDDLE THERMOCOUPLE, ROD 24, LEVEL C	35 TO	1900 DEGREES F	
792	TE-324MD	MIDDLE THERMOCOUPLE, ROD 24, LEVEL D	35 TO	1900 DEGREES F	
793	TE-363MD	MIDDLE THERMOCOUPLE, ROD 63, LEVEL D	35 TO	1900 DEGREES F	
794	TE-363ME	MIDDLE THERMOCOUPLE, ROD 63, LEVEL E	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
795	TE-363MB	MIDDLE THERMOCOUPLE, ROD 63, LEVEL B	35 TO	1900 DEGREES F	
796	TE-363MC	MIDDLE THERMOCOUPLE, ROD 63, LEVEL C	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
797	EEE-1026MZ	ZERO INPUT CHANNELS 1664 TO 1791	0 TO	40 MV	
798	EEE-1026NC	CALIBRATION INPUT CHANNELS 1664 TO 1791	0 TO	40 MV	
799	TE-316ME	MIDDLE THERMOCOUPLE, ROD 16, LEVEL E	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
800	TE-316MD	MIDDLE THERMOCOUPLE, ROD 16, LEVEL D	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
801	TE-316MF	MIDDLE THERMOCOUPLE, ROD 16, LEVEL F	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
802	TE-316MG	MIDDLE THERMOCOUPLE, ROD 16, LEVEL G	35 TO	1900 DEGREES F	
803	TE-364MG	MIDDLE THERMOCOUPLE, ROD 64, LEVEL G	35 TO	1900 DEGREES F	
804	TE-364MF	MIDDLE THERMOCOUPLE, ROD 64, LEVEL F	35 TO	1900 DEGREES F	
805	TE-328BF	SHEATH THERMOCOUPLE, ROD 28, LEVEL F	32 TO	1897 DEGREES F	
806	TE-364MD	MIDDLE THERMOCOUPLE, ROD 64, LEVEL D	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
807	TE-308MB	MIDDLE THERMOCOUPLE, ROD 8, LEVEL B	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
808	TE-328AF	SHEATH THERMOCOUPLE, ROD 28, LEVEL F	32 TO	1897 DEGREES F	
809	TE-308MD	MIDDLE THERMOCOUPLE, ROD 8, LEVEL D	35 TO	1900 DEGREES F	
810	TE-308MC	MIDDLE THERMOCOUPLE, ROD 8, LEVEL C	35 TO	1900 DEGREES F	
811	TE-301E1	SHEATH THERMOCOUPLE, ROD 01, LEVEL E, SUPER LEVEL 1	32 TO	1897 DEGREES F	
812	TE-332MD	MIDDLE THERMOCOUPLE, ROD 32, LEVEL D	35 TO	1900 DEGREES F	
813	TE-332MG	MIDDLE THERMOCOUPLE, ROD 32, LEVEL G	35 TO	1900 DEGREES F	

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
814	TE-332ME	MIDDLE THERMOCOUPLE, ROD 32, LEVEL E	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
815	TE-348MU	MIDDLE THERMOCOUPLE, ROD 48, LEVEL U	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
816	TE-348MH	MIDDLE THERMOCOUPLE, ROD 48, LEVEL H	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
817	TE-348MS	MIDDLE THERMOCOUPLE, ROD 48, LEVEL S	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
818	TE-348MY	MIDDLE THERMOCOUPLE, ROD 48, LEVEL Y	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
819	TE-357MC	MIDDLE THERMOCOUPLE, ROD 57, LEVEL C	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
820	TE-357MB	MIDDLE THERMOCOUPLE, ROD 57, LEVEL B	35 TO	1900 DEGREES F	
821	TE-357MD	MIDDLE THERMOCOUPLE, ROD 57, LEVEL D	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
822	TE-357MA	MIDDLE THERMOCOUPLE, ROD 57, LEVEL A	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
823	TE-301M2	MIDDLE THERMOCOUPLE, ROD 1, LEVEL F, SUPER LEVEL 2	35 TO	1900 DEGREES F	
824	TE-301MF	MIDDLE THERMOCOUPLE, ROD 1, LEVEL F	35 TO	1900 DEGREES F	FAILED INSTRUMENT
825	TE-349ME	MIDDLE THERMOCOUPLE, ROD 49, LEVEL E	35 TO	1900 DEGREES F	
826	TE-349MD	MIDDLE THERMOCOUPLE, ROD 49, LEVEL D	35 TO	1900 DEGREES F	
827	TE-349MC	MIDDLE THERMOCOUPLE, ROD 49, LEVEL C	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
828	TE-349MB	MIDDLE THERMOCOUPLE, ROD 49, LEVEL B	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
829	TE-318CE	SHEATH THERMOCOUPLE, ROD 18, LEVEL E, ANGLE C	35 TO	1900 DEGREES F	QUESTIONABLE
830	TE-317M7	MIDDLE THERMOCOUPLE, ROD 17, LEVEL F, SUPER LEVEL 7	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
831	TE-333AE	SHEATH THERMOCOUPLE, ROD 33, LEVEL E, ANGLE A	35 TO	1900 DEGREES F	
832	TE-333BE	SHEATH THERMOCOUPLE, ROD 33, LEVEL E, ANGLE B	35 TO	1900 DEGREES F	
833	TE-321E2	SHEATH THERMOCOUPLE, ROD 21, LEVEL E, SUPER LEVEL 2	35 TO	1900 DEGREES F	
834	TE-333MC	MIDDLE THERMOCOUPLE, ROD 33, LEVEL C	35 TO	1900 DEGREES F	FAILED INSTRUMENT
835	TE-318BD	SHEATH THERMOCOUPLE, ROD 18, LEVEL D, ANGLE B	35 TO	1900 DEGREES F	
836	TE-321AG	SHEATH THERMOCOUPLE, ROD 21, LEVEL G, ANGLE A	35 TO	1900 DEGREES F	

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
837	TE-341MA	MIDDLE THERMOCOUPLE, ROD 41, LEVEL A	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
838	TE-341MD	MIDDLE THERMOCOUPLE, ROD 41, LEVEL D	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
839	TE-341MB	MIDDLE THERMOCOUPLE, ROD 41, LEVEL B	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
840	TE-341MC	MIDDLE THERMOCOUPLE, ROD 41, LEVEL C	35 TO	1900 DEGREES F	
841	TE-325MC	MIDDLE THERMOCOUPLE, ROD 25, LEVEL C	35 TO	1900 DEGREES F	
842	TE-325MD	MIDDLE THERMOCOUPLE, ROD 25, LEVEL D	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
843	TE-325MB	MIDDLE THERMOCOUPLE, ROD 25, LEVEL B	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
844	TE-325MA	MIDDLE THERMOCOUPLE, ROD 25, LEVEL A	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
845	TE-303ME	MIDDLE THERMOCOUPLE, ROD 3, LEVEL E	35 TO	1900 DEGREES F	
846	TE-303MG	MIDDLE THERMOCOUPLE, ROD 3, LEVEL G	35 TO	1900 DEGREES F	
847	TE-303MF	MIDDLE THERMOCOUPLE, ROD 3, LEVEL F	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
848	TE-303MD	MIDDLE THERMOCOUPLE, ROD 3, LEVEL D	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
849	TE-358MF	MIDDLE THERMOCOUPLE, ROD 58, LEVEL F	35 TO	1900 DEGREES F	
850	TE-358MD	MIDDLE THERMOCOUPLE, ROD 58, LEVEL D	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
851	TE-358ME	MIDDLE THERMOCOUPLE, ROD 58, LEVEL E	35 TO	1900 DEGREES F	
852	TE-358MG	MIDDLE THERMOCOUPLE, ROD 58, LEVEL G	35 TO	1900 DEGREES F	
853	TE-309MC	MIDDLE THERMOCOUPLE, ROD 9, LEVEL C	35 TO	1900 DEGREES F	FAILED INSTRUMENT
854	TE-301AG	SHEATH THERMOCOUPLE, ROD 1, LEVEL G, ANGLE A	35 TO	1900 DEGREES F	
855	TE-301F7	SHEATH THERMOCOUPLE, ROD 1, LEVEL F, SUPER LEVEL 7	35 TO	1900 DEGREES F	FAILED INSTRUMENT
856	TE-309MB	MIDDLE THERMOCOUPLE, ROD 9, LEVEL B	35 TO	1900 DEGREES F	FAILED INSTRUMENT
857	TE-328AE	SHEATH THERMOCOUPLE, ROD 28, LEVEL E	32 TO	1897 DEGREES F	
858	TE-334ME	MIDDLE THERMOCOUPLE, ROD 34, LEVEL F, SUPER LEVEL 6	35 TO	1900 DEGREES F	
859	TE-357AC	SHEATH THERMOCOUPLE, ROD 57, LEVEL C, ANGLE A	35 TO	1900 DEGREES F	

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
860	TE-1279	SUBCHANNEL NUMBER 79 THERMOCOUPLE	35 TO	1900 DEGREES F	
861	TE-310MC	MIDDLE THERMOCOUPLE, ROD 10, LEVEL C	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
862	TE-358AD	SHEATH THERMOCOUPLE, ROD 58, LEVEL D, ANGLE A	35 TO	1900 DEGREES F	
863	TE-310ME	MIDDLE THERMOCOUPLE, ROD 10, LEVEL E	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
864	TE-310MD	MIDDLE THERMOCOUPLE, ROD 10, LEVEL D	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
865	TE-302MC	MIDDLE THERMOCOUPLE, ROD 2, LEVEL C	35 TO	1900 DEGREES F	SPURIOUS SPIKES-POWER CUTOFF
866	TE-1269	SUBCHANNEL NUMBER 69 THERMOCOUPLE	35 TO	1900 DEGREES F	
867	TE-302MB	MIDDLE THERMOCOUPLE, ROD 2, LEVEL B	35 TO	1900 DEGREES F	FAILED INSTRUMENT
868	TE-302MD	MIDDLE THERMOCOUPLE, ROD 2, LEVEL D	35 TO	1900 DEGREES F	SPURIOUS SPIKES-POWER CUTOFF
869	TE-357BD	SHEATH THERMOCOUPLE, ROD 57, LEVEL D ANGLE B	35 TO	1900 DEGREES F	
870	TE-350M7	MIDDLE THERMOCOUPLE, ROD 50, LEVEL F, SUPER LEVEL 7	35 TO	1900 DEGREES F	
871	TE-350M6	MIDDLE THERMOCOUPLE, ROD 50, LEVEL F, SUPER LEVEL 6	35 TO	1900 DEGREES F	SPURIOUS SPIKES-POWER CUTOFF
872	TE-350MF	MIDDLE THERMOCOUPLE, ROD 50, LEVEL F	35 TO	1900 DEGREES F	SPURIOUS SPIKES-POWER CUTOFF
873	TE-318ME	MIDDLE THERMOCOUPLE, ROD 18, LEVEL E	35 TO	1900 DEGREES F	SPURIOUS SPIKES-POWER CUTOFF
874	TE-318MD	MIDDLE THERMOCOUPLE, ROD 18, LEVEL D	35 TO	1900 DEGREES F	SPURIOUS SPIKES-POWER CUTOFF
875	TE-318MF	MIDDLE THERMOCOUPLE, ROD 18, LEVEL F	35 TO	1900 DEGREES F	
876	TE-1275	SUBCHANNEL NUMBER 75 THERMOCOUPLE	35 TO	1900 DEGREES F	
877	TE-312ME	MIDDLE THERMOCOUPLE, ROD 12, LEVEL E	35 TO	1900 DEGREES F	SPURIOUS SPIKES-POWER CUTOFF
878	TE-312MD	MIDDLE THERMOCOUPLE, ROD 12, LEVEL D	35 TO	1900 DEGREES F	SPURIOUS SPIKES-POWER CUTOFF
879	TE-312MC	MIDDLE THERMOCOUPLE, ROD 12, LEVEL C	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
880	TE-312MB	MIDDLE THERMOCOUPLE, ROD 12, LEVEL B	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
881	TE-328CE	SHEATH THERMOCOUPLE, ROD 28, LEVEL E	32 TO	1897 DEGREES F	
882	TE-335ME	MIDDLE THERMOCOUPLE, ROD 35, LEVEL E	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
883	TE-335MC	MIDDLE THERMOCOUPLE, ROD 35, LEVEL C	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF

Table 3 (continued)

FIGURE NUMBER	INSTRUMENT NAME	DESCRIPTION	RANGE		COMMENTS
884	TE-335MD	MIDDLE THERMOCOUPLE, ROD 35, LEVEL D	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
885	TE-335MB	MIDDLE THERMOCOUPLE, ROD 35, LEVEL B	35 TO	1900 DEGREES F	
886	TE-358AE	SHEATH THERMOCOUPLE, ROD 58, LEVEL E, ANGLE A	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
887	TE-327MB	MIDDLE THERMOCOUPLE, ROD 27, LEVEL B	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
888	TE-301F8	SHEATH THERMOCOUPLE, ROD 01, LEVEL F, SUPER LEVEL 8	35 TO	1900 DEGREES F	
889	TE-358BF	SHEATH THERMOCOUPLE, ROD 58, LEVEL F, ANGLE A	35 TO	1900 DEGREES F	FAILED INSTRUMENT
890	TE-320MD	MIDDLE THERMOCOUPLE, ROD 20, LEVEL D	35 TO	1900 DEGREES F	FAILED INSTRUMENT
891	TE-320MG	MIDDLE THERMOCOUPLE, ROD 20, LEVEL G	35 TO	1900 DEGREES F	FAILED INSTRUMENT
892	TE-328CC	SHEATH THERMOCOUPLE, ROD 28, LEVEL C	32 TO	1897 DEGREES F	
893	TE-304AD	SHEATH THERMOCOUPLE, ROD 04, LEVEL D	35 TO	1900 DEGREES F	
894	TE-363AE	SHEATH THERMOCOUPLE, ROD 63, LEVEL E, ANGLE A	35 TO	1900 DEGREES F	
895	TE-310BD	SHEATH THERMOCOUPLE, ROD 10, LEVEL D	35 TO	1900 DEGREES F	
896	TE-351MC	MIDDLE THERMOCOUPLE, ROD 51, LEVEL C	35 TO	1900 DEGREES F	FAILED INSTRUMENT
897	TE-311MC	MIDDLE THERMOCOUPLE, ROD 11, LEVEL C	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
898	TE-311MD	MIDDLE THERMOCOUPLE, ROD 11, LEVEL D	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
899	TE-359BE	SHEATH THERMOCOUPLE, ROD 59, LEVEL E, ANGLE B	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
900	TE-311MA	MIDDLE THERMOCOUPLE, ROD 11, LEVEL A	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
901	TE-326MD	MIDDLE THERMOCOUPLE, ROD 26, LEVEL D	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
902	TE-326MC	MIDDLE THERMOCOUPLE, ROD 26, LEVEL C	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
903	TE-301E7	SHEATH THERMOCOUPLE, ROD 01, LEVEL E, SUPER LEVEL 7	35 TO	1900 DEGREES F	
904	TE-326ME	MIDDLE THERMOCOUPLE, ROD 26, LEVEL E	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
905	TE-304MD	MIDDLE THERMOCOUPLE, ROD 4, LEVEL D	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
906	TE-304MC	MIDDLE THERMOCOUPLE, ROD 4, LEVEL C	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
907	TE-304ME	MIDDLE THERMOCOUPLE, ROD 4, LEVEL E	35 TO	1900 DEGREES F	SPURIOUS SPIKE-POWER CUTOFF
908	TE-304MF	MIDDLE THERMOCOUPLE, ROD 4, LEVEL F	35 TO	1900 DEGREES F	SPURIOUS SPIKE

Table 4. Thermal-Hydraulic Test Facility Test 3.06.6B

NAME	FIGURE NUMBER	TYPE CODE
DE-168	144	106
DE-20	168	106
DE-204A	162	106
DE-204B	163	106
DE-204C	164	106
DE-218	145	106
DE-336U	165	111
DE-346L	166	111
DE-36	143	106
EEE-10	98	33
FEE-1026AC	2	39
EEE-1026AZ	1	38
EEE-1026BC	117	39
FEE-1026BZ	116	38
EEE-1026IC	191	39
EEE-1026IZ	190	38
EEE-1026JC	315	39
FEE-1026JZ	314	38
FEE-1026KC	432	39
EEE-1026KZ	431	38
EEE-1026LC	557	39
EEE-1026LZ	556	38
EEE-1026MC	683	39

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
EEE-1026MZ	682	38
EEE-1026NC	798	39
EEE-1026NZ	797	38
EEE-11	99	33
FEE-12	100	33
EEE-9	97	33
EIE-10	94	32
EIE-1001B	102	30
EIE-11	95	32
EIE-12	96	32
EIE-1301	60	31
EIE-1302	90	31
EIE-1303	71	31
EIE-1304	92	31
EIE-1305	72	31
EIE-1306	36	31
EIE-1307	38	31
EIE-1308	35	31
EIE-1309	57	31
EIE-1310	91	31
EIE-1311	73	31
EIE-1312	37	31
EIE-1313	34	31

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
EIE-1314	33	31
EIE-1315	80	31
EIE-1316	40	31
EIE-1317	58	31
FIE-1318	61	31
EIE-1320	70	31
FIE-1321	39	31
EIE-1323	82	31
EIE-1324	41	31
EIE-1325	55	31
EIE-1326	63	31
EIE-1327	87	31
FIE-1328	59	31
EIE-1329	83	31
EIE-1330	81	31
EIE-1331	32	31
EIE-1332	48	31
EIE-1333	64	31
EIE-1334	62	31
EIE-1335	56	31
EIE-1337	85	31
EIE-1338	47	31
EIE-1339	31	31

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
EIE-1340	49	31
EIE-1341	88	31
EIE-1342	89	31
EIE-1343	67	31
EIE-1344	66	31
EIE-1345	53	31
FIE-1347	46	31
EIE-1348	50	31
EIE-1349	54	31
EIE-1350	65	31
EIE-1351	69	31
EIE-1352	68	31
EIE-1353	77	31
EIE-1354	52	31
EIE-1355	51	31
EIE-1356	84	31
FIE-1357	74	31
EIE-1358	75	31
EIE-1359	76	31
EIE-1360	86	31
EIE-1361	43	31
EIE-1362	42	31
EIE-1363	45	31

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
EIE-1364	44	31
EIE-9	93	32
EWE-77A	108	34
FE-1A	148	107
FE-110	184	109
FE-166	110	109
FE-18A	25	108
FE-19	109	109
FE-202	185	109
FE-216	142	109
FE-232	183	109
FE-250	186	109
FE-260	187	109
FE-280	188	109
FE-34	141	109
FE-51	180	109
FE-522	112	95
FE-550	113	96
FE-59	181	109
FE-620	114	95
FE-64	182	109
FE-720	115	95
FMFE-114	125	40

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
FMFE-170	23	35
FMFE-206	78	35
FMFE-22	21	35
FMFE-220	24	35
FMFE-264	126	40
FMFE-38	22	35
FMFE-55	122	40
FMFE-61	123	40
FMFE-66	124	40
LE-100	153	105
PDE-111	138	28
PDE-180	3	75
PDE-181	4	75
PDE-182	5	75
PDE-183	6	75
PDE-184	7	75
PDE-185	8	75
PDE-186	118	75
PDE-187	119	75
PDE-188	120	75
PDE-189	121	75
PDE-200	20	28
PDE-203	139	28

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
PDE-204	134	43
PDE-21	26	26
PDE-217	28	26
PDE-251	140	28
PDE-271	161	43
PDE-30	150	98
PDE-35	27	26
PDE-46	18	26
PDE-48	152	97
PDE-53	135	28
PDE-60	136	26
PDE-65	137	28
PDE-78	19	27
PE-102	154	24
PE-106	13	23
PE-15	127	23
PE-156	14	23
PE-16	105	23
PE-174	29	23
PE-201	15	23
PE-209	131	23
PE-224	30	23
PE-258	132	23

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
PE-26	9	23
PE-27	106	23
PE-286	133	23
PE-32	151	24
PE-42	10	23
PE-427	111	23
PE-43	107	23
PE-44	11	23
PE-526	16	29
PE-58	128	23
PE-616	17	29
PE-63	129	23
PE-68	130	23
PE-76	12	23
SE-72	79	36
TDE-28	149	99
TE-1	393	6
TE-101	159	110
TE-116	395	6
TE-1201	365	3
TE-1205	358	3
TE-1207	671	3
TE-1209	237	3

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
TE-1211	362	3
TE-1213	178	3
TE-1214	360	3
TE-1216	517	3
TE-1217	238	3
TE-1219	417	3
TE-1220	416	3
TE-1221	363	3
TE-1223	359	3
TE-1225	241	3
TE-1226	239	3
TE-1227	243	3
TE-1229	648	3
TE-1230	372	3
TE-1231	364	3
TE-1232	361	3
TE-1234	213	3
TE-1235	179	3
TE-1237	373	3
TE-1238	374	3
TE-1239	375	3
TE-1240	371	3
TE-1241	382	3

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
TE-1242	233	3
TE-1244	236	3
TE-1245	234	3
TE-1247	177	3
TE-1248	174	3
TE-1249	240	3
TE-1250	383	3
TE-1251	366	3
TE-1252	221	3
TE-1255	672	3
TE-1256	370	3
TE-1258	235	3
TE-1259	175	3
TE-1260	376	3
TE-1261	380	3
TE-1263	256	3
TE-1265	369	3
TE-1266	173	3
TE-1268	176	3
TE-1269	866	3
TE-1270	377	3
TE-1271	381	3
TE-1273	368	3

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
TE-1275	876	3
TE-1277	379	3
TE-1279	860	3
TE-1281	385	3
TE-150	390	6
TE-151	391	6
TE-152	392	6
TE-172	169	6
TE-181W	326	4
TE-182E	386	4
TE-183N	388	4
TE-183W	628	4
TE-184E	389	4
TE-184S	627	4
TE-185W	327	4
TE-186E	651	4
TE-186S	630	4
TE-187N	387	4
TE-187W	629	4
TE-188AD	460	8
TE-188AE	464	8
TE-188AF	465	8
TE-188AG	642	8

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
TE-188BE	457	8
TE-188BF	467	8
TE-188BG	469	8
TE-189AD	462	8
TE-189AE	461	8
TE-189AF	468	8
TE-189AG	459	8
TE-189BD	458	8
TE-189BE	463	8
TE-189BF	466	8
TE-189BG	455	8
TE-2	394	6
TE-208	170	6
TE-210A	101	110
TE-222	397	6
TE-24	396	6
TF-256	409	6
TE-270AE	192	10
TE-270BE	193	10
TE-271AE	194	10
TE-271BE	195	10
TE-272AE	196	10
TE-272AS	684	10

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
TE-272BE	197	10
TE-272BS	685	10
TE-273AE	316	10
TE-273BE	317	10
TE-275AE	320	10
TE-275AS	686	10
TE-275BE	321	10
TE-275BS	687	10
TE-276AE	433	10
TE-276BE	434	10
TE-277AE	435	10
TE-277BE	436	10
TE-278AE	560	10
TE-278BF	561	10
TE-279AE	562	10
TE-279AS	688	10
TE-279BE	563	10
TE-279BS	689	10
TE-28B	157	71
TE-284	410	6
TE-29	399	6
TE-291A	328	7
TE-291B	324	7

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
TE-291C	323	7
TE-291D	306	7
TE-292A	322	7
TE-292B	302	7
TE-292D	303	7
TE-293A	311	7
TE-293B	335	7
TE-293C	329	7
TE-293D	334	7
TE-293E	333	7
TE-293F	325	7
TE-294B	330	7
TE-294D	332	7
TE-294E	331	7
TE-294F	307	7
TE-295A	313	7
TE-295B	304	7
TE-295C	312	7
TE-295D	305	7
TE-296B	336	7
TE-296D	337	7
TE-301AF	581	1
TE-301AG	854	1

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
TE-301E1	811	1
TE-301E3	509	1
TE-301E7	903	1
TE-301E8	549	1
TE-301F1	546	1
TE-301F2	584	1
TE-301F3	572	1
TE-301F6	548	1
TE-301F7	855	1
TE-301F8	888	1
TE-301MF	824	2
TE-301MG	529	2
TE-301M2	823	2
TE-301M8	525	2
TE-302AB	575	1
TE-302AD	574	1
TE-302AE	576	1
TE-302BC	577	1
TE-302MB	867	2
TE-302MC	865	2
TE-302MD	868	2
TE-303BE	553	1
TE-303BF	555	1

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
TE-303CD	552	1
TE-303CE	570	1
TE-303CG	554	1
TE-303MD	848	2
TE-303ME	845	2
TE-303MF	847	2
TE-303MG	846	2
TE-304AC	569	1
TE-304AD	893	1
TE-304AF	550	1
TE-304BE	568	1
TE-304MC	906	2
TE-304MD	905	2
TE-304ME	907	2
TE-304MF	908	2
TE-305AS	452	1
TE-305BH	453	1
TE-305BU	451	1
TE-305CY	454	1
TE-305MH	775	2
TE-305MS	774	2
TE-305MU	773	2
TE-305MY	776	2

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
TE-306AA	487	1
TE-306AB	488	1
TE-306MA	757	2
TE-306MC	760	2
TE-306MD	758	2
TE-307AC	439	1
TE-307AF	441	1
TE-307BF	485	1
TE-307BF	483	1
TE-307CE	442	1
TE-307MC	779	2
TE-307MD	780	2
TE-307ME	778	2
TE-307MF	777	2
TE-308AD	299	1
TE-308BC	492	1
TE-308CB	490	1
TE-308CD	456	1
TE-308MB	807	2
TE-308MC	810	2
TE-308MD	809	2
TE-309AC	541	1
TE-309CB	551	1

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
TE-309CD	540	1
TE-309MB	856	2
TE-309MC	853	2
TE-310AF	565	1
TE-310BD	895	1
TE-310BE	567	1
TE-310BF	578	1
TE-310CC	566	1
TE-310CD	564	1
TE-310CF	579	1
TE-310MC	861	2
TE-310MD	864	2
TE-310ME	863	2
TE-311AA	545	1
TE-311AB	544	1
TE-311CC	542	1
TE-311MA	900	2
TE-311MC	897	2
TE-311MD	898	2
TE-312AE	284	1
TE-312BC	283	1
TE-312CB	285	1
TE-312CD	571	1

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
TE-312MB	880	2
TE-312MC	879	2
TE-312MD	878	2
TE-312ME	877	2
TE-313AE	630	1
TE-313BC	412	1
TE-313BF	414	1
TE-313CD	411	1
TE-313CF	413	1
TE-313CF	257	1
TE-314AF	473	1
TE-314AG	756	1
TE-314E1	477	1
TE-314E3	476	1
TE-314E7	475	1
TE-314E8	474	1
TE-314F2	447	1
TE-314F3	669	1
TE-314F6	668	1
TE-314F7	471	1
TE-314F8	470	1
TE-314MF	478	2
TE-314MG	752	2

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
TE-314M2	754	2
TE-314M8	753	2
TE-315AC	736	1
TE-315AD	484	1
TE-315AF	727	1
TE-315BD	737	1
TE-315BE	482	1
TE-315CE	472	1
TE-315MC	770	2
TE-315MD	772	2
TE-315ME	771	2
TE-315MF	785	2
TE-316AD	495	1
TE-316BE	666	1
TE-316BF	493	1
TE-316BG	443	1
TE-316CE	494	1
TE-316CG	496	1
TE-316MD	800	2
TE-316ME	799	2
TE-316MF	801	2
TE-316MG	802	2
TE-317AF	739	1

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
TE-317AG	505	1
TE-317E3	675	1
TE-317F1	738	1
TE-317F2	507	1
TE-317F3	516	1
TE-317F6	515	1
TE-317F7	514	1
TE-317F8	513	1
TE-317MF	788	2
TE-317MG	558	2
TE-317M6	559	2
TE-317M7	830	2
TE-318AE	449	1
TE-318AF	531	1
TE-318AG	446	1
TE-318BD	835	1
TE-318BE	532	1
TE-318BG	530	1
TE-318CD	673	1
TE-318CE	829	1
TE-318CF	769	1
TE-318CG	486	1
TE-318MD	874	2

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
TE-318ME	873	2
TE-318MF	875	2
TE-320AD	523	1
TE-320AE	661	1
TE-320AF	664	1
TE-320AG	674	1
TE-320PD	665	1
TE-320BE	660	1
TE-320BF	524	1
TE-320BG	521	1
TE-320CD	662	1
TE-320CE	659	1
TE-320CF	663	1
TE-320CG	522	1
TE-320MD	990	2
TE-320MG	891	2
TE-321AF	498	1
TE-321AG	836	1
TE-321E2	833	1
TE-321E3	543	1
TE-321E6	750	1
TE-321F1	647	1
TE-321F3	422	1

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
TE-321F4	421	1
TE-321F5	781	1
TE-321F6	420	1
TE-321F7	419	1
TE-321F8	755	1
TE-321MF	297	2
TE-321MG	481	2
TE-321M1	677	2
TE-321M3	676	2
TE-323AA	418	1
TE-323BC	415	1
TE-324AB	715	1
TE-324AC	499	1
TE-324AE	450	1
TE-324BD	500	1
TE-324CE	497	1
TE-324MC	791	2
TE-324MD	792	2
TE-324ME	790	2
TE-325BC	678	1
TE-325BD	680	1
TE-325CA	528	1
TE-325CB	679	1

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
TE-325CC	526	1
TE-325CD	527	1
TE-325MA	844	2
TE-325MB	843	2
TE-325MC	841	2
TE-325MD	842	2
TE-326AC	351	1
TE-326AD	289	1
TE-326AE	641	1
TE-326BB	353	1
TE-326BD	643	1
TE-326BE	649	1
TE-326CD	425	1
TE-326CE	350	1
TE-326MC	902	2
TE-326MD	901	2
TE-326ME	904	2
TE-327AC	291	1
TE-327AD	623	1
TE-327BA	430	1
TE-327BD	654	1
TE-327CB	424	1
TE-327CC	429	1

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
TE-327CD	428	1
TE-327MB	887	2
TE-328AC	681	1
TE-328AD	789	1
TE-328AE	857	1
TE-328AF	808	1
TE-328BD	519	1
TE-328BF	805	1
TE-328CC	892	1
TE-328CD	658	1
TE-328CE	881	1
TE-328CF	520	1
TE-328MC	698	2
TE-328MD	701	2
TE-328ME	699	2
TE-328MF	700	2
TE-329AC	367	1
TE-329AD	594	1
TE-329AE	200	1
TE-329BC	198	1
TE-329BD	199	1
TE-329BE	503	1
TE-329CB	500	1

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
TE-329CD	589	1
TE-329CE	591	1
TE-329MB	705	2
TE-329MC	703	2
TE-329MD	704	2
TE-329ME	702	2
TE-330AC	230	1
TE-330AD	378	1
TE-330AE	231	1
TE-330BE	310	1
TE-330CB	232	1
TE-330MB	749	2
TE-330MC	748	2
TE-330ME	751	2
TE-331RF	260	1
TE-331CD	216	1
TE-331CE	215	1
TE-331CF	214	1
TE-331MF	761	2
TE-332AE	697	1
TE-332CD	445	1
TE-332CE	440	1
TE-332CF	444	1

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
TE-332CG	448	1
TE-332MD	812	2
TE-332ME	814	2
TE-332MC	813	2
TE-333AC	511	1
TE-333AD	512	1
TE-333AE	831	1
TE-333BE	832	1
TE-333CF	510	1
TE-333MC	834	2
TE-334AF	616	1
TE-334AG	276	1
TE-334E3	622	1
TE-334E7	621	1
TE-334E8	620	1
TE-334F1	615	1
TE-334F2	614	1
TE-334F3	279	1
TE-334F6	278	1
TE-334F7	277	1
TE-334F8	613	1
TE-334MF	580	2
TE-334M6	858	2

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
TE-335BB	506	1
TE-335BD	759	1
TE-335BE	508	1
TE-335MB	885	2
TE-335MC	883	2
TE-335MD	884	2
TE-335ME	882	2
TE-337AF	423	1
TE-337AG	479	1
TE-337E3	293	1
TE-337E7	272	1
TE-337E8	427	1
TE-337F1	657	1
TE-337F6	275	1
TE-337F7	274	1
TE-337F8	273	1
TE-337MF	693	2
TE-337MG	690	2
TE-337M6	692	2
TE-337M7	691	2
TE-338AF	206	1
TE-338AG	489	1
TE-338E1	426	1

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
TE-338E3	352	1
TE-338E7	208	1
TE-338E8	207	1
TE-338F1	229	1
TE-338F2	292	1
TE-338F3	319	1
TE-338F6	308	1
TE-338F7	318	1
TE-338F8	732	1
TE-338MF	709	2
TE-338MG	706	2
TE-338M2	708	2
TE-338M8	707	2
TE-339AC	204	1
TE-339BB	203	1
TE-339BD	202	1
TE-339MB	747	2
TE-339MC	746	2
TE-339MD	744	2
TE-339ME	745	2
TE-340BC	228	1
TE-340BD	227	1
TE-340CA	226	1

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
TE-340CB	225	1
TE-340MA	784	2
TE-340MB	783	2
TE-340MC	782	2
TE-341AB	294	1
TE-341MA	837	2
TE-341MB	839	2
TE-341MC	840	2
TE-341MD	838	2
TE-342AG	295	1
TE-342BD	301	1
TE-342BE	171	1
TE-342BF	300	1
TE-342BG	309	1
TE-342CG	298	1
TE-343AD	296	1
TE-343BA	290	1
TE-343BB	287	1
TE-343BC	288	1
TE-343BD	573	1
TE-344AE	670	1
TE-344CB	503	1
TE-344CC	502	1

TABLE

NAME	FIGURE NUMBER	TYPE CODE
TE-344CD	501	1
TE-344CE	504	1
TE-344MB	716	2
TE-344MC	714	2
TE-344ME	717	2
TE-345AD	384	1
TE-345AE	598	1
TE-345AF	601	1
TE-345AG	220	1
TE-345BD	596	1
TE-345BE	599	1
TE-345BF	597	1
TE-345BG	600	1
TE-345CF	219	1
TE-345CG	602	1
TE-345MD	696	2
TE-345ME	694	2
TE-345MG	695	2
TE-347CF	595	1
TE-347CG	218	1
TE-347MD	767	2
TE-347ME	766	2
TE-347MF	768	2

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
TE-347MG	765	2
TE-348AH	258	1
TE-348AY	259	1
TE-348MH	816	2
TE-348MS	817	2
TE-348MU	815	2
TE-348MY	818	2
TE-349AE	286	1
TE-349BE	343	1
TE-349CB	346	1
TE-349CC	348	1
TE-349CD	347	1
TE-349CE	349	1
TE-349MB	828	2
TE-349MC	827	2
TE-349MD	826	2
TE-349ME	825	2
TE-350AG	639	1
TE-350E1	646	1
TE-350E3	645	1
TE-350E7	644	1
TE-350F1	345	1
TE-350F2	344	1

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
TE-350F3	653	1
TE-350F6	342	1
TE-350F7	652	1
TE-350F8	640	1
TE-350MF	872	2
TE-350M6	871	2
TE-350M7	870	2
TE-351AB	357	1
TE-351AE	356	1
TE-351BC	354	1
TE-351BD	172	1
TE-351BE	650	1
TE-351MC	896	2
TE-352AH	636	1
TE-352AS	633	1
TE-352AU	338	1
TE-352AY	638	1
TE-352BH	635	1
TE-352BS	339	1
TE-352BU	631	1
TE-352BY	637	1
TE-352CH	340	1
TE-352CS	634	1

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
TE-352CU	632	1
TE-352CY	341	1
TE-352MH	742	2
TE-352MS	741	2
TE-352MU	740	2
TE-352MY	743	2
TE-353AE	242	1
TE-353BE	205	1
TE-353BF	606	1
TE-353CC	244	1
TE-353MC	722	2
TE-353MD	723	2
TE-353ME	724	2
TE-354AF	607	1
TE-354AG	201	1
TE-354E2	491	1
TE-354E3	355	1
TE-354E6	224	1
TE-354F1	217	1
TE-354F3	592	1
TE-354F4	588	1
TE-354F5	212	1
TE-354F6	211	1

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
TE-354F7	210	1
TE-354F8	209	1
TE-354MF	721	2
TE-354MG	718	2
TE-354M5	720	2
TE-354M6	719	2
TE-355AA	262	1
TE-355BC	264	1
TE-355CB	261	1
TE-355CD	667	1
TE-355MA	710	2
TE-355MB	711	2
TE-355MC	712	2
TE-355MD	713	2
TE-356AY	268	1
TE-356BS	266	1
TE-356BU	267	1
TE-356CH	265	1
TE-356MH	787	2
TE-356MS	786	2
TE-357AC	859	1
TE-357BA	582	1
TE-357BC	547	1

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
TE-357BD	869	1
TE-357CB	583	1
TE-357CD	586	1
TE-357MA	822	2
TE-357MB	820	2
TE-357MC	819	2
TE-357MD	821	2
TE-358AD	862	1
TE-358AE	886	1
TE-358BE	538	1
TE-358BF	889	1
TE-358CD	537	1
TE-358CG	539	1
TE-358MD	850	2
TE-358ME	851	2
TE-358MF	849	2
TE-358MG	852	2
TE-359AD	534	1
TE-359AE	533	1
TE-359AF	585	1
TE-359BE	899	1
TE-359BF	587	1
TE-359CC	536	1

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
TE-359CE	518	1
TE-359CF	535	1
TE-359MC	735	2
TE-359ME	733	2
TE-359MF	734	2
TE-360AF	655	1
TE-360AG	617	1
TE-360E2	610	1
TE-360E3	618	1
TE-360E6	656	1
TE-360F3	626	1
TE-360F4	282	1
TE-360F5	281	1
TE-360F6	280	1
TE-360F7	625	1
TE-360F8	624	1
TE-360MF	728	2
TE-360MG	725	2
TE-360M3	726	2
TE-361AB	246	1
TE-361AC	247	1
TE-361AD	248	1
TE-361AE	223	1

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
TE-361BE	222	1
TE-361BJ	604	9
TE-361CE	245	1
TE-361CJ	603	9
TE-361MB	730	2
TE-361MC	729	2
TE-361MD	731	2
TE-362AC	263	1
TE-362AD	271	1
TE-362BB	270	1
TE-362CE	269	1
TE-363AE	894	1
TE-363BC	254	1
TE-363BE	253	1
TE-363CB	255	1
TE-363MB	795	2
TE-363MC	796	2
TE-363MD	793	2
TE-363ME	794	2
TE-364AD	251	1
TE-364AE	480	1
TE-364AF	608	1
TE-364AG	249	1

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
TE-364BD	605	1
TE-364BE	250	1
TE-364BF	252	1
TE-364CD	611	1
TE-364CF	610	1
TE-364CG	612	1
TE-364MD	806	2
TE-364MF	804	2
TE-364MG	803	2
TE-4B	158	110
TE-40	398	6
TE-408B	405	5
TE-45	400	6
TE-5B	401	5
TE-520B	406	5
TE-521	407	5
TE-525	103	110
TE-557	156	110
TE-57	402	6
TE-615	160	110
TE-62	403	6
TE-627	104	110
TE-67	404	6

Table 4 (continued)

NAME	FIGURE NUMBER	TYPE CODE
TE-727	155	110
TE-901	408	5
TE-920	762	5
TE-921	763	5
TE-922	764	5
TE-923	437	5
TE-924	438	5
XE-430A	147	37
XE-430B	146	37
ZE-336U	167	76
ZE-346L	189	76

Table 5. Thermocouple nomenclature

Fuel rod simulator thermocouples: TE-3nnal

Rod sheath thermocouples are designated according to one of the following two schemes:

1. When the thermocouple ends with a letter

```
TE - 3   17   A   D
          |    |   |
          |    |   +--- axial thermocouple level
          |    +----- azimuthal thermocouple location
          +----- rod number
```

The above designation refers to the sheath thermocouple in rod 17 at level D, azimuthal location A.

- 2. When the thermocouple designation ends with a number**

TE - 3 54 F8

 └── axial thermocouple level

 └── rod number

The designation refers to the sheath thermocouple in rod 54 at level F8.

Spacer grid thermocouples: TE-29na

'n' - a number 1-6 designating the spacer grid level as follows:

<u>Number</u>	<u>Between T/C levels</u>
1	A&B
2	B&C
3	C&D
4	D&E
5	E&F
6	F&G

'a' - a letter 'A'-'F' designating the subchannel into which the thermocouple is projecting as follows:

<u>Letter</u>	<u>Subchannel</u>
A	32
B	43
C	57
D	70
E	17
F	38

The spacer grids numbered 1, 2, 5, and 6 above have four thermocouples in subchannels designated 'A'-'D.' The spacer grids numbered 3 and 4 above have six thermocouples in subchannels designated 'A'-'F.'

Table 5 (continued)

Shroud box fluid thermocouples: TE-18na

'n' - a number 1-7 designating the level of the thermocouple in the shroud box as follows:

<u>Number</u>	<u>T/C level</u>
181	A
182	B
183	C
184	D
185	E
186	F
187	G

'a' - a letter designating the side of the box through which the thermocouple protrudes 'N,' 'E,' 'S,' 'W,' (the compass direction most closely matching the direction the side faces).

Shroud box wall thermocouples: TE-27nab

'n' - a number 0-9 designating the level of the thermocouples in the shroud box as follows:

<u>'n'</u>	<u>T/C level</u>
0	A
1	B
2	C
3	D
4	N/A
5	E
6	E3
7	F
8	F3
9	F7

'a' - a letter designating the thermocouple position depth

<u>'a'</u>	<u>Position</u>
A	At edge of inner shroud wall
B	At edge of outer shroud wall

'b' - a letter designating wall orientation

<u>'b'</u>	
E	East wall
S	South wall

Subchannel thermocouples: TE-12nn

'nn' - a number 01-81 equal the number of the subchannel in which it is located.

Table 5 (continued)

Thermocouple array rod thermocouples: TE-18na1

'n' - the number 8 or 9 designating which bundle site the T/C array rod is located.

8 - grid position No. 19

9 - grid position No. 22

'a' - a letter 'A' or 'B' designating which of two subchannels associated with that rod the thermocouple protrudes into.

<u>Position</u>	<u>'A' subchannel No.</u>	<u>'B' subchannel No.</u>
19	22	30
22	24	34

'1' - the thermocouple level 'D'-'G' (same as FRS thermocouple level designations).

REFERENCES

1. D. G. Morris, C. B. Mullins, and G. L. Yoder, *An Analysis of Transient Film Boiling of High Pressure Water in a Rod Bundle*, ORNL/NUREG-85 (March 1982).
2. D. K. Felde et al., *Thermal Hydraulic Test Facility (THTF) MOD 3, ORNL Blowdown Heat Transfer Program*, ORNL/TM-7842 (to be published).

Appendix A

TEST PHENOMENOLOGY

The transient experiment was initiated by breaking the outlet rupture disk assembly. Although the THTF has a rupture disk assembly at the outlet and inlet, by breaking at the outlet only, unidirectional flow up through the test section could be achieved. This was a primary aim of the test. Following the breaking of the outlet rupture disk, the pump was tripped at 0.5 s, and the bundle power was ramped up from 2.3 to 7.8 MW over the time interval 1.5–2.5 s. At approximately 5 s into the transient the bundle power was reduced to ~3 MW over a 4-s time interval and then decreased slowly until the bundle power was tripped by the high-rod-temperature trip at 10.75 s. The trip occurred when two rod sheath thermocouples exceeded the high-temperature safety limit of 1116 K (1150°F). This procedure resulted in prolonged film boiling while safely operating the bundle.

As mentioned previously the transient was initiated with the breaking of the outlet rupture disk (time 0.0 s). At time 0.0 s there is an almost instantaneous subcooled decompression from the steady-state operating pressure to the saturation pressure corresponding to the outlet fluid temperature. The measured outlet pressure is shown on microfiche Fig. 131. After the initial drop, the pressure rises slowly until ~3.5 s and then decreases again with a slow depressurization rate.

Since the test was an outlet-only break, flow through the test section, the B01 spool piece, and the B11-2 spool piece remains unidirectional throughout the transient. This can be seen in microfiche Figs. 184–186.

At the inlet spool piece the fluid is a subcooled liquid for the initial 15 s of transient.

After break initiation, fluid in the rod bundle saturates, and the fluid quality increases with time because bundle power increases, pressure decreases, and flow decreases. Rod temperature excursions, indicating departure from nucleate boiling (DNB), are recorded in the uppermost part of the bundle at ~3 s (see microfiche Figs. 297 and 308). As time progresses more of the bundle undergoes DNB, as seen in microfiche Figs. 615, 222, 288, and 290. Level B sheath thermocouples indicate no DNB (see microfiche Figs. 345, 352, and 356).

Appendix B

MASS FLUX CALCULATIONS

This appendix describes the method by which mass flux is calculated at the THTF test section boundaries and the estimated uncertainties in those calculations. Included are the mass flux calculations for the transient periods of interest.

B.1 Mass Flux Calculations for THTF Instrumented
Spool Pieces

At the THTF, instrumented "spool pieces" are used to provide measurements of volumetric flow rate, momentum flux, density, pressure, and temperature at the boundaries of the test section. A spool piece consists of a fluid thermocouple, an absolute pressure tap, a turbine meter for measuring volumetric flow or velocity (V), a drag disk for measuring momentum flux (ρV^2), and a gamma densitometer for measuring an average chordal density (ρ) of the fluid. Since the mass flux is not directly measured, it is necessary to use combinations of these instruments to determine mass flux. Homogeneous models may be used combining the turbine meter and gamma densitometer (ρV), the drag disk and the gamma densitometer ($\sqrt{\rho \cdot \rho V^2}$), and the turbine meter and drag disk ($\rho V^2/V$) to obtain mass flux. These mass flux models are incorporated into the mass flux code AMICON,¹ which operates on the transient instrument data. Where conditions permit, in subcooled or superheated flow, the density for the models is deduced from water properties based on temperature and pressure measurements and replaces the densitometer-measured density. The uncertainty in density determined in this manner is significantly less than the uncertainty inherent in the densitometer's measured density. Logic in the AMICON and water properties codes determines whether a temperature- and pressure-deduced density or a densitometer-measured density is appropriate (based on a comparison of measurements by these same instruments). For saturated flow conditions, the logic also prevents the use of a densitometer-measured density that is less than the saturated vapor density (within uncertainty bands) for the measured temperature and pressures in the spool piece. For high-quality mass flows, this effectively reduces uncertainties on the low side of the density measurements.

The mass flux results generated by AMICON are shown in Figs. B.1-B.23 for the different models and spool pieces. The locations of the spool pieces are indicated in Fig. 1 of the main text. The Bundle Outlet spool piece B01 contains a three-beam gamma densitometer. Results are shown using both a single-beam and a three-beam annular densitometer model for this spool piece. The single-beam model at the B01 site uses the center beam measurement from the three-beam densitometer. The various models

ORNL-DWG 82-4735 ETD

Fig. B.1. Mass flux vs time at BI1 site using TBM-GAM model.

ORNL-DWG 82-4736 ETD

Fig. B.2. Mass flux vs time at BI1 site using TBM-DD model.

ORNL-DWG 82-4737 ETD

Fig. B.3. Mass flux vs time at B11 site using DD-GAM model.

ORNL-DWG 82-4738 ETD

Fig. B.4. Mass flux vs time at B01 site using TBM-GAM 3 model.

ORNL-DWG 82-4739 ETD

Fig. B.5. Mass flux vs time at B01 site using TBM-GAM model.

ORNL-DWG 82-4740 ETD

Fig. B.6. Mass flux vs time at B01 site using TBM-DD model.

ORNL-DWG 82-4741 ETD

Fig. B.7. Mass flux vs time at B01 site using DD-GAM 3 model.

ORNL-DWG 82-4742 ETD

Fig. B.8. Mass flux vs time at B01 site using DD-GAM model.

ORNL-DWG 82-4743 ETO

Fig. B.9. Mass flux vs time at BI2 site using TBM-GAM model.

ORNL-DWG 82-4744 ETO

Fig. B.10. Mass flux vs time at BI2 site using TBM-DD model.

ORNL-DWG 82-4745 ETD

Fig. B.11. Mass flux vs time at BI2 site using DD-GAM model.

ORNL-DWG 82-4746 ETD

Fig. B.12. Mass flux vs time at SVI site using TBM-GAM model.

ORNL-DWG 82-4747 ETD

Fig. B.13. Mass flux vs time at SVI site using TBM-DD model.

ORNL-DWG 82-4748 ETD

Fig. B.14. Mass flux vs time at SVI site using DD-GAM model.

ORNL-DWG 82-4749 ETO

Fig. B.15. Mass flux vs time at SHI site using TBM-GAM model.

ORNL-DWG 82-4750 ETO

Fig. B.16. Mass flux vs time at SHI site using TBM-DD model.

ORNL-DWG 82-4751 ETD

Fig. B.17. Mass flux vs time at SHI site using DD-GAM model.

ORNL-DWG 82-4752 ETD

Fig. B.18. Mass flux vs time at SVO site using TBM-GAM model.

ORNL-DWG 82-4753 ETD

Fig. B.19. Mass flux vs time at SVO site using TBM-DD model.

ORNL-DWG 82-4754 ETD

Fig. B.20. Mass flux vs time at SVO site using DD-GAM model.

ORNL-DWG 82-4755 ETD

Fig. B.21. Mass flux vs time at SHO site using TBM-GAM model.

ORNL-DWG 82-4756 ETD

Fig. B.22. Mass flux vs time at SHO site using TBM-DD model.

Fig. B.23. Mass flux vs time at SHO site using DD-GAM model.

are designated as:

turbine meter - single-beam densitometer = TBM-GAM
 turbine meter - three-beam densitometer = TBM-GAM 3
 drag disk - single-beam densitometer = DD-GAM
 drag disk - three-beam densitometer = DD-GAM 3
 turbine meter - drag disk = TBM-DD

A three-region annular model² was used to reduce the three-beam densitometer results to a composite density suitable for use in the mass flux models. The model solves for a uniform density for each region in Fig. B.24 using the density indicated by each of the three beams and the length of each beam within each region. The composite pipe density is then calculated as an area-weighted average of the three region densities. The resulting equation for the composite density is

$$\bar{\rho}_{\text{Annular}} = 0.3784\rho_A + 0.5117\rho_B + 0.1099\rho_C, \quad (\text{B.1})$$

where ρ_A , ρ_B , and ρ_C are indicated in Fig. B.24 and are the densities measured by the three beams.

Fig. B.24. Diagram showing uniform density regions used in annular model for reduction of three-beam densitometer data.

B.2 Uncertainties in Mass Flux Calculations

Although the uncertainties obtained using the homogeneous models should be fairly small in single-phase flow, significant uncertainties may exist in two-phase flow where effects such as slip, void fraction, flow regime, and transient response affect the physical interpretation of the instrument output. This section will look first at estimated uncertainties in subcooled flow. This will be followed by discussion of uncertainties in steady-state and transient two-phase flow.

B.2.1 Subcooled flow uncertainty analysis

The Transient Upflow Film Boiling Test series (3.03.6AR, 3.06.6B, and 3.08.6C) was designed specifically to maintain subcooled inlet flow over most of the primary transient periods of interest in the heated bundle. The subcooled inlet flow conditions provide significantly lower and quantifiable uncertainties in the calculation of bounding conditions for the test section than are possible with two-phase flow conditions.

The mass flux (G) for subcooled flow conditions is calculated from a turbine meter measured velocity (V) and a fluid temperature- and pressure-

deduced density (ρ);

$$G = \rho V . \quad (B.2)$$

It should be noted that the primary inlet flow measurement instruments in the Upflow Film Boiling Test configuration are the 2-in. turbine meters, FE-250 and FE-260. The larger 4-in. inlet turbine meters, FE-19 and FE-166, approach or fall below the lower limits of their calibrated range over most of the transient.

The mass flux uncertainty may be estimated by the standard propagation of errors method [Eq. (D.4) in Appendix D] using individual instrument uncertainties as stated in Tables D.5-D.6, Appendix D. The variance of the mass flux is given in an analogous form to Eq. (D.4) in Appendix D:

$$\text{Variance } (G) = \sigma_G^2 = \left(\frac{\partial G}{\partial \rho} \right)^2 \sigma_\rho^2 + \left(\frac{\partial G}{\partial V} \right)^2 \sigma_V^2 . \quad (B.3)$$

Expressed in terms of the standard deviation, σ , this equation becomes:

$$\sigma_G = \sqrt{(\sigma_\rho)^2 + (\rho \sigma_V)^2} , \quad (B.4)$$

where

$$\begin{aligned} \sigma_\rho &= \text{density measurement uncertainty,} \\ \sigma_V &= \text{velocity measurement uncertainty.} \end{aligned}$$

Since the uncertainties for the turbine meter are stated in terms of percent of reading, it is convenient to express the mass flux uncertainty in a similar manner. Equation (B.4) may be restated as

$$\sigma_G(\%) = \sqrt{\sigma_\rho(\%)^2 + \sigma_V(\%)^2} . \quad (B.5)$$

For the subcooled portion of the transients, the 2σ error bands (95% confidence bands) for the turbine meter ($2\sigma_V$) are stated as 4.1% of reading (Tables D.5-D.6 of Appendix D). Transient effects are assumed negligible after the initial subcooled decompression at blowdown. A 2σ estimate for the density is based on uncertainties generated from water properties assuming 2σ deviations of temperature ($2\sigma_T$) and pressure ($2\sigma_p$) from measured values. The 2σ uncertainties from Tables D.5-D.6 of Appendix D are

$$2\sigma_T = 3.7 \text{ K } (6.7^\circ\text{F})$$

and

$$2\sigma_p = 200 \text{ kPa } (29 \text{ psi}) ,$$

where again transient uncertainty effects are assumed negligible after the initial subcooled decompression at blowdown. For the pressures and temperatures of interest, the 2σ variation in temperature is the dominant effect and results in an estimated 2σ of 1.0% of reading. Substituting the 2σ measurement uncertainties into Eq. (B.5) results in a 2σ mass flux uncertainty for subcooled flow of 4.22% of reading.

B.2.2 Two-phase flow uncertainty analysis

The two-phase mass flux uncertainty estimates will be made based on results from the Steady-State Upflow Film Boiling Test series (3.07.9) and the application of a transient turbine meter model developed by Kamath and Lahey (Ref. 3) to the Transient Upflow Film Boiling Test (3.06.6B) and the Double-Ended Cold Leg Break Test (3.05.5B). Test series 3.07.9 were tests run with upflow in steady state; these tests provide a good benchmark for steady-state two-phase uncertainties. The Kamath and Lahey model provides an assessment of the effects of slip, flow regime, and transient response on the physical interpretation of the instrument output. Test 3.05.5B was a violent transient test that will provide a worst-case transient assessment.

B.2.2.1 Steady-state two-phase flow uncertainty analysis. A limited amount of steady-state two-phase mass flux uncertainty data over an equilibrium quality range of approximately 0.8–1.4 is available from the Steady-State Upflow Film Boiling Test series. Dispersed flow is expected at the test section outlet for the high-quality flow conditions. Steady-state, subcooled flow at the test section inlet provides a reference standard for estimating the two-phase mass flux uncertainty at the test section outlet spool pieces. The various homogeneous mass flux models discussed earlier are compared with each other as functions of pressure, equilibrium quality, and inlet mass flux. Results from a steady-state version of the Kamath and Lahey model (K&L) are also provided for comparison. The comparison is useful in providing confidence limits on the transient model as applied to the THTF instruments. The Kamath and Lahey model is discussed in more detail later. The steady-state model results are plotted as the ratio of the model mass flux to the reference inlet mass flux, $G(\text{MODEL})/G(\text{REFERENCE})$, where perfect agreement is at 1.0. It should be noted that the reference subcooled inlet mass flux has 95% confidence bands of $\pm 4.22\%$ as discussed earlier.

Comparisons of the mass flux models DD-GAM 3, TBM-DD, TBM-GAM 3, and Kamath and Lahey are shown in Figs. B.25–B.27 as functions of pressure, equilibrium quality, and inlet mass flux, respectively. The results are from the horizontal Bundle Outlet spool piece (BO1). All of the models generally fall within 95% confidence bands of $\pm 50\%$. Data scatter increases somewhat for lower pressures and mass flux. The DD-GAM 3 and TBM-DD models show somewhat smaller uncertainty bands (approximately $\pm 30\%$) than the TBM-GAM and K&L models. The TBM-GAM 3 and the K&L models agree quite closely with each other over the range of test parameters.

The three-beam densitometer was used in the previous comparisons. The use of a single-beam densitometer in the models results in significantly higher uncertainties, as indicated in Figs. B.28 and B.29. Comparisons are made between the TBM-GAM and TBM-GAM 3 models in Fig. B.28

Fig. B.25. Comparison of mass flux models vs pressure at the B01 spool piece.

Fig. B.26. Comparison of mass flux models vs equilibrium quality at the B01 spool piece.

Fig. B.27. Comparison of mass flux models vs inlet mass flux at the B01 spool piece.

Fig. B.28. Comparison of turbine meter - densitometer model using single-beam and three-beam densitometers at the B01 spool piece.

Fig. B.29. Comparison of the drag disk - densitometer model using single-beam and three-beam densitometers at the B01 spool piece.

and between the DD-GAM and DD-GAM 3 models in Fig. B.29 at the B01 spool piece. Uncertainty bands increase from approximately $\pm 50\%$ for the TBM-GAM 3 model to $\pm 80\%$ for the TBM-GAM model. Uncertainty bands for the DD-GAM model are $\sim 10\%$ higher than for the DD-GAM 3 model.

Mass flux model comparisons were also made at the other two outlet spool pieces, SVO and SHO. Spool piece SVO is a vertical spool piece with downflow and follows the B01 spool piece in the normal flow direction. Spool piece SHO is a horizontal spool piece that follows SVO. As mentioned earlier, flow conditions at the upper end and outlet of the test section were primarily dispersed flow with considerable nonequilibrium for many of the data points. As the flow moves downstream from the test section outlet, equilibrium is eventually reached as the liquid droplets evaporate. For equilibrium qualities greater than 1.0, single-phase superheated steam conditions should eventually exist. The three homogeneous models are compared with equilibrium quality for the SVO spool piece in Fig. B.30. Uncertainty bands for the DD-GAM model ($\sim 70\%$) and for the TBM-DD model ($\sim 140\%$) are significantly higher than those observed at the B01 spool piece. A trend is observed with decreasing uncertainty at higher equilibrium qualities. This may indicate that the flow is approaching equilibrium conditions and that the flow is essentially single-phase superheated steam. Figure B.31 shows the same comparisons for the SHO spool piece. It appears that the flow has reached equilibrium at this spool piece. The uncertainties for all of the models at the SHO spool piece are approaching the uncertainty bands expected for single-phase

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Fig. B.30. Comparison of the mass flux models vs equilibrium quality at the SVO spool piece.

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Fig. B.31. Comparison of the mass flux models vs equilibrium quality at the SHO spool piece.

flow. (That is, the 2σ uncertainty bands for the drag disk instruments in subcooled flow are $\pm 19\%$ of reading over 10-100% of range; as a result, models using this instrument would have 2σ uncertainty bands greater than 19%.)

B.2.2.2 Transient two-phase flow uncertainty analysis. The application of the Kamath and Lahey transient two-phase turbine meter model to THTF test data is made in an attempt to assess the effects of slip, void fraction, flow regime, and transient response on the physical interpretation of the instrument output. Verification of the model in transient two-phase flow is not possible for the THTF due to the nature of the tests and system. The intent rather is to look at effects that are not accounted for in the simpler homogeneous flow models as they apply to THTF test conditions.

The turbine flowmeter model developed by Kamath and Lahey will be briefly described along with its assumptions and limitations. The computer solution technique and input parameters are also discussed.

The turbine flowmeter dynamic equation was derived from the principle of angular momentum conservation. The equation accounts for effects of nonuniformity of velocity and void profiles in conduit, imperfect guidance of the fluid by the rotor blades, rotor inertia, slip ratio, bearing friction, and windage losses. A detailed derivation of the equation of motion is presented in Ref. 3. The resulting equation of motion is shown below:

$$\begin{aligned}
 \frac{d\langle V_{Z\ell} \rangle}{dt} = & \langle |V_{Z\ell}| \rangle \frac{V_t}{(\Delta x)} - \langle V_{Z\ell} \rangle \frac{R_1}{(S + R_1)\rho_\ell} \frac{d\rho_\ell}{dt} + \frac{S}{(S + R_1)\rho_v} \frac{d\rho_v}{dt} \\
 & + \frac{S - R_2}{S + R_1} \frac{1}{\langle \alpha \rangle} \frac{d\langle \alpha \rangle}{dt} + \frac{1}{(S + R_1)} \frac{dS}{dt} - \frac{C_\ell R_1 + C_v S^2}{(S + R_1)(\Delta x)} \langle V_{Z\ell} \times |V_{Z\ell}| \rangle \\
 & + V_t \frac{R_1}{(S + R_1)} \frac{1}{\rho_\ell} \frac{d\rho_\ell}{dt} + \frac{S}{(S + R_1)} \frac{1}{\rho_v} \frac{d\rho_v}{dt} + \frac{1 - R_2}{S + R_1} \frac{1}{\langle \alpha \rangle} \frac{d\langle \alpha \rangle}{dt} \\
 & + \frac{dV_t}{dt} \frac{1 + R_1}{S + R_1} + \frac{I_{\text{rotor}}(1 + \eta_v)}{(S + R_1)R^2 A_{xs}(\Delta x)\rho_v \langle \alpha \rangle} \\
 & + \frac{\mu^{0.43} \rho_\ell^{0.57} |\omega|^{0.57} \omega (1 + \eta_v)}{(S + R_1)R A_{xs}(\Delta x) \tan \beta \rho_v \langle \alpha \rangle} [0.039(Ct_b N) R_T^{2.57} (R_b - R_T)^{-0.43} \\
 & + 0.078(L_{jb} R_S^{3.57}) \times (R_{h_1} - R_S)^{-0.43}] \quad (B.6)
 \end{aligned}$$

The angular brackets in the equation are cross-sectional average operators. The variables R_1 , R_2 , and V_t are defined by

$$R_1 = R_2 \frac{(1 - \alpha)}{\alpha}, \quad (B.7)$$

$$R_2 = \frac{\rho_l}{\rho_v} \frac{1 + \eta_v}{1 + \eta_l}, \quad (B.8)$$

and

$$V_t = \frac{\omega R}{\tan \beta}. \quad (B.9)$$

The variable definitions are listed in the nomenclature. Equation (B.6), a classical separated flow equation, is derived for arbitrary void fraction and velocity profiles by assuming that cross-sectional average products may be separated into products of averages using correlation coefficients. In this case the correlation coefficients C_l and C_v relate commonly measured values such as average cross-sectional void fraction (average density) and average cross-sectional velocity to void fraction and velocity profile weighted averages of the separate phase momentum flux. The correlation coefficients appearing in Eq. (B.6) are defined as

$$C_l = \frac{\langle (1 - \alpha) V_l^2 \rangle}{\langle 1 - \alpha \rangle \langle V_l \rangle^2} \quad (B.10)$$

and

$$C_v = \frac{\langle \alpha V_v^2 \rangle}{\langle \alpha \rangle \langle V_v \rangle^2} \quad (B.11)$$

for the liquid and vapor phases, respectively. These coefficients relate the net momentum flux to the mean velocities of the components and may assume different values for various flow regimes. The parameters are, in effect, adjustments to homogeneous model inputs for nonhomogeneous flow effects. The magnitude of the effect of these coefficients on the mass flux as applied to THTF test conditions will be discussed later.

The dynamic equation is solved using an IBM subroutine, CSMP III (Continuous System Modeling Program III), designed to solve a system of first-order differential equations with initial values.⁴ The subroutine is limited, however, to input parameters with analytical forms.

The main input to the program includes the turbine meter geometry, transient pressure, two-phase cross-sectional average density, and the turbine meter counting rate, which is proportional to the blade angular velocity. The turbine meter is a 5-bladed, 3.5-in. Flow Technology turbine meter. The gamma densitometer is a Measurements, Inc., three-beam densitometer. Discrete data are recorded during the transients by a DAS at 10-ms intervals. Analytical forms of the data were produced from the discrete data for input to the CSMP III program.

The equation for steady-state flow in a conduit may be obtained by setting all time derivatives to zero in Eq. (B.6). For steady-state model comparison, it is of interest to note that the steady-state model reduces to the Rouhani model⁵ under certain simplifying assumptions. If the correlation coefficient between void fraction and velocity profiles is unity (i.e., $C_\ell = C_v = 1$), the guidance of the fluid by the rotor blade is perfect ($\eta_\ell = \eta_v = 0$), and the drag torque is assumed negligible, then Eq. (B.6) may be further reduced to the Rouhani model equation,

$$\langle \alpha \rangle \rho_v \langle |V_v| \rangle (\langle V_v \rangle - V_t) = \langle 1 - \alpha \rangle \rho_\ell \langle |V_\ell| \rangle (V_t - \langle V_\ell \rangle) , \quad (\text{B.12})$$

which assumes a momentum balance between two phases on the turbine blades. Values of η_ℓ and η_v for the transient results that follow are assumed to be 0.2, a typical value for single-phase flow reported in Ref. 2. Parametric studies by Kamath and Lahey indicate very little difference between the 0.0 and 0.2 assumed values for η_ℓ and η_v . For the purposes of this analysis, a steady-state and transient model reference case is defined that assumes typical parameter values of $S = 1$, $C_\ell = 0.99$, $C_v = 1.06$, $\eta_\ell = 0.2$, and $\eta_v = 0.2$. Values of C_ℓ and C_v are from Ref. 3 where power law velocity and void profiles were assumed:

$$V_k = V_{c1k} (1 - r/R_o)^{1/n} \quad \text{for } n = 2-7 ,$$

and

$$\alpha = \alpha_{c1} (1 - r/R_o)^{1/m} \quad \text{for } m = 2-7 .$$

B.2.2.3 Transient two-phase solution. As stated earlier, the model incorporates the effects of rotor inertia, velocity and void profiles in the conduit, slip ratio, imperfect guidance of the fluid by the rotor blades, bearing friction, and windage losses. Of these parameters, the effects of the velocity and void profiles of the liquid phase, rotor inertia, and slip ratio were found to be the most significant for the transients of interest.

Transient model solutions were obtained from data from portions of two transient tests run at the THTF. Since reference mass flux information is not available under the transient conditions, the model results

are compared with a homogeneous mass flux model. The homogeneous mass flux is obtained from the product of the average mixture density as measured by the three-beam gamma densitometer and the average velocity as deduced from the volumetric flow measurement of the turbine meter (based on subcooled water calibration factors). Comparing the homogeneous, no slip model to the transient model will provide insight into the effects of nonhomogeneous flow for the THTF transient test conditions.

Figure B.32 shows the transient model reference case compared to the homogeneous model for the initial transient portion of Test 3.06.6B. Test 3.06.6B involved a relatively slow depressurization rate, and the observed transient peaks in mass flux for the two models appear to be in phase. The smoothed input for the transient model did not include the fine structure observed for the homogeneous model and as a result is not seen in the transient model results. Differences of ~30–40% are observed from 0.5 to 2.0 s into the transient and near the mass flux peak seen at ~3 s. From 5 s to the end of the transient period shown, the fine structure of the homogeneous model varies around that of the transient model. Figure B.33

Fig. B.32. Mass flux comparison of the transient and homogeneous models for Test 3.06.6B.

Fig. B.33. Effect of the correlation coefficient, C , on mass flux for Test 3.06.6B.

shows the effect of varying the liquid-phase distribution coefficient for the same test. The effects are considerable for higher mass flux but negligible for mass flux below $\sim 610 \text{ kg/m}^2 \cdot \text{s}$ ($125 \text{ lb}_m/\text{ft}^2 \cdot \text{s}$), with the magnitude of the mass flux increasing with decreasing C_l . It is difficult to characterize the appropriate value of C_l , especially during the initial voiding of the test section, since flow regimes may be varying considerably. Simple approximations for velocity and void profiles may yield values over the ranges indicated in Fig. B.33. A simple model for an annular flow regime results in a value of 1.35 when substituted into Eq. (B.10). A stratified flow in horizontal spool pieces may produce a value of 0.7. Flow with flat profiles both in void fraction and velocity generates a C_l of 1. Without experimental validation, however, values of C_l

obtained from simple models and applied to two-phase flow regimes, where velocity and void profiles are varying in time as well as space, may be misleading. It is of interest to note that for Test 3.06.6B, the important heat transfer data of interest is obtained from ~ 6 s to the end of the transient period shown. During this time, the effects of varying C_l are negligible. Also, during this period, the conditions in the upper test section bundle and outlet spool pieces were similar to those of the steady-state data discussed earlier.

The reference model case is compared with the homogeneous model for the faster transient of Test 3.05.5B in Fig. B.34. The reference model

Fig. B.34. Mass flux comparison of the transient and homogeneous models for Test 3.05.5B.

leads the homogeneous model by ~50 ms, presumably due to rotor inertia effects. The second peak agrees well temporally although the peak magnitude differs by ~25%. The two models do not agree very well for times shown after 1.25 s. Figure B.35 shows the effect of varying the slip ratio for the transient model for Test 3.05.5B. A change in slip ratio leads to a change in amplitude as well as temporal phase (the larger the slip ratio, the smaller the magnitude and the earlier the peak). The slip ratio of 5 is probably higher than would be expected under THTF test conditions, but the comparison shows the trends clearly.

Fig. B.35. Effect of slip ratio on mass flux for Test 3.05.5B.

An example of the relationship between the input data and the reference case transient model output is shown in Fig. B.36 for Test 3.05.5B. The curves for pressure (P), average mixture density (D), and counting rate (CR) are smoothed analytical forms of discrete data measured during the test. The void fraction (α) and mass flux (G) are generated by the model. The mass flux and turbine meter counting rate are seen to be intimately related as the impulse and response. The effect of rotor inertia is observed in the second peak where the counting rate of the turbine meter lags the model-predicted mass flux.

B.3 Summary

Mass flux uncertainties for subcooled flow using a turbine meter for volumetric flow measurements and a pressure- and temperature-deduced density are estimated at $\pm 4.22\%$ of reading (95% confidence bands).

Steady-state tests indicate two-phase flow uncertainty bands of less than $\pm 50\%$ of reading (95% confidence bands) for all models at the B01 spool piece where a three-beam densitometer is used in applicable models. The DD-GAM 3 and TBM-DD models actually show somewhat smaller uncertainty bands ($\pm 30\%$) than the TBM-GAM 3 model at the Bundle Outlet spool piece (B01). However, at the Vertical Outlet spool piece (SVO), uncertainty bands for the DD-GAM model (70%) and the TBM-DD model (140%) are significantly higher. The large uncertainties in models that use measurements from the drag disks are not particularly surprising from the standpoint of previous operating experience. The drag disks are the least reliable of the spool piece instruments in terms of repeatability and consistency of instrument response.

Significant uncertainty band increases result from using a single-beam densitometer as compared to using a three-beam densitometer. At the B01 spool piece for the turbine meter-densitometer model, the use of a single-beam densitometer results in an increase of uncertainty bands from $\pm 50\%$ (three-beam) to $\pm 80\%$ of reading. Similar results are observed for the drag disk-densitometer model, where the use of a single-beam densitometer adds an additional 10% of reading to the uncertainty bands.

The application of a transient turbine meter model to transient THTF test data provides insight into possible transient uncertainties included in turbine meter-densitometer models. Comparison of the Kamath and Lahey transient model with the homogeneous model TBM-GAM 3 indicates that the effects of the velocity and void profiles of the liquid phase, rotor inertia, and slip are the most significant for the THTF transients of interest.

During the initial transient portion of the Upflow Film Boiling Test (3.06.6B) and for mass flux greater than $\sim 610 \text{ kg/m}^2\text{s}$ ($125 \text{ lb}_m/\text{ft}^2\text{s}$), variations in the transient model mass flux of 30–50% are observed as the void and velocity profile correlation coefficient C_ℓ is varied from 1.0 over a range of 0.7–1.5. For the same test, when mass flux is less than $610 \text{ kg/m}^2\text{s}$ (the time period in which film boiling heat transfer data of interest are available), the effect of varying C_ℓ is negligible.

Increases in slip from 1.0 reduce the magnitude of the model mass flux and slow time response of the turbine meter.

Fig. B.36. Relationship between the input and output parameters of the transient model for Test 3.05.5B.

Rotor inertia effects are significant for fast transients such as the early portions of the Double-Ended Cold Leg Break Test (3.05.5B). The reference case transient model leads the homogeneous model by ~50 ms during portions of the transient, resulting in significant mass flux differences. Response time effects were not as significant for the slower transients of the Upflow Film Boiling Test (3.06.6B) although mass flux differences of 30-40% between the transient model reference case and the homogeneous model are observed.

Since the actual mass flux is not known for the transient cases, neither model may be verified. The model comparisons are able to provide test-specific information on mass flux sensitivity to uncertainties in two-phase flow parameters.

The Kamath and Lahey model results agreed well with the TBM-GAM 3 model for the Steady-State Upflow Film Boiling Test data. For this reason and because there is no additional information, in order to estimate uncertainties during the faster transient portions of the THTF tests the addition of the steady-state uncertainty estimates and the transient uncertainty estimates based on transient model comparisons to obtain a total transient uncertainty estimate would appear to be warranted. It should be noted that during the important periods of interest for the Transient Upflow Film Boiling Tests in terms of heat transfer data, the mass flux is changing fairly slowly. In addition, the outlet flow conditions of the Steady-State Upflow Film Boiling Tests were similar to the higher quality portions of the transient tests. Application of the steady-state uncertainty bands over these conditions can be made with a good degree of confidence.

Although the steady-state uncertainty data provide a good estimate of uncertainty bands over the flow conditions and parameter ranges observed for those steady-state tests, uncertainties for different quality ranges and flow regimes may be considerably different. Without data over other ranges, however, it is felt that these are the best available uncertainty estimates for use in two-phase flow conditions at the THTF. Table B.1 contains the mass flux uncertainties discussed in this appendix.

Table B.1. Mass flow errors^a

Steady state single phase

 $2\sigma = 4.22\%$ of reading

Horizontally mounted spool piece steady state two phase

DD-GAM 3, TBM-DD $2\sigma = 30\%$ of readingTBM-GAM 3 $2\sigma = 50\%$ of reading

Vertically mounted spool piece steady state two phase

DD-GAM $2\sigma = 70\%$ of readingTBM-DD $2\sigma = 140\%$ of readingTBM-GAM $2\sigma = 60\%$ of reading

Transient effects on two-phase flow

 $G > 610 \text{ kg/m}^2 \cdot \text{s}$ ($4.5 \times 10^5 \text{ lb}_m/\text{h} \cdot \text{ft}^2$) add extra 30-50% of reading $G < 610 \text{ kg/m}^2 \cdot \text{s}$ ($4.5 \times 10^5 \text{ lb}_m/\text{h} \cdot \text{ft}^2$) negligible effect

^a G	Mass flux
TBM	Turbine meter
GAM 3	Three-beam densitometer
DD	Drag disk
GAM	Single-beam densitometer

References

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4. *Continuous System Modeling Program III (CSMP III) Program Reference Manual*, SH19-7001-3, IBM (December 1975).
5. S. Rouhani, "Application of the Turbine Type Flow Meters in the Measurement of Steam Quality and Void," presented at the Symposium on In-Core Instrumentation, Oslo, June 15, 1964.

Nomenclature

A_{xs}	effective annular flow area through the blading
C	chord length of the blade
C_ℓ, C_v	correlation coefficients for the liquid (ℓ) and vapor (v) phases, respectively
G	mass flux
L_{jb}	length of the journal bearing
r	radius measured from conduit axis
R	effective radius of the rotor
R_b	radius of the meter shroud
R_o	conduit radius
R_{R_1}	bearing radius
R_s	journal radius
R_T	blade tip radius
S	slip ratio
t	time
t_b	blade thickness
V_{cl_k}	centerline velocity of phase k
V_k	velocity of phase k
V_t	turbine axial velocity
V_z	velocity of the liquid in the axial direction
α	void fraction
α_{cl}	void fraction at centerline
β	blade angle
η_ℓ, η_v	flow deviation factor for the liquid (ℓ) and vapor (v) phases, respectively
μ	dynamic viscosity of saturated liquid
ρ_ℓ, ρ_v	density of saturated liquid (ℓ) and vapor (v), respectively
ω	angular velocity of the rotor

Appendix C

ROD POWERS

Calculated rod power versus time is shown in Figs. C.1-C.60 for each of the electrically heated rods. Rods 19, 22, 36, and 46 are unheated. Section D.6 of Appendix D is devoted to discussion of rod power uncertainty. As shown in Sect. D.6 one standard deviation in power is 0.55% of reading.

Fig. C.1. Rod power vs time for rod 1.

Fig. C.2. Rod power vs time for rod 2.

Fig. C.3. Rod power vs time for rod 3.

Fig. C.4. Rod power vs time for rod 4.

Fig. C.5. Rod power vs time for rod 5.

Fig. C.6. Rod power vs time for rod 6.

Fig. C.7. Rod power vs time for rod 7.

Fig. C.8. Rod power vs time for rod 8.

Fig. C.9. Rod power vs time for rod 9.

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Fig. C.10. Rod power vs time for rod 10.

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Fig. C.11. Rod power vs time for rod 11.

Fig. C.12. Rod power vs time for rod 12.

Fig. C.13. Rod power vs time for rod 13.

Fig. C.14. Rod power vs time for rod 14.

Fig. C.15. Rod power vs time for rod 15.

Fig. C.16. Rod power vs time for rod 16.

Fig. C.17. Rod power vs time for rod 17.

Fig. C.18. Rod power vs time for rod 18.

Fig. C.19. Rod power vs time for rod 20.

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Fig. C.20. Rod power vs time for rod 21.

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Fig. C.21. Rod power vs time for rod 23.

Fig. C.22. Rod power vs time for rod 24.

Fig. C.23. Rod power vs time for rod 25.

ORNL-DWG 82-4781 ETD

Fig. C.24. Rod power vs time for rod 26.

ORNL-DWG 82-4782 ETD

Fig. C.25. Rod power vs time for rod 27.

ORNL-DWG 82-4783 ETD

Fig. C.26. Rod power vs time for rod 28.

ORNL-DWG 82-4784 ETD

Fig. C.27. Rod power vs time for rod 29.

ORNL-DWG 82-4786 ETD

Fig. C.28. Rod power vs time for rod 30.

ORNL-DWG 82-4786 ETD

Fig. C.29. Rod power vs time for rod 31.

ORNL-DWG 82-4787 ETD

Fig. C.30. Rod power vs time for rod 32.

ORNL-DWG 82-4788 ETD

Fig. C.31. Rod power vs time for rod 33.

Fig. C.32. Rod power vs time for rod 34.

Fig. C.33. Rod power vs time for rod 35.

ORNL-DWG 82-4791 ETD

Fig. C.34. Rod power vs time for rod 37.

ORNL-DWG 82-4792 ETD

Fig. C.35. Rod power vs time for rod 38.

ORNL-DWG 82-4793 ETD

Fig. C.36. Rod power vs time for rod 39.

ORNL-DWG 82-4794 ETD

Fig. C.37. Rod power vs time for rod 40.

ORNL-DWG 82-4796 ETD

Fig. C.38. Rod power vs time for rod 41.

ORNL-DWG 82-4796 ETD

Fig. C.39. Rod power vs time for rod 42.

ORNL-DWG 82-4797 ETD

Fig. C.40. Rod power vs time for rod 43.

ORNL-DWG 82-4798 ETD

Fig. C.41. Rod power vs time for rod 44.

ORNL-DWG 82-4799 ETD

Fig. C.42. Rod power vs time for rod 45.

ORNL-DWG 82-4800 ETD

Fig. C.43. Rod power vs time for rod 47.

Fig. C.44. Rod power vs time for rod 48.

Fig. C.45. Rod power vs time for rod 49.

ORNL-DWG 82-4803 ETD

Fig. C.46. Rod power vs time for rod 50.

ORNL-DWG 82-4804 ETD

Fig. C.47. Rod power vs time for rod 51.

ORNL-DWG 82-4806 ETD

Fig. C.48. Rod power vs time for rod 52.

ORNL-DWG 82-4806 ETD

Fig. C.49. Rod power vs time for rod 53.

ORNL-DWG 82-4807 ETD

Fig. C.50. Rod power vs time for rod 54.

ORNL-DWG 82-4808 ETD

Fig. C.51. Rod power vs time for rod 55.

ORNL-DWG 82-4809 ETD

Fig. C.52. Rod power vs time for rod 56.

ORNL-DWG 82-4810 ETD

Fig. C.53. Rod power vs time for rod 57.

ORNL-DWG 82-4811 ETD

Fig. C.54. Rod power vs time for rod 58.

ORNL-DWG 82-4812 ETD

Fig. C.55. Rod power vs time for rod 59.

Fig. C.56. Rod power vs time for rod 60.

Fig. C.57. Rod power vs time for rod 61.

ORNL-DWG 82-4815 ETD

Fig. C.58. Rod power vs time for rod 62.

ORNL-DWG 82-4816 ETD

Fig. C.59. Rod power vs time for rod 63.

Fig. C.60. Rod power vs time for rod 64.

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Appendix D

INSTRUMENT UNCERTAINTY ANALYSIS FOR THE THTF LOOP

Summary of Results

Two standard deviation uncertainty bands are described for critical instrumentation in the Thermal Hydraulic Test Facility (THTF). The analyzed instruments and their minimum, steady-state, 2σ error bands [root sum square (RSS), 95% confidence interval] include:

1. Turbine flowmeter	4.1% reading
2. Gamma densitometer	10.4% FS*
3. Strain gage pressure cell	1.0% FS*
4. Differential pressure cell	2.0% FS* min to 9.9% FS* max
5. Thermocouples	3.7°C min to 10.3°C max
6. Rod power instrumentation	1.1% reading
7. Strain gage drag disk	56% reading below 10% FS* 19% reading above 10% FS*

Summary of Theory

The measure of the value of a group of n data points (x_i) with statistical significance is the mean ($\bar{x}$) or expected value given by

$$\bar{x} = \sum \frac{x_i}{n}, \quad (D.1)$$

where Σ is the usual sum from data point 1 to data point n . The standard measure of the dispersion of the data is the variance [σ^2 or $V(x)$] defined by

$$\sigma^2 = \sum \frac{(x_i - \bar{x})^2}{n}. \quad (D.2)$$

However, $V(x)$ has dimensions of engineering units squared, which may be inconvenient. The square root of $V(x)$, the standard deviation (σ), is usually reported. Furthermore, in normally distributed data with mean $\bar{x}$ and variance σ^2 (a good approximation for much variation in physical data),

*Full-scale values are found in Tables D.5-D.8 under instrument range.

statistical inferences may be drawn in terms of probabilities based on the measured values of $\bar{x}$ and σ as follows:

68% probability that $\bar{x} - \sigma < x_t < \bar{x} + \sigma$,

95% probability that $\bar{x} - 2\sigma < x_t < \bar{x} + 2\sigma$,

and

99.7% probability that $\bar{x} - 3\sigma < x_t < \bar{x} + 3\sigma$,

where x_t is the true value of the variable.

Brownlee has shown¹ that the variance of a linear function

$$Z = A_0 + A_1 X_1 + A_2 X_2 = \dots A_n X_n$$

is a linear function of the variance of the variables as long as the correlation coefficients are zero, i.e., as long as they are physically unrelated. (Linearly independent variables have zero correlation coefficients, but linear independence is not a requirement.) That is,

$$V(Z) = A_1 V(X_1) + A_2 V(X_2) + \dots A_n V(X_n), \quad (D.3)$$

where the A_i 's are constants and the X_i 's are independent variables.

Similarly, Scarborough has shown² that an analogous relation holds for a system where the independent variables are not linear:

$$Z = F(Y_1, Y_2, \dots, Y_n).$$

The variance of Z is given by

$$V(Z) = \left(\frac{\partial Z}{\partial Y_1} \right)^2 V(Y_1) + \left(\frac{\partial Z}{\partial Y_2} \right)^2 V(Y_2) + \dots + \left(\frac{\partial Z}{\partial Y_n} \right)^2 V(Y_n), \quad (D.4)$$

where the correlation coefficients of the Y_i 's are zero and the value of $V(Y)$ is small compared to $(\partial Z / \partial Y_i)^2$. Notice that in situations where the standard deviation can be expressed legitimately as a percentage of the value of $\partial Z / \partial Y_i$, Eq. (D.4) can be rewritten as

$$\sigma\%(Z) = \sqrt{(\sigma\%Y_1)^2 + (\sigma\%Y_2)^2 + \dots + (\sigma\%Y_n)^2}. \quad (D.5)$$

The above equations can best be understood through the use of an illustrative example. Consider the amplifier of Fig. D.1. The uncertainty in the input voltage can be derived from the function $V_{in} = F(V_{out}, V_{offset}, GAIN)$, given the measured values for V_{out} , $V(V_{out})$, V_{offset} , $V(V_{offset})$, and $GAIN$, $V(GAIN)$, when V_{in} is the input voltage, $GAIN$ is the amplifier gain, and V_{offset} is the offset voltage.

Assuming the following data, the value of V_{in} is given by

$$V_{in} = \frac{V_{out} - V_{offset}}{GAIN},$$

and the variance in the input voltage can be found by applying Eq. (D.4) or (D.5):

$$V(V_{in}) = \frac{V(V_{out})}{GAIN^2} + \frac{V(V_{offset})}{GAIN^2} + \frac{V(GAIN) (V_{offset} - V_{out})^2}{GAIN^4}, \quad (D.6)$$

where

$$V_{out \text{ max}} = 20.0 \text{ volts},$$

$$V_{out} = 10.0 \text{ volts},$$

$$V(V_{out}) = (0.2 \text{ volts})^2 = (2\%)^2 \text{ reading},$$

$$V_{offset} = 0.5 \text{ volts},$$

$$V(V_{offset}) = (0.05 \text{ volts})^2 = (0.5\%)^2 \text{ reading},$$

$$GAIN = 200 \text{ volts/volt},$$

$$V(GAIN) = (1 \text{ volt/volt})^2 = (0.5\%)^2 \text{ reading},$$

$$V_{in} = \frac{(10.0 \text{ volts} - 0.5 \text{ volts})}{200} = 0.0475 \text{ volts},$$

Fig. D.1. Amplifier.

$$V(V_{in}) = \frac{(0.2)^2}{(200)^2} + \frac{(0.05)^2}{(200)^2} + 1^2 \frac{(-9.5)^2}{(200)^4}$$

and

$$\sigma(V_{in}) = 10^{-3} \text{ volts or } 2.1\% \text{ reading .}$$

Because V_{in} is a function of V_{out} , V_{offset} , and GAIN in the form given above, it is reasonable to assume that stating the variances as percentages of the readings is equivalent to stating the variances as percentages of the respective partial differentials. In fact, this will always be reasonable as long as the variables are of the first order. The arithmetic for computing $\sigma(V_{in})$ becomes simply

$$\sigma(V_{in}) = \sqrt{(2\%)^2 + (0.5\%)^2 + (0.5\%)^2} = 2.1\% \text{ reading .}$$

Equation (D.4) or (D.5) applied to each major component of a complex information loop is often the only method available to arrive at an uncertainty value. However, in the case of the gamma densitometer and the strain gage pressure cell, in situ standards are available that allow direct measurement of the uncertainty. Heise gages are used as in situ standards for strain gage pressure cells. Pressure and temperature measurements in subcooled water can be used to determine density with steam tables for comparison with the gamma densitometers. Such a comparison is made using a linear regression analysis based on the method of Gauss.

The equation of a line in slope-intercept form is given by

$$y = Ax + B ,$$

where A is the slope ($\Delta y/\Delta x$) and B is the value of the y intercept.

The best-fit values of A and B can be found by minimizing the sum of the distances between the experimentally determined points and the best-fit line.

The pertinent equations are

$$A = \frac{\sum x_i \sum y_i - n \sum (x_i y_i)}{(\sum x_i)^2 - n \sum (x_i)^2} \quad (D.7)$$

and

$$B = \frac{\sum (x_i y_i) \sum x_i - \sum y_i \sum (x_i)^2}{(\sum x_i)^2 - n \sum (x_i)^2} , \quad (D.8)$$

where the x_i 's are the values determined by the instrument under discussion and the y_i 's are the corresponding values determined by the in situ standard. The uncertainty of the instrument values can then be defined analogously to Eq. (D.2):

$$\sigma = \sqrt{\sum \frac{(Y_i - y_i)^2}{n}}, \quad (D.9)$$

where the Y_i 's are computed from the best-fit equation and the instrument values are y_i . A perfectly calibrated and properly operating instrument will have $A = 1.0$, $B = 0$, and $\sigma \ll \text{reading}$.

Although the slope-intercept form of an equation is one of the easiest to interpret, it does have a disadvantage: A and B are not linearly independent variables, so drawing statistical inferences about A and B in terms of their variances is hindered. A solution to this problem is to solve for the best-fit line equation in the form

$$Y = \alpha(x - \bar{x}) + \beta. \quad (D.10)$$

The variances of α and β are then known to be

$$V(\alpha) = \frac{\sigma^2}{n} \quad (D.11)$$

and

$$V(\beta) = \frac{\sigma^2}{\sum (x_i - \bar{x})^2}, \quad (D.12)$$

as shown by Brownlee,³ where σ is defined as in Eq. (D.9). We can still arrive at an estimate of $V(A)$ and $V(B)$ by modifying Eq. (D.10) to show

$$Y = \alpha x - \alpha \bar{x} + \beta,$$

which implies $a = A$ and $B = (-\alpha \bar{x} + \beta)$. Applying Eq. (D.4) yields

$$V(A) = \frac{\sigma^2}{n} \quad (D.13)$$

and

$$V(B) = \frac{\sigma^2}{n} \bar{x}^2 + \frac{\sigma^2}{\sum (x_i - \bar{x})^2} = \sigma^2 \frac{x^2}{n} + \frac{1}{\sum (x_i - x)^2} \quad (D.14)$$

Equations (D.2)-(D.5) and (D.9) should be applied with caution for several reasons.

Definitions for variance assume perfect knowledge. However, actual sampling procedures are limited to finite sample sizes, and formulas impose limits on the degrees of freedom by imposing constraints. To adjust for the limits to the number of degrees of freedom, Eq. (D.2) is modified to provide an estimator for the standard deviation denoted S such that

$$S = \sqrt{\frac{\sum (x_i - \bar{x})^2}{(n - 1)}} \quad (D.15)$$

Equation (D.9) becomes

$$S = \sqrt{\frac{\sum (Y_i - y_i)^2}{(n - 2)}} \quad (D.16)$$

Equations (D.15) and (D.16) are the proper equations to use in all sampling situations where the standard deviation is to be used as the measure of the uncertainty. Furthermore, the value for S should be substituted for the value of σ and S^2 for $V(X)$ or $V(Y)$ in each of the other equations where σ appears. Because of the common association between the standard deviation defined by Eqs. (D.15) and (D.16) with the symbol σ , the symbol σ will be used for S in the balance of this report. In a practical sense, where the standard deviation is reported as two significant figures, there is essentially no difference between σ and S [Eqs. (D.4) and (D.9) versus Eqs. (D.15) and (D.16)] as long as the number of data points is large.

A class of practical problems that arises in the actual error analysis is centered around the interpretation placed on uncertainties supplied by manufacturers. These uncertainties are often supplied as percentages in such a manner that it is difficult to determine whether it is reasonable to apply Eq. (D.5). Either it is difficult to determine how the stated error relates to the standard deviation, or it is difficult to determine whether the error can be applied as a percentage of the partial differentials required by Eq. (D.5). Furthermore, it is seldom stated whether the given uncertainties meet the required criterion of zero correlation coefficient. It is common for manufacturers to quote error bands as 2σ (95% confidence) or 3σ (99% confidence) though sometimes without assigning confidence limits. In this report it is conservatively assumed

that the error reported by instrument manufacturers is 2σ . Unless otherwise stated, it is also assumed that a statement of error as a percent with respect to the partial differentials of Eq. (D.5) is reasonable and that the correlation coefficient is zero for all variables.

The second class of problems relating to the uncertainty analysis dealt with multiple estimates of σ for a class of instruments where σ varied widely from instrument-to-instrument and from trial-to-trial. The method of choice was to use a value of σ large enough to include about 95% of the measured values. This was accomplished by using

$$\sigma \approx \bar{\sigma} + \sigma(\sigma) .$$

That is, the value of the standard deviation used was the average value for all instruments and files read plus one standard deviation of σ . This is different from the probability statements above because σ is a span that includes zero to σ . Such a distribution cannot be normal in the sense that the probability statements require.

A generalized procedure for data analysis follows:

A common form for a large system is generalized in Fig. D.2. This system consists of a number of transducers (T_i), their associated signal conditioning equipment (S_i), and the data acquisition system (DAS). The DAS is understood to include both the hardware and the software. The standard deviations of the output signals are measured by reading the information from the magnetic tape written by the DAS and applying Eq. (D.2) or D.14) over an arbitrary length of time where the process is defined as being in a steady state. The measured value of the DAS output can then be incorporated with other measures of uncertainty using Eq. (D.5). If an in situ standard is going to be used to develop the total uncertainty directly, the data for the secondary standard need to be accessed and correlated in time and space with the instruments under consideration.

The development of software to perform the above estimates may be the most time-consuming part of the analysis. The software has to be able to perform the following functions for a magnetic-tape-based system:

1. Confirm that the tape is at the beginning.
2. Confirm that the tape density and number of tracks are system compatible.
3. Locate the instrument data base (IDB) and transfer the IDB to disk or core in a rapid access format.
4. Extract certain system constants from the IDB (record length, etc.).
5. Locate the scan table.

Fig. D.2. Generalized form for a large system.

6. Use the scan table and instrument identifier code to determine the location of the desired instrument data in data records.
7. Locate the first data file of the type desired.
8. Read a fixed number of records from the data file.
9. Store data in arrays or keep running totals for averaging.
10. Compute averages and standard deviations for steady-state data in the file.
11. Write the desired combinations of data, averages, and standard deviations to arrays.
12. Locate the next data file of the type desired and repeat steps 8-12 until end-of-tape is detected.
13. At end-of-tape, write the arrays to disk for later analysis.
14. At each tape operation, check for proper positioning.
15. Analyze data written to disk as required.

The following sections provide a detailed analysis of the critical instrumentation in the THTF loop. As stated above, the exact nature of the uncertainties is not always known. The RSS value of the uncertainty is the statistically defined one if variables are unrelated (correlation coefficient = 0) and the percentage uncertainty is given as a percent of partials required for Eq. (D.5). However, to the extent that the uncertainties stated do not comply with the assumptions, the more conservative strict sum of errors may need to be applied. Both the RSS value and the strict sum value are given in the text. The RSS values are reported in tabular form at the end of this Appendix. The superscript (*) is used to denote manufacturer derived data.

D.1 Turbine Flowmeter

The turbine flowmeter channel consists of a turbine flowmeter with integral magnetic pickup, an electronics package that conditions the signal to provide an output voltage proportional to flow rate, and the DAS, which converts the analog signal in volts to digital information and writes it onto magnetic tape. In operation, the turbine blade generates an electrical pulse as it passes the magnetic pickup. The ORNL electronics package senses this pulse and with 250 μ s resets the count registers and begins accumulating the count until the next pulse disables the count. During the disabled period the count is passed to the digital-to-analog converter where it is converted to millivolt reading. The voltage divider then inverts the millivolt signal and outputs a voltage proportional to the angular velocity of the turbine blade, with 10-V full scale (FS) corresponding to 1200-Hz input signal from the flowmeter pickup. The DAS then converts the output of the ORNL electronics to a digital value and writes it onto magnetic tape. The identified sources of error in the turbine flowmeter are:

Channel noise (blade angle tolerance)	3.2%
Calibration uncertainty	2.4%
Inherent turbine linearity*	0.5%
ORNL electronics package	0.4%

A/D conversion at DAS*	0.3%
Effect of bearing change each run*	0.3%
Strict sum, 2σ error band	7.1%
RSS, 2σ error band	4.1%

The following items need to be considered when applying the above error bands to THTF data:

1. The above uncertainties are all reasonably expressed as a percent of reading. However, the value of turbine linearity quoted applies only over the range 10% rated FS through 100% rated FS. Below 10% rated FS, error bands increase rapidly (see Fig. D.3) as frictional drag becomes more significant, with a cutoff of useful information occurring near 6% of rated FS flow due to signal-to-noise problems in the electronics.

2. Random noise was measured for 30 records of data taken during Reactor Simulation Test 3.05.5B. When the standard deviation was computed for each of the 10 flowmeters without excessive channel noise, the average value (1.53% of reading) was found to agree very well with the predicted channel noise because of blade manufacturing tolerances ($72^\circ \pm 1.56\%$). It would be optimistic, however, to conclude that this is the only source of random error. Data taken over a much wider range of flows would be needed to confirm this conclusion.

3. The calibration uncertainty was estimated from two different calibration laboratories (Flow Technology, Inc., and Measurements, Inc.) independently calibrating the same turbine flowmeters. The results of those calibrations indicated approximately 1.2% (as 1σ) differences from laboratory-to-laboratory. The supposed calibration uncertainty according to the laboratories was an order of magnitude smaller based on their NBS traceability standards. The reasons for the large difference were never

Fig. D.3. Error due to turbine linearity: characteristic curve.

satisfactorily determined. This comment applies solely to turbine meters located at the SVO, SVI, SHI, and SHO spool pieces.

4. The most troublesome problems of interpreting flowmeter error are those that occur during two-phase flow. In a 1977 report⁴ MPA Associates, Inc., investigated the possible errors due to slug flow, annular flow regimes, steam-water ratios, and differential two-phase velocities. This investigation was strictly theoretical, based on momentum exchange between the blade and the fluid. These analyses were based on steady-state flow, balancing the transverse momentum of one phase against that of the second. Assuming no net momentum exchange with the rotor, the turbine response was interpreted in light of the point effective radius (established as the calibration constant) in the presence of two phases with different flow regimes and different velocity profiles. The conclusion reached was that errors up to $\pm 25\%$ might be expected.

By assuming equal probabilities for the parameters investigated, it was determined that a 1σ error band of 10% might reasonably be expected. However, until experimental verification of both model and results can be obtained, it would only be prudent to use the above figures in a qualitative manner.

D.2 Gamma Densitometer

The gamma densitometers consist of a nearly monoenergetic ^{137}Cs gamma source, an ionization chamber to detect the gamma rays, an instrument amplifier, and the DAS. In use, the gamma rays pass through the steel pipe, through the water (in whatever phase) in the pipe, and into the ionization chamber. In the ionization chamber the gamma rays are converted into an electric current such that the current is proportional to the intensity of the impinging gamma rays. The instrument amplifier takes this current and converts it into a voltage that is proportional to the input current. At the DAS the voltage is converted to a digital value and stored on magnetic tape.

Given that the source approximates a point source, the density of the water (ρ_w) in the pipe should be given by

$$\rho_w = \text{KFACTR} \ln \left(\frac{V_p - V_o}{V - V_o} \right),$$

where KFACTR is an experimentally determined constant that includes the effect of pipe diameter and the mass absorption coefficient of the water (including any dissolved salts), V_p is the output voltage when the pipe is empty, V_o is the output voltage with the source shielded (dark voltage or zero offset), and V is the output voltage when there is water in the pipe.

Due to the strong theoretical dependence of density error as a function of density, the 1σ error band was investigated as a statistical function of the density reading compared to an in situ standard based on the physical properties of the water in the pipe under known conditions of

temperature and pressure and a steady-state, one-phase flow. Ten gamma densitometers in service during Test 3.05.5B were used as a basis of the study. The output voltage of each instrument was sampled 150 times in each of ten 3-s files. The output voltage was then used to compute the water density using values of $KFACTR$, V_p , and V_o measured in a recent calibration run. Those densities were then compared to the expected densities based on water properties derived from the temperature and pressure instruments located adjacent to each gamma densitometer.

The measured uncertainty expressed as 1σ in kg/m^3 (and lb/ft^3) is shown in Table D.1. It was discovered, however, that at least part of the large variation in the uncertainties resulted from a systematic error that varied from instrument to instrument (see Fig. D.4, where the densitometer density is plotted against the water property density for DE-204B). Furthermore, the expected strong dependence of error on total density is not obvious over the range of data compared. Not all densitometers showed positive deviations from the standard as did DE-204B.

Table D.1. Absolute error analysis

Densitometer	σ (kg/m^3)	σ (lb/ft^3)
DE-20	18.9	1.18
DE-36	199.0	12.42
DE-168	3.6	0.22
DE-218	87.5	5.46
DE-204A	4.4	0.27
DE-204B	57.7	3.60
DE-204C	33.6	2.10
DE-262A ^a		
DE-262B	22.9	1.43
DE-262C	37.5	2.34
Average	52.0	3.20

^aProbable equipment failure during test.

The data for each densitometer were fit to a straight line, densitometer calculated density to water property density, using linear regression analysis. The random error, expressed as 1σ , was then calculated for each gamma densitometer using Eq. (D.16), but Y_i is the best average value from the linear regression equation. The value of uncertainty was much more uniform from densitometer to densitometer (see Table D.2). A preliminary analysis of the calibration procedure indicates that it may be possible to recalibrate the densitometers analytically to remove the systematic error. Since the analysis performed on the experimental data does not use the

Fig. D.4. Typical densitometer calibration.

Table D.2. Least-squares best-fit line
($RHO = A \times DERHO + B$)

Densitometer	A	B	σ (kg/m ³)	σ (lb/ft ³)
DE-20	0.945	64.9	8.6	0.54
DE-36	0.131	745.0	9.7	0.61
DE-168	1.000	-0.4	0.9	0.06
DE-218	0.711	176.0	2.5	0.16
DE-204A	0.981	14.0	4.4	0.27
DE-204B	1.190	-85.9	6.0	0.37
DE-204C	1.010	24.8	12.4	0.77
DE-262A ^a				
DE-262B	0.740	246.0	5.3	0.33
DE-262C	1.160	-100.0	4.5	0.28
Average			5.8	0.36

^aProbable equipment failure during test.

densitometer responses, it was not deemed worthwhile to expend the effort required to perform this recalibration.

Since the density of water at room temperature is approximately $1 \times 10^{-3} \text{ kg/m}^3$ (62.4 lb/ft³), the above results can be summarized as follows:

2 σ error band under current operating procedures 10.4% FS

The following items need to be considered when applying the above error bands to THTF data analysis:

1. An analysis of data scatter indicates an average σ of 31 kg/m³ or 3.1% FS over 150 point data files. Therefore, individual points within a file have much higher uncertainties than those stated for files as a whole.

2. No other factor has been identified which would degrade the error bands beyond the steady-state, one-phase flow values listed above. However, it should be understood that the densities computed from densitometer voltages during transients and two-phase flow are time-and-path averaged values. Furthermore, a direct application of the above data to transient, two-phase flow is done at the risk of the data user until experimental verification can be obtained.

D.3 Strain Gage Pressure Cells

The pressure channel investigated consists of a strain gage pressure cell, an instrument amplifier, and the DAS. In operation, pressure on the diaphragm of the pressure cell causes a change of resistance in the foil strain gages attached to the diaphragm. The change in resistance in the gages causes a voltage output from the cell that is proportional to the applied pressure. This output is amplified by the instrument amplifier. The DAS converts the amplifier output to digital format and writes it onto magnetic tape.

The following errors were identified as contributing to the pressure cell uncertainty:

Nonlinearity (P-sensor)*	0.3% FS
Repeatability (P-sensor)*	0.1% FS
Hysteresis (P-sensor)*	0.1% FS
Tempco, gage factor (P-sensor)*	0.5% Reading
Tempco, zero offset (P-sensor)*	0.5% FS
Gain instability (instrument amplifier)* ...	0.1% Reading
Output offset (instrument amplifier)*	0.1% FS
DAS calibration*	0.3% Reading
Location of calibration standards	0.4% FS
Strict sum 2 σ error band	2.5% FS
RSS 2 σ error band	1.0% FS

The following items need to be considered when applying the above error bands to THTF data:

It is fairly obvious that the results of the in situ calibration run (see item 2 below) agree respectably with the 2σ error band determined above. The probable reason that in situ calibration errors are smaller than the theoretically determined value can be attributed primarily to smaller than estimated temperature changes in actual operation for both gages and amplifiers. In the absence of contradictory experimental evidence, the 2σ error band for the strain gage pressure cells should be set at 1.0% FS or 200 kPa (29 psi).

1. The temperature effects were assumed to be operable over a range of only 56°C (100°F) in actual use. This seems like a reasonable assumption since the sensors themselves are installed at the end of a connecting tube ensuring cooling by ambient air flow and the instrument amplifier is mounted where ambient air flow should keep the temperature change within the 56°C (100°F) range. Channel noise was measured during Test 3.05.5B using Y_i [see Eq. (D.16)] as the average within a data file. Five instruments were sampled with 30 points per data file, 10 data files each. The 1σ value measured in this manner was quite variable, so that it was deemed expedient to select a value of σ large enough to include about 95% of the data.

2. The strain gage pressure cell does have a usable in situ standard for comparison. With data from a recent pressure cell calibration run, the standard deviation for system pressure was determined for six strain gage pressure instruments by comparing P-cell output converted to pressure using the measured calibration constants with the average reading of two Heise bourdon tube gages accurate to 20 kPa (3 psi). The results of that comparison are:

Instrument	σ (kPa)	σ (psi)	σ (% FS)
PE-26	37.2	5.4	0.18
PE-42	66.2	9.6	0.32
PE-44	18.6	2.7	0.09
PE-76	43.4	6.3	0.21
PE-106	47.6	6.9	0.23
PE-156	91.0	13.2	0.44
Average	51.0	7.4	0.24
Plus location of calibration standard	40.0	5.8	0.18
Total 2σ value	130.0	18.9	0.6

3. The in situ calibration uses the average reading of two Heise gages as system pressure. These gages may be separated by 8.53 m (26 ft) vertically. The result of the difference in static water pressure can produce an offset of ~ 40 kPa (5.8 psi) (1σ) depending on the location of the specific instrument.

4. The DAS seems to be the limiting factor in instrument response time, including the response time of the transducer itself since pressure waves should reach the diaphragm much faster than the normal sample rate. No other source of error has been identified to degrade the error band established for steady-state, one-phase flow. However, the application of the above error bands to transient or two-phase flow without corroborating data might be overly optimistic, and any such use is the responsibility of the data user.

D.4 Differential Pressure (dp) Cells

The strain gage dp cell (A, B, C) instruments are very similar to the strain gage pressure cells above, except that they have lower full-scale capability.

- A. The identified sources of error in the BLH strain gage (1380 and 6870 kPa or 200 and 1000 psi, respectively) dp cell are

Bench calibration (note 1)	2.4% FS
Tempco, gage factor (P-sensor)*	0.1% FS
Tempco, zero offset (P-sensor)*	0.1% FS
Gain instability (instrument amplifier)* ...	0.1% FS
Output offset (instrument amplifier)*	0.1% FS
A/D inaccuracy (DAS)*	0.3% FS
Random noise (note 2)	2.0% FS
Strict sum 2σ error band	5.1% FS
RMS 2σ error band	3.1% FS

- B. The identified sources of error in the BLH strain gage (1380 kPa or 200 psi) (pit) dp cell are

Bench calibration (note 1)	2.4% FS
Tempco, gage factor (P-sensor)*	0.5% Reading
Tempco, zero offset (P-sensor)*	0.5% FS
Gain instability (instrument amplifier)* ...	0.1% Reading
Output offset (instrument amplifier)*	0.1% FS
A/D inaccuracy (DAS)*	0.3% Reading
Random noise (note 2)	9.6% FS
Strict sum 2σ error band	13.5% FS
RMS 2σ error band	9.9% FS

- C. The identified sources of error in the GENISCO (41 kPa or 6 psi) strain gage dp cell

Static pressure offset	2.6% FS
Zero balance*	2.0% FS
Linearity, hysteresis*	0.4% FS
Tempco, sensitivity*	0.3% FS
Tempco, zero offset*	0.3% FS
Noise (note 1)	2.0% FS

A/D conversion DAS*	0.3% FS
Strict sum 2 σ error band	7.9% FS
RSS 2 σ error band	3.9% FS

D. The identified sources of error in the ITT Barton (25 kPa or 100 in.) dp cell are

Transduction accuracy*	0.25% FS
Static pressure effect*	0.4% FS
Tempco, zero offset*	0.2% FS
Tempco, sensitivity*	0.2% FS
Noise	2.0% FS
DAS*	0.3% FS
Strict sum 2 σ error band	3.4% FS
RSS 2 σ error band	2.1% FS

E. The identified sources of error in the Rosemount Capacitance dp cell are (see note 4)

	6.2 and 7.4 kPa (25 and 30 in.)	37 and 50 kPa (150 and 200 in.)
Transduction accuracy	0.25% FS	0.25% FS
Tempco, combined*	0.95% FS	0.14% FS
Static pressure offset	1.0% FS	1.0% FS
Stability*	0.25% FS	0.25% FS
Noise	0.2% FS	0.2% FS
DAS*	0.3% FS	0.3% FS
Strict sum 2 σ error band	3.0% FS	2.1% FS
RSS 2 σ error band	1.5% FS	1.1% FS

F. The identified sources of error in the FOXBORO force balance dp cell are

Transduction accuracy*	0.25% FS
Noise	2.0% FS
DAS	0.3% FS
Strict sum 2 σ error band	2.6% FS
RSS 2 σ error band	2.0% FS

The following items need to be considered in evaluating the above 2 σ error bands:

1. Bench calibration data were substituted for the values of nonlinearity, repeatability, and hysteresis since bench data were available and indicated significantly larger error bands for strain gage. The dp sensors in use show a dependence on system pressure for both gain and offset (see Figs. D.5 and D.6). The approach has been to use a calibration equation based on a linear regression calibration of both gain and zero offset in the form

$$P_{dp} = (P_{Ag} + B_g)[V - (P_{Az} + B_z)] ,$$

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Fig. D.5. Sensitivity calibration.

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Fig. D.6. Zero offset calibration.

where P_{dp} is the differential pressure measured by the dp cell; A_g , B_g , A_z , and B_z are the calibration coefficients; V is the sensor output voltage; and P is the system pressure. However, the linear correlation of system pressure and constants A_g , B_g , A_z , and B_z is not high enough to make the correlation better than 1.2% (as 1σ) overall.

2. When the error band was checked using digital data from Reactor Simulation Test 3.05.5B, an average value of σ equivalent to 1.0% FS was measured using 13 PDE's in service prior to blowdown. The average output was used as the standard.

3. When the strain gage dp cells are used as pit dp cells, they are connected to different parts of the system by long lines of small diameter tubing. Analysis of Test 101 showed that resonant ringing could account for an increase in the noise level (as 1σ) to 4.8% FS just prior to blowdown and up to 65% FS after blowdown when the 28-Hz (the measured resonant frequency) notch filter is used as a standard (see Fig. D.7).

4. An in situ calibration was made during steady-state scans for the Small Break LOCA II tests of October and November 1980. The uncertainty estimate used water properties as a basis of known differential pressure. The results indicated an average 1σ uncertainty of ± 0.05 kPa (0.2 in.) (0.8% FS).

5. Temperature coefficients were applied over a range of 15°C (27°F).

6. No parameter was identified that would degrade error bands beyond those listed above during two-phase flow. However, extension of the stated error bands to two-phase flow or transient conditions without supporting experimental evidence is done at the data user's risk.

Fig. D.7. PDE-200 output from Test 101.

D.5 Thermocouple Temperature Instruments

The thermocouple instruments consist of Chromel-Alumel thermocouples, a "cold-junction" reference box, and the DAS.

The following error sources were identified for thermocouple instruments:

	Minimum value		Above 350°C (660°F)
	(°C)	(°F)	
Thermocouple material*	2.2	4.0	0.76%
Random noise	0.5	1.0	
DAS calibration	1.8	3.2	0.46%
Reference junction calibration	2.2	4.0	2.2°C (4.0°F)
Reference junction controller	0.16	0.3	0.16°F (0.3°F)
Strict sum 2σ error band	6.9	12.4	(See below)
RSS 2σ error band	3.7	6.7	(See below)

Conversion of the above percentage values to degrees centigrade above 350°C (660°F) results in the following:

Temperature		2σ Error band		2σ Error band	
(°C)	(°F)	(°C)	(°F)	strict sum	
				(°C)	(°F)
350	662	3.7	6.7	7.4	13.3
400	752	4.2	7.6	8.3	14.9
450	842	4.7	8.5	9.1	16.4
500	932	5.1	9.2	10.0	18.0
550	1022	5.6	10.1	10.8	19.4
600	1112	6.1	11.0	11.7	21.1
650	1202	6.6	11.9	12.5	22.5
700	1292	7.1	12.8	13.4	24.1
750	1382	7.6	13.7	14.2	25.6
800	1472	8.0	14.4	15.1	27.8
850	1562	8.5	15.3	15.9	28.6
900	1652	9.0	16.2	16.8	30.2

The following items need to be considered when applying the above error band estimates to THTF data:

1. The reference junction box calibration error was determined by analyzing long-term calibration data from February 4, 1976, to February 10, 1981, and includes any offset from the mean set-point value of 2.666 mV. Reference junction box anomalies were discovered during a 7-day steady-state period. Controller errors up to 0.08°C (0.14°F) were observed for periods of approximately 1-h duration. Operating four units continuously over 7 days, the average error was determined to be less than 0.006°C (0.01°F).

2. Random noise was determined by analyzing the data from Reactor Simulation Test 3.05.5B for five Type Code = 6 and nine Type Code = 1 thermocouples in operation during that test for steady-state, one-phase flow conditions. Because of considerable scatter from instrument-to-instrument and file-to-file, a value of σ large enough to include approximately 95% of all data was chosen. In an effort to provide a conservative estimate, it was assumed that the noise at higher temperatures would be proportional to the millivolt signal above 350°C (660°F).

3. Data Acquisition System calibration was checked after a test calibration with the voltage output compared with a 32.0-mV input signal.

4. A thermocouple that had been in service at the THTF facility was analyzed by R. L. Anderson⁵ of the I&C standards lab to determine the effect of nickel crystal reordering. The results indicate that errors from 1.2°C (2.2°F) [near 150°C (300°F)] to 16.3°C (29.3°F) [near 900°C (1650°F)] may be expected in addition to the above values. However, the recent history of a specific thermocouple coupled with its end-to-end temperature gradient makes it difficult to extrapolate to all THTF thermocouples. The effect of crystal reordering would be to produce readings higher than actually experienced at the junction.

5. An isothermal scan taken during Test 3.06.6B was used to compare the output of 615 thermocouples believed to be operational. The measured standard (2σ) deviation of 4.0°C (7.2°F) agrees closely with the RSS estimated value of 3.7°C (6.7°F) (2σ).

D.6 Rod Power Instrumentation

The rod power instrumentation consists of two operational amplifiers, a calibrated low resistance shunt, and the DAS (see Fig. D.8). Amplifier 1 reads the voltage across the rod itself. V_1 is the output from the voltage divider. Amplifier 2 reads the voltage across the shunt. The current in the rod is then inferred using Ohm's law such that

$$I = V_2 / R_s ,$$

where I is the current in amps, V_2 is the potential across the shunt in volts, and R_s is the resistance of the shunt in ohms.

The following items were identified as probable sources of error when determining rod power:

R_s	Calibration inaccuracy*	0.26% Reading
R_s	Temperature coefficient*	0.2% Reading
V_2	Nonlinearity*	0.01% Reading
V_2	Channel noise	0.72% Reading
V_2	Tempco, gain*	0.02% Reading
V_2	Tempco, offset*	0.03% FS

ROD POWER SCHEMATIC

Fig. D.8. Rod power schematic.

V_2	DAS calibration inaccuracy*	0.30% Reading
V_1	Nonlinearity*	0.01% Reading
V_1	Channel noise	0.7% Reading
V_1	Tempco, gain*	0.02% Reading
V_1	Tempco, offset*	0.03% Reading
V_1	DAS calibration inaccuracy*	0.30% Reading
	Strict sum 2σ error band	2.6% Reading
	RSS sum 2σ error band	1.1% Reading

The following items need to be considered when applying the above error bands to THTF rod power data:

1. Temperature changes at the amplifiers were assumed to be less than or equal to 20°C (36°F). The temperature changes at the shunt were assumed to be less than or equal to 40°C (72°F). The temperature changes

chosen may be excessively large resulting in larger than necessary error bands.

2. Power determined using IV (amps times volts) above does not always agree well with an I^2R (amps squared times rod resistance) power calculation. No adequate explanation for the difference is known. Since both methods should yield the same value of power to the rods, actual error bands may be larger than stated.

3. No error source was identified that would degrade the steady-state, 2σ error band beyond those listed above.

4. Because of matched voltage divider temperature coefficients and the current calibration procedures, the error contributed by the voltage dividers is considered negligible. However, channel noise was measured at low power, so that the values used might be unnecessarily conservative. Furthermore, the resistance of the shunt is very much less than the rod, so that the voltage drop across the rod is essentially unaffected by the shunt.

D.7 Strain Gage Drag Disks

An analysis of steady-state, single-phase drag disk uncertainties based on subcooled flow calibrations from four THTF tests is presented. The data are from pretest drag disk calibrations performed on the same day of the test during heatup to blowdown conditions for Tests 3.04.7, 3.05.5B, 3.06.6B, and 3.08.6C.

The drag disks are calibrated using the turbine flowmeters (velocity, V) and pressure- and temperature-deduced density (ρ) to obtain an in situ standard momentum flux $[(\rho V^2)_{std}]$. A calibration equation is generated from a least-squares fit to the drag disk signal corresponding to the momentum flux over a range of momentum fluxes. The measured momentum flux $[(\rho V^2)_{meas}]$ is obtained by applying the calibration equation to the instrument signal. The calibration equation takes the form:

$$(\rho V^2)_{meas} = A(IS - Z)^E,$$

where IS is the instrument signal in millivolts and A , Z , and E are calibration parameters determined by the least-squares fit. The value of E is generally near 1.0.

An estimate of the uncertainty in the drag disk instrument is made by comparing the in situ standard to the instrument-measured momentum flux. The errors are formulated in terms of percent of actual momentum flux, which is approximately equivalent to percent of reading. For each data point, the percent error is calculated from

$$\% \text{ error} = \frac{(\rho V^2)_{std} - (\rho V^2)_{meas}}{(\rho V^2)_{std}}.$$

Two different drag disk instrument ranges and two different geometries (2-in. and 4-in. spool piece configurations) resulted in three different instrument measurement ranges. It was observed that values of σ for the three different types of drag disks (target and geometry) agree well with each other. It would appear reasonable to combine the data for all three types and to report average uncertainties. However, separate uncertainty estimates are made for instrument signals below 10% of maximum range due to a pronounced temperature effect that is especially noticeable at the lower readings. This effect is caused by the strain gage elements being in intimate contact with the fluid. The value of Z is the average of values taken at two different temperatures. The attempted temperature compensation is not very accurate at low signal values.

The resulting uncertainty bands for strain gage drag disks are:

2 σ error band below 10% FS		56% reading
2 σ error band above 10% FS		19% reading

The following items need to be considered when applying the above error bands to THTF data:

1. Percentage error estimates for the drag disks were compared with the subcooled data immediately preceding blowdown for the tests from which the calibration data were obtained. Average error values of 9.2% of readings (1σ) above 10% FS and 30% of readings (1σ) below 10% FS tend to support the uncertainty bands derived from calibration runs.

2. The strain gage transducer elements are exposed to the temperature environment of the loop. Temperatures significantly outside of the temperature range used during calibration will degrade the accuracy of the instrument further, especially below 10% FS.

D.8 Transient Response and Transient Errors

It is generally understood that no instrument responds infinitely fast to changes in the physical parameters being measured. That is, if the environment were to change suddenly from 200 arbitrary units to 400 arbitrary units, an instrument would initially read some value near 200 units and would approach a reading of 400 units asymptotically. A good approximation for many instruments is first-order lag (see Fig. D.9) defined by

$$V_r = V_o + (1 - e^{-T/\tau})(V_f - V_o) .$$

That is, the value indicated by the instrument (V_r) is equal to the original value (V_o) plus the value of the step function ($V_f - V_o$) multiplied by an exponential delay factor, where T is the elapsed time and τ is the 63.2% instrument response time, and V_f is the final value of the step function. Instrument error as a function of time would be represented by the area between V_f and the instrument reading line.

Fig. D.9. Instrument reading as a function of response time assuming first-order lag.

An additional problem in the THTF uncertainty analysis is introduced because the signal is sampled over discrete time intervals instead of continuously. It may be difficult to identify the exact starting point of a step function. If the step change in physical parameter occurs very near in time to the DAS sample (relative to the instrument response time), the instrument reading at that point will be in error by the total value of the change. If the DAS samples five or more response times after the step function, less than a one percent error (expressed as percent of the step function) will result.

Some arbitrariness is required, therefore, to provide a consistent definition of transient error. The method chosen was to assume that the step function occurred midway between two DAS sampling intervals (n and $n + 1$ in Fig. D.10). The error is measured at each sample point as the distance in engineering units between the modeled instrument reading and the assumed final value of the physical parameter V_f (vertical dashed lines in Fig. D.10). The uncertainty is expressed as the average of all the errors observed during an averaging interval (typically, 150 or 500 ms). The size of the step function and the length of the averaging interval were chosen with test conditions in mind.

As an example, let us consider the errors in the reading of a gamma densitometer (Sect. D.2) as a function of time. The response time on the ionization chamber is estimated at 16 ms. Assuming that the observed density decreases instantly from 750 kg/m (46.8 lb/ft) to 0 (a worst-case, blowdown situation), the errors observed at the DAS and the average error for a 100-ms averaging interval reported are shown in Table D.3.

The following items need to be considered when applying transient uncertainty values in the appendices to THTF data:

1. Although first-order lag modeling is appropriate for most instruments, it is at best a close approximation to the true instrument response.

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Fig. D.10. Instrument error as a function of DAS sampling assuming first-order lag.

Table D.3

DAS interval $n + 1n =$ 0.01 s	Error (kg/m ³)	Error (lb/ft ³)
1	549	34.2
2	249	18.3
3	157	9.8
4	84	5.3
5	45	2.8
6	24	1.5
7	13	0.8
8	7	0.4
9	4	0.2
10	2	0.1
Average	118	7.4

2. The instrument response times are estimates. When these estimates are known from averages, the standard deviation is large, indicating wide variation from instrument-to-instrument. As a result, a particularly slow instrument of a given type might show errors a factor of 2 or more worse than the average would indicate.

3. The average uncertainty values noted in the tables are extremely sensitive to the averaging interval chosen. Average errors that appear insignificant over a 500-ms averaging interval may well become significant over a 150-ms interval. A careful analysis of Table D.3 is illustrative in this light.

4. Step functions were chosen that were thought to be either representative or worst-case possibilities on a test-by-test basis. It is possible, however, that steps more severe than those chosen may have occurred.

D.9 General Comments

1. All of the above error bands were derived assuming that the specified instrument was in nominal working condition and had been recently calibrated using normal THTF calibration techniques. The error bands will not apply to defective instruments.

2. The error bands stated apply only to those items covered in the above discussion. Although every attempt has been made for the examination to be exhaustive and for the results to be conservatively stated, there is always the possibility that excessive instrument noise or out-of-spec components will cause actual readings to be outside of the given error limits (stated as 2σ).

3. The error bands given herein represent the experimenter's best judgment of the applicable uncertainties. Two points should be noted, however. First, the estimation of transient contributions to the uncertainty involves a number of assumptions and judgments. These have been documented in Sect. D.8, and the steady-state and transient contributions to the uncertainty have been listed separately in the tables to facilitate the reader who wishes to use his own estimates of the transient contribution to uncertainty if he chooses. Second, most of the data available on specific sources of instrument errors were obtained in single-phase flow. Thus, the experimenters had to rely primarily on engineering judgment to combine and extrapolate this data to two-phase flow. In most cases there is no experimental, two-phase flow data that can be used to verify the resulting uncertainty estimates.

D.10 Steady-State and Transient Instrument Uncertainties

Table D.4 provides a cross reference for instrument application numbers (IAN) and type codes. The first column provides the type code as an integer between 1 and 113, the second column lists the form of the IAN, and the "Remarks" column provides additional information to properly correlate type code to IAN for all instruments.

Table D.4. Type Code - Instrument Application Number Table

Type Code	I.A.N	Remarks
1	TE-3nnal	Special FRS Sheath Thermocouples [0.38 mm//0.015 inch] nn = 01, 14, 17, 21, 34, 37, 38, 50, 54, or 60 a = A, E, or F 1 = 1, 2, 3, 4, 5, 6, 7, 8; or E, F, or G
1	TE-3nnal	Regular FRS Sheath Thermocouples [0.51 mm//0.020 inch] nn = 01-64 (except 19,22,36,46) and (excluding 01, 14, 17, 21, 34, 37, 38, 50, 54, 60 for tests 3.06.6B, 3.08.6C, 3.07.9, 3.09.10I-X and Mothball) a = A, B, or C 1 = A, B, C, D, E, F, G, H, U, or Y
2	TE-3nnMl	Special FRS Middle Thermocouples [0.38 mm//0.015 inch] nn = 01, 14, 17, 21, 34, 37, 38, 50, 54, or 60 M = M 1 = 1, 2, 3, 4, 5, 6, 7, 8; or E, F, or G
2	TE-3nnMl	Regular FRS Middle Thermocouples [0.51 mm//0.020 inch] nn = 01-64 (except 19, 22, 36, 46) and (excluding 01, 14, 17, 21, 34, 37, 38, 50, 54, 60 for tests 3.06.6B, 3.08.6C, 3.07.9, 3.09.10I-X and Mothball) M = M 1 = A, B, C, D, E, F, or G
3	TE-12nn	Subchannel Thermocouples nn = 01-81
4	TE-18na	Shroud Wall Thermocouples n = 1, 2, 3, 4, 5, 6, or 7 a = N, E, S, or W
5	TE-xxx	Miscellaneous and Process Thermocouples xxx = 5B, 408B, 520B, 521, 901, 920, 921, 922, 923, 924, 925, 926, 927, or 936
6	TE-xxx	Loop and Process Thermocouples xxx = 1, 2, 6, 24, 29, 40, 45, 57, 62, 67, 116, 150, 151, 152, 153, 172, 208, 212, 222, 228, 256, 266, 281, 282, 284
7	TE-29na	Spacer Grid Thermocouples n = 1, 2, 3, 4, 5, or 6 a = A, B, C, D, E, or F

Table D.4 (continued)

Type Code	I.A.N	Remarks
8	TE-18na1	Array Rod Thermocouples n = 8 or 9 a = A or B 1 = A, B, C, D, E, F, or G
9	TE-361-aJ	O-ring Area Thermocouples a = A, B, or C J = J
10	TE-nab	Shroud Box Thermocouples n = 0, 1, 2, 3, 4, 5, 6, 7, 8, or 9 a = A or B b = E or S
23	PE-xxx	Strain Gage Pressure Cells [20700 kPa//3000 psi] xxx = 15, 16, 26, 27, 42, 43, 44, 58, 63, 68, 76, 88, 106, 118, 156, 174, 201, 209, 224, 258, 268, 276, 281, 282, 283, 286, 425, 427, 454, 474
24	PE-32	Force Balance Pressure Cell [both ranges]
25	PE-102	Strain Gage Pressure Cell [1380 kPa//200 psi]
26	PDE-xxx	Strain Gage dP Cell [$\pm$ 1380 kPa// $\pm$ 200 psi] xxx = 35, 46, 167, 217 21 except for tests 3.09.10I-X and 3.10.10 60 except for test 3.05.5B
27	PDE-78	Strain Gage dP Cell [$\pm$ 6900 kPa//1000 psi]
28	PDE-xxx	Strain Gage dP cell [$\pm$ 345 kPa// $\pm$ 50 psi] xxx = 7, 53, 65, 111, 203 21 only for tests 3.09.10I-X and 3.10.10 60 only for test 3.05.5B 200 except for 3.02.10C-H and Mothball 251 except for 3.02.10C-H and 3.09.10I-X
29	PE-nnn	Strain Gage Pressure Cell [2400 kPa//350 psi] nnn = 526 or 616
31	EIE-13nn	FRS Heater Rod Currents nn = 01-64 (excluding 19, 22, 36, 46)
32	EIE-xx	Generator Currents xx = 9, 10, 11, 12

Table D.4 (continued)

Type Code	I.A.N	Remarks
33	EEE-xx	Generator Voltage xx = 9, 10, 11, 12
34	EWE-77A	Primary Pump Power
35	FMFE-xxxx	Momentum Flux Flow (Drag Disk) [9 cm//3.5 inch spool piece] xxx = 22, 38, 170, 220 206 except for 3.09.10I-X 254, 264 only for 3.05.5B
36	SE-72	Primary Pump Speed
37	XE-430a	Break Wire Detector a = A or B
40	FMFE-xxx	Momentum Flux Flow (Drag Disk) [5 cm//2 inch spool piece] xxx = 14, 55, 61, 66, 114, 154, 155 206 only for 3.09.10I-X 254, 264 except for 3.04.5B
41	PDE-200	Strain Gage dP Cell [± 25 kPa// ± 100 inches water] only for tests 3.02.10C-H
42	PDE-204 PDE-261	Strain Gage dP Cell [± 125 kPa// ± 500 inches water] only for test 3.05.5B except for 3.08.6C, 3.07.9, 3.09.10I-X, and Mothball
43	PDE-nnn	Strain Gage dP Cell [± 41 kPa// ± 6 psi] nnn = 199, 271 204 except for 3.05.5B 251 only for 2.02.10C-H 261 only for 3.08.6C, 3.07.9, 3.09.10I-X, Mothball
50	LE-14nn	Experimental INEL Level Prone nn = 01 through 19
71	TE-28B	Linearized Resistance Thermometer Device
75	PDE-nnn	Capacitive dP Cell nnn = 180 through 188 189 except on 3.09.10I-X and Mothball set at 0-6.2 kPa (0-30 inches) except for 3.05.5B set at 0-37.5 kPa (0-150 inches) only for 3.05.5B

Table D.4 (continued)

Type Code	I.A.N	Remarks
76	ZE-336U ZE-346L	Inbundle Gamma Densitometer Position Indicator except for 3.09.10I-X and Mothball
77	ZE-346L	Inbundle Gamma Densitometer Position Indicator only for 3.09.10I-X and Mothball
78	PDE-251	Capacitance dP Cell [25 kPa//100 inches] only for 3.09.10I-X
79	PDE-200	Capacitance dP Cell [50 kPa//200 inches] only for Mothball
80	PDE-189	Capacitance dP Cell [7.5 kPa//30 inches] only for 3.09.10I-X and Mothball
95	FE-nnn	Turbine Flowmeter-Heat Exchanger Secondary Flow nnn = 522, 620, 720
96	FE-550	Turbine Flowmeter-Heat Exchanger Secondary Flow
97	PDE-48	Force Balance dP Cell [166 kPa//24 psi]
98	PDE-30	Force Balance dp Cell [345 kPa//50 psi]
99	TDE-28	Differential Temperature
105	PDE-761 LE-100	Force Balance dP Cell
106	DE-xxx	Single Beam Gamma Densitometer xxx = 20, 36, 168, 218 Triple Beam Gamma Densitometer xxx = 204A, 204B, 204C, 252A, 252B, 252C, 262A, 262B, 262C
107	FE-xxx	Orifice Place/Force Balance Flowmeter xxx = 1A [0-5.0E-2 m ³ /s or 0-800 gpm] 238 [0-1.0E-4 m ³ /s or 0-1.6 gpm] only 3.09.10I-X Orifice Place/Capacitance Flowmeter xxx = 282 [0-2.5E-3 m ³ /s or 0-39.3 gpm] 283 [0-3.3E-4 m ³ /s or 0-5.2 gpm] 927 [0-1.4E-4 m ³ /s or 0-2.1 gpm]

Table D.4 (continued)

Type Code	I.A.N	Remarks
108	FE-18A	Orifice Plate/Force Balance Flowmeter [4.4E-2 m ³ /s or 700 gpm] except for 3.01.10C-H, 3.09.10I-X and Mothball
	FE-18A	[1.7E-4 m ³ /s or 2.7 gpm] only for 3.01.10C-H, 3.09.10I-X and Mothball
	FE-238	except for 3.09.10I-X
109	FE-xxx	Instrument Spool Piece Turbine Flowmeter [3E-4 m ³ /s or 5 gpm] xxx = 250, 260 only for tests 3.01.10C-H, 3.09.10I-X, and Mothball [6E-4 m ³ /s or 10 gpm] xxx = 232, 280 [1.4E-2 m ³ /s or 225 gpm] xxx = 3, 51, 59, 64, 110, [1.4E-2 m ³ /s or 225 gpm] xxx = 250, 260 except for 3.01.10C-H, 3.05.5B, 3.09.10I-X, and Mothball [1.4E-2 m ³ /s or 225 gpm] xxx = 202 only for tests 3.01.10C-H, 3.09.10I-X [6E-2 m ³ /s or 1000 gpm] xxx = 19,34,166,216,440,460 [6E-2 m ³ /s or 1000 gpm] xxx = 250, 260 for 3.05.5B [6E-2 m ³ /s or 1000 gpm] xxx = 202 except for tests 3.01.10C-H, 3.09.10I-X
110	TE-xxx	Resistance Thermometer Device xxx = 4B, 101, 210A, 525, 557, 615, 627, 727
111	DE-xxx	Inbundle Gamma Densitometer xxx = 336U, 346L
112	FE-238	Orifice Plate/Force Balance Flowmeter same as type code 107 FE-238
113	LE-760	Force Balance dP Cell

Tables D.5-D.8 provide a summary listing of steady-state and transient error bands by test. Tables D.5 and D.7 have values stated in SI units. Table D.6 is the English unit version of Table D.5; Table D.8 is the English unit version of Table D.7. Nominal step function refers to a step size that is characteristic of transient phenomena that occur during the period when film boiling data are analyzed (from 4 to 17 s). Extreme step functions apply to severe transient phenomena outside the period where film boiling data are being used.

The first column in each table gives a brief instrument description. The second column provides the instrument type code. (Use Table D.4 to cross reference to IANs.) The third column provides the nominal instrument range. The fourth and fifth columns give the steady-state and transient error bands, respectively. The sixth and seventh columns provide the estimated response time and step function values used to estimate the transient uncertainty value.

The English version tables are intended for reference only. Exact correspondence of entries will be limited by significant figure rounding.

The values quoted for both steady-state and transient errors are estimates based on several assumptions. It is the responsibility of the data user to ascertain the appropriateness of these assumptions when using the included error bands for THTF data analysis.

References

1. K. A. Brownlee, *Statistical Theory and Methodology in Science and Engineering*, p. 80, John Wiley and Sons, Inc., New York, 1965.
2. J. B. Scarborough, *Numerical Mathematical Analysis*, 3rd Ed., p. 429, The John Hopkins Press, Baltimore, 1955.
3. K. A. Brownlee, *Statistical Theory and Methodology in Science and Engineering*, p. 340, John Wiley and Sons, Inc., New York, 1965.
4. Unpublished report, *Summary Two and Three Dimensional Analysis of Turbine Flowmeter Response in Two-Phase Flow*, MPR Associates, Inc. (October 11, 1977).
5. Internal memo from R. L. Anderson, I&C Division ORNL, to B. J. Veazie, *Error in BDHT Thermocouple*, June 18, 1980.

Table D.5. Test 3.06.6B

THTF Instrument Error Bands						
Instrument Description	Type Code	Instrument Range	Steady State Error	Transient Error	Estimated Response Time	Assumed Value of Step Fm.
Rod Sheath Thermocouple 0.38 mm OD	1	273 K 1309 K	3.7K < 623 K 10.3 K	0.8 K ^a	7 ms	300 K
Rod Sheath Thermocouple 0.51 mm OD	1	273 K 1309 K	3.7K < 623 K 10.3 K	3.8 K ^a	12 ms	300 K
Rod Middle Thermocouple 0.36 mm OD	2	273 K 1309 K	3.7K < 623 K 10.3 K	0.8 K ^a	7 ms	300 K
Rod Middle Thermocouple 0.51 mm OD	2	273 K 1309 K	3.7K < 623 K 10.3 K	3.8 K ^a	12 ms	300 K
Bundle Subcnn Thermocouple 1.02 mm OD	3	273 K 1309 K	3.7K < 623 K 10.3 K	2.7 K	140 ms	10 K
Shroud Box Thermocouple 1.57 mm OD	4	273 K 1309 K	3.7K < 623 K 10.3 K	5.3 K	350 ms	10 K
System Thermocouple 3.2 mm OD	5	273 K 1309 K	3.7K < 623 K 10.3 K	7.6 K	870 ms	10 K
System (Nannac) Thermocouple 6.4 mm OD	6	273 K 1309 K	3.7K < 623 K 10.3 K	0.3 K	18 ms	10 K
Spacer Grid Thermocouple 1.02 mm OD	7	273 K 1309 K	3.7K < 623 K 10.3 K	2.7 K	140 ms	10 K
Array Rod Thermocouple 1.02 mm OD	8	273 K 1309 K	3.7K < 623 K 10.3 K	2.7 K	140 ms	10 K

Table D.5 (continued)

THTF Instrument Error Bands						
Instrument Description	Type Code	Instrument Range	Steady State Error	Transient Error	Estimated Response Time	Assumed Value of Step Fn.
Rod Sheath Thermocouple 0.51 mm OD	9	273 K 1309 K	3.7K < 623 K 10.3 K	3.8 K ^a	12 ms	300 K
Shroud Box Thermocouple 1.57 mm OD	10	273 K 1309 K	3.7K < 623 K 10.3 K	5.3 K	350 ms	10 K
Strain Gage Pressure Cell	23	20700 kPa	200 kPa	N.S. ^j	0.16 ms	200 kPa
Force Balance Pressure Cell	24	3400 kPa 17000 kPa	100 kPa	157 kPa	300 ms	200 kPa
Force Balance Pressure Cell	24	3400 kPa 27000 kPa	160 kPa	157 kPa	300 ms	200 kPa
Strain Gage Pressure Cell	25	1380 kPa	17 kPa	N.S.	0.32 ms	200 kPa
Strain Gage D.P. Cell	26	+1380 kPa	43 kPa	N.S.	0.32 ms	200 kPa
Strain Gage D.P. Cell	27	+6900 kPa	210 kPa	N.S.	0.32 ms	1.7 kPa
Strain Gage ^g D.P. Cell	28	+345 kPa	11 kPa	N.S.	0.32 ms	1.7 kPa
Strain Gage Pressure Cell	29	2400 kPa	24 kPa	N.S.	0.16 ms	200 kPa
Rod Heater Current	31	800 amp	0.85% Rdg	4.7 amp	50 ms	15 amp
Generator Current	32	1000 amp	0.85% Rdg	32 amp	50 ms	100 amp
Generator Voltage	33	300 volt	0.76% Rdg	3.8 volt	50 ms	12 volt

Table D.5 (continued)

THTF Instrument Error Bands						
Instrument Description	Type Code	Instrument Range	Steady State Error	Transient Error	Estimated Response Time	Assumed Value of Step Fn.
Primary Pump Power	34	750 kW	greater of 0.5 kW or 0.3% Rdg	6.3 kW	150 ms	10 kW
Strain Gage Drag Disk	35	$\pm 0.1E5$ kg/ms ² $\pm 1.0E5$ kg/ms ²	56% Rdg 19% Rdg	157 kg/ms ²	16 ms	150 kg/ms
Primary Pump Speed	36	100 rpm 5400 rpm	20 rpm	13 rpm	150 ms	20 rpm
Breakwire Detector	37	5 volt	30 ms	N.A. ^k	20 ms	N.A.
Strain Gage Drag Disk	40	$\pm 0.3E4$ kg/ms ² $\pm 3.0E4$ kg/ms ²	56% Rdg 17% Rdg	47 kg/ms ²	16 ms	1500 kg/ms ²
Strain Gage D.P. Cell	41	± 25 kPa	0.8 kPa	N.S.	0.32 ms	1.7 kPa
Strain Gage D.P. Cell	42	± 125 kPa	4 kPa	N.S.	0.32 ms	1.7 kPa
Strain Gage D.P. Cell	43	± 41 kPa	2 kPa	N.S.	0.32 ms	1.7 kPa
Level ⁱ Indicator	50	± 10 volt	***	***	***	***
RTD	71	273 K 700 K	1.1 K 2.7 K	9.9 K	10 sec	10 K
Capacitive D.P. Cell	75	6.2 kPa	0.1 kPa	0.15 kPa	131 ms	0.25 kPa
Capacitive D.P. Cell	75	37.5 kPa	0.4 kPa	0.11 kPa	74 ms	0.25 kPa
Position Indicator	76	3.92 m	0.5% Rdg	N.A.	N.A.	N.A.
Position Indicator	77	3.33 m	0.5% Rdg	N.A.	N.A.	N.A.

Table D.5 (continued)

THTF Instrument Error Bands						
Instrument Description	Type Code	Instrument Range	Steady State Error	Transient Error	Estimated Response Time	Assumed Value of Step Fn.
Capacitive D.P. Cell	78	25 kPa	1.3 kPa	0.9 kPa	110 ms	1.7 kPa
Capacitive D.P. Cell	79	50 kPa	0.5 kPa	0.7 kPa	68 ms	1.7 kPa
Capacitive D.P. Cell	80	7.5 kPa	0.1 kPa	0.15 kPa	125 ms	0.25 kPa
Turbine ^f Flowmeter	95	0.9E-3 m ³ /s 9.5E-3 m ³ /s	4.1% Rdg	1.3E-4 m ³ /s	11 ms 1.2 ms	6.3E-4 m ³ /s
Turbine ^f Flowmeter	96	0.3E-3 m ³ /s 3.2E-3 m ³ /s	4.1% Rdg	1.3E-4 m ³ /s	8 ms 1 ms	6.3E-4 m ³ /s
Force Balance D.P. Cell	97	166 kPa	1 kPa	1.3 kPa	300 ms	1.7 kPa
Capacitive D.P. Cell	98	345 kPa	0.1 kPa	0.4 kPa	38 ms	1.7 kPa
Differential Temperature	99	228 K 283 K	3.8 K	9.9 K	10 sec	10 K
Liquid Level	105	3.81 m	0.023 m	0.16 m	300 ms	0.2 m
Liquid Level	105	1408 m	8 .5 m	0.16 m	300 ms	0.2 m
Gamma Densitometer	106	1000 kg/m ³	104 kg/m ³	5 kg/m ³	16 ms	50 kg/m ³
Orifice ^c Flowmeter	107	1.0E-4 m ³ /s	2.5E-6 m ³ /s	7.9E-6 m ³ /s	300 ms	1E-5 m ³ /s
Orifice ^c Flowmeter	107	1.35E-4 m ³ /s	3.4E-6 m ³ /s	1.1E-5 m ³ /s	300 ms	1.4E-5 m ³ /s
Orifice ^c Flowmeter	107	3.32E-4 m ³ /s	8.3E-6 m ³ /s	2.6E-5 m ³ /s	300 ms	3.3E-5 m ³ /s

Table D.5 (continued)

THIF Instrument Error Bands						
Instrument Description	Type Code	Instrument Range	Steady State Error	Transient Error	Estimated Response Time	Assumed Value of Step Fn.
Orifice ^c Flowmeter	107	2.48E-3 m ³ /s	6.2E-5 m ³ /s	2.0E-4 m ³ /s	300 ms	2.5E-4 m ³ /s
Orifice ^c Flowmeter	107	5.0E-2 m ³ /s	1.3E-3 m ³ /s	3.9E-3 m ³ /s	300 ms	5E-3 m ³ /s
Orifice ^d Flowmeter	108	1.7E-4 m ³ /s	4.2E-6 m ³ /s	1.3E-5 m ³ /s	300 ms	1.7E-5 m ³ /s
Orifice ^e Flowmeter	108	4.4E-2 m ³ /s	1.1E-3 m ³ /s	3.5E-3 m ³ /s	300 ms	4.4E-3 m ³ /s
Turbine ^{f,h} Flowmeter	109	$\pm 0.3E-4$ m ³ /s $\pm 3.0E-4$ m ³ /s	4.1% Rdg	3.1E-6 m ³ /s	8 ms 1 ms	1.5E-4 m ³ /s
Turbine ^{f,h,b} Flowmeter	109	$\pm 0.6E-4$ m ³ /s $\pm 6.1E-4$ m ³ /s	2.5% Rdg	N.A.	8 ms 1 ms	N.A.
Turbine ^{f,h,l} Flowmeter	109	$\pm 1.3E-3$ m ³ /s $\pm 1.4E-2$ m ³ /s	4.1% Rdg	1.3E-4 m ³ /s	13 ms 2 ms	6.3E-4 m ³ /s
Turbine ^{f,h,l} Flowmeter	109	$\pm 0.6E-2$ m ³ /s $\pm 6.1E-2$ m ³ /s	4.1% Rdg	1.3E-4 m ³ /s	18 ms 2 ms	1.3E-3 m ³ /s
RTD	110	273 K 700 K	1.1 K 2.7 K	9.9 K	10 sec	10 K
Inbundle Gamma Densitometer	111	1000 kg/m ³	104 kg/m ³	5 kg/m ³	16 ms	50 kg/m ³
Orifice ^c Flowmeter	112	1.0E-4 m ³ /s	2.5E-6 m ³ /s	7.9E-6 m ³ /s	300 ms	1E-5 m ³ /s
Liquid Level	113	1.18 m	0.007 m	0.16 m	300 ms	0.20 m

Table D.5 (continued)

Documentation of Steady-State and Transient Error Bands

Steady-State Error Bands: Two-standard deviations compared to in-situ standard or twice the root-sum-square of uncertainties, whichever is applicable.

Transient Error Bands: Assuming first-order lag function, response times (TAU), and step function ($V_f - V_o$) indicated—the average error seen by the DAS assuming the step function occurred midway between DAS samples. The averaging interval is 500 ms for thermocouples and 150 ms for all other instruments.

Total Error: The total error due to steady state error and transient error is the sum of the steady state and transient error bands.

Footnotes:

- a. Error bands apply to the environment as sensed at the surface of the thermocouple sheath. Larger errors may occur when data is modelled to provide temperatures at other points. Transient response is estimated by using the response time (25 ms or less) prior to swaging the sheath (0.71 mm swaged to 0.51 mm OD), then scaling using the rule: response time is inversely proportional to the outside diameter squared (OD**2 scaling). An additional 7% improvement in response time was allowed for packing of the boron nitride during swaging. The smaller thermocouples (0.51 mm swaged to 0.38 mm OD) were estimated from the values of the larger thermocouples by first scaling the 25 ms response time to the unswaged 0.51 mm diameter using OD**2 scaling, then applying OD**2 scaling and the 7% improvement for packing to the swaged 0.38 mm OD.
- b. This instrument is fitted with Flow Technology electronics that time 10-blade passings. Averaging improves the steady-state error bands but degrades transient response.
- c. Range applies specifically to instruments calibrated in subcooled liquid at a density of 1000 kg/m**3.
- d. Range applies specifically to instruments calibrated in subcooled liquid at a density of 860 kg/m**3.
- e. Range applies specifically to instruments calibrated in subcooled liquid at a density of 750 kg/m**3.
- f. Error bands apply specifically to instruments calibrated in subcooled liquid. Extended range electronics provide readings out to 0.227 m³/s for the 8.89E-2 meter diameter models; 0.028 m³/s for the 5.08E-2 meter diameter models, but the error bands apply only to 150% of nominal maximum range.
- g. Strain gage D.P. Cells used as pit cells are connected to different segments of the test section by long lines. These long lines induce resonant oscillations in the instrument that increase the steady-state errors bands to 35 kPa, and the transient error bands to 400 kPa.
- h. The turbine flowmeters (type code 109) have a flow range such that:
 $-3.0E-4 < \text{Flow} < 0.3E-4$.OR. $0.3E-4 < \text{Flow} < 3.0E-4$,
 $-6.1E-4 < \text{Flow} < 0.6E-4$.OR. $0.6E-4 < \text{Flow} < 6.1E-4$,
 $-1.4E-3 < \text{Flow} < 0.1E-3$.OR. $0.1E-3 < \text{Flow} < 1.4E-3$,
 $-6.1E-2 < \text{Flow} < 0.6E-2$.OR. $0.6E-2 < \text{Flow} < 6.1E-2$,
- i. The INEL level probe is an experimental device, and as such, does not have well documented error bands.
- j. No significant error over a 500 ms averaging interval.
- k. N.A. implies not applicable.
- l. Flow Technology supplies calibration constants over the ranges 6.3E-4 to 1.9E-2 m³/s and 5.0E-33 to 6.3E-2 m³/s respectively. The uncertainty bands for these instruments should approach the quoted values for these ranges, but special care may be required. See the section on turbine flowmeters in the critical instruments section.

Table D.5 (continued)

Basis for Steady-State and Transient Error Bands by Type Code		
Type Code	Steady State	Transient
1	Critical instrument	Manufacturer's spec, OD**2 scaling
2	Critical instrument	Manufacturer's spec, OD**2 scaling
3	Critical instrument	Work of Carroll and Sheppard
4	Critical instrument	Work of Carroll and Sheppard
5	Critical instrument	Work of Carroll and Sheppard
6	Critical instrument	Manufacturer's spec
7	Critical instrument	Work of Carroll and Sheppard
8	Critical instrument	Work of Carroll and Sheppard
9	Critical instrument	Manufacturer's spec, OD**2 scaling
10	Critical instrument	Work of Carroll and Sheppard
23	Critical instrument	Table B.2
24	Manufacturer's spec	Table B.2
25	Bench Cal. + DAS	Table B.2 (inferred)
26	Critical instrument	Table B.2
27	Critical instrument	Table B.2
28	Critical instrument	Table B.2
29	Critical instrument	Table B.2 (inferred)
31	Critical instrument	Table B.2 (inferred)
32	Inferred (type code 31)	Table B.2 (inferred)
33	Critical instrument	Table B.2 (inferred)
34	Manufacturer's spec	Manufacturer's spec
35	Critical instrument	Table B.2
36	Bench Cal. + DAS	Inferred (type code 34)
37	From test 3.03.6AR	From test 3.03.6AR
40	Critical instrument	Table B.2
43	Critical instrument	Table B.2 (inferred)
50	*****	*****
71	Bench Cal. & specs	Table B.2
75	Critical instrument	Manufacturer's spec
76	Engineering judgement	N.A.
77	Engineering judgement	N.A.
78	Critical instrument	Inferred (type code 75)
79	Inferred (type code 75)	Inferred (type code 75)
80	Inferred (type code 75)	Inferred (type code 75)
95	Inferred (type code 109)	Work of N. Chen
96	Inferred (type code 109)	Work of N. Chen
97	Critical instrument	Table B.2
98	Critical instrument	Inferred (typed code 75)
99	Inferred (type code 71)	Inferred (type code 71)
105	Manufacturer's spec	Table B.2 (inferred)
106	Critical instrument	Work of R. Shipp (manufacturer's spec)
107	In-situ calibration	Table B.2 (inferred)
108	Inferred (type code 107)	Table B.2 (inferred)
109	Critical instrument	Work of N. Chen
110	Bench Cal. & specs	Table B.2
111	Inferred (type code 106)	Inferred (type code 109)
112	Inferred (type code 107)	Table B.2 (inferred)
113	Manufacturer's spec	Table B.2 (inferred)

Table D.6. Test 3.06.6B

THTF Instrument Error Bands						
Instrument Description	Type Code	Instrument Range	Steady State Error	Transient Error	Estimated Response Time	Assumed Value of Step Fn.
Rod Sheath Thermocouple 0.015 inch OD	1	32 F 1900 F	6.7F < 662 F 18.5 F	1.4 F ^a	7 ms	540 F
Rod Sheath Thermocouple 0.020 inch OD	1	32 F 1900 F	6.7F < 662 F 18.5 F	6.8 F ^a	12 ms	540 F
Rod Middle Thermocouple 0.015 inch OD	2	32 F 1900 F	6.7F < 662 F 18.5 F	1.4 F ^a	7 ms	540 F
Rod Middle Thermocouple 0.020 inch OD	2	32 F 1900 F	6.7F < 662 F 18.5 F	6.8 F ^a	12 ms	540 F
Bundle Subchn Thermocouple 0.040 inch OD	3	32 F 1900 F	6.7F < 662 F 18.5 F	4.9 F	140 ms	18 F
Shroud Box Thermocouple 0.062 inch OD	4	32 F 1900 F	6.7F < 662 F 18.5 F	9.5 F	350 ms	18 F
System Thermocouple 0.125 inch OD	5	32 F 1900 F	6.7F < 662 F 18.5 F	13.7 F	870 ms	18 F
System (Nanmac) Thermocouple 0.25 inch OD	6	32 F 1900 F	6.7F < 662 F 18.5 F	0.5 F	18 ms	18 F
Spacer Grid Thermocouple 0.040 inch OD	7	32 F 1900 F	6.7F < 662 F 18.5 F	4.9 F	140 ms	18 F
Array Rod Thermocouple 0.040 inch OD	8	32 F 1900 F	6.7F < 662 F 18.5 F	4.9 F	140 ms	18 F

Table D.6 (continued)

THTF Instrument Error Bands						
Instrument Description	Type Code	Instrument Range	Steady State Error	Transient Error	Estimated Response Time	Assumed Value of Step Fn.
Rod Sheath Thermocouple 0.020 inch OD	9	32 F 1900 F	6.7F < 662 F 18.5 F	6.8 F ^a	12 ms	540 F
Shroud Box Thermocouple 0.062 inch OD	10	32 F 1900 F	6.7F < 662 F 18.5 F	9.5 F	350 ms	18 F
Strain Gage Pressure Cell	23	3000 psi	29 psi	N.S. ^j	0.16 ms	30 psi
Force Balance Pressure Cell	24	500 psi 2500 psi	15 psi	23 psi	300 ms	30 psi
Force Balance Pressure Cell	24	500 psi 3900 psi	23 psi	23 psi	300 ms	30 psi
Strain Gage Pressure Cell	25	200 psi	2.5 psi	N.S.	0.32 ms	30 psi
Strain Gage D.P. Cell	26	<u>+200</u> psi	6.2 psi	N.S.	0.32 ms	30 psi
Strain Gage D.P. Cell	27	<u>+1000</u> psi	30 psi	N.S.	0.32 ms	0.25 psi
Strain Gage ^g D.P. Cell	28	<u>+50</u> psi	1.6 psi	N.S.	0.32 ms	0.25 psi
Strain Gage Pressure Cell	29	350 psi	3.5 psi	N.S.	0.16 ms	30 psi
Rod Heater Current	31	800 amp	0.85% Rdg	24 amp	50 ms	75 amp
Generator Current	32	1000 amp	0.85% Rdg	95 amp	50 ms	300 amp
Generator Voltage	33	300 volt	0.76% Rdg	32 volt	50 ms	100 volt

Table D.6 (continued)

THTF Instrument Error Bands						
Instrument Description	Type Code	Instrument Range	Steady State Error	Transient Error	Estimated Response Time	Assumed Value of Step Fn.
Primary Pump Power	34	750 kW	greater of 0.5 kW or 0.3% Rdg	6.3 kW	150 ms	10 kW
Strain Gage Drag Disk	35	$\pm 0.7E4$ lb/fts ² $\pm 7.0E4$ lb/fts ²	56% Rdg 19% Rdg	106 lb/fts ²	16 ms	1000 lb/fts ²
Primary Pump Speed	36	100 rpm 5400 rpm	20 rpm	13 rpm	150 ms	20 rpm
Breakwire Detector	37	5 volt	30 ms	N.A. ^k	20 ms	N.A.
Strain Gage Drag Disk	40	$\pm 1.4E4$ lb/fts ² $\pm 1.4E5$ lb/fts ²	56% Rdg 19% Rdg	106 lb/fts ²	16 ms	1000 lb/fts ²
Strain Gage D.P. Cell	41	± 100 inch	3.2 inch	N.S.	0.32 ms	6.8 inch
Strain Gage D.P. Cell	42	± 500 inch	16 inch	N.S.	0.32 ms	6.8 inch
Strain Gage D.P. Cell	43	± 6 psi	0.3 psi	N.S.	0.32 ms	0.25 psi
Level ⁱ Indicator	50	± 10 volt	***	***	***	***
RTD	71	32 F 800 F	2.0 F 4.9 F	17.8 F	10 sec	18 F
Capacitive D.P. Cell	75	25 inch	0.4 inch	0.6 inch	131 ms	1.0 inch
Capacitive D.P. Cell	75	150 inch	16 inch	0.4 inch	74 ms	1.0 inch
Position Indicator	76	155 inch	0.5% Rdg	N.A.	N.A.	N.A.
Position Indicator	77	131 inch	0.5% Rdg	N.A.	N.A.	N.A.

Table D.6 (continued)

THTF Instrument Error Bands						
Instrument Description	Type Code	Instrument Range	Steady State Error	Transient Error	Estimated Response Time	Assumed Value of Step Fn.
Capacitive D.P. Cell	78	± 100 inch	5.2 inch	3.6 inch	110 ms	6.8 inch
Capacitive D.P. Cell	79	200 inch	2.0 inch	2.8 inch	68 ms	6.8 inch
Capacitive D.P. Cell	80	30 inch	0.4 inch	0.6 inch	125 ms	1.0 inch
Turbine ^f Flowmeter	95	15 gpm 150 gpm	4.1% Rdg	2.0 gpm	11 ms 1.2 ms	100 gpm
Turbine ^f Flowmeter	96	5 gpm 50 gpm	4.1% Rdg	2.0 gpm	8 ms 1 ms	100 gpm
Force Balance D.P. Cell	97	24 psi	0.15 psi	0.2 psi	300 ms	0.25 psi
Capacitive D.P. Cell	98	50 psi	2.6 psi	0.06 psi	38 ms	0.25 psi
Differential Temperature	99	± 50 F	6.8 F	17.8 F	10 sec	18 F
Liquid Level	105	150 inch	0.9 inch	6.2 inch	300 ms	7.9 inch
Liquid Level	105	5.5E4 inch	336 inch	6.2 inch	300 ms	7.9 inch
Gamma Densitometer	106	62.4 lb/ft ³	6.5 lb/ft ³	0.33 lb/ft ³	16 ms	3 lb/ft ³
Orifice ^c Flowmeter	107	1.6 gpm	4E-2 gpm	0.13 gpm	300 ms	0.16 gpm
Orifice ^c Flowmeter	107	2.1 gpm	0.054 gpm	0.17 gpm	300 ms	0.22 gpm
Orifice ^c Flowmeter	107	5.3 gpm	0.13 gpm	0.41 gpm	300 ms	0.52 gpm

Table D.6 (continued)

THTF Instrument Error Bands						
Instrument Description	Type Code	Instrument Range	Steady State Error	Transient Error	Estimated Response Time	Assumed Value of Step Fn.
Orifice ^c Flowmeter	107	39.3 gpm	9.8 gpm	3.2 gpm	300 ms	4.0 gpm
Orifice ^c Flowmeter	107	800 gpm	21 gpm	62 gpm	300 ms	80 gpm
Orifice ^d Flowmeter	108	2.7 gpm	0.067 gpm	0.21 gpm	300 ms	0.27 gpm
Orifice ^e Flowmeter	108	700 gpm	17.4 gpm	0.55 gpm	300 ms	70 gpm
Turbine ^{f,h} Flowmeter	109	+0.5 gpm +5.0 gpm	4.1% Rdg	0.05 gpm	8 ms 1 ms	2.4 gpm
Turbine ^{f,h,b} Flowmeter	109	+1.0 gpm +10 gpm	2.5% Rdg	N.A.	8 ms 1 ms	N.A.
Turbine ^{f,h,l} Flowmeter	109	+22 gpm +225 gpm	4.1% Rdg	0.2 gpm	13 ms 2 ms	10 gpm
Turbine ^{f,h,l} Flowmeter	109	+100 gpm +1000 gpm	4.1% Rdg	0.2 gpm	18 ms 2 ms	10 gpm
RTD	110	32 F 800 F	2.0 F 4.9 F	17.8 F	10 sec	18 F
In-bundle Gamma Densitometer	111	62.4 lb/ft ³	6.5 lb/ft ³	0.3 lb/ft ³	16 ms	3 lb/ft ³
Orifice ^c Flowmeter	112	1.6 gpm	0.04 gpm	0.13 gpm	300 ms	0.16 gpm
Liquid Level	113	46 inch	0.3 inch	6.2 inch	300 ms	7.9 inch

Table D.6 (continued)

Documentation of Steady-State and Transient Error Bands

Steady-State Error Bands: Two-standard deviations compared to in-situ standard or twice the root-sum-square of uncertainties, whichever is applicable.

Transient Error Bands: Assuming first-order lag function, response times (TAU), and step function ($V_f - V_o$) indicated—the average error seen by the DAS assuming the step function occurred midway between DAS samples. The averaging interval is 500 ms for thermocouples and 150 ms for all other instruments.

Total Error: The total error due to steady state error and transient error is the sum of the steady state and transient error bands.

Footnotes:

- a. Error bands apply to the environment as sensed at the surface of the thermocouple sheath. Larger errors may occur when data is modelled to provide temperatures at other points. Transient response is estimated by using the response time (25 ms or less) prior to swaging the sheath (0.028 inch swaged to 0.020 inch OD), then scaling using the rule: response time is inversely proportional to the outside diameter squared (OD**2 scaling). An additional 7% improvement in response time was allowed for packing of the boron nitride during swaging. The smaller thermocouples (0.020 inch swaged to 0.015 inch) were estimated from the values of the larger thermocouples by first scaling the 25 ms response time to the unswaged 0.020 inch diameter using OD**2 scaling, then applying OD**2 scaling and the 7% improvement for packing to the swaged 0.015 inch OD.
- b. This instrument is fitted with Flow Technology electronics that time 10-blade passings. Averaging improves the steady-state error bands but degrades transient response.
- c. Range applies specifically to instruments calibrated in subcooled liquid at a density of 62.4 lb/ft**3.
- d. Range applies specifically to instruments calibrated in subcooled liquid at a density of 53.7 lb/ft**3.
- e. Range applies specifically to instruments calibrated in subcooled liquid at a density of 46.8 lb/ft**3.
- f. Error bands apply specifically to instruments calibrated in subcooled liquid. Extended range electronics provide readings out to 3600 gpm for the 3.5 inch diameter models; 445 gpm for the two inch diameter models, but the error bands apply only to 150% of nominal maximum range.
- g. Strain gage D.P. Cells used as pit cells are connected to different segments of the test section by long lines. These long lines induce resonant oscillations in the instrument that increase the steady-state errors bands to 5 psi, and the transient error bands to 60 psi in the interval immediately following blowdown.
- h. The turbine flowmeters (type code 109) have a flow range such that:
 -5.0<Flow<-0.5 .OR. 0.5<Flow<5.0,
 -10.0<Flow<-1.0 .OR. 1.0<Flow<10.0,
 -225<Flow<-22 .OR. 22<Flow<225,
 -1000<Flow<-100 .OR. 100<Flow<1000.
- i. The INEL level probe is an experimental device, and as such, does not have well documented error bands.
- j. No significant error over the averaging interval.
- k. N.A. implies not applicable.
- l. Flow Technology supplies calibration constants over the ranges 10 to 300 gpm and 80 to 1000 gpm respectively. The uncertainty bands for these instruments should approach the quoted values for these ranges, but special care may be required. See the section on turbine flowmeters in the critical instruments section.

Table 6 (continued)

Basis for Steady-State and Transient Error Bands by Type Code		
Type Code	Steady State	Transient
1	Critical instrument	Manufacturer's spec, OD**2 scaling
2	Critical instrument	Manufacturer's spec, OD**2 scaling
3	Critical instrument	Work of Carroll and Sheppard
4	Critical instrument	Work of Carroll and Sheppard
5	Critical instrument	Work of Carroll and Sheppard
6	Critical instrument	Manufacturer's spec
7	Critical instrument	Work of Carroll and Sheppard
8	Critical instrument	Work of Carroll and Sheppard
9	Critical instrument	Manufacturer's spec, OD**2 scaling
10	Critical instrument	Work of Carroll and Sheppard
23	Critical instrument	Table B.2
24	Manufacturer's spec	Table B.2
25	Bench Cal. + DAS	Table B.2 (inferred)
26	Critical instrument	Table B.2
27	Critical instrument	Table B.2
28	Critical instrument	Table B.2
29	Critical instrument	Table B.2 (inferred)
31	Critical instrument	Table B.2 (inferred)
32	Inferred (type code 31)	Table B.2 (inferred)
33	Critical instrument	Table B.2 (inferred)
34	Manufacturer's spec	Manufacturer's spec
35	Critical instrument	Table B.2
36	Bench Cal. + DAS	Inferred (type code 34)
37	From test 3.03.6AR	From test 3.03.6AR
40	Critical instrument	Table B.2
43	Critical instrument	Table B.2 (inferred)
50	*****	*****
71	Bench Cal. & specs	Table B.2
75	Critical instrument	Manufacturer's spec
76	Engineering judgement	N.A.
77	Engineering judgement	N.A.
78	Critical instrument	Inferred (type code 75)
79	Inferred (type code 75)	Inferred (type code 75)
80	Inferred (type code 75)	Inferred (type code 75)
95	Inferred (type code 109)	Work of N. Chen
96	Inferred (type code 109)	Work of N. Chen
97	Critical instrument	Table B.2
98	Critical instrument	Inferred (typed code 75)
99	Inferred (type code 71)	Inferred (type code 71)
105	Manufacturer's spec	Table B.2 (inferred)
106	Critical instrument	Work of R. Shipp (manufacturer's spec)
107	In-situ calibration	Table B.2 (inferred)
108	Inferred (type code 107)	Table B.2 (inferred)
109	Critical instrument	Work of N. Chen
110	Bench Cal. & specs	Table B.2
111	Inferred (type code 106)	Inferred (type code 109)
112	Inferred (type code 107)	Table B.2 (inferred)
113	Manufacturer's spec	Table B.2 (inferred)

Table D.7. Test 3.06.6B

THTF Instrument Error Bands						
Instrument Description	Type Code	Instrument Range	Steady State Error	Transient Error	Estimated Response Time	Assumed Value of Step Fn.
Rod Sheath Thermocouple 0.38 mm OD	1	273 K 1309 K	3.7K < 623 K 10.3 K	0.8 K ^a	7 ms	300 K
Rod Sheath Thermocouple 0.51 mm OD	1	273 K 1309 K	3.7K < 623 K 10.3 K	3.8 K ^a	12 ms	300 K
Rod Middle Thermocouple 0.38 mm OD	2	273 K 1309 K	3.7K < 623 K 10.3 K	0.8 K ^a	7 ms	300 K
Rod Middle Thermocouple 0.51 mm OD	2	273 K 1309 K	3.7K < 623 K 10.3 K	3.8 K ^a	12 ms	300 K
Bundle Subchn Thermocouple 1.02 mm OD	3	273 K 1309 K	3.7K < 623 K 10.3 K	4.1 K	140 ms	15 K
Shroud Box Thermocouple 1.57 mm OD	4	273 K 1309 K	3.7K < 623 K 10.3 K	8.0 K	350 ms	15 K
System Thermocouple 3.2 mm OD	5	273 K 1309 K	3.7K < 623 K 10.3 K	11.4 K	870 ms	15 K
System (Nanmac) Thermocouple 6.4 mm OD	6	273 K 1309 K	3.7K < 623 K 10.3 K	0.4 K	18 ms	15 K
Spacer Grid Thermocouple 1.02 mm OD	7	273 K 1309 K	3.7K < 623 K 10.3 K	4.1 K	140 ms	15 K
Array Rod Thermocouple 1.02 mm OD	8	273 K 1309 K	3.7K < 623 K 10.3 K	4.1 K	140 ms	15 K

Table D.7 (continued)

THTF Instrument Error Bands						
Instrument Description	Type Code	Instrument Range	Steady State Error	Transient Error	Estimated Response Time	Assumed Value of Step Fn.
Rod Sheath Thermocouple 0.51 mm OD	9	273 K 1309 K	3.7K < 623 K 10.3 K	3.8 K ^a	12 ms	300 K
Shroud Box Thermocouple 1.57 mm OD	10	273 K 1309 K	3.7K < 623 K 10.3 K	8.0 K	350 ms	15 K
Strain Gage Pressure Cell	23	20700 kPa	200 kPa	N.S. ^j	0.16 ms	700 kPa
Force Balance Pressure Cell	24	3400 kPa 17000 kPa	100 kPa	550 kPa	300 ms	700 kPa
Force Balance Pressure Cell	24	3400 kPa 27000 kPa	160 kPa	550 kPa	300 ms	700 kPa
Strain Gage Pressure Cell	25	1380 kPa	17 kPa	N.S.	0.32 ms	700 kPa
Strain Gage D.P. Cell	26	± 1380 kPa	43 kPa	N.S.	0.32 ms	5.1 kPa
Strain Gage D.P. Cell	27	± 6900 kPa	210 kPa	N.S.	0.32 ms	5.1 kPa
Strain Gage ^g D.P. Cell	28	± 345 kPa	11 kPa	N.S.	0.32 ms	5.1 kPa
Strain Gage Pressure Cell	29	2400 kPa	24 kPa	N.S.	0.16 ms	700 kPa
Rod Heater Current	31	800 amp	0.85% Rdg	4.7 amp	50 ms	15 amp
Generator Current	32	1000 amp	0.85% Rdg	32 amp	50 ms	100 amp
Generator Voltage	33	300 volt	0.76% Rdg	3.8 volt	50 ms	12 volt

Table D.7 (continued)

THTF Instrument Error Bands						
Instrument Description	Type Code	Instrument Range	Steady State Error	Transient Error	Estimated Response Time	Assumed Value of Step Fn.
Primary Pump Power	34	750 kW	greater of 0.5 kW or 0.3% Rdg	6.3 kW	150 ms	10 kW
Strain Gage Drag Disk	35	$\pm 0.1E5$ kg/ms ² $\pm 1.0E5$ kg/ms ²	56% Rdg 19% Rdg	157 kg/ms ²	16 ms	1500 kg/ms ²
Primary Pump Speed	36	100 rpm 5400 rpm	20 rpm	13 rpm	150 ms	20 rpm
Breakwire Detector	37	5 volt	30 ms	N.A. ^k	20 ms	N.A.
Strain Gage Drag Disk	40	$\pm 0.2E5$ kg/ms ² $\pm 2.1E5$ kg/ms ²	56% Rdg 19% Rdg	157 kg/ms ²	16 ms	1500 kg/ms ²
Strain Gage D.P. Cell	41	± 25 kPa	0.8 kPa	N.S.	0.32 ms	5.1 kPa
Strain Gage D.P. Cell	42	± 125 kPa	4 kPa	N.S.	0.32 ms	5.1 kPa
Strain Gage D.P. Cell	43	± 41 kPa	2 kPa	N.S.	0.32 ms	5.1 kPa
Level ⁱ Indicator	50	± 10 volt	***	***	***	***
RTD	71	273 K 700 K	1.1 K 2.7 K	14.9 K	10 sec	15 K
Capacitive D.P. Cell	75	6.2 kPa	0.1 kPa	0.5 kPa	131 ms	0.75 kPa
Capacitive D.P. Cell	75	37.5 kPa	0.4 kPa	0.3 kPa	74 ms	0.75 kPa
Position Indicator	76	3.92 m	0.5% Rdg	N.A.	N.A.	N.A.
Position Indicator	77	3.33 m	0.5% Rdg	N.A.	N.A.	N.A.

Table D.7 (continued)

THTF Instrument Error Bands						
Instrument Description	Type Code	Instrument Range	Steady State Error	Transient Error	Estimated Response Time	Assumed Value of Step Fn.
Capacitive D.P. Cell	78	25 kPa	1.3 kPa	2.7 kPa	110 ms	5.1 kPa
Capacitive D.P. Cell	79	50 kPa	0.5 kPa	2.1 kPa	68 ms	5.1 kPa
Capacitive D.P. Cell	80	7.5 kPa	0.1 kPa	0.4 kPa	125 ms	0.75 kPa
Turbine ^f Flowmeter	95	0.9E-3 m ³ /s 9.5E-3 m ³ /s	4.1% Rdg	1.3E-6 m ³ /s	11 ms 1.2 ms	6.3E-4 m ³ /s
Turbine ^f Flowmeter	96	0.3E-3 m ³ /s 3.2E-3 m ³ /s	4.1% Rdg	1.3E-6 m ³ /s	8 ms 1 ms	6.3E-4 m ³ /s
Force Balance D.P. Cell	97	166 kPa	1 kPa	4 kPa	300 ms	5.1 kPa
Capacitive D.P. Cell	98	345 kPa	0.1 kPa	1.3 kPa	38 ms	5.1 kPa
Differential Temperature	99	228 K 283 K	3.8 K	9.9 K	10 sec	10 K
Liquid Level	105	3.81 m	0.023 m	0.16 m	300 ms	0.2 m
Liquid Level	105	1408 m	8.5 m	0.16 m	300 ms	0.2 m
Gamma Densitometer	106	1000 kg/m ³	104 kg/m ³	8 kg/m ³	16 ms	80 kg/m ³
Orifice ^c Flowmeter	107	1.0E-4 m ³ /s	2.5E-6 m ³ /s	7.9E-6 m ³ /s	300 ms	1E-5 m ³ /s
Orifice ^c Flowmeter	107	1.35E-4 m ³ /s	3.4E-6 m ³ /s	1.1E-5 m ³ /s	300 ms	1.4E-5 m ³ /s
Orifice ^c Flowmeter	107	3.32E-4 m ³ /s	8.3E-6 m ³ /s	2.6E-5 m ³ /s	300 ms	3.3E-5 m ³ /s

Table D.7 (continued)

THTF Instrument Error Bands						
Instrument Description	Type Code	Instrument Range	Steady State Error	Transient Error	Estimated Response Time	Assumed Value of Step Fn.
Orifice ^c Flowmeter	107	2.48E-3 m ³ /s	6.2E-5 m ³ /s	2.0E-4 m ³ /s	300 ms	2.5E-4 m ³ /s
Orifice ^c Flowmeter	107	5.0E-2 m ³ /s	1.3E-3 m ³ /s	3.9E-3 m ³ /s	300 ms	5E-3 m ³ /s
Orifice ^d Flowmeter	108	1.7E-4 m ³ /s	4.2E-6 m ³ /s	1.3E-5 m ³ /s	300 ms	1.7E-5 m ³ /s
Orifice ^e Flowmeter	108	4.4E-2 m ³ /s	1.1E-3 m ³ /s	3.5E-3 m ³ /s	300 ms	4.4E-3 m ³ /s
Turbine ^{f,h} Flowmeter	109	$\pm 0.3E-4$ m ³ /s $\pm 3.0E-4$ m ³ /s	4.1% Rdg	3.1E-6 m ³ /s	8 ms 1 ms	1.5E-4 m ³ /s
Turbine ^{f,h,b} Flowmeter	109	$\pm 0.6E-4$ m ³ /s $\pm 6.1E-4$ m ³ /s	2.5% Rdg	N.A.	8 ms 1 ms	N.A.
Turbine ^{f,h,l} Flowmeter	109	$\pm 1.3E-3$ m ³ /s $\pm 1.4E-2$ m ³ /s	4.1% Rdg	2.7E-5 m ³ /s	13 ms 2 ms	1.3E-3 m ³ /s
Turbine ^{f,h,l} Flowmeter	109	$\pm 0.6E-2$ m ³ /s $\pm 6.1E-2$ m ³ /s	4.1% Rdg	6.7E-5 m ³ /s	18 ms 2 ms	3.2E-3 m ³ /s
RTD	110	273 K 700 K	1.1 K 2.7 K	14.9 K	10 sec	15 K
In-bundle Gamma Densitometer	111	1000 kg/m ³	104 kg/m ³	8 kg/m ³	16 ms	80 kg/m ³
Orifice ^c Flowmeter	112	1.0E-4 m ³ /s	2.5E-6 m ³ /s	7.9E-6 m ³ /s	300 ms	1E-5 m ³ /s
Liquid Level	113	1.18 m	0.007 m	0.16 m	300 ms	0.20 m

Table D.7 (continued)

Documentation of Steady-State and Transient Error Bands

Steady-State Error Bands: Two-standard deviations compared to in-situ standard or twice the root-sum-square of uncertainties, whichever is applicable.

Transient Error Bands: Assuming first-order lag function, response times (TAU), and step function ($V_f - V_o$) indicated—the average error seen by the DAS assuming the step function occurred midway between DAS samples. The averaging interval is 500 ms for thermocouples and 150 ms for all other instruments.

Total Error: The total error due to steady state error and transient error is the sum of the steady state and error bands.

Footnotes:

- a. Error bands apply to the environment as sensed at the surface of the thermocouple sheath. Larger errors may occur when data is modelled to provide temperatures at other points. Transient response is estimated by using the response time (25 ms or less) prior to swaging the sheath (0.71 mm swaged to 0.51 mm OD), then scaling using the rule: response time is inversely proportional to the outside diameter squared (OD**2 scaling). An additional 7% improvement in response time was allowed for packing of the boron nitride during swaging. The smaller thermocouples (0.51 mm swaged to 0.38 mm OD) were estimated from the values of the larger thermocouples by first scaling the 25 ms response time to the unswaged 0.51 mm diameter using OD**2 scaling, then applying OD**2 scaling and the 7% improvement for packing to the swaged 0.38 mm OD.
- b. This instrument is fitted with Flow Technology electronics that time 10-blade passings. Averaging improves the steady-state error bands but degrades transient response.
- c. Range applies specifically to instruments calibrated in subcooled liquid at a density of 1000 kg/m**3.
- d. Range applies specifically to instruments calibrated in subcooled liquid at a density of 860 kg/m**3.
- e. Range applies specifically to instruments calibrated in subcooled liquid at a density of 750 kg/m**3.
- f. Error bands apply specifically to instruments calibrated in subcooled liquid. Extended range electronics provide readings out to 0.227 m³/s for the 8.89E-2 meter diameter models; 0.028 m³/s for the 5.08E-2 meter diameter models, but the error bands apply only to 150% of nominal maximum range.
- g. Strain gage D.P. Cells used as pit cells are connected to different segments of the test section by long lines. These long lines induce resonant oscillations in the instrument that increase the steady-state errors bands to 35 kPa, and the transient error bands to 400 kPa.
- h. The turbine flowmeters (type code 109) have a flow range such that:
 -3.0E-4<Flow<-0.3E-4 .OR. 0.3E-4<Flow<3.0E-4,
 -6.1E-4<Flow<-0.6E-4 .OR. 0.6E-4<Flow<6.1E-4,
 -1.4E-3<Flow<-0.1E-3 .OR. 0.1E-3<Flow<1.4E-3,
 -6.1E-2<Flow<-0.6E-2 .OR. 0.6E-2<Flow<6.1E-2
- i. The INEL level probe is an experimental device, and as such, does not have well documented error bands.
- j. No significant error over a 500 ms averaging interval.
- k. N.A. implies not applicable.
- l. Flow Technology supplies calibration constants over the ranges 6.3E-4 to 1.9E-2 m³/s and 5.0E-3 to 6.3E-2 m³/s respectively. The uncertainty bands for these instruments should approach the quoted values for these ranges, but special care may be required. See the section on turbine flowmeters in the critical instruments section.

Table D.7 (continued)

Basis for Steady-State and Transient Error Bands by Type Code		
Type Code	Steady State	Transient
1	Critical instrument	Manufacturer's spec, OD**2 scaling
2	Critical instrument	Manufacturer's spec, OD**2 scaling
3	Critical instrument	Work of Carroll and Sheppard
4	Critical instrument	Work of Carroll and Sheppard
5	Critical instrument	Work of Carroll and Sheppard
6	Critical instrument	Manufacturer's spec
7	Critical instrument	Work of Carroll and Sheppard
8	Critical instrument	Work of Carroll and Sheppard
9	Critical instrument	Manufacturer's spec, OD**2 scaling
10	Critical instrument	Work of Carroll and Sheppard
23	Critical instrument	Table B.2
24	Manufacturer's spec	Table B.2
25	Bench Cal. + DAS	Table B.2 (inferred)
26	Critical instrument	Table B.2
27	Critical instrument	Table B.2
28	Critical instrument	Table B.2
29	Critical instrument	Table B.2 (inferred)
31	Critical instrument	Table B.2 (inferred)
32	Inferred (type code 31)	Table B.2 (inferred)
33	Critical instrument	Table B.2 (inferred)
34	Manufacturer's spec	Manufacturer's spec
35	Critical instrument	Table B.2
36	Bench Cal. + DAS	Inferred (type code 34)
37	From test 3.03.6AR	From test 3.03.6AR
40	Critical instrument	Table B.2
43	Critical instrument	Table B.2 (inferred)
50	*****	*****
71	Bench Cal. & specs	Table B.2
75	Critical instrument	Manufacturer's spec
76	Engineering judgement	N.A.
77	Engineering judgement	N.A.
78	Critical instrument	Inferred (type code 75)
79	Inferred (type code 75)	Inferred (type code 75)
80	Inferred (type code 75)	Inferred (type code 75)
95	Inferred (type code 109)	Work of N. Chen
96	Inferred (type code 109)	Work of N. Chen
97	Critical instrument	Table B.2
98	Critical instrument	Inferred (typed code 75)
99	Inferred (type code 71)	Inferred (type code 71)
105	Manufacturer's spec	Table B.2 (inferred)
106	Critical instrument	Work of R. Shipp (manufacturer's spec)
107	In-situ calibration	Table B.2 (inferred)
108	Inferred (type code 107)	Table B.2 (inferred)
109	Critical instrument	Work of N. Chen
110	Bench Cal. & specs	Table B.2
111	Inferred (type code 106)	Inferred (type code 109)
112	Inferred (type code 107)	Table B.2 (inferred)
113	Manufacturer's spec	Table B.2 (inferred)

Table D.8. Test 3.06.6B

THTF Instrument Error Bands						
Instrument Description	Type Code	Instrument Range	Steady State Error	Transient Error	Estimated Response Time	Assumed Value of Step Fn.
Rod Sheath Thermocouple 0.015 inch OD	1	32 F 1900 F	6.7F < 662 F 18.5 F	1.4 F ^a	7 ms	540 F
Rod Sheath Thermocouple 0.020 inch OD	1	32 F 1900 F	6.7F < 662 F 18.5 F	6.8 F ^a	12 ms	540 F
Rod Middle Thermocouple 0.015 inch OD	2	32 F 1900 F	6.7F < 662 F 18.5 F	1.4 F ^a	7 ms	540 F
Rod Middle Thermocouple 0.020 inch OD	2	32 F 1900 F	6.7F < 662 F 18.5 F	6.8 F ^a	12 ms	540 F
Bundle Subchn Thermocouple 0.040 inch OD	3	32 F 1900 F	6.7F < 662 F 18.5 F	7.4 F	140 ms	27 F
Shroud Box Thermocouple 0.062 inch OD	4	32 F 1900 F	6.7F < 662 F 18.5 F	14.4 F	350 ms	27 F
System Thermocouple 0.125 inch OD	5	32 F 1900 F	6.7F < 662 F 18.5 F	20.5 F	870 ms	27 F
System (Nanmac) Thermocouple 0.25 inch OD	6	32 F 1900 F	6.7F < 662 F 18.5 F	0.7 F	18 ms	27 F
Spacer Grid Thermocouple 0.040 inch OD	7	32 F 1900 F	6.7F < 662 F 18.5 F	7.4 F	140 ms	27 F
Array Rod Thermocouple 0.040 inch OD	8	32 F 1900 F	6.7F < 662 F 18.5 F	7.4 F	140 ms	27 F

Table D.8 (continued)

THTF Instrument Error Bands						
Instrument Description	Type Code	Instrument Range	Steady State Error	Transient Error	Estimated Response Time	Assumed Value of Step Fn.
Rod Sheath Thermocouple 0.020 inch OD	9	32 F 1900 F	6.7F < 662 F 18.5 F	6.8 F ^a	12 ms	540 F
Shroud Box Thermocouple 0.062 inch OD	10	32 F 1900 F	6.7F < 662 F 18.5 F	14.4 F	350 ms	27 F
Strain Gage Pressure Cell	23	3000 psi	29 psi	N.S. ^j	0.16 ms	100 psi
Force Balance Pressure Cell	24	500 psi 2500 psi	15 psi	79 psi	300 ms	100 psi
Force Balance Pressure Cell	24	500 psi 3900 psi	23 psi	79 psi	300 ms	100 psi
Strain Gage Pressure Cell	25	200 psi	2.5 psi	N.S.	0.32 ms	100 psi
Strain Gage D.P. Cell	26	±200 psi	6.2 psi	N.S.	0.32 ms	100 psi
Strain Gage D.P. Cell	27	±1000 psi	30 psi	N.S.	0.32 ms	0.7 psi
Strain Gage ^g D.P. Cell	28	±50 psi	1.6 psi	N.S.	0.32 ms	0.7 psi
Strain Gage Pressure Cell	29	350 psi	3.5 psi	N.S.	0.16 ms	100 psi
Rod Heater Current	31	800 amp	0.85% Rdg	24 amp	50 ms	75 amp
Generator Current	32	1000 amp	0.85% Rdg	95 amp	50 ms	300 amp
Generator Voltage	33	300 volt	0.76% Rdg	32 volt	50 ms	100 volt

Table D.8 (continued)

THTF Instrument Error Bands						
Instrument Description	Type Code	Instrument Range	Steady State Error	Transient Error	Estimated Response Time	Assumed Value of Step Fn.
Primary Pump Power	34	750 kW	greater of 0.5 kW or 0.3% Rdg	6.3 kW	150 ms	10 kW
Strain Gage Drag Disk	35	$\pm 0.7E4$ lb/fts ² $\pm 7.0E4$ lb/fts ²	56% Rdg 19% Rdg	106 lb/fts ²	16 ms	1000 lb/fts ²
Primary Pump Speed	36	100 rpm 5400 rpm	20 rpm	13 rpm	150 ms	20 rpm
Breakwire Detector	37	5 volt	30 ms	N.A. ^k	20 ms	N.A.
Strain Gage Drag Disk	40	$\pm 1.4E4$ lb/fts ² $\pm 1.4E5$ lb/fts ²	56% Rdg 19% Rdg	106 lb/fts ²	16 ms	1000 lb/fts ²
Strain Gage D.P. Cell	41	± 100 inch	3.2 inch	N.S.	0.32 ms	20.5 inch
Strain Gage D.P. Cell	42	± 500 inch	16 inch	N.S.	0.32 ms	20.5 inch
Strain Gage D.P. Cell	43	± 6 psi	0.3 psi	N.S.	0.32 ms	0.7 psi
Level ⁱ Indicator	50	± 10 volt	***	***	***	***
RTD	71	32 F 800 F	2.0 F 4.9 F	26.8 F	10 sec	27 F
Capacitive D.P. Cell	75	25 inch	0.4 inch	2.0 inch	131 ms	3 inch
Capacitive D.P. Cell	75	150 inch	1.6 inch	1.2 inch	74 ms	3 inch
Position Indicator	76	155 inch	0.5% Rdg	N.A.	N.A.	N.A.
Position Indicator	77	131 inch	0.5% Rdg	N.A.	N.A.	N.A.

Table D.8 (continued)

THIF Instrument Error Bands						
Instrument Description	Type Code	Instrument Range	Steady State Error	Transient Error	Estimated Response Time	Assumed Value of Step Fn.
Capacitive D.P. Cell	78	± 100 inch	5.2 inch	10.9 inch	110 ms	20.5 inch
Capacitive D.P. Cell	79	200 inch	2.0 inch	8.4 inch	68 ms	20.5 inch
Capacitive D.P. Cell	80	30 inch	0.4 inch	1.6 inch	125 ms	3 inch
Turbine ^f Flowmeter	95	15 gpm 150 gpm	4.1% Rdg	2.0 gpm	11 ms 1.2 ms	100 gpm
Turbine ^f Flowmeter	96	5 gpm 50 gpm	4.1% Rdg	2.0 gpm	8 ms 1 ms	100 gpm
Force Balance D.P. Cell	97	24 psi	0.15 psi	0.6 psi	300 ms	0.7 psi
Capacitive D.P. Cell	98	50 psi	2.6 psi	0.2 psi	38 ms	0.7 psi
Differential Temperature	99	± 50 F	6.8 F	17.8 F	10 sec	18 F
Liquid Level	105	150 inch	0.9 inch	6.2 inch	300 ms	7.9 inch
Liquid Level	105	5.5E4 inch	336 inch	6.2 inch	300 ms	7.9 inch
Gamma Densitometer	106	62.4 lb/ft ³	6.5 lb/ft ³	0.5 lb/ft ³	16 ms	5 lb/ft ³
Orifice ^c Flowmeter	107	1.6 gpm	4E-2 gpm	0.13 gpm	300 ms	0.16 gpm
Orifice ^c Flowmeter	107	2.1 gpm	0.054 gpm	0.17 gpm	300 ms	0.22 gpm
Orifice ^c Flowmeter	107	5.3 gpm	0.13 gpm	0.41 gpm	300 ms	0.52 gpm

Table D.8 (continued)

THIF Instrument Error Bands						
Instrument Description	Type Code	Instrument Range	Steady State Error	Transient Error	Estimated Response Time	Assumed Value of Step Fn.
Orifice ^c Flowmeter	107	39.3 gpm	9.8 gpm	3.2 gpm	300 ms	4.0 gpm
Orifice ^c Flowmeter	107	800 gpm	21 gpm	62 gpm	300 ms	80 gpm
Orifice ^d Flowmeter	108	2.7 gpm	0.067 gpm	0.21 gpm	300 ms	0.27 gpm
Orifice ^e Flowmeter	108	700 gpm	17.4 gpm	0.55 gpm	300 ms	70 gpm
Turbine ^{f,h} Flowmeter	109	± 0.5 gpm ± 5.0 gpm	4.1% Rdg	0.05 gpm	8 ms 1 ms	2.4 gpm
Turbine ^{f,h,b} Flowmeter	109	± 1.0 gpm ± 10 gpm	2.5% Rdg	N.A.	8 ms 1 ms	N.A.
Turbine ^{f,h,l} Flowmeter	109	± 22 gpm ± 225 gpm	4.1% Rdg	0.4 gpm	13 ms 2 ms	21 gpm
Turbine ^{f,h,l} Flowmeter	109	± 100 gpm ± 1000 gpm	4.1% Rdg	1.1 gpm	18 ms 2 ms	50 gpm
RTD	110	32 F 800 F	2.0 F 4.9 F	26.8 F	10 sec	27 F
In-bundle Gamma Densitometer	111	62.4 lb/ft ³	6.5 lb/ft ³	0.5 lb/ft ³	16 ms	5 lb/ft ³
Orifice ^c Flowmeter	112	1.6 gpm	0.04 gpm	0.13 gpm	300 ms	0.16 gpm
Liquid Level	113	46 inch	0.3 inch	6.2 inch	300 ms	7.9 inch

Table D.8 (continued)

Documentation of Steady-State and Transient Error Bands

Steady-State Error Bands: Two-standard deviations compared to in-situ standard or twice the root-sum-square of uncertainties, whichever is applicable.

Transient Error Bands: Assuming first-order lag function, response times (TAU), and step function ($V_f - V_o$) indicated—the average error seen by the DAS assuming the step function occurred midway between DAS samples. The averaging interval is 500 ms for thermocouples and 150 ms for all other instruments.

Total Error: The total error due to steady state error and transient error is the sum of the steady state and transient error bands.

Footnotes:

- a. Error bands apply to the environment as sensed at the surface of the thermocouple sheath. Larger errors may occur when data is modelled to provide temperatures at other points. Transient response is estimated by using the response time (25 ms or less) prior to swaging the sheath (0.028 inch swaged to 0.020 inch OD), then scaling using the rule: response time is inversely proportional to the outside diameter squared (OD**2 scaling). An additional 7% improvement in response time was allowed for packing of the boron nitride during swaging. The smaller thermocouples (0.020 inch swaged to 0.015 inch) were estimated from the values of the larger thermocouples by first scaling the 25 ms response time to the unswaged 0.020 inch diameter using OD**2 scaling, then applying OD**2 scaling and the 7% improvement for packing to the swaged 0.015 inch OD.
- b. This instrument is fitted with Flow Technology electronics that time 10-blade passages. Averaging improves the steady-state error bands but degrades transient response.
- c. Range applies specifically to instruments calibrated in subcooled liquid at a density of 62.4 lb/ft**3.
- d. Range applies specifically to instruments calibrated in subcooled liquid at a density of 53.7 lb/ft**3.
- e. Range applies specifically to instruments calibrated in subcooled liquid at a density of 46.8 lb/ft**3.
- f. Error bands apply specifically to instruments calibrated in subcooled liquid. Extended range electronics provide readings out to 3600 gpm for the 3.5 inch diameter models; 445 gpm for the two inch diameter models, but the error bands apply only to 150% of nominal maximum range.
- g. Strain gage D.P. Cells used as pit cells are connected to different segments of the test section by long lines. These long lines induce resonant oscillations in the instrument that increase the steady-state errors bands to 5 psi, and the transient error bands to 60 psi in the interval immediately following blowdown.
- h. The turbine flowmeters (type code 109) have a flow range such that:
 -5.0<Flow<-0.5 .OR. 0.5<Flow<5.0,
 -10.0<Flow<-1.0 .OR. 1.0<Flow<10.0,
 -225<Flow<-22 .OR. 22<Flow<225,
 -1000<Flow<-100 .OR. 100<Flow<1000.
- i. The INEL level probe is an experimental device, and as such, does not have well documented error bands.
- j. No significant error over the averaging interval.
- k. N.A. implies not applicable.
- l. Flow Technology supplies calibration constants over the ranges 10 to 300 gpm and 80 to 1000 gpm respectively. The uncertainty bands for these instruments should approach the quoted values for these ranges, but special care may be required. See the section on turbine flowmeters in the critical instruments section.

Table D.8 (continued)

Basis for Steady-State and Transient Error Bands by Type Code		
Type Code	Steady State	Transient
1	Critical instrument	Manufacturer's spec, OD**2 scaling
2	Critical instrument	Manufacturer's spec, OD**2 scaling
3	Critical instrument	Work of Carroll and Sheppard
4	Critical instrument	Work of Carroll and Sheppard
5	Critical instrument	Work of Carroll and Sheppard
6	Critical instrument	Manufacturer's spec
7	Critical instrument	Work of Carroll and Sheppard
8	Critical instrument	Work of Carroll and Sheppard
9	Critical instrument	Manufacturer's spec, OD**2 scaling
10	Critical instrument	Work of Carroll and Sheppard
23	Critical instrument	Table B.2
24	Manufacturer's spec	Table B.2
25	Bench Cal. + DAS	Table B.2 (inferred)
26	Critical instrument	Table B.2
27	Critical instrument	Table B.2
28	Critical instrument	Table B.2
29	Critical instrument	Table B.2 (inferred)
31	Critical instrument	Table B.2 (inferred)
32	Inferred (type code 31)	Table B.2 (inferred)
33	Critical instrument	Table B.2 (inferred)
34	Manufacturer's spec	Manufacturer's spec
35	Critical instrument	Table B.2
36	Bench Cal. + DAS	Inferred (type code 34)
37	From test 3.03.6AR	From test 3.03.6AR
40	Critical instrument	Table B.2
43	Critical instrument	Table B.2 (inferred)
50	*****	*****
71	Bench Cal. & specs	Table B.2
75	Critical instrument	Manufacturer's spec
76	Engineering judgement	N.A.
77	Engineering judgement	N.A.
78	Critical instrument	Inferred (type code 75)
79	Inferred (type code 75)	Inferred (type code 75)
80	Inferred (type code 75)	Inferred (type code 75)
95	Inferred (type code 109)	Work of N. Chen
96	Inferred (type code 109)	Work of N. Chen
97	Critical instrument	Table B.2
98	Critical instrument	Inferred (typed code 75)
99	Inferred (type code 71)	Inferred (type code 71)
105	Manufacturer's spec	Table B.2 (inferred)
106	Critical instrument	Work of R. Shipp (manufacturer's spec)
107	In-situ calibration	Table B.2 (inferred)
108	Inferred (type code 107)	Table B.2 (inferred)
109	Critical instrument	Work of N. Chen
110	Bench Cal. & specs	Table B.2
111	Inferred (type code 106)	Inferred (type code 109)
112	Inferred (type code 107)	Table B.2 (inferred)
113	Manufacturer's spec	Table B.2 (inferred)

Appendix E

THREE-BEAM DENSITOMETER DENSITY

An annular model¹ is used for obtaining composite density from the three-beam densitometers installed on selected THTF spool pieces. The model solves for a uniform density for each region shown in Fig. E.1 using the density indicated by each of the three beams and the length of each beam within each region. The composite pipe density is then calculated as an area-weighted average of the three region densities. This results in an equation for the composite density of

$$\bar{\rho} = 0.3784\rho_A + 0.5117\rho_B + 0.1099\rho_C ,$$

where $\bar{\rho}$ is the composite average pipe density and ρ_A , ρ_B , and ρ_C are the measured beam densities. The calculated composite density is shown graphically in Fig. E.1.

As uncertainty estimate for homogeneous flows may be obtained using a standard propagation of errors method and the uncertainty estimates for the individual beams. The standard deviation may be estimated as

$$\sigma = [(0.3784\sigma_A)^2 + (0.5117\sigma_B)^2 + (0.1099\sigma_C)^2]^{0.5} .$$

Fig. E.1

Substituting the reported 2σ single-beam values of 104 kg/m^3 ($6.5 \text{ lb}_m/\text{ft}^3$) into the above equation gives a 2σ value of 67 kg/m^3 ($4.2 \text{ lb}_m/\text{ft}^3$) for the composite three-beam densitometer measurements.

Reference

1. K. G. Turnage et al., *Advanced Two-Phase Flow Instrumentation Program Quarterly Progress Report for April-June 1978*, ORNL/NUREG/TM-279 (January 1979).