2411 Garden Road

Monterey, CA 93940

(831) 646-5911

(800) 424-7356

Document Title: *151 Calibration Manual*

Document Number: 360191, Rev C

Publication Date: March 1990

Table of Contents

Section 1: Power-On Voltage Tests for the 143 and 465 Boards 1-1

1.1 System Interconnections 1-1

1.1.1 Sensor Connections to the 465 Current-Transmitter Boards 1-1

1.2 Testing the 143 Profiler, Power Supply, and Averager Board 1-3

1.3 465 Current-Transmitter Board Bridge-Voltage Tests ... 1-8

Section 2: Calibrating the 151 Linearization Module 2-1

2.1 Check Voltages and Wiring Interconnections 2-1

2.2 Record Flow Rates 2-2

2.3 Record "Inches H2O" 2-4

2.4 Record the Ideal Voltages on the Data Sheet 2-7

2.5 Position Sensor in Wind Tunnel or Laminar Flow Element 2-7

2.6 Measure Current-Sense Volatge 2-9

2.7 Adjusting the Zero and Span Potentiometers 2-13

2.8 Correcting the Zero and Span Voltages, R2 and R7 2-15

2.9 Calculate the Non-Linear Voltages 2-16

2.10 Graphing Data and Drawing Data From Curve 2-20

2.10.1 Graphing the Non-Linear Voltages 2-20

2.10.2 Drawing Data From the Curve 2-22

2.11 Adjusting Linear Voltages for each Breakpoint 2-26

2.12 Checking the Linear Section for Accuracy 2-28

2.13 Prepare System for Operation 2-38

Section 3: Troubleshooting 3-1

Appendix A A-1

Figures

Figure 1-1. *465 Current-Transmitter Boards Inside 195 Enclosure* 1-2

Figure 1-2. *Locations of the 143 Profiler and Linearizer Boards on the 143 Profiler, Power Supply, and Averager Board* 1-4

Figure 1-3 *143 Profiler and Linearizer Board* 1-5

Figure 1-4. *465R4 Current-Transmitter Board Test Points* 1-8

Figure 1-5. *465R5 Current-Transmitter Board Test Points* 1-9

Figure 2-1. *Calibration Velocities Recorded on Data Sheet (Example)* 2-3

Figure 2-2. *Example of Laminar Flow Element Graph for Laminar Flow Element* 2-5

Figure 2-3. *"Inches H2O" Values from Laminar Flow Element Graph Shown in Figure 2-2* 2-6

Figure 2-4 *EVA or IK-EVA System with 6 Sensors* 2-8

Figure 2-5 *Current-Sense Resistors on the 143 Profiler, Power Supply, and Averager Board (baseboard)* . 2-11

Figure 2-6. *Current-Sense Voltages Measured for an EVA Sensor* 2-12

Figure 2-7. *143 Profiler and Linearizer Board, Zero and Span Potentiometers* 2-13

Figure 2-8. *143 Profiler and Linearizer Board, Resistors R2 and R7* 2-15

Figure 2-9. *Non-Linear Voltages Calculated for each Calibration Point* 2-19

Figure 2-10. *Graph of Non-Linear Voltages vs. Ideal Voltages* 2-21

Figure 2-11. *Curve for Non-Linear Voltages vs. Ideal Voltages* 2-23

Figure 2-12. *Linearized Breakpoint Voltages* 2-24

Figure 2-13. *Data Sheet with Linearized Breakpoints, "Linear Vdc"* 2-25

Figure 2-14. *Potentiometers Adjusted for Linearization Circuit of the 143 Profiler and Linearizer Board* 2-26

Figure 2-15. *Locations of E2 and J1 on the 143 Linearizer Board* 2-29

Figure 2-16. *Completed Data Sheet for the Calibation of an EVA Sensor* 2-37

Figure A-1. *Test Connections when the 151 Rack Module is Removed from the 193 Enclosure* A-1

Tables

Table 1-1. *Sensor Cable Wire Colors and Terminal Connections* 1-3

Table 2-1. *Temperature Correction Factor* 2-10

Section 1: Power-On Voltage Tests for the 143 and 465 Boards

This section describes the power-on voltage tests that should be performed before calibrating a 143 Profiler and Signal Linearizer Board.

NOTE: Any warranty service to be performed at the customer's site must be previously approved in writing by Kurz Instruments. Nonwarranty service should be performed only by a certified electrical technician. Refer to Appendix A for component layouts and schematics.

1.1 System Interconnections

For the EVA 4000 or IK-EVA 4200 systems to operate properly, the interconnections between the Series 195 Current-Transmitter Enclosure and the Series 193 System Electronics Enclosure must be correct. In most cases, a cable harness is connected between field terminals in the 195 and 193 enclosures. Since each configuration of each EVA and IK-EVA system varies it is best to refer to the field wiring drawings supplied with your system to verify the system interconnections.

1.1.1 Sensor Connections to the 465 Current-Transmitter Boards

The sensor wires should be connected to terminal block 2 (TB2) on the appropriate 465 Current-Transmitter Board as as indicated in Figure 1-1 and Table 1-1. Verify that the four wires from each sensor in the EVA or IK-EVA probes are connected to Terminal Block 2 on the appropriate 465 Current-Transmitter Board in the Series 195 enclosure. As shown in the Table 1-1, the colors of the sensor wires may vary, depending on the kind of cable used.

For EVA 4000 transmitter-attached systems where the 195 enclosure is attached to the probe support, these connections have been made at the factory. When installing the EVA 4000 transmitter-separate and IK-EVA 4200 systems, you have to connect the sensor wires before the system is operational.

The four wires for Sensor # 1 (or Sensor A) should be connected to the 465 Current Transmitter Board #1 (FT1) in the 195 enclosure. The four wires for Sensor # 2 (or Sensor B) should be connected to the 465 Current Transmitter Board #2 (FT2), the four wires for Sensor # 3 (or Sensor C) should be connected to the 465 Current Transmitter Board #3 (FT3), and the four wires for Sensor # 4 (or Sensor D) should be connected to the 465 Current Transmitter Board #4 (FT4). The locations of the 465 Current Transmitter Boards inside the 195 enclosure are shown in Figure 1-1.

Figure 1-1. *465 Current-Transmitter Boards Inside 195 Enclosure*

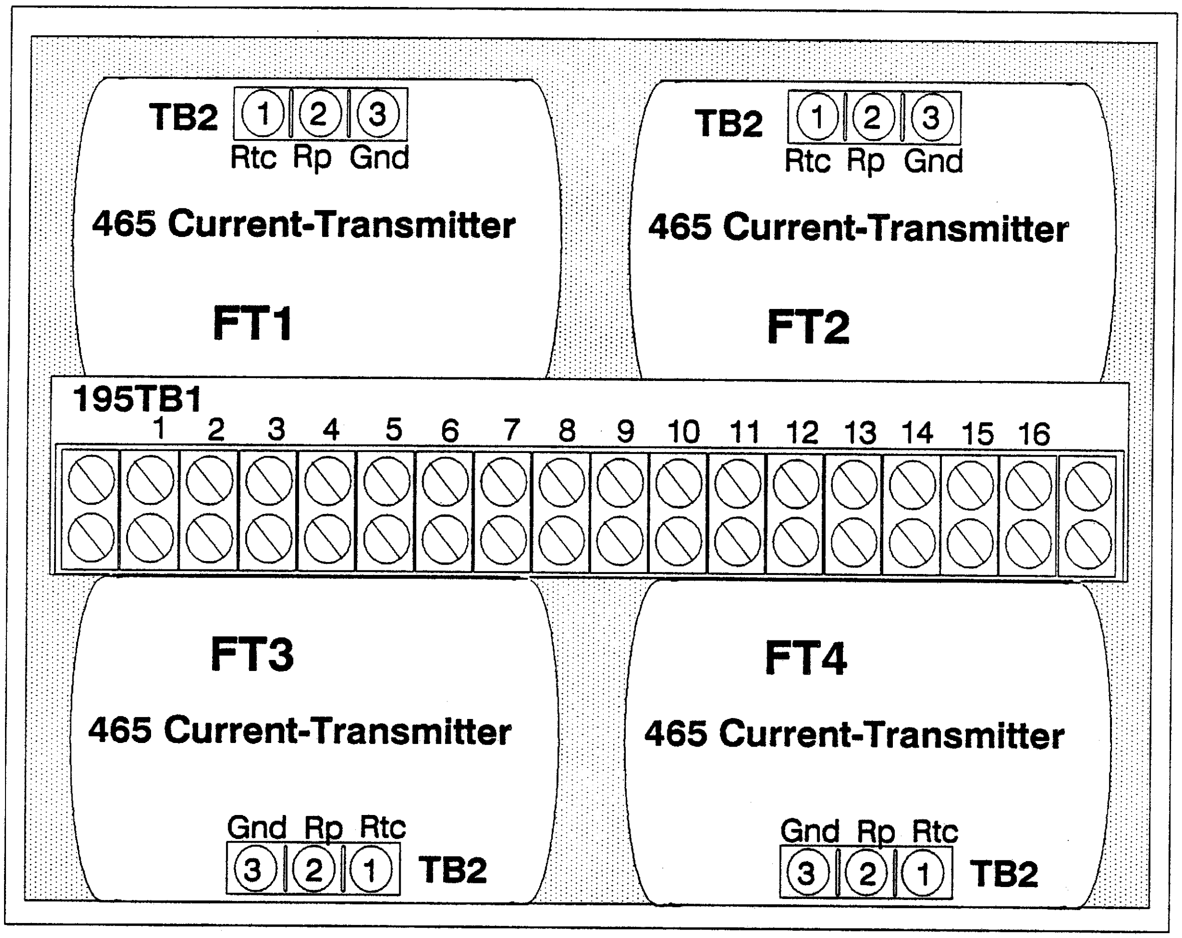


Table 1-1. *Sensor Cable Wire Colors and Terminal Connections*

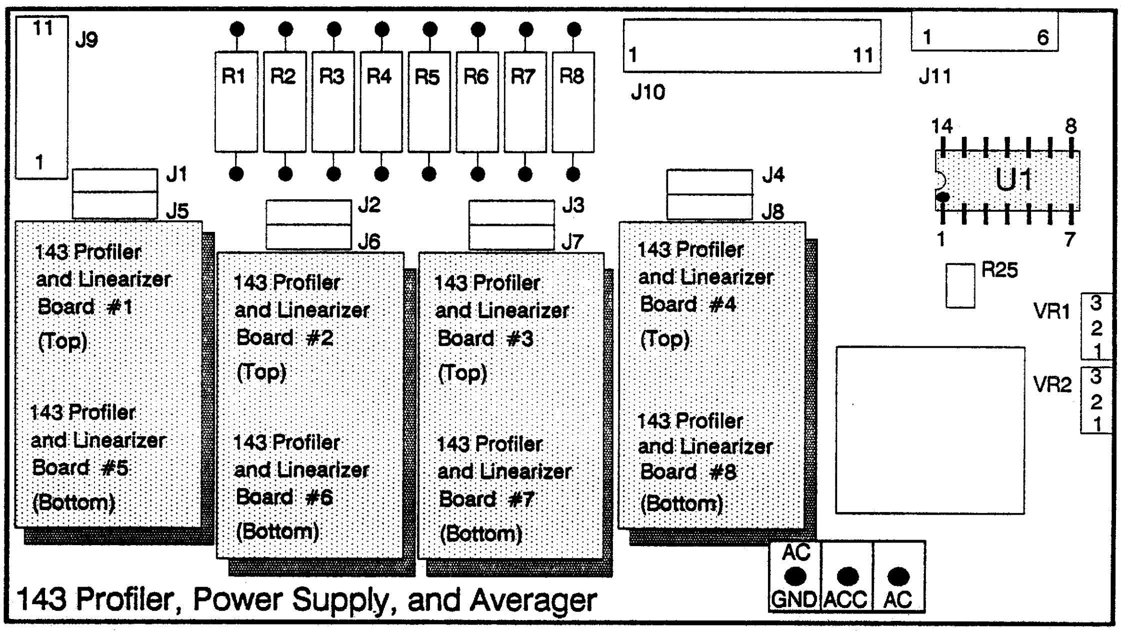
Signal	Color			Terminal
	Teflon Cable	Teflon Wire	Tefzel Cable	
R_{tc}	White/Blue	White	White/Blue	1
R_p	White/Orange	Red	White/Orange	2
R_{tc} GND	White	White	White	3
R_p GND	White/Green	Red	White/Green	3
Shield	*shield*	N/A	*shield*	*

** Shield is used on remote current-transmitter electronics and is connected to earth ground at electronics. The circuit ground used on the current-transmitter board (i.e. Rtc GND, Rp GND, and GND) is not connected to any other ground.*

1.2 Testing the 143 Profiler, Power Supply, and Averager Board

The electronics assembly inside the 151 module consist of the 143 Profiler, Power Supply, and Averager Board (baseboard) and one to eight 143 Profiler and Signal Linearization Boards (one per sensor). The smaller 143 Profiler and Signal Linearization Boards are mounted on top of the 143 Profiler, Power Supply, and Averager Board (baseboard). If there are more than 4 sensors in the system, additional 143 Profiler and Signal Linearization Boards are piggy-backed above the others. The electronic assembly is shown in Figure 1-2.

Figure 1-2. *Locations of the 143 Profiler and Linearizer Boards on the 143 Profiler, Power Supply, and Averager Board*

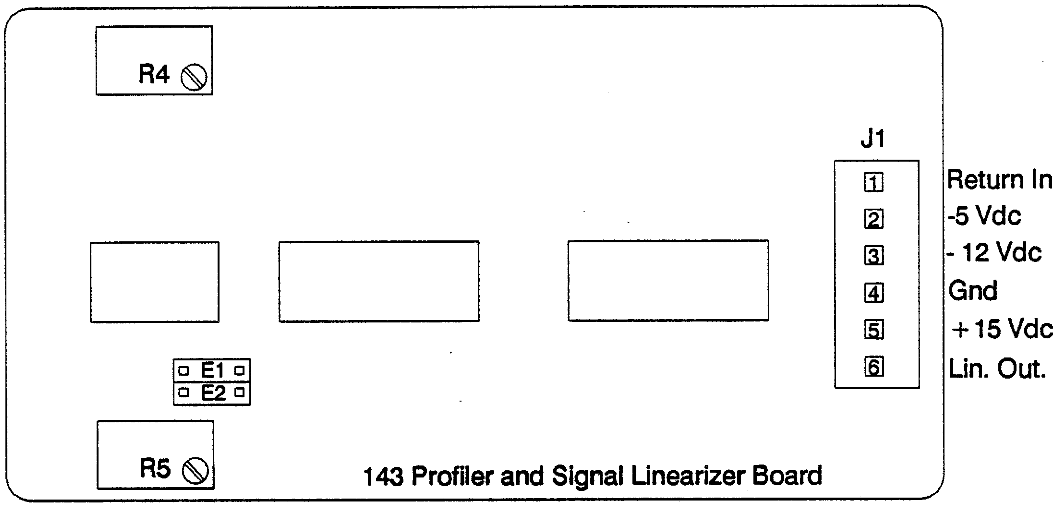


To test the power supplies provided by the 143 Profiler, Power Supply, and Averager Board, you will need:

- a digital voltmeter accurate to +/-.001 Vdc
- a flat-bladed screwdriver with a narrow blade and a long shaft

It is easiest to measure the supplies at the connector J1 on the 143 Profiler and Linearizer Boards. It is through this connector that the signals are transmitted between the 143 Profiler, Power Supply, and Averager Board (baseboard) and each of the 143 Profiler and Linearizer Boards. Refer to Figure 1-3 for the location of J1 on the 143 Profiler and Linearizer Board.

Figure 1-3. *143 Profiler and Linearizer Board*



The placement of the 143 Profiler and Linearizer Boards on the 143 baseboard is shown in Figure 1-2. The connector J1 on the linearization board for sensor #1 is connected to J1 on the 143 baseboard, J1 on the the linearization board for sensor #2 is connected to J2 on the 143 baseboard, J1 on the the linearization board for sensor #3 is connected to J3 on the 143 baseboard, and so on.

All test steps **except** step 4 can be verified with the 143 Profiler, Power Supply, and Averager Board (and the adjoining 143 linearizer boards) disconnected from the 465 board. This allows you to remove and test the 143 board outside of the enclosure. When the 143 board is removed from the enclosure a power source must be connected as follows:

AC Gnd. - Terminal Block 1, Terminal # 1
ACC - Terminal Block 1, Terminal # 2
AC - Terminal Block 1, Terminal # 3

The location of the AC connections is shown in Figure 1-2.

You can verify the power supplies to each of the linearization boards or a single board that is associated with a particular sensor. An example of the test procedure for testing the 143 circuits for sensor #1 is described in this subsection.

Step 1: Measure the voltage between pins 3 (-12 Vdc) and 4 (GND) of J1 on the 143 linearizer board for sensor #1. The voltage should be -12.000 +/- 0.36 Vdc.

As shown in Figure 1-1, the linearizer for sensor #1 is located on the left-hand side of the board. Connector J1 on the linearizer board is connected to J1 on the baseboard. If there are more than 4 sensors in the system, the linearizer for sensor #1 is mounted on top of spacers above the linearizer for sensor #5.

If this voltage is absent or out of range, check the connection between the 143 baseboard and the 143 linearizer board. If the connection is good, measure the voltage between pins 1 (GND) and 3 (-12 Vdc) of VR1 on the 143 Profiler, Power Supply, and Averager Board. If the voltage on pin 3 is absent, check the AC connections to the 143 baseboard. Refer to Figure 1-2 on page 1-4 for the locations of VR1 and the AC connections on the 143 Profiler, Power Supply, and Averager Board.

Step 2: Measure the voltage between pins 5 (+15 Vdc) and 4 (GND) of J1 on the 143 linearizer board for sensor #1. The voltage should be +15.000 +/- 0.45 Vdc.

If this voltage is absent or out of range, check the connection between the 143 baseboard and the 143 linearizer board. If the connection is good, measure the voltage between pins 2 (GND) and 3 (+15 Vdc) of VR2 on the 143 Profiler, Power Supply, and Averager Board. If the voltage on pin 3 is absent, check the AC connections to the 143 baseboard. Refer to Figure 1-2 on page 1-4 for the locations of VR2 and the AC connections on the 143 Profiler, Power Supply, and Averager Board.

Step 3: Measure the voltage between pins 2 (-5 Vdc) and 4 (GND) of J1 on the 143 linearizer board for sensor #1. Adjust R25 to get a voltage of -5.000 +/- 0.001 Vdc.

If this voltage is absent or out of range, check the connection between the 143 baseboard and the 143 linearizer board. If the connection is good, measure the voltage between pins 5 (GND) and 7 (-5 Vdc) of U1 on the 143 Profiler, Power Supply, and Averager Board. If the voltage on pin 7 is absent, check the AC connections to the 143 baseboard. Refer to Figure 1-2 on page 1-4 for the locations of U1 and the AC connections on the 143 Profiler, Power Supply, and Averager Board.

Step 4: Measure the voltage between pins 1 (RET IN) and 4 (GND) of J1 on the 143 linearizer board for sensor #1. This is the current-sense voltage derived from the sensor's return signal. With no flow passing by the sensor, the voltage should be approximately 0.6 Vdc. With maximum flow, the voltage should be approximately 2.00. This voltage is nominal. Refer to the calibration certificates that accompany your system.

If this voltage is absent or out of range, check the connection between the 143 baseboard and the 143 linearizer board. If the connection is good, measure the voltage between pin 1 (GND) and the pin 2 of J10 on the 143 Profiler, Power Supply, and Averager Board. The return signals for sensors 2 through 8 can be measured on pins 3 through 9, respectively. Refer to Figure 1-2 on page 1-4 for the locations of J10 on the 143 Profiler, Power Supply, and Averager Board.

If the voltage on J10 pin 2 (or pin 3-9) is absent, check the connections between the 195 Current-Transmitter Enclosure and the 193 System Electronics Enclosure. Refer to the field wiring interconnection drawings supplied with your system to verify that the return signal for that sensor is present at the correct field terminal. If it is not, check the appropriate 465 Current-Transmitter Board.

1.3 465 Current-Transmitter Board Bridge-Voltage Tests

To perform the current-transmitter board bridge-voltage test, you will need a digital voltage meter accurate to within +/-.001 Vdc.

Before you perform the test, check to make sure that the following four conditions are met:

- The sensor wires are correctly wired to the appropriate 465 Current-Transmitter Board as described in Section 1.1.1.
- No flow is moving past the sensor.
- AC power is supplied to the 143 Profiler, Power Supply, and Averager Board.

The test consists of checking the voltages between pairs of test points on the current-transmitter board. The test points are labeled on the board itself as "TP1", "TP2", and "TP3". They are called out for easy reference in Figure 1-4 (465R4) and Figure 1-5 (465R5). Although the 465R5 board has additional test points, only "TP1", "TP2", and "TP3" are used for this test procedure.

Figure 1-4. *465R4 Current-Transmitter Board Test Points*

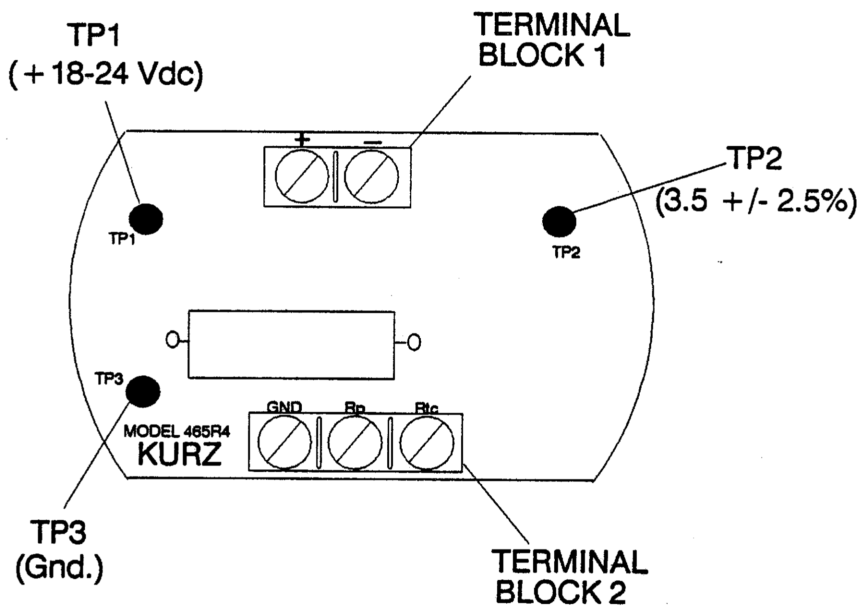
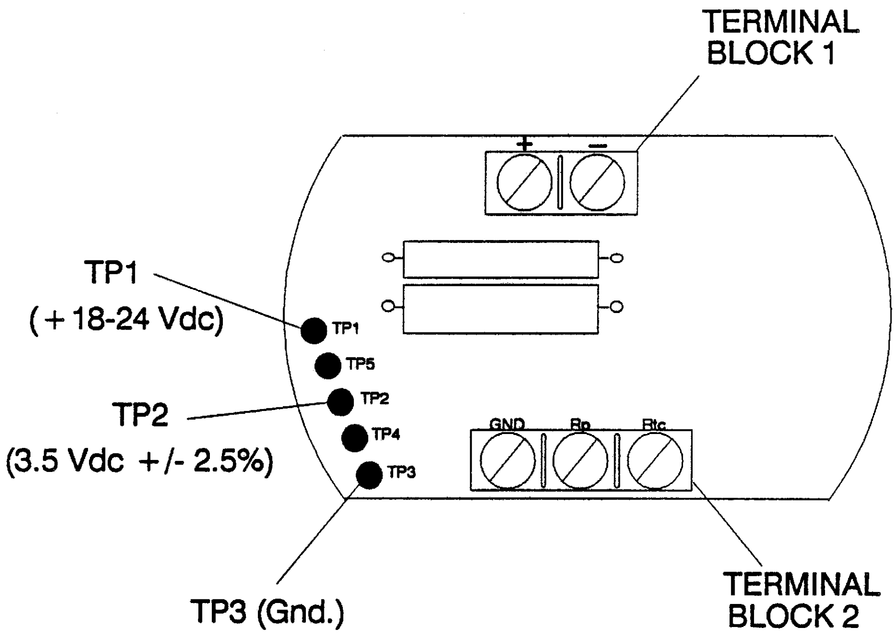


Figure 1-5. *465R5 Current-Transmitter Board Test Points*



Step 1: Check the voltage between Test Point 1 (TP1) and Test Point 3 (TP3, ground). This is the unregulated supply voltage (from the 435R1 board) and should read in the range of +18-24 Vdc.

Step 2: Check the voltage between Test Point 2 (TP2) and Test Point 3 (TP3, ground). This is the bridge voltage and should read 3.5 Vdc +/- 0.0875 (2.5% of 3.5 Vdc), under no flow conditions. This is the nominal reading; refer to your calibration certificate for the exact rated voltage of your unit.

CAUTION: If the bridge voltage is +5 Vdc or more (with no flow moving past the sensor), and the voltage does not start to drop below five volts within five to ten seconds, turn power off **immediately**. Supplying power for more than five to ten seconds under these conditions may result in damage to the probe.

Section 2: Calibrating the 151 Linearization Module

The recalibrate the 151 Linearization Module used in an EVA or IK-EVA system you will need:

- A digital voltmeter accurate to +/-.001 Vdc.
- A Laminar Flow Element (LFE) or wind tunne.l
- A thermometer placed in such a way as to accurately determine the temperature of the air flowing through the laminar flow element.
- A barometer to measure the pressure in the area in which the flow meter is calibrated.
- The certification sheets supplied by Kurz with the system.
- Laminar flow element graph that is supplied with the NBS-traceable laminar flow element.
- Data sheets or worksheets for recording calibration information. A sample calibration data sheet is provided in Appendix A. You are free to duplicate this sheet for your use when calibrating the system.

The digital voltmeter, laminar flow element, thermometer, and barometer used to calibrate the system should be NBS-traceable.

2.1 Check Voltages and Wiring Interconnections

Before you begin calibrating the 151 Linearization Module, make sure you have completed the tests described in Section 1. This includes verifying the voltages on the 143 Profiler, Power Supply, and Averager Board and 465 Current-Transmitter Boards.

Also, the connections should have been checked between:

(1.) the sensor wires and the 465 boards inside the 195 enclosure
(2.) the 195 enclosure and the 193 enclosure
(3.) the 143 Power Supply, and Averager Board (baseboard) and each 143 Profiler and Linearizer Board in the system.

If you are removing a 151 module from the 193 enclosure, refer to Appendix A for information on how to connect the electronics.

2.2 Record Flow Rates

Record the flow rates for the calibration points in the first column of the table used on the data sheet. The flow velocities are listed on the certification sheets provided with your system.

However, if you want to calibrate the system to measure a different flow range:

Step 1: Record the maximum flow rate in the last row of the flow column, point #11.

Step 2: Divide the maximum flow rate by 10. This is the decremental value that will be used to obtain flow rates for calibration points #2 through #10. For example if the maximum flow rate is 1500 SFPM (Standard Feet Per Minute) then the decremental value is 150.

Step 3: Subtract this value from the maximum flow rate (point #11) to obtain the flow rate for point #10.

For example if the maximum flow rate (point #11) is 1500 SFPM, then the value for point #10 is 1350 SFPM (1500-150). Next, subtract the decremental value from the flow rate for calibration point #10 to obtain the value for point #9 (1350-150 = 1200). Continue to subtract the decremental value from each calculated flow rate to obtain the flow rate of the preceeding calibration point until you have calculated the rate for point #2.

Step 4: After you have calculated the flow rate for calibration point #2, divide this rate by half to obtain the flow rate for calibration point #1.

Step 5: The value for calibration point #0 is 0.

If you were calibrating an EVA or IK-EVA system that had a flow range of 0-1500 SFPM, the flow ranges would be as shown in Figure 2-1.

Figure 2-1. *Calibration Velocities Recorded on Data Sheet (Example)*

	Flow Rate SFPM	Inches H_2O	Ideal Voltage	Current Sense Voltage	Non-Linear Voltage	Actual Output Voltage	Actual Output mA
0	0						
1	75						
2	150						
3	300						
4	450						
5	600						
6	750						
7	900						
8	1050						
9	1200						
10	1350						
11	1500						

	Break Point Voltage	Linear Vdc	Linear Output mA
1			
2			
3			
4			
5			
6			
7			

LFE S/N: ________________
Model #: ________________
DVM S/N: ________________
Temp. S/N: ________________
Bar. S/N: ________________
Freq. Ctr S/N: ________________
Pipe Size: ________________
Pipe Area: ________________
4-20mA Range: ____________

Date Due: ________________
LFE Area: ________________
Date Due: ________________
Date Due: ________________
Date Due: ________________
Date Due: ________________
I.D.: ________________

Model: ________________
Range: ________ Range 2: ________
Power: VAC _____ Hz _____ VDC ____
Current Mode: YES _____ NO _____
DVM Reading: ____________
Bar. Pressure: ______________ "hg
Temperature: ______________ ° F
Calculated: R2 _______ R7 _______
Summing Amp.: Rf _____ Cap ______

COMMENTS

VOLTAGE DATA
Rectified: +V: _______ -V: _______
Regulated: +V: _______ -V: _______
Vdc Ref.: ________________
BV: Zero Flow: ____________
BV: Max Flow: ____________

CURRENT SENSE VOLTAGE
Zero Flow: ______________
Max. Flow: ______________
For Sensor Safety Circuit Only:

2.3 Record "Inches H_2O"

Record the "Inches H_2O" listed for each flow range from the laminar flow element graph supplied with your laminar flow element (LFE). Depending on the type of laminar flow element you have purchased from Kurz Instruments, the flow values will either be in velocity (such as Standard Feet Per Minute, SFPM) or in units of mass flow (Standard Cubic Feet per Minute, SCFM). Examples of laminar flow element graphs and "Inches H_2O" values are shown in Figures 2-2 and 2-3, on pages 2-5 and 2-6.

The laminar flow elements are calibrated for standard conditions of 25°C (70°F) temperature and 29.92 Hg. barometric pressure. Given standard conditions, the manometer attached to the LFE should indicate the "Inches H_2O" for a specified flow rate as shown by the laminar flow element graph. For example, the graph shown in Figure 8 indicates that when the flow is increased to 1900 SFPM (under standard conditions of 25°C and 29.92 Hg. pressure) the manometer should show 2" of water.

In most cases the temperature and/or pressure will not be standard and you will adjust for these differences later in the calibration procedure.

Figure 2-2. *Example of Laminar Flow Element Graph for Laminar Flow Element*

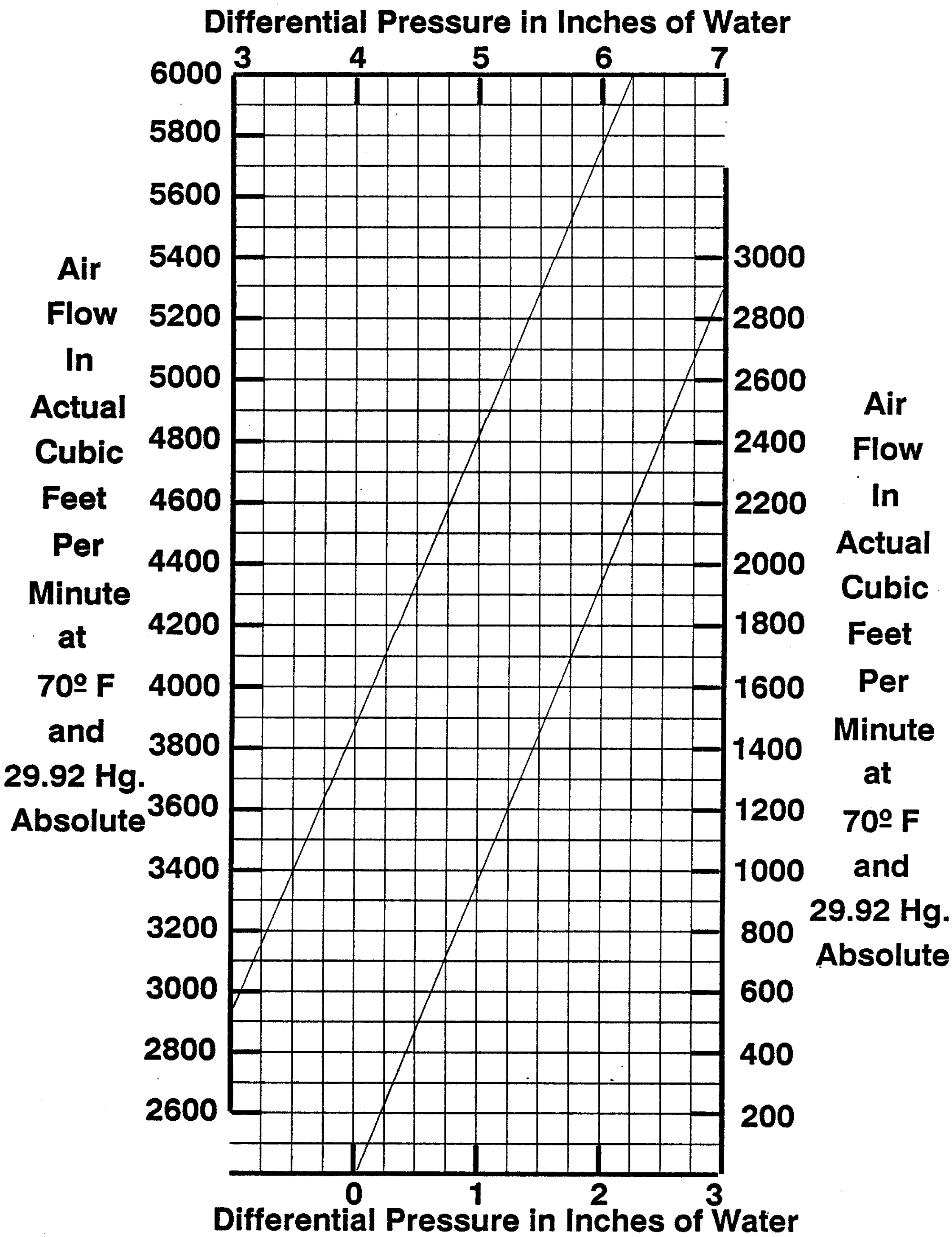


Figure 2-3. *"Inches H2O" Values from Laminar Flow Element Graph Shown in Figure 2-2*

	Flow Rate SFPM	Inches H_2O	Ideal Voltage	Current Sense Voltage	Non-Linear Voltage	Actual Output Voltage	Actual Output mA
0	0	0					
1	75	.090					
2	150	.160					
3	300	.310					
4	450	.470					
5	600	.620					
6	750	.780					
7	900	.930					
8	1050	1.090					
9	1200	1.245					
10	1350	1.410					
11	1500	1.575					

	Break Point Voltage	Linear Vdc	Linear Output mA
1			
2			
3			
4			
5			
6			
7			

LFE S/N: ______________
Model #: ______________
DVM S/N: ______________
Temp. S/N: ______________
Bar. S/N: ______________
Freq. Ctr S/N: ______________
Pipe Size: ______________
Pipe Area: ______________
4-20mA Range: ______________

Date Due: ______________
LFE Area: ______________
Date Due: ______________
Date Due: ______________
Date Due: ______________
Date Due: ______________
I.D.: ______________

Model: ______________
Range: ________ Range 2: ________
Power: VAC _____ Hz _____ VDC ___
Current Mode: YES _____ NO _____
DVM Reading: ______________
Bar. Pressure: ______________ "hg
Temperature: ______________ °F
Calculated: R2 _______ R7 _______
Summing Amp.: Rf _____ Cap _____

COMMENTS

VOLTAGE DATA
Rectified: +V: _______ -V: _______
Regulated: +V: _______ -V: _______
Vdc Ref.: ______________
BV: Zero Flow: ______________
BV: Max Flow: ______________

CURRENT SENSE VOLTAGE
Zero Flow: ______________
Max. Flow: ______________
For Sensor Safety Circuit Only:
Zener ________ V Ballast ________