KURZ INSTRUMENTS INC.™

Complex Technology Made Simple

Technical Reference

Series 155
Mass Flow Computer
User Guide

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Preface

Before You Begin

Important ***The device warranty is void if it is not installed in accordance with the installation requirements specified in this guide. Read and thoroughly understand the installation requirements before attempting to install the device. If you have any questions, contact your Kurz customer service representative before attempting installation.***

Using this Manual

Kurz Instruments, Inc., documentation includes printed manuals and product literature, Adobe Acrobat PDF files, and application online Help files. The Kurz Instruments CD contains all the available documentation files. To read PDF files, download the free Adobe Acrobat Reader from www.adobe.com.

The Kurz Instruments Web site provides additional information:

- **World Wide Web:** www.kurzinstruments.com
- **Email:** service@kurzinstruments.com
- Documentation links to the most current manuals and literature

You can access device support in the following ways:

- **Main:** 831-646-5911
- **Phone:** 800-424-7356
- **Fax:** 831-646-8901

Manual Conventions

The following table lists conventions used in the Kurz Instruments, Inc., documentation, and gives an example of how each convention is applied.

Table 1. Conventions used in this manual

Convention	For Example
Text type, click, or select (for example, field names, menus, and commands) are shown in bold.	Check the **Configuration File** checkbox.
Text appearing in a display or window is shown in courier.	`PRESS ENTER TO` `SET METER DATA`
An arrow (→) is used to separate a menu name from its menu command.	Select **Start→All Programs→Kurz Instruments→KzComm**.
Simplified directory structures and path names are used in examples. Your folder names may be different.	Programs Files\Kurz Instruments\KzComm.

Hardware Requirements

KzComm uses XMODEM, Modbus RTU, MODBUS TCP/IP, or terminal communications protocols to communicate with the Kurz MFT Series, B-Series, Series 155, and Series 2440.

- The B-Series use the XMODEM communication protocol via USB port, or the MODBUS protocol via RS-485 port or MODBUS TCP/IP. The Kurz USB device driver or FTDI USB device driver must be installed before attempting to connect a computer with a B-Series device via a USB cable.
- Series 155 Computer/Transmitter uses terminal communications via an RS-232C port.
- MFT Series and Series 2440 Portable Flow Meter use the XMODEM communications protocol via an RS-232C port.

B-Series Devices

The B-Series devices require:

- A two-wire shielded cable for Modbus RTU.
- For the XMODEM protocol, a USB Type A-to-mini B cable.

  Note The Kurz USB device driver or FTDI USB device driver must be installed before attempting to connect a computer with a B-Series device via a USB cable.

- For the Modbus TCP/IP protocol, an Ethernet cable to a Modbus TCP/IP to RS-485 gateway.

Series MFT Devices

MFT Series devices require:

- A one-to-one pin configuration of the communication cable using a DB9 connector at both ends. The cable (part #260102) is available from Kurz Instruments.

  Note If the computer has a DB-25 port instead of a DB9 com port, use a DB25-to-DB9 adapter.

- One RS-232C communication port on the computer or a USB-to-RS-232C adapter for the computer.

Series 2440 Models

Series 2440 models require:

- A one-to-one pin configuration of the communication cable using a DB9 connector at both ends. The cable (part #260102) is available from Kurz Instruments.

  Note If the computer has a DB25 port instead of a DB9 com port, use a DB25-to-DB9 adapter.

- One RS-232C communication port on the computer or a USB-to-RS-232C adapter for the computer.
- An available I/O adapter board. The I/O adapter board (part #260106 and #420334) for the Series 2440 is available from Kurz Instruments.

Series 155 Mass Flow Computer

KzComm can communicate with a Series 155 Mass Flow Computer running KAS 6.81. Series 155 configuration files can be uploaded, downloaded, and printed for reporting purposes. Functions that are not configured are not downloaded and do not appear in the report. KzComm does not support pass-through commands for reconfiguring devices connected to the Series 155.

Series 155 models require one RS-232C communication port on the computer or a USB-to-RS-232C adapter for the computer.

Software Requirements

KzComm is supported on Windows XP, Windows Vista, Windows 7, and Windows 8. All platforms require up-to-date service packs.

Note On Windows Vista, downloading the Trend Log has infrequently caused the operating system to freeze (no screen activity). Restart the computer as described in your computer hardware manual.

Basic computer knowledge is necessary for copying and moving files, navigating file structures and identifying file types, and installing applications. You will need a decompression utility to extract files from compressed file packages.

The Kurz USB device driver or FTDI USB device driver must be installed before attempting to connect a computer with a B-Series device via a USB cable. Both drivers are available during the KzComm installation, on the Kurz customer CD in the USB Device Driver folder, and on the Kurz website (kurzinstruments.com). The FTDI USB driver is a 64-bit virtual COM port (VCP) driver available from the FTDI Chip website (ftdichip.com).

Chapter 1

Introduction

Overview

This chapter provides definitions for commonly used terms and lists product approvals.

Terminology

Alarms

There are up to eight alarms available on the Series 155, depending on the model. Alarm channels are associated with a meter number. Alarms can be based on flow/temperature events or sensor kickout. Alarm events can be on/off, normally opened or closed, high, low, or high/low based on a set point. The alarms are self-clearing; however, the screen may hold the alarm until you press Clear (**C** key). There are no dead-band or hysteresis settings for the alarms.

Calibration

Output and input circuits must be matched to real voltage and currents using the Calibration parameters.

The input calibration uses various methods of substituting a zero or span voltage to the input channels for each device connected to the Series 155. (See the field wiring diagram for switch identification.) There is typically a calibrate/operate switch and (for the Calibration parameters) a switch for selecting zero or span. The span voltage must be measured with a 4.5-digit multimeter with 0.1% basic DC accuracy to calibrate the inputs. As input voltages are raised to about the 4th power to convert the raw input to a flow or velocity, this critical process must be performed using an accurate voltage standard.

Channel

Channel applies to one of the flow sensor inputs. There are up to 22 channels assigned letters A through V depending on the Series 155 model. The sensor calibration curve or linearizer table is associated with its corresponding channel. A sensor's serial number is programmed with its calibration data to facilitate connecting a sensor to the correct channel.

Channel kickout

This specifies when a defective flow element is removed from the flow calculations.

Data logging

There are three ways to extract data from the Series 155:

- Use a terminal emulator (such as Tera Term) to log the screen data and capture the output text to a file. Output data will occur about every two seconds but without a timestamp.
- Issue an x command to the terminal port for a summary of all meters with a time/date stamp. (It is recommended to turn off terminal echo.) This can be semi-parsed to be readable by a spreadsheet program for trend plots or additional data processing. The Kurz data logging program supports parsing, provides a programmable polling rate, and can average samples.

- The printer data logging port provides summary data similar to the x command. Pressing the L key on the front panel, using an internal timer, or a using remote terminal to issue the l command (lowercase “L”) sends data to the data logging port or the second serial port of the Series 155. The internal timer log interval can be set in 1 minute increments up to 999 minutes.

Flow meter	Flow meter refers to the enclosure containing the flow processing controls and the sensor support. A flow meter has at least one input channel and typically one output. The Series 155 can support up to 16 flow meters, depending on the model.
Input channel filtering	Flow noise reduction is achieved by choosing a time constant (tau, t), like that which applies to an electrical circuit with a resistor (R) and capacitor (C) making a low pass filter, t = RC. With a step change on the input, after one time constant the output will reach 63% of its final value. The settling time is about five time constants to reach the final output within 1%.
Input channel linearizer	The linearizer tables allow the Series 155 flow computer to do a LaGrange second order interpolation of the calibration data. Up to 15 points can be entered. For units with multiple temperature sets or Velocity Temperature Mapping (VTM), you can enter up to seven points per temperature with three temperatures maximum. You also specify the reference meter that has the temperature signal for this second order correction with each input channel.
Meter setup	ID, area, flow units, specific gravity (if mass flow engineering units) including channels and correction factor CCF/VCF.
Output	There are from one to eight analog output ports depending on the Series 155 model. Each output is either 0-5 V or 4-20 mA. You scale the meter output (engineering units) to the analog scales in analog output area.
Output setup	The output channel assignment and scale for a meter are programmable.
PID control	The Series 155 can operate the Kurz 730 electric valve, which regulates flow based on a fixed internal set point or an external set point using a +/- 15 VDC drive signal to open or close the valve. The PID controller can also command a 4-20 mA valve or motor speed control directly but an external integrator board is required to convert the +/- 15 VDC pulsed motor drive to a continuous current. Each PID channel uses two alarm channels.

Pulsed output	You can assign up to eight alarm output channels to be pulsed total outputs. Totalizing a specific amount of volumetric flow (CF) or mass (lb) will generate a 50 ms pulse (active low), simulating the output of a mechanical totalizing meter. The pulse rate is limited to the output update rate (0.3 to 2.4 s) and cannot be used to measure flow rate as a variable frequency. Contact Kurz for Series 155 field wiring diagrams.
Serial port	The Series 155 has two serial ports — the Terminal serial port and the Log serial port, which receives reports when you are in Log mode.
System configuration	The Series 155 flow computer (based on the model and features ordered with the system) determines your site configuration for input channels, flow meters, outputs, alarms, PID channels, pulsed outputs, logging, and standard air density. This configuration can be changed only by Kurz customer service.
System units	You can select either English or international (metric) units for system measurements. This configuration is determined when ordering the system.
Time and date	The realtime clock and calendar annotates the screen and logged output. The clock has one-minute resolution.
Totalizer reset	Each flow meter has its own flow total and elapsed time that can be reset to zero. The internal variables are limited to approximately seven digits and will accumulate the total for about four years (~1% mistrack). This parameter should be cleared every few years.

Product Approvals

In accordance with Directive 89/336/EEC for industrial, scientific and medical (ISM) equipment, all the Series 155 models are CE compliant. All mass flow computers in the Series 155 have been designed and manufactured in accordance with the EN 50081-1 light industrial, commercial, and residential equipment emissions standard and the EN 50082-2 heavy industrial equipment immunity standard. All Series 155 models have been designed and manufactured according to the electrical safety principles embodied in the Low Voltage Directive (73/23/EEC and 93/68/EEC) and use good engineering practice where other aspects of safety are concerned. All models exceed the low voltage directive by having a non-incendive safety approval from CSA (Ex nA II T4).

The complete declaration of CE compliance and safety for the Series 155 is available by contacting Kurz Instruments.

Kurz Document #	Description
430005	Declaration of CE compliance for 155Jr/Jr-Tr
430010	Declaration of CE compliance for 155A/B/B-RM
430021	Declaration of CE compliance for 155C-2/E-2/RM2
430004	Non-incendive Safety approval (Ex nC II T4) for 155Jr from KEMA
430022	Non-incendive Safety approval (Ex nC II T4) for 155Jr/Jr-Tr from CSA
430019	Non-incendive Safety approval (Ex nC II T4) for 155A/B/B-RM from CSA
430031	Non-incendive Safety approval (Ex nC II T4) for 155C-2/E-2/RM2 from CSA

Chapter 2

Menus & Settings

Overview

The Series 155 flow computers (five models supporting 1, 3, 6, 11, and 22 channels) perform the following system functions in a multipoint duct/stack monitoring system:

- 24V DC power to each flow sensor electronics board
- Flow and temperature averaging
- Kickout of dead channels from the average
- Flow rate dependent correction factors for flow profile compensation
- Provides analog output for meter data
- Meter totalization and alarms

This chapter describes the Series 155 user interface, various access modes, and step-by-step instructions for common configuration tasks.

Series 155 User Interface

The Series 155 user interface (Figure 2-1) includes a display with two rows of 16 characters and a keypad with 20 keys (some of which have dual functions).

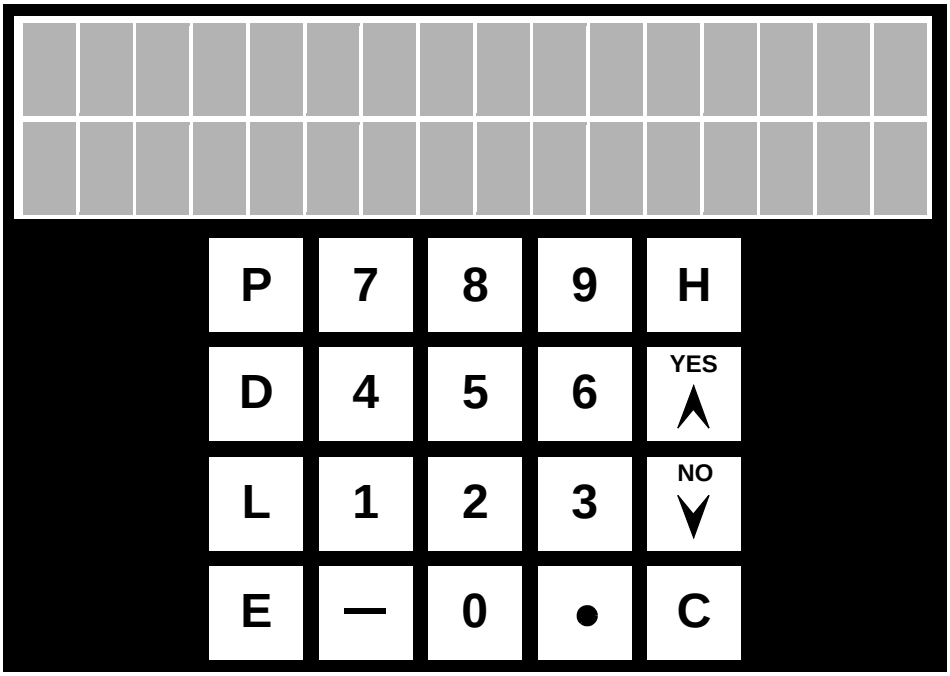


Figure 2-1. Series 155 user interface

The symbol keys are:

- The up (^) and down (v) arrow keys are used to scroll through a menu. The scroll option is available when the symbol ^v appears.

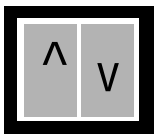


Figure 2-2. Menu suboption indicator

- The bar key (—) is used for entering negative values.
- The dot key (•) is used for entering decimal places.

The letter keys are used as follows:

- The **P** key accesses Program mode for making configuration changes to a flow meter. This is a password protected mode.
- The **D** key accesses Display mode for a view-only of each meter's flow, velocity, and temperature of the processed gas. Press the arrow keys to scroll through the list of available meters, then press **D** to scroll through a specific meter's information.
- The **L** key accesses Log mode and sends reports to the flow meter's Log serial port.
- The **E** key accesses the settings for each flow meter attached to the Series 155. The **E** key is also used as an Enter key and to accept and save changes after entering data.
- The **H** key is the Hold key, and it retains the current parameter on the screen. Press **C** to remove a hold. Press **HH** to access the help menu.
- The **C** key is used to clear a data entry field or to exit a prompt without making changes.

The alphanumeric keys include numbers 0 through 9. For data fields that accept alphabetic data, continue pressing an arrow key to cycle through the letters. For example, if you wanted to enter the letter "R," you would press an arrow key to cycle through the alphabet. Press the **E** key to save the selection and move to the next field.

Navigating the Menus

The Series 155 Mass Flow Computer can be used with any Kurz flow meter that is calibrated for:

- Velocity as insertion elements
- Volumetric/mass flow on the in-line flow elements

The Series 155 provides power to the flow element, provides a local/remote screen, linearizes the data, averages, alarms, and provides 4-20 mA scaled linear outputs. The Series 155 also post-processes the linearized signal from flow transmitters.

To operate the Series 155 control panel, use the keypad navigation keys or equivalent lowercase keys via a remote RS-232 terminal. The remote terminal operation uses a straight through DB-9 connector from a computer serial port to the data terminal port on the Series 155. The user interface is described in "Series 155 User Interface" on page 2-2.

Operating Modes

There are four operating modes for the interface following boot up.

- Executive mode scrolls through the online help and date/time while performing all flow calculations on a (2+ # channels) x 0.1 s loop time for the 4-20 mA outputs.

  Note If there is no keypad activity for 2 minutes the screen reverts to Executive mode unless you have placed a hold (press **H**) on the current screen.

- Display mode allows you to scroll through each meter for the flow, velocity, and temperature.
- Program mode allows you to configure the parameters of the flow computer.
- Boot-up error mode occurs at initial power-on of the Series 155. An error code appears if a problem is detected with any configuration or linearization data. System boot stops until you press **C** to acknowledge the error. Depending on the error, the system will attempt to operate normally using default data, which you can modify once boot-up completes. See the Troubleshooting appendix for additional information.

Help Mode

Help mode (**HH**) provides quick help for keypad options.

Table 2-1. Help Messages

Messages
P=Program mode; Press P for see or change system
D=Display mode; Press D to see meter data
L=Log mode
E=Enter; Press E to accept displayed choice
H=Hold; Press H for Hold any display
HH=Help; Press HH for Help
C=Clear; Press C to clear a “held” display or as a safe escape
To make a change push ^v or push digit keys and then press enter
Clear escapes without change

Display Mode

Display mode (**D**) provides view-only access to all flow meter data, flow rate, average velocity, and mass rate, including channels and kickout status, flow area, and channel response.

To view the parameters for a flow meter, press **D**, press the number or arrow keys to select the flow meter number (1 to 16), then press **E** to select the flow meter.

```
DISPLAY NEXT ^v
METER #XX
```

Scroll through the flow meter parameters by pressing **D** or **E**.

Note All examples use velocity for insertion and in-line flow meters. Examples for temperature, mass rate, or a sum meter are not shown. The order in which screens appear is determined by your configuration.

- Meter ID, date, and time

```
ID: meterID
hh:mm  mm/dd/yyyy
```

- Meter flow rate

```
FLOWRATE
41,045.4 SCFM
```

The meter flow rate is averaged data based on the time constant parameter specified in the Input Filter menu in Program mode. The flow rate on an insertion flow meter is the average velocity multiplied by the correction factor (at this average velocity) multiplied by the meter area.

- Meter totalization and elapsed time since the last totalizer reset

```
SCF 234567
ET = 3489.1 MIN
```

The totalization algorithm has approximately six digits of resolution, totalizes for about four years, and be within 1% of the true value. The time resolution is to 0.1 minutes for the totalization.

- Average velocity

```
AVERAGE VELOCITY
6089.45 SFPM
```

Average velocity is based on a straight average of all the input channels assigned to the flow meter multiplied by the correction factor at the raw velocity computed.

- Flow area used to multiply the average velocity

```
FLOW AREA
3.567 SQ FT
```

- Correction factor or calibration factor applied to the meter at the current raw average velocity

```
CALIBRATION
FACTOR 1.00
```

The correction factor is required to convert the point velocity measurements to the true average (as specified for the calibration in field calibration methods).

For metric meters, this will be square meters.

- Input channel

```
AVG'D CHS ABCDEF
G?IJ
```

Each input channel is represented with a letter in alphabetic sequence. An input channel that has been kicked out is indicated with a question mark (?). The example uses input channels A through J with channel H kicked out.

- Raw, unfiltered flow rate or velocity for that input channel and its corresponding input voltage from a bridge board or flow element output

```
A = 5478.46 SFPM
INPUT = 1.896 V
```

This voltage is generated from a current flowing from the bridge circuit or a 4-20 mA transmitter flowing through a current sensing resistor. The current sense resistors vary from 5 to 15 ohm for bridge boards and are typically 250 ohm for 4-20 mA inputs.

Program Mode

The Series 155 Program mode allows you to view or change configuration parameters.

To enter Program mode:

1> Press **P**.

2> Enter the user code (the default is 123456) or the tech code (the default is 654321).

The user code is limited to setting up alarms, viewing PID operation, and channel kickouts. The default access codes can be changed by Kurz customer service.

3> Press **E**.

Note Anytime you make configuration changes, the message “New Value Accepted” appears momentarily.

4> Press **P** to scroll through the Program mode functions.

Table 2-2. Program Mode Functions

Function
Reset Totalizers
Set Time & Date
Set Meter Data
Set Input Filter
Set Analog Out
Set Alarms
Set Channel Kickout
See Input Volts
Calibrate
Set Linearizers

This following sections provide common configuration tasks.

Calibrating 4-20 mA Output

The 4-20 mA calibration ensures the correct output. The 4-20 mA outputs are in cascade with the Series 155 0-5 V output. You can calibrate either the 0-5 V or the 4-20 mA but not both. The calibration menus in Program mode cover the 0-5 V output, which corresponds to 4-20 mA.

1> Enter Program mode and press **P** until the **Calibrate** menu appears.

```
PRESS ENTER TO
CALIBRATE
```

2> Press **E**.

```
PRESS ENTER FOR
OUTPUT CAL.
```

3> Press **E**.

```
SET ZERO VOLTS
CH 1 = 0.0000 V
```

4> Following the requirements specified for calibration under “Terminology,” use a current meter to monitor the 4-20 mA signal and press the number and decimal keys to set the value as close to 4.000 mA as possible. Then press **E**.

```
SET SPAN VOLTS
CH 1 = 5.0000 V
```

5> Use a current meter to monitor the 4-20 mA signal and press the number and decimal keys to set the value as close to 20.000 mA as possible. Then press **E**.

6> You will be prompted to set the values for the next output channel. Repeat the output calibration steps for all active output channels. If no other changes are required, press **C** until you exit Program mode.

Ranging 4-20 mA Output

To change the scale of the output range you must specify the zero value for 4 mA, the span for 20 mA, and the analog output channel assigned to the flow meter you want to transmit. The output units appear in either English or metric units and are determined by the flow meter measuring flow rate, mass, or temperature.

1> Enter Program mode and press **P** until the **Set Analog Output** menu appears.

```
PRESS ENTER TO
SET ANALOG OUT
```

2> Press **E**.

```
PRESS ENTER FOR
ANALOG OUT 1
```

3> You can select outputs **1** through **8** by pressing an arrow key, and then press **E**.

```
ANALOG OUT  1
ENTER METER # 1
```

4> Press an arrow key to assign flow meter **1** through **16** to specified output channel, and then press **E**.

```
OUT #1 NEXT TYPE
^v FLOW RATE
```

5> Press an arrow key to select either **FLOW RATE** or **AVG VELOCITY**, and then press **E**.

If you are measuring flow rate, flow units (KGM, PPH, PPM, SCFH, SCFM, SCMM, SLPM) are determined by the meter type and the measurement type (volume or mass).

A series of prompts appears for selecting the low and high values.

```
LO 0.00000000 SCFM
```

6> Press the number and decimal keys to increase or decrease the LO value, and then press **E**.

```
LO 0.000000 SCFM
AT  0.0000 V
```

Leaving the voltage value at 0 V equals 4 mA.

7> Press the number and decimal keys to increase or decrease the low voltage value, and then press **E**.

```
HI  1500 SCFM
```

8> Press the number keys to increase or decrease the HI value, and then press **E**.

```
HI  1500 SCFM
AT  5.0000 V
```

The 5.00 V corresponds to 20 mA, which you already calibrated.

9> Press the number and decimal keys to specify the voltage of the span value, and then press **E**.

10> You will be prompted to set the values for the next analog output. Repeat the output scaling steps for all active output channels. If no other changes are required, press **C** until you exit Program mode.

Input Calibration

Each Series 155 model has a run or operate/calibrate switch defined in the appropriate field wiring diagram. Once calibrated, another switch determines the voltage that is applied to the inputs. Placing the volt meter ground at TPx and its positive lead on TPy allows you to read the exact voltage applied to the inputs.

1> Enter Program mode and press **P** until the **Calibrate** menu appears.

```
PRESS ENTER TO
CALIBRATE
```

2> Press **E** until the Input Calibration prompt appears.

```
PRESS ENTER FOR
INPUT CAL.
```

3> Press **E**.

```
SET ZERO VOLTS
CH A = 0.0000 V
```

4> The input switch and the multimeter reading should be equal. The input switch in the zero position should match the multimeter reading 0.000 V. If the readings are not zero, press the number and decimal keys to enter the matching voltage. Then press **E**.

```
SET SPAN VOLTS
CH A = 5.0000 V
```

5> The default span is 5 V when the input switch is in the span position. Press the number and decimal keys to enter the matching voltage from the multimeter reading, and then press **E**.

6> You will be prompted to set the values for the next input channel. Repeat the input calibration steps for all active input channels.If no other active input channels are available, press **C** until you exit Program mode.

Channel Kickout

The channel kickout function is used to remove a defective or disconnected sensor from a meter average calculation. A channel kickout is due to a malfunction based on a percentage change in the linearized range, not the output range. Typically this is set from –1% to 110% of the calibrated velocity range for an insertion meter or the flow range for an in-line flow meter. This function is either on for all channels or off for all channels.

The only way to trim the kickout values between channels is by editing the linearizer data to cover more or less range. For example, on a four point K-BAR system, the readings would be 25% low if one of the sensors went out and was not removed from the average. Alternately, the sensor can fail reading high velocity and this too would be removed by having an upper limit on the range (110% for example).

1> Enter Program mode and press **P** until the **Channel Kickout** menu appears.

```
PRESS ENTER TO
SET CHAN KICKOUT
```

2> Press **E**.

```
CHAN KICKOUT OFF
^=ON v=OFF
```

3> Press an arrow key to turn channel kickout on or off. Press **E**.

```
HIGH KICKOUT AT
 110% FULL SCALE
```

4> Press the number keys to change the high kickout percentage. Press **E**.

```
LOW KICKOUT AT
 -1% FULL SCALE
```

5> Press the number keys to change the low kickout percentage. Press **E**.

The next Program mode menu option appears unless the kickout is associated with an alarm, then the alarm number prompt appears.

```
ALARM 10 IS OFF
^=ON v=OFF
```

6> Press an arrow key to turn the alarm on or off. Press **E**.

In this example, the alarm trip point options are N.O. (normally open) or N.C. (normally closed).

```
ALARM 10 IS N.O.
^=N.O. v=N.C.
```

7> Press an arrow key to determine the trip point, and then press **E**.

8> The next Program mode menu appears. Press **C** until you exit Program mode.

Meter Correction Factors

The Series 155 uses two methods for applying field derived correction factors.

- Variable Correction Factor (VCF)
- Configuration Correction Factor (CCF)

VCF allows up to seven correction factors at different average velocities. Each velocity value is used to achieve the correct flow rate. The VCF data based on the average velocity corresponds to the flow/mass rate configured for the Series 155. This method is most effective with varying flow profiles that use multiple sensors where the loss of one or two sensors is less noticeable.

CCF allows up to four correction factors at different average velocities on each sensor of a multipoint array. This method is most effective with consistent flow profiles because it recomputes the net correction factor to read the same average velocity if a sensor is disconnected or kicked out. Channel kickout must be turned on for CCF functionality.

Note Appendix A, Calibration, provides the field calibration methods to obtaining the data used for VCF or CCF meter correction factors.

The Series 155 uses the log command for collecting data on each sensor. During field calibration, connect a computer to the log port so the internal log can send data to a device connected to the second serial port. The data is required for every sensor to establish the reference rate. The interval timer for the log file retrieves data up to every minute, based on the format *hhh*:*mm*. The counter should be set to 999:00 to minimize CPU usage caused by continuous logging. Set the interval timer to minutes (for example, 000:01) only when you are acquiring data, and then reset it to 999 hours when your active logging is complete.

For both VCF and CCF, the number of correction factors determines the velocity dependent function for the correction factor.

- One point is a simple bias change at all velocities.
- Two points have a single sloping line correction.
- Three points have two lines.
- Four or more points have two lines with a curving function over the center velocity points.

Setting the VCF Correction Method

To configure the flow meter VCF correction method:

Note There must be at least one active channel to configure the correction method.

1> Enter Program mode and press **P** until the **Set Meter Data** menu appears.

```
PRESS ENTER TO
SET METER DATA
```

2> Press **E**.

```
PRESS ENTER TO
SET METER #1
```

There will an entry for each available meter.

3> Use the arrow keys to select a meter, and then press **E**.

```
ENTER METER ID:
FLOW METER 01
```

4> Press **P** to scroll through the Meter Data settings until you reach the correction factors.

Note If you mistakenly press **E** you will be in edit mode. Press **C** once to quit without making changes and return to the meter selection, and then use the arrow keys to return to the specific meter number and start over.

```
CF TYPE VCF
^=CCF v=VCF
```

5> Press the arrow keys to select the VCF correction method, and then press **E**.

```
ENTER # C.F.
DATA POINTS 5
```

For VCF you can select up to seven correction factors.

6> Press the number keys to select your number of correction factors, and then press **E**.

```
C.F. #1 = 1.000
```

7> Press the number and decimal keys to set your first correction factor, and then press **E**.

```
C.F. #1 = 1.000
AT 0.000000 SCFM
```

8> Press the number and decimal keys for the measurement units, and then press **E**.

You will repeat the steps for each set of data points based on the number of specified correction factors.

9> The next Program mode option appears. Press **C** until you exit Program mode.

Setting the CCF Correction Method

To configure the flow meter CCF correction method:

> **Note** There must be at least one active channel to configure the correction method.

1> Enter Program mode and press **P** until the **Set Meter Data** menu appears.

```
PRESS ENTER TO
SET METER DATA
```

2> Press **E**.

```
PRESS ENTER TO
SET METER #1
```

There will an entry for each available meter.

3> Use an arrow key to select a meter, and then press **E**.

```
ENTER METER ID:
FLOW METER 01
```

4> Press **P** to scroll through the Meter Data settings until you reach the correction factors.

> **Note** If you mistakenly press **E** you will be in edit mode. Press **C** once to quit without making changes and return to the meter selection, and then use the arrow keys to return to the specific meter number and start over.

```
CF TYPE CCF
^=CCF v=VCF
```

The correction factor options are configuration correction factor (CCF) and variable correction factor (VCF).

5> Press an arrow key to select the CCF correction method, and then press **E**.

```
BCF=
1
```

The bias correction factor (BCF) is a constant that is flow rate independent.

6> Keep the BCF at its default value. Press **E**.

```
ENTER # OF RM
DATA SETS 3
```

7> The reference method (RM) is the number of specified data sets or flow rates needed for collecting data. For example, if you are using 50%, 75%, and 100%, then specify three data sets. You can specify up to four sets. Press **E**.

```
ENTER RM DATA
SET 1
```

8> You must specify the RM data for each set. The sets must go from lowest to highest flow rate. For example, 50% is used for set 1, 75% for set 2, and 100% for set 3. Press an arrow key to select a different set. Press **E**.

```
Vrm1
xxxx.xx SMPS
```

Vrm1 is the reference method average velocity for set 1. The average velocity that is computed from your traverse or other reference method is used to determine the duct average velocity.

9> Press the number and decimal keys for the measurement units, and then press **E**.

```
Vds1 CH A
xxxx.xx SMPS
```

Vds1 is the observed velocity for the first available channel for the calibrated meter. This is the individual channel velocity obtained from the log file when you retrieved the reference flow data. This prompt repeats for each available channel of the multipoint flow meter.

10> Press the number and decimal keys for the measurement units, and then press **E**.

```
C.F. #1 = 0.980
AT 48.78 SMPS
```

A computed correction factor (CF) appears after you enter all active channel data.

11> Press **E** to continue to the next data set and repeat the channel data process, if available.

12> If you have finished setting the correction method, press **C** until you exit Program mode.

Daily Zero-Span Drift Check

The daily zero-span drift check substitutes a sensor input signal to the flow computer that is less than 25% full scale (zero) and a signal that is greater than 75% full scale (span). The flow system must be field calibrated and reading the correct absolute values before using the zero-span drift check to prevent incorrect percentage output values. Tracking is then confirmed by comparing the output to a previously certified response.

The Series 155 complies with Environmental Protection Agency (EPA) regulations for large energy users by providing a daily zero-span drift check of the Continuous Emissions Monitoring Systems (CEMS). However, this feature is not supported on the 155Jr and 155Jr-DC models.

Note The MFT-B Series includes a built-in zero-mid-span drift check signal that should be used instead of the one available with the Series 155.

Use the field wiring diagrams to locate the variable resistors, switches, jumpers, and terminals for your Series 155 model.

Table 2-3. Adjustments for Daily Zero-Span Setup

Adjustment	155A/B/B-RM	155C-2/E-2/RM2
Zero adjustment	R47	R110
Span adjustment	R44	R108
Local zero switch	NA	SW102, hold at zero
Local span switch	NA	SW102, hold at span
External zero drift check enable	TB22-1 and 2	TB401-9 and 10
External span drift check enable	TB21-1 and 2	TB401-11 and 12
Verification channel adjustment	R57	R103
Verification channel selection	J8 is channels A, B and C; J9 is channels D, E and F. One shut is used vertically for the verify channel.	J102, pins 1 to 22 are channels A to V. One shut is used horizontally for the verify channel.
Verification alarm contacts	User defined in Program mode to match the verification channel meter.	

Before you can implement the daily zero-span drift check, you must:

1. Adjust zero and span drift check flow values.
2. Setup of the verification meter.
3. Provide alarm verification.

The flow value for full-scale 5 VDC or 20 mA output are required in SCFM or SCMM for the calculations used for setting up the verification meter, as follows:

10%	
15%	
85%	
90%	

The following example shows the full scale flow output at 5 VDC = 3000 SCFM:

10%	300 SCFM
15%	450 SCFM
85%	2550 SCFM
90%	2700 SCFM

Adjusting and Recording Zero Flow Rate Values

1> Open the cover of the Series 155 Computer/Transmitter.

2> Adjust and record zero flow rate value.

a> Enter Display mode by pressing **D**.

b> Press **D** until the meter flow rate appears.

```
FLOW RATE
0.000000 SCFM
```

c> Press **H** to hold the screen.

3> Push the internal zero/span switch (or external contact) on the Series 155 motherboard in the ZERO position and adjust the zero variable resistor until the front panel screen indicates 10% of full scale span for your system.

4> Record the 10% value and release the switch (or external contact).

5> Press **C** to clear the hold function.

6> Press **D** until you see the **Input Voltage** screen.

7> Push internal zero/span switch (or external contact) on the Series 155 motherboard in the ZERO position and record input voltage.

8> Verify that the 4-20 mA output reads 10% of flow rate range and record value.

Adjusting and Recording Span Flow Rate Values

1> Open the cover of the Series 155 Computer/Transmitter.

2> Adjust and record span flow rate value.

a> Enter Display mode by pressing **D**.

b> Press **D** until the meter flow rate appears.

```
FLOW RATE
0.000000 SCFM
```

c> Press **H** to hold the screen.

3> Hold internal zero/span switch (or external contact) on the Series 155 motherboard in the SPAN position and adjust the Span variable resistor until the front panel screen indicates 90% of full scale value for your system.

4> Record the flow rate indication and release switch or external contact.

5> Press **C** to clear the hold function.

6> Press **D** until you see the **Input Voltage** screen.

```
A=2713 SFPM
INPUT=1.856 V
```

7> Push internal zero/span switch (or external contact) on the Series 155 motherboard in the SPAN position and record input voltage.

8> Verify that the 4-20 mA output reads 90% of flow rate range and record value.

Verifying External Control Function (155C-2/E-2/RM2 only)

1> Short the terminals labeled EXT. ZERO DRIFT CHECK ENABLE on the front panel together (terminals 9 and 10 of TB401).

2> Verify that the Series 155 flow rate indications and 4-20 mA values match the recorded data in “Adjusting and Recording Zero Flow Rate Values.”

3> Remove short from terminals 9 and 10 of TB401.

4> Short the terminals labeled EXT. SPAN DRIFT CHECK ENABLE on the front panel together (terminals 11 and 12 of TB401).

5> Verify that the Series 155 flow rate indications and 4-20 mA values match recorded data in “Adjusting and Recording Span Flow Rate Values.”

6> Remove short from terminals 11 and 12 of TB401.

Setting Up the Verification Meter

Setting Meter Definitions

1> Enter Program mode and press **P** until the **Set Meter Data** menu appears.

```
PRESS ENTER TO
SET METER DATA
```

2> Press **E**.

```
PRESS ENTER TO
SET METER #1
```

There is an entry for each available meter.

3> Press **E**.

```
ENTER METER ID:
FLOW METER 01
```

4> Press an arrow button until the screen indicates the first unused meter number, and then press **E**.

Create a meter ID such as ZERO/SPAN.

5> Use the arrow keys to select each letter or number followed by pressing **E**. When you finish entering the meter ID, press **P**.

```
NEXT TYPE ^v
INSERTION FLOW
```

The flow meter types are INSERTION FLOW, SUM FLOW, and IN LINE FLOW.

6> Press an arrow key until **INSERTION FLOW** appears, and then press **E**.

```
DISPLAY NEXT ^v
FLOW IS SCFM
```

The flow unit options are SCFM, SCFH, and PPM.

7> Press an arrow key until the **SCFM** flow unit appears, and then press **E**.

```
INCLUDE CH A
^=YES    v=NO : NO
```

You will be prompted through each channel before moving to the next prompt.

8> Press the down arrow and then **E** to bypass the channels already used by the system. Press the up arrow and then **E** to enter the first unused input channel letter.

```
ENTER FLOW AREA
 1 SQ FT
```

9> Press the number and decimal buttons to enter the flow area of the duct in square feet. Then press **E**.

```
CF TYPE VCF
^=CCF v=VCF
```

The correction factor options are configuration correction factor (CCF) and variable correction factor (VCF). Correction factors are not required for this feature.

10> Press **C** until you are prompted for the next meter number.

11> Place a jumper on the appropriate contacts to verify the channel selected in step 8.

Defining Linearization Points

This section provides steps on defining linearization points.

1> Enter Program mode and press **P** until the **Set Linearizers** menu appears.

```
PRESS ENTER TO
SET LINEARIZERS
```

2> Press **E**.

```
PRESS ENTER TO
LINEARIZE CH A
```

The channel letter reflects the zero-span verify channel previously selected.

3> Press **E**.

```
ENTER S/N:
SN-0000000001
```

The name ID must match the name specified in the Program mode Set Meter Data menu meter ID option.

4> Use the arrow keys to select each letter or number followed by pressing **E**. When you finish entering the meter ID, press **P**.

```
CH A IS SCFM
NEXT TYPE ^v
```

The unit options are DEGF, volts, SFPM, or SCFM. The units must match those listed in the Program mode Set Meter Data menu flow type.

5> Press the arrow keys to select **SCFM**, and then press **E**.

```
ENTER # OF CH A
DATA POINTS 2
```

6> Press **2** to create two data points and then press **E**.

```
PT A 1 0.0000 V
```

The prompt refers to 10% of full-scale input voltage previously recorded.

7> Press the number and decimal keys for 10% full-scale span, and then press **E**.

```
PT A 1 0.0000 V
AT 0.000000 SCFM
```

The prompt refers to 10% of full-scale flow rate previously recorded.

8> Press the number and decimal keys for 10% full-scale span, and then press **E**.

```
PT A 2 1.900 V
```

The prompt refers to 90% of full-scale input voltage previously recorded.

9> Press the number and decimal keys for 90% full-scale span, and then press **E**.

```
PT A 2 1.900 V
AT 2700 SCFM
```

The prompt refers to 90% of full-scale flow rate previously recorded.

10> Press the number and decimal keys for 90% full-scale span, and then press **E**.

You will be prompted to linearize another channel.

11> Press **C** until you exit Program mode.

Designating Alarm Trip Points

This section provides steps on setting up two alarms.

1> Enter Program mode and press **P** until the **Set Alarms** menu appears.

```
PRESS ENTER TO
SET ALARMS
```

2> Press **E**.

```
PRESS ENTER TO
SET ALARM 1
```

3> Press **E** to set alarm 1.

```
ALARM 1
ENTER METER # 1
```

4> Press the number or arrow keys to specify meter **1**, and then press **E**.

```
ALARM 1 IS ON
^=ON v=OFF
```

5> Press an arrow key to turn the alarm **ON**, and then press **E**.

```
ALARM 1 IS N.O.
^=N.O.    v=N.C.
```

6> Press an arrow key to select **N.O.** (normally open) or **N.C.** (normally closed) contacts, as required by your system. Press **E**.

```
ALARM 1 NEXT ^v
VELOCITY
```

The alarm types are flow rate, velocity, non-isokinetic, or kickout count. Flow rate and velocity are the most common selections.

7> Press an arrow key to select the type of alarm, and then press **E**.

```
ALARM 1 IS LO
1=LO 2=HI 3=HOL
```

The alarm triggers are low, high, and high and low.

8> Press **1** to select low alarm, and then press **E**.

```
LOW ALARM AT
-1.000000 SFPM
```

9> Press the number and decimal keys for a value equal to 15% of full-scale span, and then press **E**.

```
PRESS ENTER TO
SET ALARM 2
```

10> Press **E** to set alarm 2.

```
ALARM 2
ENTER METER # 2
```

11> Press the number or arrow keys to specify meter **2**, and then press **E**.

```
ALARM 2 IS ON
^=ON v=OFF
```

12> Press an arrow key to turn the alarm **ON**, and then press **E**.

```
ALARM 2 IS N.O.
^=N.O.    v=N.C.
```

13> Press an arrow key to select **N.O.** (normally open) or **N.C.** (normally closed) contacts, as required by your system. Press **E**.

```
ALARM 2 NEXT ^v
VELOCITY
```

The alarm types are flow rate, velocity, non-isokinetic, or kickout count. Flow rate and velocity are the most common selections.

14> Press an arrow key to select the type of alarm, and then press **E**.

```
ALARM 2 IS HI
1=LO 2=HI 3=HOL
```

The alarm triggers are low, high, and high and low.

15> Press **2** to select high alarm, and then press **E**.

```
HIGH ALARM AT
999 SFPM
```

16> Press the number and decimal keys for a value equal to 85% of full-scale span, and then press **E**.

You will be prompted to set another alarm.

17> Press **C** until you exit Program mode.

Note Regarding the Zero and Span control switches on the Series 155 C-2/E-2/RM2 only, the zero-span control functions at TB401 only work if SW101 the auto zero-span switch is off. The manual zero/span switch SW102 is independent of the position of SW101 the auto zero-span switch.

Alarm Verification

To verify the zero-span reference input (Verification Channel):

1> Select the zero-span meter and press **D** until the average flow appears on the screen.

```
FLOWRATE
41,045.4 SCFM
```

2> Adjust the variable resistor for the verification channel until the screen reads approximately 50% of full-scale span.

3> To verify operation of the zero-span meter low alarm, hold the zero-span switch (or external contact) in the ZERO position. You should hear the alarm click and see the low alarm message on the screen.

4> To verify operation of the zero-span meter high alarm, hold the zero-span switch (or external contact) in the SPAN position. You should hear the alarm click and see the high alarm message on the screen.

5> Release the switch to its center position or external contact. Verify that the alarms are reset and that the screen indicates 50% for full-scale span.

Flow & Field Calibration

The basic flow element calibration provided by Kurz uses standard velocity for insertion flow elements and standard volumetric flow or mass flow for in-line flow elements. The Series 155 flow computer takes the current sense voltage (CSV) from a flow element's current across a 5 ohm resistor and converts this to an engineering unit flow, velocity, volumetric rate, or mass rate. For B-Series flow elements, the Series 155 averages the linear flow from multiple sensors reading the current sense voltage across a 250 ohm resistor.

A Kurz thermal flow meter system provides repeatable readings without field calibration when properly installed for its specific application. However, field calibration is required to account for site specific velocity profile issues and any residual mistracking from temperature or pressures that are different from the initial flow element calibration. Field calibration allows a system to have repeatable readings and absolute accuracy. Kurz uses two field calibration procedures:

- Velocity traverse
- Tracer gas dilution

Velocity traverse is a de facto standard method specified by many standards organizations. It is defined in Appendix A, Calibration.

Tracer gas dilution has many advantages:

- Independent of flow measurement technology to thermal or differential pressure
- Insensitive to flow profiles
- Insensitive to process pressure and temperature
- Insensitive to many process fluid mixtures or variations

Chapter 3

Troubleshooting

Overview

This chapter provides symptoms and possible causes for troubleshooting software, hardware, and configuration issues you may encounter with the Series 155 Mass Flow Computer. It also provides the list of requirements for returning equipment to Kurz.

Symptoms

It is important to isolate any symptoms as occurring with either the Series 155 Flow Computer or the flow sensors. Table 3-1 provides typical symptoms that occur within a flow system and possible causes.

Table 3-1. Series 155 Troubleshooting

Symptom	Possible Causes
Unit will not boot-up correctly	• Battery for SRAM is dead and ERROR 01234 appears. ***Note:*** The lithium battery on the CPU board should be replaced every five years. The battery must read more than 2.0 V when the Series 155 unit is powered off. • CPU is defective.
Screen is blank	• No power to the unit (see "No 4-20 mA signal"). • Loose connectors between display/CPU board and the motherboard. • Defective electronics.
No RS-232 or RS-485 signal	• Ensure the jumpers on the motherboard are in the proper RS-232/RS-485 position. Only one of the two signals can be used at a time. • Check pin-out of RS-232. Straight through DE-9 to DE-9 female to a laptop is recommended. • Check polarity of RS-485 wiring and pin-out.
No 4-20 mA signal	• Loss of power to the flow computer. • Reversed polarity on 24 V power or 4-20 mA leads. • Self powered 4-20 mA units may have no power from the user's supply. • Open circuit in wiring. • 4-20 mA jumpers not properly configured (see field wiring diagrams). • Damaged electronics.
4-20 mA does not change with flow	• Check connection to the proper output channel. • Confirm the programmed scale for the output is not too large. • Defective sensor, bridge or electronics. • Ensure sensor cover was removed.
4-20 mA output is "noisy"	• Ensure ground is not missing. • Poor electrical contact. Make sure all electrical connections are clean and tight.
"Cross talk" between Isolated 4-20 mA outputs	• Isolated 4-20 mA outputs may be tied to unnecessary grounds. • Outputs are jumpered in the self-powered instead of the loop-powered 4-20 mA output configuration causing them to be nonisolated.
Output signal "motor boating"	• Sensor has too much leakage current, corrosion, or water damage. • Defective bridge board.

Table 3-1. Series 155 Troubleshooting (continued)

Symptom	Possible Causes
No reading from sensor or question mark on screen for that channel	• Wire to sensor is open circuit or reversed polarity. • Ensure the input voltage across the load resistors, normal is 0.8 to3.0 V or 1.0 to 5.0 V for MFT-B Series devices. • All input channels have over current protection (PTC) that causes reset if the load is removed for about 1 minute.
Unit does not read zero at zero flow	• The gas type or pressure may be different than when calibrated. • Defective electronics, bridge, or sensor.
Unit saturates before reaching full scale	• User-selected output range is too low and 4-20 mA is clipping. • Unit calibrated for a lower flow rate at the factory. • Unit calibrated for the wrong gas. • Defective bridge board or electronics.
Calibration is too low	• Check sensor orientation related to gas flow. • Ensure the unit was calibrated for the gas type in use. • Ensure the unit is setup for the duct's velocity profile. • Check the area near the sensor for a temperature profile (for example, hot duct center or cold outside). • Dirt will generally cause the reading to fall off from proper calibration. • Ensure the 4-20 mA output is calibrated. • Ensure the operating temperature is not several hundred degrees C higher than the high flow rate calibration. • Ensure the sensor is connected to the proper input channel with the correct linearization data.

Table 3-1. Series 155 Troubleshooting (continued)

Symptom	Possible Causes
Calibration is too high	• Check for sensor blockage and flow profile effects. This is a significant factor in ducts measuring less than 1 ft^2. • Check sensor orientation related to gas flow. • Ensure the unit was calibrated for the gas type in use. • Check the area near the sensor for a temperature profile (for example, hot duct center or cold outside). • Check for condensation on the sensor. • Check for pulsating flow noise (for example, from a pump inlet or exhaust). • Ensure the 4-20 mA output is calibrated. • Ensure the operating temperature is not several hundred degrees C higher than the low flow rate calibration. • Ensure the sensor is connected to the proper input channel with the correct linearization data.
Calibration does not track with temperature	• Measurement is not actual velocity. Unit measures (density x velocity) or mass-rate per unit-area. (See Appendix A of the flow element manual information on converting to actual velocity). • VTM calibration method should be used instead. • Check the area near the sensor for a temperature profile (for example, hot duct center or cold outside). • Defective sensor or bridge board. • Ensure the sensor is connected to the proper input channel with the correct linearization data.

Installation

Ensure the Series 155 flow system was installed correctly, including wiring the sensors, outputs, power, and mounting. Refer to the field wiring diagrams for an overview of the wiring. Within the cabinet of each unit is a setup sheet that provides the sensor serial number and its assigned input channel.

Mounting

The Series 155 follow NEMA4 design so they can be mounted indoors or outdoors in an ambient temperature ranging from –25°C to 60°C. Each Series 155 Flow Computer should be securely mounted vertically to support a normal viewing angle of the user screen. Separate conduit connections are provided for electrical power, inputs from flow elements, and outputs.

Power

The 155 Jr/A/B models have transformer power supplies requiring either 115/230 VAC +/- 10%, 50/60 Hz 1 phase power. Select the 115 VAC or 230 VAC power connections via soldered jumper connections. Fusing is sized for either voltage including lighting surges. Refer to the field wiring diagram for the fuse rating.

The 155-C2/E2/RM2 models have auto selecting switching power supplies and can accept any input from 85-260 VAC, 50-60 VAC, 1 phase power. The C2 model uses a 250 VA power rating and the E2/RM2 models use a 500 VA rating power connection.

A unit that is powered on performs flow calculations according to the configuration stored in its SRAM, which is powered by a lithium coin cell soldered on the backside of the CPU board where the screen and keypad are located. The lithium battery on the CPU board should be replaced every five years (it is soldered into place). The battery must read more than 2.0 V when the Series 155 unit is powered off.

Flow Element and Output Wiring

The flow element wiring, 4-20 mA inputs/outputs, and alarms are defined on the field wiring diagrams. All field wiring must be in conduits and grounded or use shielded cable and have water seals to prevent damage.

Table 3-2. Field Wiring Diagrams

Document #	Description
340155-29	155Jr field wiring diagram
340155-44	155A field wiring diagram
340155-45	155B field wiring diagram
340155-50	155Jr-DC field wiring diagram
340155-55	155C-2/E-2/RM2 field wiring diagram
340155-57	155C-2/E-2/RM2 field wiring diagram with pulsed totalizer output

Returning Equipment

If you believe your unit is working improperly, contact Kurz Customer Service:

(831) 646-5911

service@kurzinstruments.com

Before you can receive your return material authorization (RMA) number, make sure you:

- Complete the Defective Unit information
- Understand RMA requirements
- Read the cleaning and shipping requirements

Have the following information readily available for your Customer Service Representative:

Defective Unit Information

Model number	
Serial number	
Application (industry)	
Environment of installation	
Gas type	
Flow range	
Standard conditions for recalibration	
Special QA requirements (such as nuclear, military, oxygen, calibration, or certification)	
Technical contact name	
Technical contact phone number	
Billing contact name	
Billing contact phone number	
Complete shipping address	
Complete billing address	

Cleaning Equipment Before It Is Returned

Thoroughly clean all equipment you are returning to Kurz. Kurz is unable to assume the risk of receiving contaminated equipment from our customers. In the event uncleaned equipment are received, you will be contacted so arrangements can be made, at your expense, for the equipment to be picked up and cleaned before Kurz personnel handle the equipment.

Receiving an RMA Number

You will be issued an RMA number when you contact Kurz Customer Service and provide the Defective Unit information.

Important ***Kurz personnel will not accept return material shipments if an RMA number is not clearly visible on the outside of the shipping container.***

Shipping Equipment

Securely package the cleaned equipment in a sturdy container. The packing slip must reference the RMA number, model number, and serial number. ***The return address and RMA number must be clearly marked on the outside of the container.***

Ship the container prepaid to Kurz Customer Service:

Kurz Instruments, Inc.
Customer Service Dept.
2411 Garden Road
Monterey, CA 93940-5394
USA

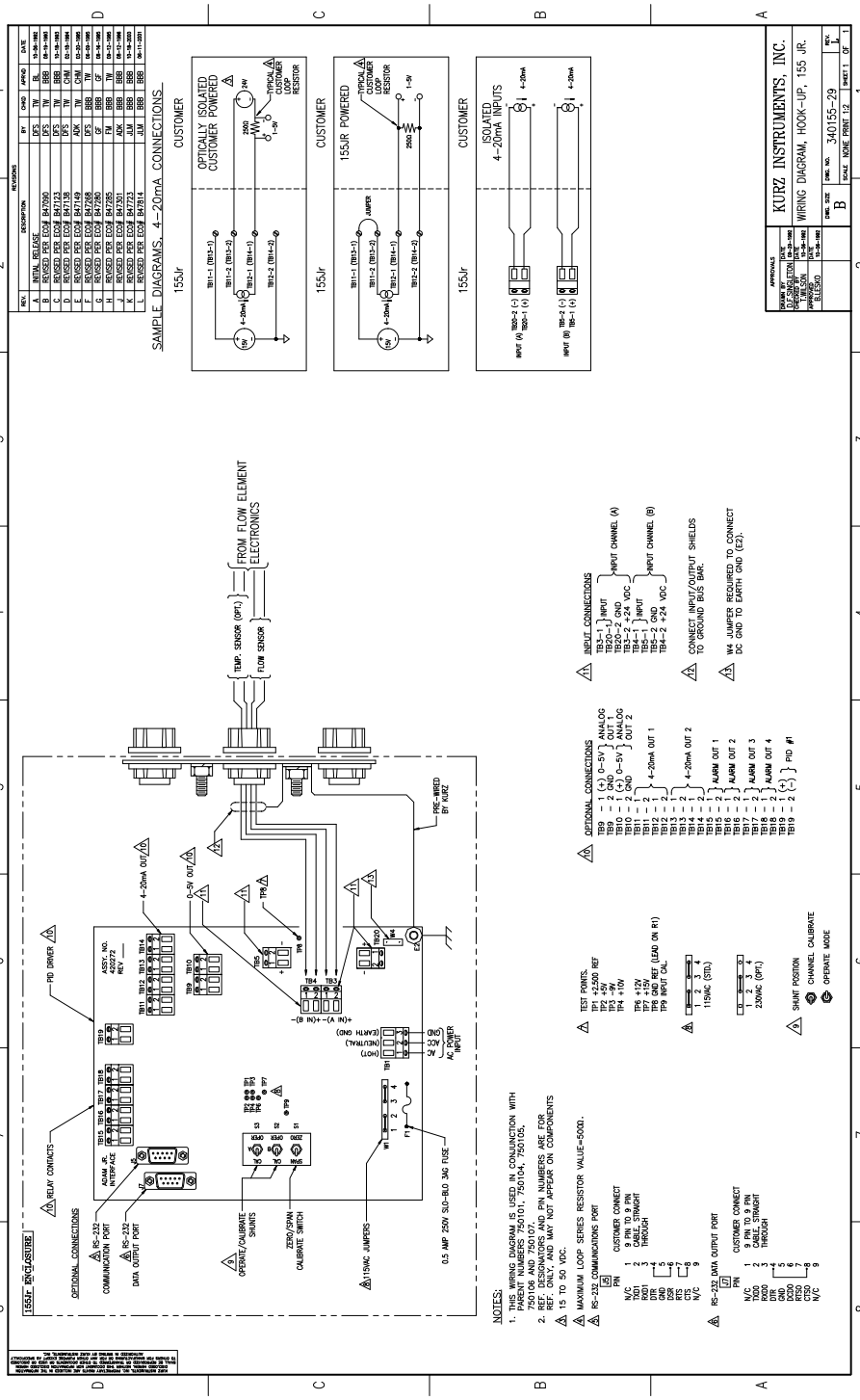
Chapter 4

Field Wiring Diagrams

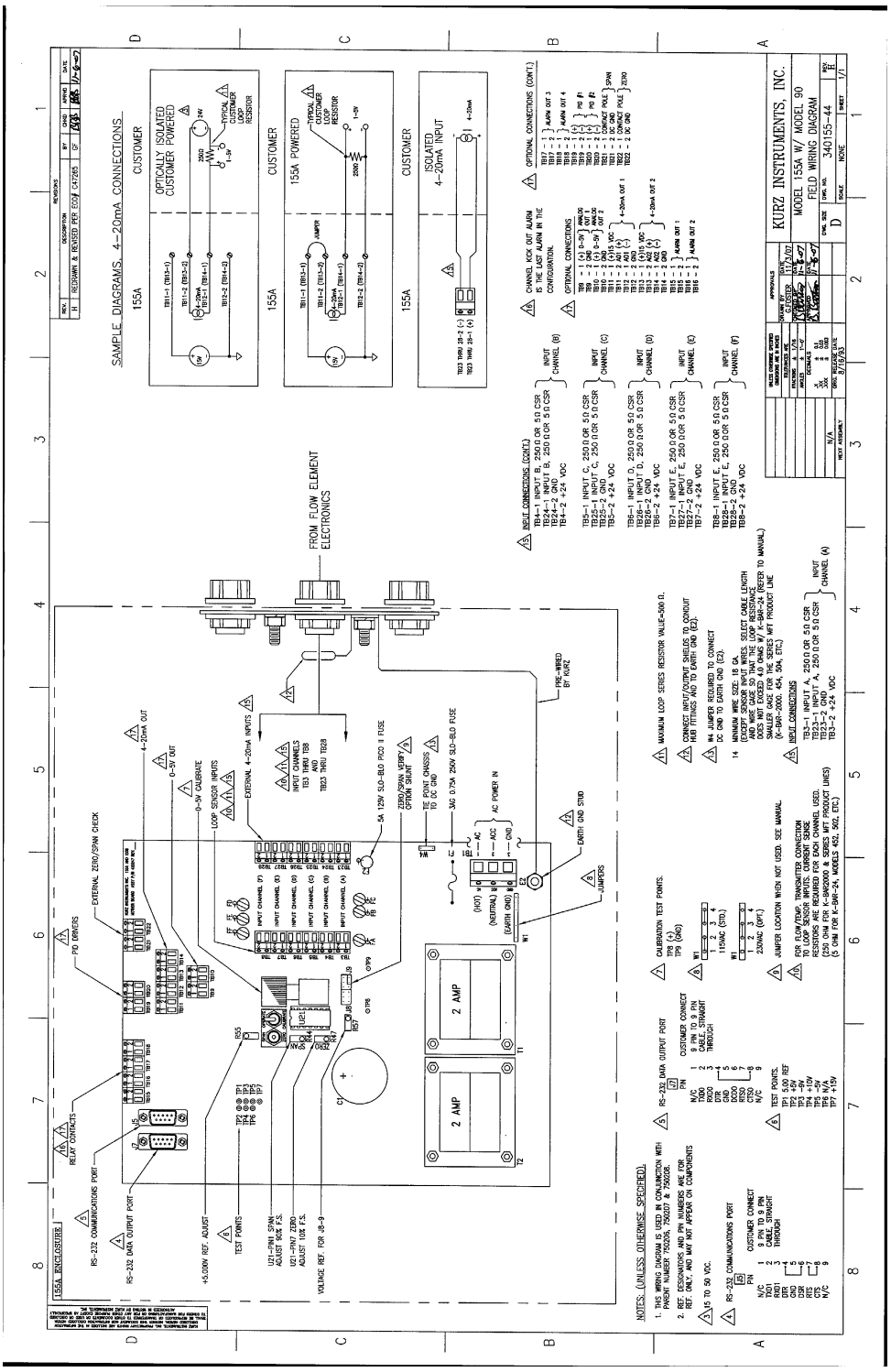
Overview

This chapter provides the field wiring diagrams for all Series 155 models. The diagrams have been scaled to fit the page. Details within each diagram are available by magnifying the page using your PDF viewer.

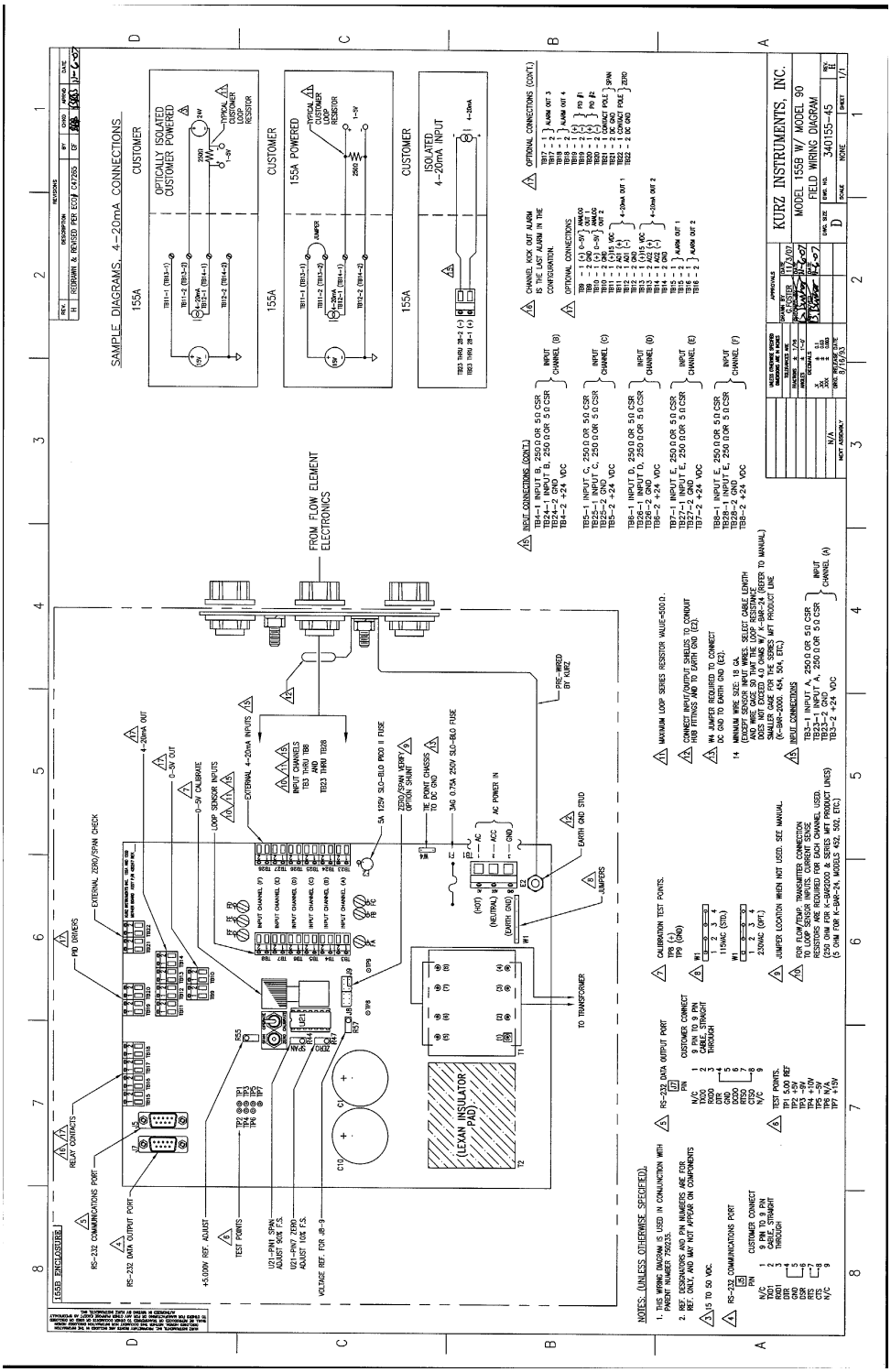
Series 155Jr



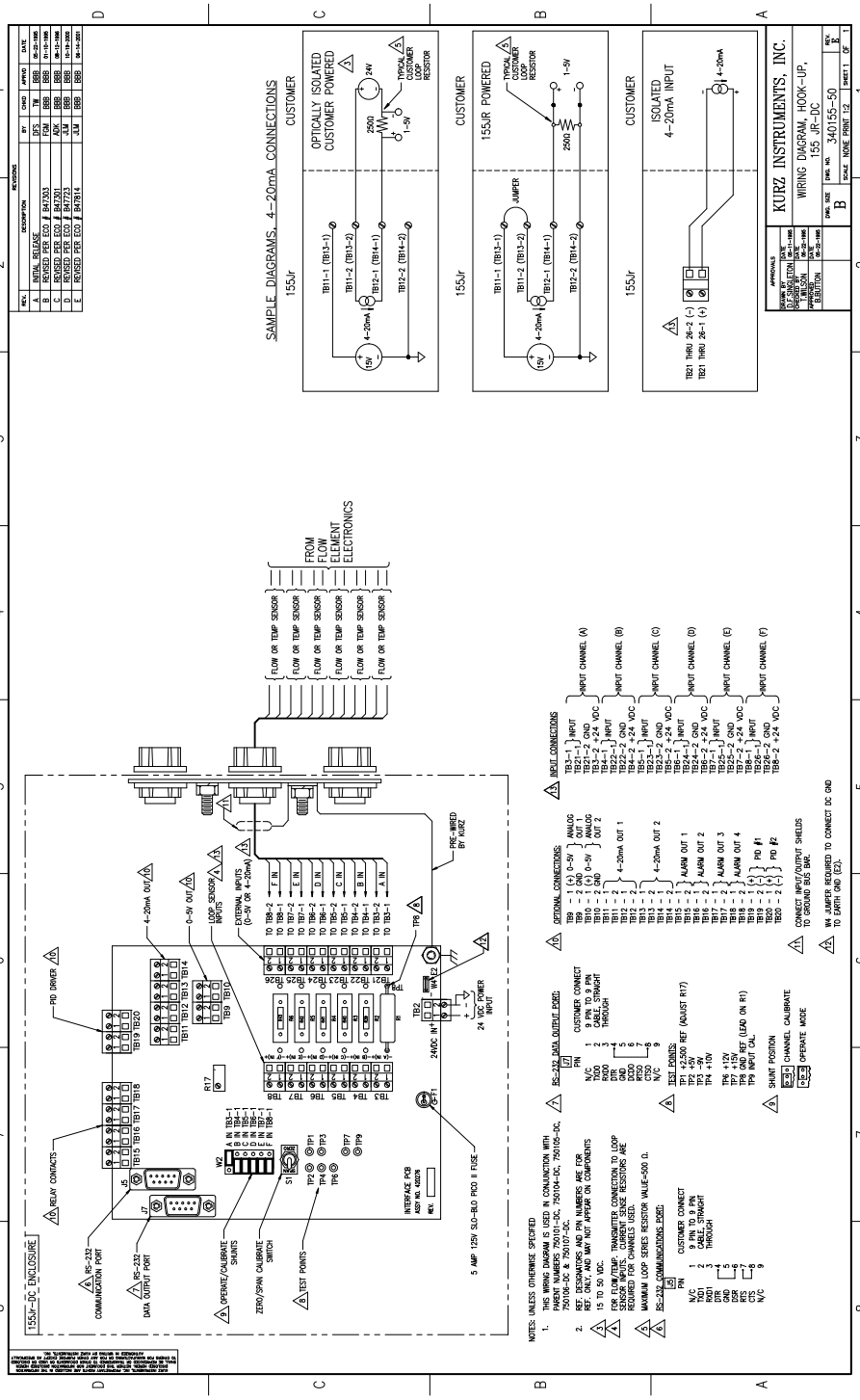
Series 155A


SAMPLE DIAGRAMS, 4–20mA CONNECTIONS
155A ENCLOSURE
KURZ INSTRUMENTS, INC.
MODEL 155A W/ MODEL 90
FIELD WIRING DIAGRAM
340155-44
NOTES: (UNLESS OTHERWISE SPECIFIED)

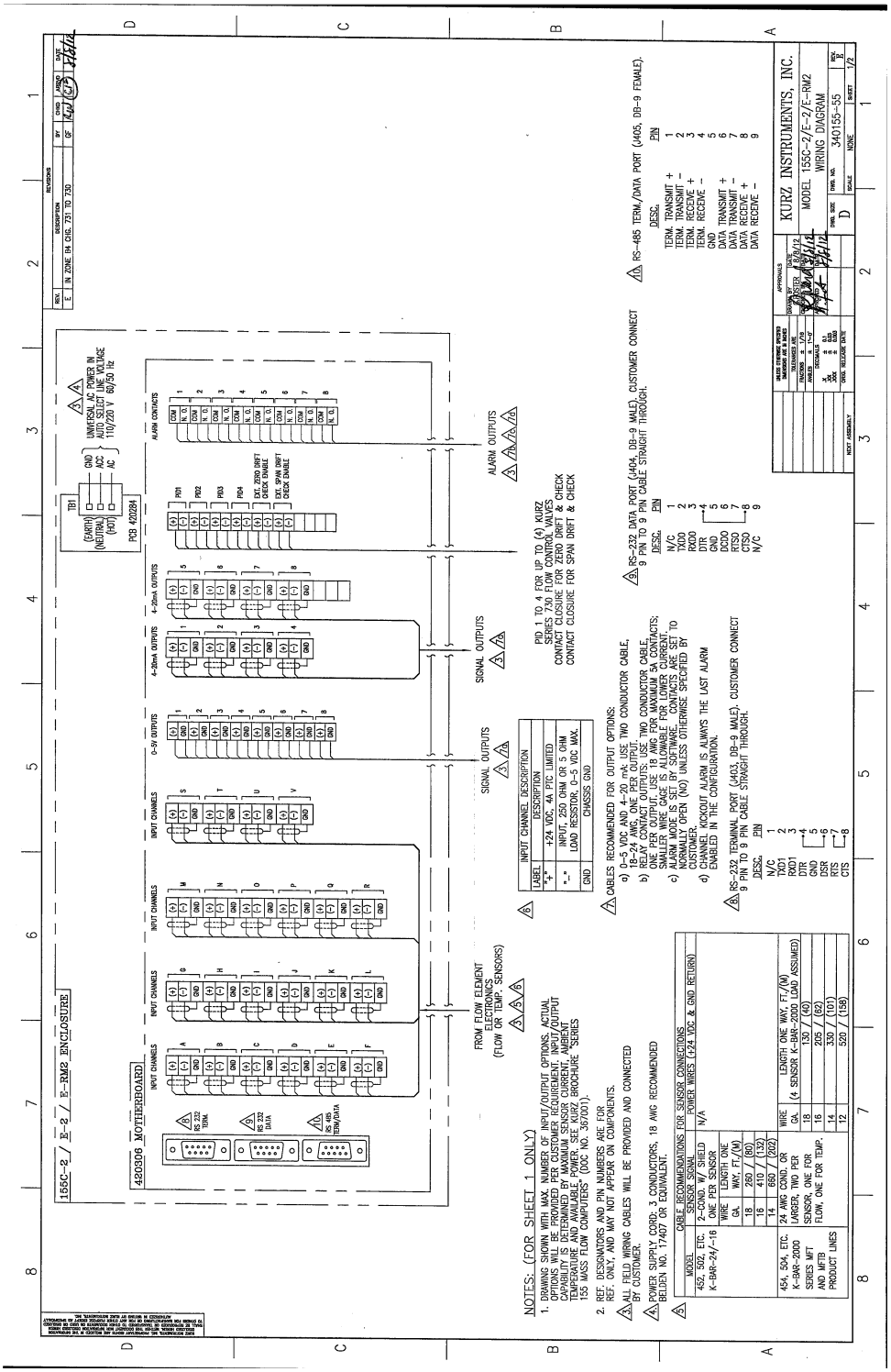
Series 155B

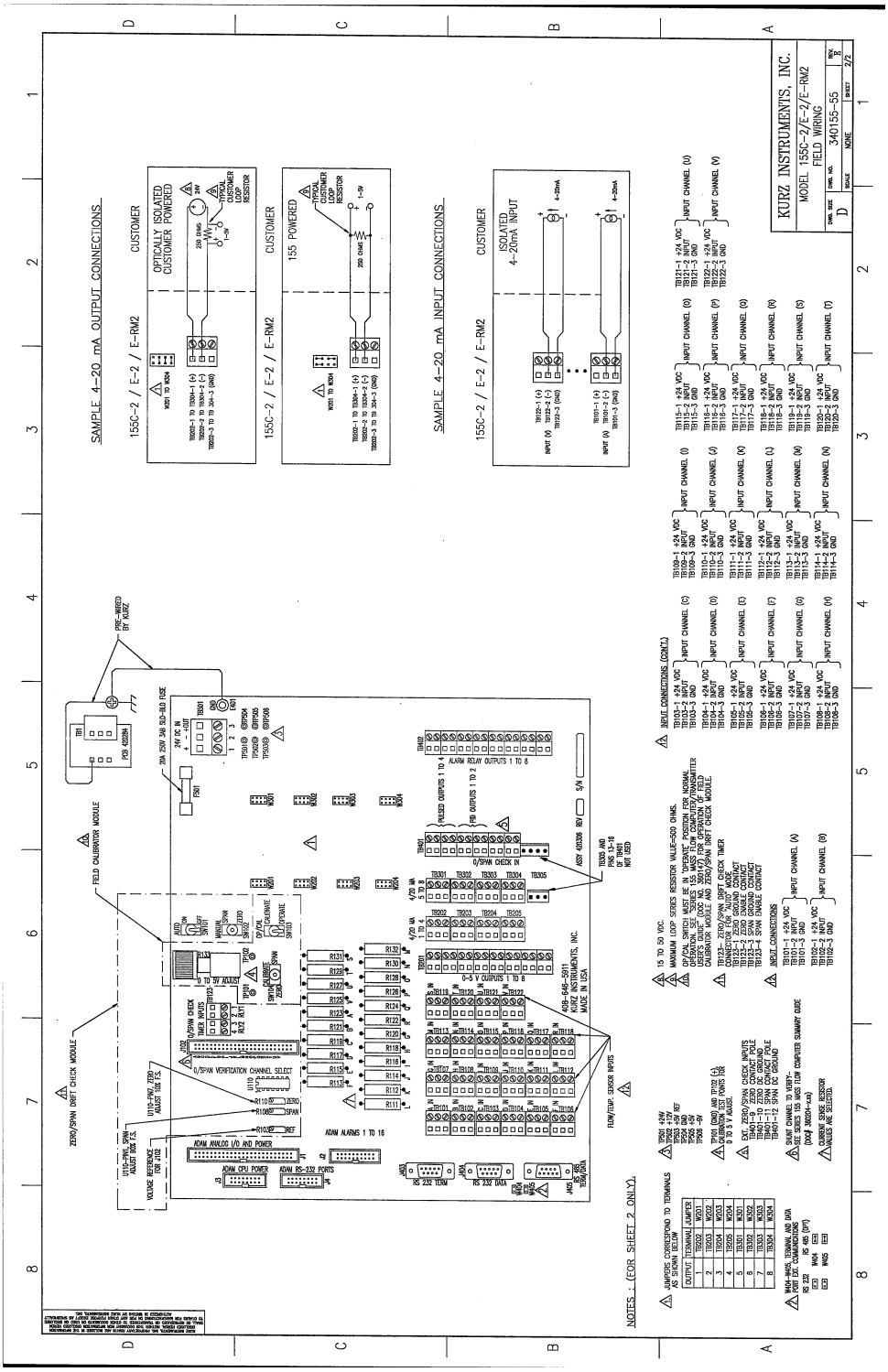

SAMPLE DIAGRAMS, 4–20mA CONNECTIONS
OPTICALLY ISOLATED CUSTOMER POWERED
155A POWERED
ISOLATED 4–20mA INPUT
CUSTOMER
155A
FROM FLOW ELEMENT ELECTRONICS
KURZ INSTRUMENTS, INC.
MODEL 155B W/ MODEL 90
FIELD WIRING DIAGRAM
340155-45
NOTES: (UNLESS OTHERWISE SPECIFIED).

Series 155Jr-DC

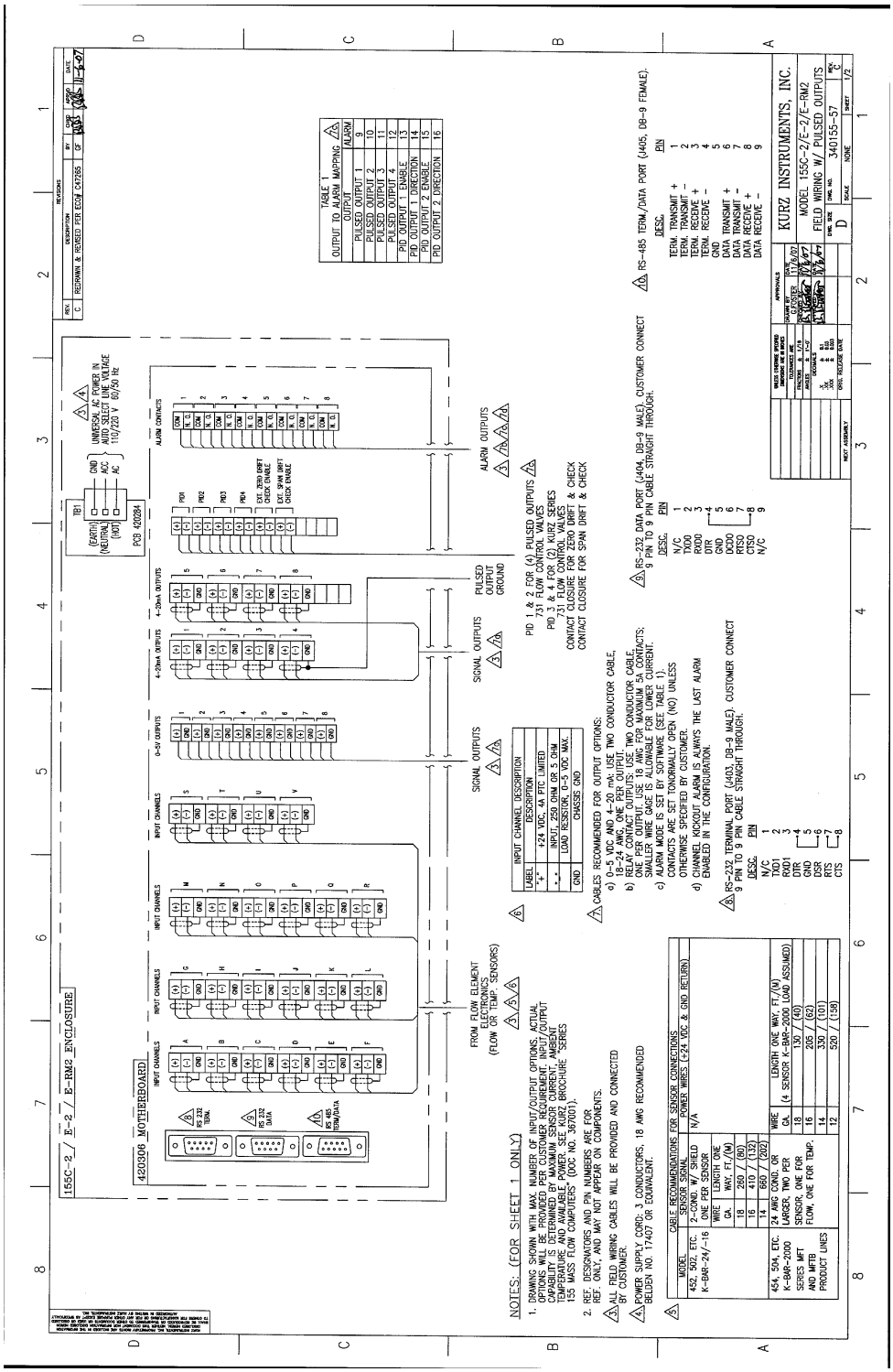


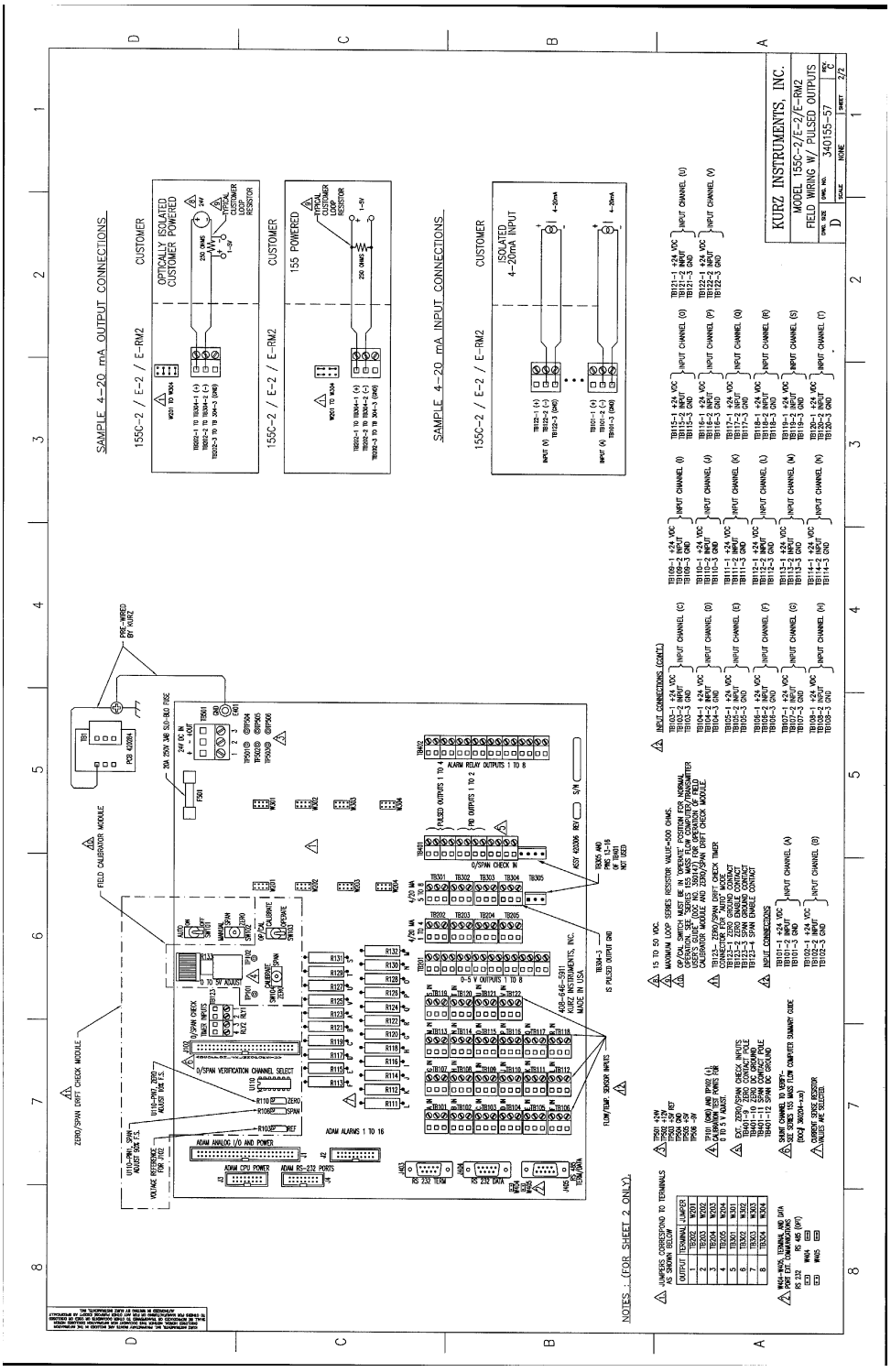
Series 155C-2/E-2/RM2




SAMPLE 4–20 mA OUTPUT CONNECTIONS
SAMPLE 4–20 mA INPUT CONNECTIONS
155C–2 / E–2 / E–RM2
CUSTOMER
OPTICALLY ISOLATED CUSTOMER POWERED
155 POWERED
ISOLATED 4–20mA INPUT
KURZ INSTRUMENTS, INC.
MODEL 155C–2/E–2/E–RM2
FIELD WIRING
340155–55
NOTES : (FOR SHEET 2 ONLY).

Series 155C-2/E-2/RM2 (w/ PTO)




SAMPLE 4–20 mA OUTPUT CONNECTIONS
SAMPLE 4–20 mA INPUT CONNECTIONS
155C–2 / E–2 / E–RM2
CUSTOMER
OPTICALLY ISOLATED CUSTOMER POWERED
155 POWERED
ISOLATED 4–20mA INPUT
KURZ INSTRUMENTS, INC.
MODEL 155C–2/E–2/E–RM2
FIELD WIRING W/ PULSED OUTPUTS
DWG. NO. 340155–57
SCALE NONE
SHEET 2/2
NOTES: (FOR SHEET 2 ONLY)

Appendix A

Calibration

Overview

The appendix provides information on checking or calibrating an installed flow meter to ensure absolute accuracy based on local factors that can influence readings, such as the velocity profile.

The procedures in this appendix are intended for engineers and technicians who are familiar with performing the velocity traverses required for the reference flow measurements and capable of setting the correction factors in the Series 155 Program mode.

Note Trace gas dilution field calibration is not provided.

Raw Velocity

Using raw velocity and reference velocity ensures the proper correction factors are loaded into a flow meter for new and recalibrated systems.

To set the calibration, you must measure the average flow or velocity using a reference method for each specified flow rate and know the flow rate and correction factor (CF) configured for the device under test (DUT). The correction factor is based on the velocity of the current flow rate, both of which are used for computing the raw indicated velocity:

Raw velocity = indicated flow/(area * CF)

The output from a multipoint K-BAR system is generally raw velocity. Single point flow meters require back-computing the raw velocity data to determine the flow output. The Kurz Modbus Client utility supports flow meter data logging in a comma-separated value (CSV) format, which can be imported into a spreadsheet application conversion. The flow meter data can then be computed to raw velocity.

Note Using an older Series 155 data logging utility to monitor the DUT during the field calibration will require you to temporarily assign a meter to each input channel to record the raw velocity from each sensor.

To compute the correction factors for the DUT, enter the reference velocity and indicated raw velocity for each sensor and for each flow rate into the DUT. Any bias or Sensor Blockage Correction Factors (SBCFs) must be accounted for when loading new variable correction factor (VCF) or configuration correction factor (CCF) data. The logged correction factor results from bias * SBCF * VCF. After loading the new VCF/CCF data, the DUT will read the flow rate as measured by the reference method.

Velocity Traverse Data Acquisition

The traverse average velocity is acquired using either of the velocity traverse reference methods. The process flow rate must be at equilibrium so the computed average from the traverse reflects the same flow rates on all access points.

Developing the insertion depth information requires the following:

- Noting the center of the velocity probe sensing element, which is 20 mm (0.78 inches) from the probe end.
- Determining the start point, which is a variable distance beyond the compression fitting's outside edge based on conditions that include duct wall thickness and tread adaptors.
- Locating the probe center at the near wall edge, and marking the probe support with a permanent marker next to the compression fitting collar.
- Using a tape measure to mark the additional traverse locations based on your initial mark.

Velocity Traverse Reference Method

You can compute the average velocity in a large process duct or stack by performing a velocity traverse. The velocity traverse method for this in-situ calibration involves dividing the duct area into equal areas and then measuring the velocity in the center of each area. The average velocity is determined by numerically averaging the data (sum the data and divide by the number of samples). The following table provides information for determining the minimum number of sample points to be taken for each flow rate.

Table A-1. Minimum Number of Sample Points

Cross-sectional area of sampling site		Diameters downstream from the nearest flow disturbance such as a bend, expansion, or contraction assuming less-than two diameters upstream from the nearest flow disturbance.				
		>8	>6 to 8	4 to 6	2 to <4	<2
m^2	ft^2	Minimum number of sample points per flow rate.				
<0.2	<2	4	6	8	Determined case-by-case	Unusable data
0.2-2.3	2-25	12	18	24	Determined case-by-case	Unusable data
>2.3	>25	20	30	40	Determined case-by-case	Unusable data

Equal Areas for a Rectangular Duct

The sample locations for rectangular ducts are determined by simply dividing a cross-section of the duct into small equal-area rectangles and then measuring at the center of each rectangle. You can achieve an accurate estimate of the duct's flow profile if there are sufficient access points; at least eight equivalent diameters downstream and at least two equivalent diameters upstream from the nearest flow disturbance such as a bend, expansion or contraction.

The recommended access points use 19.05 mm (0.75 inches) compression fittings with a nylon, teflon, or other plastic ferrule that will not permanently adhere to the test probe.

Use the following equation to find the equivalent diameter for a rectangular duct based on the minimum sample points specified in Table A-1:

ED = (2HW) ÷ (H + W)

where:

ED is the equivalent diameter of a rectangular duct.

H is the height of the duct.

W is the width of the duct.

Use the following equation to find the correct sensor insertion depth for each rectangle along the traverse axis at a particular access point:

i = 1…n, IDi = {(i - 0.5) ÷ n} × TD

where:

i indicates the specific rectangle being measured starting from the wall closest to the access point and continuing along the traverse axis.

n is the number of rectangles along the traverse axis.

IDi is the sensor insertion depth for each specific rectangle along the traverse axis.

TD is the traverse dimension for the inner duct dimension along the traverse axis.

Example 1

As shown in the following example, a test matrix with six traverse positions (at different insertion depths) along the traverse axis and five access points perpendicular to the traverse axis provide 30 test points.

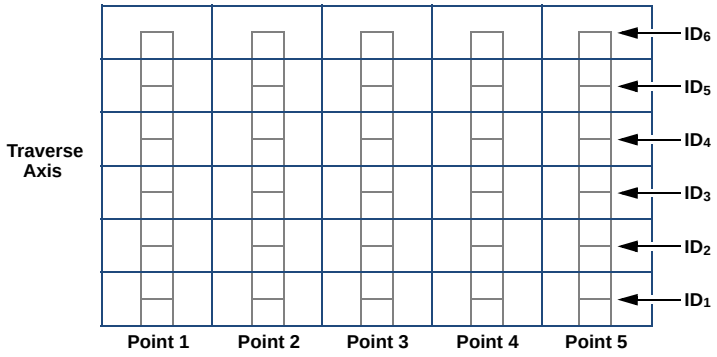


Figure A-1. Example of rectangular duct cross-section perpendicular to flow

1. A rectangular duct with a 1000 mm (39.4 inches) inner duct dimension along the traverse axis with six insertion depths has the following test points:

   $ID_1 = [(1 - 0.5) \div 6] \times 1000 \text{ mm} = 83 \text{ mm}$

   $ID_2 = [(2 - 0.5) \div 6] \times 1000 \text{ mm} = 250 \text{ mm}$

   $ID_3 = [(3 - 0.5) \div 6] \times 1000 \text{ mm} = 417 \text{ mm}$

   $ID_4 = [(4 - 0.5) \div 6] \times 1000 \text{ mm} = 583 \text{ mm}$

   $ID_5 = [(5 - 0.5) \div 6] \times 1000 \text{ mm} = 750 \text{ mm}$

   $ID_6 = [(6 - 0.5) \div 6] \times 1000 \text{ mm} = 917 \text{ mm}$

2. Collect data for each traverse point at each insertion depth.

Flow Rate 1 Example, 30 Points (75 max. per set)

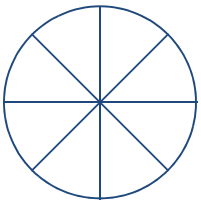
IDn	Insertion Depth (mm)	Velocity				
		Point 1	Point 2	Point 3	Point 4	Point 5
ID1	83					
ID2	250					
ID3	417					
ID4	583					
ID5	750					
ID6	917					

3. Compute the average fluid velocity by summing the data and dividing by the number of points.

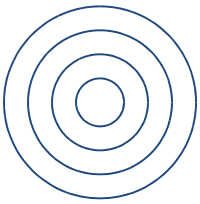
   The Series 2440 provides internal data logging and computations.
   The Series 155 repeats this process for each flow rate, up to four sets, using CCF.

Equal Areas for a Circular Duct

A circular duct can be divided along the circumference into equal area wedges like slices of a pie and/or along the radius into equal area concentric rings (the lesser diameter of the center ring is considered equal to zero).



Wedge



Concentric

Refer to Table A-1 for the minimum number of sample points based on duct size and upstream disturbances.

The recommended access points use 19.05 mm (0.75 inches) compression fittings with a nylon, teflon, or other plastic ferrule that will not permanently adhere to the test probe.

Example 2

As shown in the following example, a test matrix with five traverse positions (at different insertion depths) at four access points spaced 90° apart along the duct radius provide 20 test points.

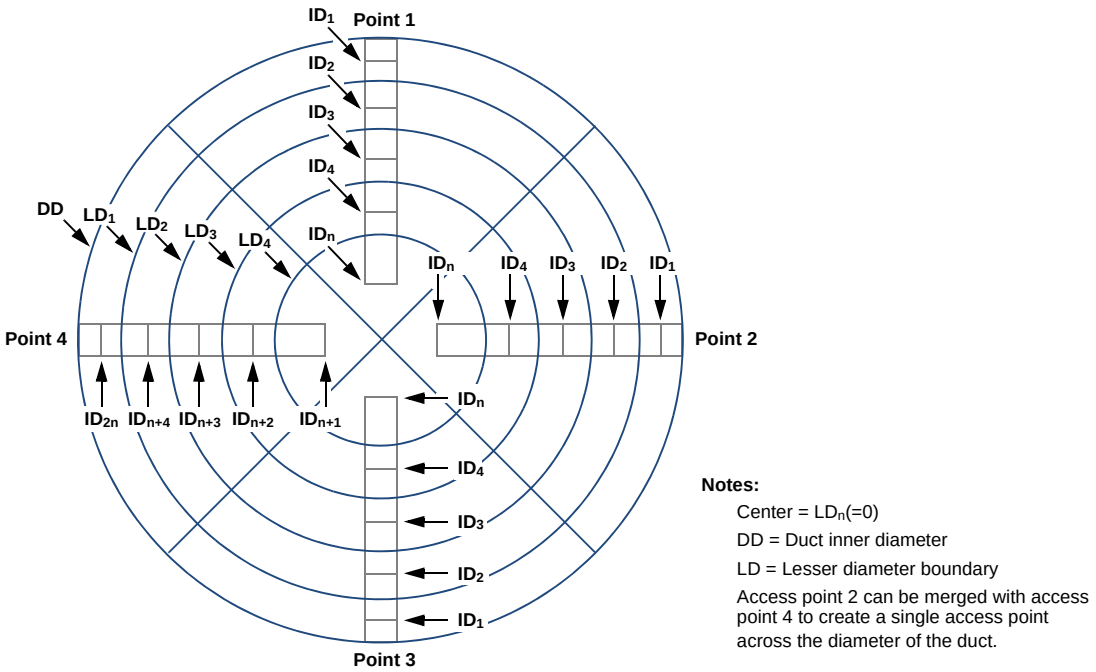


Figure A-2. Example of circular duct cross-section perpendicular to flow

Use the following equation to divide the duct along the radius into equal area concentric rings:

$$i = \ldots n,\ LD_i = \sqrt[2]{1 - (i \div n)} \times DD$$

where:

i identifies the specific ring being measured along the duct radius referenced to the inner duct wall.

n is the total number of rings being measured.

LDi is the lesser diameter boundary of the specific ring being measured along the duct radius referenced to the inner duct wall.

DD is the inside diameter of the duct wall.

After you determine the number and location of the access points, you must find insertion depth for each sector by using the following equations:

$$i = 1 \ldots n,\ ID_i = \{2 - \sqrt[2]{1 - [(i-1) \div n]} - \sqrt[2]{1 - (i \div n)}\} \times DD \div 4$$

$$i = n + 1 \ldots 2n,\ ID_i = \{2 + \sqrt[2]{[(i-1) \div n] - 1} + \sqrt[2]{(i \div n) - 1}\} \times DD \div 4$$

where:

i indicates the sector being measured along the duct radius referenced to the inner duct wall closest to the access point.

n is the total number of sectors being measured along the duct radius between the duct wall closest to the access point and the center of the duct. Do not include sectors on the other side of the center of the duct from the access point.

IDi is the sensor insertion depth for the sector being measured along the duct radius referenced to the inner duct wall closest to the access point.

DD is the inside diameter of the duct.

1. A circular duct with a 1400 mm (55 inches) diameter, assuming five insertion depths each access points 1 and 3 and ten insertion depths for a merged access point 2, has the following insertion depths:

$$ID_1 = \{2 - \sqrt[2]{1 - [(1 - 1) \div 5]} - \sqrt[2]{1 - (1 \div 5)}\} \times 1400 \text{ mm} \div 4 = 37 \text{ mm}$$

$$ID_1 = \{2 - \sqrt[2]{1 - [(2 - 1) \div 5]} - \sqrt[2]{1 - (2 \div 5)}\} \times 1400 \text{ mm} \div 4 = 116 \text{ mm}$$

$$ID_1 = \{2 - \sqrt[2]{1 - [(3 - 1) \div 5]} - \sqrt[2]{1 - (3 \div 5)}\} \times 1400 \text{ mm} \div 4 = 208 \text{ mm}$$

$$ID_1 = \{2 - \sqrt[2]{1 - [(4 - 1) \div 5]} - \sqrt[2]{1 - (4 \div 5)}\} \times 1400 \text{ mm} \div 4 = 322 \text{ mm}$$

$$ID_1 = \{2 - \sqrt[2]{1 - [(5 - 1) \div 5]} - \sqrt[2]{1 - (5 \div 5)}\} \times 1400 \text{ mm} \div 4 = 543 \text{ mm}$$

$$ID_6 = \{2 + \sqrt[2]{[(6 - 1) \div 5] - 1} + \sqrt[2]{(6 \div 5) - 1}\} \times 1400 \text{ mm} \div 4 = 857 \text{ mm}$$

$$ID_7 = \{2 + \sqrt[2]{[(7 - 1) \div 5] - 1} + \sqrt[2]{(7 \div 5) - 1}\} \times 1400 \text{ mm} \div 4 = 1078 \text{ mm}$$

$$ID_8 = \{2 + \sqrt[2]{[(8 - 1) \div 5] - 1} + \sqrt[2]{(8 \div 5) - 1}\} \times 1400 \text{ mm} \div 4 = 1192 \text{ mm}$$

$$ID_9 = \{2 + \sqrt[2]{[(9 - 1) \div 5] - 1} + \sqrt[2]{(9 \div 5) - 1}\} \times 1400 \text{ mm} \div 4 = 1284 \text{ mm}$$

$$ID_{10} = \{2 + \sqrt[2]{[(10 - 1) \div 5] - 1} + \sqrt[2]{(10 \div 5) - 1}\} \times 1400 \text{ mm} \div 4 = 1363 \text{ mm}$$

2. Collect data for each traverse point at each insertion depth.

Flow Rate 2 Example, 30 Points (75 max. per set)

IDn	Insertion Depth (mm)	Velocity		
		Point 1	Point 2	Point 3
ID1	37			
ID2	116			
ID3	208			
ID4	322			
ID5	543			
ID6	857	N/A		N/A
ID7	1078	N/A		N/A
ID8	1192	N/A		N/A
ID9	1284	N/A		N/A
ID10	1363	N/A		N/A

3. Compute the average fluid velocity by summing the data and dividing by the number of points.

   The Series 2440 provides internal data logging and computations.
   The Series 155 repeats this process for each flow rate, up to four sets, using CCF.

Traverse Probe Blockage

Small ducts must account for sensor and probe support blockage. The deeper the probe is inserted into the duct blocks more flow and causes an increase in local velocity because of the reduced internal area. When this blockage error is greater than 0.25% you can define a Sensor Blockage Correction Factor (SBCF) to make the observed reading account for the blockage as though it did not exist.

Use the following equation to determine if a SBCF is needed:

$$IDi \geq 0.0025 \times AD \div DP$$

where:

IDi is the sensor insertion depth for the specific cell being measured.

AD is the inner cross-sectional area of the duct.

DP is the diameter of the probe.

Example 3

Using a 19.05 mm (0.75 inches) diameter probe to sampling a circular duct with an inner diameter of 1400 mm (55 inches) requires the following minimum insertion depth to account for blockage:

$$IDi \geq 0.0025 \times \pi \times (1400\ mm)^2 \div 4 \div 19.05\ mm = 202\ mm$$

The SBCF can be defined with the following equation:

SBCFi = 1 - [(IDi × DP) ÷ AD]

where:

SBCFi is the SBCF at the specific insertion depth being measured.

IDi is the sensor insertion depth for the specific cell being measured.

DP is the diameter of the probe.

AD is the inner cross-sectional area of the duct.

Example 4

Using a 19.05 mm (0.75 inches) diameter probe to sampling a circular duct with an inner diameter of 1400 mm (55 inches) at a depth of 1363 mm (54 inches) for the 10th sampling point of an access point has the following SBCF:

$SBCF_{10} = 1 - \{(1363\ mm \times 19.05\ mm) \div [\pi \times (1400\ mm)^2 \div 4]\} = 0.9831$

The true velocity (VT) is found using the following equation:

VT = VI × SBCF

where:

VT is the true velocity.

VI is the indicated velocity.

Series 2440 Configuration

A thermal anemometer reads standard velocity corrected to reference conditions. For example:

25°C, 101.325 kPa

The readings are logged and then directly averaged using the equal area method.

The Series 2440 portable flow meter can average a set of traverse data of equal areas by creating a test-set memory log the same size as the traverse array. This method is faster and less error prone than filling out the tables shown in previous examples.

To configure the Series 2440 to internally log data to its test-set memory, you must setup the internal memory log with enough memory to account for the traverse size. The internal memory log has 2,300 points for trending and test-set data storage. Up to 90% of the storage is allocated to trend memory, so minimally 10% can be allocated to test-set memory.

Configuring Internal Memory Log

Note Most menus automatically exit to the main view after 2 minutes of inactivity.

To configure the internal memory log:

1> Enter Program mode by pressing **P**.

2> Enter the user code (the default is 123456).

3> Press **E**.

4> Press **P** until the **Memory Data Log** menu appears.

```
PRESS E TO SET
MEMORY DATA LOG
```

5> Press **E**.

```
SETUP: TRENDS
NEXT CHOICE ^v
```

The Setup options are **Events**, **Tests**, and **Trends**.

6> Press an arrow key to select **Trends** setup, and then press **E**.

```
TRENDS LOG: ON
^=ON  v=OFF
```

7> Press an arrow key to turn the Trend Log **ON**, and then press **E**.

```
LOG DATA MAY BE
LOST IF CHANGED
```

A warning or new value accepted message appears.

8> Press **E** to continue if necessary.

```
ENTER PERCENT OF
MEMORY USE: 50
```

9> Use the number keys to enter 50 percent, and then press **E**.

```
RESET TREND/TEST
MEMORY?     YES
```

10> If prompted press an arrow key to rest the trend/test memory **YES**, and then press **E**.

11> Press **P** to return to the setup options.

```
SETUP: TESTS
NEXT CHOICE ^v
```

12> Press an arrow key to select **Tests** setup, and then press **E**.

```
TESTS LOG: ON
^=ON  v=OFF
```

13> Press an arrow key to turn the Test Log **ON**, and then press **E**.

```
LOG DATA MAY BE
LOST IF CHANGED
```

A warning message appears.

14> Press **E** to continue.

```
ENTER MAX # OF
TEST SETS 10
```

For this example, this splits 50% of 2300 into 10 units of equal size (115 samples).

15> Press **E** to accept the default value (**10**).

```
MAX SAMPLES PER
TEST SET IS 115
```

16> Press **E** to continue or press **C** until you exit the setup options.

Storing Data in Test Memory

To store data in test memory:

1> Enter Program mode by pressing **P**.

2> Enter the user code (the default is 123456).

3> Press **E**.

4> Press **P** until the **Access Memory Log** option appears.

```
PRESS E TO
ACCESS MEM LOG
```

The memory log is used to record traverse data.

The Series 155 supports calibrating up to four flow rates, while the Series 2440 allows more than four test flow rates. You must record additional Series 155 traverse results elsewhere.

5> Press **E**.

```
SELECT TASK ^v
RECORD TEST DATA
```

The Task options are **Record Test Data**, **View Test Data**, and **Log to COM port**.

6> Press an arrow key to select **Record Test Data**, and then press **E**.

```
ENTER TEST SET
NUMBER: 4
```

7> Use the number keys to enter the number of test flow rates, and then press **E**.

You might be prompted to overwrite existing data. If you choose No, you will be prompted for another test set number.

8> Press an arrow key to select **Yes**, and then press **E**.

```
ENTER # OF TEST
SAMPLES: 30
```

The number of test samples should be less than max samples per test set. In the previous example, this was 115 samples.

9> Use the number keys to enter the traverse array size for the specified test set, and then press **E**.

```
LOG IS AUTO: NO
^=YES  v=NO
```

Automatically spaced timing requires you to move the probe to each point on the specified time interval.

10> Press an arrow key to select **No**, and then press **E**.

```
PRESS E TO START
AND E TO RECORD
```

11> Press **E**.

```
10.98 SMPS
24.6 DEGC
```

The filtered velocity and temperature settings appear. The appearance of velocity and temperature data can be modified to show temperature and flow data or flow and velocity data by pressing the arrow keys.

The standard 2-minute time-out does not apply to this prompt. It will not update until you accept the data as a test-set sample.

12> Press **E**.

```
SAMPLE #1
IS RECORDED
```

A momentary message appears showing the logged test-set number. This process continues until the entire test-set sample is defined (for this example, there are 115 samples.). When the test-set completes, the Series 2440 returns to the task prompt.

```
SELECT TASK ^v
RECORD TEST DATA
```

13> Press **E** to continue or press **C** until you exit the setup options.

Viewing the Data Stored in the Test Memory

To view the data from a test-set:

1> Enter Program mode by pressing **P**.

2> Enter the user code (the default is 123456).

3> Press **E**.

4> Press **P** until the **Access Memory Log** option appears.

```
PRESS E TO
ACCESS MEM LOG
```

The memory log is used to view traverse data.

The Series 155 supports calibrating up to four flow rates, while the Series 2440 allows more than four test flow rates. You must record additional Series 155 traverse data results elsewhere.

5> Press **E**.

```
SELECT TASK ^v
VIEW TEST DATA
```

The Task options are **Record Test Data**, **View Test Data**, and **Log to COM port**.

6> Press an arrow key to select **View Test Data**, and then press **E**.

```
ENTER TEST SET
NUMBER: 1
```

7> Use the number keys to specify the test-set data you want to view, and then press **E**.

```
VIEW: FLOW RATE
NEXT CHOICE ^v
```

You can view the velocity, temperature, or flow rate by pressing the arrow keys.

8> Use the number keys to enter the number of test-set you want to view, and then press **E**.

```
AVERAGE DATA
10.98 SMPS
```

Use the arrow keys to scroll through the average data, standard deviation, maximum and minimum values, and the velocity, temperature, or flow rate for each test-set sample.

9> Press **C** until you exit the setup options.

Velocity Probe & the Pitot Tube

The classic Pitot tube is a velocity-sensing device based on the principle of converting kinetic energy of a flow stream to potential energy as a pressure by stopping the flow. It has an impact port and a static port that do not receive any kinetic contribution. The classic Pitot tube has a velocity-dependent correction factor K of 1.0 by definition.

The S-Type Pitot tube has an upstream impact port and downstream port under slight vacuum that generates a higher differential signal and improves the turn-down ratio. This increased differential pressure (dP) comes at the price of a correction factor K (which is velocity-dependent), so the device must be calibrated against the classic Pitot design.

The basic Pitot tube equation (in actual velocity) is as follows:

$$\mathbf{v = k\,(2gdP \div \rho)^{0.5}}$$

where:

k is the correction factor, 1.0 for classic Pitot and 0.84 for S-type Pitot.

g is the acceleration of gravity, 32.2 ft/s^2.

dP is the differential pressure between the impact and static ports in lb/ft^2.

ρ is the density of the gas, lb/ft^3.

Additional calculations involve converting the dP units to inches of water and converting the gas density to a function of pressure and temperature. The results are converted to standard velocity instead of actual velocity.

The following formula converts gas density to pressure and temperature:

$$\mathbf{\rho = \rho_s\,(Ts \div Ta)(Pa \div Ps)}$$

where:

ρ_s is the standard gas density, 0.07387 lb/ft^3.

MW is the gas molecular weight, MW = 28.96.

Ts is 77°F or 25°C in absolute units so 460 + °F or 273.15 + °C.

Ta is the actual temperature in absolute units.

Pa is the actual pressure in absolute units, in PSIA or Hg.

Ps is the standard pressure which is 101.325 kPa, 14.69 PSIA, 760 mmHg or 29.92 in Hg.

The following formula converts the differential pressure (dP) from inches H_2O into lb/ft^2:

$$\text{inches } H_2O \div (27.68 \text{ in } H_2O \div lb \div in^2) \times (144\ in^2/ft^2) = (144 \div 27.68) \times lb/ft^2$$

Use the following formula to make the final calculation to convert standard velocity to actual velocity:

$$V = k\,[dP\,(144 \div 27.68)\,(2)\,(32.2) \div (MW\ 0.07387 \div 28.96)\,(Ts \div Ta)\,(Pa \div Ps)]^{0.5}\,(60)$$

$$V = 21745\ k\ [(dP \div MW)\ (Ta \div Ts)\ (Ps \div Pa)]^{0.5}\ FPM$$

Note $X^{0.5}$ is the same as the square root of X.

The molecular weight (MW) of Air is equal to 28.96, which further reduces the calculation:

$$V = k\ 4041\ [dP\ (Ta \div Ts)\ (Ps \div Pa)]^{0.5}\ FPM$$

where:

V is actual velocity in ft/min, dP is in H_2O.

k is the correction factor.

The formula for standard velocity (SFPM) is:

Vs = V (Ts ÷ Ta) (Pa ÷ Ps)

The calculation appears as follows:

$$Vs = 21745\ k\ [(dP \div MW)\ (Ts \div Ta)\ (Pa \div Ps)]^{0.5}\ SFPM$$

The calculation for Air appears as follows:

$$Vs = 4041\ k\ [dP\ (Ts \div Ta)\ (Pa \div Ps)]^{0.5}\ SFPM$$

Pitot Tube Examples

Example A The measured dP is 7.53 in H_2O on a classic Pitot tube, the gas is Air, temperature is 20.1 °C, and pressure is 28.05 Hg. To determine the standard velocity:

$Vs = 4041\ (1.0)\ [7.53\ (273.15 + 25) \div (273.15 + 20.1)\ (28.05 \div 29.92)]^{0.5} = 10826$ SFPM

Example B For measuring flue gas from a typical power plant with the following attributes:
an S-type Pitot measured at dP of 2.04 in H_2O, temperature is 460°F, pressure is 28.45 Hg in the stack with a gas mix of 15% CO_2, 10% H_2O, 73% N_2, 2% 0_2.
To determine the actual velocity and standard velocity:

Molecular weight:

$MW = 0.15 \times (12 + 2 \times 16) + 0.10\ (2 \times 1+16) + 0.73\ (2 \times 14) + 0.02\ (2 \times 16) = 29.48$

Actual velocity:

$V = 21745\ (0.84)\ [2.04 \div 29.48\ (460 + 460) \div (460 + 77)(29.92 \div 28.56)]^{0.5} = 6437$ FPM

Standard velocity:

$Vs = 21745\ (0.84)\ [2.04 \div 29.48\ (460 + 77)\ /(460 + 460)(28.56 \div 29.92)]^{0.5} = 3587$ SFPM

Example C For measuring digester gas flow rate with the following attributes:
8" schedule 40 pipe with gas composition is 70% CH_4 and 30% CO_2, using an S-type Pitot to record data where dP = 0.42 in H_2O, temperature is 37.2°C, and the pressure is 0.68 PSIG. The ambient air pressure is 27.56 Hg.

Convert pressure into the same units:

$Pa = (0.68\ PSIG \div 14.69PSI) \times 29.92\ in\ Hg + 27.56\ in\ Hg = 28.94\ in\ Hg$

Compute the MW of the gas mix:

$MW = 0.7\ (12 + (4 \times 1)) + (0.3\ (12 + (2 \times 16))) = 24.4$

Compute the standard velocity:
$Vs = 21745\ k\ [(dP \div MW)\ (Ts \div Ta)\ (Pa \div Ps)]^{0.5}$ SFPM
$Vs = 21745\ (0.84)\ [0.42 \div 24.4\ (273.15 + 25) \div (273.15 + 37.2)(28.94 \div 29.92)]^{0.5}$
= 2310 SFPM

Assuming the measurement was from the center of the 8" duct and
the ID = 7.981 results in the following flow rate:

$SCFM = SFPM \times Area \times CF = 2310 \times 3.1416\ (7.981 \div 2 \div 12)^2 \times 0.80 = 642$ SCFM

This would be a large digester flow on a good day.

The 0.80 CF is a typical Va/Vp correction factor observed with tracer gas testing on an 8" line. Accounting for the Pitot tube blockage during the measurement results in an area reduction by (0.25 inch x 4") = 1 in^2. Converting this value to ft^2 with the previous calculations:

$SCFM = 2310 \times [3.1416\ (7.981/2/12)^2 - 1 \div 144] \times 0.8 = 629$ SCFM

Accounting for the test probe blockage is a 2% lower flow rate but slightly more accurate calculation.

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