ACCUSONIC
TECHNOLOGIES®

7500 Series Flowmeter
Technical Reference Manual

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Table of Contents

CHAPTER ONE

TABLE OF CONTENTS i
INTRODUCTION **1-1**
OVERVIEW OF THE MANUAL 1-1
THE ACCUSONIC MODEL 7500 1-2
Transducers 1-3
Cables 1-4
Flowmeter Console 1-4
Display and System Input/Output (I/O) Options 1-4
System Parameters and Setup 1-4
Self Test and System Diagnostics 1-4

CHAPTER TWO

FLOWMETER DESCRIPTION **2-1**
COMPONENT OVERVIEW 2-1
BASIC FLOWMETER CONSOLE 2-1
RACK-MOUNT CONSOLE 2-4
REMOTE FLOW TRANSMITTER UNIT 2-5
SYSTEM OVERVIEW 2-6
Measuring Fluid Stage 2-6
System Expansion 2-7
System Processor Technical Details 2-7
Flow Transmitter Technical Details 2-9

CHAPTER THREE

ACOUSTIC FLOWMETER PRINCIPLES **3-1**
MEASUREMENT SECTION CONFIGURATION 3-1
PLACEMENT OF ACOUSTIC PATHS IN ROUND PIPE 3-2
PLACEMENT OF ACOUSTIC PATHS IN AN OPEN CHANNEL OR COMPOUND SECTION 3-2
TRAPEZOIDAL EXTRAPOLATION/INTERPOLATION STRATEGIES 3-4
Top and Bottom Clearance Considerations in an Open Channel Meter 3-6
CROSSED PATHS 3-7
FLOWMETER MEASUREMENT CYCLE 3-8
Reading System Inputs 3-11
Measuring Travel Times 3-12
Signal Detection 3-13
Calculating Path Velocities 3-14
MEASURING STAGE 3-16
CALCULATING FLOW 3-17
Integration Methods 3-18
Flow Calculation Formulas for Full Pipes or Surcharged Conduits 3-19

Flow Calculation Formulas for Non-Surcharged Conduits 3-21
Updating Volume Totals 3-25
Volume totalizer after Outage 3-25
Updating System Outputs 3-26
ACOUSTIC FLOWMETER ACCURACY 3-26
Sources of Measurement Uncertainty 3-26
Sample Error Analysis (Round Pipe) 3-28

CHAPTER FOUR

UNPACKING AND INSTALLATION 4-1
PHYSICAL INSTALLATION 4-1
ELECTRICAL INSTALLATION 4-2
AC Wiring 4-2
Transducer Wiring 4-3
Transducer and Cabling Checkout 4-5
Connecting Transducer Cabling 4-5
Connecting a Printer 4-6
Level Sensor Setup 4-7
RS-232 PORT CONNECTION 4-9
RS-485 INTERCONNECTION 4-11
Cable Specifications 4-11

CHAPTER FIVE

INITIAL SETUP, GENERAL OPERATIONS 5-1
CONTROL PANEL, PARAMETERS AND VARIABLES 5-1
MENUS 5-1
Stepping Through Menus 5-3
ON LINE HELP 5-4
ENTERING PARAMETER VALUES 5-8
AutoStart 5-8
Using a Password 5-8
Using an External Keyboard 5-9
Selecting Menu Access 5-9
GENERAL PARAMETERS 5-10
SECTION PARAMETERS 5-11
PATH PARAMETERS 5-14
SAVING AND LOADING PARAMETERS 5-15
FIRST TIME POWER UP 5-16
Initial checks 5-16
Adjusting Display Contrast 5-16
First Time Diagnostics 5-17
Initial Flowmeter Setup 5-20
Procedure #1 - Set up General Parameters 5-22
Procedure #2 - Setting up Section Parameters 5-23
Procedure #3 - Setting up Path Parameters 5-25
Procedure #4 - Setting the Password (optional) 5-26

Procedure #5 - Save Configuration 5-27
Procedure #6 - Print Parameters 5-29
Measuring Flow 5-30
Interrupting Measurements 5-30
DISPLAY SCREENS 5-31
SPECIAL CONFIGURATIONS 5-34
Using Layer Boundary Parameters to Simulate a Round Pipe 5-34

CHAPTER SIX

MAINTENANCE AND REPAIRS 6-1
MAINTENANCE 6-1
Diagnostics 6-1
REPAIRS 6-6
Review of Anti-static Procedures 6-6
REPLACEMENT PROCEDURES FOR NEMA CABINETS 6-7
Replacing System Processor Circuit Boards 6-7
Replacing Transceiver Card Set 6-8
Removing the Connector Panel 6-8
Replacing Path or Stage Cards 6-9
Replacing the Pulse Transmitter 6-9
Replacing the High Voltage Power Module 6-9
Replacing the Display Card 6-10
Replacing the Keypad Card 6-11
Replacing the Membrane Keypad and LCD Panel 6-11
Replacing the Diskette Drive 6-12
Replacing the Power Supply 6-12
REPLACEMENT PROCEDURE FOR FLOWMETERS IN RACK-MOUNT CABINET 6-13
Replacing System Processor Circuit Boards 6-13
Replacing Transceiver Card Set 6-14
Removing the Connector Panel 6-14
Replacing Path or Stage Cards 6-14
Replacing the Pulse Transmitter 6-14
Replacing the High Voltage Power Module 6-14
Releasing the Front Panel 6-15
Replacing the Display Card 6-15
Replacing the Keypad Card 6-16
Replacing the Membrane Keypad and LCD Panel 6-16
Replacing the Diskette Drive 6-16

CHAPTER SEVEN

PARAMETERS AND VARIABLES 7-1
PARAMETER LIST 7-1
Always display plant totals 7-1
Autostart switch 7-1
Available velocity enabled 7-2
Average cable length per path 7-2

Average stage cable length 7-2
Averaging queue length 7-2
Bidirectional flow 7-3
Bottom channel width 7-3
Bottom velocity ratio 7-3
Channel bottom height 7-3
Cross sectional area 7-4
Current date 7-4
Current time 7-4
Data logging 7-4
Data log start 7-5
Delay time of other ducer 7-5
Differential alarm threshold 7-5
Differential flow averaging size 7-5
Differential warning threshold 7-5
Display contrast 7-5
Display mode 7-6
Display totals line 7-6
Ducer connection 7-6
Ducer type (7600, 7601, 7605, 7612 ...) 7-6
End label character 7-6
End starting number 7-7
Error Reporting 7-7
Flowrate scale factor 7-7
Format 7-8
Frequency of other ducer 7-8
Full Pipe 7-8
Inactivity Timeout 7-9
K 7-9
Layer boundary elevation 1 - n 7-9
Layer boundary width 1 - n 7-10
Leak detection switch 7-10
Log data to 7-10
Log interval 7-11
Log negative volume data 7-11
Log velocity data 7-11
Manning coefficient of roughness 7-11
Manual gain 7-12
Manual stage (1 or 2) value 7-12
Maximum bad measurements 7-12
Maximum change in flowrate 7-12
Maximum change in stage 7-13
Maximum change in velocity 7-13
Maximum expected flowrate 7-13
Maximum expected velocity 7-13
Maximum stage 7-14
Maximum stage difference 1 and 2 7-14
Menu access 7-14
Minimum flowrate 7-14
Minimum good paths 7-15

Minimum path submersion 7-15
Minimum stage 7-15
Negative over velocity alarm threshold 7-16
Negative over velocity warning threshold 7-16
Non-surcharged integration method 7-16
Number of channel layers 7-16
Over velocity alarm count 7-16
Over velocity warning count 7-16
Password control 7-17
Path angle 7-17
Path elevation 7-17
Path length 7-17
Path percent active 7-18
Path position 7-18
Path simulation 7-18
Path switch 7-19
Penstock label character 7-19
Penstock starting number 7-19
Pipe height 7-19
Pipe integration 7-20
Pipe shape 7-20
Pipe slope 7-20
Positive over velocity alarm threshold 7-20
Positive over velocity warning threshold 7-20
Protrusion of other ducer 7-21
Q FWD 1 - n 7-21
Q REV 1 - n 7-21
Radius 7-21
Receiver gain 7-22
Repetition time 7-22
Section label character 7-22
Section starting number 7-22
Section switch 7-22
Section type 7-23
Self test interval 7-23
Shape factor 7-23
Signal detection method 7-23
Simulation forward time 7-24
Simulation reverse time 7-24
Simulation source 7-24
Simulation velocity 7-24
Simulation velocity ramp scale 7-25
Single coefficient (1 - 5) 7-25
Single integration 7-25
Speed of sound in fluid 7-26
SQM 7-26
Stage averaging size 7-26
Stage ducer type 7-26
Stage interval 7-27
Stage mode 7-27

Stage (1 or 2) offset 7-27
Stage (1 or 2) range maximum 7-27
Stage (1 or 2) range minimum 7-28
Stage source 7-28
Surcharged integration method 7-28
Temperature coefficient 7-29
Temperature coefficients for 7500: 7-29
Top weight 7-30
Totalizer cutoff time 7-31
Travel time tolerance 7-31
Units 7-31
Velocity Substitution 7-31
Velocity Substitution Ratio 7-32
V FWD 1 - n 7-34
V REV 1 - n 7-34
Volume scale factor 7-34
Weight 7-35
Which Section 7-35
Width at path elevation 7-35
Zero flow offset 7-35
VARIABLE LIST 7-37
Averaged stage 7-37
Average velocity of sound 7-37
Average temperature 7-37
Delta flow 7-37
Delta flow average 7-37
Differential flow warning 7-37
Differential flow alarm 7-37
Flow average 7-37
Flow error count 7-37
Flowrate 7-37
Forward gain 7-38
Forward time 7-38
Negative volume 7-38
Positive volume 7-39
Reverse gain 7-39
Reverse time 7-39
Section status 7-39
Signal delay 7-39
Stage 1 7-39
Stage 1 signal delay 7-40
Total average flow 7-40
Total Flow 7-40
Total negative volume 7-40
Total positive volume 7-40
Total volume 7-40
Velocity 7-40
Velocity error count 7-41
Velocity of sound 7-41
Volume 7-41

GENERAL VARIABLES 7-42
SECTION AND END VARIABLES 7-42
PATH VARIABLES 7-42
LEAK VARIABLES 7-42

CHAPTER EIGHT

OUTPUTS AND REPORTS 8-1
OUTPUTS 8-1
Suggestion for Testing Outputs 8-1
Analog Outputs 8-1
Setting Up Analog Outputs 8-1
Verify Analog, Relay and Totalizer Outputs 8-4
Field Adjustment Procedure for 2-Channel 4-20 mA Output 8-4
Relay and Totalizer Outputs 8-6
General purpose relays 8-6
Leak Detection (Refer to Leak Detection - Chapter 12) 8-7
Totalizer Output 8-9
System Failure or Watchdog relay 8-9
Setting Up the General Purpose Relays 8-10
Setting Up the Totalizer Outputs 8-11
Verify Relay and Totalizer Outputs 8-11
SUMMARY OF DATA STORAGE OPTIONS 8-12
RS-232 Output 8-12
Reports 8-13
Datalogging 8-13
Listings 8-14
Parameter load/save 8-15
Error Reporting 8-15
RS-232 OUTPUTS 8-16
Setting up the RS-232 Outputs 8-19
Verifying RS-232 Output 8-20
FLOWMETER REPORTS 8-21
Setting Up Reports 8-23
DATA LOGGING 8-26
Data log file description 8-27
Error Reporting 8-28

CHAPTER NINE

ADVANCED TROUBLESHOOTING 9-1
WHAT TO DO FIRST: 9-1
STATUS LIGHTS 9-1
STATUS MESSAGES 9-2
ERROR CODES 9-3
Path, Section and Self-test Status Codes 9-3
MONITORING RAW PATH SIGNALS WITH OSCILLOSCOPE 9-12
VERIFYING AND ADJUSTING POWER SUPPLIES 9-13

Checking the system voltages 9-14
Adjusting the power supply - rack-mount cabinet 9-14
Adjusting the power supply - NEMA cabinet 9-15

CHAPTER TEN

TRANSDUCER MAINTENANCE 10-1
SIGNAL DETERIORATION 10-1
7601 SERIES TRANSDUCERS 10-3
Tools Required 10-4
7600 SERIES TRANSDUCERS 10-9
Tools Required 10-9

CHAPTER ELEVEN

MISCELLANEOUS TECHNICAL INFO 11-1
ENTERING SPECIAL KEYS 11-1
FLOW TRANSMITTER ADDRESSING 11-2
SYSTEM SPECIFICATIONS 11-4
ACCUSONIC MODEL 7500 Console 11-4
Power Requirement 11-4
Enclosure Dimensions 11-4
Environmental Requirements 11-4
Miscellaneous 11-4
Model 7520 Remote Flowmeter Transmitter 11-4
Power Requirement 11-4
Enclosure Dimensions 11-4
Environmental Requirements 11-5
Miscellaneous 11-5
REMOTE OPERATION VIA MODEM 11-6
Modem Hookup Procedure 11-6
Remote Operation 11-6
Calling up the 7500 11-6
Downloading Data Files 11-7
Re-entering Measurement Mode and Exiting the *Remote2* Program 11-7
ELECTRICAL SURGE PROTECTION FOR ACCUSONIC FLOWMETERS 11-8
Overview - Surges and Transients 11-8
The Case for an External Surge-Protection Enclosure 11-9
Protection Components 11-9
Application of Protection Devises to Accusonic Flowmeters 11-10
Summary of Standard and Optional Equipment 11-11

CHAPTER TWELVE

LEAK DETECTION SYSTEM 12-1
SYSTEM COMPONENTS 12-1
SYSTEM OPERATION 12-3

Differential Flow Determination 12-3
Over Velocity Detection 12-3
GENERAL SYSTEM OPERATION 12-5
LEAK DETECTION PARAMETER LIST 12-7
Always Display Plant Totals 12-7
Differential alarm threshold 12-7
Differential flow average size 12-7
Differential warning threshold 12-8
Leak detection switch 12-8
Negative over velocity alarm threshold 12-8
Negative over velocity warning threshold 12-8
Over velocity alarm count 12-9
Over velocity warning count 12-9
Positive over velocity alarm threshold 12-9
Positive over velocity warning threshold 12-9
GLOSSARY OF TERMS **1**

A **Glossary of Terms** and an **Index** are included at the rear of this manual.

TABLE OF TABLES

Table 1-1 Accusonic Transducers 1-3
Table 3-1 Data Verification and Substitution 3-10
Table 5-1 Flowmeter Menu Hierarchy 5-5
Table 5-2 List of General Parameters 5-10
Table 5-3 List of Section Parameters 5-11
Table 5-4 List of Path Parameters 5-14
Table 5-5 Checklist of Initial Setup Parameters 5-21
Table 6-1 System Diagnostic Error Messages 6-4
Table 6-2 Status Light Error Definitions 6-6
Table 8-1 General Purpose Relay Specifications 8-8
Table 8-2 Watchdog Relay Specifications 8-9
Table 8-3 Variables Available via RS-232 8-17
Table 9-1 Status Messages 9-2
Table 9-2 Path Status Codes 9-4
Table 9-3 Section Status Codes 9-7
Table 9-4 Self-test Status Codes 9-9
Table 9-5 Stage Status Codes 9-10
Table 9-6 Standard DC Wiring Colors 9-14
Table 11-1 Jumper positions 11-3
Table 12-1 Checklist of Initial Setup Parameters for Leak Detection System 12-10

TABLE OF FIGURES

Figure 1-1 ACCUSONIC MODEL 7500 1-2
Figure 2-1 Flowmeter Cabinets, Front Panels 2-2
Figure 2-2 NEMA-4 Flowmeter Enclosure, Inside View 2-3
Figure 2-3 Rack-mount Flowmeter Enclosure, Inside and Rear Views 2-4
Figure 2-4 Remote Flow Transmitter, NEMA Enclosure 2-5
Figure 2-5 System Overview 2-6
Figure 2-6 Larger Configurations 2-7
Figure 2-7 System Processor Group 2-9

Figure 2-8 Block diagram of Flow Transmitter ________ 2-10
Figure 3-1 Placement of Paths in Straight Round Pipe ________ 3-1
Figure 3-2 Placement of Paths in an Open Channel ________ 3-2
Figure 3-3 Five-path Open Channel Configuration ________ 3-5
Figure 3-4 Variation of Uncertainty with Stage for Five-path Open Channel Meter ________ 3-5
Figure 3-5 Multipath Reflection ________ 3-6
Figure 3-6 Crossed Path Configuration ________ 3-7
Figure 3-7 Measurement Cycle ________ 3-9
Figure 3-8 Layout of an Acoustic Path ________ 3-12
Figure 3-9 Predicted-arrival Signal Pass Gates ________ 3-14
Figure 3-10 Waveform Features Used for Signal Detection ________ 3-14
Figure 3-11 Calculation of Path Velocities ________ 3-15
Figure 3-12 Calculate and Validate Flow ________ 3-17
Figure 4-1 Location of AC Power Connections, NEMA Cabinets ________ 4-2
Figure 4-2 Transducer Numbering - Simple Pipe ________ 4-3
Figure 4-3 Transducer Numbering - Open Channel ________ 4-3
Figure 4-4 Transducer Numbering - Crossed Paths ________ 4-4
Figure 4-5 Stripping and Terminating the Transducer Cable ________ 4-4
Figure 4-6 Transducer Wiring Connections ________ 4-6
Figure 4-7 Location of Printer Connector ________ 4-6
Figure 5-1 Control Panel ________ 5-2
Figure 5-2 Two Examples of Menus ________ 5-3
Figure 5-3 Tree organization of the parameters ________ 5-7
Figure 6-1 Card Retainters ________ 6-8
Figure 6-2 Rear View of Connector Panel in Lowered Position ________ 6-9
Figure 6-3 High Voltage Module Replacement ________ 6-10
Figure 6-4 Diskette Drive Removal ________ 6-12
Figure 6-5 Releasing the Front Panel ________ 6-15
Figure 7-1 Open Channel and Compound System Parameters ________ 7-36
Figure 8-1 Hourly Report ________ 8-25
Figure 9-1 Raw Receive Signal ________ 9-12
Figure 9-2 Received Signal ________ 9-13
Figure 9-3 Power Supply Adjustment Locations ________ 9-16
Figure 9-4 Power Supply Adjustment Locations ________ 9-17
Figure 10-1 Use of Transducer Installation Gauge ________ 10-14
Figure 10-2 7601 Transducer Extraction Tool (uninstalled) ________ 10-15
Figure 10-3 Connection to 7601 Transducer ________ 10-16
Figure 10-4 Extracting 7601 Transducer using Withdrawal Tool ________ 10-17
Figure 10-5 Connection to 7600 Transducer ________ 10-18
Figure 10-6 7600 Transducer/Valve Assembly ________ 10-19
Figure 10-7 7600 Transducer Assembly with Extraction Tool Installed ________ 10-20
Figure 10-8 Model 7605 Stainless Steel Transducer ________ 10-21
Figure 10-9 Model 7625 PVC Transducer ________ 10-22
Figure 10-10 Model 7630/34 Internal Mount Transducer ________ 10-23
Figure 11-1 Address 1, the default address ________ 11-2
Figure 11-2 Address 3 ________ 11-2
Figure 12-1 Typical Section/End/Penstock Configuration ________ 12-2

CUSTOMER SPECIFIC DRAWINGS - FP

Chapter 1
Introduction

Accusonic manufactures a wide variety of acoustic flowmeters for pipelines and open channels. Its products have been in service since the early 1970's in a variety of hydroelectric, water delivery and waste industries. The ACCUSONIC MODEL 7500 provides customers with the finest flow measurement solutions for a wide range of today's applications.

Overview of the Manual

This manual is designed for technicians and engineers responsible for the installation, setup and operation of the ACCUSONIC MODEL 7500. It provides both an overview and detailed description of the instrument and the procedures used to control it and to diagnose problems. Note that this manual covers all the options available in this equipment series, and may describe functions and features not included in your system.
Chapter One introduces the equipment and summarizes the manual.

Chapter Two identifies the components of the system, describes its functional organization, and describes the measurement cycle.

Chapter Three describes the principles of acoustic flowmeters and describes the algorithms used in the calculation of flow.

Chapter Four describes how to install the flowmeter console and how to connect the transducer cables to the console.

Chapter Five describes how to turn on and operate the system and includes the step-by-step procedure for starting up the instrument and initializing parameters.

Chapter Six describes the diagnostic system and explains how to replace subassemblies.

Chapter Seven is a dictionary of all system parameters and variables.

Chapter Eight describes how to set up outputs and reports.

Chapter Nine includes information for interpreting status errors reported by the system.

Chapter Ten describes how to care for the transducers.

Chapter Eleven describes miscellaneous technical information.

Chapter Twelve describes the leak detection system (optional).

A **glossary of terms** and an **index** are included at the rear of this manual.

The 7500 Series Flowmeter

The ACCUSONIC MODEL 7500 accurately and reliably measures fluid flow in large pipes, open channels, and rivers. It can be used to measure flow in virtually any enclosed conduit, whether partially full or surcharged, and also in open channels and rivers.

The flowmeter employs an ultrasonic technique to measure average fluid velocity along several parallel paths, and then calculates total flow from these values. The equipment can be configured to meet the accuracy required in a specific application.

When used as a four or eight parallel path flowmeter on pressurized pipes, the instrument measures flow to within ±0.5% of actual flow rate.[1] Flow in pipes one foot to sixty feet in diameter can be measured economically with the system.

When used as an open channel flowmeter, the instrument is capable of measuring flow to within ±1.5% of actual flow rate.[1] The instrument collects a stage (water level) measurement from one or two integral up-looking acoustic transducer(s) or from an external stage device.

In closed conduits that are sometimes partially filled and at other times are surcharged, the instrument changes its method of computing flow in response to changes in stage.

A flowmeter consists of a minimum of three groups of elements, as shown in Figure 1-1. They include transducers, cables and the flowmeter console.

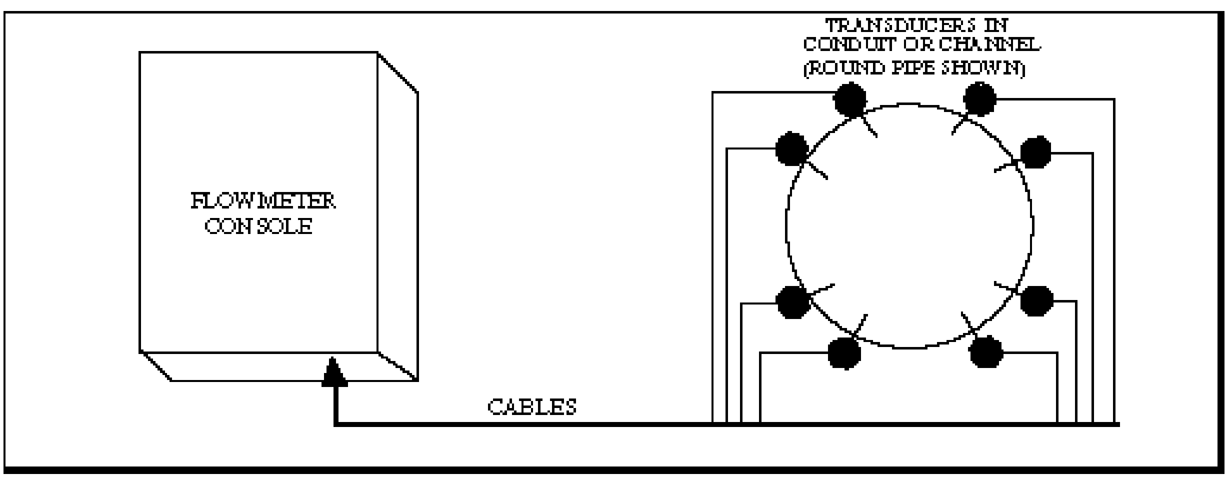

Figure 1-1 7500 Series Flowmeter System

[1] When installing according to Accusonic specifications.

Transducers

Transducers are available in a variety of styles for a variety of applications, including:

- Exposed steel pipe
- Concrete pipe
- Buried or encased pipe
- Pipe with external access only
- Pipe that cannot be dewatered for installation
- Open channels
- Rivers

Table 1-1 lists the transducers supplied by Accusonic.

Table 1-1 Accusonic Transducers

Fully Removable Transducers	
7600	High pressure, penetrating (align by oscilloscope) (1 Mhz)
7601	Low pressure, penetrating (1 Mhz)
7620	Pencil transducer for spool pieces (1 Mhz)
7655	Hazardous Locations, penetrating. Certified for Class 1, Division 1, Groups C & D. (500 kHz)
Externally Accessible Transducers	
7625	Penetrating, with plexiglass window that remains in place
7605	Stainless steel version of above, for high pressure applications
Internal Mount Transducers	
7630	Internal mount with redundant elements (1 Mhz)
7634	Internal mount with redundant elements (500 kHz) intended for long paths or use in dirty water
7616	Array mount for rectangular conduit (500 kHz)
7617	Hazardous Locations, array mount for retangular conduit. Certified for Class 1, Division 1, Group D. (500 kHz)
7656	Hazardous Locations, internal mount. Certified for Class 1, Division 1, Groups C & D. (500 kHz)
Open Channel Transducers	
7616	Array mount, for smaller channels (500 kHz)
7612	Open channel, for wider channels (200 kHz)
7615	Open channel, (500 kHz)
7611	Open channel, for channels up to 1500 feet wide (100 kHz)
Up-Looking Acoustic Stage Transducers	
7632	200 kHz
7612	200 kHz
7615	500 kHz
7616	500 kHz, array mounted

Cables

Cables are coaxial or twin-axial cable according to the transducers in use. Cable runs are typically restricted to 1000 feet, but in some applications may be longer.

Flowmeter Console

The flowmeter console is an industrial-hardened, microprocessor-based control system which can be configured to simultaneously measure flow in several pipes or channels. Furthermore, it can be expanded using add-on units to meet the needs of installations where there are many pipes or channels to measure.

Display and System Input/Output (I/O) Options

The instrument offers a variety of display and system I/O options to meet specific requirements.

The instrument is equipped with a four-line by 40-character liquid crystal display (LCD). It is also available with a two-line by 40-character alphanumeric LCD, a 25-line by 80-character CRT display or a 25-line by 80-character electroluminescent (EL) display.

System output options may include scalable analog current and voltage, digital RS-232, and binary BCD, programmable relays for alarm and totalizer pulses, as well as other specialized outputs. All process outputs are continuously updated after each measurement.

Process input options may include Binary, Binary Coded Decimal (BCD), and analog current and voltage.

There is also a printer option that allows specialized reports to be printed at preselected time intervals. The report can list a variety of measurements and conditions, such as average flow rate, accumulated total flow, and the number of measurements and percentage of measurement errors that occurred over the reporting interval.

The instrument may be equipped with a 3.5 inch or 5.25 inch diskette drive for parameter and data storage and data logging.

System Parameters and Setup

The system is pre-configured at the factory for the number of sections and the number of paths in each section. At startup, site-specific information is entered using the control panel keypad or an optional keyboard. Once configured, the system parameters are stored in battery-backed memory and may optionally be stored on diskette. System parameters can also be changed on site at any time.

Self Test and System Diagnostics

The instrument has built-in self-test routines and continually monitors the reasonableness of all measured data to ensure that the flowmeter is operating properly. If error conditions exist, the system displays the type and location of the fault in easy-to-understand messages.

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Chapter 2
Flowmeter Description

This chapter describes the principal electronic components which make up the flowmeter. It describes the hardware in detail and explains how the system monitors signal quality and maintains measurement integrity.

Component Overview

The ACCUSONIC MODEL 7500 includes a microprocessor system with keypad and display, process input and output interfaces, transducers, and cabling. The instrument is housed in a single enclosure called the *flowmeter console* or the *system console*. In larger installations, *remote units*, also called remote flow transmitters, may be located some distance away from the system console.

Units are housed in wall-mounted NEMA enclosures or in 19-inch relay racks. The basic console is also available in custom configurations that contain heating or cooling apparatus for operation in extreme temperatures.

Basic Flowmeter Console

The accompanying Figure 2-1(see page 2-2) is a front view of the basic console, shown in both the NEMA-4 and the rack-mount enclosures. Figure 2-2 (see page 2-3) is an internal view of the NEMA-4 package, showing its principal electronic subassemblies. Internal views of the rack-mount cabinet and the remote unit are shown later in the chapter (see pages 2-4 and 2-5, respectively).

NEMA-4 Enclosure **-** A steel cabinet houses the system processor for one or more flowmeters and controls a maximum of sixteen transducers (eight paths). In an open channel or compound flowmeter, the cabinet may also house two integral[1] stage sensors. In larger configurations, remote cabinets may contain remote flow transmitters and stage sensors.

Hinged Front Panel **-** Front panel swings open to the left to allow access to all components.

Fastener/Lock **-** Enclosure may be fitted with a padlock for security.

Keypad **-** Twenty-four position membrane keypad is used for setup, control and fault diagnosis.

Display **-** Backlit, alphanumeric liquid crystal display (LCD) shows four lines of information, 40 characters per line, standard. When the instrument is on-line and measuring flow, the display shows calculated flow data through the measured section(s) except when configured to show flowmeter variables or diagnostic data.

[1] Stage detectors may be integral or external. The difference lies in how they attach to the flowmeter. Integral refers to an acoustic uplooker, external can be any other type of sensor, connected via a 4-20mA current loop input.

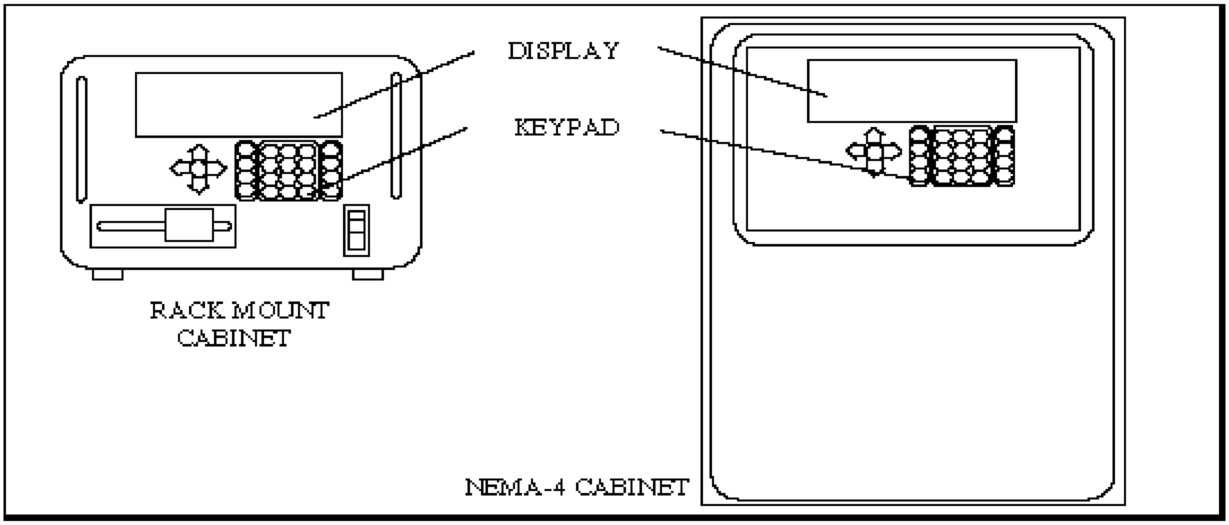

Figure 2-1 Flowmeter Cabinets, Front Panels

The following display options are also available:

- Two-line x 40 characters LCD
- 25 lines x 80 characters electroluminescent (EL)
- 25 lines x 80 characters, external CRT display

Cabling - Cables for power, data communications and for the transceivers are routed through bulkhead connectors at the bottom of the NEMA enclosure, and at the rear of the rack-mount cabinet.

Figure 2-2 (see page2-3) shows an inside view of the flowmeter cabinet. The components include:

Processor Group - Four basic cards and up to four option cards make up the system processor. The system processor stores system parameters, initiates all measurements, and calculates the flow results.

- *Processor card* - Complete microprocessor system with memory and a real time clock and calendar. The card interfaces to a standard AT bus.
- *Memory card* - Stores the flowmeter program and algorithm constants in non-volatile storage; stores site-specific parameters and intermediate results in battery-backed RAM.
- *Basic I/O card* - Watchdog timer-controlled alarm relays and LCD display driver.
- *System communications card* - Provides serial data communications between the system processor and the flow transmitters. An additional RS-232 port and parallel ports may be configured for various uses.
- Options include:
  - Diskette controller
  - Current or voltage analog output interfaces
  - Additional programmable relays
  - Supplemental data communications
  - Binary I/O interfaces (Gray code, BCD)
  - Pulse output interfaces
  - Analog stage inputs

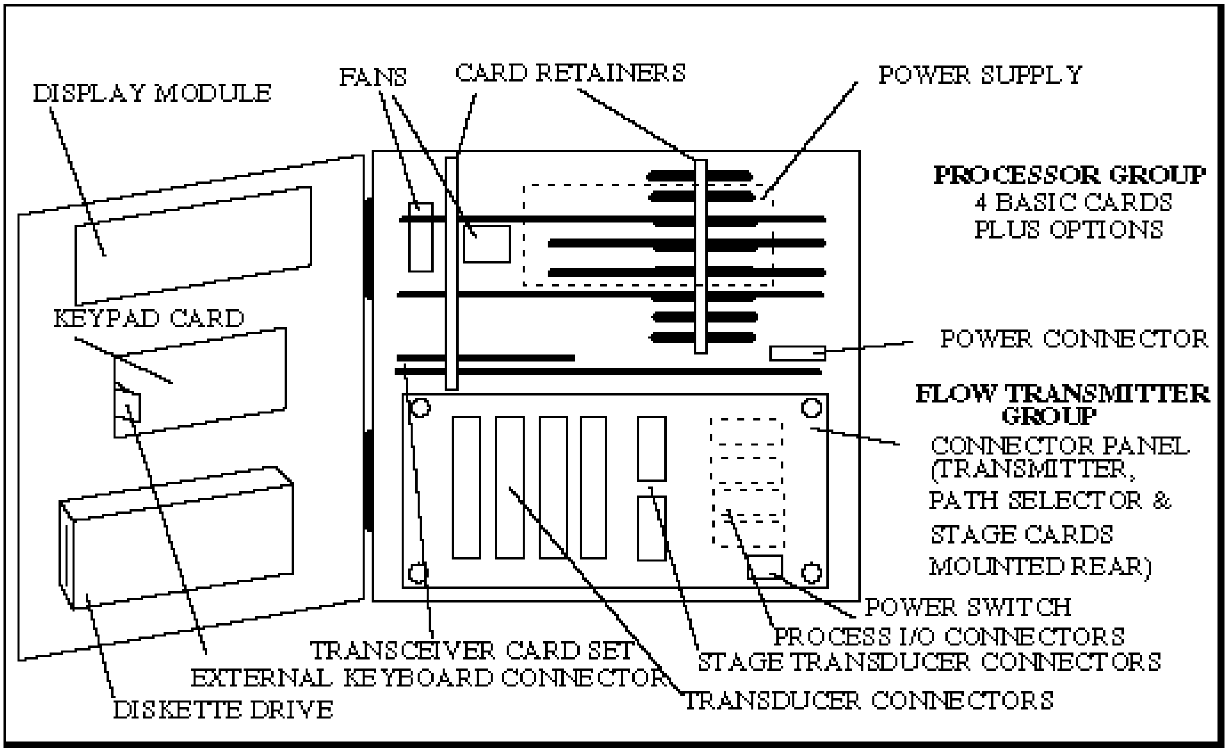

Figure 2-2 NEMA-4 Flowmeter Enclosure, Inside View

Keyboard connector - DIN-style connector located on the keypad card to which a standard autoswitching P.C. keyboard may be attached. The external keyboard is enabled by a switch on the keypad card. Chapter 5 (page 20, *Using an External Keyboard*) describes how to enable and disable an external keyboard.

Diskette drive - 3.5 inch or 5.25 inch diskette drive for data logging and backup of flowmeter configuration and control parameters.

Power connector - Terminal strip connection for AC power source.

Flow Transmitter Group - Controls all the functions necessary to measure travel time on the acoustic paths and fluid stage. Cards in the flow transmitter are:

- *Transceiver card set* - Two-card set: the larger card includes precision timing circuits, pulse detector circuits, and the Accusonic patented Signal Quality Monitor to ensure precise measurement of the pulse travel time on each path. The smaller card provides serial data communications between the flow transmitter and the system processor.
- *Pulse transmitter card* - Produces the high voltage pulse to drive a transducer.
- *Path selector cards* - Select path and direction in a travel time measurement. A card controls two paths (four transducers), up to a maximum of four cards in each cabinet.
- *Integral stage cards* - Connects an up-looking stage transducer to monitor fluid level. Maximum two stage cards in a cabinet, similar to path selector card.

Connector panel **-** Removable panel contains terminal strips for connecting transducers, communication ports, alarms and all process input and output lines. Slots for mounting the pulse transmitter, path selector cards and stage cards are on the rear of the panel.

Power supply **-** Power line input is 90-250 VAC, 47-63 Hz. Primary power supply provides ±5 VDC, ±12 VDC.

In addition to the primary power supply, other regulators and batteries located in the system are:

- High voltage power module converts 5 VDC to 180 VDC for the pulse transmitter.
- Lithium battery on the processor card provides power for the real time clock and calendar.
- NiCad battery on the memory card backs up RAM on that card.
- Voltage regulator on the Basic I/O card provides 5 VDC for the display.

Rack-mount Console

Figure 2-3 shows an inside view of the rack-mount enclosure.

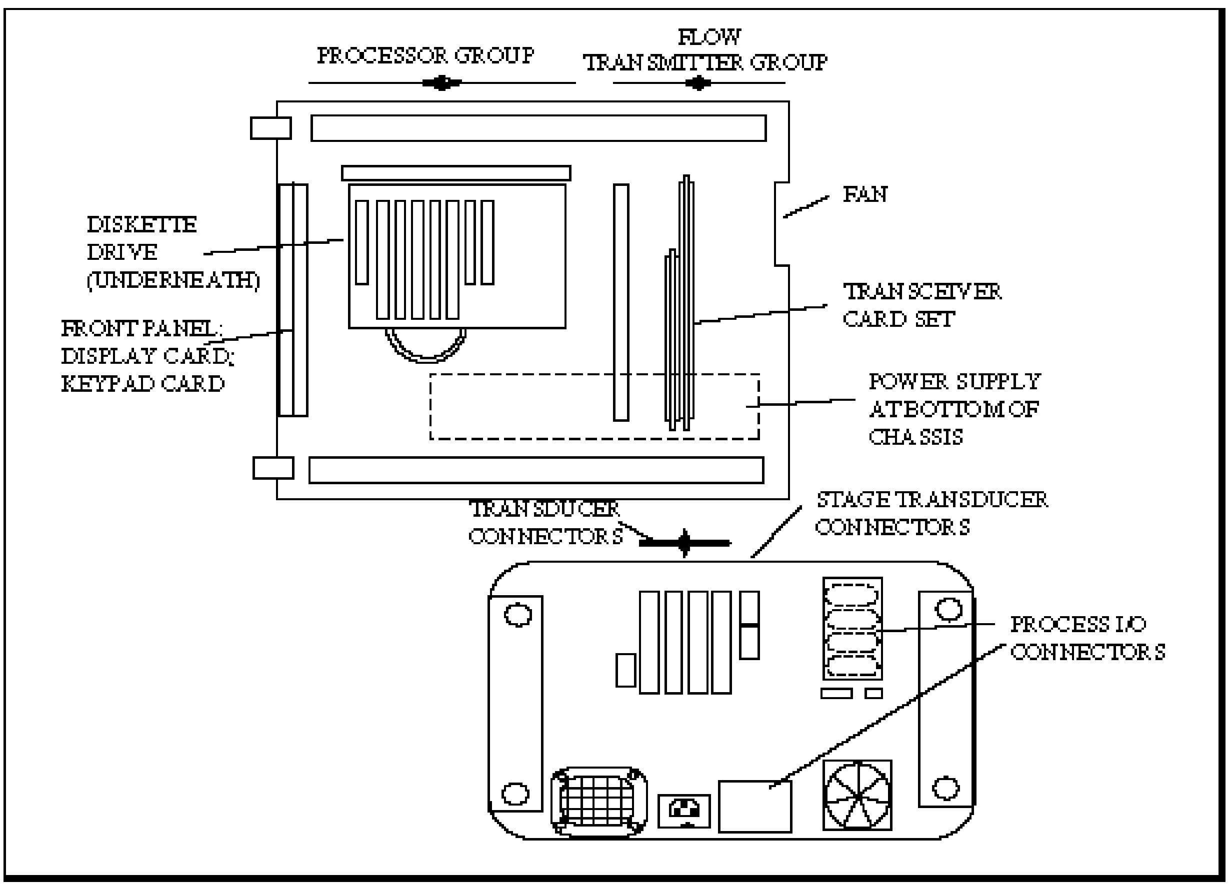

Figure 2-3 Rack-mount Flowmeter Enclosure, Inside and Rear Views

Remote Flow Transmitter Unit

Figure 2-4 shows an inside view of the remote flow transmitter in a NEMA enclosure. The rack-mount remote flow transmitter is very similar to the basic console as previously shown in Figure 2-3.

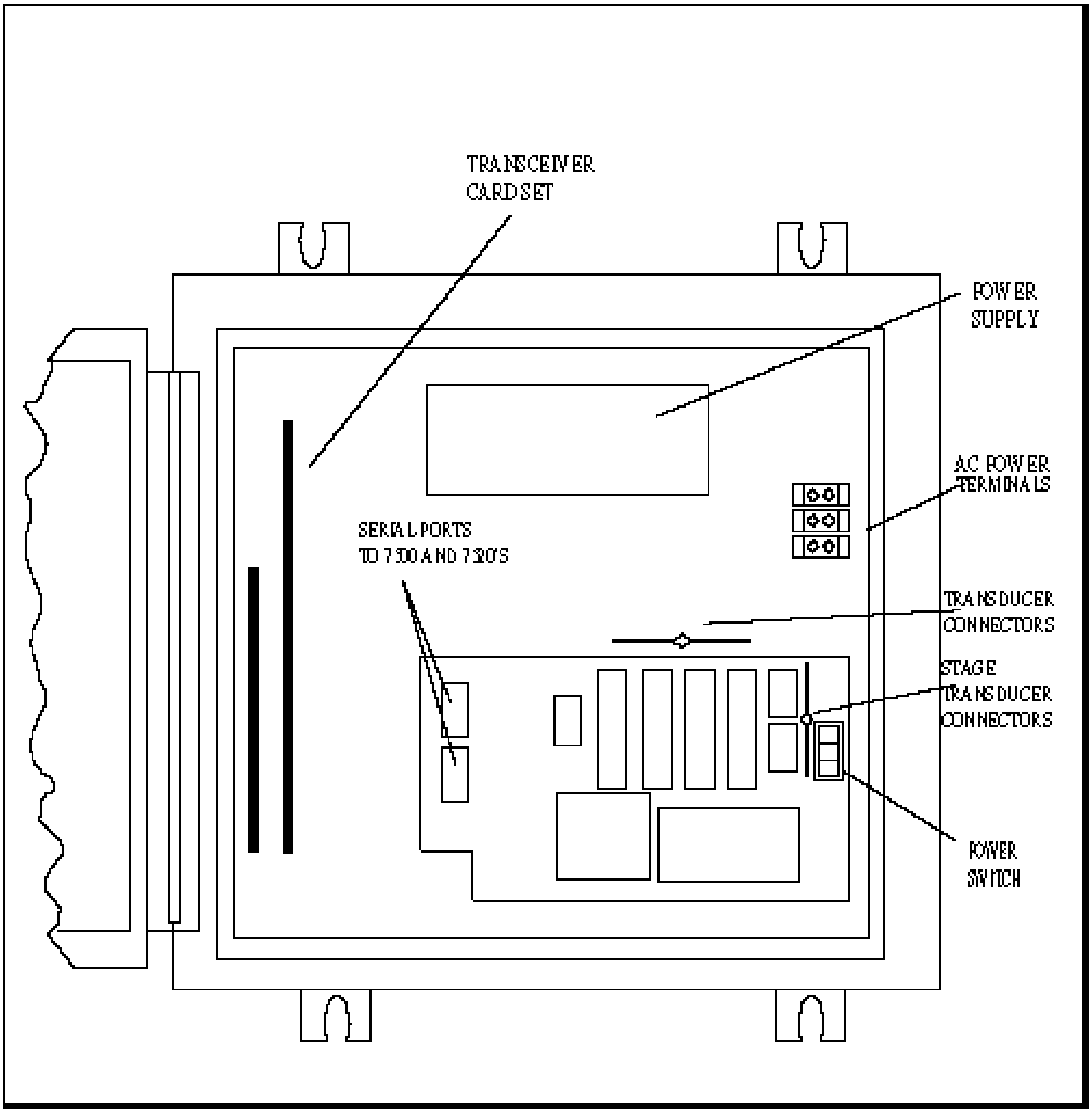

Figure 2-4 Remote Flow Transmitter, NEMA Enclosure

System Overview

The functional organization of the ACCUSONIC MODEL 7500 is shown in the block diagram of Figure 2-5. Two functional groups, the *flowmeter processor group* and the *flow transmitter group* are connected by a communications link.

The flowmeter processor group:

- ♦ Manages the overall operation of the system
- ♦ Interacts with an operator through the keypad and display
- ♦ Calculates flow
- ♦ Manages all system inputs and outputs
- ♦ Initiates system diagnostic procedures

The flow transmitter group:

- ♦ Drives the path and stage transducers
- ♦ Performs signal processing on the incoming signal
- ♦ Measures travel time for a pulse on each acoustic path
- ♦ Reports the results to the system processor

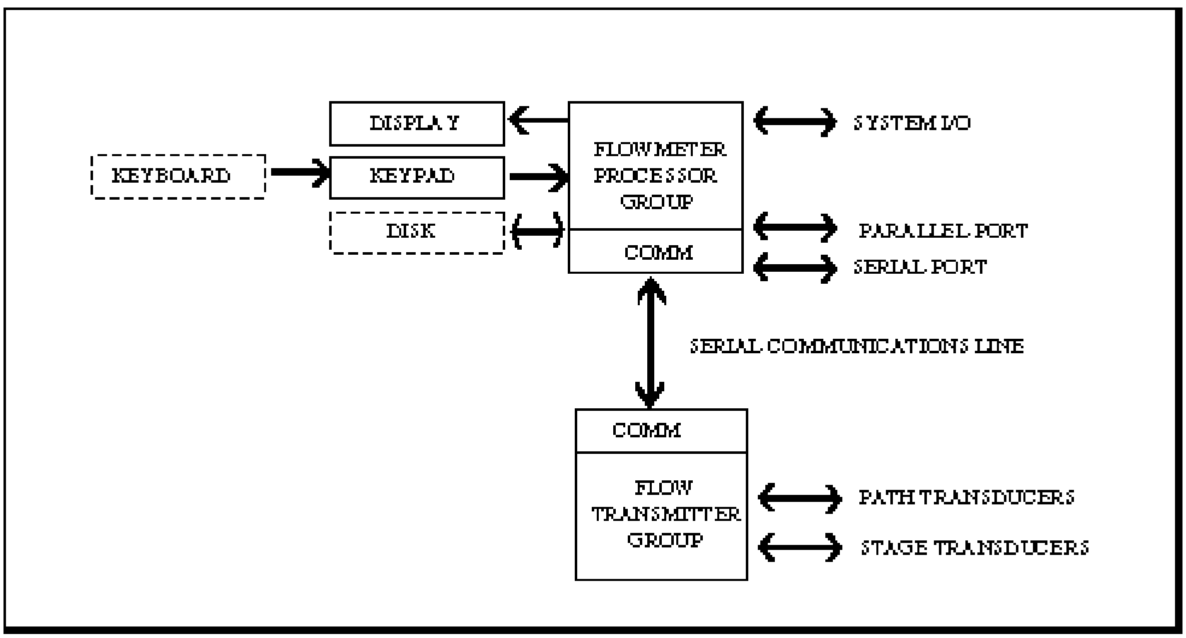

Figure 2-5 System Overview

Measuring Fluid Stage

The flowmeter accommodates a variety of fluid stage measurement equipment, including up- or down-looking acoustic devices, float wheels and pressure monitors. The flowmeter supports integral devices supplied by Accusonic as well as stand-alone stage measuring subsystems from other suppliers.

The Accusonic 7500 series compatible up-looking acoustic transducer is installed as an integral part of the instrument and shares the travel measurement and pulse transmitting and receiving facilities of the flow transmitter. Stage information from the integral up-looking device is returned to the system processor via the communications link.

External stage equipment is self-contained, and includes its own control and measurement circuits which output stage information via a digital or analog interface. In the ACCUSONIC MODEL 7500 external stage equipment connects directly to the system processor through the appropriate process input card.

System Expansion

The maximum capacity of the standard flowmeter console is eight acoustic paths and two integral stage inputs. The system can be expanded by adding remote flow transmitters, each housed in a separate cabinet. Remote flow transmitters connect to a single system processor using a serial communications link.

Figure 2-6 shows the block diagram of a larger configuration with additional flow transmitters.

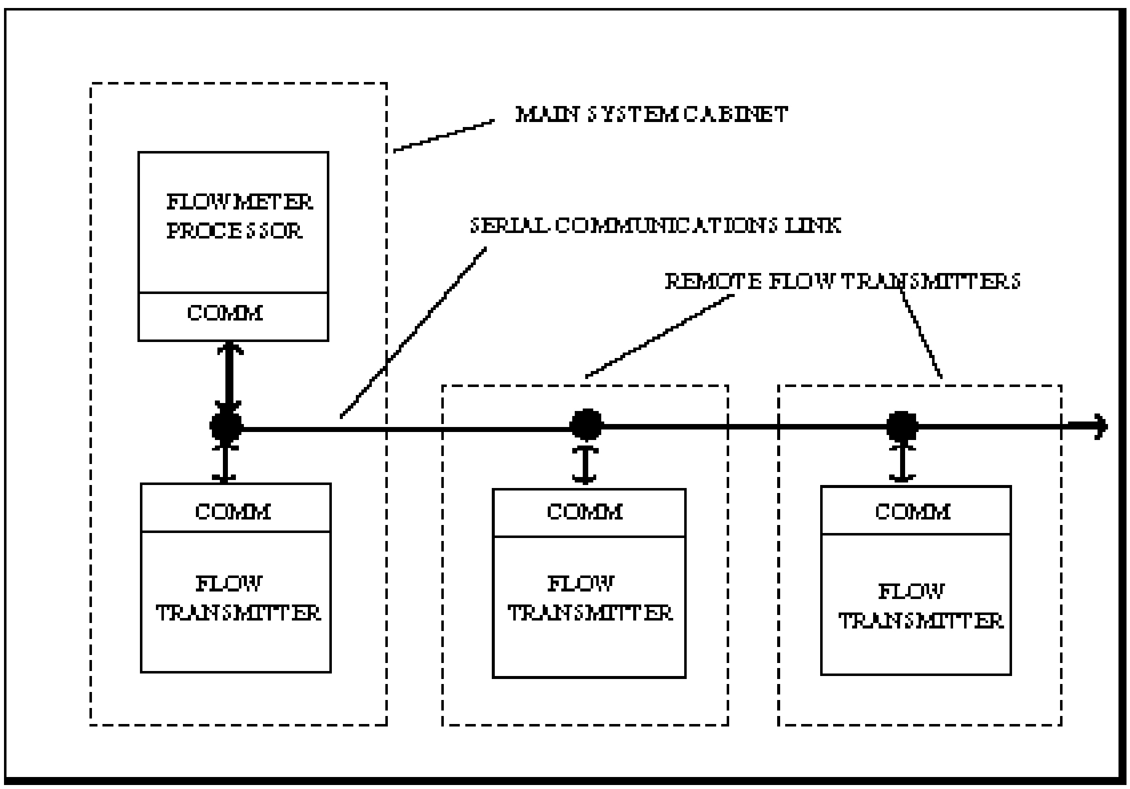

Figure 2-6 Larger Configurations

System Processor Technical Details

The system processor group is the overall control center of the instrument and directs the performance of all measurements and diagnostics. It occupies the top half of a NEMA-4 cabinet or the front section of the rack-mount cabinet.

System processor group functions include:

- Perform power-up self test, control the watchdog timer, and perform periodic system checks
- Manage operator console display and keypad
- Provide battery-backed storage of all system parameters
- Direct the operation of all flow transmitters
- Execute the flowmeter algorithms to compute total flow
- Perform reasonability checks on all velocity and flow data as it is computed
- Interpolate missing data caused by loss of signal or power interruption
- Respond to all process inputs; drive all process outputs and alarms
- Control the system diagnostics

Figure 2-7 (see page 2-9) shows a detailed block diagram of the system processor group. The principal components are:

- *Processor card* - Single board computer with local memory, battery-backed real time clock, calendar, and keypad interface. Attaches to AT bus. Battery lifetime on the real time clock is 10 years, nominal.
- *Memory card* - The memory is divided into two sections:
  - -NiCad battery-backed memory for storing parameters and non-volatile data. Battery lifetime during power loss or shutdown is one month.[2]
  - -Non-volatile storage containing the operating system and flowmeter control program.
- *Basic I/O card* - Contains hardware interface for the LCD display, watchdog timer-controlled alarm relay, and optional programmable relays. The watchdog timer indicates a system failure by closing an alarm relay if the system fails to complete a flow measurement cycle within a defined time period.
- *Communication card* - Contains line drivers and receivers for serial communications with the flow transmitter (s). The card also contains an additional serial port and a parallel port.
- *Diskette system* - Consists of a controller card and a drive unit that is available in 3.5 inch and 5.25 inch diskette size.

Primary interaction with the system is via the front panel display and keypad. During initial setup, it is useful to add a PC-compatible keyboard to simplify data entry. The external keyboard can be detached from the unit for routine operations. If a keyboard is not supplied, either use an autoswitching type or check with Accusonic to see which type is compatible.

During initial setup, the operator enters control parameters defining the type of transducers, units of measurement, and the meter section configuration. As-built locations of transducers in each section are also entered. Once these parameters have been entered, they can be transferred to battery-backed RAM on the memory card and, optionally, to diskette. During subsequent startups, the parameters are automatically loaded into the system memory from the battery-backed RAM.

The operating system, device drivers, diagnostic programs, and the flowmeter program are stored in non-volatile storage. The operating system is transferred into processor memory at power up. Status information and interim results are stored in a battery-backed RAM so that after a power interruption, the data can be restored and the system can continue without loss of data.

[2] Data may also be copied to diskette for more permanent storage.

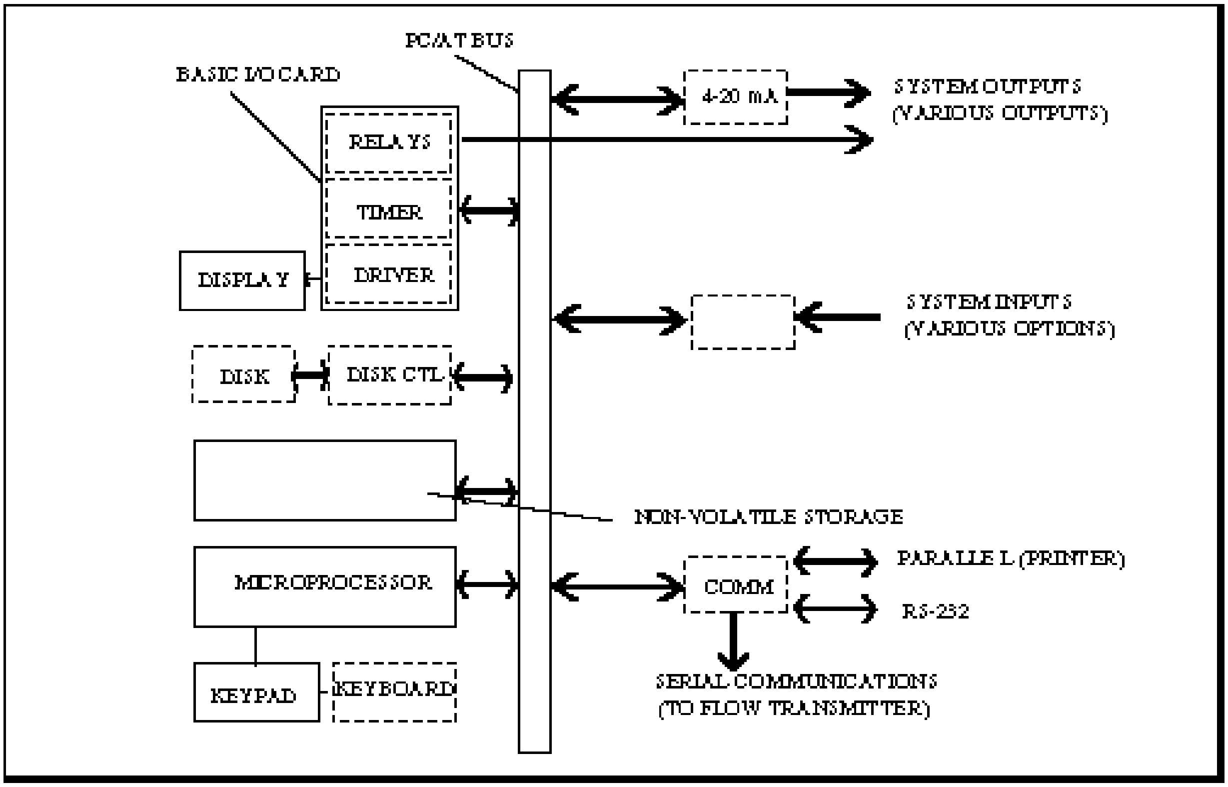

Figure 2-7 System Processor Group

Flow Transmitter Technical Details

The flow transmitter group manages the operation of the transducers under the direction of the system processor. It measures the travel time in each direction[3] on all active acoustic paths and operates any up-looking acoustic stage transducers. The flow transmitter operates independently of and asynchronously to the flowmeter processor. It receives measurement instructions, carries them out and returns the results. The flow transmitter occupies the lower half of a NEMA-4 or the rear of a rack-mount cabinet.

Flow transmitter functions are:

- Provide a transmitter signal to a transducer
- Process and detect the signal from a receiving transducer and discriminate the first negative-going pulse
- Adjust automatic gain control (agc) setting for each direction and stage
- Perform signal integrity checking on each measurement
- Update status information on the viability of each measurement
- Compute travel time on a path or group of paths, or average several consecutive readings as directed by the system processor
- Compute travel time for stage transducers (open channel or compound meter only)
- Return travel times and status of each measurement back to the system processor
- Perform periodic closed-loop self tests to verify subsystem accuracy and precision

[3] From the viewpoint of the flow transmitter (and from the flowmeter algorithms), there are two travel time measurements for each acoustic path. In this section, the term *direction* is used wherever it seems appropriate to emphasize this fact.

Figure 2-8 shows a detailed block diagram of the flow transmitter. Principal components are:

- *Transceiver* (two-card set) - Contains microprocessors, local memory and control ROM, precision time base generator, travel time counter, and receiver. The receiver has the Accusonic-patented agc and Signal Quality Monitor that ensure precise pulse waveform detection and discrimination. Also contains line drivers and receivers for communication with the system processor, and contains an array of indicator lights that show the status of the flow transmitter.
- *Transmitter card* - Generates an 800 volt pulse that drives the selected transducer and starts the travel time counter.
- *Transducer bus* - Connects transmitter and receiver circuits to path and stage cards. It includes addressing information which activates a single path or stage card and specifies the transducer(s) to be used in the current measurement. When a path travel time is being measured, the bus address also specifies direction by designating which transducer in the selected pair is the transmitter and which is the receiver.
- *Path selector card* - Contains relays which connect the sending transducer to the transmit bus, and connects the listening transducer to the receive bus. A single path selector card controls the four transducers which form two acoustic paths. Cabling between the path card and a transducer should not exceed 1000 feet without the approval of Accusonic.
- *Stage card* - Interfaces a single up-looking acoustic transducer for monitoring fluid stage or elevation; used only with open channel or compound conduit meter sections. A single stage card controls a single stage transducer.

The flow transmitter operates asynchronously to the system processor. It receives and queues commands via the communication link. Each command is processed in order of arrival and, upon completion, returns the requested data. Depending on the application, the system processor may issue a command and simply wait for the results or continue with other work.

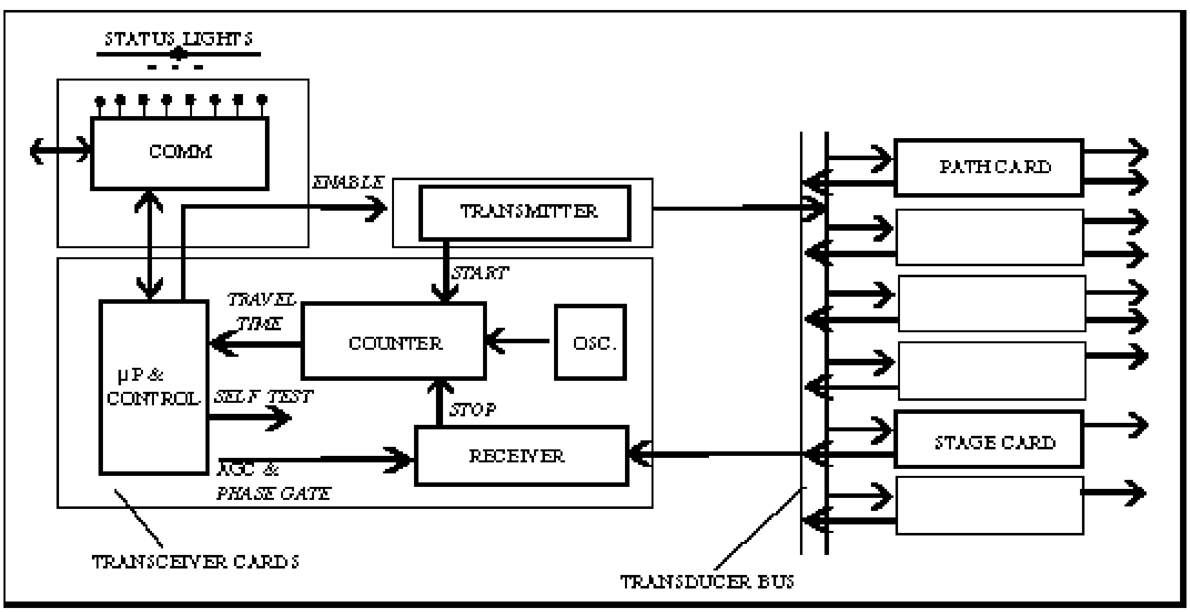

Figure 2-8 Block diagram of Flow Transmitter

The primary function of the flow transmitter is to measure travel times on the acoustic paths. The subsystem may take a single measurement on one direction or collect a set of measurements over several directions. Alternatively, it may take several consecutive sets of measurements and return the average travel time for each direction. The subsystem performs a number of data consistency and signal quality checks during a measurement and returns detailed status information along with each measurement reported.

The subsystem periodically performs a self test to verify the operation of critical circuits in the subsystem. It continually updates an array of status flags that may be tested by the system processor or displayed via the status lights on the transceiver card.

Chapter 3
Acoustic Flowmeter Principles

Accusonic acoustic flowmeters measure the transit time of ultrasonic pulses traveling along several diagonal paths through a moving fluid and derive the average downstream component of velocity across each path. The number and placement of acoustic paths and the mathematical formula used to compute flow depend on the shape and dimensions of the fluid conduit and the required accuracy of the measurement. The measurement method is based on the geometry of the conduit, the accuracy desired, and the behavior of the fluid. Under most conditions, the flowmeter does not require calibration by comparison to other flow measurements.

This chapter describes the principles of acoustic flowmeter operation and examines the underlying methods of analysis and real-world configurations. The measurement cycle is described in detail. Sources of error that affect the overall uncertainty of the measurements are also analyzed. Formulas are presented without derivation.

Measurement Section Configuration

Converting velocity to flow rate is done by multiplying the cross-sectional area by the area-averaged section velocity. Because a velocity profile is rarely accurately known, it is necessary to estimate the effect of the unknown velocity profile. This is best done by using multiple acoustic paths. The four-path configuration, shown in Figure 3-1, exhibits very uniform response over a wide range of velocity profiles.

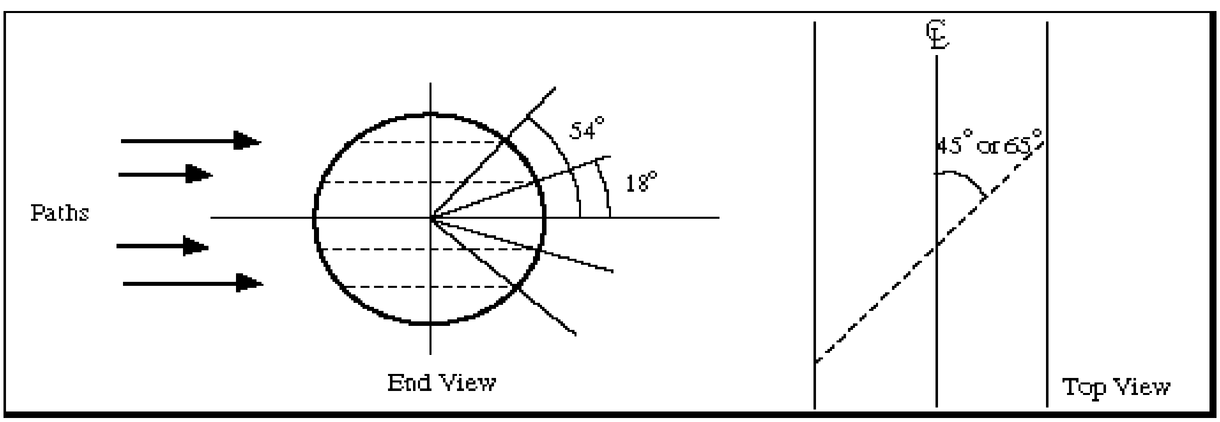

Figure 3-1 Placement of Paths in Straight Round Pipe

The spacing of paths depends on the shape of the section and the accuracy required. For closed pipes flowing full, transducer placement depends on the numerical integration technique employed for computing flow. For open channels or for pipes not filled, numerical techniques are not generally used; placement depends on variation in fluid level and on the accuracy desired.

In typical multiple-path configuration, four pairs of transducers are placed in the fluid stream to define parallel paths at selected elevations -- in a straight pipeline as shown in Figure 3-1 and in an open channel as shown in Figure 3-2 (see page 3-2).

Placement of Acoustic Paths in Round Pipe

For a four-path flowmeter in round pipe flowing full, the paths are usually parallel diagonal chords that intersect the pipe at elevations 18 and 54 degrees above and below the axis of the pipe. As a rule, paths are horizontally oriented. If there if an upstream bend in the pipe, the paths are usually rotated to a plane perpendicular to the plane of the bend. This reduces the effect of *cross flow* that is not parallel to the center axis of the pipe.

When paths are located within five diameters of a bend, additional measures should be taken as described in the section on *crossed paths* (see page 3-7). Consult Accusonic for recommended installation configurations.

Placement of Acoustic Paths in an Open Channel or Compound Section

An **open channel** is defined as a conduit, whether open or closed, in which water flows with a free surface. A **compound** installation is a closed conduit which can flow partially full as well as surcharged, thereby exhibiting the characteristics of both an open channel and a full pipe.

Because a compound installation contains the characteristics of an open channel at times, many of the same parameters are used for both types of installation. When entering parameters for an open channel, Section parameter *Surcharged integration* is irrelevant, and the Section parameter *Full pipe* should be set higher than the maximum water level, to ensure that the meter never thinks there is a surcharged condition.

Transducer placement in an open channel or compound conduit is more complex than in a pipe, since the level of the fluid may vary over a large range.

Trapezoidal integration is generally considered to be the method of choice in an open channel. It can be extremely accurate (Accusonic normally guarantees an uncertainty of 2% of flowrate in a well-defined channel, but can be 1% under ideal conditions), and can be tolerant of wide ranges of stage and number of operating paths.

The issue is one of balancing the desired accuracy over the entire range of operating conditions against cost. The system designer must consider the impact of degraded operation or worst case water levels which may result in increased integration errors.

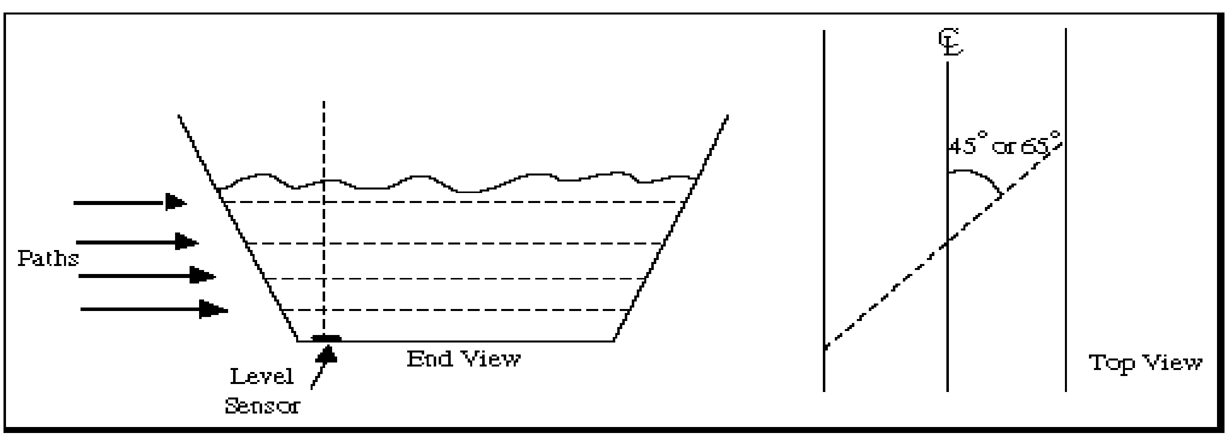

Figure 3-2 Placement of Paths in an Open Channel

Following is a generic strategy for choosing number of paths and path placement (If there is cross flow additional paths may be required):

1. Identify the lowest fluid stage for which accurate measurements are required. Normally, the lowest path is placed as low in the channel as possible. Refer to the following section, “Top and Bottom Clearance considerations in an Open Channel Meter”, for determination of minimum distance from the bottom.
2. Place another path at the minimum allowable distance below the lowest expected stage.
3. Additional paths may be placed at intermediate elevations if higher accuracy is required. The added paths are spaced in such a manner that the overall measurement uncertainty never exceeds the specified limit for any level of fluid.
   Often, only two paths are used to measure low stage flow, but in installations where high accuracy is required at low stage, there may be as many as four paths below the minimum water level. In general, four paths are required for best accuracy in any given cross section. This is because the smallest errors are in the layers bounded by paths, whereas the bottom and surface layers require the use of estimated velocity profiles in order to estimate their contribution to the total flow.
   Of course, things get more complicated and accuracy will be reduced further if the lowest path must be placed at an elevation higher than minimum to avoid signal interference from sand and/or debris in the channel bottom. This silting effect also changes the cross section area, further impacting accuracy.
4. Additional paths must be placed above these if the stage varies significantly. Usually, if the stage increases by more than the vertical distance between the two highest paths already in place, then an additional path should be incorporated to maintain accuracy. However, because the accuracy of path bounded layers is very high compared to the bottom and surface layers, the path spacing can usually be increased as their elevation increases because the total flowmeter error is reduced as the top and bottom layer flows becomes a smaller fraction of the total flow. This may not be true in all cases, however, as in the case of a trapezoidal cross section (like the California Aqueduct), where the area is increasing rapidly as the stage increases, or in some well manicured rivers in the UK where there is a narrow channel for low flows and an artificial flood plain for high flows.
5. Consideration should also be given to the accuracy requirements which may change as the flow or level varies, and also the percent of the time that these conditions may exist. These conditions affect the cost vs. accuracy tradeoff for a portion of the time that the meter is in use. For example, the accuracy requirement during a flood may not be as high as for minimum flow, where the water must be distributed evenly among many demanding users. As another example, it may not be worth designing the meter to handle a 100-year flood. On the other hand, this may be what the user wants to measure most.

Trapezoidal extrapolation/interpolation strategies

In open channel trapezoidal integration, the flow bounded by two paths (or one path and the top or bottom) is calculated by averaging the upper and lower velocities and multiplying by the area enclosed. This is very accurate, even under conditions of unusual velocity profiles, particularly when several layers are present, because errors in one layer tend to cancel errors in the adjacent layers.

Figure 3-3 shows an open channel section built with five paths. Figure 3-4 illustrates how extrapolation error affects flowmeter uncertainty as a function of fluid levels. Accuracy deteriorates as fluid level rises above a particular path until the fluid level reaches the next path, where accuracy again improves. As the fluid level rises further, the accuracy falls off again until it passes the next path, and so on.

Since with trapezoidal integration the error in the layer flows can be made small by increasing the number of acoustic paths, the main metering uncertainty is the flow in the lowest and highest areas.

Estimating the flow in the bottom layer requires a guess as to what the ratio of the average velocity in that layer is to the measured velocity at the lowest path. A quick look at the theoretical velocity profiles near a smooth/rough bottom surface will show that the bottom flow is about .75 times the lowest velocity times the bottom layer area. Setting the parameter “Bottom Velocity Ratio” to 0.5 (default) accomplishes this. The most significant error in the lower layer comes from changes in cross-sectional area due to silt level, which is unknown.

The total contribution of the bottom layer flow to the total flow will be small if the above installation suggestions are followed, so the total error will be minimal.

The same cannot be said about the surface velocity and the surface layer (above the top path). The errors are more significant for the following reasons:

1. The top layer will usually have a greater area than the bottom. The distance from the top path to the surface is relatively large because channels are generally wider at the top and the minimum distance necessary to avoid multipath problems is greater. The surface level is almost always further than the minimum distance in any event due to the unwillingness of the customer to buy additional paths.
2. The surface layer velocity is very difficult to estimate. Unlike the bottom, there is no boundary condition, so the actual velocity at the surface is unknown, and can be affected by wind, ice, floating debris, temperature layering or unusual upstream conditions (such as control structures or tethered boats). Therefore, it is virtually impossible to generate a theoretical model of this velocity profile. In operation, the flowmeter estimates the surface velocity from the two highest working path velocities. This can be anywhere from a good to a terrible guess depending mostly on how close the paths are to the surface. The meter linearly extrapolates the two highest path velocities to the following extent: If the extrapolation distance is greater than the vertical distance between two paths used for extrapolation, then the extrapolation is only carried out to the path separation distance, and that value is used as the surface velocity.

   Because the value as extrapolated may not be very accurate, this estimated surface velocity is weighted before averaging it with the highest operating path velocity to determine the flow in the top layer. This “confidence factor” is entered as the parameter “Top Weight”.

   Note that if the highest usable path is not working, then the accuracy of this procedure is significantly reduced.

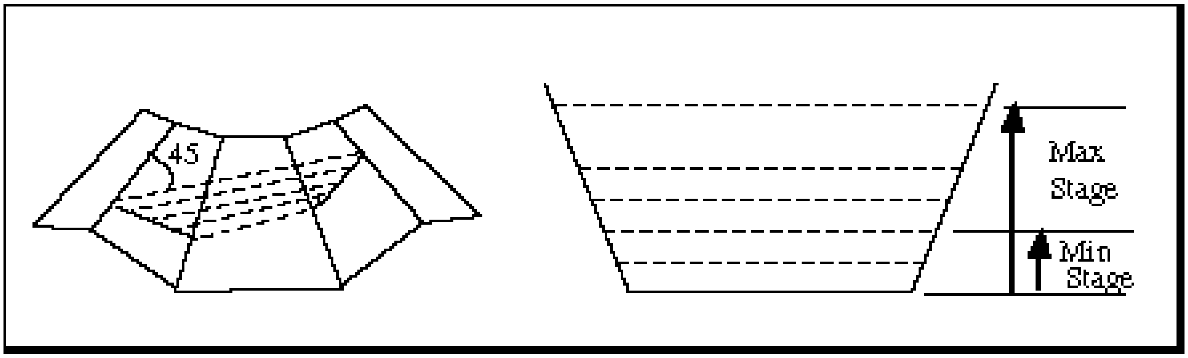

Figure 3-3 Five-path Open Channel Configuration

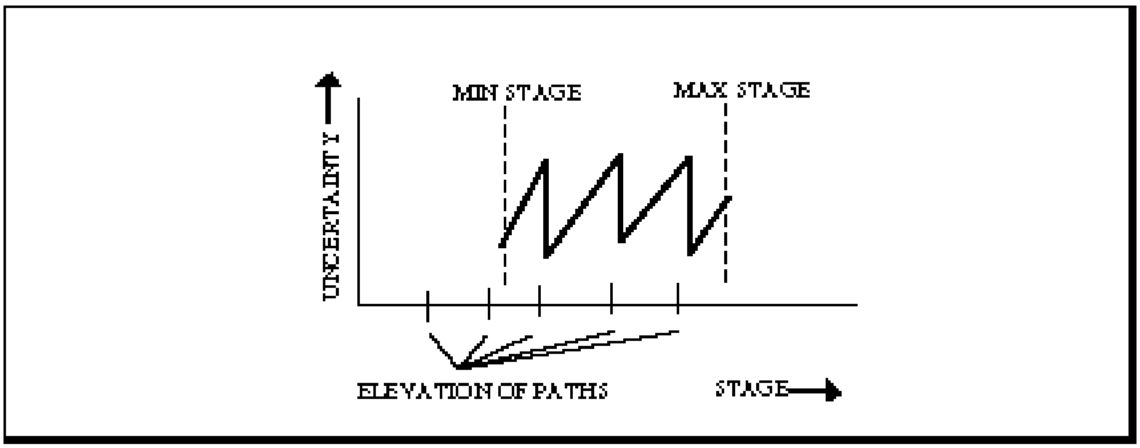

Figure 3-4 Variation of Uncertainty with Stage for Five-path Open Channel Meter

Top and Bottom Clearance Considerations in an Open Channel Meter

There are limits as to how near the bottom of the channel the lowest path can be placed, and how near the top surface of the fluid path can be reliably used. This limitation stems from a *multipath reflection*, as shown in Figure 3-5.

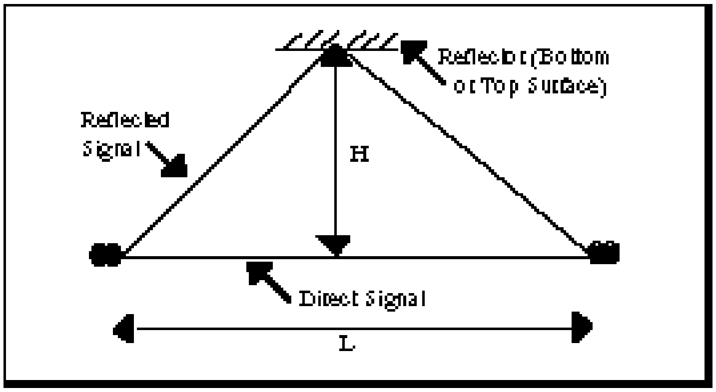

Figure 3-5 Multipath Reflection

When the acoustic path is sufficiently close to a reflector, the reflected signal arrives at the detector before the electronics can discriminate the arrival of the direct signal. In the ACCUSONIC MODEL 7500 detector circuits are set to discriminate an incoming pulse within its first full period.

The following formula shows that the minimum clearance **H** depends on operating frequency and path length.

$$H \cong \sqrt{\frac{L v_s}{2f}}$$

where:	H	= Minimum clearance required
	L	= Path length between transducers
	v_s	= Velocity of sound in fluid
	f	= Carrier frequency of acoustic pulse, Hz

The resultant value H is entered into the flowmeter as “Minimum Path Submersion”. This is used to prevent reflections from the fluid surface. Note that this value is only entered once for all paths. Therefore, it is best to use the longest path in the section to calculate ‘H’.

Crossed Paths

Under certain conditions, two planes of acoustic paths may be installed at opposite angles to improve the flow measurement accuracy. This is done when there is *cross flow*, caused by bends in a pipe, or in situations where the geometry of the conduit cannot be measured accurately.

- **Cross flow -** Where the streamlines of flow are not parallel to the conduit centerline as a result of an upstream obstruction or a transition in conduit shape or dimensions. The effect is especially pronounced when there is a bend in the conduit upstream of the measurement section.
- **Survey uncertainty -** Where the walls of the conduit are irregular, asymmetric, or (as is often the case in a river) cannot be surveyed exactly or permanently.

Figure 3-6 shows crossed paths installed in a pipe with bends. Crossed paths are typically installed at the same elevations.

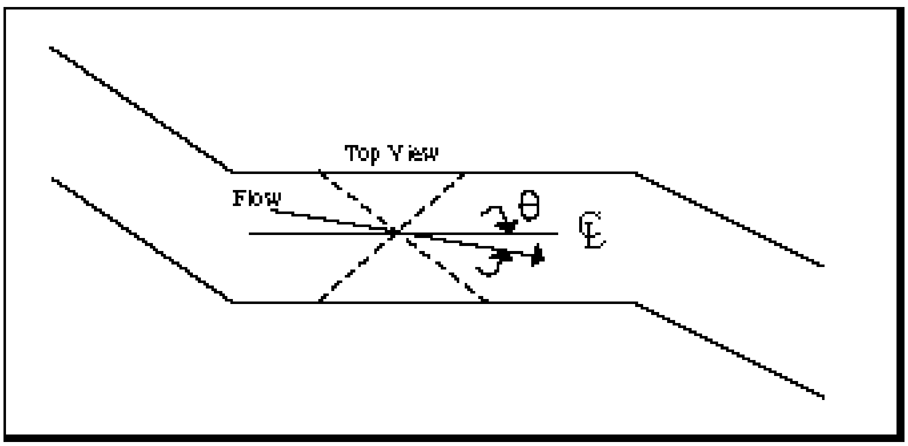

Figure 3-6 Crossed Path Configuration

Depending on the acoustic path angle θ, cross flow of 1° introduces a velocity error ranging from 1.7% for a 45° path to 3.8% for a 65° path.

When crossed paths are used, the meter treats each plane of acoustic paths as a separate “subsection” and averages the flowrates calculated for each plane to determine the flowrate through the metering section. Flowrates for the separate planes can be assigned different weights before averaging if the acoustic path angles or number of paths are not the same for each plane.

Flowmeter Measurement Cycle

For every measurement, the following six steps are performed. These six steps make up a *measurement cycle*:

- **Sample process inputs -** Collect data from external inputs, such as analog level measurement.

Measure Acoustic Stage (if present).

- **Travel time measurement -** Measure the acoustic travel times along one or more linear paths through the moving fluid.
- **Velocity calculation -** Calculate velocities on each path based on asbuilt information and measured travel times.
- **Flow Calculation -** Integrate the measured velocities over the entire cross-sectional area of the fluid to determine total volumetric flow.
- **Update volume totals -** Calculate totalized flow (volume) based on average flowrate and elapsed time.
- **Update process outputs -** Transmit results of measurement via such devices as RS-232, contact closures, or current loop outputs.

The sequence of the flowmeter measurement cycle is shown in Figure 3-7.

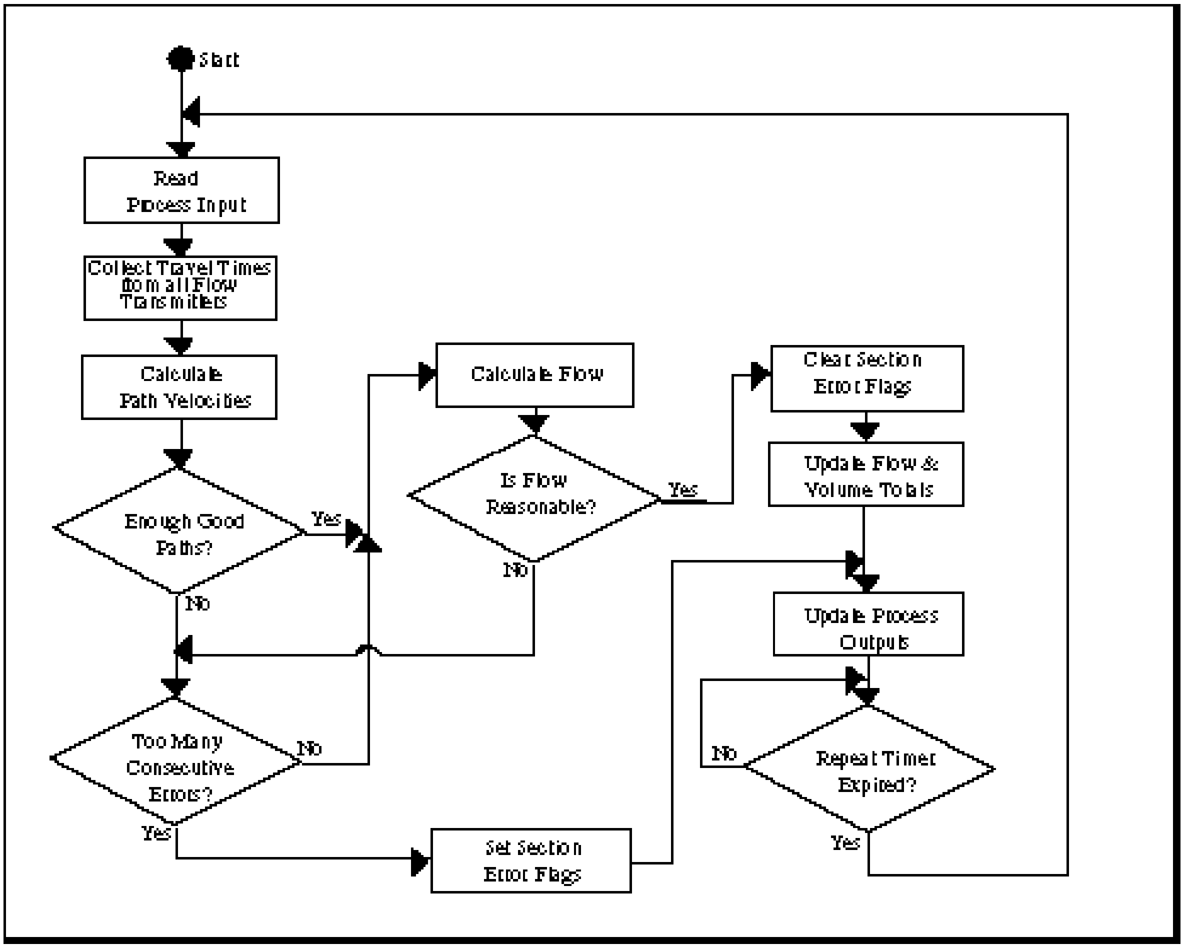

Figure 3-7 Measurement Cycle

As it proceeds through a cycle, the instrument assesses whether or not each measurement is reasonable, based on values entered during instrument setup. The instrument may reject a questionable result and substitute a value using data from the previous cycle. Table 3-1 shows which data is verified at each step in the cycle and lists the substitute values that may be used in each case. At the end of the cycle, the instrument pauses until it is time to perform the next measurement. The topics that follow the table describe the six steps of the measurement cycle in detail.

Table 3-1 Data Verification and Substitution			
Step	Error condition	Action	Value repeated with...
1. Sample inputs	No stage input	Set error codes, increment stage error counter	Reading from previous cycle[1]
	Bad stage measurement	“	“
	Stage exceeds maximum	“	“
	Stage below minimum	“	“
	Stage below path elevation (s)	Turn off any paths out of water	n/a
	Stage error counter exceeds limit	Bypass travel time data collection	n/a
2. Collect travel times	No response from flow transmitter	Set error code and increment an error counter	Readings from previous cycle[1]
	No received signal on a path (forward or reverse direction)	“	“
	Noise was detected	“	“
	Flow transmitter parameter was not set	Set error code and increment an error counter	Readings from previous cycle
	Unknown flow transmitter error	“	“
	Gain error	Set Warning Code	No Substitution,use data

[1] Previous readings is only used when the error counter has not exceeded the parameter Maximum Bad readings, otherwise an error flag is set.

Table 3-1 Data Verification and Substitution (continued)			
Step	Error condition	Action	Value replaced with...
3. Calculate velocities	Travel time out of expected range	Set error code and increment an error counter	Use velocity from previous cycle
	Velocity exceeds max.	"	"
	Velocity changed too quickly	"	"
	Error counter exceeds max.	Clear velocity output attribute	n/a
4. Calculate flow	Not enough good paths	Set an error code and increment an error counter	Use flow from previous cycle
	Flow exceeds max.	"	"
	Flow changed too quickly	"	"
	Flow error counter exceeds max.	Clear flow output attribute	"
5. Update volume totals	If any flow error counter is exceeded	Clear the total flow output attribute for that section	n/a
6. Update outputs	For any value intended for output that is marked in error	Set the output representation for the failed section according to the rules shown to the right	On the display or RS-232 port, output "-----" for the error value. Set analog and digital representation of error value to maximum high or low or no change as specified during instrument setup
[1] Previous reading is only used when the error counter has not exceeded the parameter Maximum Bad readings, otherwise an error flag is set.			

Reading System Inputs

At the beginning of the cycle the instrument reads all system inputs and integral stage monitors and automatically tailors the measurement cycle. For example, changes in stage may affect the number of active paths or may require that the flowmeter shift to a different flow calculation algorithm.

Measuring Travel Times

The propagation velocity of an acoustic signal in a moving liquid changes when there is a velocity component of the moving fluid parallel to the direction of sound propagation. A sound pulse traveling diagonally downstream across a river will be accelerated by the moving fluid; a pulse traveling diagonally upstream will be decelerated. As a result, acoustic transit times are shortened or lengthened, respectively. Figure 3-8 shows a model conduit.

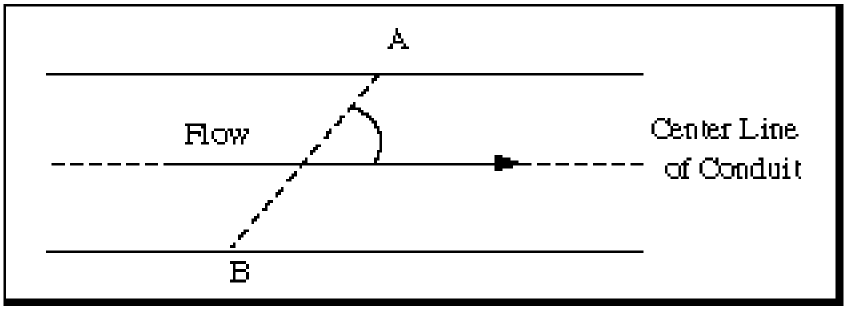

Figure 3-8 Layout of an Acoustic Path

The transit time effect is measured by placing acoustic transducers ***A*** and ***B*** at the sides of the conduit so they define a diagonal path across a section of the moving fluid. Transducers are bi-directional devices that, depending on the attached electronics, can function both as transmitters and as receivers of ultrasonic pulses.

When an acoustic pulse propagates from ***B*** to ***A*** in the downstream direction along the diagonal, the pulse of acoustic energy is carried along by the moving fluid and arrives at ***A*** sooner than if the fluid was motionless. Similarly, when the pulse propagates in the upstream direction from ***A*** to ***B***, it arrives later.

The system processor directs the flow transmitter to initiate travel time measurements. Forward and reverse travel times are measured for each path. For a stage transducer, the round-trip travel time is measured. Measurements proceed as follows:

- Microprocessor sets up path and direction via path selector cards
- Clears the travel time counter
- Enables pulse transmitter
- Transmitter emits a high voltage pulse to drive (ping) the sending transducer, and at precisely the same time, it starts the travel time counter
- Adjusts receiver gain, based on the level stored at the end of the last measurement made on that direction[1]
- Enables receiver circuits shortly before the earliest possible arrival time, as estimated from the current path length
- Checks for electrical noise on the incoming signal, sets a status flag if noise is detected

1 During the first cycle following a cold start, receiver gain is set to a level based on the length of the path being measured and the transducer type.

- Listening transducer converts the received acoustic pulse to an electrical signal and couples the incoming signal to the receiver
- Receiver waits for the incoming signal to exceed the detection threshold on the first negative-going edge
- Verifies that the correct signal features were detected
- Stops the travel time counter upon signal reception
- Signals an overflow if no signal is detected shortly after the latest possible arrival time as estimated from the current path length. This terminates the measurement on that path
- Adjusts agc level depending on the signal strength of the pulse just received; stores the new value for use in the next measurement in this direction or stage

Signal Detection

The ability to correctly detect the incoming signal pulse and to precisely discriminate the target threshold crossing on the first negative-going edge of the incoming waveform is critical to the accuracy of the flowmeter.

Factors affecting the process are:

- Flowmeter may be installed in an environment that is electrically noisy
- Debris, entrained gas, marine life and silt may cause the signal strength of the received pulse to vary over a wide range
- Active face transducers may become fouled over time

The ACCUSONIC MODEL 7500 correctly identifies the first negative-going pulse due to automatic gain control (agc), predicted-arrival signal pass gates, and the Signal Quality Monitor (SQM).

Automatic gain control adjusts the gain of the receiver according to the signal strength of a received pulse. The gain on each direction is controlled independently. At the end of each measurement, the agc adjusts up or down in response to the signal strength of the pulse just processed. The agc adjusts down if noise is detected or if the incoming signal is too strong, up if the incoming signal is weak and the noise level is low. The instrument stores the new agc setting and automatically sets up the receiver to the new level the next time a measurement is taken on the same direction.

If forward and reverse signal levels differ by more than 6dB, a path status warning is issued. This is not a critical error; it may indicate that a transducer is misaligned or failing and that it should be checked.

After power up or after a path has been inactive, the agc sets the initial gain at a level proportional to the length of the path being measured - the longer the path, the higher the gain.

Predicted-arrival gates are used to limit the time over which the pulse receiver will accept an incoming pulse. The instrument predicts the earliest arrival time and the latest arrival time for each direction based on path length and the range of possible flow through the meter section. The earliest arrival time predictions are used to define three gates: Noise gate, Range gate and Overflow gate, as shown in Figure 3-9.

Signal Quality Monitor (SQM) verifies that the incoming pulse is sufficient for reliable use and confirms that the first negative pulse of the waveform goes through the detection point at a high enough rate. It also prevents detection on the second negative-going pulse.

Figure 3-10 shows a detailed view of an incoming pulse waveform, and identifies the features used by SQM to validate the data.

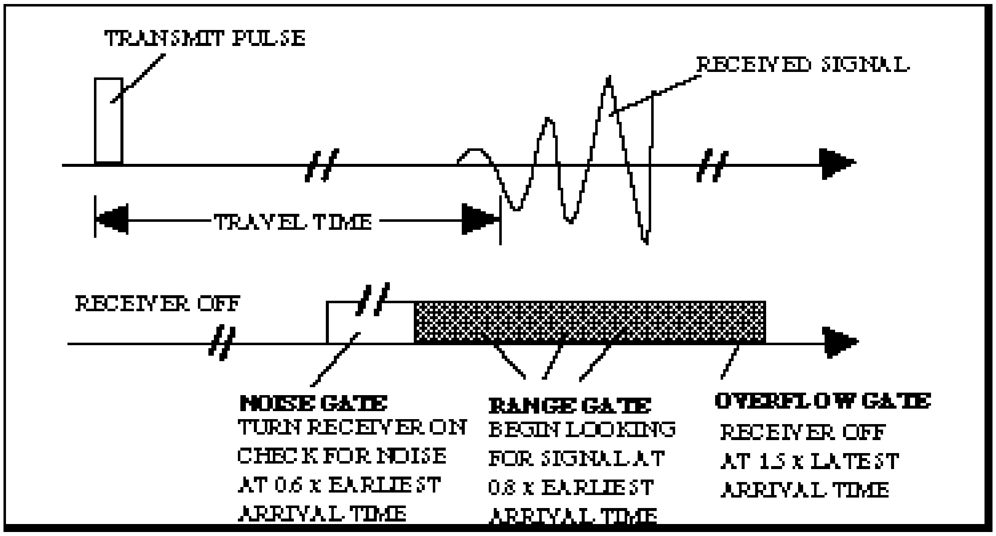

Figure 3-9 Predicted-arrival Signal Pass Gates

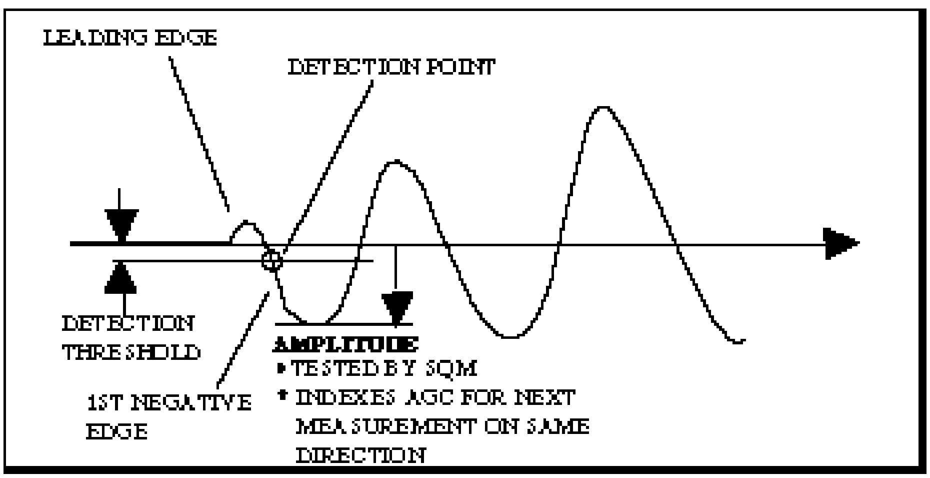

Figure 3-10 Waveform Features Used for Signal Detection

Calculating Path Velocities

The instrument calculates a fluid velocity for each acoustic path using the following formula. The key parameters are path length, angle, and forward and reverse transit times. Validity checks are performed on the data as shown in the flowchart on page 3-15 (Figure 3-11). If any data is missing or if the calculation results in a questionable value, data is flagged and a substitute value is used as shown previously in Table 3-1 (begins on page 3-10).

$$v = \frac{(T_1 - T_2)}{T_1 T_2} * \frac{L}{2\cos\theta}$$

where: v = Average velocity of the fluid across the path
T_1 = Travel time between transducers in the upstream direction
T_2 = Travel time between transducers in the downstream direction
L = Distance between transducers (acoustic path length)
θ = Angle between acoustic path and direction of fluid flow

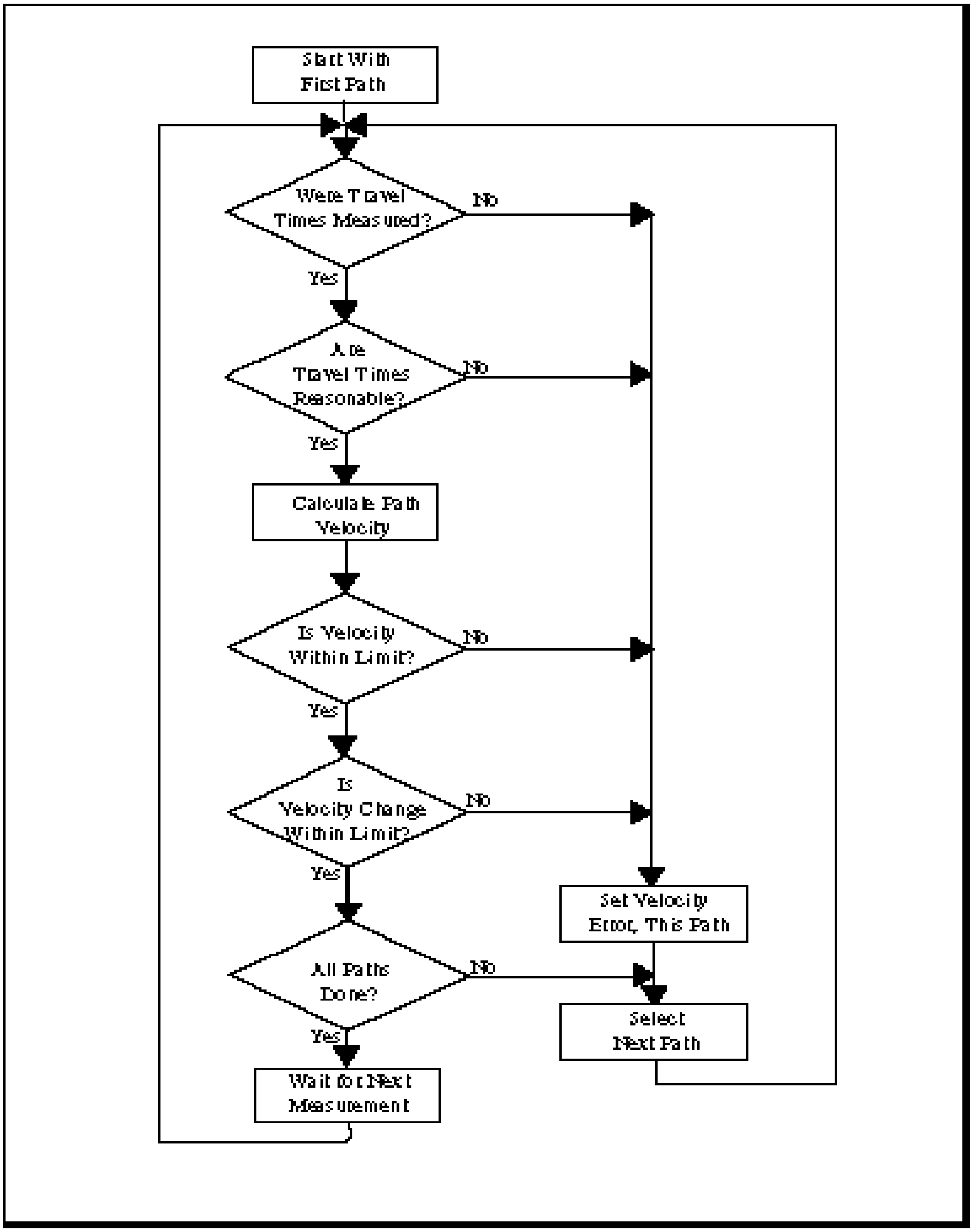

Figure 3-11 Calculation of Path Velocities

Measuring Stage

In open-channel and compound systems, the fluid level (stage) varies, and must be measured. The meter uses this level measurement to determine the cross sectional area of the fluid for calculating flowrate, and to determine which acoustic paths will be activated as they become submerged. The meter can accept level input from various types of stage sensors, including uplookers, downlookers, pressure sensors, or manual (keypad) input.

An “Uplooker” is a transducer mounted near the bottom of the channel, below the lowest expected level. The uplooker transmit an acoustic signal upward to reflect off of the surface. The electronics for the uplooker are integral to the flowmeter. When using an Accusonic uplooking transducer, AGC is used as in velocity measurement, with the same considerations. The **Predicted Arrival Gates** are set based on the parameters *Minimum Stage* and *Maximum Stage*. The total travel time is divided by two and corrected for temperature using the calculated speed-of-sound from the previous velocity measurement. Speed-of-sound is calculated based on “Good” paths that are below fluid level. If there are no “Good” paths, the stage calculation will use the default speed-of-sound from the general parameters list.

An “External” stage device is typically either an acoustic downlooker or a pressure transducer, containing its own electronic control system. The level information from these devices is accepted into the meter as a 4-20 milliamp current loop.

Normally, only one stage sensor is used, although each measurement section can be configured for redundant level data from two sensors, which need not be of the same type. For example, a sewer system could be configured with an uplooking acoustic transducer mounted off the bottom of the channel to avoid “silting”, and a downlooking mounted at the top of the channel. When the channel is nearly empty, the fluid level is below the uplooker, and the downlooker is used. When the channel is full, the downlooker is submerged, and the uplooker is used.

When using redundant stage sensors, operation is as follows:

When both sensors are operating, the stage values are compared. If the difference between them is less than the parameter *Maximum stage difference 1 and 2*, then

$$\text{Stage} = (\text{STAGE 1} + \text{STAGE 2}) / 2$$

If the difference between them is greater than *Maximum stage difference 1 and 2*, STAGE 1 is used and an error is flagged for STAGE 2. Therefore, the sensor with the greatest chance of being “right” should always be assigned to STAGE 1.

If either STAGE 1 or STAGE 2 is not working, an error is flagged and the other is used. If neither stage sensor is working, all paths will be deactivated and operation will cease until a stage measurement can be made.

Calculating Flow

To calculate flow, the instrument integrates the velocities using an integration method appropriate to the configuration of the meter and the nature of the fluid. It performs validity checks on the data as shown in the flowchart of Figure 3-12. If any data is missing or if the calculation results in a questionable value, it is flagged and a substitute value is used as shown previously in Table 3-1 (beginning on page 3-10).

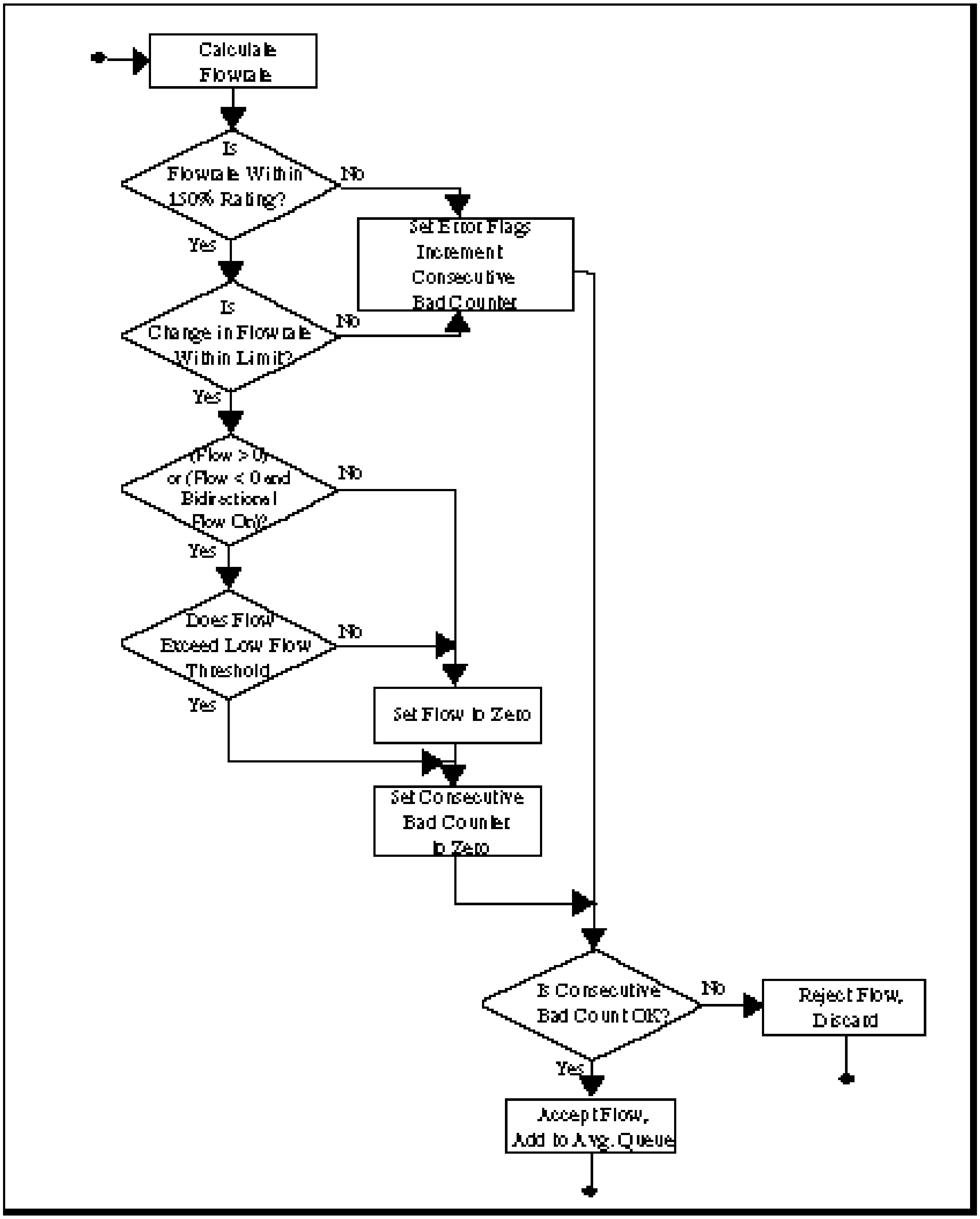

Figure 3-12 Calculate and Validate Flow

Integration Methods

The Flowmeter is designed to cater for a very wide range of possible conduit shapes, including pipes which always flow full, and conduits where the fluid sometimes fills the conduit and sometimes does not. The flowmeter operates in one of two basic modes, which the user has to choose:

- **Pipe mode -** for conduits which always flow full.
- **Compound mode -** for all other conduits, including rivers, open channels and conduits which may surcharge. For this mode, an input of fluid depth or Stage is required.

In "Pipe" mode, one of the following integration methods may be selected by the user:

- **Chebyshev integration -** for round pipes flowing full.
- **Gaussian integration -** for rectangular pipes or closed conduits of defined shape flowing full.

For either of these methods, if paths fail, the path substitution routine may be selected.

In "Compound" mode, for conduits which may surcharge, the user should first select the integration method to be used under surcharged conditions from the following:

- **Chebyshev integration -** for round pipes.
- **Gaussian integration -** for rectangular pipes or closed conduits of defined shape.
- **Area integration -** for conduits where the path locations are chosen from non-surcharged design considerations.

For any of these three methods, if paths fail, either the "Path Substitution" routine, or the "Available Velocity" routine may be selected.

- **Trapezoidal integration -** for conduits where the path locations are chosen from non-surcharged design considerations. If paths fail, the method's own special routines apply, as long as at least two paths are good.

Normally, for the non-surcharged state, in "Compound" mode, the user should select either:

- **Auto -** which enables the flowmeter to choose automatically the integration method, depending on the Stage and the number of good paths yielding velocity data. The possible choices are:

  Manning
  Single-path Trapezoidal
  Multi-path Trapezoidal
  the user selected surcharged integration method.
- **Trap -** as for "Auto", but omitting "Manning".

However, the following alternative, very restricted methods, are available if required, for the non-surcharged state:

- **Manning formula -** for use where there are no acoustic paths installed.
- **Single path integration -** for use when only one path is installed (Path #1), the user may slect either "USGS", "Polynomial" or "Trapezoidal" methods. If the path fails, the flow computation fails.

For open channels which cannot surcharge, the surcharged condition may be avoided by setting the parameter which defines the "full pipe" condition to a value above the maximum possible Stage value.

If one of the surcharged options available under the "Compound" mode is desired for use in a conduit which is always flowing full, this can be arranged by setting a manually entered value for Stage which forces the surcharged condition.

Flow Calculation Formulas for Full Pipes or Surcharged Conduits

Chebyshev integration is normally the best method for a round pipe flowing full. The formula is shown below.

$$Q = 2R^2 \sum_{i=1}^{n} w_i \bar{v}_i$$

where:	Q	= Flow
	R	= Pipe radius
	w_i	= Integration weighting factor for the *i'th* path
	$\bar{v}_i$	= Average velocity as measured along the *i'th* path
	n	= Number of acoustic paths
	i	= Acoustic path number

Gaussian integration is normally the best method for rectangular pipes or other conduits of a regular cross section flowing full. The formula is shown below.

$$Q = \frac{D}{2} \sum_{i=1}^{n} w_i \bar{v}_i L_i$$

where:	Q	= Flow
	D	= Pipe diameter
	L_i	= Width of pipe at the elevation of the *i'th* path
	w_i	= Integration weighting factor for the *i'th* path
	$\bar{v}_i$	= Average velocity as measured along the *i'th* path
	n	= Number of acoustic paths
	i	= Acoustic path number

Area integration used in surcharged conduits which have path spacing resulting from non-surcharged design considerations. An example would be a horseshoe-shaped tunnel.

$$Q = A \sum_{i=1}^{n} V_i K_i W_i$$

where:	Q	= Flowrate
	A	= Area of the pipe set by the Parameter Cross sectional area
	V_i	= Velocity as measured along the *i'th* path
	K_i	= Integration adjustment factor, normally set to 1.000
	W_i	= Weighting constant for the *i'th* path. Note that the W's for all paths should add up to unity.
	n	= Number of acoustic paths
	i	= Acoustic path number

Surcharged trapezoidal integration used in any shape of conduit in which the flow can be best visualized as being made up from the sum of a number of physical panels, each bounded by paths or the conduit top and bottom.
The flow is computed from the path velocities and the cross-section geometry. The cross section is described by the layer parameters and the Full pipe parameter.
The computation is similar to that for non-surcharged trapezoidal integration, except that the flow in the panel between the uppermost good path (or pair of crossed paths) and the conduit soffit is:
Q_{Top} = Area between uppermost good path and soffit * Velocity * (1 + Bottom Velocity Ratio)/2.
The other elements of the calculation are as described under “Multi-path Trapezoidal Integration” below.

Path substitution is a “fallback” method available only in “Pipe” mode and in the Gauss, Chebyshev and Area surcharged methods under “Compound” mode. It is designed to keep the flowmeter operating when the flow conditions are such that paths fail. The method has to be enabled by the user, and the parameter “Minimum good paths” set. When the number of good paths is less than the number installed, but more than or equal to the parameter Minimum good paths, substitute values for velocity are inserted for those paths which have failed. The substitute values are derived from user calculated path velocity ratios and current velocity readings from good paths pre-assigned from a fixed table.

Available Velocity integration is a “fallback” method available only in the Gauss, Chebyshev and Area surcharged methods under “Compound” mode. It is designed to keep the flowmeter operating when the flow conditions are such that paths fail. The method has to be enabled by the user. The flowmeter automatically selects the method when at least one path has failed. This method is inhibited if the “Velocity Substitution” routine is in operation, but will take over when the number of good paths falls below the parameter “Minimum good paths”.
The Flowrate is calculated from:

$Q = A * V_{avg}$

where:

Q	=	Flowrate
A	=	Area of the pipe set by the parameter “Cross sectional area”
V_{avg}	=	the arithmetic mean of all good path velocities.

Flow Calculation Formulas for Non-Surcharged Conduits

Path Velocities - each path is characterized by parameters describing *Length*, *Angle* and *Elevation*. In “Compound” mode, the paths must be numbered in order of elevation, with the lower path numbers having lower elevations. It is possible for pairs of paths in a section to be configured as “Crossed Paths”, and these are indicated by having the same elevation.
Paths are energized and measurements taken only if they are submerged by an amount greater than a minimum submersion parameter.
If a path fails to provide a good velocity value, because the signal is not found or the data fail to pass acceptability tests, then the last good velocity value is used for all flow calculations until the number of consecutive failures exceeds the maximum bad measurements parameter. If the value is exceeded, the path is declared to have failed, and its data are then not used for flow computation, unless and until new valid data are obtained.
Instantaneous values for velocity are averaged for paths having identical elevations, and the averaged velocity used as the velocity at that elevation. If one of the paths fails for more than the maximum bad measurements parameter, the good path will be used alone for providing the velocity at that elevation. The velocities displayed will be the path velocities for non-crossed paths, and the individuul non-averaged velocities for crossed paths. Paths which do no have identical elevations will be treated as separate paths in the Trapezoidal Integration.

Conduit Cross-section - the conduit cross-section is defined in terms of up to 16 “Layers”, each layer being described by an elevation and a width. The width of the conduit at any elevation is computed by linear interpolation between the layer widths above and below. The elevation and width of the channel bottom are defined separately. The layer elevations are independant of the path elevations. For a rectangular or trapezoidal conduit, only one layer needs to be defined, describing the top of the channel. For a closed conduit, the top-most layer elevation must be equal to or greater than the elevation of the soffit (or the Full Pipe parameter). For an open channel, the top-most layer elevation must be set above the highest possible stage.

Manning formula - used when there are no good paths operating, either because the Stage is low or because of path failure. The flow is computed from the Stage and fixed parameters of channel roughness, channel slope, and the layer parameters. The formula is only appropriate if the flow is non-critical, and if there is no “back-water”effect.
It is programmed to fail if the Stage exceeds 0.3 * Full Pipe parameter.

$$Q = A * C * n^{-1} * R^{0.667} * \sqrt{S}$$

where:
- Q = Flowrate
- A = the cross-section area of fluid at the current Stage, computed using layer data
- C = Manning constant 1.49 if English units and 1.00 if Metric units are selected
- n = the Manning coefficient of roughness
- R = Hydraulic radius, which is the Area/Wetted Perimeter
- S = Slope of the energy line. For a long pipe, the pipe slope.

Single path USGS Integration - This method is typically used after a stage-area relationship has been determined for a particular site by some comparative flow measurement method, such as current meters. Using this stage-area information, the USGS coefficients are obtained by matrix algebra and are used in the following formula to determine spatial average channel velocity:

$$ACVEL = VEL * (VFWD1 + (VFWD2 * S) + (VFWD3 * S^2))$$

where:	ACVEL	= Average channel velocity
	VEL	= Velocity as measured along the acoustic path
	VFWD	= Coefficients entered as General parameters V FWD
	S	= Stage (water depth)

Note that if velocities are less than 0, coefficients entered as General parameters V REV are used.

Flowrate is calculated as:

$$Q = ACVEL * [(QFWD1 + QFWD2 * S) + (QFWD3 * S^2)) * (QFWD4 + QFWD5 * S^{QFWD6}))]$$

Where QFWD are integration constants entered as General parameters Q FWD.

Note that if velocities are less than 0, coefficients entered as General parameters Q REV are used.

For additional information, contact Accusonic.

Single path Polynomial integration - If only one path is operating, the meter uses the coefficients entered in Section parameter *Single coefficient*, which represents a fifth-order polynomial relationship between stage (level) and area for the particular site. Flowrate is calculated as follows:

$$Q = AV$$

where: V = Velocity at the lowest path divided by a coefficient from a table providing velocity-head coefficients in open channels.

A = Area calculated as $a + bs + cs^2 + ds^3 + es^4$

where *a*, *b*, *c*, *d*, and *e* are entered as Section parameters *Single Coefficient*.

s = stage (water depth)

For further information, contact Accusonic or see the Publication *Velocity-Head Coefficients in Open Channels*.[2]

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[2] H. Hulsing *et al*, *Velocity-Head Coefficients in Open Channels*, Geological Survey Water-Supply Paper 1869-C, (Washington: United States Government Printing Office, 1966),C7.

Single-Path Trapezoidal Integration -used when only one path (or pair of crossed paths) is good, either because the Stage is low or because of path failure. The flow is computed from the variables Stage and Water Velocity, and fixed layer parameters describing the conduit dimensions.

Q = A * V/Path position coefficient

where: Q = Flowrate

A = the cross-section area of fluid at the current Stage, computed using layer data

V = the fluid velocity from the one path or pair of crossed paths

Path position coefficient is obtained from the look-up table below[3].

Ratio of path depth below surface to depth of water above bottom	Ratio of point velocity to mean velocity in the vertical
0.1	1.160
0.2	1.149
0.3	1.130
0.4	1.108
0.5	1.067
0.6	1.020
0.7	0.953
0.8	0.871
0.9	0.746
0.95	0.648

The coefficient for the depth nearest to the actual depth is selected.

[3] H. Hulsing *et al*, *Velocity-Head Coefficients in Open Channels*, Geological Survey Water-Supply Paper 1869-C, (Washington: United States Government Printing Office, 1966),C7.

Multi-path Trapezoidal Integration - used when two or more paths (or pairs of crossed paths) at different elevations are good. The flow is computed from the variables of Stage and all good path velocities, and the fixed parameters of Layer data, Path elevations, Bottom Velocity Ratio and Top weight.
The total Flow in a Section is made up of the sum of the flows in various panels. The lowest panel is bounded by the conduit walls (as defined by the layer data), conduit bottom and the lowest good path. Each intermediate panel is bounded by the conduit walls and good acoustic paths at the top and bottom. The top panel is bounded by the conduit walls, the uppermost good path and the water surface.

The flow in the lowest panel is:

$Q_{Bottom} = A_{Bottom} * V_A * (1 + \text{Bottom Velocity Ratio})/2$

where: A_{Bottom} = conduit area between the bottom and the lowest good path or pair of crossed paths
V_A = water velocity as computed from the lowest good path or pair of crossed paths

The flow in the intermediate panel above the bottom panel is:

$Q_{Int} = A_{Int} * (V_A + V_B)/2$

where: A_{Int} = conduit area between good path A and the next good path B
V_B = water velocity as computed from the next good path or pair of crossed paths

The flows in any other intermediate panels is computed similarly.

The flow in the uppermost panel bounded by the surface is:

$Q_{Top} = A_{Top} * (V_N + \text{Top Weight} * V_{Surface})/(1 + \text{Top Weight})$

where: A_{Top} = conduit area between the uppermost good path (or pair of crossed paths) and the water surface.
V_N = Water velocity computed from the uppermost good path or pair of crossed paths
$V_{Surface}$ = an estimated water velocity at the surface from a limited algebraic extrapolation of the velocities from the uppermost good path (or pair of crossed paths) and the next good path (or pair of crossed paths) below it.

If the difference in elevation between the water surface and the uppermost good path is less than the difference in elevations between the uppermost and next lower good paths, then:

$V_{Surface} = V_N + (V_N - V_M) * (\text{Stage} - E_N)/(E_N - E_M)$

where: E_N and E_M are the elevations of the uppermost good path and of the next lower good path
and V_N and V_M are the water velocities from the uppermost good path (or pair of crossed paths) and of the next lower good path (or pair of crossed paths)

If the difference in elevation between the water surface and the uppermost good path is greater than the difference in elevations between the uppermost and the next lower good paths, then:

$V_{Surface} = V_N + (V_N - V_M)$

The total Flow in the conduit = $Q_{Bottom} + \square Q_{Int} + Q_{Top}$

Updating Volume Totals

The flowmeter calculates flow rate as described above. Using the *rate*, it calculates total fluid *volume* passing through the meter since the previous cycle. It does so by:

- Averaging the flow measurement from the current cycle with a user-defined number of previous readings, and
- Computing total volume through the meter during the current cycle. This computation uses the following formula:

$$V_i = \frac{q_i + q_{i-1}}{2} * (t_i - t_{i-1})$$

where: V_i = Total volume through meter during *i'th* cycle
q_i = Flow rate measured for current cycle (after averaging with previous measurements)
q_{i-1} = Flow rate measured at the end of the previous cycle (after averaging with previous measurements)
t_i = Time at the end of the *i'th* cycle
t_{i-1} = Time at the start of the *i'th* cycle

Fluid volume for the current cycle is then added to the previous totalizer volume to determine the total fluid volume which has passed through the section.

For measurements taken just after power up, after an interruption in measurement cycles, or after certain kinds of error conditions, there may be fewer than the site-specified number of previous values available to use for averaging. Under this condition, the instrument uses whatever number of values are available (possibly none). This means that the first few flow readings on the meter after startup may show a variation in flow rate until the averaging effect takes over.

The instrument maintains three separate values of total volume: total forward volume, total reverse volume, and net total volume.

All totals are stated in site-specified aggregate units that are defined during unit setup. For example, the system might be set up such that one volume unit equals 1000 acre-feet, or one unit equals 3 million gallons.

Volume totalizer after Outage

When the steady state cycle of measurements is interrupted - either through a power failure, temporary loss of signal due to noise, or when the unit is taken off line by an operator to change parameters - the duration of the interruption determines how the instrument will estimate total volume through the meter during the period of interruption.

If the interruption is shorter than a site-specified limit (Totalizer Cutoff Time), the instrument uses the formula given above for updating the totalizer. If the interruption exceeds the specified time limit, the instrument does not attempt to update the totalizer for the period of the outage.

Updating System Outputs

During the last step of the cycle, the instrument updates system outputs. For example, if there is an analog output corresponding to flow, the signal is now set to the new or updated level. If a relay has been programmed to output a totalizer pulse each time one of the volume totals increments, this event will be triggered at the same time.

Acoustic Flowmeter Accuracy

This section of the chapter describes the kinds of error which generally *can* occur in acoustic flowmeter measurements. Later in this section, a sample analysis of system error for a round pipe is given (pg 3-28).

If you would like to review a case study and error analysis of open channel installations, consult Accusonic for available literature.

Sources of Measurement Uncertainty

There are several sources of uncertainty in the acoustic method of measuring fluid flow. Each is described below. We characterize the importance of the error and describe what steps are taken in Accusonic instrument design and installation practices to minimize the effect.

Path Length - Error in measuring length will appear in the velocity since these parameters are proportional, as shown in velocity equation described at the start of this chapter and repeated below. This error usually can be kept below 0.1% by using a steel tape measure, calipers, or a micrometer to measure the distance between transducers in every path.

$$v = \frac{(T_1 - T_2)}{T_1 T_2} * \frac{L}{2\cos\theta}$$

Path Angle - Error in measuring the angle will appear in the velocity, since velocity is inversely proportional to the cosine of the angle, as shown in the velocity formula above. For a 45° path angle, and assuming fluid flow is parallel to the centerline of the conduit, a 1° measurement error in the as-built path angle produces a 1.7% velocity error. In order to minimize this error, Accusonic specifies an installation and survey technique that produces measurement accuracy of the path angle to 6 minutes of arc, yielding an error less than 0.17%.

Radius Measurement Error - Error in measuring the radius of a round pipe appears in the flow since radius is a term in the integration formula for pipe. Assuming the pipe is round, a measurement error of 0.1% in the radius produces a 0.2% flow error. In order to minimize this error, Accusonic specifies an installation and survey technique that produces measurement accuracy of pipe radius to within 1/8 inch. In a ten-foot-diameter pipe, this is less than a 0.1% measurement uncertainty, which yields less than a 0.2% flow uncertainty.

Cross Flow Error - When there are streamline components that are not parallel to the axis of the meter section, an error analogous to path angle measurement will appear in the velocity. This effect, called cross flow, is usually caused by upstream bends, transitions in conduit shape or size or obstruction located too close to the meter section.

Cross flow cannot be easily measured. When it exists, it typically changes as a function of flow rate and fluid stage, so simple compensation cannot be used to correct the measurements. Cross flow errors can be substantially reduced by the use of crossed paths, described earlier in this chapter. When crossed paths are used, velocity measurement error is inversely proportional to the cosine of the *difference* between the two path angle errors, an error value near zero. For crossed paths, even several degrees of cross flow yield negligible velocity measurement error.

Crossed paths are also useful for correcting installation errors where the conduit is out of round or not straight, preventing accurate determination of centerline.

***Non-liquid Propagation Delays* -** Transit time measured on an acoustic path which is not part of the *moving* fluid introduces velocity error. This includes cable, logic and detector delays, acoustic delays associated with the transducer windows, and the stationary liquid delays which occur when the transducers are separated from the moving fluid (e.g. recessed into the walls of the conduit).

Accusonic has measured all transducer, logic and detector circuit, and cable delays. Stationary fluid effects, if present, can be measured from the geometry and predicted. The flowmeter software uses parameters defined during instrument setup to compensate for non-liquid propagation delays.

***Variable Acoustic Signal Strength* -** Velocity measurement error can be produced by spurious signal loss (apart from normal spreading loss) caused by fouling of the transducer faces, silt, entrained gas, marine life or debris. Furthermore, acoustic signals may be distorted by multipath reflections from debris. The most serious effect on flowmeter accuracy occurs if the receiver circuitry is unable to consistently recognize the same point (e.g. first leading edge) on every incoming pulse. The instrument employs a Signal Quality Monitor that eliminates this type of error in the path velocity measurement by rejecting unacceptable signals.

***Time Base* -** Velocity measurement error can be produced by jitter and drift in the oscillator used to control the transit time counters. The instrument uses a precision crystal oscillator having high stability and accuracy within 0.005%.

***Quantization* -** There is a true random error of ± one counting period made on every transit time measurement. The instrument uses a very high counting period (equivalent to 160 Mhz) and further reduces error by averaging over a user-selectable period. Normally, this is not a significant source of error.

***Differential Detector Errors* -** Caused when different circuits are used for the forward and reverse measurements along each path. Accusonic uses one detector circuit for both forward and reverse path measurement by sequentially connecting first to one receiving transducer and then to the other.

Level Measurement Error (open channel and compound meters only) - Has a direct effect on the overall meter accuracy which cannot be directly compensated. However, it is fairly simple to calculate the effects on accuracy for all fluid stages - this typically influences the instrument’s overall specified accuracy for a given installation.

***Integration Error* -** Defined as the difference between the flow rate calculated by integrating over the exact velocity profile and that obtained by integrating a discrete number of velocities measured on an acoustic flowmeter.

In a straight circular pipe, using four-path integration, the error is typically less than 0.1%. This level of accuracy can also be achieved under less favorable conditions by using crossed paths. Consult Accusonic for applications assistance.

In an open channel, the integration error can be significant and may be the principal component affecting overall instrument accuracy. It is convenient to evaluate the uncertainty of an open channel meter by separately considering three layers.

- ***Middle layers* -** Those bounded by active paths are a relatively small contribution to overall error. Integration accuracy is comparable to that for a closed pipe.
- ***Top layer* -** The flow between the topmost *active* acoustic path and the free surface of the fluid is uncertain to the extent that the velocity profile over that region is uncertain. A path cannot be placed arbitrarily close to the surface because of multipath effects described previously. As a result, the instrument estimates the velocity distribution by extrapolating surface velocity from measurements taken at the top two paths below the surface. This extrapolated velocity can be adjusted to account for strong winds likely to affect the surface velocity, either in or against the direction of flow. The uncertainty in extrapolated velocity distribution increases with the thickness of the layer above the topmost active path. For most meters, this uncertainty is the most significant contribution to overall device error.
- ***Bottom layer* -** The flow between the lowest active acoustic path and the bottom surface of the fluid is uncertain in the same way. The error contribution here may be smaller than that of the top layer because: The boundary condition is known, because fluid velocity at the bottom surface is zero. Furthermore, total flow of the bottom layer is usually a small proportion of total flow. Typically, this uncertainty is minimized by placing an acoustic path as close to the bottom surface as possible, consistent with the limits of reflected signals as discussed earlier in this chapter.

Sample Error Analysis (Round Pipe)

This sample summarizes the errors in a flowmeter installed in a round pipe. Details of this analysis may be found in *Acoustic Flowmeters for Pipelines*[4] and *The Application of Acoustic Flowmeters to Pipeline Flow Rate Measurement*[5]. Reprints of both papers are available from Accusonic.

Four-path flowmeters are typically specified to an accuracy ±0.5% of flow for velocity ranges from 1 foot/second up to the maximum flow. To achieve these accuracy's the flowmeter must be installed according to Accusonic specifications in a section of pipe with a minimum of ten diameters of upstream straight pipe. For installations having less than ten diameters of straight pipe upstream of the meter section, eight crossed paths (four paths in two crossed planes) may be required to maintain an accuracy of ±0.5% of flow. Consult Accusonic for critical applications.

[4] Francis C. Lowell Jr., and Fritz Hirschfeld. Mechanical Engineering, Vol. 101, Number 10, Ocotber 1979.
[5] Francis C. Lowell Jr., Unpublished, presented to the Cooling Tower Institute Symposium, 1978.

Path Length Measurement Uncertainty **-** Path length measurement is usually done with the pipe dewatered. Using steel tape measures in larger pipes and calipers or micrometers in smaller pipes, individual path length uncertainty is less than 0.15%. For example, a 1/16 inch error in a 4-foot path produces 0.13% error in the velocity calculation. However, since there are four paths and the error is random, overall flow measurement uncertainty due to path length measurement error is:

$$E_L = \frac{(0.0013)}{\sqrt{4}} = 0.00065 \qquad or \qquad 0.065\%$$

Path Angle Measurement Uncertainty **-** Path angle measurement is done with the pipe dewatered using a theodolite accurate to within ±12 seconds of arc. The primary source of error is the ability to set the theodolite up on the pipe centerline. Careful setup according to Accusonic procedures will ensure that the theodolite is within ±6 minutes of arc of true centerline. For 45° paths, the error in flow measurement due to path angle measurement error is:

$$E_\theta = 1 - \frac{\cos(45.10)}{\cos(45.00)} = 0.0017 \qquad or \qquad 0.17\%$$

The error is systematic and is not reduced by adding more paths. In a crossed path installation, however, the error is negligible.

Radius Measurement Uncertainty **-** Pipe radius is measured from the inside with the pipe dewatered. The radius is measured at several locations and is averaged to account for normal tolerance in pipe roundness. When done according to Accusonic procedures, the radius measurement is accurate to ±0.1%, which is equivalent to 1/8 inch in a ten-foot diameter pipe.

The flow measurement uncertainty due to radius measurement error is:

$$E_R = 1 - \left(\frac{1}{1.001}\right)^2 = 0.002 \qquad or \qquad 0.2\%$$

Integration Uncertainty **-** Velocity profile error has been estimated using extensive computer simulation for a wide variety of symmetrical velocity profiles. The uncertainty due to profile integration error in this instrument is typically less than 0.1% assuming there is no cross flow and a smooth symmetrical profile.

Calculating Total Bias **-** System accuracy is defined as the square root of the sum of the squared values of the individual errors. Therefore, the total flow measurement uncertainty for a four-path flowmeter is:

$$E_B \sqrt{EL^2 + E_\theta^2 + E_R^2 + E_1^2} = \sqrt{(0.065)^2 + (0.17)^2 + (0.2)^2 + (0.1)^2} = 0.25\%$$

The random error is minimized by taking an average of many readings (typically ≈ 100). This results in a random component of $E_R \approx 0.3\%$.

Calculating Total Uncertainty **-** The total uncertainty is calculated by taking the square root of the sum of the total bias and random error:

$$E_T = \sqrt{E_B^2 + E_R^2} = 0.4\%$$

Chapter 4
Unpacking and Installation

When the flowmeter arrives, inspect the packaging for signs of damage. If there is obvious external damage to the shipping container, request that the carrier's agent be present when the unit is unpacked. Be particularly careful not to destroy the shipping container during opening so that it may be used for future shipment of the unit.

Warning
Do not apply power to damaged components. Injury or further damage may occur.

Remove the flowmeter from the package and verify all parts against the packing list. Examine each of the components for physical damage. If a component is damaged, notify the carrier and follow the instructions for damage claims. Report any shipping problems immediately to Accusonic.

Physical Installation

The flowmeter should be mounted on a location so the cable run from the transducers to the main unit or to a remote flow transmitter does not exceed 1000 feet without the approval of Accusonic. In addition, the unit requires an AC connection, as well as connections to alarms or to the site process control system. If a printer is connected to the system, it will be desirable to locate it near the flowmeter during setup.

If the flowmeter is supplied in a wall-mounted cabinet, determine a suitable location with sufficient clearance so that the front panel of the unit can swing fully open without interference. Although the NEMA cabinet is sealed, it is good practice to mount the unit in a location that provides protection from the elements. The instrument should be mounted vertically and should be attached to a wall or mounting panel capable of safely supporting 100 pounds. Use 3/8 inch lag screws or carriage bolts.

If the flowmeter is supplied as a rack-mounted unit, select a rack or table location with enough clearance to allow removal of the top portion of the cabinet. The rack-mounted unit must be mounted indoors. The instrument is normally supplied with rack slides, so when a unit is mounted in a relay frame, service clearance above the unit is not necessary.

The height at which the unit is mounted must allow for easy access to the keypad and easy viewing of the display. If an external display or keyboard is used, provide a suitable table or shelf.

Electrical Installation

All wiring is brought into the unit through customer-supplied conduit connectors. Holes for the cable-conduit connectors must be drilled through the cabinet on site. The preferred location for all connectors is the bottom surface of the unit. Use separate conduit and connectors for:

- AC power supply mains
- Transducer cabling (may require more than one feedthrough)
- Alarms and low voltage relay connections
- Digital I/O, printer connections, and analog I/O

Caution
When drilling conduit holes, remove the circuit cards from the unit and drape the front panel of the device. Give particular attention to protecting the diskette drive.

AC Wiring

AC power consumption is less than 175 VA. Use #16 AWG or #14 AWG for power connections.

Rack-mount units have a standard power cord connector located on the rear of the cabinet. The connector contains 2 Amp Slo-Blo fuses located under a removable access cover. Simply attach the power cord and plug the unit into a mains outlet.

The NEMA enclosures require direct mains wiring and should be installed with a separate main power cutoff switch near the instrument.

Route AC power mains wiring into the NEMA cabinet through the appropriate feedthrough to the AC mains terminal block and connect as shown in Figure 4-1. Be sure to follow appropriate local codes and practices, and to attach a proper earth ground to the instrument.

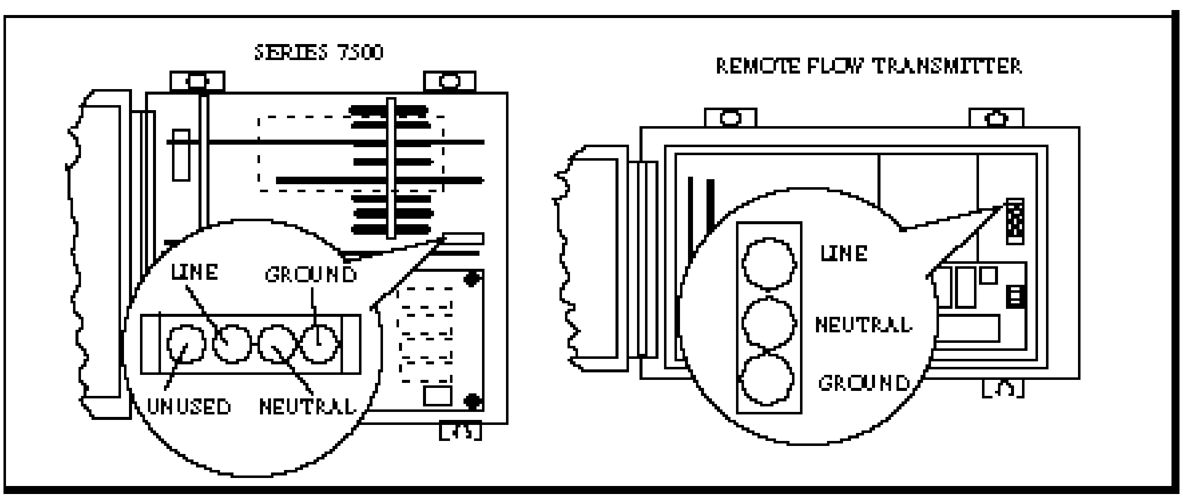


Figure 4-1 Location of AC Power Connections, NEMA Cabinets

Transducer Wiring

Pull transducer cabling through the appropriate feedthrough and trim each line, leaving enough cable to reach the transducer terminal blocks at the bottom of the flowmeter console. Tag each cable with a path number and transducer letter according to the Accusonic numbering convention as shown in Figures 4-2 through 4-4. Trim the cables, strip back 6 inches of outer sheathing from each, pull inner conductors back from inside the outer braid, solder spade lugs to the conductor and shield of each cable as shown in Figure 4-5 on page 4-4.

Do not connect the cables to the flowmeter yet. Leave the ends of the cables so that the conductors are not in contact with one another or with any metal parts on the flowmeter console.

Caution
Double-check the cable numbering and verify sufficient reach before trimming.

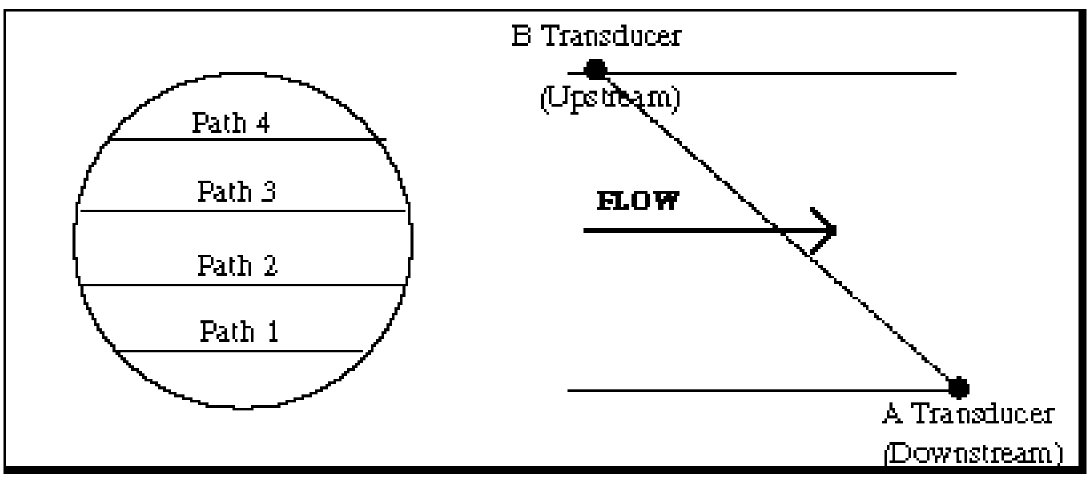


Figure 4-2 Transducer Numbering - Simple Pipe

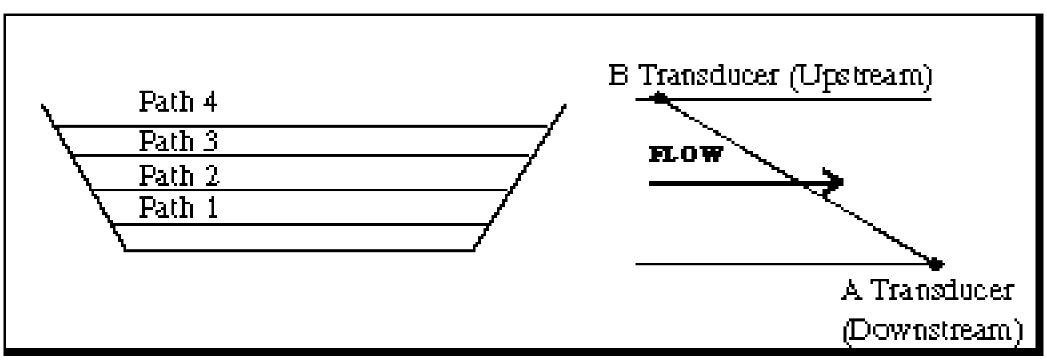


Figure 4-3 Transducer Numbering - Open Channel

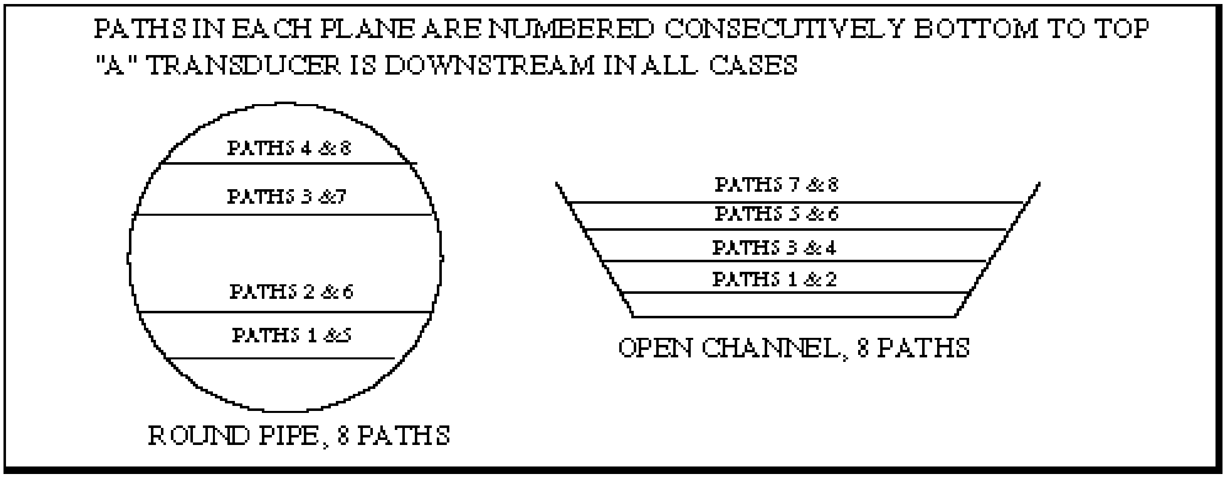


Figure 4-4 Transducer Numbering - Crossed Paths

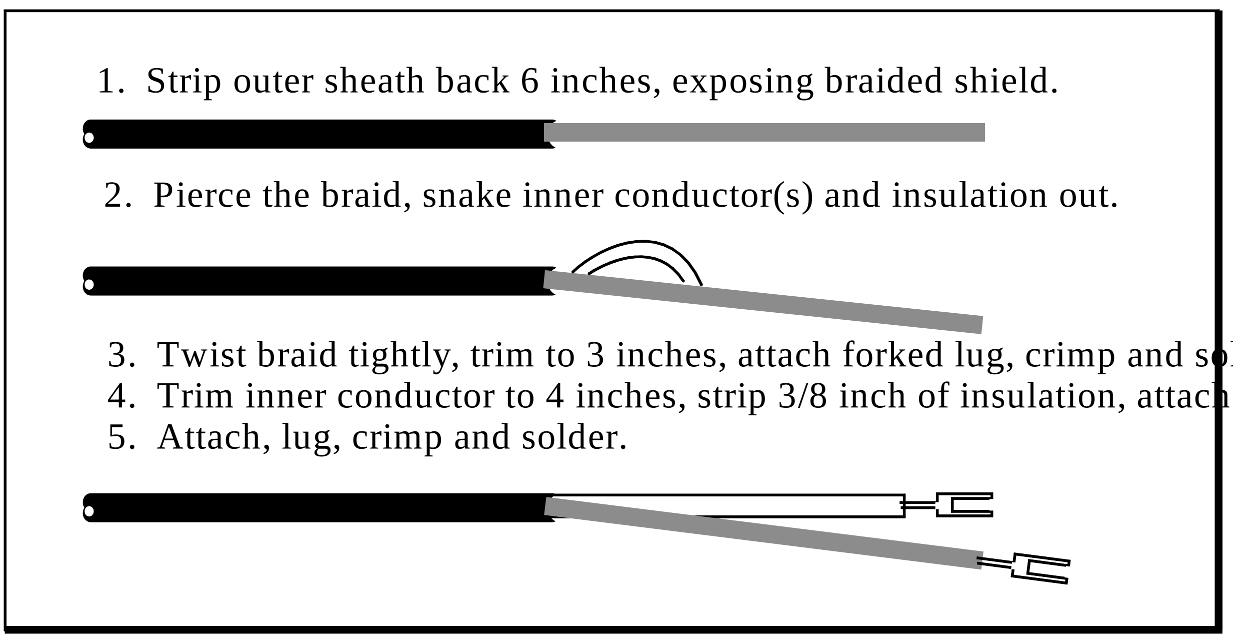


Figure 4-5 Stripping and Terminating the Transducer Cable

Transducer and Cabling Checkout

There are three steps to verify the transducer cabling and transducers:

1. Verify that there is infinite resistance across each transducer.
2. Verify that there are no internal shorts in any cable.
3. Verify continuity in the cabling.

Step 1 - Verify infinite resistance across each transducer

Measure the resistance across the transducer cable terminals using a Megohmmeter (high voltage ohmmeter) set to the highest resistance range. Each transducer should measure infinite resistance. Contact Accusonic if any transducer measures less than 20 MΩ resistance.

Test transducer resistance at the unit, with the cabling detached, if possible. This can usually be performed easily when the transducers are pipe-mounted, where the outside of the pipe is accessible, and when the transducers are fitted with E/O connectors. Use a short test cable attached to an E/O connector.

When the transducer is not accessible, or when the cable is permanently attached to the unit, do the best you can. Test the resistance at a wiring junction located as near as possible to the transducers. If it is not possible to detach the cabling back to the flowmeter console, be sure the console ends of the cables are detached from the unit and that they are not accidentally shorted together.

Step 2 - Verify that there are no internal shorts in any cable

With the free ends of all cables detached and isolated, test that the resistance across each cable is infinite.

For coaxial cable, test conductor to shield, conductor to ground and shield to ground. For twin-axial cable, test conductor to conductor, each conductor to shield, each conductor to ground, and shield to ground.

Step 3 - Verify Continuity

Work from either end of the cable and use a partner to connect pairs together, one at a time, at the far end of the cable. For each coaxial cable, short the connector to shield and measure continuity. For each twin-axial cable, short each connector to shield and measure continuity.

Connecting Transducer Cabling

After verifying that all transducer cabling is sound, connect each line to the appropriate terminal on the flowmeter console, as shown in Figure 4-6.

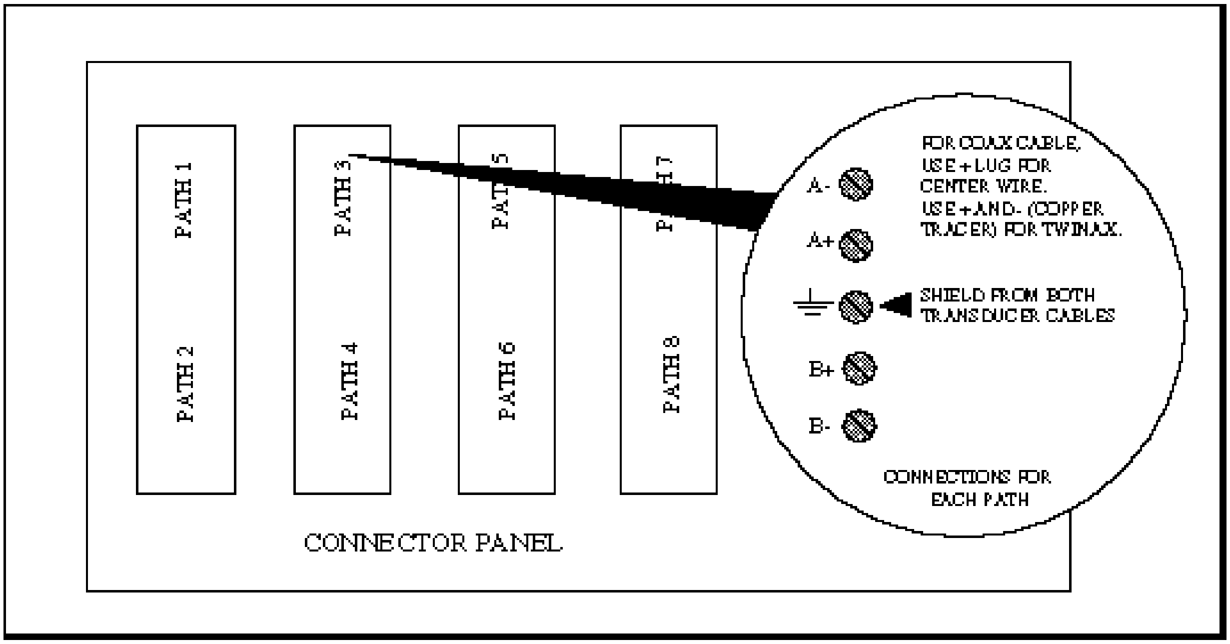


Figure 4-6 Transducer Wiring Connections

Connecting a Printer

Any PC-compatible printer with a parallel interface may be connected to the flowmeter. Even if a printer is not needed for routine operations, it is good practice to attach one to the instrument during instrument setup. The data cable between the flowmeter and the printer should not exceed 20 feet.

The printer connects via standard D-shell connector located on the connector panel as shown in Figure 4-7.

If the printer is to be used temporarily, simply route the data cable out the door of the flowmeter, and take care not to crush it by trying to shut the door. For more permanent installation, route the cable through a cable feedthrough in the bottom of the enclosure.

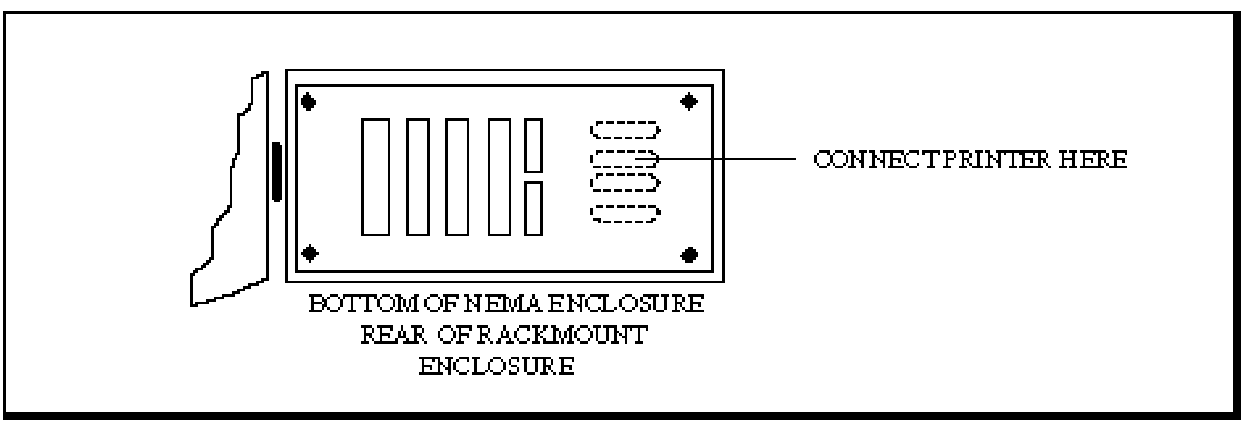


Figure 4-7 Location of Printer Connector

Level Sensor Setup

Acoustic Uplooking Transducer - If supplied by Accusonic, the acoustic uplooking transducer will be supplied with twin-axial, shielded cable. Connect the cable to the Stage 1 or Stage 2 terminal strip located to the right of the path selector cards in the Flow Transmitter section of the console. Connect + to +, - (copper tracer) and shield to -. Connect - to ground with a jumper wire.

External Stage (Level) Sensor - Any stage sensor providing a 4-20 mA process loop signal can be used by the flowmeter. The loop signal is read and converted by an analog input board mounted in the PC bus. This board utilizes a dual-slope analog-to-digital converter, which requires no calibration.

After installing the external stage sensor according to the manufacturer's instructions, use a twin-axial, shielded cable to connect the input to the terminal strip located at either TB1 or TB2 in the 7500. Refer to customer-specific drawings at the end of the 7500 manual for terminal strip locations. Connections are as follows:

Pin 1	Stage 1 shield
Pin 2	Stage 1 loop input
Pin 3	Stage 1 loop return
Pin 4	Stage 2 shield
Pin 5	Stage 2 loop input
Pin 6	Stage 2 loop return

Input impedance for each channel is 100 ohms. Both the loop input and loop return terminals must be between 0 and +4 volts relative to ground.

Once connected, the easiest way to verify proper connection and test for the presence of loop noise is to enter the diagnostic menu. The recommended procedure follows. Familiarity with proper grounding techniques is useful in determining proper shield connections to reduce loop noise pickup.

From the main menu, select [DIAGNOSE], then select [HARDWARE], then [INPUTS]. From this point, menu choices will be shown for the available inputs. Select either IN1 or IN2 and press the Enter key to accept the choice. A number will be displayed after the input data. This number is the raw, unscaled input value direct from the analog input board. The range is 0-6000 bits, with 0 bits representing 4 mA and 6000 bits representing 20 mA. Both the upper and the lower ends of the range should be checked while in the diagnostic menu to verify proper connection. It may also be helpful to monitor a steady-state level near midrange, to check for the presence of loop noise. Any "jitter" in the readings with a steady-state signal is an indication of noise. This can be used to determine the best grounding scheme.

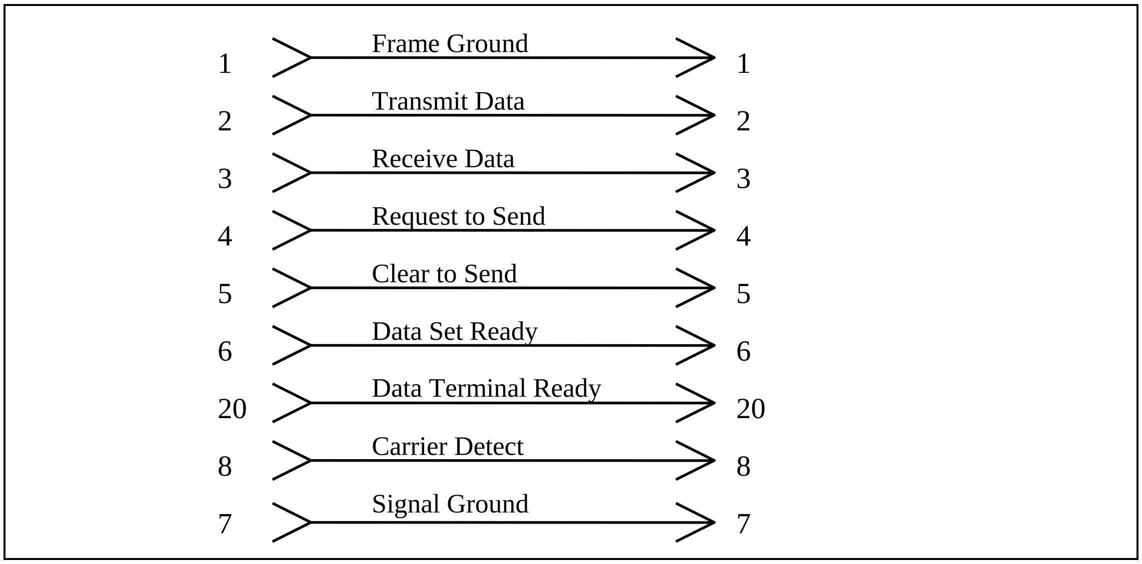
When proper operation is verified, the following procedure is used to set the software to use the input. In the SECTION parameters menu, find the parameter STAGE SOURCE. Select [EXTERN], to use the analog input. Choosing this will lead to two more choices, STAGE RANGE MAX and STAGE RANGE MIN. At these prompts, enter the range at the calibrated ends of the level sensor. The 7500 will calculate the correct offset and scale factors.

Example: The level sensor is an acoustic downlooker. It is calibrated to output 4 mA at two feet of depth, and 20 mA at 25 feet. Set STAGE RANGE MIN to 2, and STAGE RANGE MAX to 25. For multiple-section meters, this setup must be done for each section.

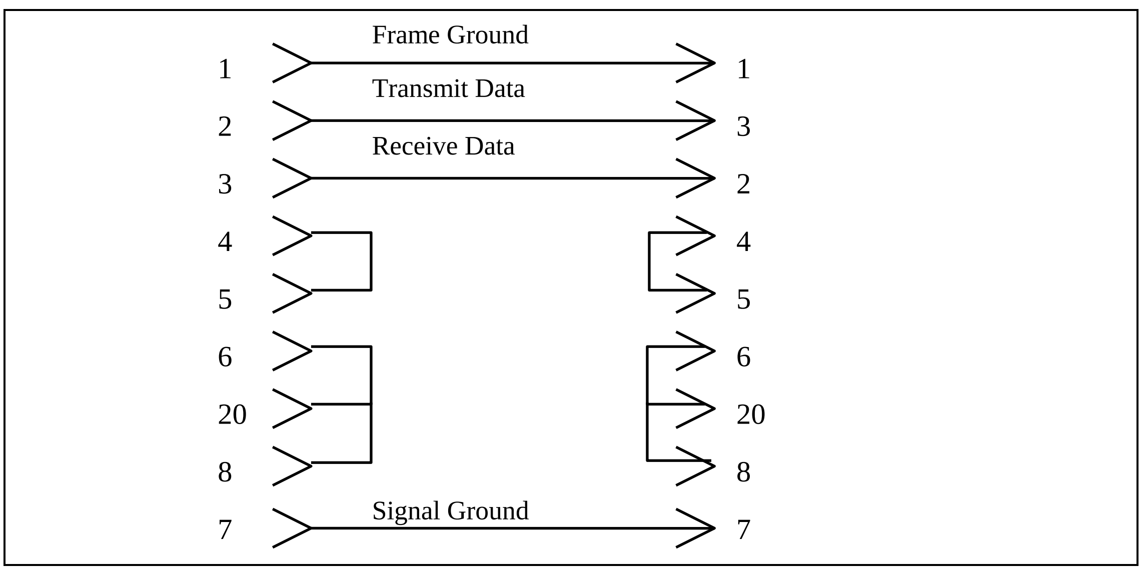
In some cases, such as cross-path installations, it may be desirable to run two sections from a single external stage sensor. This can be done by connecting both analog inputs in the level sensor's output loop and setting identical ranges for both sections, or by setting the *Stage Source* for the second section to *Section*, then choosing the section to use as the source.

RS-232 Port Connection

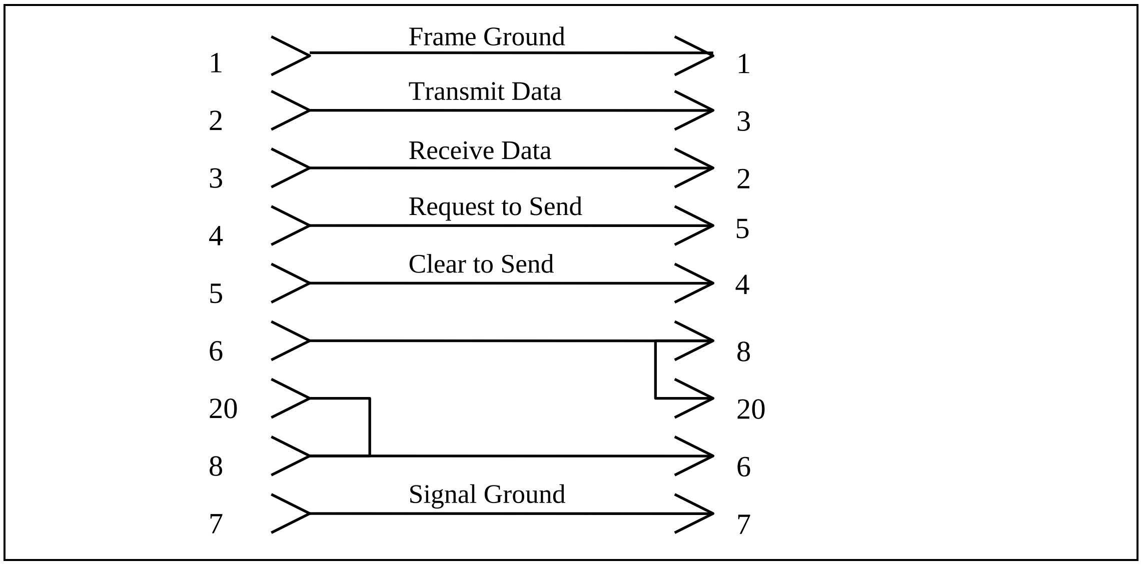
The serial port of the 7500 complies fully with the RS-232C standard with respect to signal level and hardware handshake. The port is configured as a DTE (Data Terminal Equipment) device. Therefore, connection to an external device requires a fully-pinned cable for proper operation. If correct connections are not made, the output may be erratic or may not work at all. With early versions of flowmeter software, the system may "lock up", causing a watchdog timer reset. Common cables for connection to DCE and DTE devices are shown below.



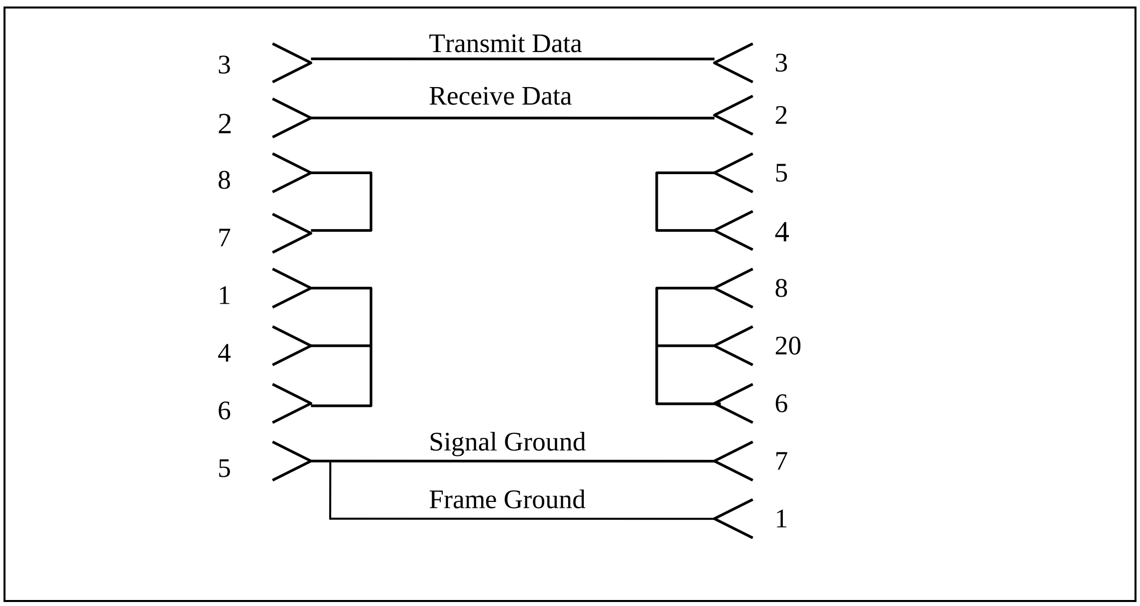
For connection to DCE devices (modems, etc.)



For connection to DTE devices (computers, terminals, etc.) with no hardware flow control. This is the most common arrangement



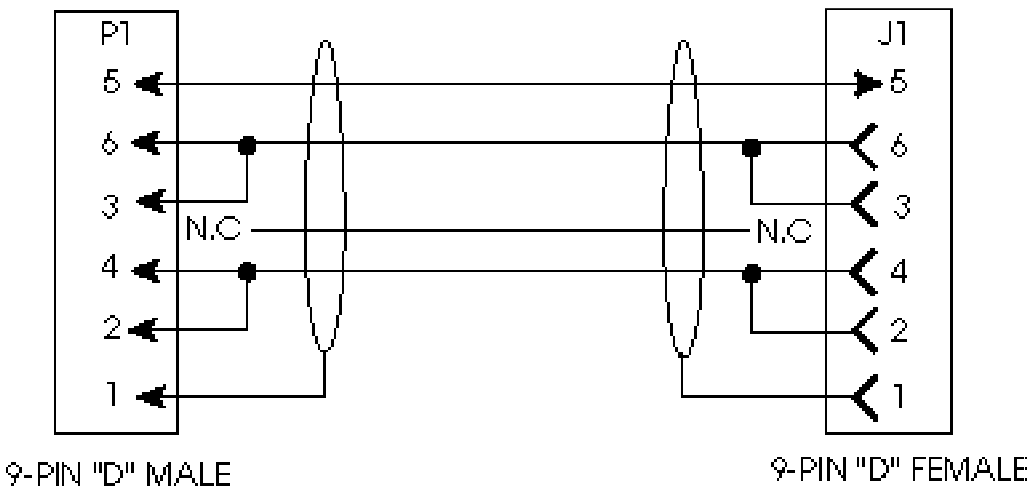
For connection to DTE devices (computers, terminals, etc.) with full hardware flow control.



For connection to DTE devices with 9-pin serial cable (laptop cable).

RS-485 Interconnection

When assembling systems with a 7500 and 7520 remote flow transmitters, it may be necessary to build the interconnecting cables at the site. Following are specifications and guidelines to help you.



Cable Specifications

• Cable Type:	Shielded, twisted pairs
• Wire Gauge:	24 AWG or larger
• Shunt Capacitance:	16pf/ft or less
• Rise Time:	Signal rise and fall time equal to or less than 13μs.
• Max Transmission Distance:	4,000 Feet
• Maximum Loss:	6db max between 7500 and last 7520
• Recommended Cable Types:	Belden #8729 Alpha # 2254/4

Chapter 5
Initial Setup, General Operations

This chapter describes setup and operation of the flowmeter using the standard front panel keypad and display. Operating differences introduced by using an external keyboard or display are also discussed. You cannot damage the instrument by entering incorrect parameters or otherwise manipulating the control panel.

Control Panel, Parameters and Variables

The control panel, which consists of a display and a keypad as shown in Figure 5-1 (see page 5-2), is used to set up the flowmeter, start measurements and perform diagnostics. Once the instrument starts taking measurements, it will continue to do so at a rate defined during setup. Flow measurements can be interrupted or halted from the front panel.

Set up the flowmeter by entering appropriate values for various parameters, or by accepting default values. Parameters define the geometry of each meter section and govern the operating modes of the instrument. All parameters are listed in this chapter. Chapter 7 contains a dictionary that defines each parameter (beginning on page 7-1) in detail and lists its default value and range of allowed values.

Variables provide a view of measurements of calculations when the unit is on line. Chapter 7 describes flowmeter variables (beginning on page 7-40) in detail.

An optional password can be used to lock the control panel and prevent change in instrument setup or an interruption in flow measurement.

Menus

Commands and control parameters are entered into the instrument using menus shown on the display. A menu appears on the control panel within a few seconds after system power up, unless the instrument has been previously set up to begin measuring flow automatically.

Most menus display the available options and you simply choose among them; in a few cases, you need to enter data. The menus are arranged in a multi-level fashion, with related options grouped together. There are numerous parameters and variables, and the hierarchy makes it possible to move among the choices with ease and to select or change one quickly.

The top line of every menu shows the currently available options, with the selected or active option shown enclosed by brackets and displayed in capital letters. If there are more options than fit on the top line, the instrument displays two arrows at the beginning or at the end of the line (<< or >>) to indicate that additional options are available. The next section, *Stepping Through Menus*, describes how to access these options.

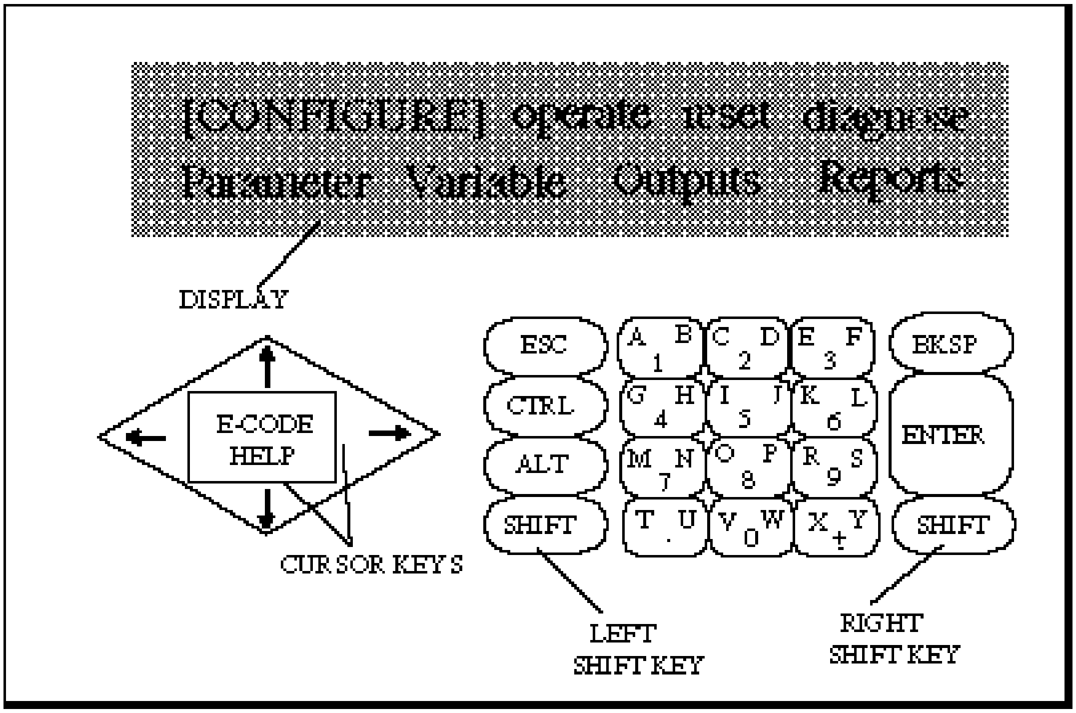


Figure 5-1 Control Panel

The second line of a menu shows a list of submenu options that correspond to the selected item. If there are no additional options, it describes the bracketed selection more fully.

Figure 5-2 (page 5-3) shows two examples of menus.

The first example shows the main menu, which has three options displayed on the top line. *Configure* is selected. The second line shows that the *Configure* function has four additional options, *Parameter*, *Variable*, *Outputs* and *Reports*.

The second example shows the submenu that appears after the *Configure* function in the main menu has been invoked by pressing **Enter**. The *Reports* function from this submenu has been selected, and another submenu appears offering two choices--*List* and *Report*. The second line in this example describes the *List* function.

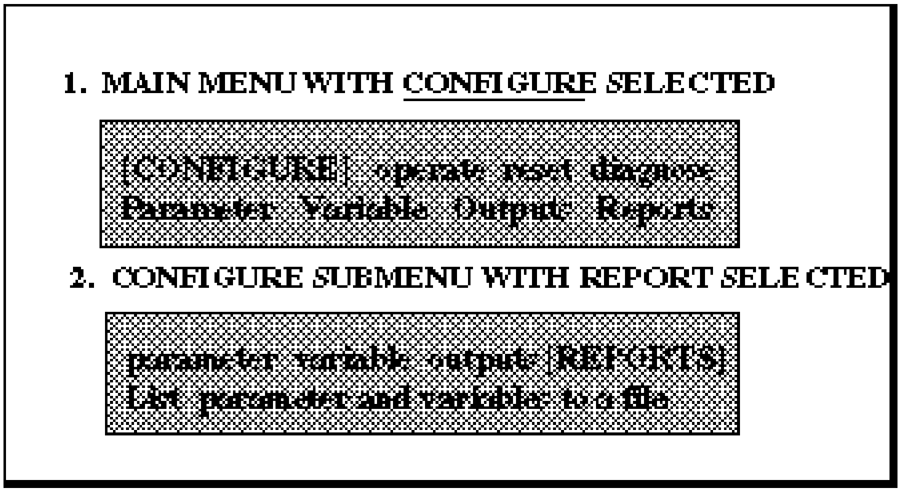


Figure 5-2 Two Examples of Menus

Stepping Through Menus

Six keys are used to navigate through the various menu options and to move through lists of parameters or variables. They include the four cursor keys (←↑→↓) plus **Enter** and **Esc**.

The left and right cursor keys (← and →) choose among different functions within a menu. In the main menu example shown previously, these two keys select a new option from the choices: *configure, operate, reset,* and *diagnose*. Selection wraps from one end of a line to the other.

Once you step through the menus and access a set of parameters and variables, the set is displayed one at a time on the second line of the display. The up and down cursor keys (↑ and ↓) choose among items within such a list.

- Pressing ↓ displays the next item in the list
- Pressing ↑ displays the previous item

These cursor keys do not wrap around from the top and bottom of the list. Pressing ↑ when the instrument is displaying the first item in a list brings up the menu which invoked the list in the first place; pressing ↓ from the last item in the list brings up the message *Press Esc to return to previous menu*.

Many parameters display a short list of available options (e.g. *On*, *Off*). The left and right cursor keys (← and →) choose among items in such a list.

If there are too many options to display on one line, arrows (<< or >>) indicate that additional options are available. The left and right cursor keys are used to bring up the options not shown.

The **Enter** key invokes the currently active selection. If the active selection has additional options, the submenu displays them. Otherwise, the instrument carries out the function invoked.

The **Esc** key steps you back to the previous menu **-** the reverse of **Enter**. Refer again to Figure 5-2. Pressing **Esc** in the first example has no effect, since the main menu is at the highest level of the system. Pressing **Esc** twice in the second example returns to the main menu. It is possible to return to the main menu at any time by repeatedly pressing **Esc**.

Note
The Esc key is also used to suspend flow measurement and activate the control panel menus.

Pressing the CTRL and Esc keys together will exit any configuration menu, automatically save parameters, and start measurement.

Table 5-1 shows the organization of menus, Tables 5-2 through 5-4 (beginning on page 5-10) list all parameters and variables. Chapter 7 defines each parameter and variable in detail.

Although the sheer quantity of parameters may seem intimidating at first, they have been assigned different “access levels” so that you only see what you need to see. At the top of the general parameters menu is the choice for access level. When access level is set to SETUP, the user will only see the minimum parameters required to get the flowmeter operational. Stepping through the menus becomes a simple matter of entering information where necessary (most have reasonable defaults, no entry is required) and going **down** through the menus. When you arrive at the bottom of a particular menu, you will automatically increment to the top of the next menu. Keep in mind that an explanation is available for any parameter by pressing the “HELP” key.

On Line Help

You may request more information about a selected option by pressing the Help key at any time. Help messages display information about the active menu. When using an external keyboard, help is available by pressing and holding the shift key and pressing the question mark key.

Table 5-1 Flowmeter Menu Hierarchy

CONFIGURE

- PARAMETER
  - Section
    - *Section 1, Section 2, etc.* *(see Table 5-3 on page 5-11)*
    - *Path 1, Path 2, etc.* *(see Table 5-4 on page 5-14)*
  - General
    - *General System Parameters* *(see Table 5-2 on page 5-10)*
  - Leak
    - *Leak Detection Parameters* *(see page 12-7)*
  - Files
    - *Save*
    - *Load*
  - Password
    - *Change Password*

- VARIABLE
  - Section
    - *Section and path variables*
  - End
    - *End variables*
  - Leak
    - *Leak detection variables*
  - General
    - *General system variables*
- OUTPUTS
  - RS-232
  - Analog
  - Digital
  - Relay
  - Totals
- REPORTS
  - List
    - *List parameters and variables to a file or printer*

Report

Define printer reports

OPERATE

Measure flow rate

RESET *Reset volumes and return to operate mode*

DIAGNOSE

SYSTEM

Keypad

Test keypad

Display

Test display

Serial

Transmit

Data transmit test

Input

Data input test

Output

Output driver test

TRANSCEIVER

Self test

Run transceiver self test

Measurement

Locate measurement failure

Stage

Locate stage failure

Tattler

Investigate tattler LEDs

HARDWARE

Inputs

Installed inputs test

Outputs

Installed outputs test

Here is the general organization of the parameters:

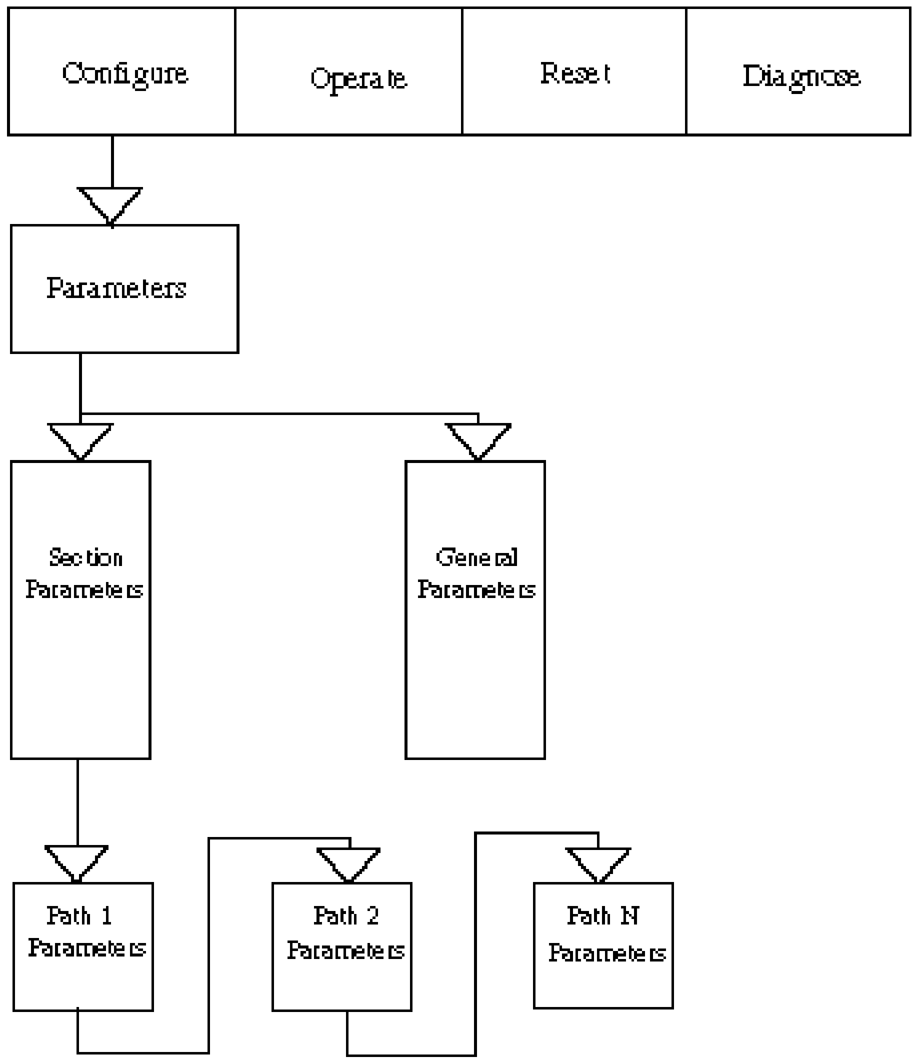


Figure 5-3 Tree organization of the parameters

Entering Parameter Values

To enter a numerical value, simply press the appropriate digit keys, including the decimal point if needed.

For very large or very small numbers, use scientific notation. Enter the whole number first, followed by the letter E and then the power of ten (positive or negative). For example, enter 6.023×10^{-23} as 6.023E-23 or enter 4.35×10^{4} by typing 4.35E4.

To enter text, first press and hold one of the two shift keys and then press the appropriate letter. Use the left shift key for letters whose legend on the key is in the top left corner; for letters marked on the top right of the key, use the right shift key. The colon (**:**) is used to specify the floppy disk as the target for data logging or parameter backup. It is entered by pressing **Ctrl-1**.

On Line Help

You may request more information about a selected option by pressing the Help key at any time. Help messages display information about the active menu. When using an external keyboard, help is available by pressing and holding the shift key and pressing the question mark key.

AutoStart

The parameter *Autostart* defines the action of the flowmeter upon power up. When *Autostart* is on, the flowmeter will bypass the menu system and proceed directly to measuring flow. When the parameter is off, the system starts up with the menus, and will await operator intervention before taking measurements. It is good practice to turn this parameter off during instrument setup.

Using a Password

A password is used to lock out the control panel and prevent changing the setup of the instrument. Password protection is in effect only when the parameter *Password control* is *on*, and the instrument is measuring flow.

However, if *Password control* is *on* and *Autostart* is *off*, when the instrument powers up it displays the system menu, where password control is *NOT* in effect. To prevent unauthorized tampering with the instrument setup, always turn *on* both *Password control* and *Autostart*.

If you forget the password, contact Accusonic.

Using an External Keyboard

The following conditions apply to the operation of the control panel when using an external keyboard:

- ♦The keyboard type must match the CPU type (XT or AT). 7500's can be equipped with either type, if you are unsure of which type is installed, use an autoswitching keyboard, which configures itself to be the correct type when the system boots.
- ♦The Keypad/keyboard slide switch located on the keypad card (near the keyboard connector) must be in the *keyboard* position.
- ♦If using an auto-switching keyboard, the system must be rebooted by turning the power switch off and then on or by pressing **Ctrl Alt Del**.
- ♦Activate the keyboard before use by pressing **Ctrl–** (i.e., press and hold the control key, press the minus key on the numeric keypad and then release both keys together.) If the keyboard is not activated the display will appear to respond with the wrong characters as keys are pressed. Pressing **Ctrl–** more than once will not cause any harm.
- ♦Deactivate the keyboard before unplugging it and switching back to the keypad by pressing **Ctrl+** (i.e., press and hold the control key, press the plus key on the numeric keypad and then release both keys together.) If the keyboard is not deactivated, the display will appear to respond with the wrong characters as keys on the keypad are pressed. The keyboard can be deactivated only using the keyboard; it cannot be deactivated from the keypad.
- ♦Enter numbers from the top row of the normal keypad, or, if using a 101-key keyboard, from the numeric keypad with **NumLock** on. Do not use **NumLock** with 88-key keyboards.
- ♦On 101-key keyboards, use the normal cursor control keys located to the left of the numeric keypad. On 88-key keyboards use the cursor control keys located on the numeric keypad and be sure **NumLock** is off.
- ♦Access the help system from an external keyboard by pressing **Shift?** (shift question-mark).
- ♦Access the status screen during measurement from an external keyboard by pressing **-** (minus key).

Selecting Menu Access

Depending on how the instrument is set up, certain parameters and variables may be hidden from the menu displays. The purpose of this is to simplify the use of the menus. For example, certain parameters usually need to be accessed once during instrument setup. Such initial setup parameters should be hidden in the course of day-to-day operations.

Menu Access may be changed at any time; it is controlled in the *General Parameters* section of the menus, as listed in Table 5-2 (page 5-10). Refer to Chapter 7 for details. There are three menu access levels:

Set Up - Parameters used during instrument setup

Limited - Parameters used in day-to-day operation, data access, and reporting

Extended - All parameters

The tables that follow list all parameters and variables and indicate the availability of each as a function of menu access. The instrument displays abbreviations for some parameters and variables. All variables are accessible at all menu access levels.

Note that, due to system enhancements, your system's menu listings may be slightly different from those set out in this chapter.

General Parameters

General parameters govern the overall operation of the instrument. They are listed in Table 5-2. Refer to Chapter 7 for details about each parameter. Any change to a general parameter takes effect immediately as it is entered.

Table 5-2 List of General Parameters

General Parameter Description and Choices	Menu Access Level		
	Set Up	Limited	Extended
Menu Access: (setup limited extended)	✓	✓	✓
Repetition time (seconds)		✓	✓
Self test interval (sec.)		✓	✓
Stage interval (seconds)	✓	✓	✓
Leak detection switch (off, on)		✓	✓
Stage mode (normal, fast)	✓	✓	✓
Datalogging (off, on)	✓		✓
Log data to: (disk,printer,both)	✓	✓	✓
Datalog Start Time	✓	✓	✓14
Datalog Interval	✓	✓	✓14
Error reporting (off,on)			✓
Autostart switch (off, on)	✓		✓
Inactivity timeout (min.)			✓
Display mode (sections, ends, both)			✓
Section label character			✓
Section starting number			✓
Units (English, metric)	✓		✓
Speed of sound in fluid	✓		✓
Password control (off, on)			✓
Averaging queue length			✓
Maximum bad measurements			✓
Travel time tolerance			✓
Display totals line (off, on)			✓
Always display flow totals (off, on)			✓
Display contrast (down, up)[1]	✓	✓	✓
Current time (HH:MM:DD)	✓	✓	✓
Current date (MM:DD:YY)	✓	✓	✓

[1] Used for LCD displays only; this has no effect on full-screen electroluminescent (EL) or CRT screens.

Section Parameters

Section parameters specify:

- Size of the section (i.e., pipe, channel, etc.)
- Operating limits (velocity, flow, etc.)
- Section-related operations

A change to a section parameter does not take effect immediately. After you finish changing section parameters the instrument prompts you to confirm them all as a group. The new values take effect at that time. The parameters are listed in Table 5-3. Refer to Chapter 7 for details about each parameter. Several of the following parameters appear only if the *Section type* is *compound*, which includes open channels.

Table 5-3 List of Section Parameters (not necessarily in order)

Section Parameter Description	Menu Access Level		
	Set Up	**Limited**	**Extended**
Section switch (off, on)	✓	✓	✓
Section type (pipe, compound)	✓		✓
Pipe integration (Cheb, Gauss)	✓		✓
Enter pipe shape (round, other)	✓2		✓2
Radius	✓1		✓1
Pipe height	✓		✓2
Shape Factor			✓2
Surcharged integration method	✓		✓
Available velocity enabled (off, on)	✓		✓
Cross sectional area	✓3		✓3
Non-surcharged integration method	✓		✓
Manning coefficient of roughness	✓		✓4
Pipe slope	✓4		✓4
Single integration	✓		✓
Single coefficient	✓5		✓5
Q FWD	✓6		✓6
Q REV	✓6		✓6
V FWD	✓6		✓6
V REV	✓6		✓6
Stage averaging size			✓
Stage source (off, manual, external, other)	✓		✓
Stage ducer type	✓7		✓7
Frequency of other transducer	✓8		✓8
Delay time of other transducer	✓8		✓8
Manual stage value	✓9		✓9
Stage (1 or 2) range maximum	✓10		✓10
Stage (1 or 2) range minimum	✓10		✓10
Stage (1 or 2) offset	✓7		✓7

Table 5-3 List of Section Parameters, Continued

Section Parameter Description	Menu Access Level		
	Set Up	**Limited**	**Extended**
Average stage cable length	✓[7]		✓[7]
Maximum stage difference 1 and 2	✓[11]		✓[11]
Channel bottom height	✓		✓
Minimum stage	✓		✓
Maximum stage	✓		✓
Maximum change in stage	✓		✓
Full pipe	✓		✓
Minimum path submersion	✓		✓
Bottom channel width	✓		✓
Number of channel layers	✓		✓
Layer boundary elevation	✓	✓	✓
Layer boundary width	✓	✓	✓
Bottom velocity ratio	✓[12]		✓[12]
Top weight	✓[12]		✓[12]
Average cable length per path	✓		✓
Ducer connection (balanced, single)	✓		✓
Signal detection method (1st Neg, zero crossing)			✓
Minimum good paths	✓		✓
Velocity substitution (off, ratio)			✓
Maximum expected velocity	✓	✓	✓
Maximum change in velocity	✓		✓
Positive over velocity warning threshold	✓		✓
Negative over velocity warning threshold	✓		✓
Over velocity warning count	✓		✓
Positive over velocity alarm threshold	✓		✓
Negative over velocity alarm threshold	✓		✓
Over velocity alarm count	✓		✓
Flowrate scale factor	✓		✓
Volume scale factor	✓		✓
Simulation source (internal, external)			✓
Totalizer cutoff time (minutes)			✓
Maximum expected flowrate	✓	✓	✓
Maximum change in flowrate	✓		✓
Minimum flowrate	✓	✓	✓
Bidirectional Flow (on off)	✓		✓

Table 5-3 List of Section Parameters, Continued

Section Parameter Description	Menu Access Level		
	Set Up	**Limited**	**Extended**
Data Logging (off, on)		✓	✓
Log flow data (off, on)		✓	✓
Log negative volume data		✓14	✓14
Log velocity data		✓14	✓14
Log stage data (off, on)		✓	✓
Temperature coefficient 1, 2 ... 5			✓
Zero Flow Offset	✓		✓

1 If *Pipe integration* is set to *Cheb.*
2 If *Pipe integration* is set to *Gauss.*
3 If *Available velocity* enabled is *On*.
4 If *Non-surcharged integration* is *Manning*.
5 If *Single integration* is *polynomial*.
6 If *Single integration* is *USGS*.
7 If *Stage source* is *acoustic.*
8 If Stage ducer type is Other.
9 If *Stage source* is *manual*.
10 If *Stage source* is *External.*
11 If redundant stages are used.
12 If *Non-surcharged integration* is *trapezoidal*.
13
14 If *Data logging* is set to *On*.

Path Parameters

Path parameters specify:

- Path geometry
- Transducer type
- Path-related operations

They are listed in Table 5-4. Refer to Chapter 7 for details about each parameter. A change to a path parameter does not take effect until all parameters for a path are confirmed as a group.

Table 5-4 List of Path Parameters

Path Parameter Description	Menu Access Level		
	Set Up	**Limited**	**Extended**
Path switch (off, on)	✓	✓	✓
Path angle	✓		✓
Weight			✓
Path elevation	✓[1]		✓[1]
Width at path elevation	✓[1]		✓[1]
Path position			✓
K	✓		✓
Transducer type (7600, 7601, 7605 ...)	✓		✓
Frequency of other ducer	✓[2]		✓[2]
Delay time of other ducer	✓[2]		✓[2]
Protrusion of other ducer	✓[2]		✓[2]
Path length	✓		✓
Path percent active	✓		✓
Signal Quality Monitor (off, on)			✓
Velocity substitution ratio			✓
Path simulation (off, velocity, times)			✓
Simulation velocity			✓[3]
Simulation forward time			✓[4]
Simulation reverse time			✓[4]
Simulation velocity ramp scale			✓
Receiver gain (auto, manual)			✓
Manual gain (dB)			✓[5]

[1] If *Pipe integration* is set to *Gaussian*.
[2] If *Transducer type* chosen is *other*.
[3] If *Path simulation* is set to *velocity*.
[4] If *Path simulation* is set to *times*.
[5] If *Receiver gain* is set to *manual*.

Saving and Loading Parameters

Unless newly entered parameters are saved to battery-backed memory or to the diskette, they will be lost if the unit is turned off or if power is interrupted. The flowmeter offers a mechanism to save the parameters so they won't be lost. Parameters can be reloaded from memory or disk.

Parameters are saved to and loaded from files. Files can exist in battery-backed memory or on floppy diskette; the system will prompt you to choose the location. Files have names, which consist of one to eight alphanumeric characters, without punctuation marks.

There may be more than one file of saved parameters in existence at any time. For example it may be useful to have different setups with distinct operating configurations.

In most cases you will save parameters to the default file in battery-backed memory. Doing so is particularly convenient for normal operations, because every time the system is turned on, it loads the parameters stored in the default file, which is named SYSTEM. If you save more than one configuration, be careful to use a different file name for each.

When you select a save or load operation, the system prompts you to specify the location of the file. *Flowmeter* refers to battery-backed memory in the flowmeter console; *Disk* refers to the floppy disk drive. If you choose to save to the flowmeter, you will be asked if the default file should be overwritten. Do not overwrite the default files unless you want the system to use the new parameters each time it is turned on.

If you choose to save parameters to floppy disk, the system prompts you to enter a filename by displaying the message *Enter file name.* When you enter the filename, it appears to the right of the message.

- To specify the default file (system), press **Enter**.

- To save parameters to a separate file, enter characters directly from the keypad using the left and right shift keys to select the letter desired. For example, press left-shift-1 to enter an A, press right-shift-1 to enter a B. The letters Q and Z cannot be entered using this technique. When the filename is complete, press **Enter**.

First Time Power Up

Be certain that all transducers, system inputs, and system outputs are connected before powering up the unit. On the rack-mount unit, the power switch is located on the front panel. On the NEMA unit, the power switch is located inside the cabinet.

Turn the flowmeter and all remote flow transmitters on. The green power-good indicators in all units should light.

Close and latch the door of the NEMA unit. After a minute or so, the instrument will show various startup messages and then display the main menu:

[CONFIGURE] operate reset diagnose
Parameter Variable Outputs Reports

Initial checks

The first time the instrument is turned on, you may wish to adjust the contrast of the display and run a quick diagnostic checkout before performing the initial setup. Running diagnostics also serves as an introduction to the menus.

Adjusting Display Contrast

If you wish to adjust the contrast on an LCD display, step through the following procedure. This procedure begins from the main menu. Return to the main menu at any time by repeatedly pressing **Esc** until the main menu appears. This procedure has no effect on a full-screen CRT or full-screen EL (electroluminescent) display.

Top line of the display shows:	Press key(s)	Explanation
[CONFIGURE] operate reset diagnose	**Enter**	Accept *Configure*
[PARAMETER] variable outputs reports	**Enter**	Accept *Parameter*
[SECTION] general files password	→	Select *General*
section [GENERAL] files password	**Enter**	Accept *General*
User Level: [SETUP] limited extended	↓	Bypass
Repetition Time (seconds):	↓	Bypass
Bypass each successive option until *Display Contrast* option is shown	↓↓	Bypass each
Display Contrast: <-Down Up->	→ or ←	Increase contrast or Decrease contrast
Display Contrast: <-Down Up->	**Esc Esc**	Go to main menu
[CONFIGURE] operate reset diagnose		At main menu

First Time Diagnostics

To perform a basic checkout of the system, step through the following sample sequence. This procedure begins from the main menu. The diagnostic tests are self explanatory, and can be terminated at any time by repeatedly pressing **Esc** until the main menu appears. The following sequence details only those diagnostics that are useful as a basic checkout at system start-up. Additional diagnostic procedures are available if problems are encountered during system operation. These diagnostics are discussed in greater detail in Chapter 6, *Diagnostics*, beginning on page 6-1.

Note

Many tests cannot be run until parameters are entered and the system is run. This is true, for example, for path diagnostics because until the path length and other parameters are defined, the system cannot operate the paths.

<table>
<tr><th>Top line of the display shows:</th><th>Press key(s)</th><th>Explanation</th></tr>
<tr><td>[CONFIGURE] operate reset diagnose</td><td>→→→</td><td>Select Diagnose</td></tr>
<tr><td>configure operate reset [DIAGNOSE]</td><td>Enter</td><td>Accept Diagnose</td></tr>
<tr><td>[SYSTEM] transceiver hardware utils</td><td>Enter</td><td>Accept System</td></tr>
<tr><td>[KEYPAD] display serial printer</td><td>Enter</td><td>Run diagnostic</td></tr>
<tr><td colspan="3">Press every key on the keypad, including the arrow keys. The display should show each key as it is pressed. Terminate the test by pressing Shift-E. The system will report statistics about the number of keys pressed. Press any key to continue.</td></tr>
<tr><td>[KEYPAD] display serial printer</td><td>→</td><td>Select Display</td></tr>
<tr><td>keypad [DISPLAY] serial printer</td><td>Enter</td><td>Run diagnostic</td></tr>
<tr><td colspan="3">The display will fill with the digit 0 in every location, and then proceed through every digit and the entire alphabet. Terminate the test at any time by pressing any key.</td></tr>
<tr><td>keypad [DISPLAY] serial printer</td><td>→</td><td>Select Serial</td></tr>
<tr><td>keypad display [SERIAL] printer</td><td>Enter</td><td>Accept Serial</td></tr>
<tr><td>[TRANSMIT] input output</td><td>Enter</td><td>Accept Transmit</td></tr>
<tr><td colspan="3">The instrument will transmit and attempt to read back characters on the serial port. A loopback connector or computer should be attached to the serial port. If there is an error, a message will be displayed. Also refer to Chapter 6 for information on diagnostics. Press any key to return to the menu.</td></tr>
<tr><td>[TRANSMIT] input output</td><td>→</td><td>Select Input</td></tr>
<tr><td>transmit [INPUT] output</td><td>Enter</td><td>Accept Input</td></tr>
<tr><td colspan="3">The instrument will attempt to read any incoming characters on the serial port. This diagnostic assumes that there is traffic on the port. If there is an error message, it will appear on the display. Refer to Chapter 6 for additional information on Diagnostics. Return to the menu by pressing any key.</td></tr>
<tr><td>transmit [INPUT] output</td><td>→</td><td>Select Output</td></tr>
<tr><td>transmit input [OUTPUT]</td><td>Enter</td><td>Accept Output</td></tr>
<tr><td colspan="3">This diagnostic tests the RS-232 device driver by continuously outputting a stream of data (ASCII characters) until Escape is pressed.If there is an error message, it will appear on the display. Refer to Chapter 6 for additional information on Diagnostics. Return to the menu by pressing Escape..</td></tr>
<tr><td>transmit input [OUTPUT]</td><td>↑</td><td>Go to previous menu</td></tr>
</table>

[KEYPAD] display serial printer	→→→	*Select Printer*
keypad display serial [PRINTER]	**Enter**	Accept *Printer*
The system displays printer status. Status display is continuous, so that if there is a problem, you can wiggle cables, turn printer on, etc. while watching the display for a status change. See Chapter 6 for status messages. Press Escape to return to the menu.		
keypad display serial [PRINTER]	**Esc**	Go to previous menu
[SYSTEM] transceiver hardware utils	→	Select *Transceiver*
system [TRANSCEIVER] hardware utils	**Enter**	Accept *Transceiver*
[TEST] run stage path align comm	**Enter**	Run *self test*
The instrument will run a brief self test of the flow transmitter, and report the results on the display. If there is an error message, continue testing by selecting Diagnose *and follow the instructions given on the screen. Also refer to Chapter 6 for information about flow transmitter diagnostics. Return to the above menu by pressing Esc.*		
[TEST] run stage path align comm	→	Select *Run Measurement*
test [RUN] stage path align comm	**Enter**	Accept *Run Measurement*
The instrument performs further diagnostics on the flow transmitter. If errors appear in the Operate mode, this test and the Stage diagnostic test may help isolate the problem. The type of error will be displayed on the console display. Also refer to Chapter 6 for information about flow transmitter diagnostics. Press Escape to return to the menu after either test.		
	Esc	Return to higher menu level
[SYSTEM] transceiver hardware utils	→→	Select Hardware
system transceiver [HARDWARE] utils	**Enter**	Accept *Hardware*
[OUTPUTS] inputs	**Enter**	Accept *Outputs*
If the system has been configured for outputs, the first output and type of output will appear on the display. Pressing the down or up arrows will toggle between installed outputs. Start with the first output shown. The following procedure shows an analog (e.g., 0-10V or 4-20 mA) output.		
OUT1 Analog 8-bit channel 0	**Enter**	To show current output level
OUT1 Analog 8-bit channel 0 = zero	**Enter**	To toggle to half or full scale
Watch the external output device to see if it reads at the corresponding level (i.e., representing zero, half-scale or full-scale) as the output is toggled. Relay outputs will toggle between On *and* Off. *Volume totalizers will increment each time* Enter *is pressed.* *Pressing* Escape *once returns to the output listing. Use the down arrow to toggle through the list and test each output. After testing all outputs, press* Escape *twice to return to the previous menu. Remember to reset any volume totalizers that have been incremented during this procedure.*		
[OUTPUTS] inputs	→	Select *Inputs*
outputs [INPUTS]	**Enter**	Accept *Inputs*
If the system is configured for inputs, the type and location of the first input will be displayed. Pressing the down or up arrows will toggle through the list of inputs.		

IN1 Analog 8-bit channel 0	**Enter**	To show current input level
IN1 Analog 8-bit channel 0 = 1032	**Esc**	Return to list of inputs
Watch the external input device to see if it is reading at the corresponding value. Relay outputs will toggle between On *and* Off. *Pressing* Escape *once returns to the input listing. Use the down arrow to toggle through the list and test each input. After testing all inputs, press* Escape *twice to return to the previous menu.*		
outputs [INPUTS]	**Esc Esc**	Go to main menu
configure operate reset [DIAGNOSE]		At main menu

Initial Flowmeter Setup

There are four required and two optional procedures to setting up the instrument:

1. Set up general parameters
2. Set up each section
3. Set up each path in each section
4. Set up the password (optional)
5. Save the configuration
6. Print parameters (optional)

The flowmeter has been factory-configured with the number of pipes or channels and the number of paths in each, as specified at time of purchase. After installation, there are a number of site-specific parameters which must be input. During the process of entering setup parameters, the *menu access* level *Setup* is recommended. See Chapter 7 for a detailed description of the setup parameters.

Site parameters are available from the site engineer who worked with Accusonic to define the application. As-built parameters are determined by survey when transducers are installed in each section. If the transducers were installed by Accusonic, the as-built parameters are on file at the Accusonic factory.

Table 5-5 is a checklist of parameters needed for initial setup.

Table 5-5 Checklist of Initial Setup Parameters	
Parameter	Value
Units (English or metric)	
The following parameters are required for each section:	
Radius (if conduit is pipe and integration is *Chebyshev*)	
Pipe Height (if conduit is pipe and integration is *Gaussian*)	
Shape Factor (if conduit is pipe and integration is *Gaussian*)	
Average cable length per path	
Minimum good paths	
Maximum expected velocity (will be calculated based on maximum expected flowrate)	
Flowrate scale factor	
Volume scale factor	
Maximum expected flowrate	
Maximum change in flowrate	
Bidirectional flow	
The following as-built parameters are required for each path in each section.	
Path angle	
Path elevation (if integration is *Gaussian* or if open channel)	
Width at path elevation (if integration is *Gaussian* or if open channel)	
K (defaults to optimum value)	
Path position (if integration is *Gaussian* or if open channel)	
Transducer type	
Path length	
Path percent active (defaults to 100%)	

Procedure #1 - Set up General Parameters

This procedure includes:

- ♦Selecting the access level
- ♦Defining frequency of flow measurements
- ♦Specifying English or metric units

To set up general parameters, step through the following procedure. This procedure begins at the main menu. Return to the main menu at any time by repeatedly pressing **Esc** until the main menu appears.

Top region of the display	Press key(s)	Explanation
[CONFIGURE] operate reset diagnose	**Enter**	Accept *Configure*
[PARAMETER] variable outputs list	**Enter**	Accept *Parameter*
[SECTION] general files password	→	Select *General*
section [GENERAL] files password	**Enter**	Accept *General*
User level: [SETUP] limited extended	**Enter**	Accept *Setup*
Repetition Time (seconds)	*Enter number of seconds between successive measurements.*	
Autostart [OFF] on	→	Select *On*
Autostart off [ON]	**Enter**	Accept *On*
Units [ENGLISH] metric	**Enter** **or** **→ Enter**	Accept *English* or select and accept *metric*
System will beep, then display: **Press Esc to return to previous menu**	**Esc**	Return to previous menu
section [GENERAL] files password	←	Select *Section*
[SECTION] general files password		Ready for next step

Procedure #2 - Setting up Section Parameters

This procedure includes:

- ♦ Selecting a section
- ♦ Turning the section on
- ♦ Specifying radius or conduit dimensions
- ♦ Entering the average cable length
- ♦ Specifying limits on flow rate and fluid velocity to be used for reasonability checks
- ♦ Setup of the path parameters for each path in the section

To set up section parameters, repeat this procedure for each section, and perform the path setup as described in Procedure #3. Be sure to set up every path in each section. This procedure does not begin at the main menu; it begins where Procedure #1 left off. To run this procedure starting from the main menu, select and accept Configure and then select *Parameter*.

As you enter path parameters, the software checks that the values entered for path length, elevation, and angle are consistent with the radius entered for the meter section. If the values are not consistent, the instrument will beep and display the message, *Possible path length error*. Double check the values entered for an error, and if the reasonability test still fails, check with Accusonic for help. In the meantime, it is possible to ignore the error and proceed with entering the remaining parameters. The flow results for the section with the possible path error, of course, will be suspect.

For each path and section you will be asked by the software whether to use the newly entered data in the current operation. This causes the set of parameters just entered to take effect as a group, but does not back up the new parameters to battery-backed memory or to the diskette. Before leaving the Configure submenus you will be asked whether to save the changes. If the changes are not saved at this time and if the flowmeter is shut down or power is lost before the data is backed up to battery-backed memory or to the diskette, the new parameters will be lost. If you wish to save the changes at this time, the system will ask you to enter a file name. There are two ways to enter the filename:

- ♦ Press the **Enter** key to select the default filename, SYSTEM.
- ♦ Enter the characters directly from the keypad using the left and right shift keys to select the letter desired. For example, press left-shift-1 to enter an A, press right-shift-1 to enter a B. The letters Q and Z cannot be entered using this technique.

An alternative rapid way to return to the Operate mode from anywhere in the parameter menus is by pressing <CTRL ESC>. This causes the parameter to be stored in the flowmeter under the default file SYSTEM, and then download them to restart measurements.

Procedure number 5 (page 5-27) also shows how to back up the data at a later time so that it will not be lost in the event of shutdown or power loss.

Section parameters are listed in Table 5-3 (beginning on page 5-11), and described in detail in Chapter 7.

The procedure for setting the section parameters is given below:

<table>
<tr><th>Top region of the display</th><th>Press key(s)</th><th>Explanation</th></tr>
<tr><td>[SECTION] general files password</td><td>Enter</td><td>Accept Section</td></tr>
<tr><td>[SECTION 1] section 2[1] etc.
OFF off</td><td>Enter
or
→ Enter</td><td>Accept selected section or select and accept next section</td></tr>
<tr><td>Section switch [OFF] on</td><td>→</td><td>Select On</td></tr>
<tr><td>Section switch off [ON]</td><td>Enter</td><td>Accept On</td></tr>
<tr><td colspan="3">Enter each section parameter as it is displayed.
See list in Table 5-3; refer to Chapter 7 for details.</td></tr>
<tr><td>[PATH 1] path 2[2] etc.
OFF off</td><td>...</td><td>Go to Procedure #3 to set up all paths. Then return here to continue with the next section.</td></tr>
<tr><td>[PATH 1] path 2 etc.</td><td>Esc</td><td>To next section</td></tr>
<tr><td colspan="3">Now accept the newly entered parameters:
Use new section 1 changes: no [YES]
Choose yes to accept the new section values, no to discard. Then press Enter.

Note: This operation accept the newly entered values and causes them to take effect. It does not backup the new values to battery-backed memory or to diskette. Until the values are backed up, they will be lost in the event the flowmeter is powered down. You will be prompted to save these values to a file before leaving the Configure submenus.</td></tr>
<tr><td colspan="3">The instrument prompts for the next section. If there are additional sections to fill in, repeat the steps above. Repeat until the parameters for all sections are entered.
After data is entered for the last section, the instrument prompts for section 1 again.
When all sections have been completed, continue with the following:</td></tr>
<tr><td>[SECTION 1] section 2 etc.</td><td>Esc
Esc
Esc</td><td>Go to main menu</td></tr>
<tr><td>[CONFIGURE] operate reset diagnose</td><td></td><td>(At main menu)</td></tr>
<tr><td colspan="3">[1] Section 2 (etc.) appears only if configured by the factory for more than one section.
[2] Path 2 path 3 (etc.) appears according to the number of paths configured by the factory for the current section of this meter.</td></tr>
</table>

Procedure #3 - Setting up Path Parameters

This procedure includes:

- Selecting a path
- Turning the path on
- Specifying geometry of the path (angle, position, length, percent active)
- Entering the type of transducer

To set up path parameters, repeat the following procedure for each path. This procedure begins after section parameters have been entered as in Procedure 2. Return to the main menu at any time by repeatedly pressing **Esc** until the main menu appears.

Path parameters are listed in Table 5-4 (see page 5-14), and described in detail in Chapter 7.

<table>
<tr><td>Top region of the display</td><td>Press key(s)</td><td>Explanation</td></tr>
<tr><td>[PATH 1]   path 2[1]   etc.
OFF   off</td><td>Enter
or
→ Enter</td><td>Accept selected path
or
select and accept
next path</td></tr>
<tr><td>Path switch   [OFF]   on</td><td>→</td><td>Select On</td></tr>
<tr><td>Path switch   off   [ON]</td><td>Enter</td><td>Accept On</td></tr>
<tr><td colspan="3">Enter each parameter as it is displayed. (See list in Table 5-4; refer to Chapter 7 for details.)
After the last parameter is entered, the instrument beeps and displays:</td></tr>
<tr><td>Press Esc to return to previous menu</td><td>Esc</td><td>To previous menu</td></tr>
<tr><td colspan="3">The instrument performs a check on the overall geometry of the path to be sure that path length is consistent with the data entered for path angle and position. If the data is not consistent, the instrument beeps and displays:
Possible path length error: [RETRY]   ignore
Choose retry and press Enter to review all path parameters again, then adjust accordingly.
Otherwise, choose ignore and press Enter to skip to the next step.</td></tr>
<tr><td colspan="3">Now confirm the newly entered parameters:
Use new path 1 changes: no   [YES]
Choose yes to accept the new path values, choose no to discard them. Then press Enter.

Note: This operation accepts the newly entered values and causes them to take effect. It does not backup the new values to battery-backed memory or to diskette. Until the values are backed up, they will be lost in the event the flowmeter is powered down. You will be prompted to save these values to a file before leaving the Configure submenus.</td></tr>
<tr><td colspan="3">Proceed to enter parameters for the next path, if any. To do so, go to the beginning of this procedure and repeat all the steps above. Repeat until the parameters for all paths are entered. After data is entered for the last path in the current section, the instrument prompts for path 1 again. When all paths are complete for this section, continue with the following.</td></tr>
<tr><td>[PATH 1]   path 2   etc.</td><td></td><td>Return to
procedure #2</td></tr>
<tr><td colspan="3">[1] Path 2   path 3 (etc.) appears according to the number of paths configured by the factory for the current section of this meter.</td></tr>
</table>

Procedure #4 - Setting the Password (optional)

The instrument is shipped with a blank password. To enter a password or to change an existing password, step through the following procedure:

Top of the display	Press key(s)	Explanation
[CONFIGURE] operate reset diagnose	**Enter**	Accept *Configure*
[PARAMETER] variable outputs reports	**Enter**	Accept *Parameter*
[SECTION] general files password	→→→	Select *Password*
section general files [PASSWORD] **Change password**	**Enter**	Accept *Password*
section general files [PASSWORD] **Enter old password:**	Type in old password, then **Enter**	If no password was ever entered, just press **Enter**
section general files [PASSWORD] **Enter new password:**	Type in new password, then **Enter**	Enter new code
section general files [PASSWORD] **Retype new password:**	Type in new password, then **Enter**	Repeat entry
Password changed successfully **Strike any key to continue.**	**Esc Esc Esc**	Go to main menu
[CONFIGURE] operate reset diagnose		At main menu

For the password to be used, you must also enable password protection. This is done in the General parameters list, under Extended menu access.

Procedure #5 - Save Configuration

This procedure includes:

- Specifying a file name
- Saving the current configuration to that file

Note
If the flowmeter is equipped with a diskette unit and you wish to save parameters to a diskette, be sure there is a blank DOS-formatted high density diskette in the drive unit.

In this procedure, parameters are saved to a file in battery-backed memory and optionally to a diskette file. Any filename will do; just bear in mind that to reload the parameters from diskette or from battery-backed memory, you must remember the name of the file in which you originally saved the data. If you skip the filename, the system will store the parameters in a default file named *SYSTEM*.

When saving to a diskette file, the system prompts you to enter a filename by displaying the message *Enter file name* on the display. As you enter the filename, it will appear to the right of the message on the second line. There are two ways to enter the filename:

- Press the **Enter** key to select the default filename, SYSTEM.
- Enter the characters directly from the keypad using the left and right shift keys to select the letter desired. For example, press left-shift-1 to enter an A, press right-shift-1 to enter a B. The letters Q and Z cannot be entered using this technique.

To save the current parameter configuration, step through the following procedure. This procedure begins at the main menu. Return to the main menu at any time by repeatedly pressing **Esc** until the main menu appears.

The procedure for saving a configuration follows:

<table>
<tr><td>Top region of the display</td><td>Press key(s)</td><td>Explanation</td></tr>
<tr><td>[CONFIGURE] operate reset diagnose</td><td>Enter</td><td>Accept Configure</td></tr>
<tr><td>[PARAMETER] variable outputs reports</td><td>Enter</td><td>Accept Parameter</td></tr>
<tr><td>[SECTION] general files password</td><td>→→</td><td>Select Files</td></tr>
<tr><td>section general [FILES] password</td><td>Enter</td><td>Accept Files</td></tr>
<tr><td>[SAVE] load</td><td>Enter</td><td>Accept Save</td></tr>
<tr><td>Save to: [FLOWMETER] disk</td><td>Enter</td><td>Accept Flowmeter</td></tr>
<tr><td>Overwrite default parameters? [YES] no</td><td>Enter</td><td>Accept Yes</td></tr>
<tr><td colspan="3">The system saves all parameters to battery-backed memory in files named SYSTEM. Upon completion the Save/Load menu is displayed again. If the flowmeter is equipped with a diskette unit, continue with the following steps, otherwise return to the main menu by repeatedly pressing ESC until the display matches the last line in this procedure.</td></tr>
<tr><td>[SAVE] load</td><td>Enter</td><td>Accept Save</td></tr>
<tr><td>Save to: [FLOWMETER] disk</td><td>→</td><td>Select Disk</td></tr>
<tr><td>Save to: flowmeter [DISK]</td><td>Enter</td><td>Accept Disk</td></tr>
<tr><td>Enter file name:</td><td>Enter</td><td>Specify default file for Save operation</td></tr>
<tr><td colspan="3">The system saves all parameters to diskette in files named B:SYSTEM. Upon completion the Save/Load menu is displayed again.</td></tr>
<tr><td>[SAVE] load</td><td>Esc Esc Esc</td><td>Go to main menu</td></tr>
<tr><td>[CONFIGURE] operate reset diagnose</td><td></td><td>At main menu</td></tr>
</table>

Procedure #6 - Print Parameters

After parameters are entered and saved, print a listing of the parameters for review purposes. The procedure that follows assumes that a compatible printer and cable have been installed according to the procedures given in Chapter 4, *Connecting a Printer* (page 4-6). The printer must be turned on and be on line.

To print parameters, step through the following procedure:

Top region of the display	Press key(s)	Explanation
[CONFIGURE] operate reset diagnose	**Enter**	Accept *Configure*
[PARAMETER] variable outputs reports	→→→	Select *Reports*
parameter variable outputs [REPORTS]	**Enter**	Accept *Reports*
[LIST] report	**Enter**	Accept *List*
[ALL] parameters variables	**Enter**	Accept *All*
List to: [PRINTER] file cancel	**Enter**	Accept *Printer*
The system prints all parameters and variables. Upon completion, the previous menu is displayed again.		
parameter variable outputs [REPORTS]	**Esc Esc**	Go to main menu
[CONFIGURE] operate reset diagnose		At main menu

If a printer is not available, a listing should be made to floppy disk. The floppy disk listing will be in standard text-file format, and will automatically be named LISTING.PRN. This can be printed later on any DOS-based PC with a printer connected.

Measuring Flow

After parameters are entered, place the flowmeter on line by selecting and accepting the Operate option from the main menu.

If *Autostart switch* is *on*, the instrument will automatically begin to measure flow immediately after the system powers up (See Chapter 7, *Parameter List* on page 7-1).

Flow measurements are made at a rate set by the parameter *Repetition time* until the process is interrupted via the control panel or the unit is shut down. Although not strictly necessary, it is good practice to take the unit off line before powering it down. This can be done by pressing **Esc**, which returns control to the main menu.

Interrupting Measurements

Flowmeter measurements may be interrupted at any time, thus returning control to the control panel menus. This may be done to gain access to parameters or variables, to run a diagnostic, to modify data logging or data reporting, or simply to shut down the unit.

After an interruption, no further measurements are taken. If the unit is left off line for a period exceeding the totalizer cutoff time, flow totalization is also interrupted (described in Chapter 3, see *Volume Totalizer after Outage* on page 3-25). While measurements are suspended, the watchdog timer is deactivated, all system inputs are ignored, and all system outputs are held at the current values.

Note that measurements are also not performed while the meter is in a Configuration menu. The General parameter *Inactivity timeout* (see page 7-10) is used to avoid loss of measurement data if the flowmeter is accidentally left in a Configuration menu. The parameter should be set to the number of minutes of measurement information that you can afford to lose. The flowmeter will automatically restart and return to Operate mode after this period of time has elapsed.

When there is no password protection in effect, simply press **Esc** to take the unit off line and return to the menu prompts. When password protection is in effect, pressing **Esc** while the instrument is making flow measurements causes the prompt *Enter Password to Abort* to appear on the display. Enter the password and then press the **Enter** key to activate the control panel menus. If the password is not entered within fifteen seconds, the system resumes measurements.

Display Screens

Several display screens are available, enabling the flowmeter operator to choose which variables will be displayed. The same variable headings will appear on a 4-line x 40-character display, full-screen display, or a separate CRT. The 4-line x 40-character display shows headings, and up to three lines of data (which may be for 3 separate sections, ends, or totals). If there are more than 3 lines of data to be displayed, the screens can be scrolled vertically using the ↑ and ↓ keys. Values from numerous measurement sections and subtotals as well as a totals line can be displayed simultaneously on a full-screen display.

When shipped from the factory, the 7500 console is typically set to display the headings shown in Mode 1 below, with flowrate and total volumes for bi-directional flow. Section status (GOOD, ALERT, or BAD) is displayed under the DATE heading.

Other display modes are available and can be activated while in measurement mode by pressing the numbers 1 through 0 or the letter A, S, W, X, or Y on the keypad or external keyboard (capital A).

When viewing any of the screen modes, status codes can be viewed by pressing the “ECODE” key or the ± key on the keypad, (press the "-" (minus) key on an external keyboard). To return from status codes to the last selected data display screen described above press BKSP, or the appropriate number or letter key.

Screen Display, Mode 1

#	FLOW	POS-VOL	NEG-VOL	DATE
S1	0.000	0	0	GOOD
S2	0.000	0	0	GOOD
T	0.000	0	0	TIME

Screen Display, Mode 2-Open Channel/Compound Installations

This mode is used for open channel/compound installations. For each section, flowrate, fluid level (stage), the integration method being used, and measurement status are displayed, as shown below.

#	FLOW	STAGE	INTEG	DATE
S1	0.000	0.0	TRAP	GOOD
S2	0.000	0.0	CHEB	GOOD
T	0.000	0.0		TIME

Screen Display, Modes 3 and 4 - Individual Path Velocities

These screens show instantaneous velocities along acoustic paths 1-4 and 5-8, respectively, and are used during system commissioning or troubleshooting, as well as during testing. The following example shows the Mode 3 display (i.e., velocities, paths 1-4, for three measurement sections).

#	VEL1	VEL2	VEL3	VEL4
S1	0.000	0.000	0.000	0.000
S2	0.000	0.000	0.000	0.000
S3	0.000	0.000	0.000	0.000

Screen Display, Modes 5 and 6 -Leak Detection

These screens are used for displaying variables associated with Leak Detection functions and are available only with the full-screen display or CRT options.

Mode 5

#	FLOW	POS VOL	NEG VOL	DATE TIME
E1	0.000	0	0	
E2	0.000	0	0	
T	0.000	0	0	
E3	0.000	0	0	
E4	0.000	0	0	

Mode 6

#	TOP FLOW	BOT FLOW	DIFF FLOW	ALARM/ STATUS
E1	0.000	0.000	0	GOOD
E2	0.000	0.000	0	GOOD

Screen Display, Mode 7 - Positive Volume Only

This screen displays only positive volumes, rather than positive and negative totals, and is used at sites where flow is unidirectional.

#	FLOW	VOLUME	STATUS	DATE
S1	0.0000	0	GOOD	
S2	0.0000	0	GOOD	
T	0.0000	0		TIME

Screen Display, Mode 8 - Leak Detection, Positive Volume Only

This screen displays only positive volume, as well as system status, date and time.

#	FLOW	VOLUME	STATUS	DATE TIME
E1	0.000	0	GOOD	
E2	0.000	0	GOOD	
E3	0.000	0	GOOD	
T	0.000	0	GOOD	
E4	0.000	0	GOOD	
E5	0.000	0	GOOD	

Screen Display, Modes 9 and 0 - Transducer Gains

These screens display forward and reverse transducer gains for paths 1-4 and 5-8, respectively, and are most useful when aligning or troubleshooting transducers.

#	1F	1R	2F	2R	3F	3R	4F	4R
S1	0	0	0	0	0	0	0	0
S2	0	0	0	0	0	0	0	0
							TIME	

Screen Display, Mode A - Temperature

Temperature is displayed on this screen. Press A on the keypad or capital A on a separate keyboard to display this screen.

#	FLOW	VOLUME	TEMP	DATE
S1	0.000	0	33.7	GOOD
S2	0.000	0	33.5	GOOD
S3	0.000	0	33.5	GOOD

Screen Display, Mode S - Stage

This screen displays stage(s) for each section. Stage will not be displayed if stage status is ‘9’ (off) and will be “dashed” if stage status is other than ‘1’ (Good), ‘8’ (alias warning) or ‘6’ (maximum difference in stages exceeded).

#	STAGE1	STAGE2	STAGE3	STAGE4
S1	0.0000	0.0000		
S2	0.0000			

Screen Display, Modes W, X, and Y

These are custom screens set up at Accusonic. They can be programmed to display any combination of variables and text, in any language. Bar graphs can also be displayed of any variable. When custom programming has not been installed, these screens are defaulted to simple single-section displays. Contact Accusonic for custom display programming.

Special Configurations

Occasionally, it may be necessary to configure the meter in a "non-standard" mode to meet a particular requirement. This section contains special configurations.

Using Layer Boundary Parameters to Simulate a Round Pipe.
When a "compound flowmeter" is set up in a pipe, the shape of the pipe has to be described using the Layer Boundary Parameters. If the pipe is round, a large number of possible ways of describing its shape in terms of trapezoidal layers can be devised.

The table below gives one possibility, which has the merits of giving very close approximations to the wetted area, with only 15 numbers to be calculated. The maximum errors occur when the stage is below 0.1 x Pipe Diameter. This is below the lowest layer and likely to be below the lowest path, and so of no relevance. At a stage of 0.05 x Pipe Diameter, the error is 4.5% of actual area. For stages between 0.1 and 0.2 x Pipe Diameter, the errors are less than 0.2%. Above 0.2 x Pipe Diameter, the errors are small.

Layer Boundary Elevation	Layer Boundary Width
0.1 x Diameter	0.612 x Diameter
0.2 x Diameter	0.807 x Diameter
0.3 x Diameter	0.920 x Diameter
0.4 x Diameter	0.984 x Diameter
0.5 x Diameter	1.003 x Diameter
0.6 x Diameter	0.987 x Diameter
0.7 x Diameter	0.920 x Diameter
0.8 x Diameter	0.807 x Diameter
0.9 x Diameter	0.612 x Diameter
1.0 x Diameter	0.205 x Diameter

Other Parameters which have to be set as part of this scheme:

Bottom Channel Width:	0.205 x Diameter
Bottom Velocity Ratio:	0.5
Channel Bottom Height:	0.000
Top Weight:	0.0

All Path Elevations in terms of measured distance above the channel bottom.

Chapter 6 Maintenance and Repairs

Maintenance

Accusonic recommends biweekly inspection during the first two months of operation, and monthly thereafter:

- Inspect transducers and remove built-up debris to ensure that performance is not degraded. Inspect cables and other parts for wear and replace as necessary.
- Visually inspect inside the electronics cabinet for signs of damage and check that both fans in the cabinet are operating.
- If the system has a chassis-style enclosure, clean the dust filter on the rear panel monthly. More frequent cleaning may be required in dusty environments.
- If the system has a NEMA enclosure, brush away any accumulated dust or dirt. The system maintains its temperature by transferring heat through the walls of the enclosure. Dirt buildup will result in heat buildup and potential early failure.
- Recheck transducer cables for isolation and leakage, as described in Chapter 4, *Transducer Cabling and Checkout* on page 4-5).

Diagnostics

Problems in the system processor group can be located using system diagnostics. Chapter 5 describes First Time Diagnostics (beginning on page 28) procedures recommended at the time of initial system setup and for use any time a problem occurs with one of these components. These include diagnostics of the:

- Keypad
- Display
- Serial inputs and outputs
- Analog inputs and outputs
- Printer
- Transceiver Self-test

Additional diagnostic procedures are described below. These procedures are recommended if the section status displays BAD during normal operation, indicating that good measurements are not being made by the flowmeter. Section status is displayed by pressing the "ECODE" key or the +/- key on the keypad, or by pressing the minus sign (-) on a separate keyboard. Press ESCape to toggle back to normal display screen.

Information on the Error Codes is available by pressing the HELP key on the keypad, or by pressing **Shift?** (Shift and question-mark keys) on a separate keyboard. Also see Chapter 9 for additional information on the error codes, as well as possible causes, and suggested troubleshooting.

System Reset (Procedure 1)

If the Section Status Error Code displays C or H during operation, perform the following procedure to reset the transceiver. This procedure begins at the main menu.

Top line of the display	Press key(s)	Explanation
[CONFIGURE] operate reset diagnose	→→→	Select Diagnose
configure operate [DIAGNOSE]	**Enter**	Accept Diagnose
[SYSTEM] transceiver hardware utils	→	Select Transceiver
system [TRANSCEIVER] hardware utils	**Enter**	Accept Transceiver
[TEST] run stage path align comm	→→→→→	Select Comm
test run stage path align [COMM]	**Enter**	Accept Comm
[RESET] statistics	**Enter**	Perform software reset of transceiver
RESET sent	**EscEscEsc**	Return to main menu

From main menu, select Operate mode and watch the meter for several minutes to see if Section Status error codes reappear.

Transceiver Diagnostics (Procedure 2)

If the transceiver has been reset and section error codes of C or H continue to appear in the Operate mode, continue with transceiver diagnostics by performing the following procedure, which begins at the main menu.

Top line of the display shows:	Press key(s)	Explanation
[CONFIGURE] operate reset diagnose	→→→	Select Diagnose
configure operate [DIAGNOSE]	**Enter**	Accept Diagnose
[SYSTEM] transceiver hardware utils	→	Select Transceiver
system [TRANSCEIVER] hardware utils	**Enter**	Accept Transceiver
[SELF-TEST] measure stage comm align	→	Select Measure
self-test [MEASURE] stage comm align	**Enter**	Accept Measure

The system performs diagnostics on the flow transmitter and displays messages to help isolate the problem. These error messages are listed in Table 6-1 (see page 6-4). Note that some of these messages are for informational purposes only and do not indicate an error. If any other messages are displayed, try correcting the problem by replacing the transceiver card set, as described later in this chapter.

Table 6-1 (see page 6-4) also indicates other cards or cables which might be replaced in response to specific diagnostic error messages, if replacing the transceiver card has not corrected the problem. Procedures for replacing other cards are described later in this chapter.

Table 6-1 System Diagnostic Error Messages
+10 Volt internal supply failure
+12 Volt external supply failure
+2.5 Volt internal reference failure
-12 Volt external supply failure
Active transmit (Information only)
AGC D/A A/D Linearity test failure
Background test failure
Bad input data string in past (Also try replacing the Communications board)
Believability test failure
Communication protocol error (Also try replacing the Communications board)
Continuous noise in past
Continuous noise now
Data rejected - bad SQM
Data rejected - noise
Differential gain 6 dB
Global fakes in use now (Informational only)
Hardware failed to reset
Hardware test function error
Impulse noise in past
Impulse noise now
Input buffer overflow
Invalid measurement (T 1/16 Tbar)
No receive - counter overflow
Oscillator test failure
Output buffer overflow
Passive transmit (Informational only)
Path enable bit not set (Also try replacing Communications board)
Path parameters not set (Also try replacing Communications board)
Path selector not connected (Also try replacing the Path Selector cards and cables)
Pcodes in use now (Informational only)
RAM in use test failure
Read Timeout! Any key to continue (No communication with COMM board/device driver) (Also try replacing the Communications board)
Receiver detector level failure
Self test enable bit not set (Also try replacing Communications board)
Self test errors
Self test parameters not set
Stage errors. Time counter did not start
Time counter did not start
Transmitter did not charge (Also try replacing Transmitter board and cables)
Transmitter not connected (Also try replacing Transmitter board and cables)
Unidentified interrupt
Unknown background testing error
Write Timeout! Any key to continue (Could not write to the device driver - driver hung up)

Stage (Level) Diagnostics (Procedure 3)

In Open Channel or Compound installations only, if the Stage Status Error Code displays 2, H or C during operation, perform the following procedure, which begins at the main menu:

Note

This stage diagnostic is only valid when the stage device is an Acoustic uplooker. If the stage device is connected via an analog input, use the hardware input to diagnose the stage device.

[CONFIGURE] operate reset diagnose	→→→	Select Diagnose
configure operate [DIAGNOSE]	**Enter**	Accept Diagnose
[SYSTEM] transceiver hardware utils	→	Select Transceiver
system [TRANSCEIVER] hardware utils	**Enter**	Accept Transceiver
[SELF-TEST] measure stage comm align	→→	Select Stage
self-test measure [STAGE] comm align	**Enter**	Accept Stage

Stage Diagnostic errors: following is a list of all possible errors you will encounter when using the stage diagnostic module, and suggested courses of action:
No errors found - Normal operation

PARAMETER ERRORS: These generally occur because stage parameters have not been activated. Note that stage parameters must be entered *and downloaded* for stage diagnostics to run. Download by entering measurement mode.
Stage on/off mask not set
Stage parameters not set
Stage enable bit not set
Global fakes in use now
Pcodes in use now
HARDWARE ERRORS: The following indicate Transceiver board failures. If any of these errors occur, the Transceiver board should be replaced, as it is not field repairable and requires recalibration if parts are replaced.
Unknown Transceiver failure
Hardware failed to reset
Believability test failure
Time counter did not start
AGC D/A A/D Linearity test failure
-12 Volt external supply failure
Receiver detector level failure
Oscillator test failure
RAM in use test failure
Unknown background testing error

Other hardware errors, probably not on the Transceiver.

Transmitter did not charge - Check 180V light, if out, replace 180V supply. If lit, replace Transmitter board.
Transmitter not connected - Reseat or replace transmitter, cabling to transceiver.
Stage selector not connected - Reseat or replace Stage board, cabling between transceiver and Transmitter.

COMMUNICATIONS ERRORS - These errors indicate a problem between the PC side and communications board or between the communications board and the transceiver. Both the Transceiver board and the Communications board should be replaced.

Table 6-2 Status Light Error Definitions

0	System has been reset since power up (normally on)
1	Unused
2	Unexpected interrupt (system problem, may be outside the flow transmitter section)
3	Initialization error
4	Serial communications problem
5	Communication hardware error
6	Transceiver error, run Transceiver Self Test and Diagnose procedures in Chapter 5
7	Transceiver group error; on when any of LEDs 2-6 (above) is on

Repairs

All repairs must be done with the instrument turned off. As a further precaution, turn off the electrical supply to the flowmeter at the external circuit breaker.

Warning
If transducers are attached to the flowmeter, do not attempt any repairs to the unit during an electrical storm.

Separate procedures are supplied for flowmeters mounted in NEMA and rack-mounted cabinets.

Review of Anti-static Procedures

The flowmeter contains CMOS integrated circuits which are susceptible to damage from static discharge. Always use anti-static procedures when handling components inside the cabinet. The best procedure is to wear a grounding wrist strap attached to a bare metal surface inside the cabinet. At the very least, discharge any possible static buildup by touching a bare metal surface in the cabinet immediately before handling any electronic assembly.

Replacement Procedures for NEMA Cabinets

Replacing System Processor Circuit Boards

To replace system processor circuit cards (those located in the upper half of the cabinet), first remove the card retainers, as shown in Figure 6-1 (see page 6-8). Both retainers must be removed to gain access. After the retainers are out of the way, the cards pull out.

Depending on the instrument configuration, there may be slots for eight or ten cards in the processor group. Except for the system processor card, there are no fixed slot locations. The flowmeter is shipped with a configuration sheet detailing the actual location of circuit cards in your instrument. A copy of the configuration sheet is kept on file at the factory.

Before removing a circuit card, always double check its identity by finding a connector or external connection to that card, and then tracing it back to the unit. Alternatively, the cards are labeled in etch along one edge, and most bear at least one identifying label from the manufacturer.

Before disconnecting any cables from a circuit card, be sure to note the location and orientation of the connectors to ensure that they can be reinstalled correctly. Some cable connectors in the system are NOT polarized; if installed backwards, they can cause damage.

Specific considerations:

- **System processor card -** Has two cables which must be detached before removing the card. Refer to system As-built drawings in the rear of this manual for card locations.
- **Basic I/O card -** Has three cables which must be removed.
- **System communications card -** Has at least one and possibly four cables plugged into it. Furthermore, if the flowmeter is attached to remote flow transmitters, there will be additional components on the card. Be sure to replace the card with the proper type. See configuration sheet for details.
- **Diskette controller card** and **System I/O cards -** All have at least one cable. Be sure to note the configuration and reattach the cables correctly to the replacement card. These connectors are not keyed and will cause damage if installed backwards.

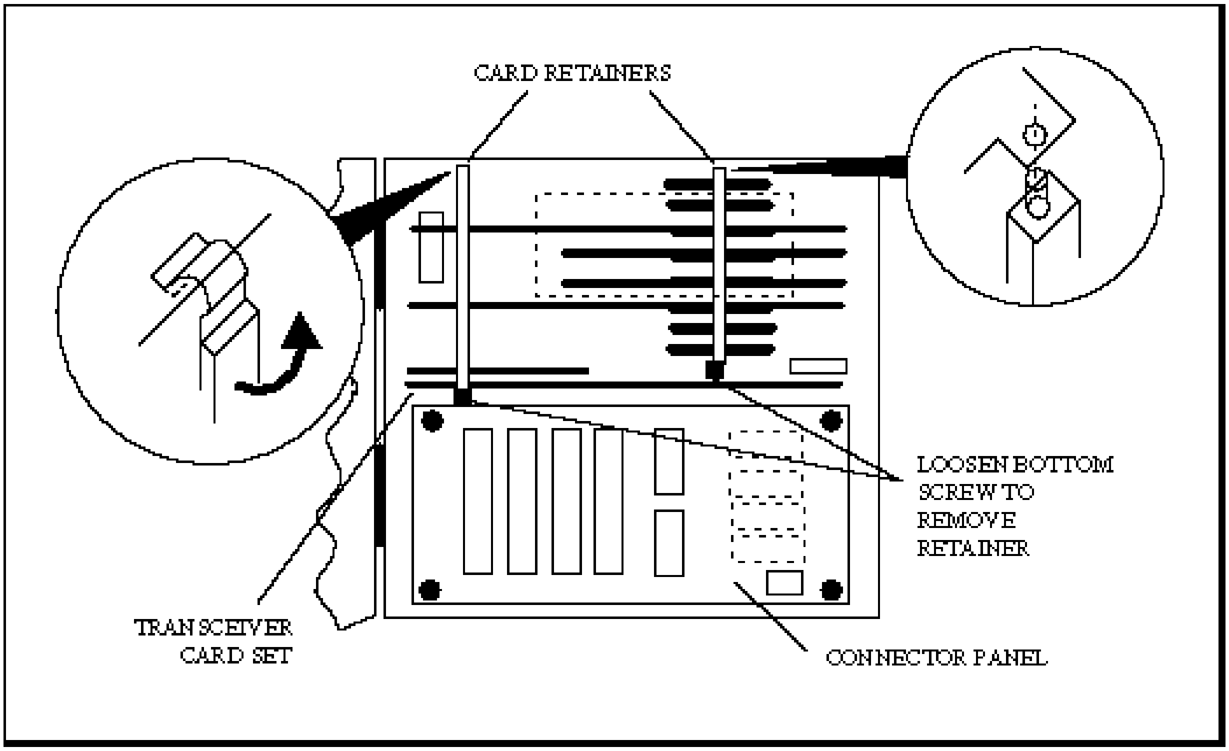


Figure 6-1 Card Retainters

Replacing Transceiver Card Set

The transceiver card set is held in place by the left card retainer. Remove the retainer and remove the two cards together after removing the cable attached to the upper right hand side of the two-card set. In most cases the cards are replaced as a pair. If necessary, remove the two ribbon cables to separate the cards.

Removing the Connector Panel

Remove the connector panel (Figure 6-2 on page 6-9) to gain access to the path and stage cards, the pulse transmitter and the high voltage power module.

Remove the panel by loosening four captive thumbscrews marked with arrows and located approximately in the corners of the panel.

Gently pull the panel forward and let it rest on the lower surface of the cabinet. The cables mounted on the rear panel will prevent it from dropping completely out of the way.

Depending on the configuration of the instrument, there will be one or two narrow ribbon cables which obstruct access into the area behind the connector panel.

Unplug the cables at the far end of any cables. Note the location of the mating connectors to ensure correct reassembly.

Replacing Path or Stage Cards

Path and stage cards are mounted on the back of the connector panel, as shown below in Figure 6-2. They are exposed and accessible after the connector panel is removed. The cards simply unplug from the panel for replacement. Be sure to install a replacement card in the same slot.

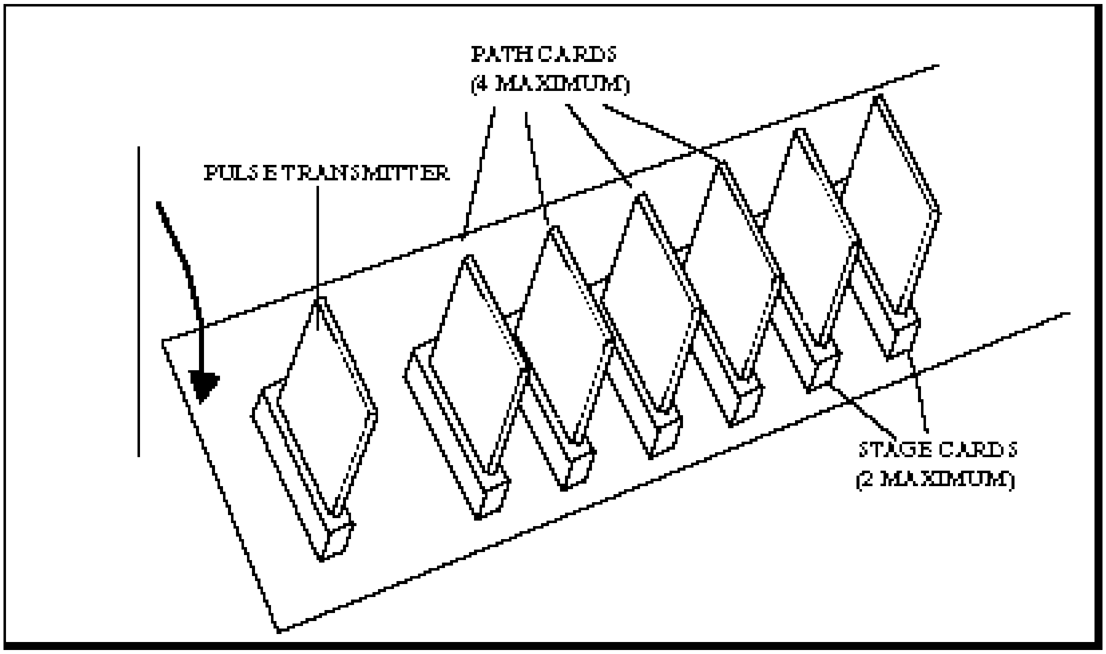


Figure 6-2 Rear View of Connector Panel in Lowered Position

Replacing the Pulse Transmitter

The pulse transmitter is located on the back of the connector panel as shown above in Figure 6-2. Remove the ribbon cable before pulling the card from its socket.

Reverse the procedure to reassemble.

Replacing the High Voltage Power Module

The high voltage power module is attached to the left end of the plate supporting the connector panel as shown below in Figure 6-3.

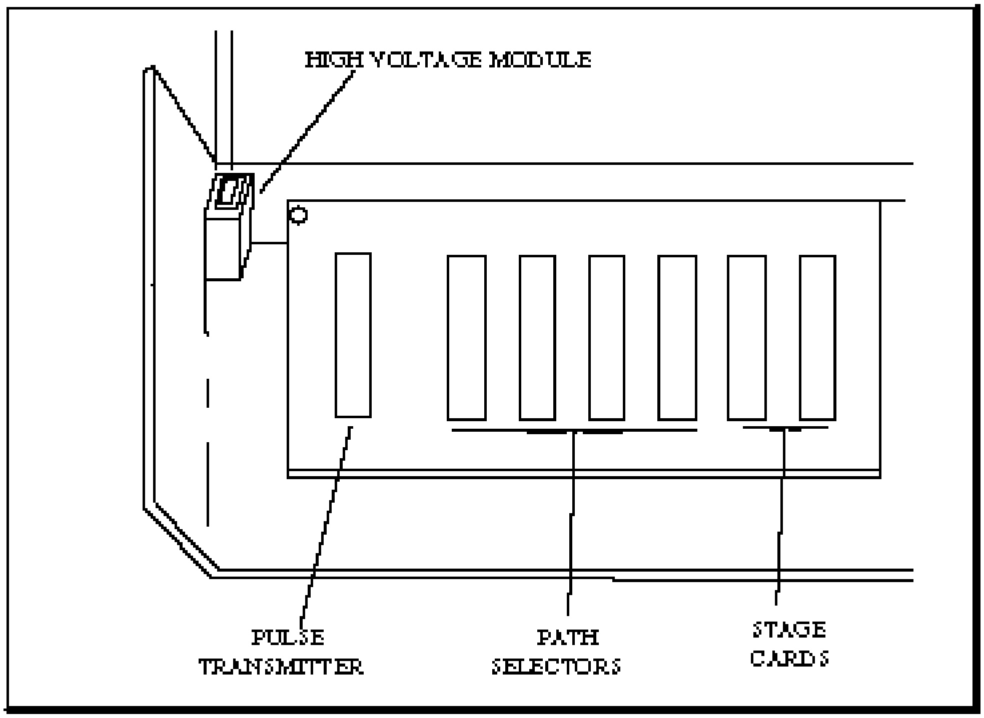


Figure 6-3 High Voltage Module Replacement

First detach the connector panel from the cabinet by releasing four captive fasteners marked with white arrows.

To remove the module, first disconnect the two cables to gain clearance. Then remove four screws and unplug the entire module. Reverse the procedure to reassemble.

Replacing the Display Card

The display card is located inside the cabinet on the back side of the hinged front panel, at the top.

To replace the display card, unplug the pigtail wiring connection at the left of the card.

Disconnect the flex-circuit cable from the right side of the card - be careful not to tug on the cable or bend or twist it. Remove four nuts to detach and remove the card.

Reverse the procedure to reassemble.

Replacing the Keypad Card

The keypad card is located inside the cabinet centered on the back side of the hinged front panel.

To replace the keypad card, disconnect two cables from the right side of the card. If there is an external keyboard connected to the left side of the card, disconnect it. Remove four screws to detach the card and remove it.

Reverse the procedure to reassemble.

Replacing the Membrane Keypad and LCD Panel

The membrane keypad and the LCD panel are removed and replaced as a single assembly.

To replace the assembly, first remove the display card and the keypad card as described above.

Loosen ten bolts holding the retaining flange that secures the assembly in place. Be careful in removing the last few bolts so that the unit doesn't fall out of the front panel. If the sealing gasket has stuck to the assembly, remove it gently.

Clean the gasket and mating surfaces with isopropyl alcohol.

Reverse the procedure to reassemble.

Replacing the Diskette Drive

The diskette drive is located inside the cabinet on the back side of the hinged front panel, at the bottom. Refer to Figure 6-4.

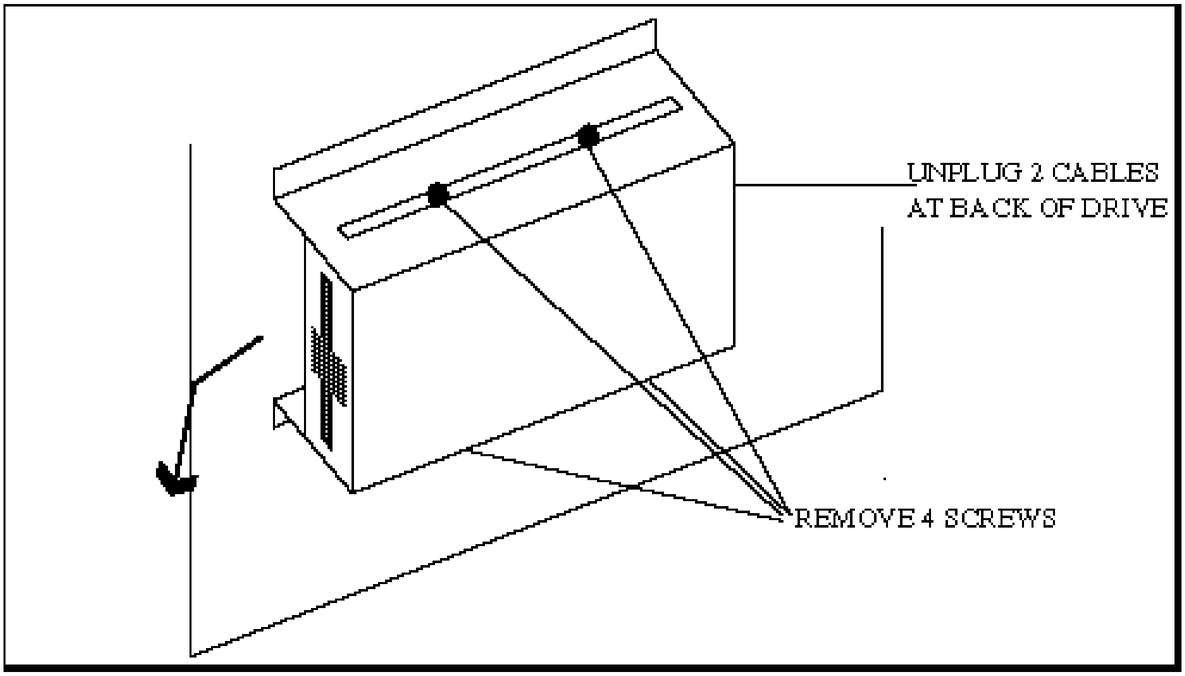


Figure 6-4 Diskette Drive Removal

To remove the diskette drive, unplug the two cables at the back (right side) of the drive. Remove four screws **-** two on the top and two on the bottom surfaces of the drive enclosure. Do *not* remove the four screws that attach the drive enclosure to the front panel of the cabinet.

Cock the diskette drive slightly by holding the front (left side) of the unit away from the front panel, and push the rear of the unit (right side) away from you. This allows the disk drive to slide out to the left.

Reverse the procedure to reassemble.

Replacing the Power Supply

Replacement of the power supply requires substantial disassembly of the flowmeter. Contact Accusonic for details before attempting this procedure.

Replacement Procedure for Flowmeters in Rack-mount Cabinet

The rack-mount is available in two configurations, one for table top use, and the other for mounting in a standard NEMA relay rack or cabinet. Replacement procedures are identical in both cases. Unless otherwise noted, directions *left* and *right* are as viewed from the front of the cabinet.

When the cabinet is mounted in a NEMA rack, perform replacement procedures with the unit pulled fully forward on its slides. The only exception is when releasing the rear connector panel - that procedure is easier when the unit is pushed all the way back into the rack.

Replacing System Processor Circuit Boards

To replace system processor circuit cards (those located in the front half of the cabinet), first remove the top cover of the unit, and then remove the card retainer located along the left edge of the cards. Release the retainer by loosening two screws. After the retainers are out of the way, the cards pull out.

Depending on the instrument configuration, there may be slots for eight or ten cards in the processor group. Except for the system processor card, there is no fixed slot location for any of the cards. The flowmeter is shipped with a configuration sheet detailing the actual location of circuit cards in your instrument. A copy of the configuration sheet is kept on file at the factory.

Before removing a circuit card, always double check its identity by locating a connector or external connection to that card, and then tracing it back to the unit. Alternatively, the cards are labeled in etch along one edge, and most bear at least one identifying label from the manufacturer.

Before disconnecting any cables from a circuit card, be sure to note the location and orientation of the connectors to ensure that they can be reinstalled correctly. Some cable connectors in the system are NOT polarized; if installed backwards, they can cause damage.

Specific considerations:

- **System processor card -** Has two cables which must be detached before removing the card. Refer to system As-built drawings in the rear of this manual for card locations.
- **Basic I/O card -** Has three cables which must be removed.
- **System communications card -** Has at least one and possible four cables plugged into it. Furthermore, if the flowmeter is attached to remote flow transmitters, there will be additional components on the card. Be sure to replace the card with the proper type. See configuration sheet for details.
- **Diskette controller card** and **System I/O cards -** All have at least one cable. Be sure to note the configuration and reattach the cables correctly to the replacement card. These connectors are not keyed and will cause damage if installed backwards.

Replacing Transceiver Card Set

To remove the transceiver card set first remove the top cover of the unit. Detach the cable plugged into the back lower right-hand corner of the larger card. Remove both cards together; in most cases the cards are replaced as a pair. If necessary, remove the two ribbon cables to separate the cards.

Removing the Connector Panel

This procedure is performed to gain access to the path and stage cards, and the pulse transmitter.

To remove the rear connector panel from a rack-mount cabinet used on a table top, it is necessary to first remove the side panels to gain access to the screws that secure the connector panel to the unit. When the cabinet is located in a rack, the screws remain accessible even when the side panels are in place.

Remove the panel by loosening four screws located along the sides of the back panel.

Gently pull the panel away from the unit and let it rest on the attached cables which will keep the panel from dropping completely out of the way.

Depending on the configuration of the instrument, there will be one or two narrow ribbon cables which might obstruct access into the area behind the connector panel.

Unplug the cables at their far end. Note the location of the mating connectors to ensure correct reassembly.

Replacing Path or Stage Cards

Path and stage cards are mounted on the back of the connector panel, as previously shown in Figure 6-2 (page 6-9). They are exposed and accessible after the connector panel is removed. The cards simply unplug from the panel for replacement. Be sure to install a replacement card in the same slot.

Replacing the Pulse Transmitter

The pulse transmitter is located on the back of the connector panel as previously shown in Figure 6-2 (page 6-9). Remove the ribbon cable before pulling the card from its socket.

Reverse the procedure to reassemble.

Replacing the High Voltage Power Module

The high voltage power module is accessible from below the unit.

To remove the module, remove the bottom panel and disconnect two cables from the module. Then remove four screws and unplug the entire unit. Reverse the procedure for reassemble.

Releasing the Front Panel

The front panel holds the display and keypad and their respective control cards. It must be released from the unit to service these components. Remove the top panel of the unit to gain access to two slide-lock bars which hold the front panel in place.

To release the panel, lightly push the front panel into the unit to release the pressure on the slide-lock bars and use a screwdriver to slide each bar as shown in Figure 6-5. The slide-lock bars are not captive.

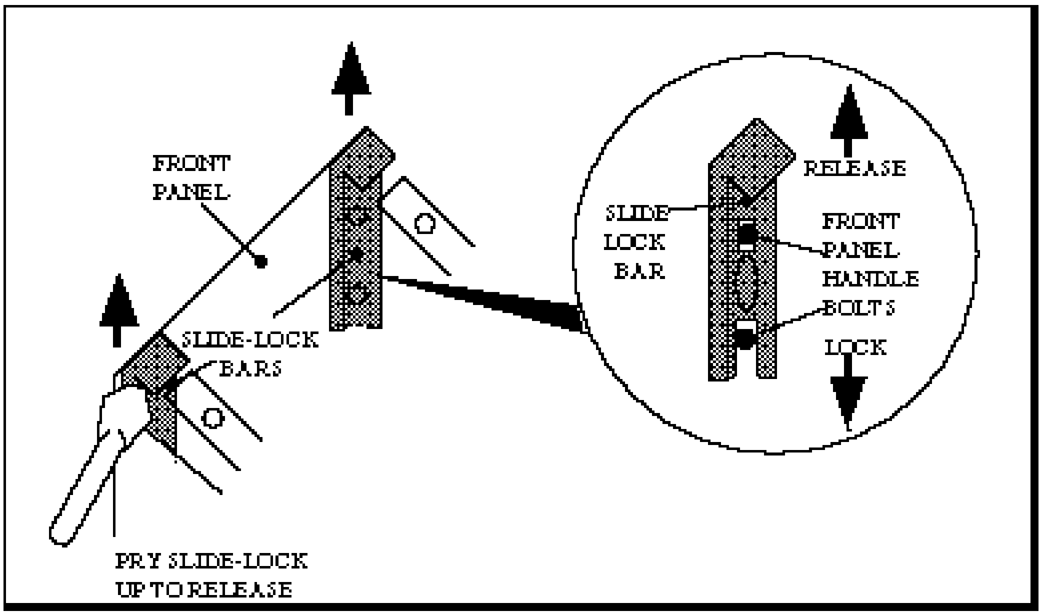


Figure 6-5 Releasing the Front Panel

To reassemble, hold the panel in place and lightly press it toward the rear of the unit. Reach into the unit and reattach the slide-locking bars, one on each side of the panel. Slide the slide-lock bar over the tangs on the bolts from the front panel handles and then press each bar downward to lock the assembly in place.

Replacing the Display Card

The display card is located inside the cabinet on the back side of the front panel, at the top.

To replace the display card, first release the front panel as described above and then unplug the pigtail wiring connection at the left of the card.

Disconnect the flex-circuit cable from the right side of the card - be careful not to tug on the cable or bend or twist it. Remove four nuts to detach and remove the card.

Reverse the procedure to reassemble.

Replacing the Keypad Card

The keypad card is centered on the back side of the front panel.

To replace the keypad card, first release the front panel as described above and then disconnect two cables from the right side of the card. If there is an external keyboard connected to the left side of the card, disconnect it. Remove four screws to detach and remove the card.

Reverse the procedure to reassemble.

Replacing the Membrane Keypad and LCD Panel

The membrane keypad and the LCD panel are an integral unit that is replaced as a single assembly.

To replace the assembly, first release the front panel and then remove the display card and the keypad card as described above.

Reverse the procedure to reassemble.

Replacing the Diskette Drive

The screws that hold the diskette drive in place are accessible from the bottom of the unit. Remove four screws - two on each side of the drive as shown in Figure 6-4(see page 6-12).Do *not* remove the four screws that attach the drive bracket to the unit. After releasing the screws, the drive slides out through the front panel.

FORCED PAGE BREAK FOR PAGE NUMBERING REASONS - REMOVE FROM MANUAL.

Chapter 7
Parameters and Variables

Parameters and variables are listed in alphabetic order. Each entry lists the parameter type, the menu access levels in which the parameter is displayed, the range of allowed values and the default value. When the symbol # appears for range, it means that an integer, a whole number, or a number in scientific notation in the range 10^{-38} to 1×10^{38} may be entered.

Table 5-1 on page 16 summarizes the flowmeter menu hierarchy.

Refer to Figure 7-1 on page 36 for a diagram of an open-channel parameters application.

Parameter List

Always display plant totals

Specifies what to do with "Total Flowrate" if one or more measurement sections are "BAD". In the OFF position any bad section will prevent the calculation of total plant flow. In the ON position total plant flow will be displayed and will indicate valid even if a section is bad (the section may be bad because it is dewatered). The flowrate for the bad section(s) will not be added to the total. WARNING! Set this to OFF on leak-detection systems! Setting it to ON may cause false detection of leaks if there is a flowmeter failure.

Autostart switch

Specifies whether the flowmeter bypasses the menu system upon power up and automatically begins flow measurement. *On* bypasses the menus and is recommended in case of power failure while the system is unattended.

Type:	General parameter
Menu levels:	Setup, Extended
Range:	Off, On
Default:	On

Available velocity enabled

In compound installations when the metering section is surcharged, the meter can be enabled to use the velocities from all operating paths to determine a flowrate if the number of working paths is less than the number required for the other method chosen. This enables the meter to continue operating if one or more paths temporarily drop out. Accuracy will be somewhat less than if all paths are operating. See Chapter 3, *Flow Calculation Formulas*, beginning on page 3-18, for further information.

Type:	Section
Menu levels:	Setup, Extended
Range:	Off, On
Default:	On

Average cable length per path

The average length in system units of the transducer cables measured from the path selector card to the transducers. Averaged for all paths in the meter section.

Type:	Section parameter
Menu levels:	Setup, Extended
Range:	#
Default:	0

Note

Practical operating range is 0-1000 feet, 350 meters.

Average stage cable length

The average length in system units of the acoustic stage transducer cable or cables measured from the stage card to the transducer(s).

Type:	Section
Menu levels:	Setup, Extended
Range:	#
Default:	0

Averaging queue length

The maximum number of flow rate measurement samples used in calculating an average flow rate. This represents the size of a queue in which flow rate measurements are stored for averaging. As each measurement is made, an entry is added to the averaging queue until the number of entries equals this setting. Once the queue is filled, each new entry replaces the oldest entry in the queue. Upon first startup or any time flow measurements are interrupted for a length of time exceeding *Totalizer cutoff time*, the averaging queue is flushed.

Type:	General parameter
Menu levels:	Extended
Range:	0 to 2000
Default:	10

Bidirectional flow

Defines whether the flowmeter accounts for reverse flow through the section. If *On*, reverse flow will be calculated and subtracted from totalizer output. If *Off*, reverse flow is set to zero and has no effect on the totalizer.

Type:	Section parameter
Menu levels:	Setup, Extended
Range:	Off, On
Default:	Off

Bottom channel width

In open channel and compound installations, one of the parameters required to define the channel or conduit cross section. The value is expressed in feet or meters, according to the general parameter *Units*. Other parameters are *Number of channel layers*, *Channel layer height*, and *Channel layer width*.

Type:	Section
Menu levels:	Setup, Extended
Range:	0 - 5000
Default:	0

Bottom velocity ratio

In open channel and compound installations, a coefficient of friction is used to extrapolate velocity between the bottom acoustic path and the conduit bottom and between the top path and the conduit top when the conduit is surcharged. .

Type:	Section
Menu levels:	Setup, Extended
Range:	0 - 1
Default:	.5

Channel bottom height

Height of the channel or conduit bottom above a datum, such as sea level.

Type:	Section
Menu levels:	Setup, Extended
Range:	-100 to 15,000
Default:	0

Cross sectional area

The area to be used by the meter in calculating flowrate if the area method of integration, or the available velocity method of integration is being used under surcharged conditions. See Section parameter *Available velocity enabled* (page 2).

Type: Section

Menu levels: Setup, Extended

Range: #

Default: 0

Current date

The current date is displayed in format MM.DD.YY

Type: General

Menu levels: Setup, Limited, Extended

Range: 01.01.80 to 12.31.99

Default: Current date

Current time

The current time is displayed in format HH.MM.SS.

Type: General

Menu levels: Setup, Limited, Extended

Range: 00.00.00 to 23.59.59

Default: Current time

Data logging

Allows various types of data to be averaged and printed or stored on diskette. When the Section parameter is set to *On*, enables logging of flow and positive volume and allows selective logging of negative volumes and individual path velocities. Log files on disk are organized by meter section. See section parameter *Log data to* (page 10) for how to specify the destination for printing or for diskette backup. When the General parameter is set to *On*, system totals for flowrate and volumes will be logged.

Type: General and Section parameter

Menu levels: General parameter--Setup, Extended

Section parameter--Limited, Extended

Range: Off, On

Default: Off

Data log start

Defines the time, in 24-hour format (hh:mm:ss) when data logging is to begin. 00:00:00 is midnight, 12:00:00 is noon. Data logging continues at the interval set for the parameter *Log interval* until the parameter *Data logging* is turned *Off*.

Type:	General parameter
Menu levels:	Limited, Extended
Range:	00:00:00 to 23:59:59
Default:	00:00:00

Delay time of other ducer

In Section parameter *Stage source*, if *Acoustic* and *Other* are chosen in successive menu levels, enter the signal delay of the transducer, in seconds. This is also required if *Other* is chosen in Path parameter *Ducer type*. The value entered should include transit time through both ducer windows (2 x thickness/speed of sound) plus 1/2 of wave period (1µs for 500kHz ducer) plus 0.2µs for electronic delays.

Type:	Section and Path parameter
Menu levels:	Setup, Extended
Range:	# (in seconds)
Default:	0

Differential alarm threshold

See Chapter 12, Leak Detection System, page 12-7.

Differential flow averaging size

See Chapter 12, Leak Detection System, page 12-7.

Differential warning threshold

See Chapter 12, Leak Detection System, page 12-7.

Display contrast

Used to increase or decrease contrast of an LCD display. This parameter has no effect when a CRT or full-screen electroluminescent (EL) display is in use.

Type:	General parameter
Menu levels:	Setup, Limited, Extended
Range:	Down, Up
Default:	n/a

Display mode

Selects whether data will be displayed on screens 1 & 2, by individual sections, ends (which are factory configured combinations of sections) or both.

Type: General parameter

Menu levels: Extended

Range: Sections, Ends, Both

Default: Sections

Display totals line

Allows the operator to turn off the Totals line at the bottom of the display.

Type: General parameter

Menu levels: Extended

Range: Off, On

Default: On

Ducer connection

The 7500 is configured at the factory for the type of transducer cable connection, usually single line.

Type: Section parameter

Menu levels: Setup, Extended

Range: Balanced, Single

Default: Single

Ducer type (7600, 7601, 7605, 7612 ...)

Specifies the model of the Accusonic transducers in the section. Since each model transducer has a different internal signal delay, correct specification of this parameter is critical to the accuracy of flow calculations.

Type: Path parameter

Menu levels: Setup, Extended

Range: 7600, 7601 etc.

Default: 7600

End label character

A single character used to identify a factory-configured combination of sections on the console display. Typically used in leak detection systems.

Type: General parameter

Menu levels: Extended

Range: Alphanumeric

Default: E

End starting number

The number to label the first end in the series of ends attached to this flowmeter. See General parameter *End label character* above.

Type: General parameter

Menu levels: Extended

Range: #

Default: 1

Error Reporting

Error reporting is a diagnostic tool. When enabled, status information will be stored on a floppy disk when data status is bad (other than 1,9, or x) for more than *Maximum Bad Measurements*. Stored information will consist of date, time and status codes. Additional menu choices will enable storage of flowrate, stage, velocities and gains. Information will be stored on every measurement cycle. Error reporting requires that a blank, formatted disk be in the floppy drive.

Type: General

Menu levels: Extended

Range: On or Off

Default: Off

Flowrate scale factor

The flowmeter calculates flow rate in cubic feet per second (cfs) or cubic meters per second (cms), depending on whether English or metric units have been chosen in the General parameters list. These flow rates can be scaled by the *Flowrate scale factor* to reflect other flow units. Common flow rate scale values are:

If units are in	Desired flow rate in	Flowrate scale factor
Feet	million gallons/day (mgd)	0.646272
	gallons/minute (g/m)	448.8
	gallons/second (g/s)	7.48
Meters	liters/second (l/s)	1,000.0
	cubic meters/hour (cm/h)	3600.0
	megaliters/day (mld)	86.40

Type: Section parameter

Menu levels: Setup, Extended

Range: #

Default: 1

Format

Format is used with digital outputs. It allows the user to choose the part of the selected variable to be sent to the output. Enter as:

<total number of digits to output>**.**<number of decimal places>

For example:

A BCD output of stage is desired. 16 bits of output are available, which will provide four BCD digits. The range of stage is 310.25 to 336.51 feet. Format could be set to 4.1, which would cause the BCD output to range from 3102 to 3365 (decimal point is not output). For better resolution, format could be set to 4.2. The BCD output would then range from 1025 to 3651. In this case, the most-significant digit is always a ‘3’, so there is no need to output it. The input can be strapped to ‘3’ at the receiving device.

Type:	Output parameter
Menu Levels:	Setup, Limited, Extended
Range:	#
Default:	0.0

Note

Practical operating range depends on output hardware installed.

Frequency of other ducer

In Section parameter *Stage source*, if *Acoustic* and *Other* are chosen in successive menu levels, enter the frequency of the acoustic transducer being used. This is also required if *Other* is chosen in Path parameter D*ucer type*.

Type:	Section and Path parameter
Menu levels:	Setup, Extended
Range:	#
Default:	0.0

Full Pipe

In compound installations, the stage (level) value which indicates a surcharged conduit for purposes of changing to the integration method chosen in the section parameter *Surcharged integration*.

Type:	Section parameter
Menu levels:	Setup, Extended
Range:	0 - 100
Default:	0

Inactivity Timeout

The length of time (in minutes) the system can be left unattended and out of measurement mode. If no keys are pressed for this length of time, the system will reset and begin measurement automatically. This feature will only work if the General parameter *Autostart* has been set to *On.* Setting the inactivity timeout period to 0 deactivates the feature.

Type: General parameter

Menu levels: Extended

Range: #

Default: 10

K

An integration factor for the specified path according to the type of installation. For example, for a four-path section in round pipe, K should be set to 1 for each path.

Type: Path parameter

Menu levels: Setup, Extended

Range: #
Default: 1 - for sections with 1 or 4 paths
0.996 for sections with 2 paths
0.5 - for sections with eight crossed paths

Layer boundary elevation 1 - n

In open channel and compound installations, the elevation of the particular layer above the site datum. They are used for defining the channel cross section. The layer elevations need not correspond to acoustic path heights. Elevations of each layer is expressed in feet or meters, according to the general parameter *Units*. Channel layer elevations are taken from the as-built survey sheet and should not be changed after setup. The number of channel layers to be defined is determined by the section parameter *Number of channel layers*. The value for the top layer must be greater than or equal to the parameter *Pipe Full* in a Compound meter, and *Maximum Stage* in an open channel.

Type: Section

Menu levels: Setup, Extended

Range: 0 - 100

Default: 0

Layer boundary width 1 - n

In open channel and compound installations, the width of the particular layer as measured at the top of the layer for defining the channel cross section. Width of each layer is expressed in feet or meters, according to the general parameter *Units*. Channel layer widths are taken from the as-built survey sheet and should not be changed after setup. The number of channel layer widths to be defined is determined by the section parameter *Number of channel layers*. Side slope of each layer is calculated based on this width, the width of the layer beneath it (or bottom channel width) and the layer height.

Type: Section

Menu levels: Setup, Extended

Range: 0 - 5000

Default: 0

Leak detection switch

Enables the leak detection system algorithms. Note that this parameter appears twice on the flowmeter menu--once as a General parameter and again under the specific Leak detection option. The switch must be turned on in the General parameter list in order to enable the system to perform the calculations required for leak detection. It must also be enabled under the Leak detection option for each pipeline/penstock for which leak detection functions should be performed.

Type: General and Leak detection parameter

Menu levels: Setup, Limited, Extended

Range: Off , On

Default: Off

Log data to

Specifies the destination for data logging. Data logging will occur only if the section parameter *Data Logging* is *On*. If disk is selected, there must be a formatted diskette in the diskette drive unit. If printer is selected, data is sent to the parallel printer port.

Type: General parameter

Menu levels: Limited, Extended

Range: disk, printer, both

Default: n/a

Note

When a logging diskette is more than 80% full, the flowmeter displays a warning message on the control panel.

Log interval

Defines the interval over which data is averaged. At the end of each interval, data is recorded on whatever device or devices have been selected with the section parameter *Log data to*. Expressed in 24 hour format (hh:mm:ss). This parameter appears in the menus only if the section parameter *Data Logging* is *On*.

Type: General parameter

Menu levels: Limited, Extended

Range: 00:00:00 to 24:00:00

Default: 00:10:00 (ten minutes)

Log negative volume data

Specifies whether reverse flow is to be logged. Data logging will occur only if the Section or General parameter *Data Logging* is *On*.

Type: Section parameter

Menu levels: Limited, Extended

Range: Off, On

Default: Off

Log velocity data

Specifies whether velocity measurements are included in the log report. If this parameter is *Off* and the section parameter *Data logging* is *On*, flowrate and positive volume are logged..

Type: Section parameter

Menu levels: Limited, Extended

Range: Off, On

Default: Off

Manning coefficient of roughness

In open channel and compound installations, the coefficient of roughness to be used in the Manning formula for calculating flow based on level measurement alone. The Manning formula is appropriate only in sites where a stage/discharge relationship is applicable and where no acoustic paths are submerged and/or operating. The coefficient of roughness is usually between 0.010 and 0.030. See Chapter 3 description of Manning Equation on page 3-21.

Type: Path parameter

Menu levels: Extended

Range: #

Default: None

Manual gain

Specifies the path receiver gain in decibel (dB) units. This parameter has no effect unless the path parameter *Receiver gain* is set to *Manual*. Should be used only for troubleshooting; see parameter *Receiver gain* (page 21).

Type: Path parameter

Menu levels: Extended

Range: #

Default: None

Manual stage (1 or 2) value

In open channel or compound installations, if *Manual* is chosen in Section parameter *Stage source*, the meter will use a fixed value as the fluid level in the channel or conduit. This value will override all other stage inputs and is used only if no level variation is expected or for testing purposes.

Type: Section

Menu levels: Setup, Extended

Range: #

Default: 0

Maximum bad measurements

The maximum number of consecutive measurements failing a reasonability test before the flowmeter signals an alarm. When a bad measurement is detected and the number of bad measurements does not exceed this value, the last good value is substituted for the bad value. When the number of bad measurements is exceeded, the flow may be computed using an alternative or modified integration method.

Type: General parameter

Menu levels: Extended

Range: #

Default: 10

Note

Bad measurements are not used in flow rate averaging.

Maximum change in flowrate

Maximum allowable rate of change in flow rate between consecutive measurements, expressed in cubic feet/second^2 or cubic meters/second^2 according to the general parameter *Units*. If a measurement exceeds this limit, the consecutive bad counter for the section is incremented. The new value will be the last good value plus or minus the maximum change parameter value. If the new reading does not “catch up” to the present reading within “MAXIMUM BAD MEASUREMENTS”, the section will fail.

Type: Section parameter

Menu levels: Setup, Extended

Range: #

Default: Calculated: 10% of the value specified for *Maximum expected flowrate*

Maximum change in stage

Maximum allowable rate of change in stage (level) per second, expressed in feet or meters, according to the general parameter *Units*. If a measurement exceeds this limit, the consecutive bad counter for the section is incremented, and the measured value is not used for flow calculation. This parameter is used to filter out bad stage measurements which may be caused by submerged debris.

Type: Section

Menu levels: Setup, Extended

Range: 0 - 100

Default: 0.5

Maximum change in velocity

Maximum allowable rate of change in velocity between consecutive measurements, expressed in feet/second^2 or meters/second^2 according to the general parameter *Units*. If a measurement exceeds this limit, the consecutive bad counter for the path is incremented. The new value will be the last good value plus or minus the maximum change parameter value. If the new reading does not “catch up” to the present reading within “MAXIMUM BAD MEASUREMENTS”, the path will fail.

Type: Section parameter

Menu levels: Extended

Range: #

Default: 20

Maximum expected flowrate

Maximum allowable flow measurement, expressed in cubic feet/second or cubic meters/second according to the general parameter *Units*. If a measurement exceeds 1.5 times this value, the consecutive bad counter for the section is incremented, and the measured value is not used for flow calculation. Enter the actual maximum flow rate expected. The flowmeter adds the appropriate safety factor.

Type: Section parameter

Menu levels: Setup, Limited, Extended

Range: #

Default: Calculated: (Velocity =100) times area of the section

Maximum expected velocity

Maximum allowable velocity measurement, expressed in feet/second or meters/second according to the value of the general parameter *Units*. If a measurement exceeds 1.5 times this value, the consecutive bad counter for the path is incremented, and the measured value is not used for flow calculation.

Type: Section parameter

Menu levels: Setup, Limited, Extended

Range: #

Default: Calculated: Maximum expected flowrate/area of section

Maximum stage

Defines the maximum value of stage (level) that the flowmeter will use. Expressed in feet or meters, according to the general parameter *Units*, above the reference datum (see parameter *Channel bottom height* page 3). In a compound installation this value is usually set equal to or above the value set in parameter *Full pipe*.

Type: Section

Menu levels: Setup, Extended

Range: 0 - 1000

Default: 0

Maximum stage difference 1 and 2

The maximum acceptable difference in feet or meters between redundant stage measurements. If this parameter is exceeded, the value from the Stage 1 sensor only is used. If only one sensor is working, its value is used.

Type: Section

Menu levels: Setup, Extended

Range: 0 - 100

Default: 0

Menu access

Specifies which parameters and variables will be displayed while navigating the menus.

Type: General parameter

Menu levels: Setup, Limited, Extended

Range: Setup, Limited, Extended

Default: Setup

Minimum flowrate

Defines the minimum absolute value of flow rate that the flowmeter will display. Expressed in cubic feet/second or cubic meters/second according to the value of the general parameter *Units*. Flow measured in either direction that is less than this limit displays as zero flow rate and is not totalized.

Type: Section parameter

Menu levels: Setup, Limited, Extended

Range: #

Default: 0

Minimum good paths

In a pipe installation, the minimum number of paths which must show valid measurements before a flow rate calculation will be made. When fewer than this number of valid paths are operating, the flowmeter signals a section error and flow calculation stops. To ensure measurement integrity, this parameter must be set to the number of paths in the section. If the parameter is set to three for a four-path section, the failure of a single path will not be signaled, and the last good value for velocity for the failed path will be used forever, unless new valid data are obtained. If path substitution is enabled, a value for failed paths will be provided from other good paths.

Type: Section parameter

Menu levels: Setup, Extended

Range: #

Default: Total number of paths in section

Minimum path submersion

The minimum distance above each acoustic path that the stage (level) measurement must indicate before the acoustic path is activated, as calculated by the minimum clearance required to avoid multipath reflections. The value depends on operating frequency and path length. (See Chapter 3, page 3-6 for formula.)

Type: Section

Menu levels: Setup, Extended

Range: 0 - 20

Default: 0

Minimum stage

Defines the minimum value of stage (level) that the flowmeter will use. Expressed in feet or meters, according to the general parameter *Units*, above the reference datum (see parameter *Channel bottom height* on page 3). If the stage measurement is below this value, the consecutive bad counter for the section is incremented, and the measured value is not used for flow calculation.

If an Acoustic uplooker is used, 6” (0.15m) above the face of the stage transducer is suggested. Add stage offset to 6” to get minimum stage. For other stage measurement devices, minimum stage is dependent on device limits and/or channel limits.

Type: Section

Menu levels: Setup, Extended

Range: 0 - 1000

Default: 0

Negative over velocity alarm threshold

See Chapter 12, Leak Detection System page 12-8.

Negative over velocity warning threshold

See Chapter 12, Leak Detection System page 12-8.

Non-surcharged integration method

In open channels and in compound installations when the conduit is not surcharged, this specifies the integration method to be used by the meter. The default choice, *Auto*, will set the meter to automatically select Manning, single path trapezoidal or multi-path trapezoidal depending on stage and the number of good paths. If Trapezoidal is chosen the Manning option is inhibited. Choice of any of the other methods will lock the meter into that method regardless of the number of paths submerged, as long as the conduit is not surcharged. The choice of integration is determined based on requirements established at the time of system configuration and should not be changed without consulting Accusonic. See Chapter 3, *Flow Calculation Formulas*, beginning on page 3-18, for further information.

Type:	Section parameter
Menu levels:	Setup, Extended
Range:	Auto, Trapezoidal, Single path, Manning
Default:	Auto

Number of channel layers

In open channel and compound installations, the number of layers used in defining the channel or conduit cross section. For regularly shaped trapezoidal channels, only one layer may need to be defined, including the parameters *Bottom channel width*, *Channel layer height 1*, and *Channel layer width 1*. For irregularly shaped channels, up to 16 separate layers, each with separate height and width, may be defined.

Type:	Section
Menu levels:	Setup, Extended
Range:	1 - 16
Default:	8

Over velocity alarm count

See Chapter 12, Leak Detection System, page 12-8.

Over velocity warning count

See Chapter 12, Leak Detection System, page 12-9.

Password control

Specifies whether a password protection is in effect. Password protection prevents unauthorized users from interrupting measurements or changing parameters on the instrument. See Chapter 5 (pages 19 and 37) for information on setting or changing a password.

Type: General parameter

Menu levels: Extended

Range: Off, On

Default: Off

Note

If Password control *is* On *and* Autostart switch *is* Off *and the unit is powered down for any reason, it will restart in the menu system, thereby allowing parameters to be changed. For complete protection from tampering, set both* Password control *and* Autostart switch *to* On*.*

Path angle

Specifies the angle in degrees between an acoustic path and the centerline of the meter section. This is obtained from the as-built survey data sheet and should not be changed after setup.

Type: Path parameter

Menu levels: Setup, Extended

Range: #

Default: 45°

Path elevation

For Gaussian installations, the elevation of the path from the pipe center line. These are obtained from the as-built survey data sheet, and should not be changed after setup.For Open or Compound channels, the elevation is relative to the site datum. Paths must be numbered in order of elevation. Paths of identical elevation are assumed to be crossed.

Type: Path parameter

Menu levels: Setup, Extended

Range: #

Default: 0

Path length

Length of the path from transducer face to transducer face, expressed in meters or feet according to the general parameter *Units*. This is obtained from the as-built survey data sheet and should not be changed after setup.

Type: Path parameter

Menu levels: Setup, Extended

Range: #

Default: 0

Path percent active

Specifies the percent of the path that is within the moving fluid. For example, if both transducers forming a 1 meter path are recessed into the conduit walls by 1 cm, the value for this parameter would be 98 (%). This is obtained from the as-built survey data sheet and should not be changed after setup.

Type: Path parameter

Menu levels: Setup, Extended

Range: 0 to 100

Default: 100

Path position

Elevation in degrees of a path above the centerline of the conduit. This value is used to calculate constants for pipe integration. Default values change according to integration method and the number of paths in the section.

Type: Path parameter

Menu levels: Setup, Extended

Range: #

Default: For 2-path section: ±30°, according to path number

For 4-path section: Path 1, -54°; path 2, -18°; path 3, 18°; path 4, 54°

Path simulation

Used for system testing. Specifies the simulation parameter, *Simulation forward time, Simulation reverse time* or *Simulation velocity*, used as the source of travel times for simulation. When set to *Times*, the forward and reverse simulation times are used. When set to *Velocity*, the velocity is first converted to travel times and these times are used. Normally *Off*. See parameters *Simulation forward time*, *Simulation reverse time*, *Simulation source*, *Simulation velocity*, and *Simulation velocity ramp*. On the keypad, pressing Ctrl - ↑ will ramp the velocity up by the simulation velocity ramp scale, pressing Ctrl - ↓ will ramp down by this scale. On an external keyboard, the PG-UP key will ramp up, the PG-DN key will ramp down. → resets all simulated velocities to the un-ramped value. ← sets all simulated velocities to 0.

Type: Path parameter

Menu levels: Extended

Range: Off, Velocity, Times

Default: Off

Note

Flow rate for the path is not measured when Path simulation is set to Velocity or Times.

Path switch

Specifies whether measurements are to be made along the path. If the path is turned *Off*, the last good velocity from the path will continue to be used for flow calculation. Set *On* to activate path measurements. To remove this path's contribution from the flow calculation, enter a very small value for K, e.g. 0.0000001.

Type:	Section parameter
Menu levels:	Setup, Limited, Extended
Range:	Off, On
Default:	Off

Penstock label character

A single character used to identify a section, penstock or unit line on the console display.

Type:	General parameter
Menu levels:	Extended
Range:	Alphanumeric
Default:	P

Penstock starting number

The number to label the first penstock in the series of penstocks attached to this flowmeter.

Type:	General parameter
Menu levels:	Extended
Range:	#
Default:	1

Pipe height

Distance, expressed in meters or feet according to the general parameter *Units*, from the bottom of the pipe to the top of the pipe as measured at the center of the cross section. Only accessible if the section parameter *Pipe integration* is set to *Gauss*.

Type:	Section parameter
Menu levels:	Setup, Extended
Range:	#
Default:	0

Pipe integration

Specifies whether Chebyshev or Gaussian integration method will be used. The choice of integration method is specified by Accusonic and should not be changed. See Chapter 3, *Flow Calculation Formulas* beginning on page 3-18.

Type:	Section parameter
Menu levels:	Limited, Extended
Range:	Cheb, Gauss
Default:	Cheb

Pipe shape

Specifies the cross-sectional shape of the conduit at the meter section. Used only in Gauss integration.

Type:	Section parameter
Menu levels:	Limited, Extended
Range:	Round, Other
Default:	Round

Pipe slope

In open channel and compound installations, the slope to be used in the Manning formula for calculating flow based on level measurement alone. The Manning formula is appropriate only in sites where a stage/discharge relationship is applicable and where no acoustic paths are submerged and/or operating. The value represents the slope of the pipe parallel to its centerline axis. Enter as Rise/Run.

Type:	Section parameter
Menu levels:	Setup, Extended
Range:	#
Default:	0

Positive over velocity alarm threshold

See Chapter 12, Leak Detection System, page 12-9.

Positive over velocity warning threshold

See Chapter 12, Leak Detection System, page 12-9.

Protrusion of other ducer

If *Other* is chosen in Path parameter D*ucer type*, transducer protrusion must also be entered for each path. Note that protrusion is path-specific--the value for inner paths will differ from that for outer paths. Protrusion is always entered in inches, regardless of any other unit selected.

Type: Path parameter

Menu levels: Setup, Extended

Range: # (in inches)

Default: 0.0

Q FWD 1 - n

In open channel and compound installations, the forward single path integration constant, used only when the USGS single path integration method is chosen in section parameter *Single path integration*.

Type: Section parameter

Menu levels: Setup, Extended

Range: #

Default: 0

Q REV 1 - n

In open channel and compound installations, the reverse single path integration constant, used only when the USGS single path integration method is chosen in section parameter *Single integration*.

Type: Section parameter

Menu levels: Setup, Extended

Range: #

Default: 0

Radius

Specifies the radius of the pipe at the center of the metering section in meters or feet according to the general parameter *Units*. Only used when the section parameter *Pipe Integration* is set to *Cheb*. This is obtained from the as-built survey data sheet and should not be changed after setup.

Type: Section parameter

Menu levels: Setup, Extended

Range: #

Default: 0

Receiver gain

Specifies whether the receiver gain for the path will be set automatically (i.e., automatic gain control, agc) or manually. Normally set to *auto*, except during transducer alignment and troubleshooting. (See parameter “Manual Gain”, page 12.)

Type: Path parameter

Menu levels: Extended

Range: Auto, Manual

Default: Auto

Repetition time

Specifies in seconds the time between flow measurements and display updates for all sections.

Type: General parameter

Menu levels: Limited, Extended

Range: #

Default: 2

Section label character

A single character used to identify a section, penstock or unit line on the console display.

Type: General parameter

Menu levels: Extended

Range: Alphanumeric

Default: S

Section starting number

The number to label the first section in the series of sections attached to this flowmeter.

Type: General parameter

Menu levels: Extended

Range: #

Default: 1 1

Section switch

Specifies whether a meter section is in use. When *Off*, section parameters for this section are not displayed in the menus.

Type: Section parameter

Menu levels: Setup, Limited, Extended

Range: Off, On

Default: Off

Section type

Specifies the type of flowmeter application. Choose *compound* for open channels and for conduits flowing partially full at times and surcharged at others. Choose *pipe* only for conduits that are always surcharged (flowing full).

Type: Section parameter

Menu levels: Setup, Extended

Range: Pipe, Compound

Default: Pipe

Self test interval

Specifies the time in seconds between self-tests. When a bad self-test is detected, a follow-up test is always performed and repeats to the limit specified in the general parameter *Maximum bad self-tests*. When set to 0, self-testing is not performed.

Type: General parameter

Menu levels: Limited, Extended

Range: #

Default: 100

Shape factor

Factor used with Gaussian integration to correct for irregularities in the conduit shape. The factor is calculated from as-built parameters; it is site-specific and should not be changed after setup.

Type: Section parameter

Menu levels: Extended

Range: 0.995 to 1.005

Default: 1.0

Signal detection method

Specifies the signal detection method. Should only be changed under the direction of Accusonic.

Type: Section parameter

Menu levels: Extended

Range: 1st neg, Zero crossing

Default: 1st neg

Simulation forward time

Forward travel time (in seconds) to be used by flow transmitter to simulate a path velocity. See path parameter *Path simulation* on page 18.

Type:	Path parameter
Menu levels:	Extended
Range:	#
Default:	0

Simulation reverse time

Reverse travel time (in seconds) to be used by flow transmitter to simulate a path velocity. See path parameter *Path simulation* on page 18.

Type:	Path parameter
Menu levels:	Extended
Range:	#
Default:	0

Simulation source

Used for system testing. Specifies the kind of simulation to be used if the path parameter *Path simulation* is *On*. When set to *Internal*, the system processor uses a simulated value of velocity or travel time to calculate section flow. When set to *External*, the flow transmitter uses a simulated value of velocity or travel time to calculate path velocity. The path parameter *Path simulation* governs whether a velocity or a travel time is used. This parameter does not turn simulation on. See parameter *Path simulation* (pg 18), *Simulation forward time* (pg 23), *Simulation reverse time* (pg 24) and *Simulation velocity* (pg 24). *External* is a better test of the complete system--it tests the flow transmitter and communications link as well as the CPU.

Type:	Section parameter
Menu levels:	Extended
Range:	Internal, External
Default:	Internal

Simulation velocity

Value of velocity to be used by system processor to simulate section flow rate. See section parameter *Simulation source* on page 24.

Type:	Path parameter
Menu levels:	Extended
Range:	#
Default:	8

Simulation velocity ramp scale

Used for system testing. Specifies how much the simulated value of velocity currently in use increases or decreases per second as the CTRL-up and CTRL-down-arrow keys on the control panel are pressed. As the cursor keys are pressed, the new velocity value is determined by the following:

New velocity = *previous velocity* + (*Simulation velocity* * *Ramp scale*)

Type: Path parameter

Menu levels: Extended

Range: #

Default: n/a

See “Path Simulation” on page 18 for more information.

Single coefficient (1 - 5)

The straight single path polynomial coefficients used when the Polynomial integration method is chosen in Section parameter *Single integration*. These coefficients are the terms of a fifth-order polynomial equation for fitting a flow curve to a set of velocities. See Chapter 3, *Flow Calculation Formulas*, beginning on page 3-18, for further information.

Type: Section parameter

Menu levels: Setup, Extended

Range: #

Default: 0

Single integration

In open channel and compound installations when only one acoustic path is installed, this parameter determines the method of single-path integration to be used by the meter. The choice of integration is determined based on requirements established at the time of system configuration and should not be changed without consulting Accusonic. See Chapter 3, *Flow Calculation Formulas*, beginning on page 3-18, for further information. The single path must be Path 1 of the section.

Type: Section parameter

Menu levels: Setup, Extended

Range: USGS, Polynomial, Trapezoidal

Default: Trapezoidal

Speed of sound in fluid

Specifies the speed of sound in the fluid in meters/second or feet/second according to the general parameter *Units*. Flowmeter accuracy does not depend on the accuracy of this value.

Type: General parameter

Menu levels: Extended

Range: #

Default: 4800 (English units)

1450 (Metric units)

SQM

Specifies whether Signal Quality Monitor (SQM) is in use. During normal operations, this should always be *On*. See Chapter 3 page 3-14 for details.

Type: Path parameter

Menu levels: Extended

Range: Off, On

Default: On

Stage averaging size

The maximum number of stage (level) measurement samples used in calculating an average stage for use in flow measurement calculation. This represents the size of a queue in which stage measurements are stored for averaging. As each measurement is made, an entry is added to the averaging queue until the number of entries equals the setting. Once the queue is filled, each new entry replaces the oldest entry in the queue. Upon first startup or any time stage measurements are interrupted for a length of time exceeding *Totalizer cutoff time*, the averaging queue is flushed and restarted.

Type: Section parameter

Menu levels: Extended

Range: 1 - 1000

Default: 10

Stage ducer type

In open channel or compound installations, if an integral acoustic stage transducer is chosen in Section parameter *Stage source*, the transducer model must be entered. If *Other* is chosen for this parameter, additional parameters for Frequency and Delay must be entered.

Type: Section parameter

Menu levels: Setup, Extended

Range: 7612, 7615, 7616, 7632, other

Default: 0

Stage interval

Stage measurement repetition rate in seconds. This is independent of the path measurement rate chosen in General parameter *Repetition time*.

Type: General parameter

Menu levels: Setup, Extended

Range: #

Default: 5

Stage mode

If *Normal* is selected, the meter will search at every Stage interval over the entire range for a reading until it finds the current stage (level). If *Fast* is selected, the meter will remember the last stage value and will start seeking the level in that range first. *Normal* mode can take up to 5 seconds to make a stage measurement. If *Fast* mode is chosen, it will default to *Normal* mode briefly whenever the stage signal is lost. Recommended setting is 'FAST'.

Type: General parameter

Menu levels: Setup, Limited, Extended

Range: Normal, Fast

Default: Normal

Stage (1 or 2) offset

The height of the stage (level) source above a reference datum, such as the conduit bottom.

Type: Section parameter

Menu levels: Setup, Extended

Range: -100 to 15,000

Default: 0

Stage (1 or 2) range maximum

In open channel and compound installations, sets the scale for values from an external stage (level) source to be used by the meter. For example, if an acoustic downlooker is being used and is calibrated to output 4 to 20 mA from 1 to 5 feet, enter a maximum of 5. The meter will calculate scaling and offset parameters based on the type of input hardware in use. See also *Stage (1 or 2) range minimum*.

Type: Section parameter

Menu levels: Setup, Extended

Range: #

Default: 0.0

Stage (1 or 2) range minimum

In open channel and compound installations, sets the scale for values from an external stage (level) source to be used by the meter. For example, if an acoustic downlooker is being used and is calibrated to output 4 to 20 mA from 1 to 5 feet, enter a minimum range of 1. The meter will calculate scaling and offset parameters based on the type of input hardware in use. See also *Stage (1 or 2) range maximum*.

Type: Section parameter

Menu levels: Setup, Extended

Range: #

Default: 0.0

Stage source

In open channel or compound installations, the source of stage (level) measurements used in determining the cross sectional area for use in calculating flowrate. Choose *acoustic* when stage measurement is being done by an integral uplooking level sensor. Two different stage sources can be chosen for each section. *Manual* allows entry of a fixed value, see parameter *Manual stage value*. *External* allows selection of an alternate input such as a 4-20 mA current loop or a BCD source. *Section* selects the level measurement from another flow measurement section for use.

Type: Section

Menu levels: Setup, Extended

Range: Off, Manual, External, Section, Acoustic

Default: Acoustic on *Stage 1 source*

Off on *Stage 2 source*

Surcharged integration method

In compound installations, this specifies the integration method to be used when the conduit is full. The choice of method depends on the shape of the conduit, placement of transducers, and other operational requirements, e.g., whether flow calculations should continue if one or more acoustic paths is not operating. Generally, the choice of integration method is determined based on requirements established at the time of system configuration and should not be changed without consulting Accusonic. In open channels, set Section parameter *Full pipe* to some large value, so that the meter will never switch to a surcharged integration method. See Chapter 3, *Flow Calculation Formulas*, beginning on page 3-18, for further information.

Type: Section parameter

Menu levels: Setup, Extended

Range: Chebyshev, Gaussian, Trapezoidal, Area

Default: Chebyshev

Temperature coefficient

Temperature is calculated based on the derived velocity of sound in the fluid. These coefficients are the terms of a fifth-order polynomial equation for fitting a temperature curve to a set of velocities.

Type: Section parameter

Menu levels: Extended

Range: #

English Default: Coefficients: #1 -62502.5156

#2 39.90736

#3 -0.00851368

#4 6.072802E-007

#5 0

Metric Default: Coefficients: #1 -32078.05

#2 67.25613

#3 -0.0471539

#4 1.105531E-005

#5 0

Temperature coefficients for 7500:

Enter these coefficients for operation in other than distilled water or if output in celsius units is desired.

Note

The figures displayed will be rounded to 6 significant figures but stored to 7 significant figures.

For Distilled water:

Metric units, output in degrees Celsius:
Temperature Coef. 1: -32078.05
Temperature Coef. 2: 67.25613
Temperature Coef. 3: -0.04715139
Temperature Coef. 4: 1.105531E-005
Temperature Coef. 5: 0

English units, output in degrees Fahrenheit:
Temperature Coef: 1: -62502.5156
Temperature Coef. 2: 39.90736
Temperature Coef. 3: -0.00851368
Temperature Coef. 4: 6.072802E-007
Temperature Coef. 5: 0

For Salt water (salinity= 35 ppt):

Metric units, ouput in degrees Celsius:
- Temperature Coef. 1: -68450.77
- Temperature Coef. 2: 138.8034
- Temperature Coef. 3: -0.0939744
- Temperature Coef. 4: 2.124461E-005
- Temperature Coef. 5: 0

English units, output in degrees Fahrenheit:
- Temperature Coef. 1: -125797.61
- Temperature Coef. 2: 77.7423
- Temperature Coef. 3: -0.0160364
- Temperature Coef. 4: 1.104515E-006
- Temperature Coef. 5: 0

Top weight

In open channel and compound installations, the top weighting velocity coefficient is used to correct the extrapolated surface velocity. This value is used only in multipath trapezoidal integration when the conduit is not surcharged. When using trapezoidal integration in a surcharged conduit, the *bottom velocity ratio* is used for calculating flow between the top path and the top of the conduit.

Note

The meter uses the velocities from the two top operating acoustic paths to extrapolate a velocity for the panel above the top path. See Section 3 page 3-24, Multi-path Trapezoidal Integration.

Type:	Section
Menu levels:	Setup, Extended
Range:	#
Default:	0.1

Totalizer cutoff time

Specifies the maximum time limit in minutes over which the flowmeter will interpolate flow if measurements are suspended or interrupted. See Chapter 3, *Section: Volume Totalizer After Outage*, page 3-25.

Type: Section parameter

Menu levels: Extended

Range: #

Default: 10

Travel time tolerance

The maximum allowable difference between measured travel time and the travel time calculated using speed of sound in the fluid and the path length. Expressed as a percentage. If this value is exceeded, the measurement is considered bad and the *consecutive bad measurement* counter is incremented.

Type: General parameter

Menu levels: Extended

Range: #

Default: 10

Units

Specifies whether English or metric units are in use. When this parameter is set to English, linear dimensions are expressed in feet, total volume in cubic feet, and flow in cubic feet/second. When set to metric, values are given in meters, cubic meters, and cubic meters/second.

Type: General parameter

Menu levels: Setup, Extended

Range: English, metric

Default: English

Velocity Substitution

If an acoustic path stops making good measurements, a velocity can be substituted for that path in calculating flowrate. In order for velocity substitution to take place, the Section parameter *Minimum number of good paths* must be reduced by the number of paths whose velocities can be substituted. If *Off* is chosen, no substitution will be performed. The last good measurement on the path will be used.

If *Ratio* is chosen, the velocity calculated for a mirror path will be used to calculate a velocity for the bad path. Typically, outer paths (i.e., paths 1 and 4) serve as mirror paths for each other and inner paths (i.e., paths 2 and 3) serve as mirror paths for each other. If there is no mirror path or if the velocity along that path is also bad, the meter will search for the first good path and will use that velocity in calculating a substitute velocity. The substitute velocity is calculated using ratios determined and entered into the meter at the time of system commissioning, when path velocities are logged at typical operating points and a velocity profile is established. See Path parameter *Velocity substitution ratio*.

The substitute velocity is calculated as:

Substitution velocity = good path's velocity x (bad path's velocity substitution ratio / good path's velocity substitution ratio)

The substituted velocity will not be used in logged data, and will not appear in RS-232 outputs (velocity will be dashed).

Note

Velocity substitution cannot be used with leak-detection systems, compound systems when the pipe is not full, or with trapezoidal integration.

Type: Section parameter

Menu levels: Extended

Range: Off, Ratio

Default: Ratio

Velocity Substitution Ratio

Ratios to be used in calculating substitute velocities for individual paths are determined during system commissioning by measuring average velocities for all paths at normal operating flowrates. See Section parameter *Velocity Substitution*. These velocities can be entered directly, if desired, or they can be normalized to path 1 and the calculated value entered. Following are two examples of how to determine velocity substitution ratios.

Example 1: The measurement section is installed in a turnout where the flowrate rarely changes. In this case, the velocity profile is known. There is no need to take a range of data points, and no need to normalize. Simply log velocities for long enough to get a good average, then enter the averaged velocities directly as ratios.

Path	Velocity
1	8.59
2	12.34
3	13.73
4	10.85

If path 3 were to fail, the flowmeter would use the velocity from path 2 (the mirror path) and calculate a substitute velocity using the formula:

Substitution velocity = good path's velocity x (bad path's velocity substitution ratio / good path's velocity substitution ratio)

13.73 = 12.34 X (13.73 / 12.34). In this example, 13.73 would be the substitute velocity. The accuracy of the substitution is very good in this case, because the flowrate (and consequently the velocity profile) doesn't change.

Example 2: The flowrate for the section usually ranges between 500 and 800 CFS. A set of velocities would be taken for each path over the range of flows as follows:

Path	Velocity @ 500	Velocity @ 600	Velocity @ 700	Velocity @ 800
1	4.02	4.95	5.66	6.43
2	5.34	6.57	7.72	8.96
3	5.13	6.24	7.29	8.53
4	4.53	5.65	6.86	8.01

The velocities at each flowrate would then be normalized to path 1 so that they can be averaged over the range of flows. To normalize, use the following calculation:

Path N ratio = Path N's good velocity / Path 1's good velocity

Path	Normalized Velocity @ 500	Normalized Velocity @ 600	Normalized Velocity @ 700	Normalized Velocity @ 800	Average Normalized Vel
1	1.00	1.00	1.00	1.00	1.000
2	1.328	1.327	1.364	1.393	1.353
3	1.276	1.261	1.288	1.327	1.288
4	1.127	1.141	1.212	1.246	1.182

The Average Normalized Velocity would then be entered as each paths Velocity Substitution Ratio.

If path 1 were to fail and the flowrate were 700 CFS, the flowmeter would use the velocity from path 4 (the mirror path) and calculate a substitute velocity using the formula:

Substitution velocity = good path's velocity x (bad path's velocity substitution ratio / good path's velocity substitution ratio)

Plugging in actual numbers yields: 5.803 = 6.86 X (1.00 / 1.182). In this example, 5.803 would be substituted for the original value of 5.66. The accuracy of the substitution will depend on the variation in velocity profile over the range of flows.

If good velocities are not known at the time of system setup, set the ratios to 1.0.

Type: Path parameter

Menu levels: Extended

Range: #

Default: 1.0

V FWD 1 - n

In open channel and compound installations, the forward average channel velocity constant, used only when the USGS single path integration method is chosen in section parameter *Single path integration*.

Type: Section

Menu levels: Setup, Extended

Range: #

Default: 0

V REV 1 - n

In open channel and compound installations, the reverse average channel velocity constant, used only when the USGS single path integration method is chosen in section parameter *Single path integration*.

Type: Section

Menu levels: Setup, Extended

Range: #

Default: 0

Volume scale factor

The flowmeter calculates flow rate in units determined by the *Flowrate scale factor*. The totals based on these flow rates are divided by the Volume scale factor to obtain volume in the desired units according to the following formula:

Volume in desired units = Totalized measured units / Scale factor

Some common volume scale factors are:

If flow is scaled to	Desired volume in	Set volume scale to
Cubic feet/second	acre-feet	43,560.0
	cubic feet	1.0
	liters	0.0353356
	gallons	0.13368984
	mg	133,689.84
Gallons/second	gallons	1.0
	mg	1,000,000.0
mgd	mg	86,400.0
Cubic meters/second	gallons	0.00379
	liters	0.001
	cubic feet	0.02833
Cubic meters/hour	1000 cubic meters	3,600,000.0

If a totalized pulse output circuit is used, each pulse represents an increment of one volume unit.

Type: Section parameter

Menu levels: Setup, Extended

Range: #

Default: 43,560 (English units)

1,000 (Metric units)

Weight

A weighting factor denoting the importance of the path. The path velocity is multiplied by the weight and other factors to determine flow rate. Path weights are assigned based on conduit shape and integration method. They should not be changed without consulting Accusonic. If 0 is entered the default value appropriate for the number of paths and integration method will be returned.

Type: Path parameter

Menu levels: Extended

Range: #

Default: 0.217079 (for outer paths of a 4-path section) using Chebyshev integration

0.568319 (for inner paths of a 4-path section) using Chebyshev integration

0.7854 (for both paths of a 2-path section) using Chebyshev integration

Which Section

Determine the source of stage (level) data, if a stage (level) value from another section is chosen for use in determining the cross-sectional area for use in calculating flowrate.

Type: Section parameter

Menu level: Extended

Range:

Default:

Width at path elevation

Width of the conduit at the path height. Used with the Gaussian integration method and in open channel installations. This value is from the as-built survey sheet prepared at the time of transducer installation and should not be changed without consulting Accusonic.

Type: Path parameter

Menu levels: Setup, Extended

Range: #

Default: 0

Zero flow offset

This value is added to the calculated flowrate to correct for zero flow offset. Example: If flowrate is displayed as 2.1 CFS at zero actual flow, enter -2.1 to correct the offset.

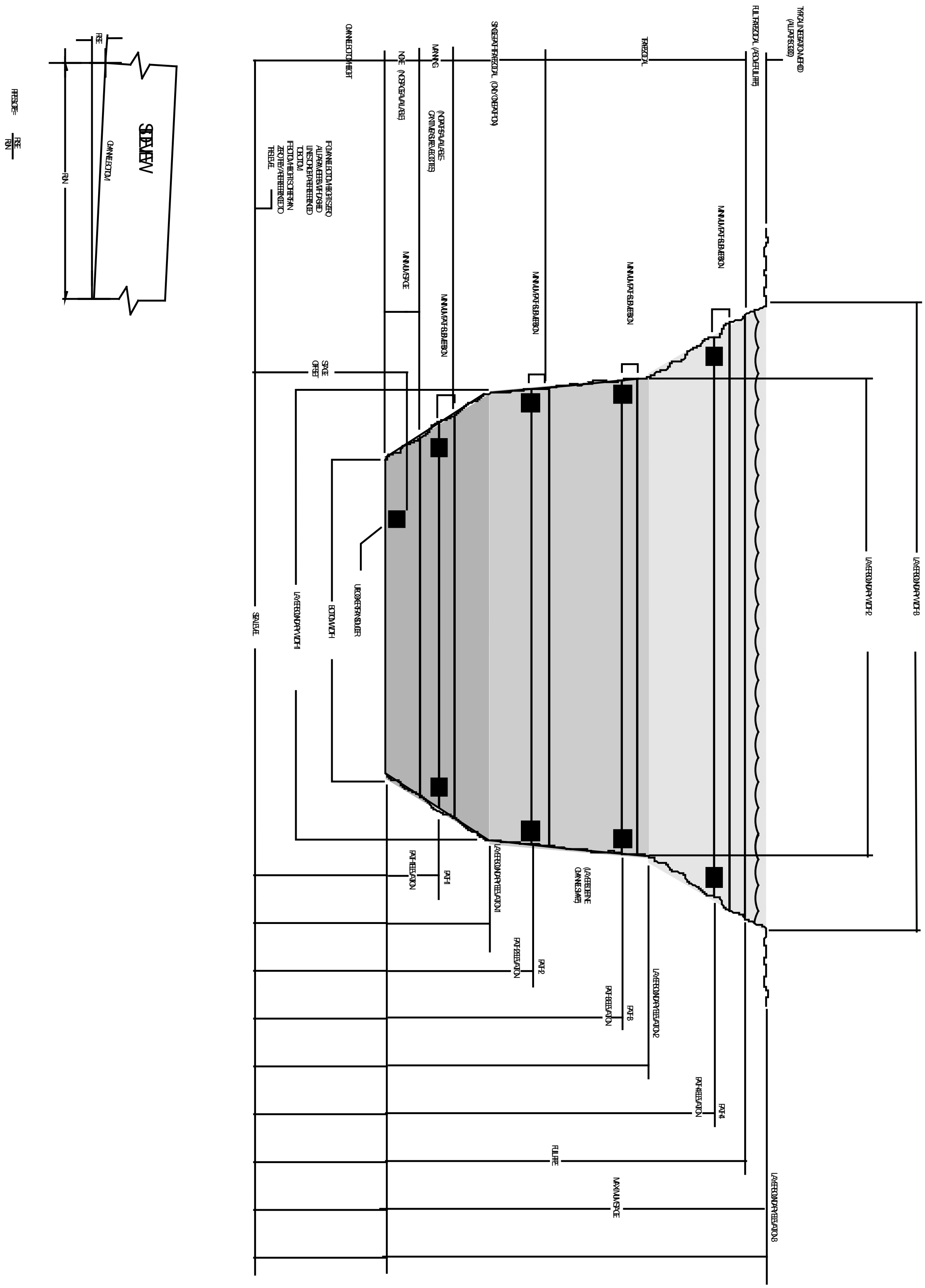


FIGURE 7-10 OPEN CHANNEL AND CONDUIT SYSTEM PARAMETERS

Variable List

Variables are listed in alphabetical order. All variables are available at all menu levels.

Any Volume Variable (positive, negative or total) can be reset by entering 0 while the variable is displayed. All volumes in the system can be reset by selecting RESET from the top-level menu.

Averaged stage

The running average of stage measurements in the measurement section as calculated using the number of measurements specified in the parameter *Averaging size*. This will be the average of Stage 1 and Stage 2 if both are being used and are within the parameter *Maximum stage difference 1 and 2.*

Type: Section variable
Display Screen: 2

Average velocity of sound

Average of velocities of sound through the fluid in the measurement section or some combination of sections, as calculated for the individual paths.

Type: Section and End variable

Average temperature

Average temperature of fluid in the measurement section or some combination of sections, as calculated using temperatures calculate for individual paths.

Type: Section and End variable
Display Screen: A

Delta flow

The difference between instantaneous flowrates calculated at the two ends of a pipeline leak detection system. This value is added to the differential flow averaging queue.

Type: Leak detection variable
Display Screen: 6

Delta flow average

The running average of the difference between flowrates at two ends of a pipeline leak detection system.

Type: Leak detection variable
Display Screen: 6

Differential flow warning

Reads "OFF" unless the differential flow average has exceeded the leak detection parameter *Differential warning threshold*. If the threshold is exceeded, a warning relay closes as this variable changes to ON.

Type: Leak detection variable
Display Screen: 6

Differential flow alarm

Reads "OFF" unless the differential flow average has exceeded the leak detection parameter *Differential alarm threshold*. If the threshold is exceeded, an alarm relay indicating a leak closes as this variable changes to ON.

Type: Leak detection variable
Display Screen: 6

Flow average

Average flow rate through the measurement section or some combination of sections, as calculated using the number of flow rate measurements specified in the parameter *Averaging queue length*.

Type: Section and End variable
Display Screen: 1,2,8,A

Flow error count

The number of consecutive errors in the flow error counter. When this count exceeds the parameter *Maximum bad measurements*, an error is flagged. The error count is reset to 0 when flow is good.

Type: Section variable

Flowrate

The flowrate calculated for the measurement section from individual path velocities.

Type: Section and End variables

Forward gain

This gain level is adjusted in response to the single strength of the last acoustic pulse received in the forward direction on this path. The receiver will be set at this gain level the next time a measurement is taken in the same direction on this path.

Type: Path variable
Display Screen: 9,0

Forward time

Forward travel time in seconds (in the downstream direction) for the individual path.

Type: Path variable

Negative volume

Accumulated volume in the negative direction in the measurement section or some combination of sections.

Type: Section and End variable
Display Screen: 1

Positive volume

Accumulated volume in the positive direction in the measurement section or some combination of sections.

Type: Section and End variable
Display Screen: 1,5

Reverse gain

This gain level is adjusted in response to the signal strength of the last acoustic pulse received in the reverse direction on this path. The receiver will be set at this gain level the next time a measurement is taken in the same direction on this path.

Type: Path variable
Display Screen: 9,0

Reverse time

Reverse travel time in seconds (in the upstream direction) for the individual path.

Type: Path variable

Section status

Status codes based on internal system diagnostics. The first set of 8 digits after the section number are path status or error codes (PATH); the next set of two digits/characters represent stage or level (SG), followed by overall section status (S) and two digits representing self-test (ST). See Chapter 9 for detailed code explanations and recommended actions.

Type: Section variable
Display Screen: 1,2,6,7,8,A

Signal delay

Total electronic signal delay in the system. The delay is calculated based on parameters entered for cable length, transducer type, signal detection method, etc..

Type: Path variable

Stage 1

The instantaneous elevation of the water surface relative to the site datum is computed from data from the stage sensor, which may be an acoustic uplooking transducer, an acoustic downlooking transducer, or a pressure sensor. If there are redundant stage sensors in one metering section, *Stage 2* will appear as a variable as well.

Type: Section variable

Stage 1 signal delay

The total electrical and mechanical signal delay, which is subtracted from the acoustic travel time. This value includes cable, receiver, and transducer delays and is calculated by the system based on parameters entered.

Type: Section variable

Total average flow

The sum of the flow averages through all measurement sections.

Type: General variable
Display Screen: 1,2,5,6,7,8,A

Total Flow

The sum of the instantaneous flow rates through all measurement sections.

Type: General variable

Total negative volume

The sum of accumulated negative volumes of all measurement sections.

Type: General variable
Display Screen: 1

Total positive volume

The sum of accumulated positive volume of all measurement sections.

Type: General variable
Display Screen: 1

Total volume

The sum of all accumulated positive and negative volumes of all measurement sections.

Type: General variable
Display Screen: 7,8,A

Velocity

The average velocity calculated for the individual path.

Type: Path variable
Display Screen: 3,4

Velocity error count

The number of consecutive errors in the velocity error counter. When this count exceeds the parameter *Maximum bad measurements*, if the number of good paths is less than the parameter *Minimum good paths*, flow calculation stops and an alarm is signaled. Otherwise, the last good velocity for the path is used in calculating flowrate.

Type: Path variable

Velocity of sound

Velocity of sound calculated for the individual path using measured travel times.

Type: Path variable

Volume

The sum of accumulated positive and negative volumes through the measurement section or some combination of sections.

Type: Section and End variable
Display Screen: 7,8,A

GENERAL VARIABLES

General variables reflect the overall operation of the flowmeter. They are listed below.

- Total average flow
- Total flow
- Total negative volume
- Total positive volume
- Total volume

SECTION AND END VARIABLES

Section variables monitor detailed operation of one section. End variables monitor the operation of one end of a pipeline or penstock, which might be composed of a single section or of more than one section. Section and End variables are listed below.

- Averaged stage[1]
- Average velocity of sound
- Average temperature
- Flow average
- Flow error count[1]
- Flowrate
- Negative volume[2]
- Positive volume[2]
- Section status[1]
- Stage 1 and/or 2[1]
- Stage 1 and/or 2 signal delay[1]
- Volume[2]

PATH VARIABLES

Path variables monitor operation of individual paths. Path variables are listed below.

- Forward gain
- Forward time
- Reverse gain
- Reverse time
- Signal delay
- Velocity
- Velocity error count
- Velocity of sound

LEAK VARIABLES

Leak detection variables reflect the differential flowrates of more than one end. Leak detection variables are listed below.

- Delta flow
- Delta flow average
- Differential flow warning
- Differential flow alarm

---

[1] Section variable only

[2] May be reset to zero by entering 0 via the control panel while the variable is displayed. Resetting these variables has no effect on external totalizers.

FORCED PAGE BREAK FOR PAGE NUMBERING REASONS. REMOVE FROM MANUAL.

Chapter 8
Outputs and Reports

Outputs

The flowmeter can be tailored to output a variety of flowmeter variables in a format suitable for use by a process controller (plc) or external computer. For example, the outputs may be used to drive a real time data acquisition system or even a spreadsheet.

Data values can be output in analog or digital form; events and alarms may also appear as relay contact closures. Analog outputs are typically 0-10 V or 4-20 mA; digital data is typically in ASCII format from the RS-232 ports, although other specialized outputs are available.

Suggestion for Testing Outputs

Use simulated data as a simple way to test analog and digital output parameters. To exercise all settings, run the system with simulated values at minimum and maximum output ranges, at one or more points in range, and also at overflow and underflow values. This is usually easier than altering actual fluid flow to test the outputs. For further information, refer to the descriptions of the path parameters *Simulation Velocity* and *Simulation Velocity Ramp Scale* in Chapter 7 on page 7-25.

When connecting to outputs, operation of external equipment and correct connection can be easily verified by the use of the I/O diagnostics. Verification routines for the various outputs are found under the *Diagnose* menu choice. Procedures for following these routines are set out below. Menu choices will only appear for installed hardware. Analog outputs can be set to zero, half-scale, or full-scale. Relay and totalizer outputs can be toggled. This provides a quick way to verify hardware operation without software/setup complications.

Analog Outputs

This section describes how to set up the analog outputs for a specified section variable. It also explains how to scale each output and define its behavior during error conditions.

Setting Up Analog Outputs

To set up analog outputs, select *Configure* from the main menu, then select *Output*. From the *Output* menu, select *Analog*. The menu shows a choice for every output installed at the factory. These are labeled *Analog1*, *Analog2*, etc. Each analog output can be independently assigned to one of several variables. More than one analog output may be assigned to the same variable.

Determining Offsets and Scale Factors

Each output may be independently scaled. Once you have selected the desired variable, the menu prompts for *maximum* and *minimum*. The *maximum* is the value of the variable for which a full scale analog output is required, the *minimum* is the value of the variable for which a minimum output is required (typically 4mA for 4-20mA output or 0V for 0-10V output).

The lower limit of any output may be set to zero or to any value. The following two examples illustrate how this is done.

Example 1:	Desired output value:	Flowrate
	Desired output range:	0 to 450 CFS

Set the following parameters:

ANALOG1	= FLOWAVG
MAXIMUM	= 450.0
MINIMUM	= 0

Example 2:	Desired output value:	Flowrate
	Desired output range:	-100 to +300 CFS

Set the following parameters:

ANALOG1	= FLOWAVG
MAXIMUM	= 300
MINIMUM	= -100

The value going to the output is the same value as seen on the screen; i.e., it is scaled to CFS, MGD, etc.

Selecting Action for Flowmeter Section Error Conditions

There are two possible error conditions which can occur with an analog output. The first and most important is the behavior of the output on a system failure of some kind, for example, an insufficient number of good paths. In this case, the example below illustrates the options for analog output behavior under these conditions. Note that the flowrate display will be dashed.

The second error condition occurs when the flowmeter output variable is outside the dynamic range of the analog output device. Under these conditions, the analog output clamps at the lowest output level if the output variable underflows or at the highest output level if the output variable overflows. For example, if the output range of the variable flowrate is defined to be 0-1,000 cfs, corresponding to 4 to 20 mA output, a flowrate of 1,010 cfs or a negative flowrate drives the analog output to 20 mA or to 4 mA, respectively. Voltage outputs behave in the same manner.

During analog output setup, the menu prompts for the *Error Action* to be taken by the output during a system error condition. The two choices are *Hold* and *Fixed*.

Hold causes the output to remain at the same value as before the error.

Fixed prompts for the value you would like the output to go to under an error condition. The *Fixed Value* entered is conditioned by the parameters *maximum* and *minimum* before it is output to the analog channel, as shown in the following example.

Example 3:	Desire output value:	Flowrate
	Desire output range:	0 to 450 CFS
	Desired output on system error:	450 CFS
Set the following parameters:		
	ANALOG1	= FLOWAVG
	MAXIMUM	=450.0
	MINIMUM	= 0
	ERROR ACTION	= FIXED VALUE
	FIXED VAL	= 450

With a small adjustment to the scaling and offset factors, the error action feature can be used to remotely signal an error condition. In the example shown, the normal output will be from 2.2% to 100% of the range. During an error event, the flowrate at the output will be 0% (-10 CFS, an impossible plant condition), indicating an error. Note that a small part of the output range will be lost (in this case 2.2%), causing a small loss in resolution.

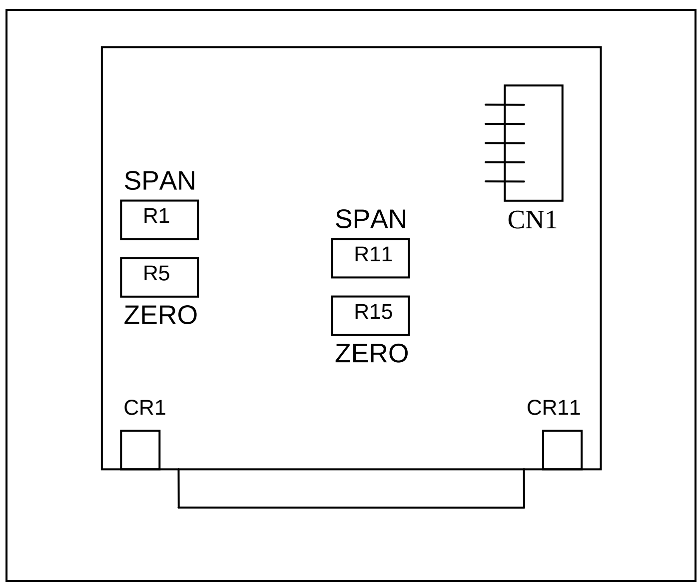
Example 4:	Desire output value:	Flowrate
	Desire output range:	0 to 450 CFS
	Desired output on system error:	-10 CFS
Set the following parameters:		
	ANALOG1	= FLOWAVG
	MAXIMUM	=450.0
	MINIMUM	= -10
	ERROR ACTION	= FIXED VALUE
	FIXED VAL	= -10.0

Verify Analog, Relay and Totalizer Outputs

The following procedure is used to verify that analog outputs (e.g., 0-10V or 4-20mA), relays, and totalizers are operating correctly. The procedure begins at the main menu.

Top line of the display shows:	Press key(s)	Explanation
configure operate reset [DIAGNOSE]	**Enter**	Accept *Diagnose*
[SYSTEM] transceiver hardware utils	→→	Select *Hardware*
system transceiver [HARDWARE] utils	**Enter**	Accept *Hardware*
[OUTPUTS] inputs	**Enter**	Accept *Outputs*
If the system has been configured for outputs, the first output and type of output will appear on the display. Pressing the down or up arrows will toggle between installed outputs. Start with the first output shown. The following procedure shows an analog (e.g., 0-10V or 4-20mA) output.		
OUT1 Analog 8-bit channel 0	**Enter**	To show current output level
OUT1 Analog 8-bit channel 0 = zero	**Enter**	To toggle to half or full scale
Watch the external output device to see if it reads at the corresponding level (i.e., representing zero, half-scale or full-scale) as the output is toggled. Relay outputs will toggle between On *and* Off. *Volume totalizers will increment each time* Enter *is pressed.* *Pressing* Escape *once returns to the output listing. Use the down arrow to toggle through the list and test each output. After testing all outputs, press* Escape *twice to return to the previous menu. Remember to reset the volume totalizers that have been incremented during this procedure.*		

Field Adjustment Procedure for 2-Channel 4-20 mA Output



Equipment required:

- Misc screwdrivers
- Small flat-bladed screwdriver
- Calibrated Digital Ammeter

Procedure:

1. Turn off power to the flowmeter.
2. Locate the six-pin output terminal strip. This will be mounted on the right-hand side of the path-select panel in NEMA enclosures, and on the rear panel in rack-mount enclosures. The output driver board is located behind connector.
3. It may be necessary to disconnect the path

cables to adjust the outputs in a NEMA enclosure. Do this only if required. There is usually enough service loop in the cables to allow lowering the panel.

4. On NEMA units, there are four captive thumbscrews in the corners of the path-select panel. These allow the panel to be lowered for access to the output converter boards.
5. For rack-mount units, the rear panel can be lowered by removing four flat-headed screws in the corners of the rear panel. If the unit is being used as a portable, the rack ears (sides) of the unit may need to be removed first (six #2 phillips screws each).
6. The output converter will be a small circuit board approximately 3 inches (75mm) square. It plugs into the six-pin output terminal strip.
7. The board should be calibrated while connected to the operating load. Disconnect one side of the output loop and connect the Ammeter in series.
8. Disconnect the wire from pin 2 of the terminal strip and connect Ammeter positive lead to pin 2. Connect ammeter minus lead to the wire removed from pin 2.
9. From main 7500 menu, choose [DIAGNOSE], then select [HARDWARE], then [OUTPUTS]. Scroll down through the menu until you come to 12-bit Analog output channel 0. Press ENTER and the display will respond with ‘-> zero’. The output is now set to 0 scale.
10. Set the channel 0 ZERO potentiomer (labelled R1 on the board) so that the ammeter reads 4.00 mA
11. Press ENTER twice more. The display will respond with ‘-> full’. The output is now set to full scale.
12. Set the channel 0 SPAN potentiomer (labelled R5) to read 20.00 mA.
13. Pressing ENTER will scroll through zero, half, and full-scale. Verify that zero is still 4.00 mA (tweak if necessary), and that half-scale is 12.0 mA.
14. Disconnect the ammeter and reconnect the wire you removed from pin 2.
15. Disconnect the wire from pin 5 of the six-pin terminal strip and connect Ammeter positive lead to pin 5. Connect ammeter minus lead to the wire removed from pin 5.
16. Press ESC to exit from testing channel 0. Press the down-arrow to go down to the second output, 12-bit Analog output channel 1.
17. Press ENTER and the display will respond with ‘-> zero’.
18. Set the channel 1 ZERO potentiomer (labelled R11 on the board) so that the ammeter reads 4.00 mA
19. Press ENTER twice more. The display will respond with ‘-> full’. The output is now set to full scale.
20. Set the channel 1 SPAN potentiomer (labelled R15) to read 20.00 mA.
21. Pressing ENTER will scroll through zero, half, and full-scale. Verify that zero is still 4.00 mA (tweak if necessary), and that half-scale is 12.0 mA.
22. Disconnect the ammeter and reconnect the wire you removed from pin 5.
23. Repeat for any additional output boards. If there are multiple boards, they can be unplugged from their output connector to gain access to lower boards. There is no need to turn the power off when doing this, only the output loop is being broken.
24. Press ESC to exit the current channel test. Press the down-arrow to scroll down to the next output. Repeat the above steps for all outputs.
25. When calibration is complete, Turn off power and reverse the disassembly process. The calibration is complete.

Relay and Totalizer Outputs

Flowmeter options include general purpose operator-assignable relays and a watchdog relay. Relays may be wire-OR'd or diode-OR'd together to derive composite signals. Each relay has a separate user-set software counter. The relay-activating condition must continue for the number of measurements exceeding this counter value before the relay will activate.

General purpose relays

The flowmeter may be equipped with one or more general purpose relays. Each relay is a 2–Form C (DPDT) with both make and break contacts. When a relay activates, its make contacts close and its break contacts open. The electrical specifications are given in Table 8-2 on page 8-8.

The function of each relay is set and can be reassigned from the menus on the control panel. An example procedure is set out later in this Chapter. No relay functions are assigned at the factory unless specified by the customer at the time the order is placed.

A relay can be assigned to one of several functions. Not all of the functions need to be assigned (there may be fewer relays installed than there are functions), nor must every relay be assigned to a function - it may be reserved for a future use. The following lists the name of each function, its shorthand notation (which is what appears in the control panel menus) and how it operates:

***Section Status - SSTAT* -** Activates when a path returns too many consecutive bad measurements and there are no longer enough good paths to make a flow calculation for that section. Indicates that the section variable *Section Status* does not equal 1 (good) or 9 (off) or S (path substitution in use) for a number of consecutive bad measurements exceeding the general parameter *Maximum bad measurements.*

***Self Test Failure - SELFTEST* -** Activates when the system detects too many bad self tests in a row on a flow transmitter.

Indicates that the flow transmitter self test result is not equal to 1 (good) or 9 (off).

***Loss of Signal - SIGLOSS* -** Activates if no signal is detected on one or more paths in the section.

***Mismatched gain on two directions of one path - GAIN* -** Activates whenever the gain between the forward and reverse directions on any path differs by more than 6 dB. This can be an early warning of cable or transducer failure. This condition is not considered a bad measurement.

***System Error - SYSTEM* -** Activates when any of the functions *Section status, Stage status, Self test failure* or *Loss of Signal* activates. System relays can be assigned to an individual section or as a General relay, in which case it will close on any of those conditions in any section.

Flow measurements - FLOW **-** Activates when specified flow condition occurs (four options):

- ***Flow is Positive - FLOWPOS*** **-** Flow measured through a section is in the forward direction.
- ***Flow is Negative - FLOWNEG*** **-** Flow measured through a section is in the reverse direction.
- ***Flow Over Error - FLOWOVER***[1] **-** Exceeds a specified value for a specified number of consecutive measurements.
- ***Flow Under Error - FLOWUNDER***[1] **-** Flowrate is below a specified value for a specified number of consecutive measurements.

Stage-Activates as follows:

- **Stage Over**[1] **-** Average stage (water level) measured is higher than a specified value.
- **Stage Under**[1] **-** Averaged stage (water level) measured is lower than a specified value.
- **Stage Error -** No stage (water level) data is provided by any level sensor. If there are multiple stage sources, relay will not activate until ALL are bad.

Leak Detection (Refer to Leak Detection - Chapter 12)

Differential Flow **-**The differential flow relay activates to indicate a leak in the pipeline. Each relay corresponds to a differential flow threshold parameter, as follows:

- **Differential flow warning -** Differential warning threshold.
- **Differential flow alarm -** Differential alarm threshold.

Velocity measurements **- VELOCITY -** Activates when excessive velocities are measured in the forward or reverse direction. This capability is designed to provide Leak Detection capability with only a single-point measurement. Therefore, because velocities may be very high, Signal Quality filtering is not used. Each relay corresponds to an over-velocity threshold parameter, as follows:

- **Positive over-velocity warning -** Positive over-velocity warning threshold.
- **Positive over-velocity alarm -** Positive over-velocity alarm threshold.
- **Negative over-velocity warning -** Negative over-velocity warning threshold.
- **Negative over-velocity alarm -** Negative over-velocity alarm threshold.

[1] For the Over and Under functions, the menu system prompts for both the under/over limit and the number of consecutive bad measurements allowed before the alarm activates.

Table 8-1 General Purpose Relay Specifications	
Relay Type	2–Form C
Contact material	Gold-clad silver alloy
Contact resistance (initial)	50 mOhm
Contact resistance (end of life)	200 mOhm
Max switched rating	60 W or 125 VA
Max switched voltage	50 V AC or DC
Mechanical life, operations	100,000,000
Electrical life, operations Dry circuit 30 VDC, 2A 125 VAC, 1A 30 VDC, 1A 125 VAC, 1/2A	 50,000,000 500,000 500,000 2,000,000 2,000,000
Operate time, typ	3 ms
Release time, typ	2 ms
Contact bounce, NO side, typ	1.5 ms
Contact bounce, NC side, typ	2.5 ms
Contact to contact capacitance, typ	1.0 pF
Contact to coil capacitance, typ	2.0 pF
Insulation, 25°C,50% R.H., 500 VDC	1000 MOhm, min

Totalizer Output

A totalizing accumulator increments each time a specified volume is measured through one section or all sections. The totalizer can be tailored to activate on the basis of the positive flow measurement or the negative flow measurement.

A totalizer indicates that *Total Volume* (or *Positive volume* or *Negative volume*) has incremented. It is important that the value of *Volume scale factor* be chosen so that no more than one increment can occur during a single measurement period. The system can produce only one totalizer pulse per measurement.

An example of setting up the totalizer outputs is set on page 8-11 of this chapter.

System Failure or Watchdog relay

The watchdog relay activates if there is a hardware or a software error detected by the system controller. This is a low-power relay.

Table 8-2 Watchdog Relay Specifications

Relay Type	1-Form C
Contact resistance, initial	200 mOhm
Max switched rating	3 W
Max switched voltage	28 V
Max switched current	.25 A
Electrical life, operations Low levels Rated load	 100,000,000 10,000,000
Operated time, typ	0.25 ms
Release time, typ	0.25 ms
Contact bounce, NO side, typ	0.5 ms
Contact bounce, NC side, typ	1.5 ms
Insulation, 20°C	10^{10} Ohms

Setting Up the General Purpose Relays

In this example, relay number 2 is assigned the function SSTAT.

Top region of the display	Press key(s)	Explanation
[CONFIGURE] operate reset diagnose	**Enter**	Accept *Configure*
[PARAMETER] variable outputs reports	**→→**	Select *Outputs*
parameter variable [OUTPUTS] reports	**Enter**	Accept *Outputs*
[RS232] analog digital relay totals	**→→→**	Select *relay*
rs232 analog digital [RELAY] totals	**Enter**	Accept *Relay*
[RELAY 1] relay 2 ...[1]	**→**	Select *Relay 2*
relay 1 [RELAY 2] ...	**Enter**	Accept *Relay 2*
RELAY 2 **Output switch: [OFF] on**	**→ Enter**	Turn relay *on*
RELAY 2 **Output type: general [SECTION] leak**	**Enter**	Accept *Section*
[SECTION 1] **ON**	**Enter**	Accept *Section 1*
RELAY 2 SECTION 1 **Output when [SSTAT] selftest >>**	**Enter**	Accept *SSTAT*
RELAY 2 SECTION 1 **Max. Bad Measurements: 0**	**Type any value and Enter**	Define the relay counter value
RELAY 2[2] **Press Esc...**	**Esc Esc Esc**	Return to main menu
[CONFIGURE] operate reset diagnose		At main menu

Before leaving the Outputs menu you will be asked whether to save the outputs you have defined. Follow the procedure described in Chapter 5 for saving to battery-backed memory or to a diskette.

[1] Additional relays are listed if they are installed.

[2] Pressing Esc once here returns you to the Relay 1, Relay 2... menu where you may assign other relays.

Setting Up the Totalizer Outputs

In this example, Totalizer number one is assigned to indicate an increment in positive volume in flowmeter section 1.

Top region of the display	Press key(s)	Explanation
[CONFIGURE] operate reset diagnose	**Enter**	Accept *Configure*
[PARAMETER] variable outputs reports	**→→**	Select *Outputs*
parameter variable [OUTPUTS] reports	**Enter**	Accept *Outputs*
[RS232] analog digital relay totals	**→→→→**	Select *Totals*
rs232 analog digital relay [TOTALS]	**Enter**	Accept *Totals*
[TOTALIZER 1] totalizer 2 ...[1]	**Enter**	Accept *Totalizer 1*
TOTALIZER 1 **Output Switch: off [ON]**	**Enter or** **→ Enter**	To turn totalizer relay on
TOTALIZER 1 **Output type: general [SECTION]**	**Enter**	Accept *Section*
[SECTION 1] **ON**	**Enter**	Accept *Section 1*
TOTALIZER 1 SECTION 1 **Section variable: [PVOLUME] nvolume**	**Enter**	Accept *PVolume*
TOTALIZER 1[2] **SECTION 1** **Press Esc...**	**Esc Esc Esc**	Return to main menu
Before leaving the Outputs menu you will be asked whether to save the outputs you have defined. Follow the procedure described in Chapter 5 for saving to battery-backed memory or to a diskette.		
[CONFIGURE] operate reset diagnose		At main menu

[1] Additional totalizers are listed if they are installed.

[2] Pressing Esc once here returns you to the Totalizer 1, Totalizer 2... menu where you may assign other totalizers.

Verify Relay and Totalizer Outputs

The procedure for verifying general purpose relay and totalizer outputs is set out on page 8-4.

Summary of Data Storage Options

The following describes the difference between *Reports*, *Data logging*, *Listings*, *Parameter load/save, Error Reporting*, and *RS-232 Output*. Data Storage type is shown in **BOLD**. Samples are shown in Small Type.

RS-232 Output

- What is stored:

One output of each variable after measurement cycle.
If "averaged" outputs are selected, they are averaged over the selected averageing queue length.

- Format:

AXCII text, with Token identifiers before each variable.

- Destination device:

Serial Port - designed to go to a Terminal or PC for logging.

- Sample:

```
DATE: 12.01.94
TIME: 16.25.29

FLWA-1: 138.49765
VEL1-1: 2.8787517
VEL2-1: 3.2599885
VEL3-1: 3.2887631
VEL4-1: 3.1109835

FLWA-2: 138.95862
VEL1-2: 2.8566508
VEL2-2: 3.2461038
VEL3-2: 3.3234835
VEL4-2: 2.9337661
```

Reports

- What is stored:

Averaged output of flow, stage, volumes, and totals (in a multi-section meter).
Time and Date are included.
Start time and report interval can be selected.
Text headers can be customized.

Note: *The averaged output value of each variable = (sum of all measurements / number of measurements during the report period).*

- Format:

ASCII text, English language headers.

- Destination devices:

Printer, Floppy Disk

- Sample:

```
Karr Dam Power Plant
                    Quarterly Report

                              FLOW     STAGE    P-VOL
                          ======== ======== ========
Mon Mar 06 1995 13.00.20      321 measurements
  END-1  (100% good)     1000.000  --------     1900
  END-2  (100% good)     1002.000  --------     1870
  END-3  (100% good)     2120.000  --------     2100
                          ======== ======== ========
                 totals:  4122.000              5870

Mon Mar 06 1995 14.00.30      323 measurements
  END-1  (100% good)     1000.000  --------     2100
  END-2  (100% good)     1003.000  --------     2070
  END-3  (100% good)     2100.000  --------     2532
                          ======== ======== ========
                 totals:  4103.000              6702
```

Datalogging

- What is stored:

Averages of flowrate, Volume, Stage, and Velocities.
Start time and datalog interval can be selected.

Note: *The averaged output value of each variable = (sum of all measurements / number of measurements during the report period).*

- Format:

Comma-delimited ASCII test with a quote-delimited time/date stamp. Designed to be read directly into popular speadsheets.

- Destintation devices:

Floppy Disk, Printer (printer output is not very useful).

- Sample:

```
"950306132143",1000.300,0,,,100
"950306132155",1010.400,0,,,100
```

Listings

- What is stored:

Textual representation of parameters and/or variables. Text only, cannot be loaded back into the flowmeter in this format.

- Format:

ASCII text

- Destination devices:

Printer, Floppy Disk

- Sample:

7500 Software: REV 4.12
Customer: Ypsilanti Power
Job No.: FP12345

Parameter List

Gen. Parameters

Menu Access: extended
Repetition Time (sec.): 2
Self Test Interval (sec.): 100
Stage Interval (sec.): 5
Leak Detection Switch: off
Stage Mode: fast
Data Logging: off
Log Data To: disk
Data Log Start: 00.00.00
Log Interval: 00.10.00
Error Reporting: off
Auto Start Switch: off
Inactivity timeout (min): 0
Units: english
Speed of Sound in Fluid: 4800.0
Password Control: off
Averaging Queue Length: 10
Max. Bad Measurements: 10
Travel Time Tolerance: 20.0
Display mode: both
Display totals line: on
Current Time: 13.20.30
Current Date: 03.06.95

Section 1 Parameters
Section Switch: on
Section Type: pipe
Pipe Integration: cheb
Radius: 5.0000
Stage 1 Source: acoustic
Stage 2 Source: off
Average Cable Length Per Path: 0.0
Ducer Connection: single
Sig. Det. Method: 1st_neg

Parameter load/save

- What is stored:

Binary representation of parameters. Used only to save parameters to disk.

- Format:

Binary

- Destination devices:

Flowmeter (battery-backed RAM), Floppy Disk.

- Sample:

Not available, not readable by eye.

Error Reporting

- What is stored:

Flowmeter results during error conditions. This is a log of variables recorded during periods when acoustic paths have failed or flowrate cannot be measured, to be used as troubleshooting information.

Instantaneous values of Flowrate, Stage(s), Velocities, and Gains can be selected.

- Format:

ASCII text. Designed to be read on-site with a laptop computer equipped with any text editor.

- Destination device:

Floppy disk file with filename ERRLOG.HIS.

- Sample:

```
Nov 18 10:21:04    1      21111111 1  B 1
        FLOW       702.062832
      STAGES       5.100000  0.000000  5.100000
        VELS       1.400000  1.200000  1.300000  1.400000  1.500000  1.600000  1.700000  1.800000
   FWD GAINS       45  3  3  6  4  3  6  6
   REV GAINS       48  3  4  5  3  4  8  6
```

RS-232 Outputs

A single RS-232 port is available in the basic flowmeter; others are optional and must be configured at the factory. Refer to page 4-9 for RS-232 Cable Configuration Information. Each available RS-232 port may be independently configured to output one or more selected flowmeter variables.

Data is normally output at the conclusion of each measurement cycle.The output stream from each port is a series of message segments in ASCII format delimited by carriage return/linefeed pairs (i.e., ASCII **OD/0A**$_{16}$ or **012/015**$_{8}$). An additional carriage return/linefeed pair terminates the output from each measurement.

There is at least[2] one message segment in the stream for each variable. A message segment consists of the (abbreviated) variable name followed by the colon character (ASCII value **03A**$_{16}$ or **072**$_{8}$) followed by its value. The format of the value depends on the variable.

In addition to the usual RS-232 setup parameters (baud rate, start/stop bits, etc.), a menu choice is provided for compatibility with Accusonic 7430-series controllers. This choice allows the user to select several different protocols:

- STX ETX. When selected, a Start-of-Text character (ASCII 2) will be transmitted before the measurement data packet. An End-of-Text character (ASCII 3) will be transmitted at the end of the packet.
- POLL. The 7500 will not transmit any data until it receives a polling character (ASCII $0F_{16}$ or 015_{8}).
- BOTH. The 7500 will wait for a polling character, then transmit a data packet framed by STX/ETX characters. Select this option for operation with a 7430-series controller.

Table 8-1 (page 8-17) lists the flowmeter variables available via the RS-232 ports. It shows the abbreviation for each as it appears in the message segment and details the format of the value reported. Variables are listed in the order in which they appear in the setup menu and in which they will be output.

To configure the RS-232 outputs, refer to the procedure that follows the table.

[2]For variables with multiple values (e.g. path velocities) there is a separate packet for each value.

Table 8-3 Variables Available via RS-232

Variable Name	Data Format[1] in Message Segment
General Variables	
Total flow	TLFLOW: [-]nnn.nnnnn[e-rrr]<CR><LF>
Total average flow	TLFLWA: [-]nnn.nnnnn[e-rrr]<CR><LF>
Total volume	TLVOLM: [-]nnn.nnnnn[e-rrr]<CR><LF>
Total positive volume	TLPVOL: [-]nnn.nnnnn[e-rrr]<CR><LF>
Total negative volume	TLNVOL: [-]nnn.nnnnn[e-rrr]<CR><LF>
Time:	TIME: hh.mm.ss<CR><LF>
Date:	DATE: mm.dd.yy<CR><LF>
Section Variables	
Flowrate	FLOW-<s>: [-]nnn.nnnnn[e-rrr]<CR><LF>
Flow average	FLWA-<s>: [-]nnn.nnnnn[e-rrr]<CR><LF>
Volume	VOLM-<s>: [-]nnn.nnnnn[e-rrr]<CR><LF>
Positive volume	PVOL-<s>: [-]nnn.nnnnn[e-rrr]<CR><LF>
Negative volume	NVOL-<s>: [-]nnn.nnnnn[e-rrr]<CR><LF>
Averaged Stage	STAG-<s>: [-]nnn.nnnnn[e-rrr]<CR><LF>
Section status	STAT-<s>:cccccccccccccccc<CR><LF>
Integration method	INTG-<s>:iiii<CR><LF>
Path velocities	VEL<p>-<s>: [-]nnn.nnnnn[e-rrr]<CR><LF>
Path travel times fwd	TMF<p>-<s>: [-]nnn.nnnnn[e-rrr]<CR><LF>
Path travel times rev	TMR<p>-<s>: [-]nnn.nnnnn[e-rrr]<CR><LF>
Path gains fwd	GNF<p>-<s>:gg<CR><LF>
Path gains rev	GNR<p>-<s>:gg<CR><LF>
Velocity of sound	VSD<p>-<s>: [-]nnn.nnnnn[e-rrr]<CR><LF>
Average velocity of sound	AVG<p>-<s>: [-]nnn.nnnnn[e-rrr]<CR><LF>
Average temperature	TEMP-<s>: [-]nnn.nnnnn[e-rrr]<CR><LF>

Table 8-3 Variables Available via RS-232 (continued)

Leak Detection Variables	
Delta flow	DFLW-1: [-]nnn.nnnnn[e-rrr]<CR><LF>
Delta flow avg.	DFLA-l: [-]nnn.nnnnn[e-rrr]<CR><LF>
End Variables	
End flow	EFLW-<e>: [-]nnn.nnnnn[e-rrr]<CR><LF>
End average flow	EFLA-<e>: [-]nnn.nnnnn[e-rrr]<CR><LF>
End volume	EVOL-<e>: [-]nnn.nnnnn[e-rrr]<CR><LF>
End positive volume	EPVL-<e>: [-]nnn.nnnnn[e-rrr]<CR><LF>
End negative volume	ENVL-<e>: [-]nnn.nnnnn[e-rrr]<CR><LF>
End stage avg.	ESTG-<e>: [-]nnn.nnnnn[e-rrr]<CR><LF>
End velocity sound avg	EVAG-<e>: [-]nnn.nnnnn[e-rrr]<CR><LF>
End temperature	ETMP-<e>: [-]nnn.nnnnn[e-rrr]<CR><LF>

1 <p> path no.
<s> section no.
<e> end no.
[-] optional minus sign
nn... up to 8 digits
[e-rrr] optional exponent (if < .000001)
cc... 16 character path status codes,
iiii integration method
gg path gain [-27..100]
<CR> carriage return
<LF> linefeed
<STX> optional start-of-text character
<ETX> optional end-of-text character

Setting up the RS-232 Outputs

In this example we set up the RS-232 output.

Top region of the display	Press key(s)	Explanation
[CONFIGURE] operate reset diagnose	**Enter**	Accept *Configure*
[PARAMETER] variable outputs reports	→→	Select *Outputs*
parameter variable [OUTPUTS] reports	**Enter**	Accept *Outputs*
[RS232] Analog Digital Relay Totalizer	**Enter**	Accept *RS232*
RS232 1 ... [1]	**Enter**	Accept *RS232 1*
[OFF] on	→	Select *On*
off [ON]	**Enter**	Accept *On*
[ASSIGN] setup	→	Select *Setup*
assign [SETUP]	**Enter**	Accept *Setup*
Baud rate: **300 1200 2400 [9600] 19200 38400**	**Enter**	Accept *9600* or select and accept another baud rate
Data bits: 7 [8]	**Enter**	Accept *8* or select and accept *7*.
Parity: [NONE] odd even	**Enter**	Accept *None* or select and accept *odd* or *even*.
Stop bits: [1] 2	**Enter**	Accept *1* or select and accept *2*.
Protocol: [NONE] stx_etx poll both	**Enter**	Accept *None* or select and accept another protocol.
	Esc	Return to *assign/setup* menu
[ASSIGN] setup	**Enter**	Accept *Assign*
Output type: [GENERAL] sect end leak	**Enter**	Accept *General*
Display scrolls through the list of variables shown in Table 8-2. Select and accept the option *On* for any variable whose value you want output to the selected RS-232 port. After the last variable is shown, the following menu is displayed:		
[ASSIGN] setup	**Esc**[2] **Esc Esc Esc Esc**	Return to main menu
Before leaving the Outputs menu you will be asked whether to save the outputs you have defined. Follow the procedure described in Chapter 5 for saving to battery-backed memory or to a diskette.		
[CONFIGURE] operate reset diagnose		At main menu

[1] Options RS232 2 RS232 3 ...etc. appear only if additional ports were installed at the factory.

[2] Press *Esc* once to return to the menu RS232 1 RS232 2. Repeat the procedure to define other RS-232 outputs, if they are available on your system.

Verifying RS-232 Output

The following procedure is used to verify that RS-232 outputs are operating correctly. The procedure begins at the main menu.

Top line of the display shows:	Press key(s)	Explanation
[CONFIGURE] operate reset diagnose	→→→	Select *Diagnose*
configure operate [DIAGNOSE]	**Enter**	Accept *Diagnose*
[SYSTEM] transceiver hardware utils	**Enter**	Accept *System*
[KEYPAD] display serial printer	→→	Select *Serial*
keypad display [SERIAL] printer	**Enter**	Accept *Serial*
[TRANSMIT] input output	→→	Select *Output*
transmit input [OUTPUT]	**Enter**	Accept *Output*
This diagnostic tests the RS-232 device driver by continuously outputting a stream of data (ASCII characters) until Escape *is pressed. If there is an error message, it will appear on the display. Refer to Chapter 6 for additional information on Diagnostics. Return to the menu by pressing* Escape.		

Flowmeter Reports

The instrument can be tailored to print summary reports at hourly, daily, monthly or any other interval. A report can be set up to print at the designated interval without further operator intervention, or it can be logged to disk for printing later. Up to three separate reports may be defined, with each report differing either in reporting frequency, in the data which it presents, or in destination. There are two major types of reports. A Flow report includes one or more of the following variables and reports data for individual sections and ends.

- Date, time
- Flow rate - True average taken over the specified report interval
- Positive volume - Total forward volume through the meter at the time of the report
- Negative volume - Total reverse volume through the meter at the time of the report
- Total volume - Net volume through the meter at the time of the report
- Stage - True average of fluid level over the specified report interval

Information is reported and totalized for all meter sections turned on at the time of the report. In addition, the overall percentage of good path readings is summarized by section.[3]

A Leak Detection report includes the following information for each penstock or pipeline for which leak detection is enabled and operating:

- Date, time
- Top Flow - Average flow rate through all sections at the top end taken over the specified report interval
- Bottom Flow - Average flow rate through all sections at the bottom end taken over the specified report interval
- Average Differential Flow - Average, over the report interval, of the difference between flow rates measured at the top and bottom ends of the pipeline.
- Total Flow - The sum of the instantaneous flow rates through all sections at the bottom end
- Maximum Differential - The maximum difference between instantaneous flow rates calculated
  by the meter measured at the top and bottom ends of the pipeline during the report interval.
- Minimum Difference - The minimum difference calculated by the meter between instantaneous flow rates measured at the top and bottom ends of the pipeline during the report interval.

[3] The percentage of good path readings is calculated in accordance with the general parameter *Maximum bad measurements.* That is, if in a series of measurements the number of *consecutive* bad measurements never exceeds the specified limit, then the overall measurement report will show as *100% good*, even though one or more bad measurements may have actually occurred.

The example on the following page describes setting up a total flow report and directing it to print every other day at 7:00 am. A similar method is used to create other reports or to log a report to disk.

The procedure that follows assumes that a compatible printer and cable have been installed according to the procedures given in Chapter 4, *Connecting a Printer* on page 4-6. The printer must be turned on and be on line.

To set up the reports, step through the procedure shown on the following page.

A sample hourly report printout follows the procedure (Figure 8-1 on page 8-25).

Setting Up Reports

[CONFIGURE] operate reset diagnose	**Enter**	Accept *Configure*
[PARAMETER] variable outputs reports	**→→→**	Select *Reports*
parameter variable outputs [REPORTS]	**Enter**	Accept *Reports*
[LIST] reports	**→**	Select *Reports*
list [REPORTS]	**Enter**	Accept *Reports*
[REPORT 1] report 2 report 3	**Enter**	Accept *Report 1*
[OFF] on	**→**	Select *On*
off [ON]	**Enter**	Accept *On*
Report data: [FLOW] leak	**Enter**	Accept *Flow data*
Report to: [PRINTER] disk both	**Enter**	Accept *Printer*
Report header: Daily/hourly/other report	**Ctrl - Bksp and → →→ ...**	Delete the headings you don't need; use the cursor keys to move across text that you want to keep.
Report header:	**Alternate Day Report**	Type in a suitable header such as *Alternate Day Report*. Up to 40 characters are allowed. This will appear as the top line of the report.
Report header: Alternate Day Report:	**Enter ↓**	Accept new header. Go to next menu item.
Report title: Enter your name here	**Crtl - Bksp ...**	Delete the existing text.
Report title:	**XYZZY CORP**	Type in suitable header such as your company name. Up to 40 characters are allowed. Appears at the top line of jump pages[2].
Report title: XYZZY Corp	**Enter ↓**	Accept new title. Go to next menu item.
Report type: [DAILY] hourly other	**→→**	Select *Other*
Report type: daily hourly [OTHER]	**Enter**	Accept *Other*
Report start date (MM.DD.YY):	**01.01.93 Enter ↓**	Enter suitable date; accept it and go to next menu item.
Report start time (HH.MM.SS):	**07.00.00 Enter ↓**	Enter a suitable time; accept it and go to next menu item.

Setting Up Reports (continued)

Report interval (HH.MM.SS):[3]	**00.00.00 Enter ↓**	Enter 0 hour interval; accept it and go to next menu item.
Report interval days[4]**:**	**2 Enter ↓**	Enter 2 day interval; accept it and go to next menu item.
Flowrate: off [ON]	**→ and Enter**	Select ON for each Variable that you want included in the report. Enter to accept this choice.
Averaged stage: [OFF] on		
Positive volume: [OFF] on		
Negative Volume: [OFF] on		
Volume: [OFF] on		
Totals: [OFF] on		
Report 1 **Press Esc...**	**Esc Esc Esc**[5]	Return to main menu
Before leaving the Reports menu, you will be asked whether to save the reports you have defined. Follow the procedure described in Chapter 5 for saving to battery-backed memory or to a diskette. (As in earlier procedure)		
[CONFIGURE] operate reset diagnose		At main menu

1 A new page is fed to the printer and Report type is printed on the top line if, during the intervening period of a report, any other material was sent to the printer. This can happen when both daily and hourly reports are defined.

2 A subsequent instance of a report prints on the same page as the previous instance if it fits and if no other report was sent to the printer during the intervening period. When the new instance will not fit, a new page is fed to the printer and Report title is printed on the top line.

3 Does not appear if report type is daily or hourly. If report interval will be greater than 24 hours, enter 00.00.00 or another time increment up to 24.00.00 here and proceed to report interval days.

4 This value (in days) will be added to the number of hours, minutes, and seconds entered in the previous parameter.

5 Pressing Esc once here returns you to the menu Report 1, Report 2 ... where you may define up to three different reports.

HOURLY REPORT

	FLOW	P-VOL	N-VOL	T-VOL
	=======	=======	=======	======
Mon Jan 04 1993 08.00.00	1325	measurements		
SECT-1 (100% good)	2.976	28	0	28
SECT-2 (100% good)	939.573	10557	0	10557
	=======	=======	=======	======
totals:	943	10585	0	10585
Mon Jan 04 1993 09.00.00	1382	measurements		
SECT-1 (100% good)	3.006	28	0	28
SECT-2 (100% good)	939.573	10635	0	10635
	=======	=======	=======	======
totals:	943	10663	0	10663
Mon Jan 04 1993 10.00.00	1386	measurements		
SECT-1 (100% good)	3.078	29	0	29
SECT-2 (100% good)	939.573	10712	0	10712
	=======	=======	=======	======
totals:	943	10741	0	10741
Mon Jan 04 1993 11.00.00	1382	measurements		
SECT-1 (100% good)	3.146	29	0	29
SECT-2 (100% good)	939.573	10790	0	10790
	=======	=======	=======	======
totals:	943	10819	0	10819

Figure 8-1 Hourly Report

Data logging

Section and System Variables can be logged to a disk drive or printer at user-definable intervals. The choice of disk drive is set at the time of system configuration at the factory and is burned into Programmable Read Only Memory (PROM). The default drive is B:, the instrument's integral floppy disk drive.

The following procedure shows how to turn data logging on for an individual section. Logging of system totals for flowrate and volumes, as well as log start time interval, is accessed under the *General* parameters.

Top region of the display	Press key(s)	Explanation
[CONFIGURE] operate reset diagnose	**Enter**	Accept *Configure*
[PARAMETER] variable outputs reports	**Enter**	Accept *Parameter*
[SECTION] general files password	**Enter**	Accept *Section*
[SECTION 1] Section 2 etc. **ON**	**Enter**	Accept *Section 1*
Bypass each successive option until *Data logging* option is shown	**↓↓...**	Bypass
Data logging: [OFF] on	**→**	Select *ON*
Data logging: off [ON]	**↓**	Accept *ON*
Log Flow Data: [OFF] on	**Enter or → Enter**	Select and accept *ON to log flowrates & volumes*
Log Velocity Data: [OFF] on	**Enter or → Enter**	Log acoustic path velocities
Log Stage Data: [OFF] on	**Enter or → Enter**	Log fluid level data
Temperature Coefficient 1	**Esc Esc**	Return to Configure Parameters Menu
[SECT] General Leak Files Password	**→**	Select General
Sect [GENERAL] Leak Files Password	**Enter**	Accept General
Bypass each successive option until *Data logging* option is shown	**↓↓...**	Bypass
Data logging [OFF] on	**→**	Select On
Data loggingoff [ON]	**Enter**	Accept On
Log data to [DISK] printer both	**Enter or → Enter**	Accept Disk or choose Printer or Both and Accept one of these options
Data Log Start (HH:MM:SS):	**00:00:00**	Enter the time you want data logging to begin
Log Interval (HH:MM:SS):	**00:10:00**	Enter to accept logging at 10-minute intervals or enter and accept another interval
Auto Start Switch:	**Esc Esc**	Return to Configure Parameters Menu
Before leaving the Parameter menu you will be prompted to use/save the new settings.		

Data log file description

When data logging is turned on, variables *Flowrate* and *Positive volume* are logged automatically to the file **SECT1FLW.PRN**. The number relates to the measurement section; so, for example, if data logging is enabled for section 3, an additional log file will be generated with the filename **SECT3FLW.PRN**. The logfiles are quote- and comma- delimited, and can be read directly into common spreadsheet programs.

Filenames and formats are as follows:

SECT1FLW.PRN contains true-running averages of *Flowrate* and *Volume*.

File format is:

“YYMMDDHHMMSS”,flow,total volume,temperature,,percent good<CR><LF>

If negative volume logging is enabled, file format will be:

“YYMMDDHHMMSS”,flow,total volume,temperature,positive volume,negative volume,percent good<CR><LF>

SECT1STG.PRN contains averages of stage (fluid level) data for the section. Enabling logging for flow will turn on stage logging automatically.

File format is:

“YYMMDDHHMMSS”,stage1,stage2,average stage,integration method<CR><LF>

Both *Stage1* and *Stage2* (if any) are averages over the data logging interval.

The third variable, *Average stage*, is the average of *Stage1* and *Stage2* when they are within the parameter *Maximum difference in stage*. When they are not, *Stage1* alone is used. This is the value used in the flow calculation.

Integration method is not averaged. It is a snapshot of the method in use at the time the log is written.

SECT1VEL.PRN contains true running averages of velocities.

File format (4 path section) is:

“YYMMDDHHMMSS”,VEL1,VEL2,VEL3,VEL4<CR><LF>

If the section has 6 paths, the file format will be:

“YYMMDDHHMMSS”,VEL1,VEL2,VEL3,VEL4,VEL5,VEL6<CR><LF>

SECT1AGC.PRN contains instantaneous snapshots of Automatic Gain Control (AGC) data. This information is typically logged during troubleshooting only, as it uses up large amounts of disk space and is not useful or required when the meter is operating normally. Enabling logging for velocities will turn on AGC logging automatically.

File format is:

“YYMMDDHHMMSS”,path 1 forward gain,path 1 reverse gain,path 1 forward agc tattler, path 1 forward noise level, path 1 forward noise history,path 1 reverse agc tattler, path 1 reverse noise level, path 1 reverse noise history,(repeat for all paths in the section)<CR><LF>

GENFLW.PRN

File format is:

“YYMMDDHHMMSS”,total flow,total volume,total positive volume,total negative volume, <CR><LF>

Error Reporting

Error reporting is a troubleshooting tool. Enabling it will create a disk log of variables generated when the flowmeter is in an error condition. This is a handy tool for trapping those errors which only occur when the system cannot be attended, such as intermittent faults that only happen at night or during storms. Variables are logged on every measurement that error conditions are met.
The error conditions are controlled by the parameter “Start Logging on Path Errors” as follows:

- If set to ON, logging will begin when any path is in error for more consecutive measurements than the number entered in the parameter “Maximum Bad Measurements”.
- If set to OFF, error logging begins after “Maximum Bad Measurements” has been exceeded for a measurement section and the section has been declared “bad”. Note that the if the failure is due to a path error, “Maximum Bad Measurements” must be exceeded for the path before the counter starts for the section, and that the failures in both cases must be sequential. For example, if “Maximum Bad Measurements” is set to 10 and “Start Logging on Path Errors” is set to OFF, it will take 20 consecutive bad measurements before logging begins.

The first line of the log contains date and time, section number, and path, stage, section, and self-test error codes.
Menu choices are available to log flowrate, velocities, stages, and gains:

- The logged flowrate is the instantaneous flow as calculated from all velocities that have not been marked as bad (failed consecutively for more measurements than the parameter “Maximum Bad Measurements”).
- Logged velocities are either:
  - The current instantaneous value, or
  - The last good value, which will be retained until exiting measurement mode. Retained velocities will continue to be used in the flow calculation until “Maximum Bad Measurements” has been exceeded. The status of this is not indicated in the error log.
- Three stage values are logged. They are (in order); Stage 1, stage 2, and averaged and arbitrated stage (the stage in use at the time to calculate flow). If there is only one stage measurement device in the system, stage 2 value will always be 0.0.
- Logged gains are instantaneous values as returned from the latest path measurement.

FORECED PAGE BREAK FOR PAGE NUMBERING REASONS - REMOVE FROM MANUAL.

Chapter 9
Advanced Troubleshooting

This Chapter includes information for interpreting status errors reported by the system. It also includes the procedure for monitoring raw path signals with an oscilloscope, and explains how to verify and adjust the system power supply.

What to do first:

When approaching a “broken” 7500 to determine the fault, pay attention to what you see and hear. Much troubleshooting can be done over the telephone by a call to Accusonic, and the more information you have, the easier it will be. Look for the following things:

♦ Is there anything on the display?

If there is, what is it? If the flowmeter is operating normally, and you are looking at an operational screen, you should see flowrate(s) and volumes, with the status area of the display showing “GOOD”. This is normal operation.

If there is a problem at this level, the status area will display “BAD”. Press the ECODE key on the keypad to switch to the status display. All error codes should be “1”. If not, refer to the tables that follow for a detailed explanation of error codes, as well as possible causes and suggested troubleshooting.

In cases where the flowmeter is located remotely and the only indication of proper operation is a current loop or serial data stream, the flowmeter can appear to be “broken” if it is left out of measurement mode. If left in the menu system, no measurements will be made, and no data will be output. Current loops and relays will hold the value of the last measurement. Restart measurement mode and see if things operate normally. If they do and this becomes a recurrent problem, refer to the manual section on entering and enabling passwords.

Status Lights

♦ If there is nothing on the display, check the following:

Is the power switch turned on? If so, check the green power indicator lights to the left of the path connections. They will be located on the lower left of the NEMA box, and on the left side of the rear panel of a chassis/rack mount unit. These lights indicate the correct operation of the various power supplies in the unit. All three should be lit. If all are extinguished and the power switch is on, verify that there is power to the unit. If there is, check the system fuse. This is located adjacent to the power switch in a NEMA unit. On a chassis unit, the fuse is located inside the IEC power receptacle on the rear of the box. Pull out the power cord and use a small screwdriver to access the fuse. If the fuse is good, the main system power supply may be bad.

♦ If there is power to the unit and all three lights are lit, look at the lights on the communications board. There are two groups of indicator lights located on the communications board. The first, a group of four, is used to indicate hardware/software errors. The leftmost is labeled “WP”. This indicates operation of the Watchdog Timer, a hardware device which monitors software operation. It should be flashing approximately once per second. The second one is labeled “R”, indicating reset. During normal operation, it will not be lit. If the system is left out of measurement mode, it will flash once every 22 seconds, resetting the transceiver. The last two lights in this group are labeled “+V” and “-V”, and are system voltage monitors. If either of these are lit, the transceiver will not operate correctly. If either is lit, look at the three green power-monitor lights just to the left of the path cable connections. If the green lights are all lit but the power monitors on the communications board are not, the problem may be in the connection to the boards or the power supply levels may need to be adjusted (see section). If one or more of the green lights is also out, the problem is probably in the power supply.

The other group of lights, a set of eight, indicates measurement errors on the flow transmitter. During normal operation, all are off; an error is signaled by a lit status light as shown in Table 6-2 on page **Error! Bookmark not defined.**. During power-up or immediately after a reset, all eight lights will flash during a reinitialization test. The sequence is:

ON for one second
OFF for one second
ON again for one second
OFF.

During a power-up, all lights will stay off. If the system has been reset, light 0 will remain on. During periods of inactivity, when the system is out of measurement mode and there is no communication to the flow transmitter group, this initialization sequence will happen every 22 seconds.

Status Messages

Most of the Non-diagnostic display screens have a one-word status message displayed on the right side of the screen. The following table describes the significance of the three possible messages:

Table 9-1 Status Messages

Message	**Possible Cause**	**Recommended Action**
GOOD	Normal Operation. Occasional path errors will not cause an ALERT.	No Action Required.
ALERT	One or more paths have more consecutive errors than allowed by the parameter *Maximum Bad Measurements*, -or- There is a Section Status error (causes Alert message immediately).	Switch to Status Code display to determine fault. Refer to Path, Section, or Stage error code tables starting on the next page of this chapter.
BAD	There is a Section Status error that has persisted for more measurements than allowed by the parameter *Maximum Bad Measurements.*	Switch to Status Code display to determine fault. Refer to Error Code listings later in this chapter.

Error Codes

Path, Section and Self-test Status Codes

The status screen displays error codes based on internal diagnostics. The first 8 digits after the unit number are path status error codes (labeled PATH), the second 2 digits represent stage or level (SG), the next is the overall section status (S), and the last 2 digits are self-test (ST). Pressing the "ECODE" key or the ± key will display the status screen. (Press unshift - on keyboard-only systems.)

For example, during normal operation, the status code for a meter measuring on 4 acoustic paths in each of two sections will look like the following (note that there is no stage (level) being measured in this example):

UNIT	--PATH--	SG	S	ST
1	1111		1	11
2	1111		1	11

Note that signal quality and travel time checking is performed on every received signal. It is important to understand that occasional (and in some cases, frequent) errors may be unavoidable in some installations where there is a high level of signal attenuation and/or electrical or mechanical noise. The software filtering parameters are designed to allow operation in these unfavorable conditions and to report the source of the problem. Unless these errors are nearly continuous, there is no reason to suspect the accuracy of the flowrate output.

For maintenance and troubleshooting purposes, it is the trend of error frequency that should be noted, along with possible correlation with other site conditions. For example, more path status 3 (SQM) errors would be expected at a hydro plant when operating at minimum lake levels. Possible air entrainment at the intake caused by operating at minimum lake levels causes signal attenuation or occasional electrical noise pulses, causing incorrect travel times, which in turn results in out-of-tolerance time measurements or unreasonable path velocities, section flowrate or change in flowrate.

Table 9-2 Path Status Codes

CODE	PATH STATUS	POSSIBLE CAUSE	RECOMMENDED ACTION
1	Path on and working.	Normal operation.	No action required.
2	No forward time received.	Broken cable. Failed transducer. Blocked path (air, logs, fish, etc.) Pipe not full of water. The parameters *Path length* and/or *Transducer type* may be incorrectly set.	Check cable. Replace transducer. Check path parameters.
3	Forward signal SQM[1] error. (Signal is present but not strong enough.)	Weak or failing transducer. Entrained air, fish, or debris. Weak or failing cable.	Check transducer. Check cable.
4	Forward time greater than expected.	Air in water. Blocked direct path. *Path length* parameter set too short. Any of the above combined with electrical or mechanical noise.	See introductory note and section on monitoring raw path signals with an oscilloscope.
5	No reverse time received.	See 2.	See 2.
6	Reverse signal SQM error.	See 3.	See 3.
7	Reverse time greater than expected.	See 4.	See 4.
8	Velocity greater than maximum allowed. (All SQM and range gate tests have been passed, but velocity calculates to be greater than section parameter *Maximum expected velocity*.)	Section parameter *Maximum expected velocity* may be set too low. Consistent source of valid-looking spurious signal.	Set section parameter *Maximum expected velocity* higher. Check all velocities in Variable list for reasonableness. If unreasonable or varying, see introductory note and section on monitoring raw path signals with an oscilloscope.
9	Path is turned off.	Normal condition if path operation is not required.	None. To turn path on, change path parameter to *On*.

CODE	PATH STATUS	POSSIBLE CAUSE	RECOMMENDED ACTION
A	Velocity changed faster than allowed.	If status code is sporadic, noise or acoustic interference, or section parameter *Maximum change in velocity* may be too low.	Scope raw signal on path selector backplane. See section on monitoring raw path signals with an oscilloscope. Set section parameter *Maximum change in velocity* higher. See introductory note.
B	Excessive difference in signal level between forward and reverse direction. (The difference between forward and reverse signal levels exceeds 6 dB.)	A cable or transducer may be failing or transducer may be misaligned.	Check cables. Check transducer alignment. Replace transducer.
C	Communications error.	7500 cannot communicate with indicated flow transmitter.	Check cabling between 7500 and remote flow transmitter. Make sure power switch on remote flow transmitter is on. Check green power supply LEDs on remote flow transmitter. Check power fail LEDs on communications board.
D	Impulse Noise detected.[1]	Interference from another flow transmitter. Electrical noise pick up from the AC mains, or induced through the transducer cables.	Connect as-blank. Turn off other flow transmitters to isolate. See section on monitoring raw path signals with an oscilloscope.
E	Impulse Noise in Past-Adjusting Gain (Data will not be rejected). [1]	See D.	See D.
F	Impossible velocity ($\Delta T > 1/16T$) on the path.	Noise.	See section on monitoring raw path signals with an oscilloscope.
H	Hardware error while starting measurement.		Restart. Run self-test. Run diagnostics to determine cause.
J	Flow transmitter parameter was not set.	Interference on communications line. Error between communications board and transceiver.	Restart. Run self-test.
K	Path is turned off at flow transmitter.	Error between communications board and transceiver.	Retry by going into parameter list, exit and restart (parameters will be downloaded).

CODE	PATH STATUS	POSSIBLE CAUSE	RECOMMENDED ACTION
L	Missed measurement. (No response from flow transmitter.)	See K.	Contact Accusonic. Occasional missed measurements are normal, particulary if outputting a lot of RS-232 data.
M	Continuous Noise in Past-Adjusting Gain (Data will not be rejected).	Noise Pickup on previous measurement - See N.	See N.
N	Continuous Noise Detected	Electrical noise pickup thru AC Line or on Transducer Cables.	Determine cause of noise - See section on Monitoring Raw Path Sigs with an oscilloscope.
X	Path is above stage level and has been turned off by the system.	Normal operation.	No action required. System will turn path on when level rises and path is submerged.

[1] Note that occasional SQM and noise errors are normal. They may occur while the AGC circuits are seeking to normalize the system gain.

Table 9-3 Section Status Codes

CODE	SECTION STATUS	POSSIBLE CAUSE	RECOMMENDED ACTION
1	Good flow calculation.	Normal operation.	No action required.
2	Too many bad paths.	*Maximum bad measurements* exceeded on too many paths at the same time.	Check path status codes. Check path parameters.
3	Flow greater than maximum allowed.	If continuous: Flow exceeds section parameter *Maximum expected flowrate*. If sporadic: Interference causing valid-looking velocities that calculate to be too high a flow.	Increase section parameter *Maximum expected flowrate.* Increase value of parameter *Maximum velocity*. Recheck parameter values for reasonableness. Determine cause of excessive noise, see introductory note.
4	Flow changed faster than allowed in software.	May happen when system is turned on or when site conditions change. Section parameter *Maximum change in flowrate* may be set too low (default is 10% of *Maximum expected flowrate*). Interference causing valid-looking velocities that calculate to be too high a flow.	Wait to see if status code changes. Note any other errors. Set section parameter *Maximum change in flowrate* higher. Reduce value of parameter *Maximum change in velocity*. Refer to introductory comments; see above.
5	No response from flow transmitter.	Hardware failure.	Check green power supply LEDs on path select panel (normally on). Check power fail LEDs on transceiver communications board (normally off). Check cabling, interface converters, communication lines. Refer to power supply procedures below.
6	Stage Error		See Stage Status code for additional information.
9	Flowmeter section is turned off.	Normal condition. When section operation is not required.	None. To turn section on, change section parameter to On.

Table 9-3 Section Status Codes (continued)

CODE	SECTION STATUS	POSSIBLE CAUSE	RECOMMENDED ACTION
A	Insufficient information to choose integration method.	No stage information, no paths available.	See Stage and Path Codes to determine fault.
B	Submerged path failure	One or more paths have failed. Flow will be calculated based on working paths, but accuracy will be compromised.	See Path Codes to determine fault; repair path(s).
S	Path substitution in use.	One or more Acoustic paths are bad, values from other paths are being substituted.	See Path Codes to determine fault.

Table 9-4 Self-test Status Codes

CODE	SELF-TEST STATUS	POSSIBLE CAUSE	RECOMMENDED ACTION
1	Good self-test.	Normal operation.	No action required.
2	Background test failure.		Run transceiver diagnostic for more information.
3	Transmitter not connected.		Check cable between transceiver and transmitter.
4	Hardware failed to reset		Turn off and restart.
5	Transmitter did not charge.	Defective transmitter.	Check 180V inverter. (Green LEDs on path selector board will indicate if 5V and 12V are on and 180V is not.) Check LED on transmitter board. It should be lit when charging, should flash during normal operation. Refer to power supply procedures below.
6	Travel time counter did not start.	Fatal transceiver error.	Replace transceiver board.
9	Self test is off	General parameter *Self Test Interval* is set to 0.	Set General parameter *Self Test Interval* to a value other than 0.
D	SQM error.	Self-test relay failure. 180V inverter failure. Transmitter failure.	Replace transceiver board.
E	Noise error.	Electrical noise entering through AC line.	Determine source of noise; does system work with self-test turned off? See section on monitoring raw path signals with an oscilloscope. Replace transceiver.
F	Impossible velocity on the path.	Electrical noise.	See introductory comments..
H	Hardware error.		Run transceiver diagnostic for more information.
J	Self-test parameter not set.	Transceiver/communication board problem.	Restart by going into parameter list, exiting and beginning Operate. (Parameters will be downloaded.) Replace hardware.
K	Self-test is turned off at the flow transmitter.	See J.	See J.
L	Missed measurement (no response from flow transmitter)	Error between processor group and flow transmitter.	Occasional missed measurements are normal, particularly if outputting a lot of RS-232 data,or when operating with all simulated velocities.

Table 9-5 Stage Status Codes

CODE	STAGE STATUS	POSSIBLE CAUSE	RECOMMENDED ACTION
1	Good stage.	Normal operation.	No action required.
2	No stage received.		If an acoustic uplooking transducer, run diagnostics.
		Parameter *Stage transducer type* incorrectly set.	Check that proper type of stage transducer has been selected in *Stage transducer type* parameter.
		Broken cable.	Check cable.
		Transducer misaligned.	Check stage transducer alignment. Must be 90° to surface
		Broken stage sensor.	If external stage source (e.g., acoustic downlooker, pressure transducer) check the analog input line. Replace stage sensor.
3	Stage changed too rapidly.	*Maximum change in stage* parameter set too low.	Check parameter *Maximum change in stage* for reasonableness.
		Transducer misaligned.	Check stage transducer alignment.
		Noise on stage cabling.	See introductory Note.
		Fish, logs, etc. temporarily blocking acoustic uplooker path and causing early return.	
4	Stage less than *Minimum stage.*	Parameter *Minimum stage* set too high.	Check parameter *Minimum stage* for reasonableness.
		May be real.	Visually check water level, if possible.
5	Stage greater than *Maximum stage*.	Parameter *Maximum stage* set too low.	Check parameter *Maximum stage* for reasonableness. Check input scaling if not acoustic.

Table 9-5 Stage Status Codes (Continued)			
CODE	**STAGE STATUS**	**POSSIBLE CAUSE**	**RECOMMENDED ACTION**
6	Parameter *Maximum difference Stage 1 and 2* exceeded	Parameter setting may be unreasonable. Transducer may be misaligned. Broken stage sensor.	Check parameter *Maximum difference Stage 1 and 2* for reasonableness. Check acoustic transducers' alignment. Check cabling. If an acoustic uplooker, use system diagnostics. Verify actual stage, then turn off stages one at a time to verify which one is correct.
7	Stage out of range	External source current loop values out of range, i.e., system read 21 mA in a 4-20 mA loop. Broken stage sensor.	Recalibrate external stage sensor for actual possible range of levels. Replace stage sensor.
8	Stage less than 2x *Minimum Stage*	Stage value is less than twice *Minimum Stage* - may be good, or may be a multiple surface-transducer bounce. This is only a warning, data will not be rejected.	Verify actual stage, compare to measured. If ok, ignore it. If not, set *Minimum Stage* higher.
L	Missed measurement (no response from flow transmitter)	Error between processor group and flow transmitter	Increase “Stage Interval” or set “Stage Mode” to fast. Occasional missed measurements are normal.

Monitoring Raw Path Signals with Oscilloscope

At times, it may be useful to monitor the raw acoustic signals on the path selector backplane. This may help identify noisy or fouled transducers or identify 60 Hz (AC line) or inverter noise in the system. It is also used for transducer alignment. Oscilloscope requirements are: 100 Mhz minimum bandwidth, dual timebase (for delayed trigger), external trigger. Due to the transient nature of the signal being viewed, it is best to use a waveform-recording instrument such as a digital storage scope.

1. Connect the trigger probe of the scope to the terminal marked *As-blank+*, located on the left side of the transducer connector panel. Ground the probe to the terminal marked *As-blank Com*.

   Connect the signal input probe to the raw signal test points on the path select back plane, as shown in Figure 9-1. Access to these test points should not require any disassembly.

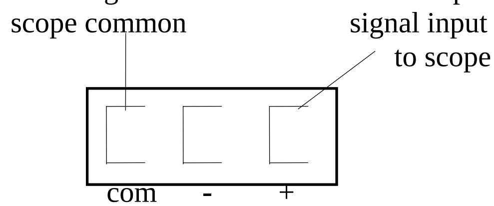


Figure 9-1 Raw Receive Signal

Note
The connector panel is located inside the NEMA cabinet, or on the back of the rack-mount cabinet.

2. Estimate the expected signal transit time as:

   transit time = path length / 4.8
      where:
      transit time is in milliseconds
      path length is in feet

   For example, the transit time is about 2 ms for a ten foot path.

Note
Be sure to use path length, not pipe diameter. If you don't know the path lengths, use the flowmeter menus to look up path parameters.

3. Set the scope horizontal sweep to about 1/4th the estimated transit time per division. For example, for a 2 ms transit time, set the sweep to 0.5 ms/division.
4. Set triggering to external with negative sync. (Trigger from *As-blank* signal)
5. As the path fires, a signal similar to that shown in Figure 9-2 should appear on the scope. Look at the area of the waveform just before the received pulse and just after the pulse for noise or interference. Use delayed trigger to expand the critical area.
6. Switch the scope to line sync to see if 60 Hz or 120 Hz noise is present on the line.

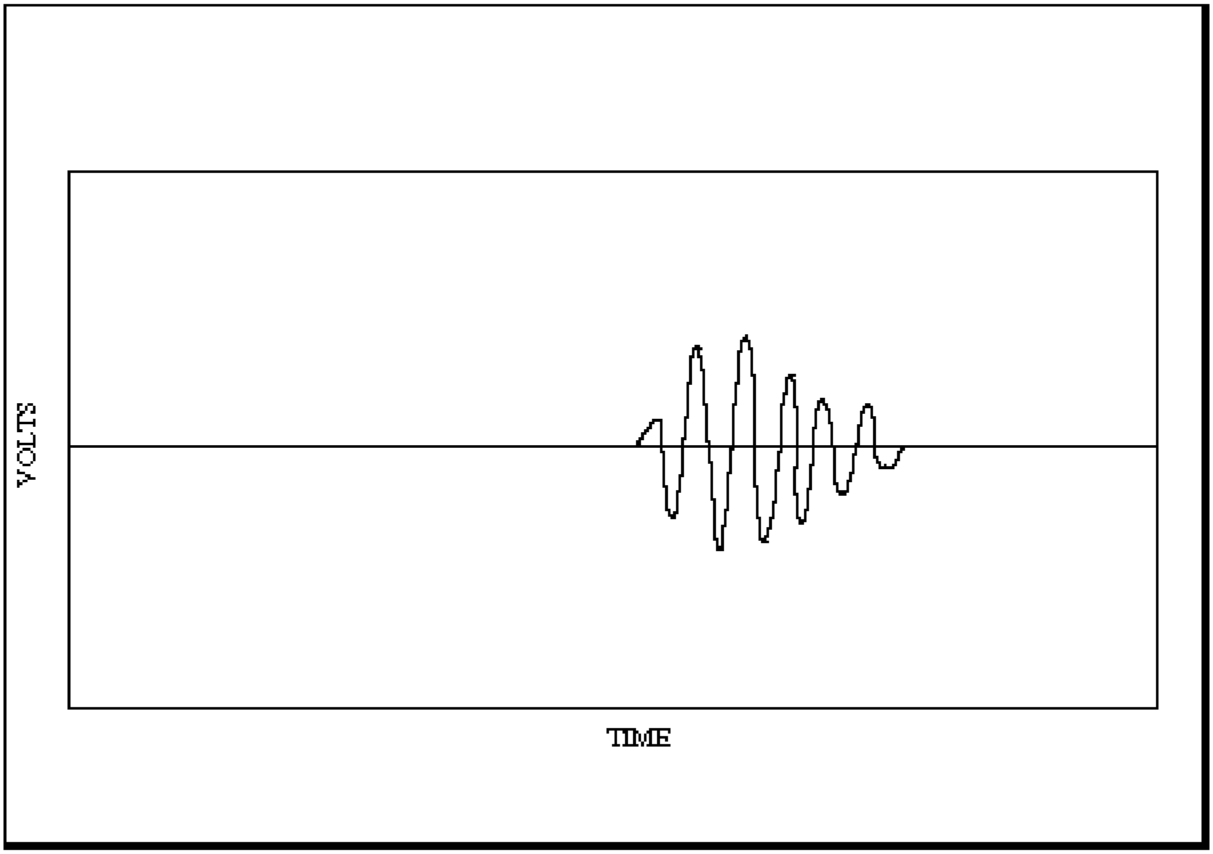


Figure 9-2 Received Signal

Verifying and Adjusting Power Supplies

If the system is inoperative, first verify that the power switch is turned on. If so, verify that there are lights on somewhere in the system. There are LED's on the watchdog board, the transceiver communications board, and the path-select backplane when the system is turned on. If not, the AC mains power may be off, the fuse near the power switch may be blown, or the power supply may be damaged. If there are lights, proceed to check the system voltages as described below. If the voltages are out of specification, it may be possible to readjust the power supply (as described below), or it may be necessary to replace the entire supply.

Note

There is also a fuse on the power supply. Its rating is quite high, so there is only a remote chance that it will blow. The fuse is easily accessible from the bottom of the rack-mount cabinet. In the NEMA cabinet, substantial disassembly of the unit is necessary before the power and its fuse are accessible; consult Accusonic before attempting to reach the power supply in a NEMA cabinet.

Checking the system voltages

Check the system voltages by measuring them with a digital voltmeter to obtain accurate readings. Voltages are distributed throughout the cabinet and may be measured at any convenient location. They can be identified by standard colors used for DC wiring. Use the following table of standard wiring colors to locate a test point for each voltage. For DC ground, use the *As-blank Com* terminal on the transducer connector panel. Readings should be within 5% of nominal. If one or more voltages is present, but out of spec, it may be possible to readjust that level at the power supply.

Table 9-6 Standard DC Wiring Colors

Color	Voltage (nominal)
Red	+5.0 ± 0.25 volts
Yellow	+12.0 ± 0.5 volts
Blue	-12.0 ± 0.5 volts
Violet	-5.0 ± 0.25 volts
Orange	180-225 volts

Adjusting the power supply - rack-mount cabinet

Power supply adjustments are easily accessible in the rack-mount cabinet. The adjustments are made with the system turned on and with all cards and connections in place.

If the system is mounted on the slides in a relay rack, simply pull the unit all the way out on the slides. Remove 6 screws from the bottom of the unit and drop the bottom panel.

If the system is on a table, turn it over, remove six screws and lift off the bottom plate. The power supply will be exposed; the adjustment pots are located as shown in Figure 9-3.

Caution

AC mains voltages are exposed at the power supply.

Adjusting the power supply - NEMA cabinet

Exposing the power supply in a NEMA cabinet requires careful disassembly of the flowmeter electronics and should only be undertaken after consultation with Accusonic.

Part of the complexity stems from the fact that the power supply adjustments need to be made under load, so the system must be disassembled in a manner that leaves most of the electronics connected. However, the transducers do not need to be connected. If possible, move the system to a bench in order to simplify the process. Disconnect the transducer wiring from the instrument.

The procedure requires at least two people to carry out.

1. Power down the system before disassembling the unit.
2. Locate four nuts in the far corners of the cabinet retaining the white main plate.
   These nuts hold the entire system in place.
3. Have another person hold the unit in place while you remove the four nuts.
4. Slowly start to pull the system out, and notice which cables must be detached.
   Typically, these are the cables that run from the system electronics to the front panel.
5. Hold the system in place and disconnect the cables. It is good practice to mark the polarity of each connector to eliminate the chance of miswiring later. If possible, do not disconnect the DC wiring harness.
   When the system frame is removed from the cabinet, the power supply is exposed. The adjustment points are shown in Figure 9-3.
6. Support the system frame on the bench close enough to the cabinet so the DC wiring can be connected, and if possible, reconnect the cables to the front panel.

Warning

Take appropriate measures to ensure that personnel will not come in contact with the circuit cards or wiring when the unit is turned on.

Caution

AC mains voltages are exposed at the power supply and at other points in the system.

7. Turn on the system, and adjust the supplies as necessary. *Be careful not to go over +5% above range, or severe damage can be caused to many system components.*
8. Turn off the system power.
9. Assemble the system and connect the transducers.

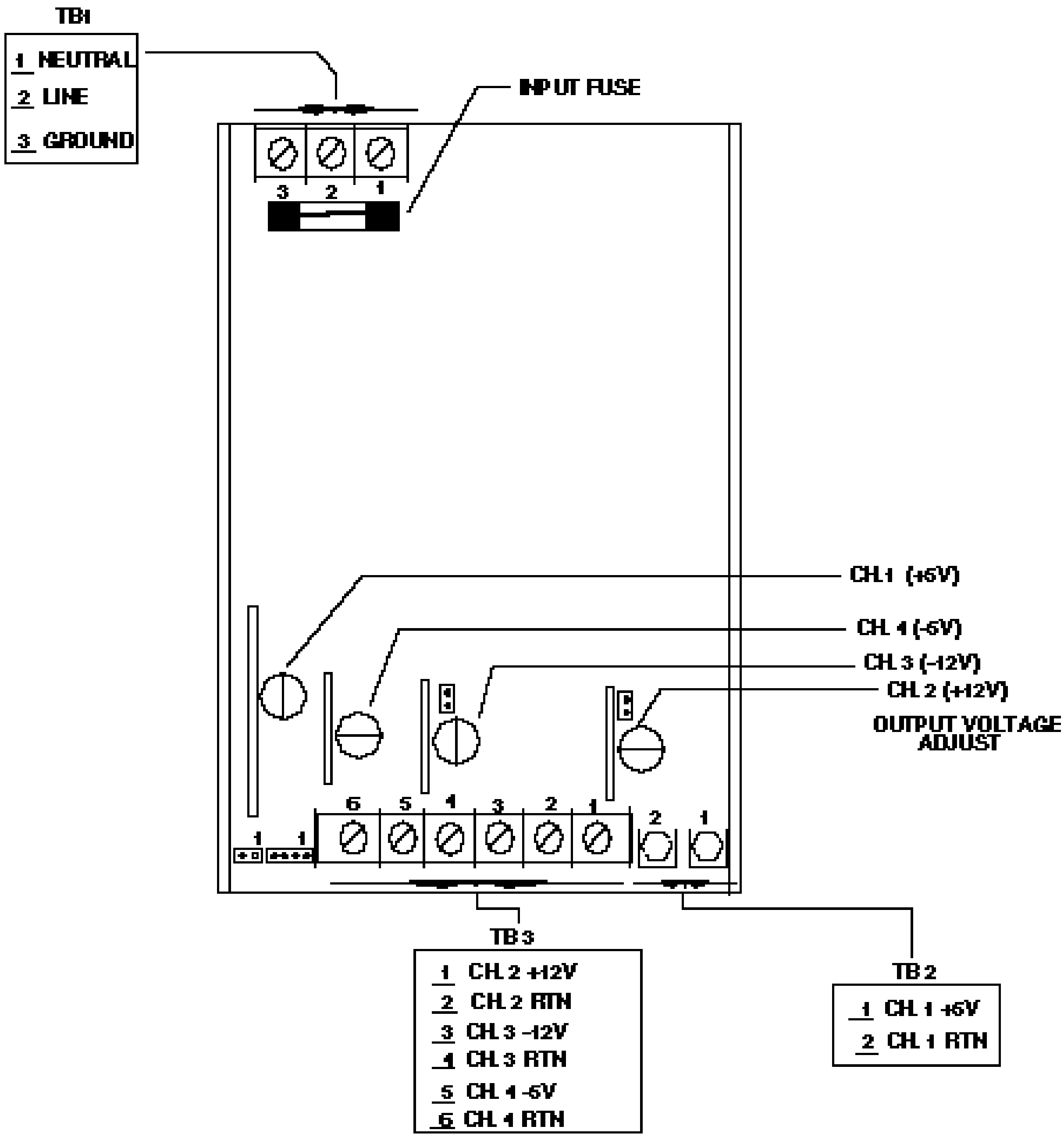


Figure 9-3 Power Supply Adjustment Locations

(150 Watt Supply - Gold Case)

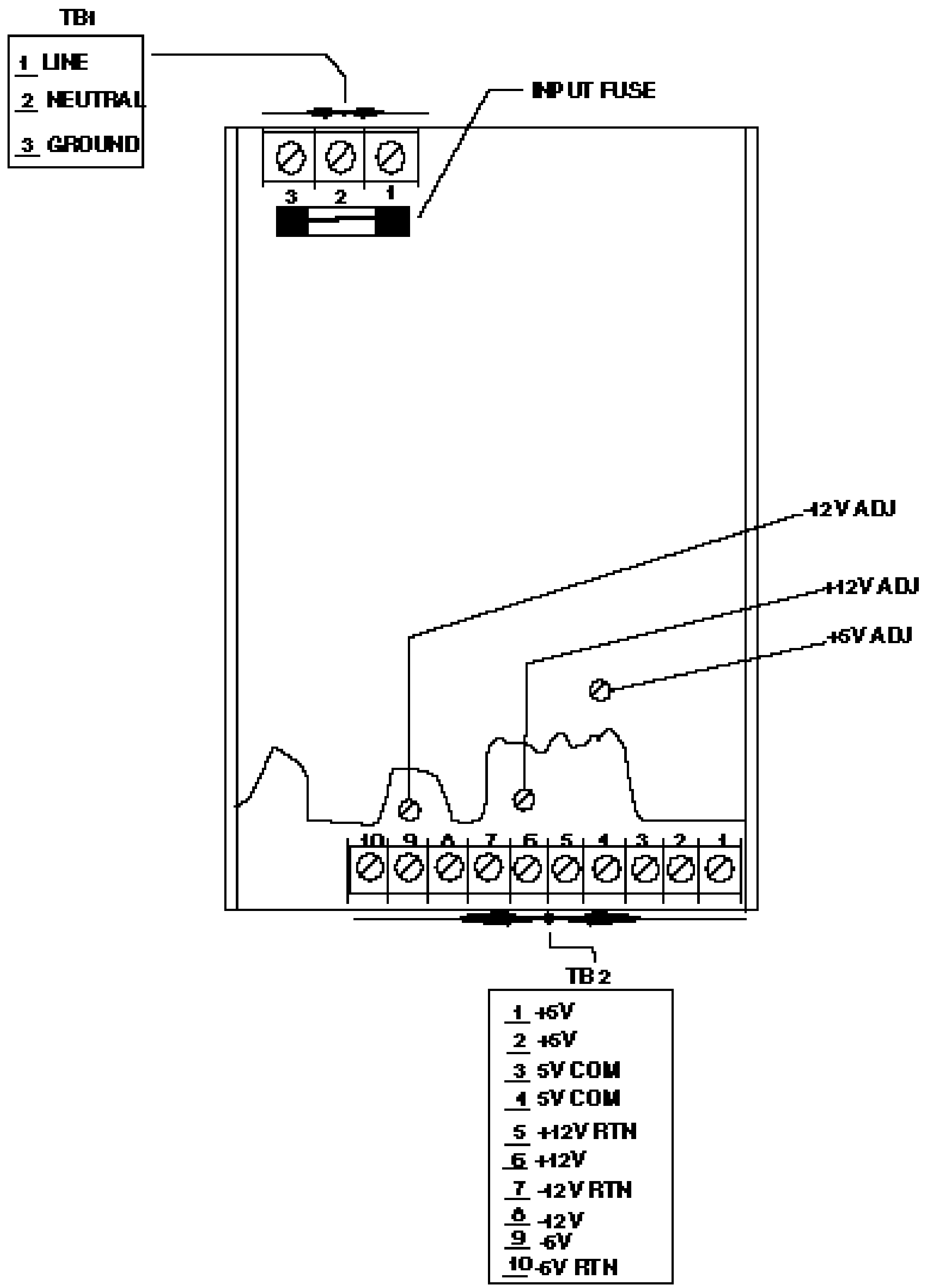


Figure 9-4 Power Supply Adjustment Locations

(275 Watt Supply - Silver Case)

FORCED PAGE BREAK FOR PAGE NUMBERING REASONS - REMOVE FROM MANUAL.

Chapter 10
Transducer Maintenance

Ultrasonic transducers require little maintenance. They need attention only when the signal shows signs of deterioration. The following safeguards apply:

- The connector-ends of transducers - those which lie outside of the conduit - should be protected from the weather and from vermin so as to retain electrical integrity.
- Devices not in service should be protected from the weather and extreme humidity (95% max) and stored at a temperature between -20°C and 60°C.

Signal deterioration

After a period of time, the signal level of the transducer signal may deteriorate. This is usually due to the growth of algae or buildup of mineral deposits on the face of the transducer. The rate at which foreign matter builds up on a transducer face varies, depending on the ambient water conditions. Under normal water conditions, Accusonic recommends that transducer signals be checked for deterioration monthly at first, and then annually. Under severe conditions, more frequent testing may be appropriate. The simplest method is to monitor the AGC values for each path. See path variables *Forward gain* (7-39) and *Reverse gain* (page 7-40*)* in Chapter 7.

In many cases, signal deterioration may be caused by loose, wet, frayed, or worn transducer cables or connections. When signal deterioration is observed or suspected, be sure to check the wiring before assuming that foreign matter has built up on the transducer face or that there is trouble with the transducer itself. Consult the procedures given in *Transducer and Cabling Checkout* in Chapter 4 on 4-5. to check out the transducer wiring and external junctions.

If signal strength drops below acceptable levels, the appropriate action to be taken depends on the type of the transducer.

For internal mount transducers (Models 7630 and 7634) - most of which are installed with dual active elements - try switching elements to see if the problem clears up. If not, the only option is to run the flowmeter with a path shut down (which degrades accuracy), switch on path substitution (which also degrades accuracy), or to dewater the pipe and clean, inspect, and possibly replace the unit.

Note
When switching to a backup element in a dual-element transducer, it is necessary to change the path parameters Path length and Path angle accordingly, unless the elements on both ends of the path are changed.

For fixed-window transducers (Models 7605 and 7625) the active elements of can be replaced from outside the conduit, but cleaning of the acoustic window requires dewatering the conduit.

If the transducers are subjected to high temperatures (> 140°), which can occur if the pipe is dewatered and exposed to strong sunshine, the coupling grease between the transducer element and the window can deteriorate. If this occurs, or whenever the transducer element is removed for inspection or replaced, a 1/32" (1mm) layer of grease should be applied to the flat face of the transducer element. Appropriate grease obtainable from Accusonic.

For removable transducers (Models 7600, 7601, 7635, 7620), remove the unit according to the procedures recommended by Accusonic, and then clean, inspect, and possibly replace the unit.

Danger

Removing a transducer from a pressurized pipe MUST be done in strict accordance with Accusonic procedures. Failure to do so may result in serious injury to personnel or in damage to the transducer or other equipment nearby.

Note

Transducers are position-dependent. When replacing a transducer, always verify that the replacement unit is of the same type as the unit removed. In particular, pay attention to the angle, position, and length designators (i.e., 45°,60°,65°; inner vs. outer; Short or Long) that are part of the model and serial number designators marked on the body of the unit.

7601 Series Transducers

The transducers are installed in special feedthroughs which allow for removal of the transducer without dewatering the pipe or disturbing the alignment of the unit. A special tool must be used. The following is a step-by-step procedure for removal, cleaning, and reinsertion of the transducer.

DANGER
THE TRANSDUCER IS PROBABLY UNDER CONSIDERABLE PRESSURE FROM THE LIQUID IN THE PIPE. ANY ATTEMPT TO REMOVE A TRANSDUCER IN ANY OTHER MANNER THAN OUTLINED BELOW MAY CAUSE SERIOUS INJURY TO PERSONS IN THE GENERAL AREA.

Caution
The 7601 transducers are equipped with a gauge for confirming that the locking pin is fully engaged. Measurements with the gauge and an independent test is required to confirm that the locking pin is seated. If the gauge is missing, do not proceed. Never loosen the locking pin unless the transducer removal tool supplied by Accusonic is installed in complete accordance with the procedure given below.

Caution
Always work from the side of the transducer feedthrough, so that if an error or a component failure results in the transducer blowing out of its seat, you are not in the exit trajectory. Keep the trajectory area clear of other personnel.

Warning
Read through the entire procedure below to be certain you understand it completely. IF YOU DO NOT UNDERSTAND ANY PORTION OF THIS PROCEDURE, STOP FURTHER WORK, DO NOT CONTINUE!

Notes
Transducers are position-specific. Always reinstall a transducer in the same feedthrough position from which it was removed. When replacing one transducer with a new one, double check that the part number of the new unit exactly matches the number of the old one.

Hydrostatic pressure is pushing radially outward on the transducer at all time, including during removal and replacement of the transducer. During normal operations, the transducer is held in place against this pressure by the union nut shown in Figure 10-1 on page 10-14. When the nut is removed, then the locking pin prevents transducer movement. It is extremely important that locking pin engagement be confirmed (using the supplied gauge) before attempting to remove the union nut.

The locking rings which are installed in numbered pairs - the serial numbers are stamped on the opposite mating faces. Parts from on locking ring must not be interchanged with other units. If a ring is disassembled, it must be reassembled using a matched pair.

Tools Required

- ♦ 7601 series clearance gauge (attached to transducer fitting on the conduit)
- ♦ Model 7642 series transducer jacking mechanism (order from Accusonic)
- ♦ Medium (8 inch) crescent wrench (or 1/2 inch (13mm) open-end wrench)
- ♦ 3/8 inch hex (Allen) wrench

1. Verify the following safety conditions are met as shown in Figure 10-1 on page 10-14.

   Locking pin is fully engaged **-** Check that the clearance between the shoulder of the pin and the face of the locking ring is less than the specified limit. Check this by trying to slide the u-shaped end of the clearance gauge under the pin as shown. It must not fit.

   Locking Ring is tightly installed **-** Check that lock washers (spacers) are installed between both sets of mating faces of the two halves of the locking ring. Verify that the hardware is tight and that the lock washers are compressed flat.

   Union nut rotates freely - Check that the union nut turns freely and exhibits no resistance to turning caused by back pressure on the nut from the transducer behind it after it has been loosened one-half turn.

   If any one of these conditions is not met, there may be a safety hazard. Leave the union nut in place, **STOP WORK** on the transducer **IMMEDIATELY** and contact Accusonic for advice.

2. Locate the jacking screw in the jacking mechanism, shown in Figure 10-2 on page 10-15. Make certain that the valve on the jacking mechanism is fully open.

3. Spin the bearing lever so that the threaded tip of the jacking screw is retracted inside the tool valve. The jacking screw should extend beyond the bearing lever about two inches (50mm) as shown in the inset of Figure 10-2 on page 10-15. It may be necessary to rock the valve slightly to allow the jacking screw clearance. Set the jacking mechanism on a clean surface (free of mud or debris), in easy reach for the following steps.

4. Slowly loosen the union nut.

Caution

There should be no resistance caused by back pressure from the transducer acting upon it after it has been loosened one-half turn. If there is, or if you observe any movement of the transducer itself, ***STOP WORK****.Immediately clear the area around the transducer of personnel and contact Accusonic for advice.*

5. Gently remove the union nut from the feedthrough assembly as shown in Figure 10-3 on page 10-16.

   At all times, be alert for any transducer movement.

Caution

*If, at any time before the jacking tool finally is in place, you observe that the transducer moves even slightly, **STOP ALL WORK**. Immediately clear the area around the transducer of personnel and contact Accusonic for advice.*

6. Gently pull the E-O connector out of the body of the transducer as shown in Figure 10-3 on page 10-16. Be alert for transducer movement.

7. Slowly screw the threaded collar of the jacking mechanism valve over the mating thread of the transducer feedthrough. Screw the tool on until in bottoms.

Note

For the first three full turns, be sure to support the far end of the jacking tool so that it does not exert undue torque on the transducer and feedthrough assembly. Be alert for transducer movement.

8. Slowly rotate the bearing lever to advance the tip of the jacking screw into contact with the end of the transducer. This must be done by feel, since the two components meet inside the tool valve. Stop when contact is made.

9. While holding the bearing lever stationary, use a wrench to gently and slowly turn the jacking screw so that it advances into the end of the transducer and begins to engage the inside thread of the transducer.

10. Alternate between turning the bearing lever and then holding it stationary and advancing just the jacking screw to continue threading the jacking screw into the transducer. Do not force it. Continue until the screw bottoms.

Note

As you screw the tool into place, it is necessary to alternately advance and back off on the bearing handle because two threads of different pitches are being taken up at the same time.

11. After the jacking screw bottoms in the transducer, back the screw off slightly so that it will be easier to separate the two later.

12. Turn the bearing lever so that the jacking screw presses the transducer unit assembly inward *slightly*, thereby releasing tension on the locking pin.

Note

The locking pin should rotate easily when it is freed. If necessary, work the bearing lever forward and backward (moving the transducer slightly in and out of the feedthrough) until the pin is free.

13. Slowly loosen the transducer locking pin.

14. Rotate the bearing lever to withdraw the transducer 3/4 of an inch (20mm).

15. Tighten the locking pin firmly against the shaft of the transducer and then back it off one quarter of a turn. This prevents water leakage from around the locking pin.

16. Continue to extract the transducer just until the second O-ring on the transducer body becomes visible - about 3/4 (20mm) inch of the transducer is visible. The transducer face is now clear of the ball valve. (See Figure 10-4 on page 10-17)

17. Close the jacking tool valve.

18. Continue turning the bearing lever until the transducer is entirely clear of the valve. Unscrew and remove the transducer from the jacking screw.

19. Inspect the transducer face for growth or buildup. Remove any buildup with a hard nylon scrubber (Dobie) and a mild detergent (Joy).

Note
Handle the transducer with care. Do not cut or nick the O-rings or try to remove them from the transducer.

Caution
Once a transducer face has been cleaned, do not contaminate it with grease, oil or hand or finger prints, as such film will degrade performance of the unit.

20. Screw the transducer back onto the jacking tool.

Notes
Transducers are position-specific. Always reinstall a transducer in the same location from which it was removed.

When replacing one transducer with a new one, double check that the part number of the new unit exactly matches the number of the old one. Make certain that an inner path transducer is replaced with an inner unit and that an outer path transducer is replaced with an outer unit.

21. Just prior to assembly, *lightly* lubricate the O-rings with an appropriate O-ring grease, Parker O-Lube or equivalent.

Warning
Do not use a silicone-based grease.

22. Turning the bearing lever, advance the face of the transducer until it just reaches the valve opening.

23. Use a 1/2 inch (13mm) open face wrench on the hex end of the jacking screw to rotate the jacking screw until the alignment slot on the transducer is in alignment with the locking pin on the conduit.

Note

Hold the wrench in place during the following steps to help keep the transducer in alignment until it engages the alignment pin located on the inside end of the feedthrough.

24. Continue to turn the bearing lever, advancing the transducer into the valve housing until the middle O-ring on the transducer just slips inside the valve housing.

25. Slowly open the valve all the way.

26. Continue to ease the transducer into the mount until either it meets increased resistance or until the shoulder of the jacking screw comes flush with the bearing lever. Do not advance the jacking screw shoulder past the surface of the bearing lever.

Notes

It may be necessary to rock the valve handle back and forth slightly to allow the transducer to slip through the valve.

If the transducer stops prior to the fully inserted position, it is probably out of alignment. Rock the jacking screw back and forth slightly using the 1/2 inch (13mm) wrench until the unit aligns with the alignment pin and is free to advance further.

Caution

Use only enough pressure during insertion to overcome the back pressure from fluid in the pipe. If you try to force the transducer into place when it is misaligned, you will damage the unit, possibly jamming it in the fitting.

27. When the transducer is home, screw in the locking pin until it bottoms. Then back off the pin one quarter turn to allow the transducer to center itself in the mount.

28. Refer again to Figure 10-1 on page 10-14 and verify that the following safety conditions are met:

    Locking pin is fully engaged - Check that the clearance between the shoulder of the pin and the face of the locking ring is less than the specified limit. Check this by trying to slide the u-shaped end of the clearance gauge under the pin as shown. It must not fit.

    Locking Ring is tightly installed - Check that lock washers (spacers) are installed between both sets of mating faces of the two halves of the locking ring. Verify that the hardware is tight and that the lock washers are compressed flat.

    If any of these conditions is not met, there may be a safety hazard. Leave the tool in place. Try removing and reinserting the transducer, and rechecking the safety conditions.

    If that doesn't solve the problem, STOP WORK IMMEDIATELY and contact Accusonic for advice.

29. Remove the jacking mechanism assembly from the transducer's feedthrough assembly.

30. Reconnect the E-O connector and screw in the union nut.

Caution

Before leaving the transducer, be certain that the locking pin is fully engaged and that the union nut and the E-O connector are installed as shown in Figure 10-1 on page 10-14.

This completes removal and assembly of the 7601 Series transducer.

7600 Series Transducers

The transducers are contained in a special mount which allows for removal of the transducer without dewatering the pipe or disturbing the alignment of the unit. A special tool must be used.

The following is a step-by-step procedure for removal, cleaning, and reinsertion of the transducer.

DANGER
THE TRANSDUCER IS PROBABLY UNDER CONSIDERABLE PRESSURE FROM THE LIQUID IN THE PIPE. ANY ATTEMPT TO REMOVE A TRANSDUCER IN ANY OTHER MANNER THAN OUTLINED BELOW MAY CAUSE SERIOUS INJURY TO PERSONS IN THE GENERAL AREA.

Caution
The 7600 transducers are equipped with a padlock locking rod to prevent tampering with the transducer when the proper tool is not in place. Never unlock the padlock unless the transducer removal tool supplied by Accusonic has been installed as described in the following procedures. Never leave an unlocked transducer unattended for even a short period of time.

Caution
Always work from the side of the transducer feedthrough, so that if an error or a component failure results in the transducer blowing out of its seat, you are not in the exit trajectory. While working on the transducer, keep the trajectory area clear of other personnel.

Warning
Read through the entire procedure below to be certain you understand it completely.
IF YOU DO NOT UNDERSTAND ANY PORTION OF THIS PROCEDURE, STOP FURTHER WORK, DO NOT CONTINUE!

Note
Transducers are position-specific. Always reinstall a transducer in the same location from which it was removed. When replacing one transducer with a new one, double check that the part number of the new unit exactly matches the number of the old one.

Tools Required

- 7661-L or 7661-S series transducer jacking mechanism (order from Accusonic)
- Medium (8 inch) crescent wrench
  (or a 1/2 inch (13mm) open-end wrench and a 1 inch (25mm) open-end wrench)
- Key to the transducer padlock (all padlocks shipped by Accusonic use the same key)
- 1/8 inch (3mm) hex (Allen) wrench

1. Verify the following three safety conditions are met as shown in Figure 10-6 on page 10-19:

   Locking Rod is padlocked - Check that the padlock on the locking rod is locked. The locking rod should not be in contact with the transducer, and it should be free to slide back and forth.

   Clamp bar is secure - Check that the two bolts (1/2 inch (13mm) heads) holding the clamp bar are tight.

   Clamp bar jack screw is fully engaged - Check that the jack screw on the clamp bar presses tightly against the shoulder of the transducer.

   If any of these conditions is not met, STOP WORK on the transducer immediately and contact Accusonic for advice.

Caution

If, at any time before the jacking tool is finally in place, you observe that the transducer moves even slightly, STOP ALL WORK. Immediately clear the area around the transducer of personnel and contact Accusonic for advice.

Warning

Do not loosen any set screws on the transducer mount. They are locked in place during setup and alignment of the unit, and must not be disturbed.

2. Locate the jacking tool and retract the jacking screw so that the hex end of the screw extends 1 inch (25mm) from the tool. Set the tool on a clean surface (free of mud or debris), in easy reach for the following steps.

3. Remove the conduit clamp and gently pull the E-O connector out of the body of the transducer cable connector as shown in Figure 10-5 on page 10-18.

4. Slowly loosen the clamp screw. Fluid pressure should press the transducer tightly against the screw as it turns, pushing the transducer up and out of its seat slightly. Continue loosening the screw until the transducer moves out of its seat about 1/8 inch (3mm) and the shoulder of the transducer back contacts the locking rod.

Note

If the transducer fails to move as the screw is loosened, it may be jammed, or there may be low pressure in the conduit. Try alternately tightening and loosening the clamp screw or manually pulling on the transducer to release it. If it does not move, contact Accusonic for advice.

Warning

Never allow more than 1/16 (1.5mm) inch clearance between the contact point of the clamp screw and the transducer. If the transducer is caught and suddenly breaks free when there is too much clearance, the resulting impact could damage the equipment or cause a safety hazard.

5. Loosen the clamp screw another full turn, retracting it completely from the transducer.

6. Unscrew the two bolts (1/2 inch (13mm) heads) holding the clamp bar and remove it.

Caution

Always work from the side of the transducer mount, so that if an error or a component failure results in the transducer blowing out of its seat, you are not in the exit path. While working on the transducer, keep the downrange trajectory area clear of other personnel.

7. Bolt the jacking tool to the transducer mount using the clamp bar mounting holes as shown in Figure 10-7 on page 10-20. Tighten all four bolts.

8. Rotate the jacking screw to advance the tip of the screw into the recess on the transducer.

9. Use a wrench to tighten the jacking screw until the transducer no longer presses on the locking rod. When pressure on the locking rod is released, the rod should slide freely from side to side.

Note

Do not tighten the jacking screw past the point where the locking rod is freed.

10. Unlock and remove the padlock and remove the locking rod.

11. Retract the jacking screw slightly (fluid pressure should press the transducer tightly against the jacking screw), and push it out of its seat as the screw is backed off.

Note

If the transducer fails to move as the jacking screw is loosened, it may be jammed or there may be low pressure in the conduit. Try alternately tightening and loosening the jacking screw and pulling on the transducer to release it. If it does not move, contact Accusonic for advice.

Warning

Never allow more than 1/16 (1.5mm) inch clearance between the contact point of the jack and the transducer. If the transducer is caught and then suddenly breaks free when there is too much clearance, the resulting impact could damage the equipment and cause a safety hazard.

12. Continue to retract the transducer until 7 5/8 (195mm) inch of the round transducer body (not counting the square back) is exposed.

Warning

Retracting the transducer too far may allow fluid to leak from the mount.

13. Close the valve on the transducer mount.

14. Completely back off the jacking screw.

15. Grasp the transducer by the square shank and the cable connector and rotate it back and forth slightly to pull it completely out of the mount.

Note
The transducer mount has a movable collar and yoke that serve to align the transducer in the conduit. These were set, locked and sealed during installation. If the collar or yoke are loose now, the transducer will need to be realigned; contact Accusonic for advice.

16. Inspect the transducer face for growth or buildup. Remove any buildup with a hard nylon scrubber (Dobie) and mild detergent (Joy).

Note
Handle the transducer with care. Do not cut or nick the O-rings or try to remove them from the transducer. Do not bend the connector. Protect sealing surfaces from abuse.

Caution
Once the transducer face has been cleaned, do not contaminate it with grease, oil or hand or finger prints, as such film will degrade the performance of the unit.

17. Just prior to assembly, *lightly* lubricate the O-rings with an appropriate O-ring grease, Parker O-Lube or equivalent.

Warning
Do not use silicone-based grease.

18. Gently slide the transducer approximately 1/2 inch (13mm) into the mount - just until it remains in place.

Notes
Transducers are position-specific. Always reinstall a transducer in the same location from which it was removed.

When replacing one transducer with a new one, double check that the part number of the new unit exactly matches the number of the old one. Make certain that an inner path transducer is replaced with an inner unit and that an outer path transducer is replaced with an outer unit.

Caution
Be sure that the connector shaft that extends from the transducer back is positioned so that it will engage with the saddle located on the mount as the transducer is pressed into place.

19. Tighten the jacking screw until the pointed tip engages the recess on the transducer.

20. Use a 1/2 (13mm) inch open face wrench on the hex end of the jacking screw to tighten the jacking screw and press the transducer into the mount. Stop when only 7 5/8 inches (195mm) of the round transducer body (excluding the square back) is visible above the shoulder of the mount.

21. Slowly open the valve all the way.

22. Continue to tighten the screw and press the transducer into the mount until either it meets increased resistance or until the shoulder of the jacking screw comes flush with the bearing level. Do not advance the jacking screw shoulder past the surface of the face of the jacking tool.

Notes

It may be necessary to rock the valve handle back and forth slightly to allow the transducer to slip through the valve.

Be sure that the connector shaft of the transducer properly seats in the alignment yoke. If necessary, rotate the transducer into alignment by pulling on the body of the cable connector.

23. When the transducer is home, reinstall the locking rod and lock the padlock. Make certain that the locking rod cannot be removed from the mount.

24. Slowly loosen the jacking screw until the shoulder of the transducer presses tightly against the locking rod.

Caution

Until the transducer is snug against the locking rod, never allow more than 1/16 inch (1.5mm) clearance between the contact point of the jack and the transducer. If the transducer is caught and suddenly breaks free when there is too much clearance, the resulting impact could damage the equipment or cause a safety hazard.

25. Loosen four bolts (1/2 inch (13mm) heads) and remove the jacking tool from the transducer mount.

26. Install the clamp bar using the same bolts; tighten both bolts.

27. Finger-tighten the clamp screw until it is snug against the recess on the transducer.

28. Tighten the clamp bar jack screw with a 1 inch (25mm) wrench until the transducer bottoms in the mount. Do not over tighten.

29. Connect the E-O connector and screw on the conduit clamp.

Caution

Before leaving the transducer, be certain that the locking rod is fully engaged and padlocked and that the E-O connector is installed as shown in Figure 10-6 on page 10-19 .

This completes removal and assembly of the 7600 Series transducer.

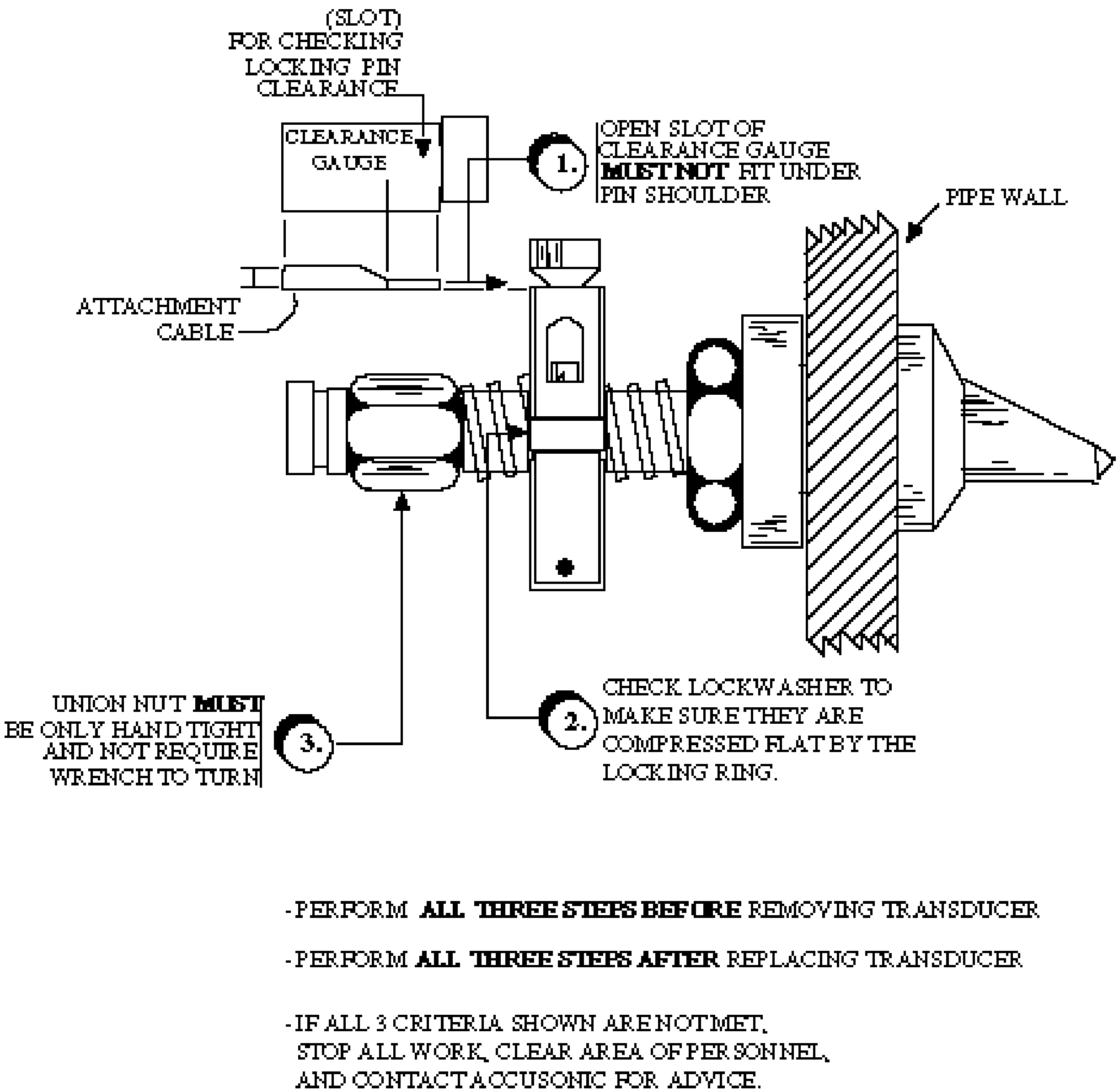


Figure 10-1 Use of Transducer Installation Gauge

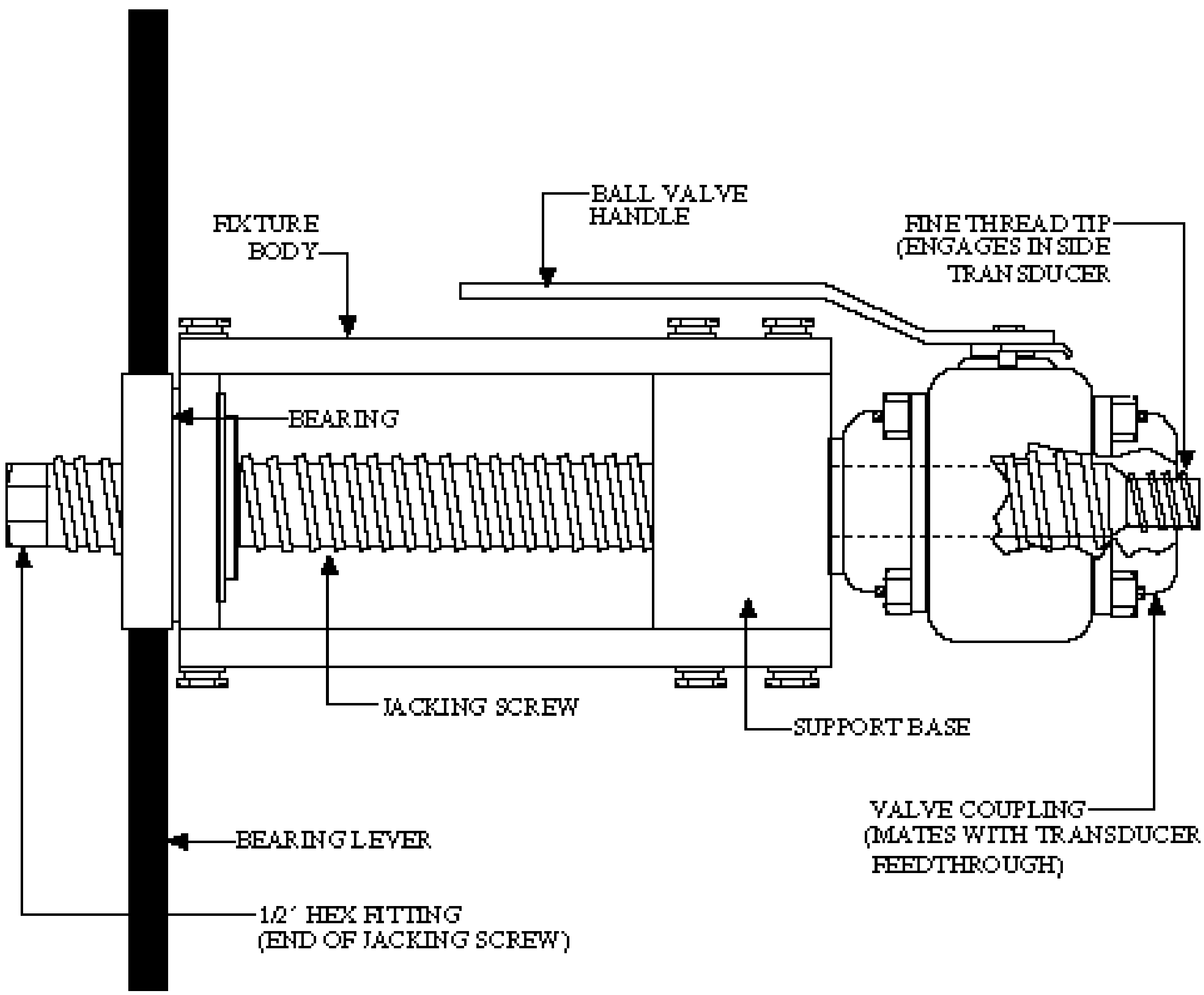


Figure 10-2 7601 Transducer Extraction Tool (uninstalled)

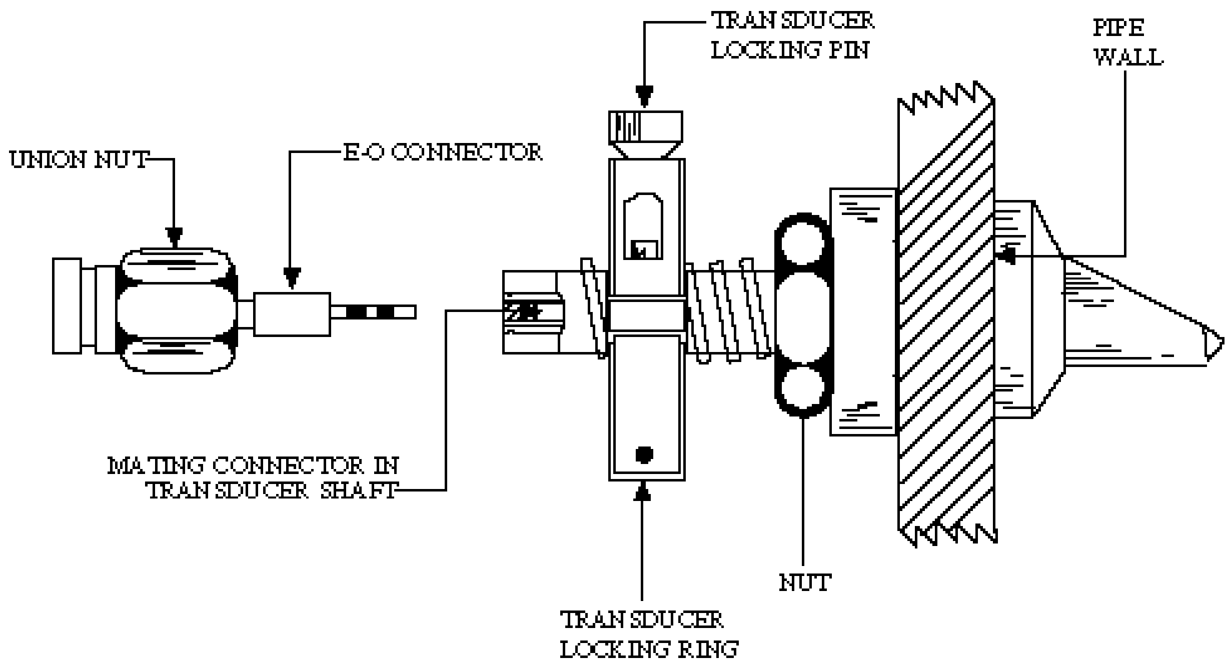


Figure 10-3 Connection to 7601 Transducer

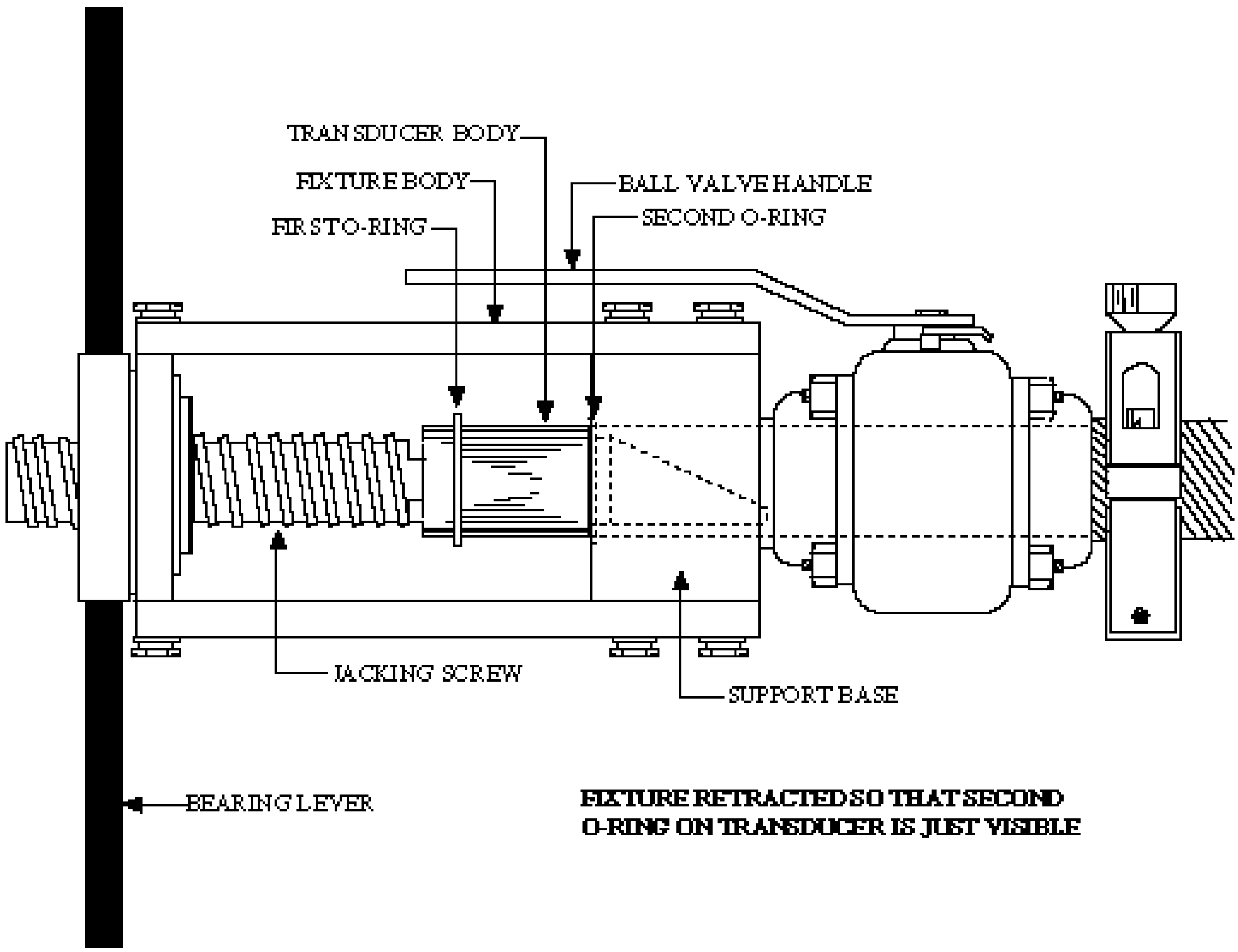


Figure 10-4 Extracting 7601 Transducer using Withdrawal Tool

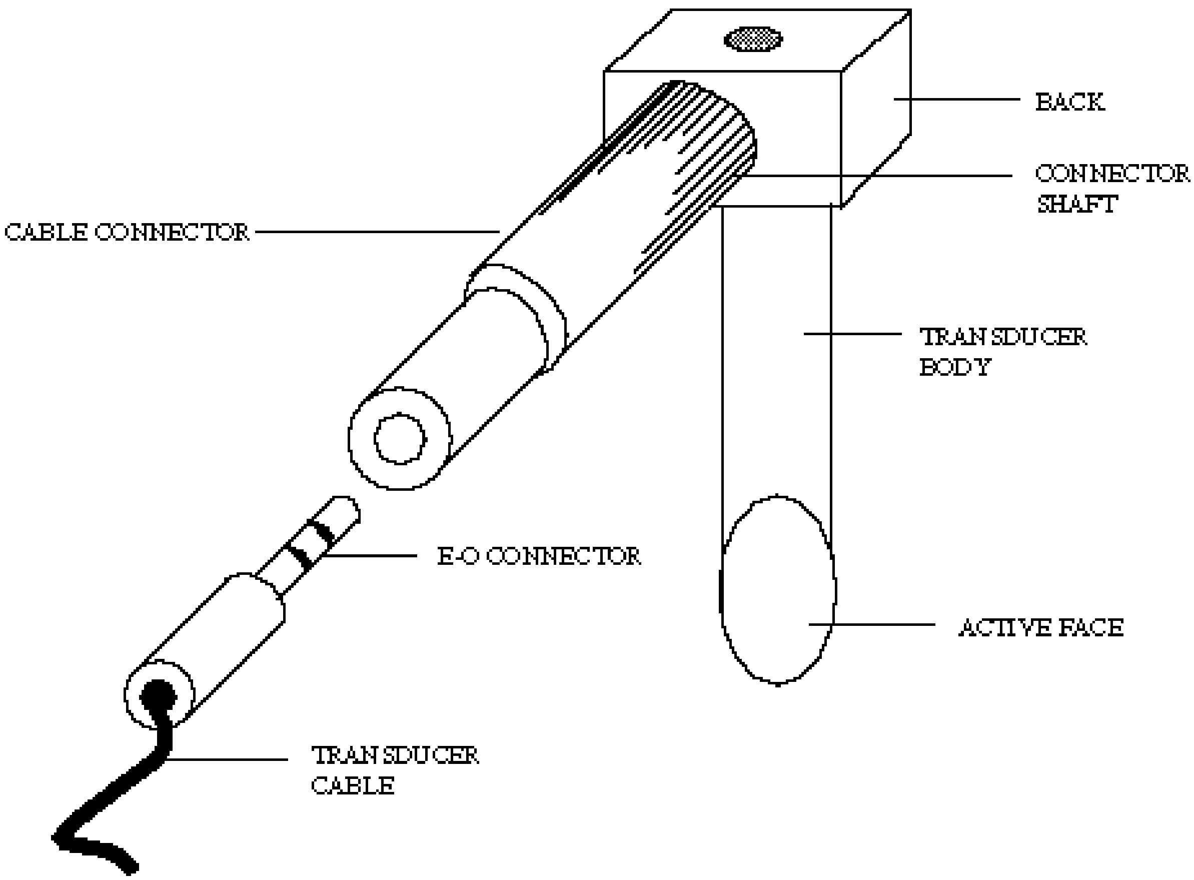


Figure 10-5 Connection to 7600 Transducer

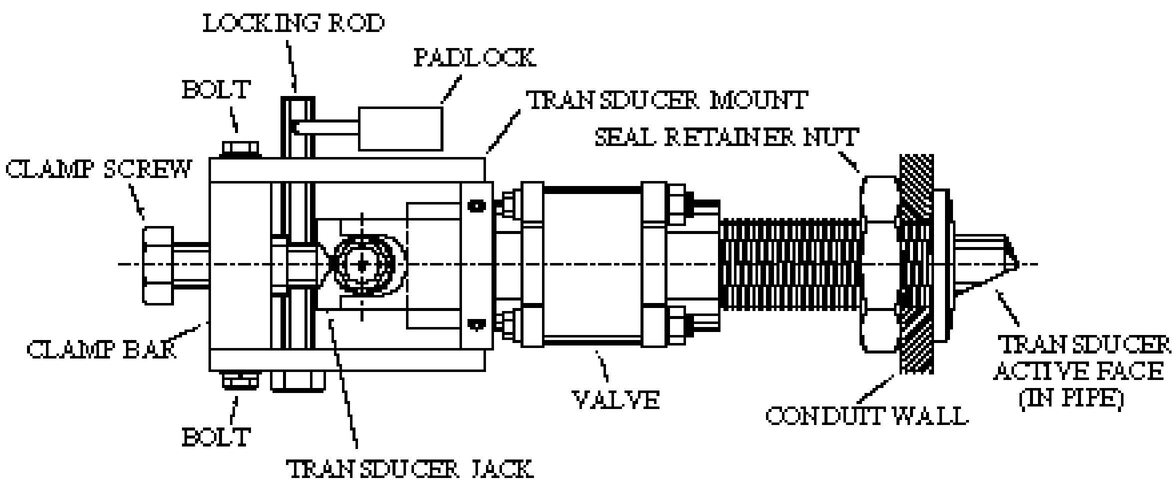


Figure 10-6 7600 Transducer/Valve Assembly

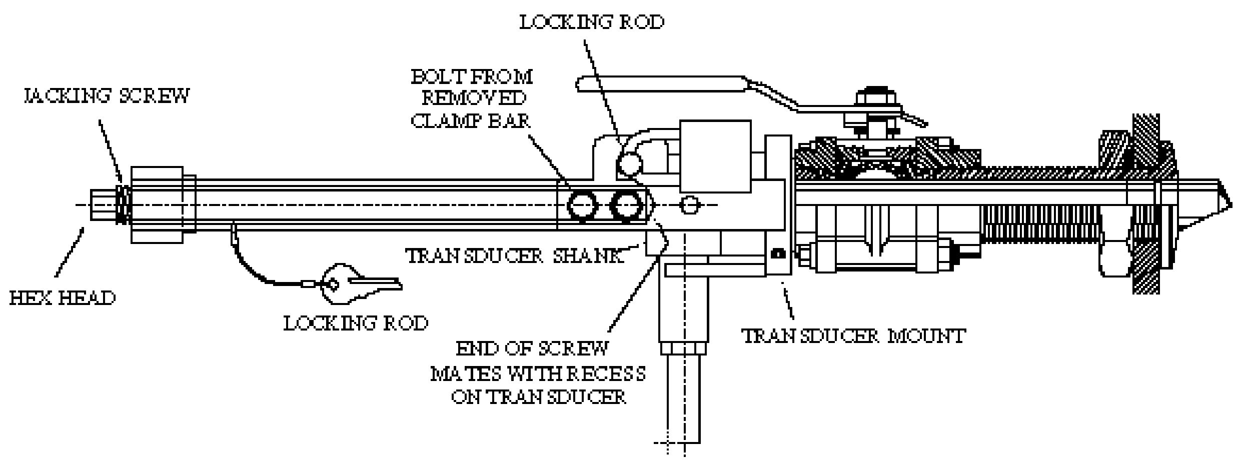


Figure 10-7 7600 Transducer Assembly with Extraction Tool Installed

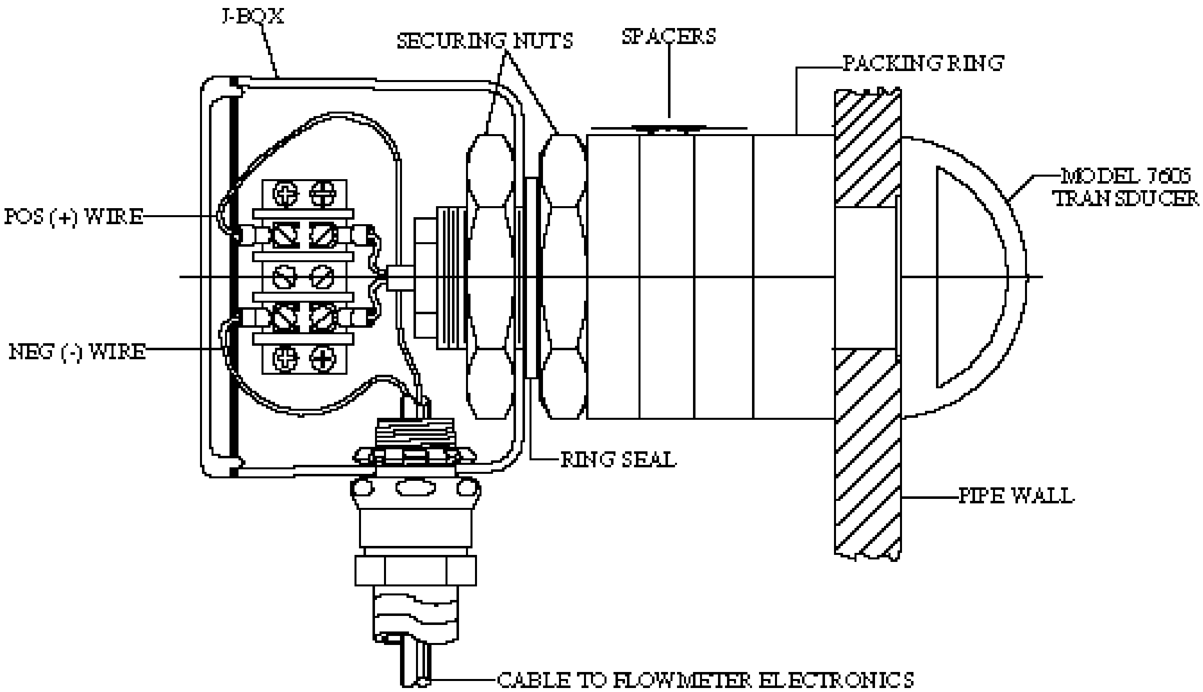


Figure 10-8 Model 7605 Stainless Steel Transducer

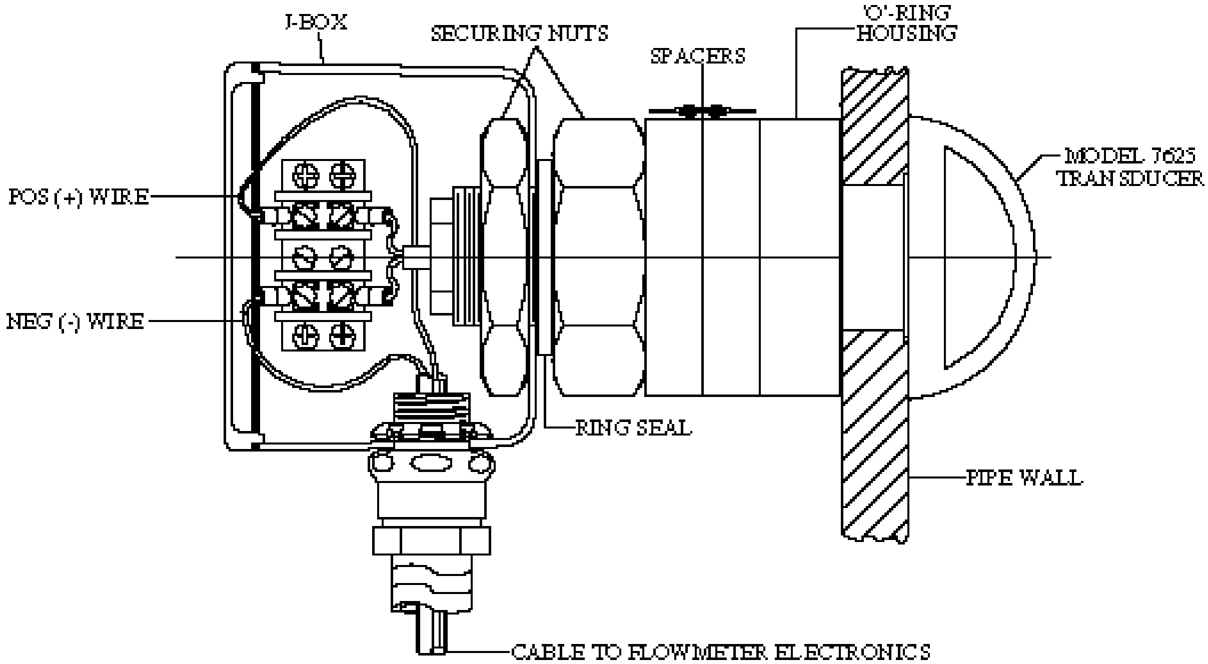


Figure 10-9 Model 7625 PVC Transducer

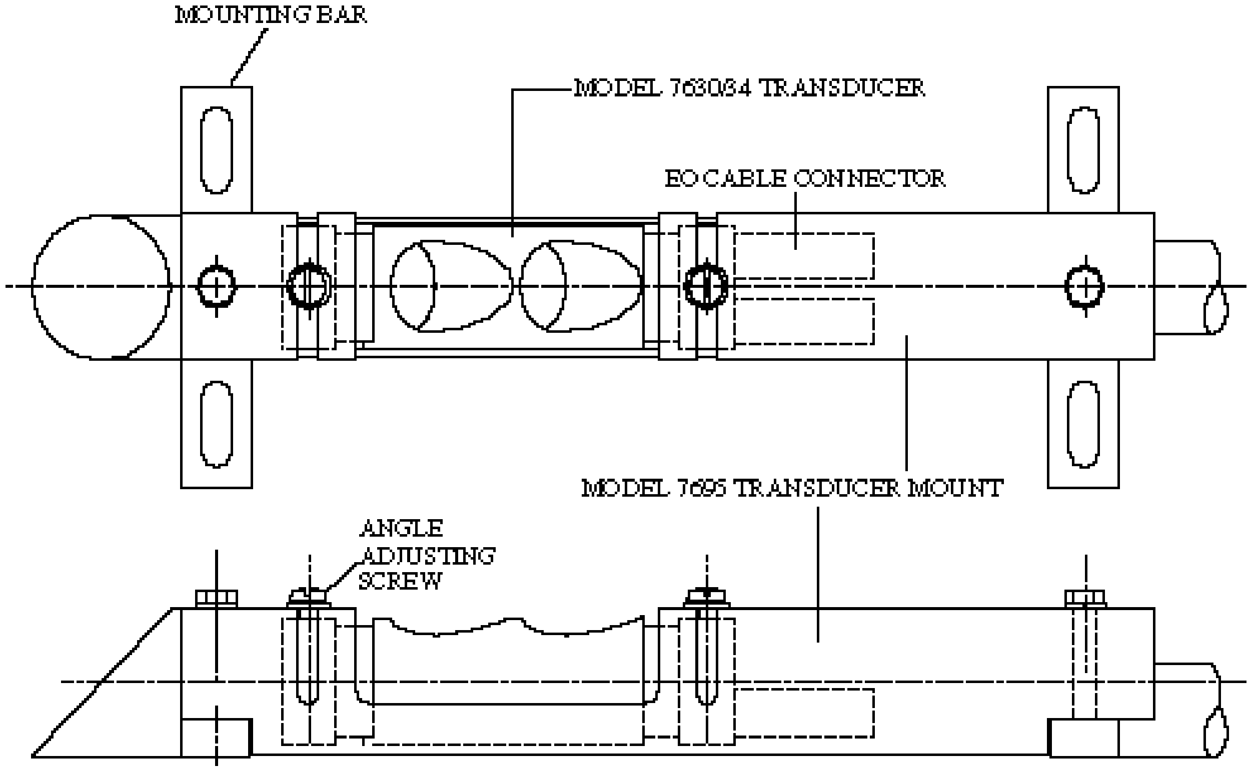


Figure 10-10 Model 7630/34 Internal Mount Transducer

Chapter 11
Miscellaneous Technical Info

The chapter contains information that may be useful when using the 7500, however, the information following doesn't fall into specific categories. The following information is included:

- Entering special keys
- Flow transmitter addressing
- System specifications
- Remote operation via modem

Entering Special Keys

In addition to the basic 7500 keys, the following "hidden" keys are available. Some keys may not be available on older versions.

Key Combination	Resulting Keystroke	Notes
<CTRL 1>	**:**	Colon
<CTRL 2>	<space>	Space
<CTRL 3>	*****	star (filename or extension wildcard)
<CTRL 4>	>	Right Arrow (redirect)
<CTRL 5>	\	Backslash (shows as forward slash on LCD display)
<CTRL 6>	**?**	Question Mark (single character wildcard)
<CTRL 7>	=	Equals
<CTRL 8>	**Q**	Uppercase Q (not directly available on keypad)
<CTRL 9>	**Z**	Uppercase Z (not directly available on keypad)
<CTRL 0>	**,**	Comma
<CTRL ±>	Insert	Insert State toggle. Handy when editing lines of text.
<CTRL DownArrow>	PageDown	Will get you to the top of the next lower menu structure. For example, if you are in a Section menu , this will jump directly down to a Path menu.
<CTRL ESC>		Escapes from any point in Configure menu, saves changes to flowmeter, and goes back to operate mode.
STATUS or -		When pressed at the top-level menu, will display software revision information.

Also, since the keypad hardware emulates the PC numeric Keypad, any keystroke can be entered by use of the three-key ALT sequence. A table of equivalents is available.

For Example,

to enter:	press ALT and the numbers:
_ (underscore)	9 5
" (quote)	3 4

Flow Transmitter Addressing

In order for the 7500 system to communicate with the 7520 remote flow transmitter, the transceiver communication boards in the 7520(s) are *addressed*. The address is set via a set of jumpers on the communications board. Each 7520 flow transmitter in a system must have a unique address, and the address must be one that the 7500 is expecting (these are set at the factory and burned into PROM). If the 7520 is not addressed correctly, it will not make measurements or respond with measurement data. If two or more 7520s are set to the same address, they will respond to the same commands, causing data collisions and very unstable operation. Figure 1 shows the location of the address jumpers on the communication board and Table 1 on the next pagelists the available addresses and jumper settings. Note that if an address is changed, the system must be restarted for the new address to be read in and used. There may be jumpers in positions 11 to 26, these do not affect addressing and should be left alone.

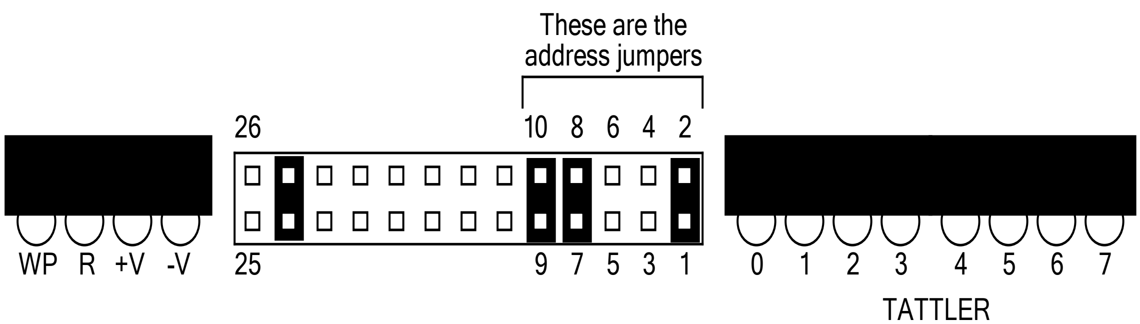


Figure 11-1 Address 1, the default address

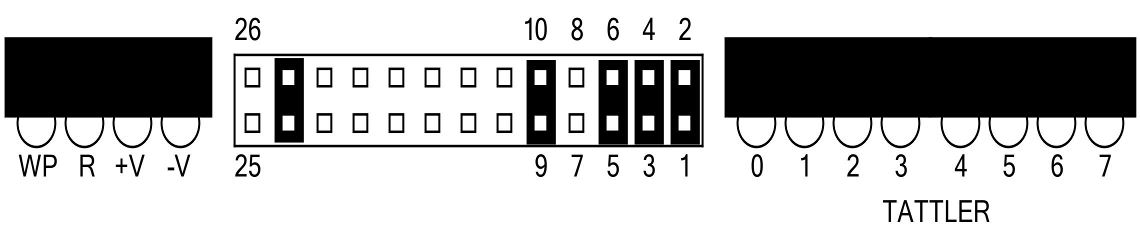


Figure 11-2 Address 3

Table 11-1 Jumper positions

jumper position	9 to 10	7 to 8	5 to 6	3 to 4	1 to 2	notes
address						
1	1	1	0	0	1	Default address. Use in 7500's.
2	1	1	0	0	0	First 7520 address.
3	1	0	1	1	1	2nd 7520 address.
4	1	0	1	1	0	
5	1	0	1	0	1	
6	1	0	1	0	0	
7	1	0	0	1	1	
8	1	0	0	1	0	
9	1	0	0	0	1	
10	1	0	0	0	0	
11	0	1	1	1	1	
12	0	1	1	1	0	
13	0	1	1	0	1	
14	0	1	1	0	0	
15	0	1	0	1	1	
16	0	1	0	1	0	
17	0	1	0	0	1	
18	0	1	0	0	0	
19	0	0	1	1	1	
20	0	0	1	1	0	

Example: The address for the board shown in Figure 11-1 is 1, the default address. Figure 11-2 shows a board set at address 3.

System Specifications

ACCUSONIC MODEL 7500 Console

Power Requirement

90-250 VAC, 47-63 Hz
160 VA Nominal
(Optional Heater can consume an additional 200 Watts)

Enclosure Dimensions

NEMA 4 Wall Mount: 24"h x 20"w x 11"d, 38 kg/85 lbs.
NEMA 4X Wall Mount: 24"h x 20"w x 11"d, 38 kg/85 lbs.
Chassis (table-top or rack-mount): 11"h x 19"w x 21"d`, 20.4 kg/45 lbs.

Environmental Requirements

Storage:	0° - 140° F (60° C) 0% - 95 % Relative Humidity
Operating:	32° - 122° F (0-50° C) - without optional heater -20° - 122° F (-29°-50° C) - with optional heater 0% - 95% Relative Humidity

Miscellaneous

Equivalent Clock counting Frequency:	160 Mhz
Number of Acoustic Paths:	1-8 (can be increased by adding Model 7520 remote flow transmitters)
Number of Measurement Sections:	1-8 (can be increased to 16 by adding Model 7520 remote flow transmitters)

Model 7520 Remote Flowmeter Transmitter

(Requires ACCUSONIC MODEL 7500 for system operation)

Power Requirement

90-250 VAC, 47-63 Hz
135 VA Nominal
(Optional Heater can consume an additional 200 Watts)

Enclosure Dimensions

NEMA 4 Wall Mount: 20"h x 20"w x 10"d, 27 kg/60 lbs.
NEMA 4X Wall Mount: 20"h x 20"w x 10"d, 27 kg/60 lbs.
Chassis (table-top or rack-mount): 11"h x 19"w x 21"d, 20.4 kg/45 lbs.

Environmental Requirements

Storage:	0° - 140° F (60° C) 0% - 95% Relative Humidity
Operating:	32° - 122° F (0° - 50° C) without optional heater -20° to 122° F (-29° - 50° C) with optional heater 0% - 95% Relative Humidity

Miscellaneous

Equivalent Clock counting Frequency:	160 Mhz
Number of Acoustic Paths:	1-8
Communication Link with Model 7500:	2-wire RS-485 (Proprietary Protocol)
Max Distance from 7500:	4000 feet (1220 Meters)
Number of Measurement Sections:	1-8 (defined in Model 7500)

Note:
Specifications are subject to change without notice.

Remote Operation via Modem

Some consoles are supplied with auto-answer modems for monitoring and troubleshooting of the flowmeter from any off-site location. Check the configuration sheet supplied with your unit to determine whether modem operation is included. Note that the following are required for operation via modem:

- Telephone line dedicated to flowmeter use
- PC at the off-site location with compatible modem and *Remote 2 Call* software package

Modem Hookup Procedure

If modem operation is included in your system, locate the modem. Plug one end of the extension cable supplied with the system into the modem. Plug the other end into a nearby telephone jack. Any extension with standard RJ-11 connectors can be used for this connection.

Remote Operation

On the PC at the off-site location, activate the software program used to invoke modem operation. Through the software program, call the telephone number of the dedicated flowmeter line. The flowmeter modem will answer the call, and all information on the flowmeter screen will be shown on the off-site PC screen as well.

The flowmeter can now be monitored and controlled by the keyboard from the off-site PC, including changing system parameters and examining system variables, for example, flowrates, volumes, and individual path status, travel times, velocities and gains. Other actions available from the off-site location include enabling datalogging or other outputs, running diagnostics, and troubleshooting.

See Chapter 5 for information on control of the meter from an external keyboard and for procedures for stepping through program menus.

Calling up the 7500

The Accusonic *Remote2 Call* program is used for calling up the 7500 from a remote PC and for downloading data to the remote PC. The *Remote2 Call* program must be loaded on the remote PC, and the dialing directory must contain the telephone number of the flowmeter and any necessary passwords. The following procedure is then used to call up and download data from the 7500.

- At the remote computer, invoke the program by typing **R2CALL<Enter>.**
- Using the down cursor, highlight the flowmeter phone number and press **<Enter>.** R2CALL will complete the connection and log in. The flowmeter measurement screen should appear:

#	FLOW	POS-VOL	NEG-VOL	Oct 26 94
S1	142.9	9801	0	GOOD
S1	155.1	1202	0	GOOD
T	398.0	11003	0	12:45:30

At this point, any operation that can be performed when in front of the flowmeter can be performed remotely. Some typical uses:

- Parameters, operational modes, or display screens can be changed.
- Diagnostics can be run.
- Variables can be viewed.
- Data or error log files can be downloaded to the calling PC.

Downloading Data Files

- Press **<Escape>** to exit measurement mode. (This is important, as *Remote2* can tie up the flowmeter for longer than the 50-second watchdog timer reset time, causing the flowmeter to reset and disconnect unexpectedly).
- Press **<CTRL><ESC**ape> keys. The Remote2 menu will pop up.
- Type "**R**" or scroll down to menu choice **Receive a file from the host**.
- Press **<Enter>** to receive files.
- Where prompted to enter a filename, type **B:*.PRN** and press **<Enter>.**

The next menu choice tells *Remote2* where to put the log files:

- Press **<Enter>** to put the files in the current directory.
- Press **<Enter>** again to start the transfer. Transfer progress will be displayed with gas-gauge-style progress indicators.

When the transfer has been completed, the screen will display a menu of the transferred files. There will be files for flowrate and volume, there may also be files for stage and velocities depending on whether these variables were selected for logging.

- Press **<Escape>** to exit this menu and return to the Main Menu.

A note on Data Logging quantities:

With logging turned on for three sections of flowrate and stage, each log point adds approximately 250 bytes to the disk. Therefore, if the log interval is set to five minutes, about 72 Kbytes of data will be logged per day. The disk will fill up in a little over two weeks.

Consideration should also be given to the time required to download quantities of data over the telephone line. For example, 72 Kbytes of data will take approximately 15 minutes to download at 2400 baud.

Re-entering Measurement Mode and Exiting the *Remote2* Program

At the Main Menu:

- Select "**Continue using the host**" and press **<Enter>.**
- From the 7500 menu, select **"Diagnose".**
- When the diagnostic menu appears, press the "." key to enter the utility menu.
- From the utility menu, select **"System".**
- At the "A>" prompt, type **DEL B:*.PRN** and press **<Enter>.** This will erase all of the data files from the log disk in the flowmeter.
- Press **<Escape>** three times to return to the Main Menu.
- Select **"Operate"** from the Main Menu.
- Wait for all of the status indicators to show GOOD, the press **<CTRL><Escape>** to pop up the *REMOTE2* menu again.
- Press "**H**" to select "Hang Up".
- Press **<Enter>.**
- Press **<Escape>** again to exit *Remote2*.

Electrical Surge Protection for Accusonic Flowmeters

This section provides an overview of the types of protection available to suppress damaging electrical transients, and their specific application to Accusonic flowmeters.

Overview - Surges and Transients

Transients and surges can come from many sources. The most common are:

- Industrial transients. These can be generated by switching electrical equipment such as pumps.
- Static discharges when personnel in a dry environment touch grounded electrical equipment.
- Lightning strikes.

There are several mechanisms by which transients can cause damage. The first, and most common, is when a transient is either directly, inductively, or capacitively coupled into electronic circuitry.

Induced transients are typically fast pulses, having rise times of less than 10 microseconds. If one were to select a component to carry such pulses, one would probably use a very small capacitor. This is relevant to this discussion, as will be seen shortly.

Damage to equipment is caused when a high voltage transient attempts to return to ground through the flowmeter electronics. Transient protection schemes attempt to divert the transient energy to ground before it reaches the equipment. The intent is to provide an easier (lower impedance) path for the transient to get to ground via the protection circuitry than through the flowmeter electronics, so a good earth ground is essential. Large-diameter ground cable should be used to minimize the resistance to ground.

The second mechanism is ground potential difference between electrical units. This can be caused by a variety of reasons, ranging from an event such as the energy from a near lightning strike raising the local grid potential to a poor ground connection. The damage is caused when one devices potential is significantly different than another and they are electrically connected by a communication line or current loop. The voltage difference becomes greater than the driving or receiving device can tolerate, and damage occurs.

This type of damage can also be caused simply as a result of a poor ground connection, allowing one device to charge, or "float" above ground by an excessive amount.

Two types of transient current flow may occur:

- Differential mode (also called normal mode) transients are transients that occur from line to line. These are the most common.
- Common mode transients appear from line to ground.

The Case for an External Surge-Protection Enclosure

The American Heritage Dictionary defines a capacitor as “an electric circuit element ... consisting of two metallic plates separated by a dielectric”. The Teflon and PVC insulation used in the flowmeters wiring have excellent dielectric properties. Therefore, any two pieces of insulated wire running in parallel or even laying across one another will form a capacitor. The value will probably be very small, but remember that very small capacitors are ideal for coupling the narrow pulses that characterize transients. *Any two wires in contact with one another can provide a path for conduction of transients, even if their conductors are insulated.*

In a system such as the ACCUSONIC MODEL 7500, there are many subsystems. Wires are routed throughout the enclosure, with power wires crossing digital and signal cables. If a transient enters the enclosure on a transducer cable and this cable crosses other wiring, the transient will attempt to flow to ground through the easiest path. If the relay for that path is open (it usually will be), the easiest path to ground will be through the crossed wiring and the electronics.

The best defense against transients is space filled with air. A 7540LP (separate non-conductive enclosure containing transient-diversion devices) has a large, carefully laid-out air gap between protected and unprotected wiring. There is no danger of susceptible wiring accidentally crossing when the equipment is properly installed.

Where space does not allow for mounting a second enclosure, protective circuitry can be mounted inside the flowmeter enclosure. Great care must be taken to insure that wiring is routed correctly, and cannot be moved in the future to create a transient path that would result in damage.

Protection Components

This section describes individual types of protection components. Their application will be discussed in the next section.

- *Isolation Transformers* - Generally provide very good rejection of high-energy transients. A properly applied transformer will couple only the required amount of energy, any excess is radiated harmlessly to air. They can be used for AC signals only, as they block the passage of Direct Current. Transducer/Path transformers have an additional interwinding layer to prevent arcing between primary and secondary windings. This layer is intended to be connected to ground.
- *Gas tubes* are used to absorb high-energy transients. They are composed of a gas-filled tube with conductors at either end. When the voltage between the conductors rises sufficiently, the gas between them ionizes, becoming a conductor. Gas tubes are relatively slow to fire (typically 1 to 100 μS, time depends on rise time of the transient), but will shunt tremendous amounts of energy without damage to themselves.
- *Zener* or *avalanche* diodes are semiconductor devices with controlled breakdown voltage properties. Below the breakdown voltage, they are essentially an open circuit, above the voltage, they conduct. They are fairly slow to conduct and will not handle much power.
- *Transzorbs* are used to absorb fast, low-energy transients. They are equivalent to a very fast (response times are typically in the single nanosecond range) zener diode. They are available in a variety of voltage ranges.
- *Metal Oxide Varistors (MOVs)* are devices which change resistance as the applied voltage changes. They have a relatively high capacitance, which delays their conductance on fast transients.
- *Line filters* are inductor/capacitor combinations designed to block pulsed, continuous, and intermittent radio-frequency interference. They are not designed to be transient protection devices, although they may be partially effective in many cases.

As can be seen from the above descriptions, each type of component has its advantages in terms of response speed and power handling. Until somebody designs a fast transient absorption device with unlimited power-handling capability, carefully chosen combinations of devices are usually the most effective.

Application of Protection Devices to Accusonic Flowmeters

Power Line:

- Accusonic typically uses Line Isolation Transformers combined with MOVs. The transformer radiates the excess energy from large spikes, the MOVs absorb anything that gets through the transformer. The transformer isolates the AC line side of the electronics from ground, providing protection from both normal and common mode transients, and allowing it to lift above ground when necessary. Equipment ground is maintained for safety, and the transformer case, core, and an internal electrostatic shield are all tied to ground.
- Active transient suppression can be used in applications where space is unavailable for an isolation transformer. The system has a response time of less than five nanoseconds, and “tracks” the AC sinusoid, normalizing any defects. Spikes on the line are blocked and any notches are filled. Although it sounds like the ideal solution, this type of system provides no security against ground potential differences.
- Line filters are installed in the model 7510 flowmeter as standard equipment.

Transducers and cables:

- Transducer inputs to the flowmeter electronics console are protected by specially-wound transformers. The transformer is matched to the frequency of the transducer. The transducers themselves require no protection, as they handle 1,000 Volt transmit pulses repeatedly in the course of flow measurement.

4-20 mA Process Control Loops:

- Process control loops are DC coupled, so they can’t be positively protected against transients. There will always be a direct path for the transient to enter the equipment. The only defense is to try to shunt it to ground before it causes any damage. Accusonic offers transzorb-based “protectors”, which will help somewhat with common-mode transients in a non-isolated control loop output. If the transient is big enough, the protection device may absorb it, fail, and not be available to protect against the next incident.
- Process loops are typically one of the first things to fail in the event of ground potential differences between the flowmeter and other equipment. The ground potential difference exceeds the compliance of the output, and the device fails.
- The solution to both of these problems is to use an isolated output. The input-to-output isolation is typically over 1,000 Volts, handling all but the most extreme differences, in addition to providing inherent protection against common-mode transients. Transzorb-based “protectors” can also be installed, which will help absorb differential-mode transients in an isolated system.

RS-232 Serial links:
RS-232 outputs are also DC-coupled (see discussion in 4-20 process loops above). Zener or avalanche diode-based protectors are used, with the same effectiveness discussed above.

RS-485 Serial data bus:
The RS-485 serial data bus is also DC coupled, making it very difficult to protect. In addition, the signal voltage levels are very low. Typical signal levels are only around 5 Volts, with the absolute maximum levels being +12 and -7 Volts. Any difference in ground potential between remote flow transmitters on the bus will cause, at minimum, communications link failure, or at maximum, extensive electronic component failure in the equipment.
After mixed results with commercially-available RS-485 communications devices, Accusonic has designed their own. The device electrically isolates the flowmeter from the bus up to a maximum of 1500 Volts. Each leg of the communications bus is protected by:

- A gas tube, chosen to activate above 70-90 Volts, and absorb large amounts of energy.
- A Transzorb, which quickly clamps the line to 7 volts.
- A fast, high-current diode, which protects against transients with negative polarity.
- A thermal fuse. If large continuous voltages are placed on the communications lines, this will heat up and increase resistance, decreasing the voltage to the RS-485 device.
- There is an additional gas tube which conducts above 1000V. It is to keep both communication lines within 1000V of ground, protecting the RS-485 device from isolation-barrier damage.

Summary of Standard and Optional Equipment

This section lists which protection equipment is stock and what is optionally available.

Standard Equipment:

RS-485 protection as described above (RS-485 is installed to communicate with 7520 remote flow transmitters. 7520s have the same level of protection.)

Optional Equipment:

AC Line isolation transformer
Active transient suppressor for AC Line (Amber Industries AI-105)
External path isolation transformers (mounted in 7540LP)
Isolated analog outputs
RS-232 output surge protector
Parallel printer port surge protector
Telephone line “lightning sponge” (when remote access modem is installed)

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Chapter 12 Leak Detection System

The Accusonic Leak Detection System operates by comparing flowrates measured over time by flowmeters located at two or more locations on a pipeline. While the leak detection system must be sensitive enough to detect a leak, it must also be designed to minimize the possibility of false alarm trips due to transient flow conditions that occur during normal plant operation and load changes, or due to normal measurement variability, rejected readings, and hardware failure.

In many systems, the pipe diameter and configuration are not the same at the two ends, and the upstream pipe geometry is normally complicated by the presence of bends and valves very close to the meters. If the two flowmeters are to be compared, they must therefore be tolerant of these effects. By using multiple acoustic paths in each measurement section, Accusonic flowmeter accuracy is high and relatively unaffected by upstream flow conditions. This allows optimum leak detection performance.

Accusonic has developed specialized leak detection algorithms to aid in detecting small leaks where the differential flows might be small but steady over along period of time, and large, potentially catastrophic, leaks where the differential flows will be large but must be detected within a very short period of time.

Relays are provided to signal a warning or an alarm if the differential flowrates indicate a leak. These relays can be used to operate annunciators or to initiate valve or gate closures.

The system also provides for warning or alarm relays based on excessive velocities measured through one or more of the flowmetering sections.

System Components

The leak detection system comprises a 7500 console, possibly with remote flow transmitters, and one or more remote flow transmitters, together with associated transducers and cables sufficient for flow measurement in each section. All remote flow transmitters communicate with the 7500 console via a serial communications link. The 7500 console contains specialized software to carry out the flow comparison/leak detection functions and provides an alarm if a leak is detected.

Under ideal operating conditions, the combined flowrates through all sections at either end of the pipeline should be the same. Ideal conditions are seldom achieved, however, and under normal conditions flowrates can vary significantly from one end of the penstock to the other. These differences can be caused by many things, for example, the time lag after a valve is closed or the oscillations caused by a surge chamber. To compensate for these conditions the leak detection software filters the differential flowrates and provides multiple detection thresholds, all under operator control.

Note
The following terms are used when setting parameters in the 7500 Leak Detection System.

Section - Used to describe each location in which transducers are installed. One flowmeter electronics console can measure flow in more than one section.

End - Used to describe one or more sections whose flowrates are added to determine a total flowrate at one end of a pipeline. Typically, a leak detection system contains two ends, whose flowrates are compared to detect a leak. Either end may be composed of one or more sections, as shown below.

Pipeline or penstock - Used to describe the overall configuration of a flowmeter system which might be composed of one or more ends, each composed of one or more sections. This is a typical configuration used in leak detection systems where one or more section flowrates are combined into end flowrates for purposes of comparison.

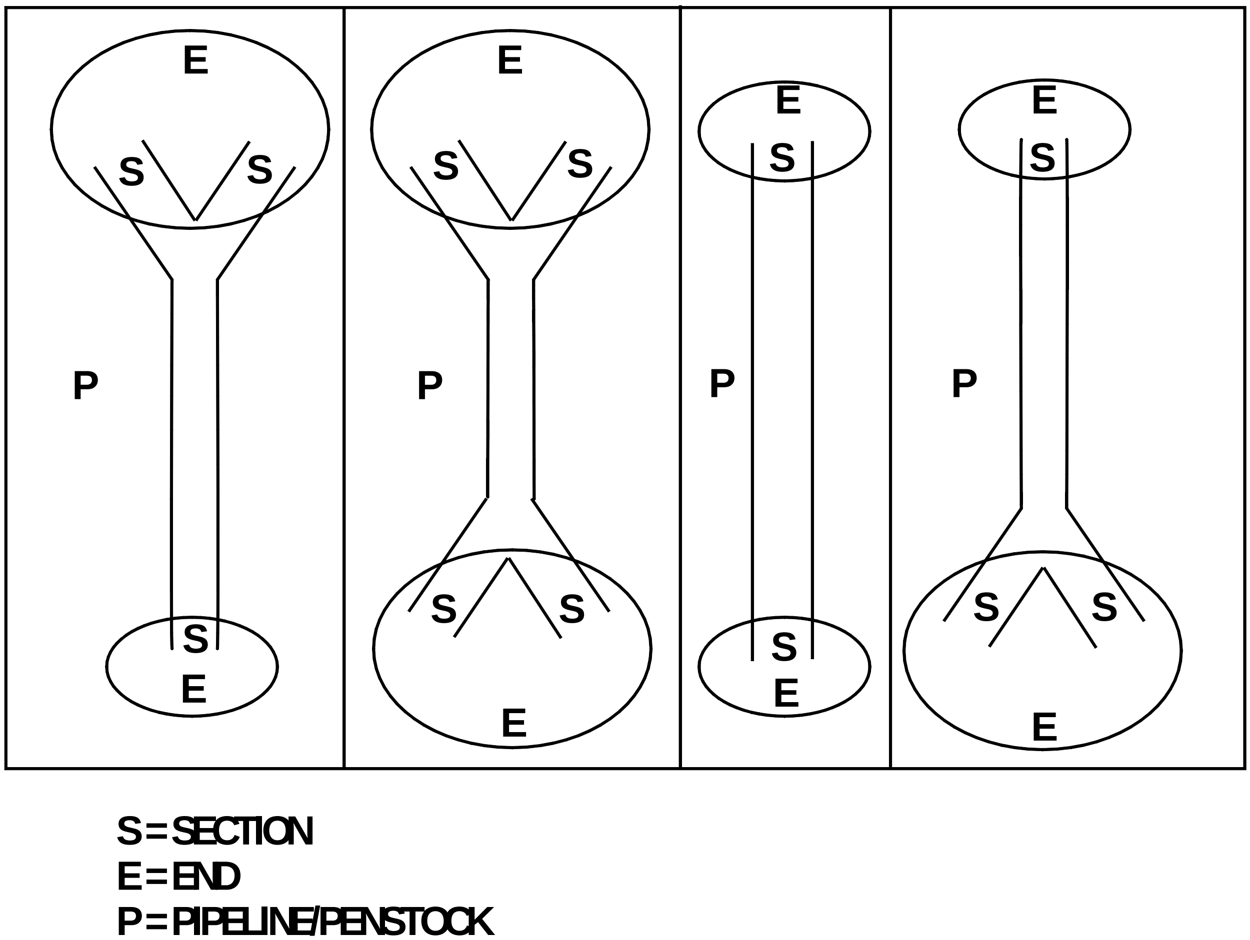


Figure 12-1 Typical Section/End/Penstock Configuration

System Operation

Differential Flow Determination

The 7500 leak detection system maintains a running average of the difference between the total flowrates at each end of each pipeline. This average is calculated from a queue of instantaneous signed flowrate differences between ends of each pipeline. Operator-settable parameters control the number of measurements that will be averaged (queue size), as well as the values representing warning and alarm thresholds. If the average differential exceeds the first threshold, a warning relay is closed; if the average differential flowrate exceeds the second threshold, an alarm relay is closed. These thresholds are site-specific and are determined at the time of system commissioning based on typical operating conditions.

Differential flow calculations do not occur unless the flow measurements at each end are valid. Additionally, any system failure will prevent the flow differential relay from tripping. In particular, the watchdog timer, individual transceiver self tests, section and path measured values must all be within limits specified by their respective parameters, with no path/section errors present.

At startup (first measurement), the averaging queue contains zeroes, so the flow differentials can appear abnormally high because of normal measurement variability, which is typical of instantaneous flow measurements. To prevent an erroneous differential flow alarm, the program calculates the differential average as the sum of the values currently in the queue divided by the total size of the queue. This has the effect of raising the threshold values at startup to prevent false trips.

Over Velocity Detection

In addition to differential flow warnings and alarms (for pumping and siphons), the leak detection system also provides for warnings and alarms based on positive and negative over-velocity thresholds. Extreme velocities can be used to detect a leak even in the case where a pipe rupture causes acoustic paths to stop operating so that the meter is unable to calculate flow in one or more sections.

The system operates by calculating the instantaneous average of all good velocities for each section. This average velocity is then compared to the over-velocity warning and alarm threshold values entered as site-specific parameters. The threshold is an absolute value, but totals of the threshold crossings are signed. A positive threshold count is incremented each time the velocity exceeds the positive threshold value and is decremented each time it falls below the positive threshold value. The same concept is applied to the negative threshold, but the signs are reversed for negative flow. If either count exceeds a user-entered value, a relay is closed.

Velocities used in the average velocity calculation must pass all the normal requirements of a good velocity except the Signal Quality Monitor (SQM), and the section parameters *Minimum good paths, Maximum expected velocity and Maximum change in velocity*. The reason for not requiring valid SQM is that very high velocities produce low pressures, which increase the likelihood of cavitation in the vicinity of the transducers. Cavitation will reduce signal strength.

Since the pipe will probably flow partially empty in the event of a major rupture, acoustic paths should always be installed horizontally in a leak-detection system.

Note

*All relays are **not** latching; the closure is present as long as the condition causing the closure is present. In the event of a catastrophic leak, once the over velocity alarm relay is tripped, acoustic paths will begin to fail, and the hardware failure alarm relay will close. At this point, the over velocity alarm relay will open. A second, latching relay tripped by the over velocity relay is required to ensure valve closure under these conditions.*

General System Operation

The leak detection program sequence follows.

- Measure travel times for each section at both ends of the pipeline (as described in Chapter 3, beginning on page **Error! Bookmark not defined.**.)
- Calculate average velocity for each section (ignoring SQM and *Minimum good paths* parameter)
- Calculate instantaneous flowrate for each section (using all filtering parameters)
- Calculate average flowrate for each section
- Calculate total instantaneous flowrate for each end of the pipeline (if more than one section at either end of the pipeline)
- Calculate total average flowrate for each end of the pipeline.
- If all average flowrates are good, calculate differential flow from instantaneous flowrates at both ends and add to queue.

- if average velocity > positive over velocity **warning** threshold
    - positive over velocity **warning** count = positive over velocity **warning** count + 1

  else
    - positive over velocity **warning** count = positive over velocity **warning** count -1 (not to decrement below 0)

- If average velocity < negative over velocity **warning** threshold
    - negative over velocity **warning** count = negative over velocity **warning** count + 1

  else
    - negative over velocity **warning** count = negative over velocity **warning** count **-** 1 (not to decrement below 0)

- if positive over velocity **warning** count > maximum over velocity **warning** count
    - enable positive over velocity **warning** relay

  else
    - disable positive over velocity **warning** relay

- if negative over velocity **warning** count > maximum over velocity **warning** count
    - enable negative over velocity **warning** relay

  else
    - disable negative over velocity **warning** relay

- if average velocity > positive over velocity **alarm** threshold
    - positive over velocity **alarm** count = positive over velocity **alarm** count + 1

  else
    - positive over velocity **alarm** count = positive over velocity **alarm** count **-** 1 (not to decrement below 0)

- If average velocity < negative over velocity **alarm** threshold
    - negative over velocity alarm count = negative velocity **alarm** count + 1

  else
    - negative over velocity **alarm** count = negative over velocity **alarm** count **-**1 (not to decrement below 0)

- if positive over velocity **alarm** count > maximum over velocity **alarm** count
    - enable positive over velocity **alarm** relay

  else
    - disable negative over velocity **alarm** relay

- if | differential flow | > **warning** threshold, close the differential **warning** relay

- if | differential flow | > **alarm** threshold, close the differential **alarm** relay

Note

All relays are ***not*** *latching; the closure is present as long as the condition causing the closure is present. In the event of a catastrophic leak, once the over velocity alarm relay is tripped, acoustic paths will begin to fail, and the hardware failure alarm relay will close. At this point, the over velocity alarm relay will open.* ***A second, latching relay tripped by the over velocity relay is required to ensure valve closure under these conditions.***

Leak Detection Parameter List

Always display plant totals

Although this is not a leak detection parameter, its setting affects the operation of a leak detection system. As previously stated, flow comparison will not be done if one or more flow rates are “BAD”. Setting this parameter to “ON” will allow comparison (and potentially false detection of leaks) during hardware failure conditions.

It is strongly suggested that this parameter be set to OFF.

Menu levels:	Extended
Range:	OFF, ON
Default:	OFF

Differential alarm threshold

The value with which the differential flow average is compared in determining whether to close the alarm relay. This value is typically determined at the time of system commissioning based on site-specific operations. This threshold should be set to a higher value than the parameter *Differential warning threshold*.

Menu levels:	Setup, Limited, Extended
Range:	#
Default:	0

Differential flow average size

Defines the number of different flowrate measurements that will be averaged by the leak detection software. This represents the size of the a queue in which the difference between flowrates at the two ends of a pipeline are stored for averaging. As each differential flowrate is calculated, an entry is added to the averaging queue until the differential flow averaging queue equals this setting. Once the queue is filled, each new entry replaces the oldest entry in the queue. Upon first startup, the differential flow average queue is zeroed.

Menu levels:	Setup, Limited, Extended
Range:	#
Default:	25

Differential warning threshold

The value with which the differential flow average is compared in determining whether to close the warning relay. This value is typically determined at the time of system commissioning based on site-specific operations. This threshold should be set to a lower value than the parameter *Differential alarm threshold*.

Menu levels:	Setup, Limited, Extended
Range:	#
Default:	0

Leak detection switch

Enables the leak detection system algorithms. Note that this parameter appears twice on the flowmeter menu--once as a General parameter and again under the specific Leak detection option. The switch must be turned on in the General parameter list in order to enable the system to perform the calculations required for leak detection. It must also be enabled under the Leak detection option for each pipeline/penstock for which leak detection functions should be performed.

Type:	General and Leak detection
Menu levels:	Setup, Limited, Extended
Range:	Off On
Default:	Off

Negative over velocity alarm threshold

Defines the velocity at which a negative velocity alarm counter will be incremented for leak detection purposes. All available instantaneous path velocities reported for a meter section are averaged; this average is then compared to the *Negative over velocity alarm threshold* and a counter is incremented/decremented based on whether the threshold is exceeded.

Type:	Section
Menu levels:	Setup, Limited, Extended
Range:	#
Default:	Negative 150% of *Maximum expected velocity*

Negative over velocity warning threshold

Defines the velocity at which a negative velocity warning counter will be incremented for leak detection purposes. All available instantaneous path velocities reported for a meter section are averaged; this average is then compared to the *Negative over velocity warning threshold* and a counter is incremented/decremented based on whether the threshold is exceeded.

Type:	Section parameter
Menu levels:	Setup, Limited, Extended
Range:	#
Default:	Negative *Maximum expected velocity*

Over velocity alarm count

A value which, when reached, will cause the meter to close the alarm relay. The flowmeter increments the positive over velocity counter each time the average of all available instantaneous path velocities exceeds the Section parameter *Positive over velocity alarm threshold* and decrements the counter each time the average falls below that threshold. If the running total in the counter reaches this value, the over velocity alarm relay is closed. A separate counter is incremented/decremented for negative velocities based on the parameter *Negative over velocity alarm threshold*.

Type:	Section
Menu levels:	Setup, Limited, Extended
Range:	#
Default:	25

Over velocity warning count

A value which, when reached, will cause the meter to close the warning relay. The flowmeter increments the positive over velocity counter each time the average of all available instantaneous path velocities exceeds the Section parameter *Positive over velocity warning threshold* and decrements the counter each time the average falls below the threshold. If the running total in the counter reaches this value, the over velocity warning relay is closed. A separate counter is incremented/decremented for negative velocities based on the parameter *Negative over velocity warning threshold*.

Type:	Section
Menu levels:	Setup, Limited, Extended
Range:	#
Default:	25

Positive over velocity alarm threshold

Defines the velocity at which a positive velocity alarm counter will be incremented for leak detection purposes. All available instantaneous path velocities reported for a meter section are averaged; this average is then compared to the *Positive over velocity alarm threshold* and a counter is incremented/decremented based on whether the threshold is exceeded.

Type:	Section
Menu levels:	Setup, Limited, Extended
Range:	#
Default:	Positive 150% of *Maximum expected velocity*

Positive over velocity warning threshold

Defines the velocity at which a positive velocity warning counter will be incremented for leak detection purposes. All available instantaneous path velocities reported for a meter section are averaged; this average is then compared to the *Positive over velocity warning threshold* and a counter is incremented/decremented based on whether the threshold is exceeded.

Type:	Section parameter
Menu levels:	Setup, Limited, Extended
Range:	#
Default:	Positive *Maximum expected velocity*

Table 12-1 Checklist of Initial Setup Parameters for Leak Detection System

Parameter	Value
The following General Parameters are required for leak detection:	
Leak Detection Switch (should be ON):	
The following Leak Detection System Parameters are required for each pipeline:	
Leak Detection Switch (should be ON for each pipeline for which leak detection is desired):	
Differential flow averaging size	
Differential warning threshold	
Differential alarm threshold	
The following parameters are required for each section:	
Positive over velocity warning threshold	
Negative over velocity warning threshold	
Over velocity warning count	
Positive over velocity alarm threshold	
Negative over velocity alarm threshold	
Over velocity alarm count	

Glossary of Terms

~A~

Accumulated total flow* -** The quantity of liquid that has flowed over a period of time. This is the *flowrate* with time removed. For example, if the flowrate was 10 cubic feet per second, and 10 seconds had elapsed, the *Accumulated Total Flow* would be 100 cubic feet. Also called *Totalized Flow* or *Total Volume.**

***Acoustic Path* -** In the 7500 system, an acoustic path is comprised of a pair of aligned transducers and the liquid between them. This is the required hardware to measure the velocity of the liquid at one elevation.

***Analog output interfaces* -** Outputs are used to communicate variables (such as flowrate or volume) calculated by the 7500 to external equipment, such as a SCADA system or datalogger. A typical example of an analog output would be a 4-20 milliamp current loop representing flowrate. As the flowrate incresed, the current in the loop would increase. A variety of interface types are available to communicate with most types of systems.

***Analog stage inputs* -** *Stage* (level) measurement information can be input to the 7500 as a 4-20 mA current loop. Parameters are available to scale and offset the current loop input to represent fluid elevation. Analog stage inputs are an optional feature, they must be installed and inititally cofigured at Accusonic.

***Automatic gain control (agc)* -** A patented feature of the 7500 system, causes the signal level from each transducer to be adjusted independently on each measurement cycle. This is most useful where there are changing acoustic conditions in the measurement section, such as temporary occurrences of entrained air, or schools of fish. This will also compensate for slowly failing transducers, providing a longer service life.

***Autoswitching P.C. keyboard* -** A PC-Compatible keyboard that senses the type of CPU at boot or power-up time and adjusts its output to be compatible.

***Average flow rate* -** The 7500 calculates an instantaneous flowrate by integrating velocities at various levels in the fluid. Due to hydraulic conditions, the instantaneous flowrate can be somewhat unstable. Therefore, flowrates are *averaged* **-** many samples are added together and the sum is divided by the number of measurements to provide a smoother flowrate for display and outputs.

~B~

***Balanced-line* -** A method of transducer-to-electronics connection for use in electrically noisy environments. Twin-axial cable is used, and positive and negative signal lines are run ungrounded. Any electrical noise present is induced onto both lines. Since the receiving electronics only looks at the *difference* between the lines, the noise common to both is ignored.

***BCD (Binary Coded Decimal)* -** A form of parallel digital *I/O (I*nput/*O*utput), in which numbers are represented in *binary* format, but arranged by digit. Each digit is made up of four bits, so a three-digit number (the output range would be 0 to 999), would require 12 discreet output lines. This type of I/O has some inherent error-checking, in that the total of the binary weights can add up to 15, but a ‘9’ is the maximum allowable conversion value.

***Binary I/O interfaces* -** A type of *I/O (I*nput/*O*utput) where data is transferred via parallel digital lines. Each line has a binary (1, 2, 4, 8, 16, etc.) value, adding all of the lines yields the value. Depending on the accuracy required, as many as 24 discreet lines could be required for a single data point. This type of I/O is generally faster than a serial I/O port and more accurate than an analog connection, but much more complex than either, due to the greater number of connections that must be made.

~C~

***Coaxial cable* -** A transmission cable consisting of a conducting outer metal tube enclosing and insulated from a central conducting core. This type of cable is used for carrying the high-frequency electrical signal between flowmeter and transducers.

***Compound* -** A closed conduit which can flow partially full as well as surcharged, exhibiting the flow characteristics of both an open channel and full pipe.

***Cross flow* -** Where the streamlines of flow are not parallel to the conduit centerline as a result of an upstream obstruction or a transition in conduit shape or dimensions.

~D~

***Datalogging* -** A feature of the 7500 flowmeter allowing flow measurement data to be stored on an internal floppy disk.

~E~

End **-** A combination of one or more sections. Provides a subtotal of flowrates and volumes for multiple sections. A typical use would be in a low-head hydroelectric station where several conduits, each with a measurement section, would feed a single turbine, and the total flowrate through the turbine should be displayed. The result of these subtotals is called an *end variable* in this manual (these are subtotals of *section variables*).

Extrapolation error **-** A form of error occurring when there are an insufficient number of acoustic paths to accurately measure real variations in velocity across a measurement section, and the flowmeter must extrapolate by using the velocity of the closest working path for the unknown velocity.

~F~

Flow calculation **-** Integrate the measured velocities over the entire cross-sectional area of fluid to determine total volumetric flow.

Flow Transmitter **-** A subsystem which measures acoustic travel times in a measurement section and returns the results. In the 7500/7520 system, this is comprised of a transceiver, transceiver communication board, transmitter, path selectors, and path-select backplane.

~G~

Gain **-** The amount of amplification required to make the raw acoustic signal (as returned from the receiving transducer) usable by the transceivers signal-detection circuitry.

General parameter - Any *parameter* (user input defining system operation) common to all of the measurement sections in a flowmeter. Examples would be measurement repetition rate, display contrast, or speed of sound in water.

General variable - Any *variable* (result calculated by the flowmeter) that is the sum of all measurement sections. Examples would be total flowrate and total volume.

~H~

Hardware handshake **-** A flow control interface consisting of one or more hardware lines designed to assure proper data flow with no loss. For example, two pieces of equipment using a serial line to communicate would use *handshake lines* to signal each other when they needed more time to receive data.

~L~

***Leak Detection* -** A special system configuration where flow measurement is made at two ends of a pipe and compared. If the difference is outside of a user-set limit for a user-set time, a valve-closure signal is generated to prevent leaks.

***Leak parameter* -** Any *parameter* (user input defining system operation) used to configure leak detection (see above) system operation. Examples would be Differential Warning Threshold and Differential Alarm Threshold.

***Leak variable* -** A *variable* (result calculated by the flowmeter) used for leak detection (see above). Examples would be Maximum Differential Flow and Differential Alarm Status.

***Loop noise* -** Electrical noise in an analog current loop output. Noise can be induced onto an output loop by nearby electrical noise sources, or can be caused by the loop source. If the noise is caused by external sources, it can usually be cured by proper grounding.

~M~

***Measurement cycle* -** A complete measurement, including acquisition of path travel times, acquisition of stage (fluid level), calculation of flowrate and totalized volume, display of calculated variables, and output of results.

***Multipath reflection* -** A condition which exists when an acoustic path is located too close to a reflector, such as a pier or the fluid surface. The acoustic signal takes both a direct path and a bounce path, combining with itself at the receiving transducer. The result is a distorted signal which rarely yields a correct result.

~N~

***Negative-going edge* -** The part of the received acoustic signal used for detection. Also called *first negative*.

***NEMA-4* -** A specification of the National Electric Manufacturers Association which states that an enclosure will protect the contents against windblown dust, rain, splashing water, and hose-directed water.

***Net total volume* -**The combination of Positive and Negative Volumes for all measurement sections.

***Non-volatile storage* -** A type of parameter storage that retains information when power is interrupted. In the 7500 system, this is accomplished by using an internal battery to continuously power a small section of memory.

~O~

Open Channel **-** Any conduit, whether open or closed, in which water flows with a free surface.

Overvelocity **-** A special alarm type which will actuate when the fluid in a pipe flows faster than a preset level. Flowrate and status of most other alarms are disregarded. Intended to close a safety valve in the event of a large break in a pipe.

~P~

Parallel port **-** A type of *I/O (I*nput/*O*utput) where data is transferred via multiple digital lines. In the 7500 system, this usually refers to the printer connection.

Parameter **-** An *entered value* that the flowmeter uses for measurement and calculation.

Path parameter - Any *parameter* (user input defining system operation) used to configure the operation of a single acoustic path. Examples: Path Length, Transducer Type.

Path variables **-** A *variable* (result calculated by the flowmeter) calculated for a single acoustic path. Examples: Velocity, Speed of Sound.

Pipe **-** Normal enclosed conduit which flows completely full.

Predicted-arrival gates - These are part of the 7500's data-validity system. The maximum and minimum possible arrival times of the signal on the acoustic path are calculated based on the speed of sound in the fluid and the maximum velocity of the fluid. Any signal appearing outside of these times is considered to be noise and is ignored.

Processor group **-** The "smart side" of the 7500 system. Controls the measurement cycle. Takes travel time and error information from the *Flow Transmitter*, calculates flow rates, volumes, and all other variables, then displays and outputs the results.

Pulse output interface **-** A form of serial output, usually used to transmit increments of totalized volume. Normally consists of a relay which closes briefly (closure time is 1/4 second in the 7500), then re-opens.

~S~

***Section* -** Used to describe each conduit in which transducers are installed. A section can be part of a pipe, a river or a sewer. One flowmeter electronics console can measure flow in more than one section.

***Section parameter* -** Any *parameter* (user input defining system operation) used to configure the operation of a measurement *section* (see above). Examples: Pipe Radius, Maximum Expected Flowrate.

***Section variable* -** A *variable* (result calculated by the flowmeter) calculated for a measurement *section* (see above). Examples: Flowrate, Volume.

***Stage* -** The level of fluid in a conduit.

***Survey uncertainty* -** Used to describe an error condition when the walls of the conduit are irregular, asymmetric, or (as is often the case in a river) cannot be surveyed exactly or permanently.

***System* -** Used to describe the flowmeter console with any remote transmitters, transducers in all sections controlled by the console and remote transmitters, and associated cabling.

~T~

***Totalizer cutoff time* -** The maximum time limit over which the flowmeter will interpolate flow if measurements are suspended or interrupted. This is entered into the 7500 as a parameter. If the interruption is shorter than the entered time, the 7500 calculates volume for the outage time. If the interruption exceeds the specified time limit, the instrument does not calculate volume for the outage period. Refer to Chapter 3, *Flow Calculation Formulas,* beginning on page **Error! Bookmark not defined.** for formula describing what is used for flowrate.

***Total forward volume* -** The quantity of liquid that has flowed over a period of time in the positive direction (positive is defined as “in the direction of gravity”. In this direction, a turbine at a pump/ generation plant would be generating). This is the *flowrate* with time removed. For example, if the flowrate was 10 cubic feet per second, and 10 seconds had elapsed, the forward volume would be 100 cubic feet. Total forward volume is the sum of all section forward volumes.

***Total reverse volume* -** Same as *Total forward volume* (see above), but in the negative direction. Negative is defined as “opposing gravity”. In this direction, a turbine at a pump/generation plant would be pumping.

***Twin-axial cable* -** A transmission cable consisting of a conducting outer metal tube enclosing and insulated from two central conducting cores. This type of cable is used for carrying the high-frequency electrical signal between flowmeter and transducers. Twin-axial cable is used in place of coaxial cable in high-noise environments, so that the signal can be carried in *balanced-line* mode.

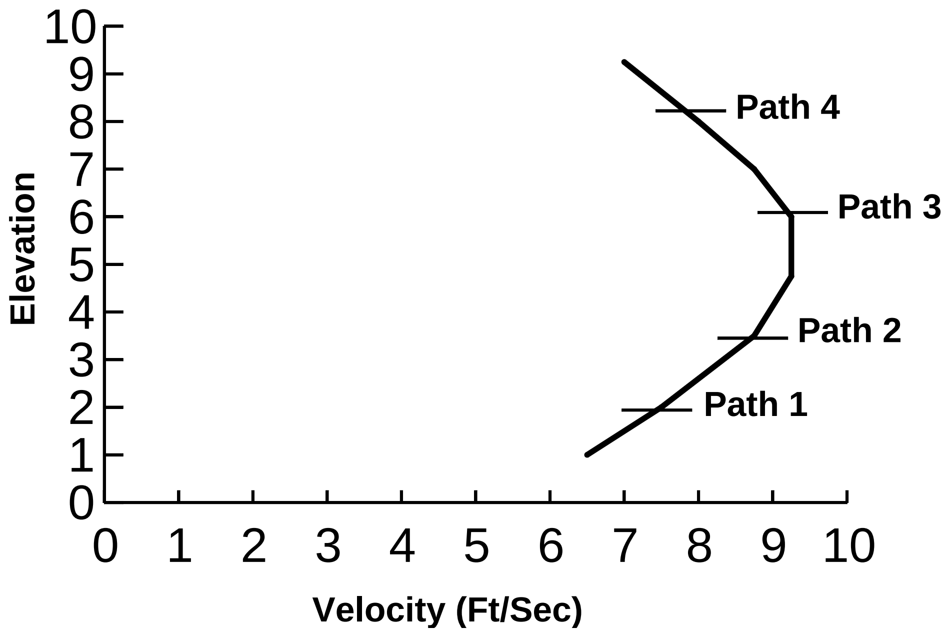
~V~

Variable **-** The *result* of a measurement and flow calculation.

Velocity measurement **-** measures the average velocity along one or more linear paths through the moving fluid.

Velocity Substitution **-**An Accusonic flowmeter feature which can allow the flowmeter to continue to operate and make a best-guess estimate of the flowrate if one or more acoustic paths fail. The velocity of the “mirror” path (most likely to reflect any changes in velocity profile) is substituted for the failed path. See the description of the velocity substitution parameters (page **Error! Bookmark not defined.**) for information on how to enable and configure this feature.

Velocity Profile **-**A graphical representation of the fluid velocities at various elevations in the conduit. The velocity profile can change substantially as flowrate changes.



~W~

Watchdog timer **-** A hardware timer chain and relay designed to reset the system if there is a loss of software control. The timer continually tries to count down to zero. The system software, if in control, resets the timer after every measurement cycle. If the software goes out of control and the timer is allowed to count down to zero, a hardware reset occurs.

Waveform - A two-dimensional representation of a electrical signal, usually on an oscilloscope.

—A—

AC Power Connections, 4-2
Accuracy, 1-2, 3-28
Addressing the Flow Transmitter, 11-2
Always display flow totals, 12-7
Analog
  error conditions, 8-3
  offsets and scale factors, 8-2
  setting up, 8-1
Automatic Gain Control (agc), 2-10, 3-13

—C—

Cables
  RS-232, 4-9
  RS-485, 4-11
Compound Sections in Round Pipes 5-34
Connecting Transducer Cabling, 4-3
Contrast
  adjusting, 5-16

—D—

Data Log File Description, 8-27
Data Logging, 8-26
Diagnostics, 5-17, 6-1
Differential alarm threshold, 12-7
Differential flow average size, 12-7
Differential warning threshold, 12-8
Display Screen, 5-31

—E—

Error Codes, 9-3
  path, 9-4
  section, 9-7
  self-test, 9-9
  Stage, 9-10
Error Reporting, 8-12, 8-15, 8-28

—F—

Flow
  calculating, 3-17, 9-7
  differential, 12-3
Flow Transmitter, 2-1, 2-7, 2-8, 2-9
Flow Transmitter Group, 2-4, 2-9–2-11

—G—

Gain
  displaying, 5-33
  entering, 7-12, 7-22

—H—

Help, **5-8**

—I—

Installation, 4-1
Integration method
  description, 3-18
  displaying, 5-31
  selecting, 7-16, 7-25, 7-28

—K—

Keyboard, 2-9
Keys
  hidden, 11-1

—L—

Leak Detection
  description, 12-1
Leak detection switch, 12-8
Lights, Error 6-6, 9-1

—M—

Maintenance, 6-1
Menu Access, 5-9
Menus, 5-1
  hierarchy, 5-5
  stepping through, 5-3
  tree, 5-7
Monitoring Raw Path Signals, 9-12

—N—

Negative over velocity alarm threshold, 12-8
Negative over velocity warning threshold, 12-8

—O—

Outputs, 8-1
  analog, 8-1
  relay, 8-4, 8-6
    setting up, 8-10
    specifications, 8-8
  RS-232, 8-16
    connection, 4-9
    format, 8-17
    setting up, 8-19
    verifying, 8-20
  testing, 8-1
  totalizer, 8-4, 8-9
    setting up, 8-11
  verifying, 8-4
  watchdog, 8-9

Over velocity alarm count, 12-8
Over Velocity Detection, 12-3
Over velocity warning count, 12-9

—P—

Parameters
- always display plant totals, 7-1, 12-7
- autostart switch, 5-8, 7-1
- available velocity enabled, 7-2
- average cable length per path, 7-2
- average stage cable length, 7-2
- averaging queue length, 7-2
- bidirectional flow, 7-3
- bottom channel width, 7-3
- bottom velocity ratio, 7-3
- channel bottom height, 7-3
- cross sectional area, 7-4
- current date, 7-4
- current time, 7-4
- data log start, 7-5
- data logging, 7-4
- delay time of other ducer, 7-5
- display contrast, 7-5
- display mode, 7-6
- display totals line, 7-6
- ducer connection, 7-6
- ducer type (7600, 7601, 7605, 7612...), 7-6
- end label character, 7-6
- end starting number, 7-7
- entering, 5-10
- error reporting, 7-7
- flowrate scale factor, 7-7
- format, 7-8
- frequency of other ducer, 7-8
- full pipe, 7-8
- general, 5-10, 5-22
- inactivity timeout, 5-30, 7-9
- K, 7-9
- layer boundary elevation 1 - n, 7-9
- layer boundary width 1 - n, 7-10
- leak detection
  - Always display flow totals, 12-7
  - differential alarm threshold, 12-7
  - differential flow average size, 12-7
  - differential warning threshold, 12-8
  - leak detection switch, 12-8
  - negative over velocity alarm threshold, 12-8
  - negative over velocity warning threshold, 12-8
  - over velocity alarm count, 12-9
  - over velocity warning count, 12-9
  - positive over velocity alarm threshold, 12-9
  - positive over velocity warning threshold, 12-9
- leak detection switch, 7-10
- loading and saving, 5-27, 5-28
- log data to, 7-10
- log interval, 7-11
- log negative volume data, 7-11
- log velocity data, 7-11
- manning coefficient of roughness, 7-11
- manual gain, 7-12
- manual stage (1 or 2) value, 7-12
- maximum bad measurements, 7-12
- maximum change in flowrate, 7-12
- maximum change in stage, 7-13
- maximum change in velocity, 7-13
- maximum expected flowrate, 7-13
- maximum expected velocity, 7-13
- maximum stage, 7-14
- maximum stage difference 1 and 2, 7-14
- menu access, 7-14
- minimum flowrate, 7-14
- minimum good paths, 7-15
- minimum path submersion, 7-15
- minimum stage, 7-15
- non-surcharged integration method, 7-16
- number of channel layers, 7-16
- password control, 7-17
- path, 5-14, 5-25
- path angle, 7-17
- path elevation, 7-17
- path length, 7-17
- path percent active, 7-18
- path position, 7-18
- path simulation, 7-18
- path switch, 7-19
- penstock label character, 7-19
- penstock starting numbers, 7-19
- pipe height, 7-19
- pipe integration, 7-20
- pipe shape, 7-20
- pipe slope, 7-20
- printing, 5-29
- protrusion of other ducer, 7-21
- Q FWD 1 - n, 7-21
- Q REV 1 - n, 7-21
- radius, 7-21
- receiver gain, 7-22
- repetition time, 7-22
- saving and loading, 5-15, 5-27
- section, 5-11, 5-23
- section label character, 7-22
- section starting number, 7-22
- section switch, 7-22
- section type, 7-23
- self test interval, 7-23
- shape factor, 7-23
- signal detection method, 7-23
- simulation forward time, 7-24
- simulation reverse time, 7-24
- simulation source, 7-24
- simulation velocity, 7-24
- simulation velocity ramp scale, 7-25
- single coefficient (1 - 5), 7-25
- single integration, 7-25
- speed of sound in fluid, 7-26
- SQM, 7-26
- stage (1 or 2) offset, 7-27
- stage (1 or 2) range maximum, 7-27
- stage (1 or 2) range minimum, 7-28
- stage averaging size, 7-26

stage ducer type, 7-26
stage interval, 7-27
stage mode, 7-27
stage source, 7-28
surcharged integration method, 7-28
temperature coefficient, 7-29
top weight, 7-30
totalizer cutoff time, 7-31
travel time tolerance, 7-31
units, 7-31
V FWD 1 - n, 7-34
V REV 1 - n, 7-34
velocity substitution, 7-31
velocity substitution ratio, 7-32
volume scale factor, 7-34
weight, 7-35
which section, 7-35
width at path elevation, 7-35
zero flow offset, 7-35
Password, 5-8, 5-26
Path Selector, 2-4
Paths
crossed, 3-7, 3-21
Positive over velocity alarm threshold, 12-9
Positive over velocity warning threshold, 12-9
Power Interruption, 2-8
Power Supply, 2-4, 11-4
checking and adjusting, 9-13
color code, 9-14
Printer
connection, 4-6
printing listings. *Also see "Reports"*
Processor Group, 2-2, 2-6, 2-8
Pulse Transmitter, 2-3

—R—

Remote Access, 11-6
Repairs, 6-6
Reports, 8-21
printer connection, 4-6
setting up, 8-23
RS-232. *See* Outputs
RS-485
Interconnect cable, 4-11

—S—

Scaling
flowrate, 7-7
volume, 7-34
Self-Test, 9-9
Setup, 5-1, 5-22
initial, 5-21
Simulating flowrate, 7-18
Specifications, 11-4

Stage
connection, 4-7
description, 2-1, 2-3, 2-10
displaying, 5-33
error codes, 9-10
measuring, 2-8, 3-16
Stage Range, 4-7, 7-27
Surge Protection 11-8

—T—

Temperature
coefficients, 7-29
displaying, 5-33
Transceiver, 2-3, 2-10
diagnostics, 6-3
resetting, 6-2
Transducer
connection, 4-3
Transducer and Cabling Checkout, 4-5
Transducer Maintenance, 10-1
Transducers
7600 series
replacing, 10-9
7601 series
replacing, 10-3
models, 1-3
Transmitter, 2-10
Troubleshooting, 9-1

—V—

Variables, 7-37
average temperature, 7-37
average velocity of sound, 7-37
averaged stage, 7-37
delta flow, 7-37
delta flow average, 7-37
differential flow alarm, 7-38
differential flow warning, 7-37
flow average, 7-38
flow error count, 7-38
Flowrate, 7-38
forward gain, 7-38
forward time, 7-38
negative volume, 7-38
positive volume, 7-39
reverse gain, 7-39
reverse time, 7-39
section status, 7-39
signal delay, 7-39
stage 1, 7-39
stage 1 signal delay, 7-40
total average flow, 7-40
total flow, 7-40
total negative volume, 7-40
total positive volume, 7-40
total volume, 7-40
velocity, 7-40

velocity error count, 7-41
velocity of sound, 7-41
volume, 7-41
resetting, 7-37
Velocities, 8-17
calculating, 3-14
displaying, 5-32
simulating, 7-18
substituting, 7-31

IMPORTANT

NOTE TO ELECTRICIAN AND/OR INSTALLER OF THIS EQUIPMENT:

IF THIS EQUIPMENT IS BEING INSTALLED IN A WASTEWATER ENVIRONMENT, BE SURE TO OBSERVE THE FOLLOWING:

TO PREVENT DAMAGE TO ELECTRICAL AND ELECTRONIC CIRCUITS IT IS IMPERATIVE THAT ACIDIC SEWER AND OTHER CONDENSING VAPORS BE PREVENTED FROM ENTERING FLOWMETER ENCLOSURE.

MAKE SURE THAT ALL CONDUITS AND CABLES ENTERING THIS ENCLOSURE ARE SEALED WITH POURED SEALS IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE SAFETY REQUIREMENTS.

IF PERMANENT SEALS ARE NOT BEING INSTALLED AT THIS TIME,BE SURE TO PROVIDE TEMPORARY SEALING MEANS SUCH AS ELECTRICIAN'S PUTTY. (DO NOT USE RTV SEALANT, IT GIVES OFF ACETIC VAPORS).

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