HART® Field Device Specification Guide:

HART® Field Device Specification for Daniel Liquid Ultrasonic Flow Meters revision 2

DANIEL™ MEASUREMENT AND CONTROL, INC.
AN EMERSON PROCESS MANAGEMENT COMPANY
HOUSTON, TEXAS

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DANIEL®

EMERSON.
Process Management

Important Instructions

Daniel™ Measurement and Control, Inc. (Daniel) designs, manufactures and tests its products to meet many national and international standards. Because these instruments are sophisticated technical products, you must properly install, use and maintain them to ensure they continue to operate within their normal specifications. The following instructions must be adhered to and integrated into your safety program when installing, using and maintaining Daniel products.

- Read all instructions prior to installing, operating and servicing the product. If this instruction manual is not the correct manual, call 1-713-827-6314 (24-hour response number for both Service and Sales Support) and the requested manual will be provided. Save this instruction manual for future reference.
- If you do not understand any of the instructions, contact your Daniel representative for clarification.
- Follow all warnings, cautions and instructions marked on and supplied with the product.
- Inform and educate your personnel in the proper installation, operation and maintenance of the product.
- Install your equipment as specified in the installation instructions of the appropriate instruction manual and per applicable local and national codes. Connect all products to the proper electrical and pressure sources.
- To ensure proper performance, use qualified personnel to install, operate, update, program and maintain the product.
- When replacement parts are required, ensure that qualified people use replacement parts specified by the manufacturer. Unauthorized parts and procedures can affect the product's performance and place the safe operation of your process at risk. Look-alike substitutions may result in fire, electrical hazards or improper operation.
- Ensure that all equipment doors are closed and protective covers are in place, except when maintenance is being performed by qualified persons, to prevent personal injury.
- ALWAYS READ AND FOLLOW THE DANIEL ULTRASONIC GAS FLOW METER REFERENCE, INSTALLATION, AND OPERATIONS MANUAL AND ALL PRODUCT WARNINGS AND INSTRUCTIONS.
- Use of this equipment for any purpose other than its intended purpose may result in property damage and/or serious personal injury or death.
- Before opening the flameproof enclosure in a flammable atmosphere, the electrical circuits must be interrupted.

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DANIEL™ MEASUREMENT AND CONTROL, INC.
Daniel Liquid Ultrasonic Flow Meter Reference, Installation, and Operations Manual

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INTRODUCTION

1. INTRODUCTION

This section defines the scope of the Daniel HART® Field Device Specification Guide: Daniel Liquid Ultrasonic Meters Functional Requirements Specification (FDS).

1.1 Scope

The Daniel Measurement and Control, Inc. Division of Emerson Process Management HART® Field Device Specification Guide: for Daniel Liquid Ultrasonic Flow Meters, revision 2, with the Expansion Board with HART, and firmware revision 1.70, complies with HART® Protocol Revision 5. This document specifies all the device specific features and documents the HART® Protocol implementation details (e.g., the Engineering Codes supported). The functionality of this Field Device is described sufficiently to allow its proper application in a process and its complete support in HART® capable Host Applications.

1.2 Purpose

This specification is designed to complement other documentation by providing a complete, unambiguous description of this field device from an Expansion Board with HART Communication perspective.(e.g., the 3-9000-750 Rev D or later) Daniel Liquid Ultrasonic Flow Meter *Reference, Installation, and Operations Manual).*

Daniel Division of Emerson Process Management products page:

http://www2.emersonprocess.com/en-US/brands/daniel/Flow/ultrasonics/Pages/Ultrasonic.aspx

NOTICE

To access the product manual, from the Daniel products page (above link), select the Daniel Model 3804 Liquid Ultrasonic Flow Meter link, click the Documentation tab, expand the Manuals & Guides tab, then select the manual.

1.3 Who should use this document?

This specification is designed to be a technical reference for Expansion Board with HART capable Host Application Developers, System Integrators, and knowledgeable End Users. It also provides functional specifications (e.g., commands, enumerations and performance requirements) used during Field Device Development, maintenance and testing. This document assumes the reader is familiar with Expansion Board with HART Protocol requirements and terminology.

1.4 Abbreviations and Definitions

The following is a list of commonly used definitions used throughout this document:

ACRONYM	DEFINITION
^{o}C	Degrees Celsius (alternatively, degrees Centigrade)
A/D	Analog-to-Digital
ADC	Analog to Digital Converter
API	Application Program Interface
ATEX	Atmospheres Explosives (French)
CPU	Central Processing Unit
D/A	Digital-to-Analog
DAC	Digital to Analog Converter
DD	Device Description (Expansion Board with HART)
EDDL	Electronic Device Description Language (Expansion Board with HART)
FPGA	Field-Programmable Gate Array
HART®	Highway Addressable Remote Transducer
Hz	Hertz
I/O	Input(s)/Output(s)
LED	Light-Emitting Diode
LUSM	Liquid UltraSonic Meter
mA	Milliamperes (also referred to as milliamps)
Rx	Receive
Tx	Transmit

1.5 References

The documents referenced within the text of this document are listed in the table below:

Title	Document number, revision, date
American Petroleum Institute (API) Manual of Petroleum Measurement Standards (MPMS) Chapter 21 - Flow Measurement Using Electronic Metering Systems Section 2 - Electronic Liquid Volume Measurement and Section 5.8.	First Edition, June 1998
HART® SMART Communications Protocol Specification (also includes the specifications listed below in italics)	*HCF_SPEC 11, Rev. 5.10 (14-Dec-2000)*
Field Device Specification Guide	*HCF_LIT-18, Rev 11.0 (18 April, 2001)*
FSK Physical Layer Specification	*HCF_SPEC 54, Rev. 8.1 (24-Nov-1999)*
Data Link Layer Specification	*HCF_SPEC 81, Rev. 7.1 (27-Nov-1996)*
Command Summary Specification	*HCF_SPEC 99, Rev. 7.1 (15-Jan-1997)*
Universal Command Specification	*HCF_SPEC 127, Rev. 5.2 (15-Jan-1997)*
Common Practice Command Specification	*HCF_SPEC-151, Rev. 7.1 (15-Jan-1997)*
Common Tables	*HCF_SPEC 183, Rev. 12.0 (11-Dec-2000)*
Appendix 1 - Command Specific Response Code Definitions	*HCF_SPEC 307, Rev. 4.1 (15-Jan-1997)*
Daniel Liquid Ultrasonic Flow Meter Reference, Installation, and Operations Manual	*P/N 3-9000-750 Rev. D (or later)http://www2.emersonprocess.com/en-US/brands/daniel/Flow/ultrasonics/Pages/Ultrasonic.aspx*

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DEVICE IDENTIFICATION

2. INTRODUCTION

This section details the Expansion Board with HART identification and physical description.

2.1 Expansion Board with HART Identification

The Expansion Board with HART Field Device Identification summary is shown in Table 2-1 below.

Table 2-1 Expansion Board with HART Field Device Identification Summary

Manufacturer Name:	Daniel Measurement and Control, Inc.	**Model Name(s):**	Expansion Board with HART
Manufacture ID Code:	13 (D Hex)	**Device Type Code:**	40 (28 Hex)
HART® Protocol Revision:	5	**Device Revision:**	2
Number of Device Variables:	3 (0, 6, 7)		
Physical Layers Supported:	Bell 202 FSK	**Note: HART® Hardware Revision**	3
Physical Device Category:	Daniel Liquid Ultrasonic Flow Meter		

2.2 Physical Description

The Expansion Board with HART provides communication flexibility with Daniel Liquid Ultrasonic Flow Meters. The Expansion Board with HART provides communication with other field devices, and ultimately, communicates key diagnostic information through PlantWeb® architecture.

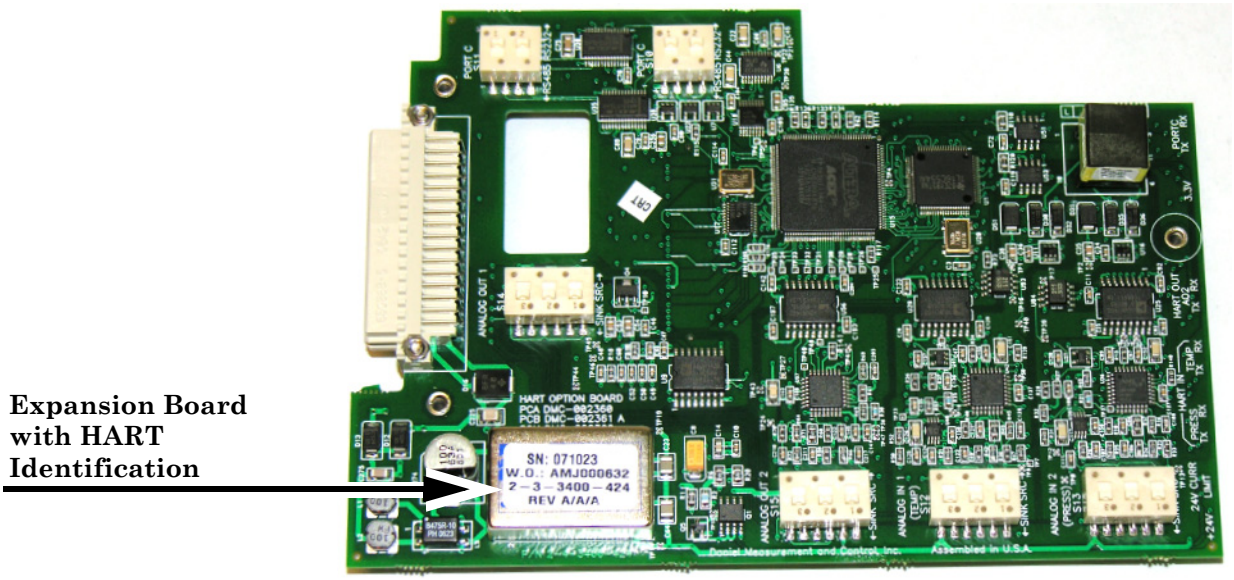

Figure 2-1 Expansion Board with HART

The Expansion Board with HART name plate is located on the bottom left corner of the board along with the Daniel™ Measurement and Control, Inc., part numbers and revision level.

PRODUCT OVERVIEW

3. INTRODUCTION

This section specifies the purpose and application of the Expansion Board with HART.

3.1 Device Function, Purpose and Features

The Expansion Board with HART enables communication with other field devices, and ultimately, communicates key diagnostic information through the PlantWeb® architecture.

All analog inputs and outputs are isolated from each other and isolated from the system with a minimum isolation of 500 V.

3.2 Process Connections

The Expansion Board with HART is optionally used in place of the optional Expansion Board. Thus, the Expansion Board with HART connects to the Daniel Liquid Ultrasonic Meter CPU and Field Connection boards in the same manner as the optional Expansion Board and fits within the existing electronics housing.

3.3 External Interfaces (electrical and non-electrical)

NOTICE

HART® temperature and pressure features referenced in this section are currently unavailable.

Any pressure and/or temperature input read via the Expansion Board with HART is configured using a hand-held communicator (e.g., Emerson's 375 Field Communicator) and not via the meter such as for device address, device tag, limits, and units. The Expansion Board with HART is compliant with Asset Management Solutions (AMS™) software applications that provides operator interface between the Expansion Board with HART enabled field device and the remote PC.

Additionally, pressure and/or temperature input read via HART® is not multi-dropped (due to API MPMS Chapter 21 requirement) (**Future release**).

The only device configuration handled by the meter is Burst Mode and preamble length if supported by the pressure and/or temperature transmitter (**Future release**).

3.4 Other Required Equipment

The Expansion Board with HART is backward compatible with the Daniel Expansion Board.

An RS-232C/RS-485 (half duplex) serial communication port for Modbus communication is provided as Port C.

Any programmable device on the Expansion Board with HART (such as a FPGA) is programmed via the CPU Board.

PRODUCT INTERFACES

4. INTRODUCTION

This section discusses the Expansion Board with HART communications, electrical interface, and input and output requirements.

4.1 Process Interface

The Expansion Board with HART is capable of communicating with a flow computer or other interface devices via HART® and enables PlantWeb® connectivity. The HART® host (AMS or Emerson 375 Handheld Communicator, etc.) reads the pressure and temperature process variables.

The Expansion Board with HART provides an RS-232C/RS-485 Half-duplex serial communications port (Port C) connected via J16 on the Field Connection Board. The board also provides two independent analog input circuits and 16-bit, 4 -20mA analog output circuits.

LED status indicators show 24V power, 24V current limit, TX and RX serial communication port, and HART® slave communication via Analog Output 2.

4.2 Sensor Input Channels

NOTICE

HART® temperature and pressure features referenced in this section are currently unavailable.

The Expansion Board with HART provides two independent analog input circuits used either in conventional 4-20 mA service or as a digital HART® Master for pressure and/or temperature input. Full HART® functionality is provided so that any commercially available HART transmitter which meets the specifications of the HART® Communications Foundation can be connected to the Daniel™ Liquid Ultrasonic Flow Meter.

The handles live pressure input (gage or absolute as specified by the user configuration data point *InputPressureUnit*) as indicated by the user-configurable data point *PressureLiveInput* (encoded as follows: Analog (0), or HART® (1)) when the *EnablePressureInput* is set to Live (1).

The Analog selection indicates input via sampled conventional 4-20 mA signal. The HART® selection indicates input via HART® communication with a transmitter.

The firmware handles live temperature input as indicated by the user-configurable data point *TemperatureLiveInput* (encoded as follows: Analog (0), or HART (1) when the *EnableTemperatureInput* is set to Live (1). The Analog selection indicates input via sampled conventional 4-20 mA signal. The HART® selection indicates input via HART® communication with a transmitter.

The Expansion Board with HART must be installed to select the HART® option for *PressureLiveInput* and/or *TemperatureLiveInput*.

Pressure and/or temperature inputs from conventional 4-20 mA input or HART® signal(s) is sampled at least once per second. Due to this requirement, the pressure and/or temperature HART® inputs only supports point-to-point mode (i.e., multi-dropping is not be supported).

For pressure and/or temperature inputs via HART®, the meter puts the HART® transmitter in Burst Mode (if it is available).

For pressure and/or temperature inputs via HART®, the meter attempts to set the HART® transmitter to a user-configurable preamble length (when that functionality is available). The preamble length configuration parameter defaults to the minimum (5) preamble length (20 maximum preamble length).

Live pressure values (from conventional 4-20 mA input or read digitally via HART®) are written to the *LiveFlowPressure* data point.

Live temperature values (from conventional 4-20 mA input or read digitally via HART®) is written to the *LiveFlowTemperature* data point.

When pressure and/or temperature is read via HART®, the corresponding status information is used to update the corresponding measurement's validity data point (i.e., *PressureValidity* and/or *TemperatureValidity*).

When pressure and/or temperature is read via HART®, the corresponding status information is external-world readable via one or more data points.

Regardless of the data source, pressure and/or temperature value(s) are averaged at least once every 5 seconds with the results written to the *FlowPressure* and *FlowTemperature* data points (respectively).

The user-configurable offset (zero) and gain calibration values (*LiveFlowPressureOffset*, *LiveFlowPressureGain*, *LiveFlowTemperatureOffset*, and *LiveFlowTemperatureGain*) are applied to live conventional 4-20 mA inputs but are not applied to inputs read digitally via HART®.

The HART® slave supports the HART® Rev. 5 commands listed in Section 8 through Section 10.

For pressure and/or temperature inputs via HART®, if the primary variable units are not supported by the meter or not valid for the expected input (such as reading a pressure unit for the temperature input), then the input is considered invalid and the error is indicated via the *PressIsLiveDigitalUnitInvalid* and/or *TempIsLiveDigitalUnitInvalid* data point(s).

The *PressIsLiveDigitalUnitInvalid* and *TempIsLiveDigitalUnitInvalid* error indicators shall be assigned to the Field I/O status group bits 14 and 15, respectively, with "Red" status levels.

A live HART® input is considered invalid if any of the following is detected:

- the transmitter device indicates a malfunction via the status byte bit 7
- the transmitter device indicates that the primary variable is out of its limits via the status byte bit 0
- the data unit is invalid
- the meter is unable to communicate with the transmitter device (such as not receiving a reply to HART® Command 1).

4.2.1 Communication Port(s)

An RS-232C/RS-485 (half duplex) serial communication port for Modbus communication is provided as Port C on the Expansion Board with HART. The
RS- 232C/RS-485 (Half Duplex) communication lines are connected via Field Connection Board connector J16 as indicated:

Table 4-1 Field Connection Board J16 - Port C

Pin	RS 232C	RS 485 Half Duplex
1	RX	RX/TX+
2	TX	RX/TX-
3	COM	COM

4.2.2 Expansion Board with HART Analog Inputs

NOTICE

HART® temperature and pressure features referenced in this section are currently unavailable.

The Expansion Board with HART provides two independent analog input circuits that can be used either in conventional 4-20 mA service or as a digital HART® Master for pressure and/or temperature input. Full HART functionality is provided so that any commercially available HART transmitter which meets the specifications of the HART® Communication Foundation can be connected to the Daniel™ Liquid Ultrasonic Flow Meter. Conventional analog inputs are sampled using a 16 bit A/D converter.

Each analog input circuit resistance provides a minimum resistance of 230 ohms. This requirement is for communication with a HART field communicator device so that an external resistor is not necessary.

Analog Input 1 (AIN1), representing fluid temperature, is input via J12 (with pin 1 for AIN1+, pin 2 for AIN1-).

Analog Input 2 (AIN2), representing fluid pressure (absolute or gage), is input via J12 (with pin 3 for AIN2+, pin 4 for AIN2).

Each analog input's current mode (sink or source) is configured via a switch. The two current mode configuration switches are numbered sequentially so that the AIN1 configuration switch is the lower numbered switch (i.e., if AIN1's switch is S12, then AIN2's switch is numbered S13).

4.2.3 Expansion Board with HART Analog Outputs

Two 16 bit, 4-20 mA analog outputs are provided on the Expansion Board with HART. The analog output(s) are capable of outputting 3.5 mA to 21 mA signal(s). Each analog output is capable or sourcing or sinking at least 21 mA.

The Expansion Board with HART has two analog output current modes (sink or source) configured via switches S14 and S15 (i.e., AOUT1's switch is S14 and AOUT2's switch is S15).

Analog output 1 (AOUT1), is output via J11 (where pin 1 is AOUT1+, pin 2 is AOUT1) and, if provided, the second analog output, AOUT2, is output via J10 (where pin 1 is AOUT2+, pin 2 is AOUT2). Each of the analog outputs are isolated from each other and from the system.

Analog output 2 (AO2) is user-configurable (via a configuration parameter) as either a conventional 4-20 mA output (like AO1) or as a HART® slave.

The firmware supports two independently-configurable analog outputs (AO1 and AO2).

For conventional operation, the analog outputs provide identical but separate configuration parameters including, but not limited to, the currently available AO1 configuration parameters (such as for content and scaling configuration). These new configuration parameters follow

the same naming convention as the AO1-related configuration parameters (which retains their current names).

Table 4-2 Analog Output Characteristics

Direction		**Values (percent of range)**	**Values (e.g., in mA)**
Linear Over-Range	Down greater than	-3.125%	3.5 mA
	Up less than	+106.25%	21 mA
Maximum Current		+106.25%	21 mA
Multi-drop Current Draw		4 mA (Available in sink mode only)	
Lift-Off Voltage		7 V	@ full scale

The HART® selectable output Primary Variable (via any serial, Ethernet, or HART® slave port) for Daniel Liquid Ultrasonic Flow Meters is:

- uncorrected volumetric flow rate

The Expansion Board with HART output Secondary through Quaternary Variables (via any serial, Ethernet, or HART® slave port) from among the choices available for the Primary Variable and additionally the following choices (if applicable):

- live pressure value
- live temperature value

The selectable units for each of the HART® Primary through Quaternary Variables (via any serial, Ethernet, or HART® slave port) are displayed from among the appropriate units currently supported by the Daniel Liquid Ultrasonic Flow Meter. For example, the volumetric flow rate unit of barrels per minute is only supported by the Daniel Liquid Ultrasonic Flow Meter; thus, barrels per minute are among the volumetric flow rate units selectable for the Daniel Liquid Ultrasonic Flow Meter but not available as a selection for the Daniel™ Gas Ultrasonic Flow Meter.

The user-configuration outputs are listed below (via any serial, Ethernet, or HART® slave port):

NOTICE

Configuration via the HART® slave port, requires Device-Specific Commands.

- for each frequency output: maximum frequency, content, relationship to flow direction, B channel action upon error, A and B channel phase relationship, and output scaling
- for each digital output: content, and polarity
- for each analog output (conventional 4-20 mA operation): content, relationship to flow direction, and output scaling

The user is able to trim the analog outputs via the methods shown in the table below.

Table 4-3 Analog Output Trim

Analog Output	Trim via HART® interface?	Trim via Serial or Ethernet interface?
1 (non HART®)	No	Yes
2 (HART®)	Yes	Yes

The user is able to zero the meter (i.e., perform zero-flow calibration) via any serial, Ethernet, or HART® slave port.

The HART® slave output supports configurable preamble length (5 to 20 preamble length).

The HART® slave supports the HART® Rev. 5 commands listed in Section 8, through Section 10.

The HART® slave does not support transfer functions.

Each analog output has individually configurable alarm selections. The selections includes:

- Very Low (3.5 mA)
- Low (4.0 mA), High (20 mA)
- Very High (20.5 mA)
- Hold Last Value
- None

The configuration is indicated by the corresponding *AOXActionUponInvalidContent* data point.

Each analog output is considered saturated if the "pre-trimmed" value is (strictly) outside the range [3.5, 20.5] mA. Note that a value less than 4 mA should only occur if the output is invalid and the invalid content is selected to be represented by a fixed 3.5 mA output. The database point *AOXIsSaturated* is used to indicate the saturation status.

For each analog output, after the saturation determination is made, then the DAC limits of [3.5, 21] mA is applied to the pre-trimmed value. The resulting value is written to the appropriate *AOXOutput* database point (so that the point's meaning is consistent with the pre-HART® firmware).

The analog output trim zero and gain values (stored in database points *AOXCurrentTrimZero* and *AOXCurrentTrimGain*, respectively) are always applied to the analog output's pre-trimmed, DAC-limited value (i.e., the value stored in the database point *AOXOutput*) as shown in Equation 4-1 (all values in milliamps except the dimensionless gain). The DAC limits ([3.5, 21] mA) is applied to the resultant trim value (*AOXTRIM*) and DAC-limited result is stored in the database point *AOX-OutputTrimmed* and output to the DAC.

Equation 4-1 AOXOutput Trim

$$AOX_{TRIM} = (AOXCurrentTrimGain \times (AOXOutput - 4)) + 4 + AOXCurrenTrimZero$$

DEVICE VARIABLES

5. INTRODUCTION

The Expansion Board with HART does not use Device Family commands.

5.1 Device Variable 0 - Uncorrected Flow Rate

The flow-condition volumetric flow rate is the result of applying expansion correction and flow-profile correction to the raw volumetric flow rate derived as shown in Equation C-1 subject to the low-flow cut-off (see Annex C). *If the resulting value is below the low-flow cut-off value, it is set to zero.* The low-flow cut-off volumetric flow rate (**CutRate**) is the specified low-flow velocity threshold (**ZeroCut**) converted to a volumetric flow rate.

Device Variable			
Number:	0	**Name**	Uncorrected Flow Rate
Classification:	66 Volumetric Flow	**Unit Codes**	(see Table 11-1)

5.2 Device Variable 6 - Pressure

When the Expansion Board with HART is used, the meter samples the input analog signal(s) and updates the corresponding data point (**LiveFlowPresure**) once per second *regardless of the input selection* (disabled, live, or fixed).

Every five seconds, the meter updates the "in-use" flow-condition pressure and temperature values (**FlowPressure** and **AbsFlowPressure**) depending upon the input selection, validity of the input data, and the selected data source upon alarm (see Table 11-4).

The flow-condition pressure is configurable (via the **EnablePressureInput** data point) to be:

- disabled (0)
- live (1) (4-20 mA input signal, requires the Option Board) or
- fixed (2)

Device Variable			
Number:	6	**Name**	Pressure
Classification:	65 Pressure	**Unit Codes**	(see Table 11-4)

If an input is live, then the values corresponding to the minimum and maximum input (4 and 20 mA, respectively) are specified via data points **MinInputPressure** and **MaxInputPressure**.

To configure the live pressure, plus associated alarms, configure the data points in Table 11-11.

5.3 Device Variable 7 - Temperature

When the Option Board is used, the meter samples the input analog signal(s) and updates the corresponding data point (**LiveFlowTemperature**) once per second *regardless of the input selection* (disabled, live, or fixed).

Every five seconds, the meter updates the "in-use" flow-condition pressure and temperature values (**FlowTemperature**) depending upon the input selection, validity of the input data, and the selected data source upon alarm according to Table 11-5.

The flow-condition temperature is configurable (via the **EnableTemperature-Input** data point) to be:

- disabled (0)
- live (1) (4-20 mA input signal, requires the Option Board) or
- fixed (2)

Device Variable			
Number:	7	**Name**	Pressure
Classification:	64	**Unit Codes**	(see Table 11-5)

If an input is live, then the values corresponding to the minimum and maximum input (4 and 20 mA, respectively) are specified via data points **MinInputTemperature** and **MaxInputTemperature.**

To configure the live temperature, plus associated alarms, configure the data points in Table 11-12.

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HART DYNAMIC VARIABLES

6. INTRODUCTION

This section documents the HART® primary, secondary, tertiary, and quaternary variables.

6.1 Fixed Dynamic Variables

There are no fixed Dynamic Variables for this device.

6.2 Dynamic Variables with Configurable Mapping

The Daniel™ Expansion Board with HART allows the following user-configurable Dynamic Variables to be mapped to the Device Variables:

Table 6-1 Dynamic Variables Configurable Mapping

Dynamic Variable	Device Variable Number	Name
PV	0	• 0 Uncorrected Flow Rate • 6 Pressure • 7 Temperature
SV	0, 6, 7	• 0 Uncorrected Flow Rate • 6 Pressure • 7 Temperature
TV	0, 6, 7	• 0 Uncorrected Flow Rate • 6 Pressure • 7 Temperature
QV	0, 6, 7	• 0 Uncorrected Flow Rate • 6 Pressure • 7 Temperature

The default primary Dynamic Variable is Uncorrected Flow Rate for all meters.

NOTICE

If Analog Output 2 is not configured to represent absolute flow, the current will go to zero when the actual flow is not in the configured flow direction. The primary variable always represents the measured value regardless of the configured flow direction.

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STATUS INFORMATION

7. INTRODUCTION

This section documents the Expansion Board with HART primary, secondary, tertiary, and quaternary variables.

The meter status information is derived from Boolean database points. For host display purposes, the status information is divided into three categories:

- Failed - indications that the meter is not working properly and has lost measurement
- Maintenance - indications that the meter requires operator intervention
- Advisory - indications that the meter has information but is still measuring flow and does not require operator intervention

The meter uses the following mechanisms for communicating the status information to the host system:

- the Device Status Byte sent with every slave response,
- the Read Additional Device Status Universal Command 48 (see Section 7.2)
- the device-specific command for reading detailed status information Command 140 (see Section 10.14).

Device-Specific Command 141 (see Section 10.15) is used to acknowledge status Boolean database points that require acknowledgement.

These groups are displayed on the AMS screen and communicated via Universal Command 48 (see Section 7.2) unless it is indicated via the device status byte.

The database point mapping for the Device Status Byte is shown in Table 7-1. Command 48 database point mapping is shown in Table 7-2. Note that for Command 48, only the first 16 bytes (numbered 0 through 15) shall be sent by the HART® Slave. Additional Device Status is communicated via Device Specific Command 140 (illustrated in the command definition in Section 10.14).

7.1 Field Device Status

Table 7-1 Device Status Byte Database Point Mapping

DEVICE STATUS BIT	DEFINITION	EXPLANATION	RELATED DATABASE POINT(S)
7 (msb)	**Device Malfunction** - The device detected a serious error or failure that compromises device operation.	This is the logical OR'ing of the related database points.	• *IsCommErrAcqBd* • *WatchDogReset* • *IsElecVoltOutOfRange* • *IsUnkAcqBdRev*
6	**Configuration Changed** - An operation was performed that changed the device's configuration.		• *DidCnfgChksumChg*
5	**Cold Start** - A power failure or Device Reset has occurred.	For the Daniel Liquid Ultrasonic Meter platform, the term "cold start" is used to refer to the initial start of the board (when all non-volatile database points are initialized to their default values) whereas the term "warm start" is used to refer to a power failure. Thus, the HART® term "cold start" is equivalent to the Daniel Liquid Ultrasonic Meter platform term "warm start." Note that this bit is automatically reset by the first command that recognizes it (refer to HCF_SPEC 99 rev. 7.1, ver. A, section 3.3) although the database point is not reset.	• *DidPowerFail*
4	**More Status Available** - More status information is available via Command 48, Read Additional Status Information.	This bit is set whenever a Command 48 bit is active. Refer to Table 7-2 for the Command 48 bit map.	N/A
3	**Loop Current Fixed** - The Loop Current is being held at a fixed value and is not responding to process variations.	This bit is set whenever the AO2 current output is fixed (whether via HART® Command 40 or via enabling the test mode). Thus, it is the logical OR'ing of the related database points.	• *IsAO2EnableTest* • *AO2IsFixed*
2	**Loop Current Saturated** - The loop Current has reached its upper (or lower) endpoint limit and cannot increase (or decrease) any further.		• *AO2IsSaturated*

Table 7-1 Device Status Byte Database Point Mapping

DEVICE STATUS BIT	DEFINITION	EXPLANATION	RELATED DATABASE POINT(S)
1	**Non-Primary Variable Out of Limits** - A Device Variable not mapped to the PV is beyond its operating limits.	This bit is set whenever any Device Variable not mapped to the PV is out-of-limits. It is the logical OR'ing of the related out-of-limits database points. It uses the AO2Content database point to determine which Device Variable is mapped to the PV.	• *IsMeterVelAboveMaxLmt* • *AvgSndVelIsOutOfLimits* • *FlowPressureIsOutOfLimits* • *FlowTemperatureIsOutOfLimits*
0 (lsb)	**Primary Variable Out of Limits** - The Primary Variable is beyond its operating limit.	This bit is set whenever the Device Variable mapped to the PV is out-of-limits. It uses the AO2Content database point to determine which Device Variable is mapped to the PV. Note that some Device Variables do not have limits and thus do not have associated out-of-limits database points.	• *AO2Content*

7.2 Command 48 - Additional Device Status

Request Data Bytes

Table 7-2 Command 48 - Additional Device Status

<table>
<tr><th>Byte</th><th>Format</th><th>Description</th></tr>
<tr><td>0</td><td>Bits</td><td>Failed Status Byte 0
<table>
<tr><th>Bit</th><th>Description</th><th>Related Database Point(s)</th></tr>
<tr><td>7 (msb)</td><td>Acquisition Mode Indicator</td><td>• IsAcqMode</td></tr>
<tr><td>6</td><td>Meter cold-start indicator.</td><td>• DidColdStart</td></tr>
<tr><td>5</td><td>Acquisition Mode Latched indicator</td><td>• IsAcqModeLatched</td></tr>
<tr><td>4</td><td>Number of operating chords below specified minimum latched indicator</td><td>• IsTooFewOperChordsLatched</td></tr>
<tr><td>3</td><td>Number of operating chords below specified minimum</td><td>• IsTooFewOperChords</td></tr>
<tr><td>2</td><td>Acquisition board communi-cations error latched indicator</td><td>• IsCommErrAcqBdLatched</td></tr>
<tr><td>1</td><td></td><td></td></tr>
<tr><td>0 (lsb)</td><td></td><td></td></tr>
</table></td></tr>
<tr><td>1</td><td>Bits</td><td>Maintenance Status Byte 0
<table>
<tr><th>Bit</th><th>Description</th><th>Related Database Point(s)</th></tr>
<tr><td>7 (msb)</td><td>Chord A is hard failed</td><td>• IsHardFailedA</td></tr>
<tr><td>6</td><td>Chord B is hard failed</td><td>• IsHardFailedB</td></tr>
<tr><td>5</td><td>Chord C is hard failed</td><td>• IsHardFailedC</td></tr>
<tr><td>4</td><td>Chord D is hard failed</td><td>• IsHardFailedD</td></tr>
<tr><td>3</td><td></td><td></td></tr>
<tr><td>2</td><td></td><td></td></tr>
<tr><td>1</td><td></td><td></td></tr>
<tr><td>0 (lsb)</td><td></td><td></td></tr>
</table></td></tr>
</table>

Table 7-2 Command 48 - Additional Device Status

<table>
<tr><th>Byte</th><th>Format</th><th>Description</th></tr>
<tr><td>2</td><td>Bits</td><td>Maintenance Status Byte 1
<table>
<tr><th>Bit</th><th>Description</th><th>Related Database Point(s)</th></tr>
<tr><td>7 (msb)</td><td>Flow-condition pressure invalid indicator</td><td>• PressureInvalid</td></tr>
<tr><td>6</td><td>Flow-condition temperature invalid indicator</td><td>• TemperatureInvalid</td></tr>
<tr><td>5</td><td></td><td>• Reserved</td></tr>
<tr><td>4</td><td>Live digital pressure invalid unit indicator</td><td>• PressIsLiveDigitalUnitInvalid</td></tr>
<tr><td>3</td><td>Live digital temperature invalid unit indicator.</td><td>• TempIsLiveDigitalUnitInvalid</td></tr>
<tr><td>2</td><td>Live digital pressure latched indicator</td><td>• PressureInvalidLatched</td></tr>
<tr><td>1</td><td>Live digital temperature latched indicator</td><td>• TemperatureInvalidLatched</td></tr>
<tr><td>0(lsb)</td><td></td><td></td></tr>
</table></td></tr>
<tr><td>3</td><td>Bits</td><td>Maintenance Status Byte 2
<table>
<tr><th>Bit</th><th>Description</th><th>Related Database Point(s)</th></tr>
<tr><td>7 (msb)</td><td>Clock invalid indicator</td><td>• IsClkInvalid</td></tr>
<tr><td>6</td><td></td><td>• Reserved</td></tr>
<tr><td>5</td><td></td><td>• Reserved</td></tr>
<tr><td>4</td><td>Indicator that the meter should be warm-started</td><td>• IsWarmStartReq</td></tr>
<tr><td>3</td><td></td><td></td></tr>
<tr><td>2</td><td></td><td></td></tr>
<tr><td>1</td><td></td><td></td></tr>
<tr><td>0 (lsb)</td><td></td><td></td></tr>
</table></td></tr>
</table>

Table 7-2 Command 48 - Additional Device Status

<table>
<tr><th>Byte</th><th>Format</th><th>Description</th></tr>
<tr><td>4</td><td>Bits</td><td>Advisory Status Byte 0
<table>
<tr><th>Bit</th><th>Description</th><th>Related Database Point(s)</th></tr>
<tr><td>7 (msb)</td><td>Invalid measurement indicator - logical OR'ing of the related database points</td><td>• QFlowValidity (inverted)
• Freq1DataValidity (inverted)
• Freq2DataValidity (inverted)
• AO1DataValidity (inverted)
• AO2DataValidity (inverted)
• HARTAO2SVValidity (inverted)
• HARTAO2TVValidity (inverted)
• HARTAO2QVValidity (inverted)
• HARTAO2Slot0Validity (inverted)
• HARTAO2Slot1Validity (inverted)
• HARTAO2Slot2Validity (inverted)
• HARTAO2Slot3Validity (inverted)</td></tr>
<tr><td>6</td><td>* HART Pressure Input Device Status - logical OR'ing of the related database points

* Future availability</td><td>• PressHARTIsCommErr
• PressHARTIsDevMalfunction
• PressHARTIsConfigChanged
• PressHARTDidColdStart
• PressHARTIsMoreStatusAvailable
• PressHARTIsLoopCurrentFixed
• PressHARTIsLoopCurrentSaturated
• PressHARTIsNonPVOutOfLimits
• PressHARTIsPVOutOfLimits</td></tr>
<tr><td>5</td><td>* HART Temperature Input Device Status - logical OR'ing of the related database points

* Future availability</td><td>• TempHARTIsCommErr
• TempHARTIsDevMalfunction
• TempHARTIsConfigChanged
• TempHARTDidColdStart
• TempHARTIsMoreStatusAvailable
• TempHARTIsLoopCurrentFixed
• TempHARTIsLoopCurrentSaturated
• TempHARTIsNonPVOutOfLimits
• TempHARTIsPVOutOfLimits</td></tr>
<tr><td>4</td><td>Power failure indicator</td><td>• DidPowerFail</td></tr>
<tr><td>3</td><td>Latched alarm indicator</td><td>• IsMeterVelAboveMaxLmtLatched</td></tr>
<tr><td>2</td><td></td><td></td></tr>
<tr><td>1</td><td></td><td></td></tr>
<tr><td>0 (lsb)</td><td></td><td></td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Byte</th><th>Format</th><th>Description</th></tr>
<tr><td>5</td><td>Bits</td><td>Advisory Status Byte 1
<table>
<tr><th>Bit</th><th>Description</th><th>Related Database Point(s)</th></tr>
<tr><td>7 (msb)</td><td>One or more logs full indicator - logical OR'ing of the related database points</td><td>• IsHourlyLogFull
• IsDailyLogFull
• IsAuditLogFull
• IsAlarmLogFull
• IsSystemLogFull</td></tr>
<tr><td>6</td><td></td><td>• IsFreq1EnableTest</td></tr>
<tr><td>5</td><td></td><td>• IsFreq2EnableTest</td></tr>
<tr><td>4</td><td>AO1 fixed indicator - Logical OR'ing of the related database points</td><td>• IsAO1EnableTest
• AO1IsFixed</td></tr>
<tr><td>3</td><td></td><td>• AO1IsSaturated</td></tr>
<tr><td>2</td><td></td><td>Reserved</td></tr>
<tr><td>1</td><td></td><td>Reserved</td></tr>
<tr><td>0 (lsb)</td><td></td><td>• IsElecTempOutOfRange</td></tr>
</table></td></tr>
<tr><td>6</td><td>Enum-8</td><td>Operating Mode #1 (set to 250 "Not Used")</td></tr>
<tr><td>7</td><td>Enum-8</td><td>Operating Mode #2 (set to 250 "Not Used")</td></tr>
<tr><td>8-10</td><td>Unsigned-24</td><td>Analog Output Saturated, Respectively LSB to MSB: AO1, AO2, … AO24</td></tr>
<tr><td>11-13</td><td>Unsigned-24</td><td>Analog Output Fixed, Respectively LSB to MSB: AO1, AO2, …, AO24</td></tr>
</table>

<table>
<tr><td>14</td><td>Bits</td><td>Advisory -- Advanced Diagnostic Alarms
<table>
<tr><th>Bit</th><th>Description</th><th>Related Database Point(s)</th></tr>
<tr><td>7 (msb)</td><td></td><td>Reserved</td></tr>
<tr><td>6</td><td></td><td>Reserved</td></tr>
<tr><td>5</td><td></td><td>Reserved</td></tr>
<tr><td>4</td><td></td><td>Reserved</td></tr>
<tr><td>3</td><td></td><td>• IsReverseFlowDetected</td></tr>
<tr><td>2</td><td></td><td></td></tr>
<tr><td>1</td><td></td><td></td></tr>
<tr><td>0 (lsb)</td><td></td><td></td></tr>
</table></td></tr>
<tr><td>15</td><td>Bits</td><td>Advisory -- Advanced Diagnostic Alarms Latched
<table>
<tr><th>Bit</th><th>Description</th><th>Related Database Point(s)</th></tr>
<tr><td>7 (msb)</td><td></td><td>Reserved</td></tr>
<tr><td>6</td><td></td><td>Reserved</td></tr>
<tr><td>5</td><td></td><td>Reserved</td></tr>
<tr><td>4</td><td></td><td>Reserved</td></tr>
<tr><td>3</td><td></td><td>• IsReverseFlowDetectedLatched</td></tr>
<tr><td>2</td><td></td><td></td></tr>
<tr><td>1</td><td></td><td></td></tr>
<tr><td>0 (lsb)</td><td></td><td></td></tr>
</table></td></tr>
<tr><td>16-24</td><td>Bits, Unsigned-24 or Enum</td><td>Not used at this time and thus not sent.</td></tr>
</table>

UNIVERSAL COMMANDS

8. INTRODUCTION

This section documents the HART® Universal Commands.

8.1 HART® Universal Commands

Table 8-1 HART® Universal Commands for Slave Implementation

Command	Function	Description
0	Read Unique Identifier	Returns identity information about the meter including: the Device Type, revision levels, and Device ID.
1	Read Primary Variable	Returns the Primary Variable value along with its Unit Code.
2	Read Loop Current and Percent Of Range	Reads the Loop Current and its associated Percent of Range.
3	Read Dynamic Variables and Loop Current	Reads the Loop Current and up to four predefined Dynamic Variables. The Dynamic Variables and associated units are defined via Commands 51 and 53.
6	Write Polling Address	Used to set the meter's polling address and loop current mode.
11	Read Unique Identifier Associated With Tag	If the specified tag matches that of the meter, it responds with the Command 0 response.
12	Read Message	Reads the Message contained within the meter.
13	Read Tag, Descriptor, Date	Reads the Tag, Descriptor, and Date contained within the meter.
14	Read Primary Variable Transducer Information	Reads the Transducer (meter) Serial Number, Limits/Minimum Span Units Code, Upper Transducer Limit, Lower Transducer Limit, and Minimum Span for the Primary Variable transducer.
15	Read Device Information	Reads the alarm selection code, transfer function code, range values units code upper range value, Primary Variable lower range value, damping value, write protect code, and private label distributor code.
16	Read Final Assembly Number	Reads the Final Assembly Number associated with the meter.
17	Write Message	Write the Message into the meter.
18	Write Tag, Descriptor, Date	Write the Tag, Descriptor, and Date Code into the meter.
19	Write Final Assembly Number	Write the Final Assembly Number into the meter.

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COMMON-PRACTICE COMMANDS

9. INTRODUCTION

This section documents the Expansion Board with HART additional device status optional Common-Practice Commands.

9.1 Supported Common-Practice Commands

The device features, functionality, and restrictions of the Common-Practice Commands are listed in the table below.

Table 9-1 HART® Common-Practice Commands

Command	Function	Description
33	Read Device Variables	Allows a Master to request the value of up to four Device Variables.
38	Reset Configuration Changed Flag	Resets the configuration changed indicator (Device Status Byte bit 6).
40	Enter/Exit Fixed Current Mode	Forces the Loop Current to the requested value.
42	Perform Device Reset	Forces the meter to perform a warm start (equivalent to cycling the power off and then back on to the meter).
44	Write Primary Variable Units	Selects the units in which the Primary Variable and its range will be returned.
45	Trim Loop Current Zero	Trims the zero or lower endpoint value of the Loop Current exactly to its minimum. This trim is typically performed by adjusting the Loop Current to 4.00 mA and sending the measured value to the meter.
46	Trim Loop Current Gain	Trims the gain or upper endpoint value of the Loop Current exactly to its maximum. This trim is typically performed by adjusting the Loop Current to 20.0 mA and sending the measured value to the meter.
48	Read Additional Device Status	Returns meter status information not included in the Response Code or Device Status Byte.
50	Read Dynamic Variable Assignments	Reads the Device Variables assigned to the Primary, Secondary, Tertiary, and Quaternary Variables.
51	Write Dynamic Variable Assignments	Allows the user to assign Device Variables to the Primary, Secondary, Tertiary, and Quaternary Variables
53	Write Device Variable Units	Selects the units in which the selected Device Variable will be returned.
54	Read Device Variable Information	Responds with the transducer serial number, the Limits, Damping Value (not applicable), and Minimum Span of the Device Variable along with the corresponding engineering units.
59	Write Number Of Response Preambles	Sets the number of asynchronous preamble bytes to be sent by the meter before the start of a response message.

9.2 Burst Mode

This device does not support Burst Mode.

9.3 Catch Device Variable

This device does not support a Catch Device Variable.

DEVICE-SPECIFIC COMMANDS

10. INTRODUCTION

This section documents the Device-Specific Commands implemented for the Expansion Board with HART for Daniel Liquid Ultrasonic Flow Meters.

10.1 Public, Device-Specific Commands

This section lists the Expansion Board with HART Device-Specific Commands in each of the following subsections as defined by:

- command number and command name
- functional description
- command's operation (i.e., read/write/command)
- request data (Byte stream position, data format and descriptions)
- response data (Byte stream position, data format and descriptions)
- Command-specific response codes

10.2 Command 128 Write Analog Output Configuration

This command is used to configure the meter's specified analog output. The meter provides two analog outputs: Analog Output 1 (AO1) and Analog Output 2 (AO2). Analog Output 1 supports only conventional 4-20 mA output whereas Analog Output 2 supports both conventional 4-20 mA output and HART® output. This command is primarily provided to allow configuration of Analog Output 1. It can be used to configure Analog Output 2 but the preferred method is to configure the output via the supported HART® Universal and Common commands.

Request Data Bytes

Byte	Format	Description	Explanation
0	Unsigned-8	Analog output selector (0 for Analog Output 1, 1 for Analog Output 2)	Used to select which analog output to be configured
1	Unsigned-8	Device Variable assigned to the specified analog output	Used to set *AOXContent*. When this assignment is a configuration change, the remaining data bytes are ignored. However, for the response, the remaining data bytes should reflect the data for the newly assigned device variable.
2	Enum-8	Upper and Lower Range Values Units Code (see Section 11)	Specifies the units for the requested Upper and Lower Range Values. This units code is only pertinent for interpreting this command's data values and for the units of the response's data values. It does not update any units-related data points.
3-6	Float	Upper Range Value	Used to set *AOXFullScaleVolFlowRate*
7-10	Float	Lower Range Value	Reserved
11	Enum-8	Flow direction to be represented by specified analog output	• *0=Reverse* • *1=Forward* • *2=Absolute* *(indicates flow regardless of flow direction*
12	Enum-8	Alarm Selection Code (see Section 11)	0=High (20mA), 1=Low (4mA), 239=Hold Last Value, 240=Very Low (3.5mA), 241=Very High (20.5mA), 251=None. Used to set (new data point) AOXAction-UponInvalidContent (direct mapping).

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Analog output selector
1	Unsigned-8	Device Variable assigned to the specified analog output
2	Enum-8	Upper and Lower Range Values Units Code (see Section 11) for the assigned Device Variable. If the device variable assigned is modified, then the configured HART default units code for the Device Variable is used.
3-6	Float	Upper Range Value for the assigned Device Variable
7-10	Float	Lower Range Value for the assigned Device Variable
11	Enum-8	Flow direction represented by specified analog output
12	Enum-8	Alarm Selection Code - 0=High (20mA), 1=Low (4mA), 239=Hold Last Value, 240=Very Low (3.5mA), 241=Very High (20.5mA), 251=None.

Command-Specific Response Codes

Code	Class	Description	Explanation
0	Success	No Command-Specific Errors	
1		Undefined	
2	Error	Invalid Selection	Unit code, Flow direction or alarm code selection invalid.
3-4	Error	Undefined	
5	Error	Too Few Data Bytes Received	
6	Error	Device-Specific Command Error	Lower range value > Upper range value
7	Error	In Write Protect Mode	
8		Undefined	
9	Error	Lower Range Value Too High	Lower Range Value was above the Upper Transducer Limit or some other physical device limitation is exceeded.
10	Error	Lower Range Value Too Low	Lower Range Value was below the Lower Transducer Limit or some other physical device limitation is exceeded.
11	Error	Upper Range Value Too High	Upper Range Value was above Upper Transducer Limit.
12	Error	Upper Range Value Too Low	Upper Range Value was below the Lower Transducer Limit.
13-14		Undefined	
15	Error	Invalid Analog Channel Code Number	The analog channel does not exist in this field device. (This is returned if the analog output number is neither 0 nor 1.)
16-27		Undefined	
28	Error	Invalid Device Variable Index	The requested Device Variable does not exist in this field device or is not supported by the requested command or operation. (This is returned if an invalid Device Variable selection is requested.)
29-31		Undefined	
32	Error	Busy	
33-127		Undefined	

10.3 Command 129 Read Analog Output Configuration

This command is used to read the meter's specified analog output configuration. The meter provides two analog outputs: Analog Output 1 (AO1) and Analog Output 2 (AO2). Analog Output 1 supports only conventional 4-20 mA output whereas Analog Output 2 supports both conventional 4-20 mA output and HART® output.

Request Data Bytes

Byte	Format	Description	Explanation
0	Unsigned-8	Analog output selector (0 for Analog Output 1 for Analog Output 2)	Used to select which analog output to be configured

Response Data Bytes

Same as Command 128 Write Analog Output Configuration.

Command-Specific Response Codes

Code	Class	Description	Explanation
0	Success	No Command-Specific Errors	
1-14		Undefined	
15	Error	Invalid Analog Channel Code Number	The analog channel does not exist in this field device. (This is returned if the analog output number is neither 1 nor 2.)
16-31		Undefined	
32	Error	Busy	
33-127		Undefined	

10.4 Command 130 Write Frequency and Digital Output Configuration

This command is used to configure the meter's specified frequency output pair and its associated digital output pair. The meter provides two frequency output pairs: Frequency Output Pair 1 (Freq1A and Freq1B) and Frequency Output Pair 2 (Freq2A and Freq2B). Associated with each Frequency Output Pair is a Digital Output Pair: Digital Output Pair 1 (DO1A and DO1B) is associated with Frequency Output Pair 1, Digital Output Pair 2 (DO2A and DO2B) is associated with Frequency Output Pair 2.

Request Data Bytes

Byte	Format	Description	Explanation
0	Unsigned-8	Frequency/Digital Output Pair selector (0 for Pair 1 or 1 for Pair 2)	Used to select which frequency/digital output pair to be configured
1	Unsigned-8	Device Variable assigned to the specified Frequency Output Pair	• *0=Uncorrected flow rate.* Used to set *Freq*X*Content*. When this assignment is a configuration change, the remaining data bytes are ignored. However, for the response, the remaining data bytes should reflect the data for the newly assigned device variable.
2	Enum-8	Upper and Lower Range Values Units Code (see Section 11.)	Specifies the units for the requested Device Variable and Upper and Lower Range Values. This units code is only pertinent for interpreting this command's data values and for the units of the response's data values. It does not update any units-related data points.
3-6	Float	Upper Range Value	Used to set *Freq*X*FullScaleVolFlowRate*. This value corresponds to the maximum frequency (set via *Freq*X*MaxFrequency*).
7-10	Float	Lower Range Value	Used to set *AO*X*MinVel*. Write is rejected if volumetric flow rate is selected as the device variable and the Lower Range Value is non-zero.
11-12	Enum-16	Maximum Frequency (Hertz)	Allowed values are 1000 and 5000 Hz. Used to set *Freq*X*MaxFrequency*.
13	Enum-8	Flow direction to be represented by Frequency Output Pair	• *0=Reverse* • *1=Forward* • *2=Absolute (indicates flow regardless of flow direction)* • *3=Bidirectional* (Phase A indicates forward direction flow, Phase B indicates reverse direction flow). Used to set *FreqXDir*.
14	Enum-8	Frequency B Phase zero-on-error configuration	0=don't zero on error, 1=zero on error Used to set *IsFreqXBZeroedOnErr*.
15	Enum-8	Frequency B Phase relative to Frequency A Phase configuration	• *0=Lag when forward flow, lead when reverse flow* • *1=Lead when forward flow, lag when reverse flow* This configuration is ignored when Bidirectional flow direction is requested (see above). Used to set *FreqXBPhase*.

16	Unsigned-8	Frequency feedback correction percentage	Values within [0, 100] percent. Used to set *FreqXFeedbackCorrectionPcnt*.
17	Enum-8	Selected Digital Output A inverted polarity configuration	• *0=Normal polarity* • *1=Inverted polarity* This is used to set *DOXAIsInvPolarity*
18	Enum-8	Selected Digital Output A content selector	• *0=Corresponding Frequency Output Pair Validity* • *1=Flow Direction* This is used to set *DOXAContent* data point but it is NOT a direct mapping.
19	Enum-8	Selected Digital Output B inverted polarity configuration selector	• *0=Normal polarity* • *1=Inverted polarity* This is used to set *DOXBIsInvPolarity*
20	Enum-8	Selected Digital Output B content selector	• *0=Corresponding Frequency Output Pair Validity* • *1=Flow Direction* This is used to *DOXBContent* data point but it is NOT a direct mapping.

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Frequency/Digital Output Pair selector (0 for Pair 1 or 1 for Pair 2)
1	Unsigned-8	Device Variable assigned to the specified Frequency Output Pair
2	Enum-8	Upper and Lower Range Values Units Code (see Section 11.) for the assigned Device Variable. If the device variable assigned is modified, then the configured HART default units code for the Device Variable is used.
3-6	Float	Upper Range Value for the assigned Device Variable
7-10	Float	Lower Range Value for the assigned Device Variable
11-12	Enum-16	Maximum Frequency (Hertz)
13	Enum-8	Flow direction to be represented by Frequency Output Pair
14	Enum-8	Frequency B Phase zero-on-error configuration
15	Enum-8	Frequency B Phase relative to Frequency A Phase configuration
16	Unsigned-8	Frequency feedback correction percentage
17	Enum-8	Selected Digital Output A inverted polarity configuration
18	Enum-8	Selected Digital Output A content
19	Enum-8	Selected Digital Output B inverted polarity configuration
20	Enum-8	Selected Digital Output B content

Command-Specific Response Codes

Code	Class	Description	Explanation
0	Success	No Command-Specific Errors	
1		Undefined	
2	Error	Invalid Selection	Requested maximum frequency, feedback percentage invalid Frequency Phase B, Digital Output inverted polarity or Digital Output content invalid.
3	Error	Passed Parameter Too Large	
4	Error	Passed Parameter Too Small	
5	Error	Too Few Data Bytes Received	
6	Error	Device-Specific Command Error	
7	Error	In Write Protect Mode	
8		Undefined	
9	Error	Lower Range Value Too High	Lower Range Value was above the Upper Transducer Limit or some other physical device limitation is exceeded.
10	Error	Lower Range Value Too Low	Lower Range Value was below the Lower Transducer Limit or some other physical device limitation is exceeded.
11	Error	Upper Range Value Too High	Upper Range Value was above Upper Transducer Limit.
12	Error	Upper Range Value Too Low	Upper Range Value was below the Lower Transducer Limit.
13-14		Undefined	
15	Error	Invalid Frequency/Digital Output Pair Number	The frequency/digital output pair requested does not exist in this field device. (This is returned if the number is neither 0 nor 1.)
16-27		Undefined	
28	Error	Invalid Device Variable Index	The requested Device Variable does not exist in this field device. (This is returned if an invalid Device Variable selection is requested.)
29-31		Undefined	
32	Error	Busy	
33-127		Undefined	

10.5 Command 131 Read Frequency and Digital Output Configuration

This command is used to read the meter's specified frequency output pair and its associated digital output pair configuration. The meter provides two frequency output pairs: Frequency Output Pair 1 (Freq1A and Freq1B) and Frequency Output Pair 2 (Freq2A and Freq2B). Associated with each Frequency Output Pair is a Digital Output Pair: Digital Output Pair 1 (DO1A and DO1B) is associated with Frequency Output Pair 1, Digital Output Pair 2 (DO2A and DO2B) is associated with Frequency Output Pair 2. The parameters are returned using the units code selection for the Device Variable represented by the specified frequency output pair.

Request Data Bytes

Byte	Format	Description	Explanation
0	Unsigned-8	Frequency/Digital Output Pair number (1 or 2)	Used to select which frequency/digital output pair to be configured

Response Data Bytes

Same as Command 130 Write Frequency and Digital Output Configuration.

Command-Specific Response Codes

Code	Class	Description	Explanation
0	Success	No Command-Specific Errors	
1-14		Undefined	
15	Error	Invalid Frequency/Digital Output Pair Number	The frequency/digital output pair does not exist in this field device. (This is returned if the number is neither 1 nor 2.)
16-31		Undefined	
32	Error	Busy	
33-127		Undefined	

10.6 Command 132 Write Flow Pressure Configuration

This command is used to configure the meter's flow-condition pressure. The input can be disabled, a conventional 4-20 mA input, a HART® input, or fixed at a specified value. For conventional 4-20 mA and HART® inputs, Analog Input 2 (AI2) is used for pressure.

Request Data Bytes

Byte	Format	Description	Explanation
0	Enum-8	Input Selector Code	• *0=None* • *1=Live 4-20 mA* • *2=Fixed (specified).* • ***3=Live HART* Used to set *EnablePressureInput* and *PressureLiveInput* data points. * The Live HART input selector code is not supported by v1.60 and later firmware.
1	Enum-8	Units Code (see Section 11)	Specifies the units for related values (such as alarm values, range values, fixed (specified) value). This units code is only pertinent for interpreting this command's data values and for the units of the response's data values. It does not update any units-related data points.
2-5	Float	Conventional Analog or Fixed Upper Alarm Value	Used to set *HighPressureAlarm*. This value is only applicable if the Input Selector Code is 1 (live conventional 4-20 mA analog) or 2 (fixed/specified). It is ignored for all other Input Selector Code values. For Input Selector Code 3 (live HART), the *HighPressureAlarm* data point is set based upon the Upper Transducer Limit value read from the device.
6-9	Float	Conventional Analog or Fixed Lower Alarm Value	Used to set *LowPressureAlarm*. This value is only applicable if the Input Selector Code is 1 (live conventional 4-20 mA analog) or 2 (fixed/specified). It is ignored for all other Input Selector Code values. For Input Selector Code 3 (live HART), the *LowPressureAlarm* data point is set based upon the Lower Transducer Limit value read from the device.
10-13	Float	Conventional Analog Upper Range Value	Used to set *MaxInputPressure*. This value is only applicable if the Input Selector Code is 1 (live conventional 4-20 mA analog). It is ignored for all other Input Selector Code values. For Input Selector Code 3 (live HART), the *MaxInputPressure* data point is set based upon the Upper Range Value read from the device.
14-17	Float	Conventional Analog Lower Range Value	Used to set *MinInputPressure*. This value is only applicable if the Input Selector Code is 1 (live conventional 4-20 mA analog). It is ignored for all other Input Selector Code values. For Input Selector Code 3 (live HART), the *MinInputPressure* data point is set based upon the Upper Range Value read from the device.

Byte	Format	Description	Explanation
18-21	Float	Fixed Value	Used to set *SpecFlowPressure*. This value is only applicable if the Input Selector Code is 2 (fixed/specified). It is ignored for all other Input Selector Code values.
22	Enum-8	Pressure and Temperature Alarm Selection Code(see Section 11)	This selects the input action upon alarm and is applicable to both pressure and temperature inputs. Used to set *FlowPOrTSrcUponAlarm* although it is not a direct mapping: • *239 Hold Last Output Value* → *set FlowPOrTSrcUponAlarm to 0;* • *242 Used Fixed Value* → *set FlowPOrTSrcUponAlarm to 1 (Fixed value).*
23	Enum-8	Absolute pressure input type indicator	• *0=gage* • *1=absolute* Used to set *InputPressureUnit*.
24-27	Float	Atmospheric Pressure Value	Required when the input pressure is gage. Used to set *AtmosphericPress*.

Response Data Bytes

Byte	Format	Description
0	Enum-8	Input Selector Code
1	Enum-8	Units Code (see Section 11)
2-5	Float	Conventional Analog or Fixed Upper Alarm Value
6-9	Float	Conventional Analog or Fixed Lower Alarm Value
10-13	Float	Conventional Analog Upper Range Value
14-17	Float	Conventional Analog Lower Range Value
18-21	Float	Fixed Value
22	Enum-8	Pressure and Temperature Alarm Selection Code (see Section 11)
23	Enum-8	Absolute pressure input type indicator (1=absolute, 0=gage)
24 - 27	Float	Atmospheric Pressure Value

Command-Specific Response Codes

Code	Class	Description	Explanation
0	Success	No Command-Specific Errors	
1		Undefined	
2	Error	Invalid Selection	Input selector code or alarm code selection invalid.
3-4		Undefined	
5	Error	Too Few Data Bytes Received	
6	Error	Device-Specific Command Error	This is used to indicate an error when either (a) lower alarm value > upper alarm value, (b) lower range value > upper range value, or (c) a requested value is outside its sanity limits. * Also used for unsupported selector code, e.g. Live HART is not supported v1.60 and later firmware.
7	Error	In Write Protect Mode	
8		Undefined	
9	Error	Lower Range Value Too High	Lower Range Value was above the Upper Transducer Limit or some other physical device limitation is exceeded.
10	Error	Lower Range Value Too Low	Lower Range Value was below the Lower Transducer Limit or some other physical device limitation is exceeded
11	Error	Upper Range Value Too High	Upper Range Value was above Upper Transducer Limit.
12	Error	Upper Range Value Too Low	Upper Range Value was below the Lower Transducer Limit.
13-31		Undefined	
32	Error	Busy	
33-127		Undefined	

10.7 Command 133 Read Flow Pressure Configuration

This command is used to read the meter's flow-condition pressure input configuration. The parameters are returned using the Pressure Device Variable configured units code.

Request Data Bytes

Byte	Format	Description	Explanation
None			

Response Data Bytes

Same as Command 132 Write Flow Pressure Configuration.

Command-Specific Response Codes

Code	Class	Description	Explanation
0	Success	No Command-Specific Errors	
1-31		Undefined	
32	Error	Busy	
33-127		Undefined	

10.8 Command 134 Write Flow Temperature Configuration

This command is used to configure the meter's flow-condition temperature. The input can be disabled, a conventional 4-20 mA input, a HART® input, or fixed at a specified value. For conventional 4-20 mA and HART® inputs, Analog Input 1 (AI1) is used for temperature.

Request Data Bytes

Byte	Format	Description	Explanation
0	Enum-8	Input Selector Code	0=None, 1=Live 4-20 mA, 3=Live HART, 2=Fixed (specified). Used to set *EnableTemperatureInput* and *TemperatureLiveInput* data points. * The Live HART input selector code is not supported byv1.60 and later firmware.
1	Enum-8	Units Code (see Section 11)	Specifies the units for related values (such as alarm values, range values, fixed (specified) value). This units code is only pertinent for interpreting this command's data values and for the units of the response's data values. It does not update any units-related data points.

Byte	Format	Description	Explanation
2-5	Float	Conventional Analog or Fixed Upper Alarm Value	Used to set *HighTemperatureAlarm*. This value is only applicable if the Input Selector Code is 1 (live conventional 4-20 mA analog) or 2 (fixed/specified). It is ignored for all other Input Selector Code values. For Input Selector Code 3 (live HART), the *HighTemperature-Alarm* data point is set based upon the Upper Transducer Limit value read from the device.
6-9	Float	Conventional Analog or Fixed Lower Alarm Value	Used to set *LowTemperatureAlarm*. This value is only applicable if the Input Selector Code is 1 (live conventional 4-20 mA analog) or 2 (fixed/specified). It is ignored for all other Input Selector Code values. For Input Selector Code 3 (live HART), the *LowTemperature-Alarm* data point is set based upon the Lower Transducer Limit value read from the device.
10-13	Float	Conventional Analog Upper Range Value	Used to set *MaxInputTemperature*. This value is only applicable if the Input Selector Code is 1 (live conventional 4-20 mA analog). It is ignored for all other Input Selector Code values. For Input Selector Code 3 (live HART), the *MaxInputTempera-ture* data point is set based upon the Upper Range Value read from the device.
14-17	Float	Conventional Analog Lower Range Value	Used to set *MinInputTemperature*. This value is only applicable if the Input Selector Code is 1 (live conventional 4-20 mA analog). It is ignored for all other Input Selector Code values. For Input Selector Code 3 (live HART), the *MinInputTemperature* data point is set based upon the Upper Range Value read from the device.
18-21	Float	Fixed Value	Used to set *SpecFlowTemperature*. This value is only applicable if the Input Selector Code is 2 (fixed/specified). It is ignored for all other Input Selector Code values.
22	Enum-8	Pressure and Temperature Alarm Selection Code (see Section 11)	This selects the input action upon alarm and is applicable to both pressure and temperature inputs. Used to set *FlowPOrTSrcUponAlarm* although it is not a direct mapping: • *239 Hold Last Output Value* → *set FlowPOrTSrcUponAlarm to 0* • *242 Used Fixed Value* → *set FlowPOrTSrcUponAlarm to 1 (Fixed value).*

Response Data Bytes

Byte	Format	Description
0	Enum-8	Input Selector Code
1	Enum-8	Units Code (see Section 11)
2-5	Float	Conventional Analog or Fixed Upper Alarm Value
6-9	Float	Conventional Analog or Fixed Lower Alarm Value
10-13	Float	Conventional Analog Upper Range Value
14-17	Float	Conventional Analog Lower Range Value
18-21	Float	Fixed Value
22	Enum-8	Pressure and Temperature Alarm

Command-Specific Response Codes

Code	Class	Description	Explanation
0	Success	No Command-Specific Errors	
1		Undefined	
2	Error	Invalid Selection	Input selector code or alarm code selection invalid.
3-4		Undefined	
5	Error	Too Few Data Bytes Received	
6	Error	Device-Specific Command Error	This is used to indicate an error when either: • *lower alarm value > upper alarm value* • *lower range value > upper range value* or • *a requested value is outside its sanity limits.* * Also used for unsupported selector code, e.g. Live HART is not supported v1.60 and later firmware.
7	Error	In Write Protect Mode	
8		Undefined	

Code	Class	Description	Explanation
9	Error	Lower Range Value Too High	Lower Range Value was above the Upper Transducer Limit or some other physical device limitation is exceeded.
10	Error	Lower Range Value Too Low	Lower Range Value was below the Lower Transducer Limit or some other physical device limitation is exceeded
11	Error	Upper Range Value Too High	Upper Range Value was above Upper Transducer Limit.
12	Error	Upper Range Value Too Low	Upper Range Value was below the Lower Transducer Limit.
13-31		Undefined	
32	Error	Busy	
33-127		Undefined	

10.9 Command 135 Read Flow Temperature Configuration

This command is used to read the meter's flow-condition temperature input configuration. The parameters are returned using the Temperature Device Variable configured units code.

Request Data Bytes

Byte	Format	Description	Explanation
None			

Response Data Bytes

Same as Command 134 Write Flow Pressure-Specific Configuration.

Command-Specific Response Codes

Code	Class	Description	Explanation
0	Success	No Command-Specific Errors	
1-31		Undefined	
32	Error	Busy	
33-127		Undefined	

10.10 Command 136 Write Device Units

This command is used to write the device's units. Note that the meter utilizes the Flow Rate Time Units Code to derive all flow rate units. For example, the Volumetric Flow Rate Units Code (used for the uncorrected volumetric flow rate device variable) is derived from the Volume Units Code and the Flow Rate Time Units Code: if the Volume Units Code is cubic meters and the Flow Rate Time Units Code is (per) hour, then the derived Volumetric Flow Rate Units Code is cubic meters per hour. The supported HART® Units Codes are listed in Section 11.

Request Data Bytes

Byte	Format	Description
0	Enum-8	Volume Units Code (see Table 11-1)
1	Enum-8	Flow Rate Time Units Code (see Table 11-2)
2	Enum-8	Pressure Units Code (see Table 11-4)
3	Enum-8	Temperature Units Code (see Table 11-5)
4	Enum-8	Velocity Units Code (see Table 11-6)

Response Data Bytes

Byte	Format	Description
0	Enum-8	Volume Units Code
1	Enum-8	Flow Rate Time Units Code
2	Enum-8	Pressure Units Code
3	Enum-8	Temperature Units Code
4	Enum-8	Velocity Units Code

Command-Specific Response Codes

Code	Class	Description	Explanation
0	Success	No Command-Specific Errors	
1		Undefined	
2	Error	Invalid Selection	One or more of the units code selection(s) is/are invalid.
3-4		Undefined	
5	Error	Too Few Data Bytes Received	
6		Undefined	
7	Error	In Write Protect Mode	
8-31		Undefined	
32	Error	Busy	
33-127		Undefined	

10.11 Command 137 Read Device Units

This command is used to read the device's units. The response message content is different between the gas and liquid meters as indicated below.

Request Data Bytes

Byte	Format	Description	Explanation
None			

Response Data Bytes

Same as for Command 136 Write Device Units (according to the meter type).

Command-Specific Response Codes

Code	Class	Description	Explanation
0	Success	No Command-Specific Errors	
1-31		Undefined	
32	Error	Busy	
33-127		Undefined	

10.12 Command 138 Write Device Variable Range

This command is used to write a specified device variable's upper and lower range values. This command is used to scale graphs, charts, etc. for displaying device variable values on host system (HART® Field Device Specification Guide: Daniel Liquid Ultrasonic Meters) screens.

Request Data Bytes

Byte	Format	Description	Explanation
0	Unsigned-8	Device Variable Selector	Specifies the device variable for which the range values are to be set. Note that the pressure and/or temperature device variable range values cannot be written if the value(s) is/are input live via HART since the range values are determined by reading the transmitter primary variable range.
1	Enum-8	Units Code (see Section 11)	Specifies the units for the specified range values. This units code is only pertinent for interpreting this command's data values and for the units of the response's data values. It does not update any units-related data points.
2-5	Float	Upper Range Value	
6-9	Float	Lower Range Value	

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Selector
1	Enum-8	Range Values Units Code (see Section 11)
2-5	Float	Upper Range Value
6-9	Float	Lower Range Value

Command-Specific Response Codes

Code	Class	Description	Explanation
0	Success	No Command-Specific Errors	
1		Undefined	
2	Error	Invalid Selection	Units code selection invalid.
3-4		Undefined	
5	Error	Too Few Data Bytes Received	

Code	Class	Description	Explanation
6-8		Undefined	
9	Error	Lower Range Value Too High	Lower Range Value was above the Upper Transducer Limit or some other physical device limitation is exceeded.
10	Error	Lower Range Value Too Low	Lower Range Value was below the Lower Transducer Limit or some other physical device limitation is exceeded.
11	Error	Upper Range Value Too High	Upper Range Value was above Upper Transducer Limit.
12	Error	Upper Range Value Too Low	Upper Range Value was below the Lower Transducer Limit.
13-27		Undefined	
28	Error	Invalid Device Variable Index	The requested Device Variable does not exist in this field device or is not supported by the requested command or operation. (This is returned if an invalid Device Variable selection is requested.)
29-31		Undefined	
32	Error	Busy	
33-127		Undefined	

10.13 Command 139 Read Device Variable Range

This command is used to read a specified device variable's upper and lower range values. This command is expected to be used to scale graphs, charts, etc. for displaying device variable values on host system () screens.

Request Data Bytes

Byte	Format	Description	Explanation
0	Unsigned-8	Device Variable Selector	Specifies the device variable for which the range values are to be read.

Response Data Bytes

Same as for Command 138 Write Device Variable Range.

Command-Specific Response Codes

Code	Class	Description	Explanation
0	Success	No Command-Specific Errors	
1-4		Undefined	
5	Error	Too Few Data Bytes Received	
6-27		Undefined	
28	Error	Invalid Device Variable Index	The requested Device Variable does not exist in this field device or is not supported by the requested command or operation. (This is returned if an invalid Device Variable selection is requested.)
29-31		Undefined	
32	Error	Busy	
33-127		Undefined	

10.14 Command 140 Read Detailed Status

This command is used to read detailed status information (i.e., status information that provides detail beyond that of the response status byte and Common Command 48 (Read Additional Device Status see Table 7-2). The purpose of having a separate device-specific command is to limit what is seen and logged by the AMS® Alert Monitor.

Request Data Bytes

Byte	Format	Description	Explanation
None			

Response Data Bytes

Byte	Format	Description
0	Bits	Failed Detail Screen Status Byte 0
1	Bits	Failed Detail Screen Status Byte 1 (for future use)

Failed Detail Screen Status Byte 0

Bit	Description	Related Database Point(s)
7 (msb)		• *Reserved*
6	Indicates communication error with Acquisition board.	• *IsCommErrAcqBd*
5	Indicates electronics voltage out-of-range.	• *IsElecVoltOutOfRange*
4	Indicates memory error (acknowledged by writing to FALSE).	• *Reserved*
3	Indicates the watchdog performed a meter warm-start.	• *WatchDogReset*
2	Indicates unknown Acquisition Board revision - firmware upgrade is required.	• *IsUnkAcqBdRev*
1		
0 (lsb)		

<table>
<tr><th>Byte</th><th>Format</th><th>Description</th></tr>
<tr><td>2</td><td>Bits</td><td>Maintenance Detail Screen Status Byte 0
<table>
<tr><th>Bit</th><th>Description</th><th>Related Database Point(s)</th></tr>
<tr><td>7 (msb)</td><td>Noise energy exceeded maximum limit (chord A).</td><td>• DidExceedMaxNoiseA†</td></tr>
<tr><td>6</td><td>Signal-to-noise ratio below minimum threshold (chord A).</td><td>• IsSNRTooLowA†</td></tr>
<tr><td>5</td><td>Measurement quality check failed (chord A).</td><td>• DidTmDevChkFailA†</td></tr>
<tr><td>4</td><td>Acquisition mode sound speed out of (min, max) range (chord A).</td><td>• IsAcqSndSpdRangeErrA†</td></tr>
<tr><td>3</td><td>Delta time measurement error (chord A).</td><td>• DidDltTmChkFailA†</td></tr>
<tr><td>2</td><td>Signal quality below minimum threshold (chord A).</td><td>• IsSigQltyBadA†</td></tr>
<tr><td>1</td><td>Sound speed out of range error (Measurement mode, chord A).</td><td>• IsMeasSndSpdRangeA†</td></tr>
<tr><td>0 (lsb)</td><td></td><td></td></tr>
</table></td></tr>
<tr><td>3</td><td>Bits</td><td>Maintenance Detail Screen Status Byte 1
<table>
<tr><th>Bit</th><th>Description</th><th>Related Database Point(s)</th></tr>
<tr><td>7 (msb)</td><td>Chord A detection error.</td><td>• IsDetectionErrA†</td></tr>
<tr><td>6</td><td>Signal discarded due to distortion (chord A).</td><td>• IsSigDistortedA†</td></tr>
<tr><td>5</td><td></td><td></td></tr>
<tr><td>4</td><td></td><td></td></tr>
<tr><td>3</td><td></td><td></td></tr>
<tr><td>2</td><td></td><td></td></tr>
<tr><td>1</td><td></td><td></td></tr>
<tr><td>0 (lsb)</td><td></td><td></td></tr>
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<table>
<tr><th>Byte</th><th>Format</th><th>Description</th></tr>
<tr><td>4</td><td>Bits</td><td>Maintenance Detail Screen Status Byte 2
<table>
<tr><th>Bit</th><th>Description</th><th>Related Database Point(s)</th></tr>
<tr><td>7 (msb)</td><td>Noise energy exceeded maximum limit (chord B).</td><td>• DidExceedMaxNoiseB†</td></tr>
<tr><td>6</td><td>Signal-to-noise ratio below minimum threshold (chord B).</td><td>• IsSNRTooLowB†</td></tr>
<tr><td>5</td><td>Measurement quality check failed (chord B).</td><td>• DidTmDevChkFailB†</td></tr>
<tr><td>4</td><td>Acquisition mode sound speed out of (min, max) range (chord B).</td><td>• IsAcqSndSpdRangeErrB†</td></tr>
<tr><td>3</td><td>Delta time measurement error (chord B).</td><td>• DidDltTmChkFailB†</td></tr>
<tr><td>2</td><td>Signal quality below minimum threshold (chord B).</td><td>• IsSigQltyBadB†</td></tr>
<tr><td>1</td><td>Sound speed out of range error (Measurement mode, chord B).</td><td>• IsMeasSndSpdRangeB†</td></tr>
<tr><td>0 (lsb)</td><td></td><td></td></tr>
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<tr><td>5</td><td>Bits</td><td>Maintenance Detail Screen Status Byte 3
<table>
<tr><th>Bit</th><th>Description</th><th>Related Database Point(s)</th></tr>
<tr><td>7 (msb)</td><td>Chord B detection error.</td><td>• IsDetectionErrB†</td></tr>
<tr><td>6</td><td>Signal discarded due to distortion (chord B).</td><td>• IsSigDistortedB†</td></tr>
<tr><td>5</td><td></td><td></td></tr>
<tr><td>4</td><td></td><td></td></tr>
<tr><td>3</td><td></td><td></td></tr>
<tr><td>2</td><td></td><td></td></tr>
<tr><td>1</td><td></td><td></td></tr>
<tr><td>0 (lsb)</td><td></td><td></td></tr>
</table></td></tr>
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<tr><th>Byte</th><th>Format</th><th>Description</th></tr>
<tr><td>6</td><td>Bits</td><td>Maintenance Detail Screen Status Byte 4
<table>
<tr><th>Bit</th><th>Description</th><th>Related Database Point(s)</th></tr>
<tr><td>7 (msb)</td><td>Noise energy exceeded maximum limit (chord C).</td><td>• DidExceedMaxNoiseC†</td></tr>
<tr><td>6</td><td>Signal-to-noise ratio below minimum threshold (chord C).</td><td>• IsSNRTooLowC†</td></tr>
<tr><td>5</td><td>Measurement quality check failed (chord C).</td><td>• DidTmDevChkFailC†</td></tr>
<tr><td>4</td><td>Acquisition mode sound speed out of (min, max) range (chord C).</td><td>• IsAcqSndSpdRangeErrC†</td></tr>
<tr><td>3</td><td>Delta time measurement error (chord C).</td><td>• DidDltTmChkFailC†</td></tr>
<tr><td>2</td><td>Signal quality below minimum threshold (chord C).</td><td>• IsSigQltyBadC†</td></tr>
<tr><td>1</td><td>Sound speed out of range error (Measurement mode, chord C).</td><td>• IsMeasSndSpdRangeC†</td></tr>
<tr><td>0 (lsb)</td><td></td><td></td></tr>
</table></td></tr>
<tr><td>7</td><td>Bits</td><td>Maintenance Detail Screen Status Byte 5
<table>
<tr><th>Bit</th><th>Description</th><th>Related Database Point(s)</th></tr>
<tr><td>7 (msb)</td><td>Chord C detection error.</td><td>• IsDetectionErrC†</td></tr>
<tr><td>6</td><td>Signal discarded due to distortion (chord C).</td><td>• IsSigDistortedC†</td></tr>
<tr><td>5</td><td></td><td></td></tr>
<tr><td>4</td><td></td><td></td></tr>
<tr><td>3</td><td></td><td></td></tr>
<tr><td>2</td><td></td><td></td></tr>
<tr><td>1</td><td></td><td></td></tr>
<tr><td>0 (lsb)</td><td></td><td></td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Byte</th><th>Format</th><th>Description</th></tr>
<tr><td>8</td><td>Bits</td><td>Maintenance Detail Screen Status Byte 6
<table>
<tr><th>Bit</th><th>Description</th><th>Related Database Point(s)</th></tr>
<tr><td>7 (msb)</td><td>Noise energy exceeded maximum limit (chord D).</td><td>• DidExceedMaxNoiseD†</td></tr>
<tr><td>6</td><td>Signal-to-noise ratio below minimum threshold (chord D)</td><td>• IsSNRTooLowD†</td></tr>
<tr><td>5</td><td>Measurement quality check failed (chord D).</td><td>• DidTmDevChkFailD†</td></tr>
<tr><td>4</td><td>Acquisition mode sound speed out of (min, max) range (chord D).</td><td>• IsAcqSndSpdRangeErrD†</td></tr>
<tr><td>3</td><td>Delta time measurement error (chord D).</td><td>• DidDltTmChkFailD†</td></tr>
<tr><td>2</td><td>Signal quality below minimum threshold (chord D).</td><td>• IsSigQltyBadD†</td></tr>
<tr><td>1</td><td>Sound speed out of range error (Measurement mode, chord D).</td><td>• IsMeasSndSpdRangeD†</td></tr>
<tr><td>0 (lsb)</td><td></td><td>•</td></tr>
</table></td></tr>
<tr><td>9</td><td>Bits</td><td>Maintenance Detail Screen Status Byte 7
<table>
<tr><th>Bit</th><th>Description</th><th>Related Database Point(s)</th></tr>
<tr><td>7 (msb)</td><td>Chord D detection error.</td><td>• IsDetectionErrD†</td></tr>
<tr><td>6</td><td>Signal discarded due to distortion (chord D).</td><td>• IsSigDistortedD†</td></tr>
<tr><td>5</td><td></td><td></td></tr>
<tr><td>4</td><td></td><td></td></tr>
<tr><td>3</td><td></td><td></td></tr>
<tr><td>2</td><td></td><td></td></tr>
<tr><td>1</td><td></td><td></td></tr>
<tr><td>0 (lsb)</td><td></td><td></td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Byte</th><th>Format</th><th>Description</th></tr>
<tr><td>10</td><td>Bits</td><td>Maintenance Detail Screen Status Byte 8
<table>
<tr><th>Bit</th><th>Description</th><th>Related Database Point(s)</th></tr>
<tr><td>7 (msb)</td><td>Analog Output 2 test enable.</td><td>• IsAO2EnableTest</td></tr>
<tr><td>6</td><td>Analog Output 2 fixed current value (for trim).</td><td>• AO2IsFixed</td></tr>
<tr><td>5</td><td></td><td></td></tr>
<tr><td>4</td><td></td><td></td></tr>
<tr><td>3</td><td></td><td></td></tr>
<tr><td>2</td><td></td><td></td></tr>
<tr><td>1</td><td></td><td></td></tr>
<tr><td>0 (lsb)</td><td></td><td></td></tr>
</table></td></tr>
<tr><td>11</td><td>Bits</td><td>Maintenance Detail Screen Status Byte 9
<table>
<tr><th>Bit</th><th>Description</th><th>Related Database Point(s)</th></tr>
<tr><td>7 (msb)</td><td></td><td>Reserved</td></tr>
<tr><td>6</td><td></td><td>Reserved</td></tr>
<tr><td>5</td><td></td><td>Reserved</td></tr>
<tr><td>4</td><td></td><td>Reserved</td></tr>
<tr><td>3</td><td></td><td></td></tr>
<tr><td>2</td><td></td><td></td></tr>
<tr><td>1</td><td></td><td></td></tr>
<tr><td>0 (lsb)</td><td></td><td></td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Byte</th><th>Format</th><th>Description</th></tr>
<tr><td>12</td><td>Bits</td><td>Advisory Detail Screen Status Byte 0
<table>
<tr><th>Bit</th><th>Description</th><th>Related Database Point(s)</th></tr>
<tr><td>7 (msb)</td><td>Indicates Flow-condition volumetric flow rate validity.</td><td>• QFlowValidity (inverted)</td></tr>
<tr><td>6</td><td></td><td>Reserved</td></tr>
<tr><td>5</td><td></td><td>Reserved</td></tr>
<tr><td>4</td><td></td><td>Reserved</td></tr>
<tr><td>3</td><td></td><td>Reserved</td></tr>
<tr><td>2</td><td></td><td>Reserved</td></tr>
<tr><td>1</td><td></td><td></td></tr>
<tr><td>0 (lsb)</td><td></td><td></td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Byte</th><th>Format</th><th>Description</th></tr>
<tr><td>13</td><td>Bits</td><td>Advisory Detail Screen Status Byte 1
<table>
<tr><th>Bit</th><th>Description</th><th>Related Database Point(s)</th></tr>
<tr><td>7 (msb)</td><td>Indicates HART pressure transmitter device malfunction</td><td>• PressHARTIsDevMalfunction</td></tr>
<tr><td>6</td><td>Indicates HART pressure transmitter configuration changed.</td><td>• PressHARTIsConfigChanged</td></tr>
<tr><td>5</td><td>Indicates HART pressure transmitter cold started.</td><td>• PressHARTDidColdStart</td></tr>
<tr><td>4</td><td>Indicates HART pressure transmitter has more status available</td><td>• PressHARTIsMoreStatusAvailable</td></tr>
<tr><td>3</td><td>Indicates HART pressure transmitter loop current is fixed.</td><td>• PressHARTIsLoopCurrentFixed</td></tr>
<tr><td>2</td><td>Indicates HART pressure transmitter loop current is saturated.</td><td>• PressHARTIsLoopCurrentSaturated</td></tr>
<tr><td>1</td><td>Indicates HART pressure transmitter non-Primary Variable is out of limits.</td><td>• PressHARTIsNonPVOutOfLimits</td></tr>
<tr><td>0 (lsb)</td><td>Indicates HART pressure transmitter Primary Variable is out of its limits</td><td>• PressHARTIsPVOutOfLimits</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Byte</th><th>Format</th><th>Description</th></tr>
<tr><td>14</td><td>Bits</td><td>Advisory Detail Screen Status Byte 2
<table>
<tr><th>Bit</th><th>Description</th><th>Related Database Point(s)</th></tr>
<tr><td>7 (msb)</td><td>Temperature device malfunction</td><td>• TempHARTIsDevMalfunction</td></tr>
<tr><td>6</td><td>Temperature config changed</td><td>• TempHARTIsConfigChanged</td></tr>
<tr><td>5</td><td>Temperature cold started</td><td>• TempHARTDidColdStart</td></tr>
<tr><td>4</td><td>Temperature more status</td><td>• TempHARTIsMoreStatusAvailable</td></tr>
<tr><td>3</td><td>Temperature loop current fixed</td><td>• TempHARTIsLoopCurrentFixed</td></tr>
<tr><td>2</td><td>Temperature loop current saturated</td><td>• TempHARTIsLoopCurrentSaturated</td></tr>
<tr><td>1</td><td>Temperature non-PV out of limits</td><td>• TempHARTIsNonPVOutOfLimits</td></tr>
<tr><td>0 (lsb)</td><td>Temperature PV out of limits</td><td>• TempHARTIsPVOutOfLimits</td></tr>
</table></td></tr>
<tr><td>15</td><td>Bits</td><td>Advisory Detail Screen Status Byte 3
<table>
<tr><th>Bit</th><th>Description</th><th>Related Database Point(s)</th></tr>
<tr><td>7 (msb)</td><td>Indicates HART Pressure transmitter communication error.</td><td>• PressureHARTIsCommErr</td></tr>
<tr><td>6</td><td>Indicates HART Temperature transmitter communication error.</td><td>• TempHARTIsCommErr</td></tr>
<tr><td>5</td><td>Frequency 1 pair validity indicator.</td><td>• Freq2DataValidity (inverted)</td></tr>
<tr><td>4</td><td>Frequency 2 pair validity indicator.</td><td>• Freq1DataValidity (inverted)</td></tr>
<tr><td>3</td><td>Analog output 2 validity</td><td>• AO2DataValidity (inverted)</td></tr>
<tr><td>2</td><td>Analog output 1 validity</td><td>• AO1DataValidity (inverted)</td></tr>
<tr><td>1</td><td>Analog Output 1 test enable.</td><td>• IsAO1EnableTest</td></tr>
<tr><td>0 (lsb)</td><td>Indicates whether AO1 current is fixed or not.</td><td>• AO1IsFixed</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Byte</th><th>Format</th><th>Description</th></tr>
<tr><td>16</td><td>Bits</td><td>Advisory Detail Screen Status Byte 4
<table>
<tr><th>Bit</th><th>Description</th><th>Related Database Point(s)</th></tr>
<tr><td>7 (msb)</td><td>Hourly log full indicator.</td><td>• IsHourlyLogFull</td></tr>
<tr><td>6</td><td>Daily log full indicator.</td><td>• IsDailyLogFull</td></tr>
<tr><td>5</td><td>Audit log full indicator.</td><td>• IsAuditLogFull</td></tr>
<tr><td>4</td><td>Alarm log full indicator.</td><td>• IsAlarmLogFull</td></tr>
<tr><td>3</td><td>System log full indicator.</td><td>• IsSystemLogFull</td></tr>
<tr><td>2</td><td>HART (via AO2) Secondary Variable validity indicator.</td><td>• HARTAO2SVValidity (inverted)</td></tr>
<tr><td>1</td><td>HART (via AO2) Tertiary Variable validity indicator.</td><td>• HARTAO2TVValidity (inverted)</td></tr>
<tr><td>0 (lsb)</td><td>HART (viaAO2) Quaternary Variable validity indicator.</td><td>• HARTAO2QVValidity(inverted)</td></tr>
</table></td></tr>
<tr><td>17</td><td>Bits</td><td>Advisory Detail Screen Status Byte 5
<table>
<tr><th>Bit</th><th>Description</th><th>Related Database Point(s)</th></tr>
<tr><td>7 (msb)</td><td>Velocity above meter maximum velocity limit</td><td>• IsMeterVelAboveMaxLmt</td></tr>
<tr><td>6</td><td></td><td>Reserved</td></tr>
<tr><td>5</td><td>Flow-condition pressure out-of-limits indicator.</td><td>• FlowPressureIsOutOfLimits</td></tr>
<tr><td>4</td><td>Flow-condition temperature out-of-limits indicator.</td><td>• FlowTemperatureIsOutOfLimits</td></tr>
<tr><td>3</td><td>HART Command 33 Slot 0 validity indicator.</td><td>• HARTAO2Slot0Validity (inverted)</td></tr>
<tr><td>2</td><td>HART Command 33 Slot 1 validity indicator.</td><td>• HARTAO2Slot1Validity (inverted)</td></tr>
<tr><td>1</td><td>HART Command 33 Slot 2 validity indicator.</td><td>• HARTAO2Slot2Validity (inverted)</td></tr>
<tr><td>0 (lsb)</td><td>HART Command 33 Slot 3 validity indicator.</td><td>• HARTAO2Slot3Validity (inverted)</td></tr>
</table></td></tr>
<tr><td colspan="3">† These database points are only indicated if the corresponding chord is hard failed (i.e., if IsHardFailedX is TRUE where X is the corresponding chord). Thus, if the corresponding chord is not hard failed (i.e., if IsHardFailedX is FALSE), then the chord's related detail status bits shall all be zero regardless of the associated database point's value. For example, if IsHardFailedA is FALSE and DidExceedMaxNoiseA is TRUE, then byte 2 bit 0 is indicated as 0 (as are all byte 2 bits) since the chord is not hard failed.</td></tr>
</table>

Command-Specific Response Codes

Code	Class	Description	Explanation
0	Success	No Command-Specific Errors	
1-31		Undefined	
32	Error	Busy	
33-127		Undefined	

10.15 Command 141 Acknowledge Alarm

This command is used to acknowledge (clear/reset) an acknowledgeable alarm. The request includes an enumeration to specify which alarm to acknowledge where the enumeration is as listed in the table below:

Enumeration	Alarm
0	*Reserved*
1	*Reserved*
2	*WatchDogReset*
3	*DidCnfgChksumChg*
4	*DidColdStart*
5	*DidPowerFail*
6	Reserved
7	Reserved
8	Reserved
9	Reserved
10	Reserved

Enumeration	Alarm
11	Reserved
12	IsReverseFlowDetectedLatched
13	Reserved
14	IsCommErrAcqBdLatched
15	IsMeterVelAboveMaxLmtLatched
16	TemperatureInvalidLatched
17	PressureInvalidLatched
18	IsAcqModeLatched
19	IsTooFewOperChordsLatched
20	Reserved
21	Reserved

The acknowledgeable alarm DidCnfgChksumChg can also be acknowledged via Common Command 38. The DidPowerFail acknowledgeable alarm is automatically reset according to the HART Device Status requirements. The meter shall also reset any DidColdStart alarm when the DidPowerFail alarm is automatically reset. However, this "automatic reset" would only apply to HART (for the Field Device Status byte) and would not clear the database point(s). Acknowledging DidColdStart or DidPowerFail via this command shall clear the specified database point.

Request Data Bytes

Byte	Format	Description	Explanation
0	Enum-8	Alarm identifier	Selects the alarm to be acknowledged.

Response Data Bytes

Byte	Format	Description
0	Enum-8	Alarm identifier

Command-Specific Response Codes

Code	Class	Description	Explanation
0	Success	No Command-Specific Errors	
1		Undefined	
2	Error	Invalid Selection	The selected alarm to acknowledge does not exist.
3-4		Undefined	
5	Error	Too Few Data Bytes Received	
6-31		Undefined	
32	Error	Busy	
33-127		Undefined	

10.16 Command 142 Write Digital Input Configuration

This command is used to configure the meter's specified digital input configuration. The meter provides a single digital input that can be used to gate a calibration pass (such as for synchronizing the meter's calibration with prover switches).

Request Data Bytes

Byte	Format	Description	Explanation
0	Enum-8	Digital input selector	• *0=general purpose* • *1=used for calibration).* *Used to set DI1IsInvPolarity.*
1	Enum-8	General purpose polarity	• *0=normal* • *1=inverted* Applicable when the digital input is used as a general purpose input. Specifies the digital input polarity for interpreting the input value. Used to set *IsDI1UsedForCal.*
2	Enum-8	Calibration input polarity	• *0=active high* • *1=active low* Applicable when the digital input is used for calibration. Specifies the digital input polarity for starting/stopping calibration. Used to set *IsDI1ForCalActiveLow.*
3	Enum-8	Calibrating gating type	• *0=edge gated* • *1=state gated* Applicable when the digital input is used for calibration. Specifies the digital input polarity for starting/stopping calibration. Used to set *IsDI1ForCalStateGated.*

Response Data Bytes

Byte	Format	Description
0	Enum-8	Digital input usage selector (0=general purpose, 1=used for calibration)
1	Enum-8	(Bit 2) General purpose polarity (0=normal, 1=inverted)
2	Enum-8	(Bit 1) Calibration input polarity (0=active high, 1=active low)
3	Enum-8	(Least Significant Bit, Bit 0) Calibrating gating type (0=edge gated, 1=state gated)

Command-Specific Response Codes

Code	Class	Description	Explanation
0	Success	No Command-Specific Errors	
1		Undefined	
2	Error	Invalid Selection	Input usage selector, general purpose polarity, calibration input polarity or gating type selection invalid.
3-4		Undefined	
5	Error	Too Few Data Bytes Received	
6		Undefined	
7	Error	In Write Protect Mode	
8-31		Undefined	
32	Error	Busy	
33-127		Undefined	

10.17 Command 143 Read Digital Input Configuration

This command is used to read the meter's specified digital input configuration. The meter provides a single digital input that can be used to gate a calibration pass (such as for synchronizing the meter's calibration with prover switches).

Request Data Bytes

Byte	Format	Description	Explanation
None			

Response Data Bytes

Same as for Command 136 Write Digital Input Configuration.

Command-Specific Response Codes

Code	Class	Description	Explanation
0	Success	No Command-Specific Errors	
1-31		Undefined	
32	Error	Busy	
33-127		Undefined	

10.18 Command 144 Perform Velocity Zero Calibration

Commands 144 and 145 are used to perform velocity zero calibration on liquid ultrasonic flow meters. Two commands are used to achieve command-query separation (http://en.wikipedia.org/wiki/Command-Query Separation). This simplifies the acquisition of velocity zero calibration status in a HART® host edit display or when used in a DDL method. The engineering units for velocity are pre-configured in the device.

The command's request and response data bytes as well as the command-specific response codes are indicated below (with the functional requirements following associated Command 145):

Request Data Bytes

Byte	Format	Description	Explanation
None			

Response Data Bytes

Byte	Format	Description
0	Enum-8	Zero calibration process status. This should be included in the HART® Field Device Specification Guide: Daniel Liquid Ultrasonic Meters screen so that a DDL post-read method can use status change to 2 to accept/reject proposed zero calibration value.

Code	Description
0	Zero calibration process inactive
1	Zero calibration process in progress
2	Zero calibration process completed successfully
3	Zero calibration process failed due to chord failure during process
4	Zero calibration process failed due to too-large offset
5	Zero calibration process failed due to too-large estimated maximum deviation

1	Unsigned-8	Zero calibration duration in minutes (for initial/default value displayed for user) (*ZeroFlowCalReqDuration*)
2	Unsigned-8	Zero calibration progress % (zero when status is 0) updated every 5 seconds
3	Enum-8	Zero flow velocity Units Code (see Section 11)
4-7	Float	Instantaneous zero flow velocity (*DryCalVel*) (included for display/charting purposes)

8-11	Float	Proposed zero calibration value ("zero flow velocity offset") (only relevant when the zero calibration process status is 2)

Command-Specific Response Codes

Code	Class	Description	Explanation
0	Success	No Command-Specific Errors	
1-31		Undefined	
32	Error	Busy	
33-127		Undefined	

10.19 Command 145 Write Velocity Zero Calibration Control

This command is used to control the velocity zero calibration process on liquid ultrasonic flow meters.

The command's request and response data bytes as well as the command-specific response codes are indicated below (with the functional requirements following):

Request Data Bytes

<table>
<tr><th>Byte</th><th>Format</th><th>Description</th><th>Explanation</th></tr>
<tr><td>0</td><td>Enum-8</td><td>Zero calibration control
<table>
<tr><th>Code</th><th>Description</th></tr>
<tr><td>0</td><td>Exit/abort zero calibration process</td></tr>
<tr><td>1</td><td>Start zero calibration process</td></tr>
<tr><td>2</td><td>Accept proposed zero calibration value and exit process</td></tr>
</table></td><td>Controls the meter's zero calibration process.</td></tr>
<tr><td>1</td><td>Unsigned-8</td><td>Zero calibration duration (minutes)</td><td>This byte is only relevant when the zero calibration control value is 1. This value specifies the zero calibration process duration in minutes within the range [2, 10]. The default is duration is 4 minutes. This sets the ZeroFlowCalReqDuration data point.</td></tr>
</table>

Response Data Bytes

Byte	Format	Description	Explanation
0	Enum-8	Zero calibration control **Code** / **Description** 0 – Exit/abort zero calibration process 1 – Start zero calibration process 2 – Accept proposed zero calibration value and exit process	
1	Unsigned-8	Zero calibration duration (minutes) (ZeroFlowCalReqDuration)	

Command-Specific Response Codes

Code	Class	Description	Explanation
0	Success	No Command-Specific Errors	
1		Undefined	
2	Error	Invalid Selection	The requested zero calibration control value is invalid (outside of its limits) or the specified duration is outside of its limits.
3-4		Undefined	
5	Error	Too Few Data Bytes Received	
6	Error	Device-Specific Command Error	The requested zero calibration control value is inappropriate (such as attempting to accept a zero calibration value after a failed calibration or attempting to start a zero calibration while one is already in progress).
7	Error	In Write Protect Mode	
8-31		Undefined	
32	Error	Busy	
33-127		Undefined	

Velocity Zero Flow Calibration Functional Requirements

The functional requirements for performing zero flow calibration via the Series 100 Plus Board request and response messages listed above are as follows:

1. When the meter is not currently in the zero calibration process, it enters the zero calibration process upon receiving HART® Command 145 with the zero calibration control value of 1. Upon entering the zero calibration process, the zero calibration process status is set to 1 (in progress).
2. The zero calibration process duration (in minutes) is set according to the "Zero calibration duration" value received with the calibration start command (if valid).
3. While in the zero calibration process, once per second the meter reads the uncalibrated and dry-calibrated flow velocities (via the *AvgWtdFlowVel* and *DryCalVel* data points) and the meter's chord status values (via the IsFailedForBatchA…*IsFailedForBatchD* data points).
4. While in the zero calibration process, once per five seconds the meter updates the zero calibration progress which is a percentage of completion based upon the specified duration. A new data point (*ZeroFlowCalProgress*) is created for indicating the progress.
5. The meter exits any calibration process in progress if any chord failure is detected (via the *IsFailedForBatchA…IsFailedForBatchD* data points). In this case, the meter responds to a calibration status read request (via Command 144) with the zero calibration process status value of 3.

6. While the meter is in the zero calibration process prior to the completion of the specified process duration, it responds to an exit/ abort request (via Command 145 control value of 0). In this case, the meter changes the zero calibration process status value to 0 (inactive).
7. While the meter is in the zero calibration process prior to the completion of the specified process duration, it ignores requests to re-start the calibration (via Command 145 control value of 1) and responds with the Device-Specific Command Error Response Code.
8. While the meter is in the zero calibration process prior to the completion of the specified process duration, it responds to all calibration status read requests (via Command 144) with the zero calibration process status value of 1 (zero calibration in progress).
9. While the meter is in the zero calibration process prior to the completion of the specified process duration, it ignores requests to accept the proposed zero calibration value (via Command 145 control value of 2) and responds with the Device-Specific Command Error Response Code.
10. When the zero calibration process reaches the specified process duration, then the meter determines whether the calibration was successful or not as follows:

    (a) If the absolute value of the proposed zero calibration value (calculated as shown below) is greater than 0.02 ft/sec, then the zero calibration failed. In this case, the meter responds to the next calibration process status read request (via Command 144) with a zero calibration process status value of 4.

    The proposed zero calibration value is calculated as follows:

$$ZeroCalibrationValue = -\overline{AvgWtdFlowVel}$$

    where

    $\overline{AvgWtdFlowVel}$ is the average of the average weighted flow velocity values (ft/sec)

(b) If the dry-calibrated flow velocity Estimated Maximum Deviation (calculated as shown below) is greater than 0.002 ft/sec, then the zero calibration failed. In this case, the meter responds to the next calibration process status read request (via Command 144) with a zero calibration process status value of 5.

The dry-calibrated flow velocity Estimated Maximum Deviation is calculated as follows:

$$EstimatedMaximumDeviation_{DryCalVel} = 3 \times \frac{\delta_{DryCalVel}}{\sqrt{N}}$$

where

$^{o}DryCalVel$ is the dry-calibrated flow velocity standard deviation during the process (ft/sec)

N is the number of dry-calibrated flow velocity values taken during the process

(c) Otherwise, the zero calibration completed successfully and the meter responds to the next calibration process status read request (via Command 144) with a zero calibration process status value of 2 and the proposed zero calibration value (in the HART®-configured velocity units).

11. When a zero calibration process ends unsuccessfully (i.e., with a status value of 3, 4, or 5), the meter ignores requests to accept the proposed zero calibration value (via Command 145 control value of 2). In this case, the meter responds with the Device-Specific Command Error Response Code.

12. When a zero calibration process ends unsuccessfully (i.e., with a status value of 3, 4, or 5), the meter continues to respond to zero calibration process status read requests (via Command 144) with the same status response until the calibration is exited/aborted (via Command 145 control value of 0) or re-started (via Command 145 control value of 1).

    (a) In this case, the meter responds to the exit/abort command by setting the status value to 0 (inactive).

    (b) In this case, the meter responds to the start command by setting the status value to 1 (in progress).

13. When the zero calibration process ends successfully, the meter continues to respond to zero calibration process status read requests

(via Command 144) with the successful completion response (status value of 2) until any other following occurs:

(a) The proposed zero calibration value is accepted (via Command 145 control value of 2) - in this case the meter writes the proposed zero calibration value to the FwdA0 and RevA0 data points and set the status value to 0 (inactive).

(b) The proposed zero calibration value is rejected via exiting the process (via Command 145 control value of 0) - the meter discards the proposed zero calibration value and set the status value to 0 (in active).

(c) The proposed zero calibration value is rejected via re-starting the process (via Command 145 control value of 1) - the meter discards the proposed zero calibration value and re-start the process. In this case, the meter sets the status value to 1 (in progress).

14. When the meter is not in the zero calibration process, it responds to requests to exit/abort (via Command 145 control value of 0) with the Device-Specific Command Error Response Code.

15. When the meter is not in the zero calibration process, it responds to requests to accept the proposed zero calibration value (via Command 145 control value of 2) with the Device-Specific Command Error Response Code.

Possible HART Master Perspective

From the user a HART™ master's perspective, the process for performing a zero calibration might be as follows (Note: there is more than one way to implement the process):

- Repeatedly issue Command 144 until the meter responds with a zero calibration process status value of 0 (inactive) or issue Command 145 with zero calibration control value of 0 (abort zero calibration process) to force a zero calibration process status value of 0 (inactive) not equal to 1 (i.e., no zero calibration already in progress). The meter is now ready to start a new zero calibration.
- Issue Command 145 with zero calibration control value of 1 (start zero calibration process) and a calibration duration. The meter will respond with response code 2 if the calibration duration is outside of its limits.
- Repeatedly issue Command 144 until the meter responds with a zero calibration process status value of either 2 (process completed successfully) or 3, 4, or 5 (process failed). If the zero calibration process completed successfully, then the zero calibration value is returned in the previously-configured velocity units.
- After the process completes successfully, issue Command 145 with zero calibration control value of 2 to accept the new zero calibration value (which writes the new value to the *FwdA0* and *RevA0* non-volatile data points) or 0 to abort the zero calibration process (which rejects the zero calibration result).
- If the process completes unsuccessfully, then issue Command 145 with zero calibration control value of 0 (abort zero calibration process) to exit the process or with zero calibration control value of 1 to re-start the process.

10.20 Command 147 Read Miscellaneous Parameters

This command is used to read miscellaneous HART® parameters.

Request Data Bytes

Byte	Format	Description	Explanation
None			

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Polling Address (the least-significant 4 bits of the short frame address)
1	Unsigned-8	Number of preamble bytes to be sent with the response message from the Slave to the Master

Command-Specific Response Codes

Code	Class	Description	Explanation
0	Success	No Command-Specific Errors	
1-31		Undefined	
32	Error	Busy	
33-127		Undefined	

10.21 Command 153 Read Running Averages

This command reads the running average data. The running average reported is a snapshot capture from the latest register point update in the HART slave. Units for turbulence values are percentage. Cross Flow, Symmetry, and Profile do not have units. Swirl Angle is always in degrees. The unit codes for other values in the message can only be the units allowed for that type of variable. Unit code tables used by the meter are specified in Section 11.

Request Data Bytes

Byte	Format	Description	Explanation
None			

Response Data Bytes

Byte	Format	Description	Related Database Points
0-3	Float	Reads the datapoint Running Average Flow Temperature. Used for forward and reverse baseline temperature.	• *RunningAvgFlowTemperature*

Byte	Format	Description	Related Database Points
4-7	Float	Reads the datapoint Average Flow Pressure. Used for forward and reverse baseline pressure.	• *RunningAvgFlowPressure*
8-11	Float	Reads the datapoint Average Turbulence A. Used for forward and reverse baseline turbulence.	• *RunningAvgTurbulenceA*
12-15	Float	Reads the datapoint Average Turbulence B. Used for forward and reverse baseline turbulence.	• *RunningAvgTurbulenceB*
16-19	Float	Reads the datapoint Average Turbulence C. Used for forward and reverse baseline turbulence.	• *RunningAvgTurbulenceC*
20-23	Float	Reads the datapoint Average Turbulence D. Used for forward and reverse baseline turbulence.	• *RunningAvgTurbulenceD*
24-27	Float	Reads the datapoint Running Average Average Flow. Used for forward and reverse baseline average flow.	• *RunningAvgAvgFlow*
28-31	Float	Reads the datapoint Average Cross Flow. Used for forward and reverse baseline cross flow.	• *RunningAvgCrossFlow*
32-35	Float	Reads the datapoint Average Profile Factor. Used for forward and reverse baseline profile factors.	• *RunningAvgProfileFactor*
36-39	Float	Reads the datapoint Average Swirl Angle. Used for forward and reverse baseline swirl angle.	• *RunningAvgSwirlAngle*
40-43	Float	Reads the datapoint Average Symmetry. Used for forward and reverse baseline symmetry.	• *RunningAvgSymmetry*
44-47	Float	Reads the datapoint Average Standard Deviation of Cross Flow.	• *RunningAvgSDevCrossFlow*
48-51	Float	Reads the datapoint Average Standard Deviation of Profile Factor.	• *RunningAvgSDevProfileFactor*
52-55	Float	Reads the datapoint Average Standard Deviation of Symmetry.	• *RunningAvgSDevSymmetry*
56	Enum-8	Reads the datapoint Running average validity.	• *IsRunningAvgValid*

Byte	Format	Description	Related Database Points
57	Enum-8	Sets the forward or reverse flow direction.	FlowDirection • *0= Reverse* • *1= Forward*
58	Enum-8	Units Code for Temperature values	Units for Average Flow Temperature. See Table 11-5.
59	Enum-8	Units Code for Pressure values	Units for Average Flow Pressure. See Table 11-4.
60	Enum-8	Units Code for flow velocity	Units code for Average Flow. See Table 11-6.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-31		Undefined
32	Error	Busy
33-127		Undefined

10.22 Command 154 Read Baselines

This command reads the forward or reverse baseline values depending upon the parameter passed in the command request. The turbulence, profile factor, symmetry, and cross flow units are percentages. Swirl Angle is always in degrees. If *IsAnyBaselineAvail* is FALSE, then this command responds with “command not implemented” error.

Request Data Bytes

Byte	Format	Description	Explanation
0	Enum-8	Forward / Reverse Selection	• *0 = Reverse* • *1 = Forward*

Response Data Bytes

Byte	Format	Description	Related Database Points
0	Enum-8	Forward/Reverse selection	• *0 = Reverse* • *1 = Forward*
1-4	Float	Reads the datapoint Profile Factor (direction depends on request byte 0)	• *FwdBaselineProfileFactor* or *RevBaselineProfileFactor*

Byte	Format	Description	Related Database Points
5-8	Float	Reads the datapoint Flow Pressure (direction depends on request byte 0)	• *FwdBaselineFlowPressure or RevBaselineFlowPressure*
9-12	Float	Reads the datapoint Turbulence A (direction depends on request byte 0)	• *FwdBaselineTurbulenceA or RevBaselineTurbulenceA*
13-16	Float	Reads the datapoint Turbulence B (direction depends on request byte 0)	• *FwdBaselineTurbulenceB or RevBaselineTurbulenceB*
17-20	Float	Reads the datapoint Turbulence C (direction depends on request byte 0)	• *FwdBaselineTurbulenceC or RevBaselineTurbulenceC*
21-24	Float	Reads the datapoint Turbulence D (direction depends on request byte 0)	• *FwdBaselineTurbulenceD* or *RevBaselineTurbulenceD*
25-28	Float	Reads the datapoint Average Flow (direction depends on request byte 0)	• *FwdBaselineAvgFlow or RevBaselineAvgFlow*
29-32	Float	Reads the datapoint Cross Flow (direction depends on request byte 0)	• *FwdBaselineCrossFlow or RevBaselineCrossFlow*
33-36	Float	Reads the datapoint forward or reverse Swirl Angle (direction depends on request byte 0)	• *FwdBaselineSwirlAngle* or *RevBaselineSwirlAngle*
37-40	Float	Reads the datapoint forward or reverse Symmetry (direction depends on request byte 0)	• *FwdBaselineSymmetry or RevBaselineSymmetry*
41-44	Float	Reads the datapoint forward or reverse Temperature (direction depends on request byte 0)	• *FwdBaselineFlowTemperature* or *RevBaselineFlowTemperature*

Byte	Format	Description	Related Database Points
45	Unsigned-8	Reads the datapoint Baseline Not Set Boolean	• *IsFwdBaselineNotSet or IsRevBaselineNotSet*
46	Enum-8	Units Code for Flow Temperature	Units for Flow Temperature. See Table 11-5
47	Enum-8	Units Code for Flow Pressure	Units for Flow Pressure. See Table 11-4
48	Enum-8	Units Code for flow velocity	Units for Average Flow. See Table 11-1

Command-Specific Response Codes

Code	Class	Description	Explanation
0	Success	No Command-Specific Errors	
1		Undefined	
2	Error	Invalid Selection	Invalid value for Forward / Reverse Selection
3-31		Undefined	
32	Error	Busy	
33-127		Undefined	

10.23 Command 155 Write Baselines

Writes forward or reverse baseline values depending upon the first byte in command. **Note:** The date is set by meter if baseline set is successful and the baseline comment will be set to "Set by HART". The **IsFwdBaselineNotSet** and **IsRevBaselineNotSet** Booleans will be cleared if the baseline set was successful. This is to be done in the MarkIII by writing the Booleans for individual points, with the logic handling setting the global baseline not set Boolean. When the firmware is updated, and more datapoints are added, the baseline(s) will be handled correctly. The units for turbulence, profile factor, symmetry, and cross flow units are percentages. Swirl Angle is always in degrees. Turbulences must be between 0 and 100%. Profile factor and average flow must be greater than or equal to 0. If **IsAnyBaselineAvail** is FALSE, then this command responds with “command not implemented” error.

Request Data Bytes

Byte	Format	Description	Explanation
0	Enum-8	Forward / Reverse Selection	• *0 = Reverse* • *1 = Forward*
1-4	Float	Writes the datapoint FwdBaselineProfileFactor or RevBaselineProfileFactor (depends on request byte 0)	• *FwdBaselineProfileFactor or RevBaselineProfileFactor*
5-8	Float	Writes the datapoint FwdBaselineFlowPressure or RevBaselineFlowPressure (depends on request byte 0)	• *FwdBaselineFlowPressure or RevBaselineFlowPressure*
9-12	Float	Writes the datapoint FwdBaselineTurbulenceA or RevBaselineTurbulenceA (depends on request byte 0)	• *FwdBaselineTurbulenceA or RevBaselineTurbulenceA*
13-16	Float	Writes the datapoint FwdBaselineTurbulenceB or RevBaselineTurbulenceB (depends on request byte 0)	• *FwdBaselineTurbulenceB or RevBaselineTurbulenceB*
17-20	Float	Writes the datapoint FwdBaselineTurbulenceC or RevBaselineTurbulenceC (depends on request byte 0)	• *FwdBaselineTurbulenceC or RevBaselineTurbulenceC*
21-24	Float	Writes the datapoint FwdBaselineTurbulenceD or RevBaselineTurbulenceD (depends on request byte 0)	• *FwdBaselineTurbulenceD or RevBaselineTurbulenceD*
25-28	Float	Writes the datapoint FwdBaselineAvgFlow or RevBaselineAvgFlow (depends on request byte 0)	• *FwdBaselineAvgFlow or RevBaselineAvgFlow*
29-32	Float	Writes the datapoint FwdBaselineCrossFlow or RevBaselineCrossFlow (depends on request byte 0)	• *FwdBaselineCrossFlow or RevBaselineCrossFlow*
33-36	Float	Writes the datapoint FwdBaselineSwirlAngle or RevBaselineSwirlAngle (depends on request byte 0)	• *FwdBaselineSwirlAngle or RevBaselineSwirlAngle*
37-40	Float	Writes the datapoint FwdBaselineSymmetry or RevBaselineSymmetry (depends on request byte 0)	• *FwdBaselineSymmetry or RevBaselineSymmetry*
41-44	Float	Writes the datapoint FwdBaselineFlowTemperature or RevBaselineFlowTemperature(depends on request byte 0)	• *FwdBaselineFlowTemperature or RevBaselineFlowTemperature*
45	Enum-8	Units Code for Flow Temperature	Units for Flow Temperature. See Table 11-5.
46	Enum-8	Units Code for Flow Pressure	Units for Flow Pressure. See Table 11-4

Byte	Format	Description	Explanation
47	Enum-8	Units Code for flow velocity	Units for Average Flow. See Table 11-6

Response Data Bytes

Byte	Format	Description	Related Database Points
0	Enum-8	Forward / Reverse Selection	• *0 = Reverse* • *1 = Forward*
1-4	Float	Writes the datapoint Forward or Reverse Baseline Profile Factor (depends on request byte 0)	• *FwdBaselineProfileFactor or RevBaselineProfileFactor*
5-8	Float	Writes the datapoint Forward or Reverse Baseline Flow Pressure (depends on request byte 0)	• *FwdBaselineFlowPressure or RevBaselineFlowPressure*
9-12	Float	Writes the datapoint Forward or Reverse Baseline Turbulence A (depends on request byte 0)	• *FwdBaselineTurbulenceA or RevBaselineTurbulenceA*
13-16	Float	Writes the datapoint Forward or Reverse Baseline Turbulence B (depends on request byte 0)	• *FwdBaselineTurbulenceB or RevBaselineTurbulenceB*
17-20	Float	Writes the datapoint Forward or Reverse Baseline Turbulence C (depends on request byte 0)	• *FwdBaselineTurbulenceC or RevBaselineTurbulenceC*
21-24	Float	Writes the datapoint Forward or Reverse Baseline Turbulence D (depends on request byte 0)	• *FwdBaselineTurbulenceD or RevBaselineTurbulenceD*
25-28	Float	Writes the datapoint Forward or Reverse Baseline Average Flow (depends on request byte 0)	• *FwdBaselineAvgFlow or RevBaselineAvgFlow*
29-32	Float	Writes the datapoint Forward or Reverse Baseline Cross Flow (depends on request byte 0)	• *FwdBaselineCrossFlow or RevBaselineCrossFlow*
33-36	Float	Writes the datapoint Forward or Reverse Baseline Swirl Angle (depends on request byte 0)	• *FwdBaselineSwirlAngle or RevBaselineSwirlAngle*
37-40	Float	Writes the datapoint Forward or Reverse Baseline Symmetry (depends on request byte 0)	• *FwdBaselineSymmetry or RevBaselineSymmetry*
41-44	Float	Writes the datapoint Forward or Reverse Baseline Flow Temperature (depends on request byte 0)	• *FwdBaselineFlowTemperature or RevBaselineFlowTemperature*
45	Enum-8	Units Code for Flow Temperature	Units for Flow Temperature. See Table 11-5
46	Enum-8	Units Code for Flow Pressure	Units for Flow Pressure. See Table 11-4.
47	Enum-8	Units Code for Flow Velocity	Units for Average Flow.See Table 11-6

Command-Specific Response Codes

Code	Class	Description	Explanation
0	Success	No Command-Specific Errors	
1		Undefined	
2	Error	Invalid Selection	Invalid value for Forward / Reverse Selection
3	Error	Passed Parameter Too High	A baseline value was too high
4	Error	Passed Parameter Too Low	A baseline value was too low
5	Error	Too Few Bytes Received	
6		Undefined	
7	Error	In Write Protect Mode	
8-11		Undefined	
12	Error	Invalid Units Code	One or more of the units codes are invalid
13-31		Undefined	
32	Error	Busy	
33-127		Undefined	

10.24 Command 159 Read Meter Chord Data

This command will read meter flow related data (flow velocities, sound velocities and turbulence). The units code values for velocity are specified in Section 11. Turbulence units are always percentage.

Request Data Bytes

Byte	Format	Description	Explanation
None			

Response Data Bytes

Byte	Format	Description	Related Database Points
0-3	Float	Flow Velocity Chord A	• *FlowVelA*
4-7	Float	Flow Velocity Chord B	• *FlowVelB*
8-11	Float	Flow Velocity Chord C	• *FlowVelC*
12-15	Float	Flow Velocity Chord D	• *FlowVelD*
16-19	Float	Sound Velocity Chord A	• *SndVelA*

Byte	Format	Description	Related Database Points
20-23	Float	Sound Velocity Chord B	• *SndVelB*
24-27	Float	Sound Velocity Chord C	• *SndVelC*
28-31	Float	Sound Velocity Chord D	• *SndVelD*
32-35	Float	Turbulence Chord A	• *TurbulenceA*
36-39	Float	Turbulence Chord B	• *TurbulenceB*
40-43	Float	Turbulence Chord C	• *TurbulenceC*
44-47	Float	Turbulence Chord D	• *TurbulenceD*
48	Enum-8	Units Code for velocity	Units Code that applies to all velocity values in this message. See Table 11-6

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-31		Undefined
32	Error	Busy
33-127		Undefined

10.25 Command 160 Read Meter Flow Data

This command reads flow related data (symmetry, cross flow, flow direction, profile factor, and swirl angle) along with sound velocity and the volume related to the reverse flow alarm. The units code for velocity and volume are defined in Section 11. Symmetry, Cross Flow, and Profile Factor are ratios and do not have units. Swirl Angle is always in degrees.

Request Data Bytes

Byte	Format	Description	Explanation
None			

Response Data Bytes

Byte	Format	Description	Related Database Points
0-3	Float	Symmetry	• *Symmetry*
4-7	Float	Cross Flow	• *CrossFlow*
8-11	Float	Profile Factor	• *Profile Factor*
12-15	Float	Swirl Angle	• *SwirlAngle*

Byte	Format	Description	Related Database Points
16-19	Float	Average Flow Velocity	• *AvgFlow*
20-23	Float	Average Sound Velocity	• *AvgSndVel*
24-27	Float	Reverse Flow Volume	• *ReverseFlowVol*
28-31	Float		Reserved
32-35	Float		Reserved
36	Enum-8	Sets the flow direction	FlowDirection • *0= Reverse* • *1= Forward*
37	Enum-8	Units code for velocity	Units code that applies to all velocity values in this message.Table 11-6
38	Enum-8	Units code for volume	Units code for volume values. Table 11-1.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-31		Undefined
32	Error	Busy
33-127		Undefined

10.26 Command 161 Read Path Signal Amplitude Data

This command reads the path Signal Amplitude data. Voltage units codes in Table 11-9.

Request Data Bytes

Byte	Format	Description	Explanation
None			

Response Data Bytes

Byte	Format	Description	Related Database Points
0-3	Float	Signal Amplitude A upstream	• *SignalAmplitudeA1*
4-7	Float	Signal Amplitude A downstream	• *SignalAmplitudeA2*
8-11	Float	Signal Amplitude B upstream	• *SignalAmplitudeB1*
12-15	Float	Signal Amplitude B downstream	• *SignalAmplitudeB2*
16-19	Float	Signal Amplitude C upstream	• *SignalAmplitudeC1*

Byte	Format	Description	Related Database Points
20-23	Float	Signal Amplitude C downstream	• *SignalAmplitudeC2*
24-27	Float	Signal Amplitude D upstream	• *SignalAmplitudeD1*
28-31	Float	Signal Amplitude D downstream	• *SignalAmplitudeD2*
32	Enum-8	Units for amplitude points	A HART Units enum indicating the units for all the amplitude values in this message. See Table 11-9 voltage unit codes.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-31		Undefined
32	Error	Busy
33-127		Undefined

10.27 Command 162 Read Noise Amplitudes

This command reads the path noise amplitudes. Units codes for voltage are specified in Table 11-9.

Request Data Bytes

Byte	Format	Description	Explanation
None			

Response Data Bytes

Byte	Format	Description	Related Database Points
0-3	Float	Noise Amplitude A upstream	• *NoiseAmplitudeA1*
4-7	Float	Noise Amplitude A downstream	• *NoiseAmplitudeA2*
8-11	Float	Noise Amplitude B upstream	• *NoiseAmplitudeB1*
12-15	Float	Noise Amplitude B downstream	• *NoiseAmplitudeB2*
16-19	Float	Noise Amplitude C upstream	• *NoiseAmplitudeC1*
20-23	Float	Noise Amplitude C downstream	• *NoiseAmplitudeC2*
24-27	Float	Noise Amplitude D upstream	• *NoiseAmplitudeD1*
28-31	Float	Noise Amplitude D downstream	• *NoiseAmplitudeD2*

Byte	Format	Description	Related Database Points
32	Enum-8	Units for amplitudes	A HART Units enum indicating the units for all the amplitude values in this message. See Table 11-9 voltage unit codes.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-31		Undefined
32	Error	Busy
33-127		Undefined

10.28 Command 163 Read Path SNR Data

This command reads the SNR (signal-to-noise ratio) values for each path. SNR values are in decibels. Unit codes for decibels are specified in Table 11-8.

Request Data Bytes

Byte	Format	Description	Explanation
None			

Response Data Bytes

Byte	Format	Description	Related Database Points
0-3	Float	Signal Noise Ratio A upstream	• *SNRA1*
4-7	Float	Signal Noise Ratio A downstream	• *SNRA2*
8-11	Float	Signal Noise Ratio B upstream	• *SNRB1*
12-15	Float	Signal Noise Ratio B downstream	• *SNRB2*
16-19	Float	Signal Noise Ratio C upstream	• *SNRC1*
20-23	Float	Signal Noise Ratio C downstream	• *SNRC2*
24-27	Float	Signal Noise Ratio D upstream	• *SNRD1*
28-31	Float	Signal Noise Ratio D downstream	• *SNRD2*
32	Enum-8	Units	HART Unit code for SNR ratio. See Table 11-8 decibel unit codes.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-31		Undefined
32	Error	Busy
33-127		Undefined

10.29 Command 164 Read Path Percent Good

This command reads the percentage of "good" batch firings for all paths for upstream and downstream flow directions. Units are fixed to percentage.

Request Data Bytes

Byte	Format	Description	Explanation
None			

Response Data Bytes

Byte	Format	Description	Related Database Points
0-3	Float	Percent Good Path A upstream	• *PctGoodA1*
4-7	Float	Percent Good Path A downstream	• *PctGoodA2*
8-11	Float	Percent Good Path B upstream	• *PctGoodB1*
12-15	Float	Percent Good Path B downstream	• *PctGoodB2*
16-19	Float	Percent Good Path C upstream	• *PctGoodC1*
20-23	Float	Percent Good Path C downstream	• *PctGoodC2*
24-27	Float	Percent Good Path D upstream	• *PctGoodD1*
28-31	Float	Percent Good Path D downstream	• *PctGoodD2*

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-31		Undefined
32	Error	Busy
33-127		Undefined

10.30 Command 165 Read Path Gains

This command reads all path gain values. The decibel units code is a device specific units code see Table 11-8. **Note:** If the gains in the meter are currently in some other unit than decibels (such as hardware or software gain), the HART® slave must convert the values to decibels.

Request Data Bytes

Byte	Format	Description	Explanation
None			

Response Data Bytes

Byte	Format	Description	
0-3	Float	Gain when transducer A1 (upstream) is receiving a signal	• *GainA1*
4-7	Float	Gain when transducer A2 (down-stream stream) is receiving a signal	• *GainA2*
8-11	Float	Gain when transducer B1 (upstream) is receiving a signal	• *GainB1*
12-15	Float	Gain when transducer B2 (down-stream stream) is receiving a signal	• *GainB2*
16-19	Float	Gain when transducer C1 (upstream) is receiving a signal	• *GainC1*
20-23	Float	Gain when transducer C2 (down-stream stream) is receiving a signal	• *GainC2*
24-27	Float	Gain when transducer D1 (upstream) is receiving a signal	• *GainD1*
28-31	Float	Gain when transducer D2 (down-stream stream) is receiving a signal	• *GainD2*
32	Enum-8	Units	HART Units enum for all gain points read. Must be dB units. See Table 11-8.

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-31		Undefined
32	Error	Busy
33-127		Undefined

10.31 Command 166 - Read Flow Analysis Configuration

This command reads flow analysis configuration data. See Table 11-6 for flow velocity units and Table 11-1 for volume units.

Request Data Bytes

Byte	Format	Description	Explanation
None			

Response Data Bytes

Byte	Format	Description	Related Database Points
0-3	Float	Reads the database point Flow Analysis Low Flow Limit	• *FlowAnalysisLowFlowLmt*
4-7	Float	Reads the database point Flow Analysis High Flow Limit	• *FlowAnalysisHighFlowLmt*
8-11	Float	Reads the database point Reverse Flow Volume Limit	• *ReverseFlowVolLmt*
12-15	Float	Reads the database point Reverse Flow Detection Zero Cut. This value is a flow velocity and has the same units as the other flow velocity values in this message.	• *ReverseFlowDetectionZeroCut*
16	Enum-8	Reads the Units code enum for flow velocity	Units code for all flow velocity values in this message. See Table 11-6.
17	Enum-8	Reads the Units code for volume values	Units code for *ReverseFlowVolLmt*.See Table 11-1
18	Enum-8	Enables reverse flow detection. Reads the database point Reverse Flow Detection Enabled	• *IsReverseFlowDetectionEnabled*
19	Enum-8	Are Baselines Available. If this database point is FALSE, the baselines are not available to be set in the meter (does not apply to this meter type). The DD can use this variable to disable the baseline menus.	• *IsAnyBaselineAvail*

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-31		Undefined
32	Error	Busy
33-127		Undefined

10.32 Command 167 Write Flow Analysis Configuration

This command writes flow analysis related data. See Table 11-1 for flow volume units code and Table 11-6 velocity units codes.

Request Data Bytes

Byte	Format	Description	Explanation
0-3	Float	Writes the database point Flow Analysis Low Flow Limit	• *FlowAnalysisLowFlowLmt*
4-7	Float	Writes the database point Flow Analysis High Flow Limit	• *FlowAnalysisHighFlowLmt*
8-11	Float	Writes the database point Reverse Flow Volume Limit	• *ReverseFlowVolLmt*
12-15	Float	Writes the database point Reverse Flow Detection Zero Cut	• *ReverseFlowDetectionZeroCut*
16	Enum-8	Units code for flow velocity values	Units code for flow velocity values. This unit applies to all flow values including Reverse Flow Limit. This must be a units code that is valid for velocity. See Table 11-6.
17	Enum-8	Units code for volume values	Units code for Reverse Flow Limit. This must be a valid units code for volume. See Table 11-1.
18	Enum-8	Enable for reverse flow detection. Writes the point Reverse Flow Detection Enabled	• *IsReverseFlowDetectionEnabled.*

Response Data Bytes

Byte	Format	Description	Related Database Points
0-3	Float	Flow Analysis Low Flow Limit - Lower flow velocity limit for performing flow analysis diagnostics	• *FlowAnalysisLowFlowLmt*
4-7	Float	Upper flow velocity limit for performing flow analysis diagnostics	• *FlowAnalysisHighFlowLmt*
8-11	Float	Reverse Flow Volume Limit	• *ReverseFlowVolumeLmt*
12-15	Float	Reverse Flow Detection Zero Cut	• *ReverseFlowDetectionZeroCut*
16	Enum-8	Units code for flow velocity values	See Table 11-6 for velocity units.
17	Enum-8	Units code for volume	See Table 11-1 for volume units.
18	Enum-8	Reverse Flow Detection Enabled	• *IsReverseFlowDetectionEnabled*

Command-Specific Response Codes

Code	Class	Description	Explanation
0	Success	No Command-Specific Errors	
1		Undefined	
2	Error	Invalid Selection	Boolean neither 0 or 1
3	Error	Passed Parameter Too High	Alarm limit too high
4	Error	Passed Parameter Too Low	Alarm limit too low (or negative)
5	Error	Too Few Bytes Received	
6		Undefined	
7	Error	In Write Protect Mode	
8-31		Undefined	
12	Error	Invalid Units Code	The units code for velocity or volume is not valid
13-31		Undefined	
32	Error	Busy	
33-127		Undefined	

10.33 Command 168 Read General Meter Information

Reads the General meter information for use in the device information screen.

Request Data Bytes

Byte	Format	Description	Explanation
None			

Response Data Bytes

Byte	Format	Description	Related Database Point
0-1	Unsigned Integer	Reads the database point Device Number	• *DeviceNumber*
2-7	Packed ASCII	Reads a PACKED ASCII string which is just the major version number and the minor version number followed by spaces padded out to 8 characters. This string will not be stored in nvram but shall be created from CPUBdSwIntVer by the HART Slave. The string will be in the format%d.%d (major.minor), numbers only	• *FirmwareVersion*
8-19	Packed ASCII	Reads the database point MeterSerialNumber converted to a PACKED ASCII 16 character string. If serial number is shorter than 16 characters, the number will be padded with spaces, if it is longer than 16 characters, the number will be truncated to 16 characters.	• *MeterSerialNumber*

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1-31		Undefined
32	Error	Busy
33-127		Undefined

10.34 Command 169 Read Flow Totals

This command reads the flow totals. The flow totals will be sent as 4 byte integers rolling over at 999,999,999 so that same mechanism used in Modbus for flow totals can be used. See Table 11-1 for volume units code values.

Request Data Bytes

Byte	Format	Description	Explanation
None			

Response Data Bytes

Byte	Format	Description	Related Database Points
0-3	Unsigned-32	Reads the database point Pos-VolFlow with a maximum limit of 999,999,999	• *PosVolFlow*
4-7	Unsigned-32	Reads the database point NegVolFlow with a maximum limit of 999,999,999.	• *NegVolFlow*
8-11	Unsigned-32	Reads the database point Pos-VolBase with a maximum limit of 999,999,999.	• *PosVolBase*
12-15	Unsigned-32	Reads the database point NegVolBase with a maximum limit of 999,999,999	• *NegVolBase*
16-19	Unsigned-32		Reserved
20 - 23	Unsigned-32		Reserved
24-27	Unsigned-32		Reserved
28-31	Unsigned-32		Reserved
32	Enum-8	Units code for volume	Units code for all volume related values in this message. This must be a valid units code for volume values.See Table 11-1.
33	Enum-8		Reserved
34	Enum-8		Reserved

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors

Code	Class	Description
1-31		Undefined
32	Error	Busy
33-127		Undefined

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MEASUREMENT UNITS TABLES

11. INTRODUCTION

The units tables and conversion factors in this section are used for ultrasonic measurement.

11.1 Volume Units

Table 11-1 Volume Units

Unit Code	Description
40	Gallons
41	Liters
43	Cubic Meters
46	Barrels
*112	Cubic feet

* Shaded areas in the table indicate measurement is not applicable to Daniel Liquid Ultrasonic Meters.

11.2 Time Units (Flow Rate)

Table 11-2 Time Units

Unit Code	Description	Meter Type (L=liquid)
51	(Per) Second	L
50	(Per) Minute	L
52	(Per) Hour	L
53	(Per) Day	L

11.3 Volumetric Flow Rate Engineering Unit Codes

Table 11-3 Flow Rate Units

Unit Code	Description	Meter Type (G=gas, L=liquid)
16	Gallons per minute	L
17	Liters per minute	L
19	Cubic meters per hour	G, L
22	Gallons per second	L
24	Liters per second	L
*26	Cubic feet per second	
*27	Cubic feet per day	
28	Cubic meters per second	G, L
29	Cubic meters per day	G, L
*130	Cubic feet per hour	G
131	Cubic feet per minute	L
132	Barrels per second	L
133	Barrels per minute	L
134	Barrels per hour	L
135	Barrels per day	L
136	Gallons per hour	L
138	Liters per hour	L
235	Gallons per day	L
246	Liters per day	L

* Shaded areas in the table indicate measurement is not applicable to Daniel Liquid Ultrasonic Meters.

11.4 Pressure Units

Table 11-4 Pressure Units

Unit Code	Description
6	Pounds per square inch
11	Pascals
12	Kilopascals
237	Megapascals

11.5 Temperature Unit Codes

Table 11-5 Temperature Units

Unit Code	Description
32	Degrees Celsius
33	Degrees Fahrenheit
35	Kelvin

11.6 Velocity Units

Table 11-6 Velocity Units

Unit Code	Description
20	Feet per second
21	Meters per second

11.7 Unit Conversion

Table 11-7 Conversion Factors per Unit of Measurement

Conversion Factors	Unit of Measurement
(°F-32)x(5/9)–>°C (°C+273.15)–>K	
1	K/°C
5/9	°C/°F
10^{-6}	MPa/Pa
0.006894757	MPa/psi
0.1	MPa/bar
0.101325	MPa/atm
0.000133322	MPa/mmHg
0.3048	m/ft
0.0254	m/in
10^{3}	dm^3/m^3
10^{-6}	m^3/cc (=m^3/cm^3)
$(0.3048)^3$	m^3/ft^3
$(0.0254)^3$	m^3/in^3
3600	s/h
86400	s/day
10^{3}	g/kg
0.45359237	kg/lbm
4.1868	kJ/kcal
1.05505585262	kJ/ BtuIT
10^{-3}	Pa•s/cPoise
1.488	Pa•s/(lb/(ft•s))

11.8 Decibel Units

Table 11-8 Decibel Units

Unit Code	Description
247	Decibels (dB)

11.9 Voltage Units

Table 11-9 Voltage Units

Unit Code	Description
36	Millivolts
38	Volts

11.10 Pressure and Temperature Tables

Flow-Condition Pressure and Temperature

Table 11-10 Flow-Condition Pressure and Temperature Data Source

Input Type (EnablePressureInput or EnableTemperatureInput)	**Data Validity** (PressureValidity or TemperatureValidity)	**Data Source Upon Alarm** (FlowPOrTSrcUponAlarm)	**"In-Use" Data Source** (FlowPressure or FlowTemperature)
Disabled	N/A	N/A	"In-Use" value unchanged
Live	Valid	N/A	Average of live values (*LiveFlowPressure or LiveFlowTemperature*)
	Invalid*	Last good value	"In-Use" value unchanged
		Fixed	Fixed data point (*SpecFlowPressure or SpecFlowTemperature*)
Fixed	Valid	N/A	Fixed data point (*SpecFlowPressure or SpecFlowTemperature*)
	Invalid	Last good value	"In-Use" value unchanged
		Fixed	Fixed data point (*SpecFlowPressure or SpecFlowTemperature*)
*Live input can be invalid due to (a) one or more live values is/are at or outside the alarm limits, or (b) the input is being calibrated.			

Live Pressure

Table 11-11 Data Points for Pressure Inputs

Daniel CUI™ Display Name	**Data Points, Options and Guidelines**
Is pressure gage or absolute?	Data points affected: - **InputPressureUnit** Options: • Gage (FALSE) • Absolute (TRUE)
Atmospheric pressure	Data points affected: - **AtmosphericPress** Options: • Enter a value (KPaa or psia) within the range [30.0, 108.40 KPaa] Guidelines: • This data point is only applicable when the input pressure unit is specified as gage.
Live pressure, Min input	Data points affected: - **MinInputPressure** Options: • Enter the pressure (KPag or psig if gage, KPaa or psia if absolute) that corresponds to a 4 mA input signal. The pressure must be within the range [0, 280e3 KPag or KPaa].
Live pressure, Max input	Data points affected: - **MaxInputPressure** Options: • Enter the pressure (KPag or psig if gage, KPaa or psia if absolute) that corresponds to a 20 mA input signal. The pressure must be within the range [0, 280e3 KPag or KPaa].
Pressure alarm, Low limit	Data points affected: - **LowPressureAlarm** Options: • Enter a value (KPag or psig if gage, KPaa or psia if absolute) within the range [0, 280e3 KPag or KPaa]. An alarm is generated when the pressure is at or below this limit value.
Pressure alarm, High limit	Data points affected: - **HighPressureAlarm** Options: • Enter a value (KPag or psig if gage, KPaa or psia if absolute) within the range [0, 280e3 KPag or KPaa]. An alarm is generated when the pressure is at or above this limit value.

Live Temperature

Table 11-12 Data Points for Temperature Inputs

Daniel CUI™ Display Name	**Data Points, Options and Guidelines**
Live temperature, Min input	Data points affected: - **MinInputTemperature** Options: • Enter the temperature (°C or °F) that corresponds to a 4 mA input signal. The temperature must be within the range [-273.15 °C, 200 °C].
Live temperature, Max input	Data points affected: - **MaxInputTemperature** Options: • Enter the temperature (°C or °F) that corresponds to a 20 mA input signal. The temperature must be within the range [-273.15 °C, 200 °C].
Temperature alarm, Low limit	Data points affected: - **LowTemperatureAlarm** Options: • Enter a value (°C or °F) within the range [-130 °C, 200 °C]. An alarm is generated when the temperature is at or below this limit value.
Temperature alarm, High limit	Data points affected: - **HighTemperatureAlarm** Options: • Enter a value (°C or °F) within the range [-130 °C, 200 °C]. An alarm is generated when the temperature is at or above this limit value.

PERFORMANCE

12. INTRODUCTION

This section discusses the Expansion Board with HART performance capabilities.

12.1 Sampling Rates

Primary temperature sensor	• Live values = 1/sec • Calc. = on average of 5 sec
Internal (cold-junction) sensor sample	1 per second
PV digital value calculation SV digital value calculations	Depends on Configuration • Typical 1 per second • Can be as long as 1 per 5 seconds
Analog output update	Depends on configuration • 250ms • Can be as long as 1 second

The typical update rate of each HART® device and dynamic variable is once per second.

Stack size and Filters are two operational conditions which cause variance in the update rate.

12.2 Power-Up

On power-up, when functioning correctly, the Expansion Board with HART green LED indicators show 3.3 volt and +24 volt power. A red LED for +24V current limit reached indicator.

A pair of TX active and RX active green LED indicators are provided for each serial communication port.

A pair of TX active and RX active green LED indicators are provided for the HART slave communication via Analog Output 2.

All LED indicators are located on the card edge that is visible when the meter electronics enclosure end cap is removed.

12.3 Device Reset

This section describes the effect of Device Reset (Command 42) and any other reset methods. The device **must** respond to Command 42 before executing the Device reset. Command 42 forces the meter to perform a warm start (equivalent to cycling the power to the meter off and then back on).

Typical time to reset

65 seconds

Maximum delay

79 seconds

Mode(s) effected

All modes are effected.

12.4 Self Test

Refer to Section 5.10 in the *Daniel Liquid Ultrasonic Flow Meter Reference, Installation and Operations Manual* (P/N 3-9000-750 for self test details.

http://www2.emersonprocess.com/en-US/brands/daniel/Flow/ultrasonics/Pages/Ultrasonic.aspx

NOTICE

To access the product manual, from the Daniel products page (above link), select the Daniel Model 3804 Liquid Ultrasonic Flow Meter link, click the Documentation tab, expand the Manuals & Guides tab, then select the manual.

12.5 Command Response Delay

Table 12-1 shows the minimum, typical, and maximum delays before the device responds to a HART command. (Timed from end of the stop bit of the Check Byte of the master request (STX), to the beginning of the start bit of the first preamble character of the response (ACK).

The response delay is not command specific, however, the write configuration commands generally require more time.

Table 12-1 Command Response Delay

Minimum	5 ms
Typical	15 ms
Maximum	80 ms

12.6 Busy and Delayed-Response

If the meter cannot respond within the prescribed time, the Busy Response code is returned.

12.7 Long Messages

Largest size of data field used for Commands 132 and 133 is 30 response bytes (including the two status bytes).

12.8 Non-Volatile Memory

Daniel Liquid Ultrasonic Flow Meters use Flash and NVRAM technology for non-volatile memory.

All configuration parameters are held in non-volatile memory until a "write command" is executed. Flash memory (the operating system kernel, the file system, and the firmware) is upgraded via MON2000™. Refer to the *Daniel Liquid Ultrasonic Flow Meter Reference, Installation, and Operations Manual* (P/N 3-9000-750) Section 5.9, Upgrading the Meter Program for detailed instructions: http://www2.emersonprocess.com/en-US/brands/daniel/Flow/ultrasonics/Pages/Ultrasonic.aspx .

12.9 Operating Modes

No alternative operating modes are available for this device.

12.10 Write Protection

Daniel Liquid Ultrasonic Flow Meters have a write protection hardware switch located on the CPU Board (switch S-2 Position 4 open or pushed away from the board to write-protect the meter configuration). Refer to the *Daniel Liquid Ultrasonic Flow Meter Reference, Installation, and Operations Manual* (P/N 3-9000-750) Figure 2-2 for switch details:

http://www2.emersonprocess.com/en-US/brands/daniel/Flow/ultrasonics/Pages/Ultrasonic.aspx

HART® Device-Specific Commands are rejected in write-protect mode (see Section 10 for a detailed list of applicable commands).

12.11 Damping

Damping time for Daniel Liquid Ultrasonic Meters is approximately 1.64 seconds affecting only the PV and the loop current signal.

ANNEX A CAPABILITY CHECKLIST

A.1 DEVICE CAPABILITY CHECKLIST

Below is a brief checklist of the device capabilities.

Table A-1 Capability Checklist

Manufacturer, Model, and Revision	**Daniel Measurement and Control, Inc. HART® Field Device Specification Guide: Daniel Liquid Ultrasonic Meters Rev. 2**
Device type	Sensor
HART protocol revision	Rev. 5.0
Number and type of process connections	2 - Pressure and Temperature
Number and type of host connections	2 - AMS™ and Emerson 375 Communicator
Number of Device Variables	3
Number of Dynamic Variables	4
Mappable Dynamic Variables	4
Number of Common-Practice Commands implemented	13
Number of Device-Specific commands	33
Bytes of additional device status	15 (Command 48)
Alternative operating modes	N/A (HART® Rev 5)
Burst-Mode	No
Capture Device Variable	No
Write-protection	Yes

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ANNEX B DEFAULT CONFIGURATION

B.1 DEFAULT CONFIGURATION

This is a complete list of the default device configuration (parameter values, variable mapping, switch positions) which are factory set, unless user-specified when the device is ordered.

Table B-1 Device Factory Settings Configuration

Parameter	**Default value**
Lower Range Value	See Section 11 HART® Units Tables
Upper Range Value	See Section 11 HART® Units Tables
PV Unit(s)	Uncorrected Flow Rate
Sensor Type	Pressure / Temperature
Number of Wires	3
Damping Time Constant	~1.64
Fault-indication	LED Status Indicators
Write Protection Switch	CPU board S2 position 4 • Open (up position) write protection on • Down (closed position) write protection off
Number of Response Preambles	• 5 minimum • 20 maximum

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ANNEX C DEVICE VARIABLE CALCULATIONS

C.1 INTRODUCTION

This section consists of the calculations used by Daniel Liquid Ultrasonic Flow Meters for the device variables summarized in Section 5.

For HART® communications purposes, the Daniel Liquid Ultrasonic Meter applies the following calculations:

- Uncorrected Flow Rate
- Pressure
- Temperature

All Daniel Liquid Ultrasonic Flow Meter Calculations are discussed in Appendix B of the *Daniel Series 3800 Liquid Ultrasonic Flow Meter Reference, Installation and Operations Manual* (P/N 3-9000-750). To download this manual from the Daniel web site use the link below.

http://www2.emersonprocess.com/en-US/brands/daniel/Flow/ultrasonics/Pages/Ultrasonic.aspx

NOTICE

To access the product manual, from the Daniel products page (above link), select the Daniel Model 3804 Liquid Ultrasonic Flow Meter link, click the Documentation tab, expand the Manuals & Guides tab, then select the manual.

C.2 UNCORRECTED FLOW RATE

Equation C-1 Flow-Condition Volumetric Flow Rate

$$Q_{Flow} = (Q_{Raw})(ExpCorr_P)(ExpCorr_T)(CorrFctr)$$

where

Q_{Flow} = flow-condition volumetric flow rate (m^3/h) (**QFlow**)

Q_{Raw} = "raw" volumetric flow rate (m^3/h) (**QMeter**)

$ExpCorr_P$ = expansion correction factor due to pressure (dimensionless) (**ExpCorrPressure**)

$ExpCorr_T$ = expansion correction factor due to temperature (dimensionless) (**ExpCorrTemperature**)

$CorrFctr$ = profile-effect correction factor (**CorrectionFactor**)

C.3 PRESSURE

The flow-condition absolute flow pressure is calculated as shown in Equation C-2.

Equation C-2 Flow-Condition Absolute Pressure

$$P_{abs,f} = P_f + P_{Atmosphere} \qquad InputPressureUnit = FALSE(Gage)$$

$$P_{abs,f} = P_f \qquad InputPressureUnit = TRUE(Absolute)$$

where

$P_{abs,f}$ = flow-condition absolute pressure (MPaa) (**AbsFlowPressure**)

P_f = flow-condition pressure (MPa if **InputPressureUnit**=FALSE, MPaa if **InputPressureUnit**=TRUE) (**FlowPressure**)

$P_{Atmosphere}$ = (specified) atmospheric pressure (MPaa) (**AtmosphericPress**)

C.4 TEMPERATURE

The meter is capable of correcting the raw volumetric flow rate for the effect of pipe expansion due to temperature changes. Note that for the temperature-effect expansion correction factor to be calculated, the correction must be enabled (via the **EnableExpCorrTemp** data point) and the flow-condition temperature must be available (i.e., the **EnableTemperatureInput** data point must be set to 'Live'(1) or 'Fixed'(2), see Section 4.1). The temperature-effect calculation is shown in Equation C-3. If the temperature-effect expansion correction factor is *not* calculated, it is set to 1.0.

Equation C-3 Temperature-Effect Expansion Correction

$$ExpCorr_T = 1 + [3 \times \alpha \times (T_f - T_{ref})]$$

where

$ExpCorr_T$ = expansion correction factor due to temperature (dimensionless) (**ExpCorrTemperature**)

α = pipe linear expansion coefficient due to temperature (K^{-1}) (**LinearExpansionCoef**)

T_f = flow-condition temperature (K) (**FlowTemperature**)

T_{ref} = reference temperature for the pipe linear expansion coefficient (K) (**RefTempLinearExpCoef**)

Reynolds Number

Reynolds Number is a dimensionless value that represents the nature of the liquid flow within the pipe. Reynolds Number is calculated as shown in Equation C-4.

Equation C-4 Reynolds Number

$$Re = \left(\frac{4}{\pi}\right)\frac{Q_{Raw}\ \rho_{(P_f,T_f)}}{D_{in}\ \mu}$$

where

Re = Reynolds Number (dimensionless) (**ReynoldsNumber**)

π = geometric constant, pi (dimensionless) (3.14159...)

Q_{Raw} = "raw" volumetric flow rate (m^3/h) (**QMeter**)

$\rho_{(P_f,T_f)}$ = fluid mass density at the flow condition (specified via **SpecRhoMixFlow**) (kg/m3) (**RhoMixFlow**)

D_{in} = pipe inside diameter (m) (**PipeDiam**)

μ = dynamic viscosity (Pa • s) (**Viscosity**)

ANNEX D AMS™ DEVICE OPERATIONS

This section consists of the AMS™ Suite device operations used by HART® Field Device Specification Guide: Daniel Liquid Ultrasonic Meters. For detailed information refer to the AMS™: Intelligent Device Manager.

D.1 OVERVIEW

This section consists of the AMS™ Suite configuration and settings used by HART® Field Device Specification Guide: Daniel Liquid Ultrasonic Meters and assumes the device is connected, power is applied and the device is functioning correctly. Menu selections include *Overview, Configure* and *Service Tools.* Each of the menu choices are detailed in the following sections.

NOTICE

See Section E.2 375 Field Communicator Menu tree for fast key selections.

D.2 OVERVIEW MENU

The AMS™ Suite device *Overview* screen provides the user with a graphical view of the meter's Status, the Primary Purpose Variable, and Shortcut buttons for Device Information, Analog Output 2 Trim and Display Meter K Factors. Other menu selections include *Device Information* and *Alerts.*

Overview > Device Information

The *Device Information* screen consists of the following:

- HART parameters
  - Device ID (CPU serial number)
  - Tag
- Device Parameters
  - Firmware revision
  - Meter serial number
  - Device model number
  - Write protect
  - DD revision, build number

Overview > Alerts

The *Alerts* screen consists of the following:

- Failed - Fix Now
- Maintenance - Fix Soon
- Advisory

NOTICE

Alerts are sorted in the three groups by severity and some alarms remain active "latched" until acknowledged.

Overview > Zero Flow

The *Zero Flow* screen consists of the following:

- Start Zero
  - Zero Calibration Velocity (m/s)
  - Zero Calibration Status
  - Zero Calibration Progress (%)
- Abort Zero
- End Zero

D.3 CONFIGURE MENU

Review or change the default configuration (factory set) for Daniel Gas Ultrasonic Meters using AMS™ Suite Configure menu.

The Configure menu includes:

- Guided Setup
- Manual Setup
- Alert Setup
- Calibrate

Guided Setup

After installation, use these wizards to configure the HART parameter units, meter outputs, and baseline characteristics used to diagnose the meter health at a later time.

The *Guided Setup* screen consists of the following:

- Initial Setup
  - Setup Units
  - Setup Outputs
  - Setup Baseline

Manual Setup Menu

The *Manual Setup* screen consists of the following:

- Device Variables Mapping
- Units
- Analog Output 1 and Analog Output 2 (HART)
- Frequency and Digital Outputs 1 and 2
- Temperature
- Pressure
- Digital Input

Alert Setup

The *Alert Setup* screen consists of the following:

- Flow Analysis Alerts
  - Detect Reverse Flow
  - Set Flow Range Limits
- Baseline Parameters (read-only values)
  - Setup Baseline (after initial installation)
  - Forward or Reverse Baseline Parameters
    - Profile Factor
    - Swirl Angle
    - Symmetry
    - Cross-Flow
    - Turbulence A
    - Turbulence B
    - Turbulence C
    - Turbulence D
    - Average Flow Velocity
    - Temperature
    - Pressure

Calibrate

The *Calibrate* screen consists of the following:

- Analog Output 2 Trim
- Zero Flow

D.4 SERVICE TOOLS MENU

Review or change the default configuration (factory set) for HART® Field Device Specification Guide: Daniel Liquid Ultrasonic Meters using the AMS™ Suite Process variables.

The *Service Tools* screen consists of the following:

- Alerts
- Variables
- Trends

Alerts

See Section D.2.

Variables

The *Variables* screen consists of the following:

- Flow Data
- Path Performance
- Path Signal Quality
- Flow Totals
- All Variables

Trends

The *Trends* screen consists of the following:

- Primary Variable
- Secondary Variable
- Tertiary Variable
- Quaternary Variable

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ANNEX E 375 FIELD COMMUNICATOR MENU TREE

This section consists of the 375 Field Communicator Menu Tree diagrams and Fast Key Sequences (Table E-1) for Daniel Liquid Ultrasonic Flow Meters.

NOTICE

The Menu Tree diagrams and Fast Key sequences are only valid for Revision 1 of the HART® Field Device Specification Guide.

E.1 375 FAST KEY SEQUENCES

The Table below provides Fast Key Sequences for the most common Daniel Liquid Ultrasonic meter configuration parameters when using a 375 Field Communicator.

Table E-1 375 Fast Key Sequences

FUNCTION	FAST KEY INPUT SEQUENCE
Analog Output 1 Content	2,1,3,1
Analog Output 1 Direction	2,1,3,2
Analog Output 1 Lower Range	2,1,3,3
Analog Output 1 Upper Range	2,1,3,4
Analog Output 1 Alarm Action	2,1,3,5
Analog Output 2 Content	2,1,4,1
Analog Output 2 Direction	2,1,4,2
Analog Output 2 Lower Range	2,1,4,3
Analog Output 2 Upper Range	2,1,4,4
Analog Output 2 Alarm Action	2,1,4,5
Start Analog Output Trim	3,4,1,1
Calibrate Zero Flow	3,4,2
Calibrate Zero Flow Velocity	3,4,2,1 (read only)

Table E-1 375 Fast Key Sequences

Calibrate Zero Flow Status	3,4,2,2 (read only)
Calibrate Zero Flow Progress	3,4,2,3 (read only)
Calibrate Start Zero Flow	3,4,2,4
Calibrate Abort Zero Flow	3,4,2,5
Calibrate End Zero Flow	3,4,2,6
Device Variable Mapping	2,1,1
Device Variable Mapping PV	2,1,1,1
Device Variable Mapping SV	2,1,1,2
Device Variable Mapping TV	2,1,1,3
Device Variable Mapping QV	2,1,1,4
Digital Input	2,1,9
Digital Input General Polarity	2,1,9,1
Digital Input Calibration Polarity	2,1,9,2
Digital Input Calibration Gating	2,1,9,3
Digital Output 1	2,1,5,2
Digital Output 1 CH A Content	2,1,5,2,1
Digital Output 1 CH A Polarity	2,1,5,2,2
Digital Output 1 CH B Content	2,1,5,2,3
Digital Output 1 CH B Polarity	2,1,5,2,4
Digital Output 2	2,1,6,2
Digital Output 2 CH A Content	2,1,6,2,1
Digital Output 2 CH A Polarity	2,1,6,2,2
Digital Output 2 CH B Content	2,1,6,2,3
Digital Output 2 CH B Polarity	2,1,6,2,4
(Flow) Pressure	2,1,8
(Flow) Pressure Source	2,1,8,1
(Flow) Pressure Fixed	2,1,8,2
(Flow) Pressure Alarm Selection	2,1,8,3
(Flow) Temperature	2,1,7
(Flow) Temperature Source	2,1,7,1
(Flow) Temperature Fixed	2,1,7,2

Table E-1 375 Fast Key Sequences

(Flow) Temperature Alarm Selection	2,1,7,3
Frequency & Digital 1	2,1,5
Frequency Output 1	2,1,5,1
Frequency Output 1 Content	2,1,5,1,1
Frequency Output 1 Direction	2,1,5,1,2
Frequency Output 1 B Zeroed on Error	2,1,5,1,3
Frequency Output 1 B Phase	2,1,5,1,4
Frequency Output 1 Max Frequency	2,1,5,1,5
Frequency Output 1 Lower Range	2,1,5,1,6
Frequency Output 1 Upper Range	2,1,5,1,7
Frequency Output 1 K-Factor	2,1,5,1,8
Frequency & Digital 2	2,1,6
Frequency Output 2	2,1,6,1
Frequency Output 2 Content	2,1,6,1,1
Frequency Output 2 Direction	2,1,6,1,2
Frequency Output 2 B Zeroed on Error	2,1,6,1,3
Frequency Output 2 B Phase	2,1,6,1,4
Frequency Output 2 Max Frequency	2,1,6,1,5
Frequency Output 2 Lower Range	2,1,6,1,6
Frequency Output 2 Upper Range	2,1,6,1,7
Frequency Output 2 K-Factor	2,1,6,1,8

E.2 375 FIELD COMMUNICATOR MENU TREE

The 375/475 Field Communicator provides real-time HART® communications with Daniel 3800 Series Liquid Ultrasonic Flow Meters.

The following figures show details of the 375 Handheld Communicator Menu Tree.

- *Diagram Page 1 - Liquid USM Series Root Menu; Overview, Configure>Manual Setup*
- *Diagram Page 2 - Configure>Manual Setup (continued) and Alerts Setup*
- *Diagram Page 3 - Service Tools>Alerts and Variables*
- *Diagram Page 4 - Service Tools>Variables (continued), Service Tools>Trends, and Service Tools>Maintenance*

Liquid USM Root Menu

1. Overview
2. Configure
3. Service Tools

Overview Menu

1. Device Status: *Good, Failed, Maintenance, or Advisory*
2. Comm Status: *Polled*
3. Uncorr Volume Rate — Value UOM
4. Display K-Factors
5. Zero Calibration
6. Device Information

Device Status Menu

1. Refresh Alerts
2. No Active Alerts*
3. List F: <Alert Label>**
4. List M: <Alert Label>***
5. List A: <Alert Label>****

Note
* Displayed when No Active Alert is present
** Displayed when Active Alert with category *'Failed'* is present
*** Displayed when Active Alert with category *'Maintenance'* is present
****Displayed when Active Alert with category *'Advisory'* is present

Device Information

1. Identification
2. Revisions
3. Alarm Type and Security

Device Identification

1. Tag	Value
2. Model Number	Value
3. Meter Serial Number	Value
4. CPU Serial Number	Value
5. Date	Value
6. Descriptor	Value
7. Message	Value

Zero Calibration

1. Velocity	Value UOM
2. Status	Value
3. Progress	Value %
4. Start	
5. Abort	
6. End	

Revisions

1. Universal	Value
2. Field Device	Value
3. Hardware	Value
4. Software	Value
5. Firmware	Value
6. DD	Value
7. DD Build	Value

Alarm Type and Security

1. AO1 Alarm Action	Value
2. AO2 Alarm Action	Value
3. Write Protect Status	Value

Configure Menu

1. Manual Setup
2. Alert Setup

Manual Setup

1. Device Variables Mapping
2. Units
3. Analog Output 1
4. Analog Output 2 (HART)
5. Frequency & Digital output 1
6. Frequency & Digital output 2
7. Temperature
8. Pressure
9. Digital Input

See Sheet 2

Device Variables Mapping

1. Primary Variable	Value
2. Secondary Variable	Value
3. Third Variable	Value
4. Fourth Variable	Value

Units

1. Volume Units	Value
2. Flow Rate Time Units	Value
3. Velocity Units	Value
4. Pressure Units	Value
5. Temperature Units	Value

Analog Output 1

1. Content	Value
2. Direction	Value
3. Lower Range	Value UOM
4. Upper Range	Value UOM
5. AO1 Alarm Action	Value

Analog Output 2 (HART)

1. Content (PV)	Value
2. Direction	Value
3. Lower Range	Value UOM
4. Upper Range	Value UOM
5. AO2 Alarm Action	Value
6. HART Parameters	

HART Parameters

1. Tag	Value
2. Date	Value
3. Descriptor	Value
4. Message	Value
5. Final Assembly Num	Value
6. Poll Address	Value
7. Response Preambles	Value

Service Tools

1. Alerts
2. Variables
3. Trends
4. Maintenance

See Sheet 3

Frequency & Digital Output 1

1. Frequency Output 1
2. Digital Output 1

Frequency & Digital Output 2

1. Frequency Output 2
2. Digital Output 2

Frequency Output 1 or Frequency Output 2

1. Content	Value
2. Direction	Value
3. B Phase Zeroed	Value
4. B Phase	Value
5. Maximum Frequency	Value Hz
6. Lower Range	Value UOM
7. Upper Range	Value UOM
8. Display K-Factors	

Digital Output 1 or Digital Output 2

1. Channel A Content	Value
2. Channel A Polarity	Value
3. Channel B Content	Value
4. Channel B Content	Value

Liquid USM Configure Menu (continued)

1. Overview
2. Configure
3. Service Tools

Configure Menu

1. Manual Setup
2. Alert Setup

Manual Setup

1. Device Variables Mapping
2. Units
3. Analog Output 1 (HART)
4. Analog Output 2
5. Frequency & Digital output 1
6. Frequency & Digital output 2
7. Temperature
8. Pressure
9. Digital Input

See Sheet 1

Temperature

1. Temperature Source	Value
2. Fixed Temperature	Value UOM
3. Alarm Selection	Value
4. Lower Range	Value UOM
5. Upper Range	Value UOM
6. Low Limit	Value UOM
7. High Limit	Value UOM

Pressure

1. Pressure Source	Value
2. Fixed Pressure	Value UOM
3. Alarm Selection	Value
4. Lower Range	Value UOM
5. Upper Range	Value UOM
6. Low Limit	Value UOM
7. High Limit	Value UOM
8. Gage or Absolute	Value
9. Atmospheric Press	Value UOM

Digital Input

1. General Polarity	Value
2. Calibration Polarity	Value
3. Calibration Gating	Value

Alert Setup

1. Flow Analysis Alerts

Flow Analysis Alerts

1. Detect Reverse Flow
2. Set Flow Range Limits

Detect Reverse Flow

1. Detect Reverse Flow	Value
2. Enable	
3. Configure	

Configure Reverse Flow Detection

1. Rev Flow Zero Cutoff	Value UOM
2. Rev Flow Vol Limit	Value UOM

Set Flow Range Limits

1. Lower Velocity Lmt	Value UOM
2. Upper Velocity Lmt	Value UOM

1. Alerts
2. Variables
3. Trends
4. Maintenance

Alerts

1. Refresh Alerts
2. No Active Alerts*
3. List F: <Alert Label>**
4. List M: <Alert Label>***
5. List A: <Alert Label>****

Note
* Displayed when No Active Alert is present
** Displayed when Active Alert with category *'Failed'* is present
*** Displayed when Active Alert with category *'Maintenance'* is present
****Displayed when Active Alert with category *'Advisory'* is present

Variables

1. Flow Data
2. Path Information
3. Flow Totals
4. All Variables

See Sheet 4

Flow Data

1. Flow Velocity
2. Sound Velocity
3. Flow Values
4. Flow Analysis

Flow Velocity[1]

1. Chord A	Value UOM
2. Chord B	Value UOM
3. Chord C	Value UOM
4. Chord D	Value UOM

Sound Velocity[1]

1. Chord A	Value UOM
2. Chord B	Value UOM
3. Chord C	Value UOM
4. Chord D	Value UOM

Flow Values

1. Flow Direction	Value
2. Avg Flow Velocity	Value UOM
3. Avg Sound Velocity	Value UOM

Flow Analysis[2]

1. Profile Factor	Value
2. Swirl Angle	Value deg
3. Symmetry	Value
4. Cross-Flow	Value
5. Turbulence A	Value %
6. Turbulence B	Value %
7. Turbulence C	Value %
8. Turbulence D	Value %

Path Information

1. Performance
2. Gain
3. SNR
4. Signal
5. Noise

Performance[1]

1. Performance A1	Value %
2. Performance A2	Value %
3. Performance B1	Value %
4. Performance B2	Value %
5. Performance C1	Value %
6. Performance C2	Value %
7. Performance D1	Value %
8. Performance D2	Value %

Gain[1]

1. Gain A1	Value dB
2. Gain A2	Value dB
3. Gain B1	Value dB
4. Gain B2	Value dB
5. Gain C1	Value dB
6. Gain C2	Value dB
7. Gain D1	Value dB
8. Gain D2	Value dB

SNR[1]

1. SNR A1	Value dB
2. SNR A2	Value dB
3. SNR B1	Value dB
4. SNR B2	Value dB
5. SNR C1	Value dB
6. SNR C2	Value dB
7. SNR D1	Value dB
8. SNR D2	Value dB

Signal[1]

1. Signal A1	Value mV
2. Signal A2	Value mV
3. Signal B1	Value mV
4. Signal B2	Value mV
5. Signal C1	Value mV
6. Signal C2	Value mV
7. Signal D1	Value mV
8. Signal D2	Value mV

Noise[1]

1. Noise A1	Value mV
2. Noise A2	Value mV
3. Noise B1	Value mV
4. Noise B2	Value mV
5. Noise C1	Value mV
6. Noise C2	Value mV
7. Noise D1	Value mV
8. Noise D2	Value mV

Flow Totals

1. Volume Totals

Volume Totals

1. Fwd Uncorrected Vol	Value UOM
2. Rev Uncorrected Vol	Value UOM

1. All chord parameters are always displayed for Device Number=3804 and only Chords A & B are displayed for Device Number=3802

2. All chord parameters are always displayed for Device Number=3804 and only Chords A & B are displayed for Device Number=3802.

Profile Factor, Swirl Angle, Symmetry, Cross-Flow shall not be displayed for 3802 meters.

Liquid USM Service Tools>Variables (continued)
Liquid USM Service Tools>Trends and
Liquid USM Service Tools>Maintenance

1. Alerts
2. Variables
3. Trends
4. Maintenance

Variables

1. Flow Data
2. Path Information
3. Flow Totals
4. All Variables

All Variables

1. Variable Summary
2. Primary Variable
3. Secondary Variable
4. Third Variable
5. Fourth Variable

Primary Variable

1. Uncorr Volume Rate	
2. Uncorr Volume Rate	Value UOM
3. Status: Good	

Secondary Variable*

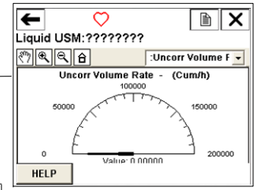
1. Uncorr Volume Rate	
2. Uncorr Volume Rate	Value UOM
3. Status: Good	

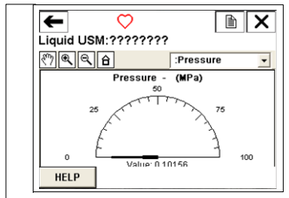
Third Variable*

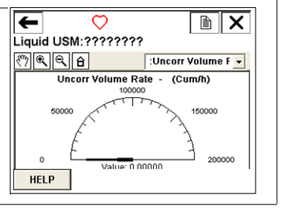
1. Pressure	
2. Avg Flow Velocity	Value UOM
3. Status: Good	

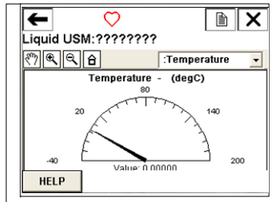
Fourth Variable*

1. Temperature	
2. Avg Sound Velocity	Value UOM
3. Status: Good	









Primary Variable

1. Uncorr Volume Rate	
2. Uncorr Volume Rate	Value UOM
3. Status: Good	
4. Upper Range	Value UOM
5. Lower Range	Value UOM

Secondary Variable

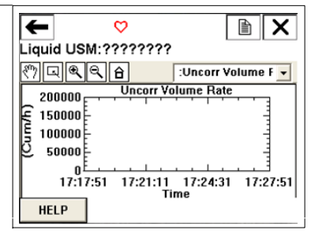
1. Uncorr Volume Rate	
2. Uncorr Volume Rate	Value UOM
3. Status: Good	
4. Upper Range	Value UOM
5. Lower Range	Value UOM

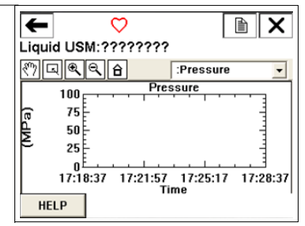
Third Variable

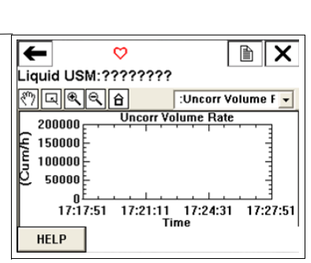
1. Pressure	
2. Pressure	Value UOM
3. Status: Good	
4. Upper Range	Value UOM
5. Lower Range	Value UOM

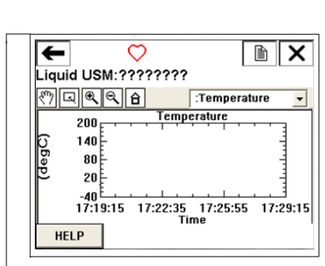
Fourth Variable

1. Temperature	
2. Temperature	Value UOM
3. Status: Good	
4. Upper Range	Value UOM
5. Lower Range	Value UOM









Maintenance

1. Routine Maintenance
2. Zero Calibration

Routine Maintenance

1. Analog Output 2 Trim

Zero Calibration

1. Velocity	Value UOM
2. Status	Value
3. Progress	Value %
4. Start	
5. Abort	
6. End	

*** Note**
The factory default value for all variables is Uncorr Flow Rate and must be set as the Primary Variable for Daniel 3800 Series Liquid Ultrasonic Meters. Secondary, Third and Fourth variable selections are:

- **Pressure**
- **Temperature**

ANNEX F REVISION HISTORY

F.1 DOCUMENT RELEASE

This is this initial release of the Daniel HART® Field Device Specification Guide: Daniel Liquid Ultrasonic Meters.

F.2 CHANGES FROM REV 1 TO REV 2

Page/Section	Description of Change
Title Page	• Revision level from 1 to 2 • Date from 30 September 2007 to 29 May 2009
Table of Contents	• Changed title from HART Option Board to Series 100 Plus Option Board in Sections 2.0, 4.1.2, 4.1.3 and 5 • Changed Section headings from level X.0 to X.1 • Changed title from Section 8 Universal Commands to add new section, Alert Resolutions • Changed remaining Section Numbers/Titles • Added Section 11.18 - 11.42 new commands for v1.70 of the Firmware • Changed titles in Annex D for Wave .5 requirements • Added Section F.2 to Annex F for revision history changes
List of Figures	• Changed title from HART Option Board to HART® Option Board
List of Tables	• Table 9-1 to 13-1 re-pagination of section titles after adding Alert Resolutions • Added Table 12-12 Decibel Units and 12-13 Voltage Units
Section 1	• Changed Section 1.0 to 1.1 and re-numbered remaining sections • Section 1.2 - Added link to Daniel Liquid Ultrasonic web page • Sec 1.4- changed title from HART Option Board to HART® Option Board • Section 1.5 - And added reference to HCF Field Device Specification Guide LIT-18
Section 2	• Changed Section 2.0 to 2.1 and re-numbered remaining sections • Changed HART Protocol Revision from 5.1 to 5 • Changed Device Revision from 1 to 2 • Changed Hardware revision from 1 to 3
Section 3	• Renamed Heading 3. from Product Overview to Introduction • Changed Section 3.0 to 3.1 and re-numbered remaining sections • Changed title from HART Option Board to HART® Option Board
Section 4	• Renamed Heading 4. from Product Interfaces to Introduction • Changed Section 4.0 to 4.1 and re-numbered remaining sections • Changed name from HART Option Board to HART® Option Board • Changed Section references from Section 8, 9 and 10 to Sections 9-11

Page/Section	Description of Change
Section 5	• Renamed Heading 5. from Device Variables to Introduction • Changed Section 5.0 to 5.1 and re-numbered remaining sections • Changed title from HART Option Board to Series 100 Plus Option Board • Changed Table references from 11-1, 11-4, 11-5, 11-5, 11-9, 11-10 to 12-1, 12-4, 12-5, 12-11, 12-12
Section 6	• Changed Section 6.0 to 6.1 and re-numbered remaining sections • Changed title from HART® Option Board Dynamic-Variables to HART® Dynamic-Variables • Changed title from HART Option Board to Series 100 Plus Option Board
Section 7	• Changed Section 7.0 to 7.1 and re-numbered remaining sections • Re-pagination of section references from 10-13 to 11-13, 10-14 to 11-14 • Added 8.0 Alert Resolutions reference • Added note: Status bit numbers from 0-13 to 0-15 • Added missing datapoints to Table 7-1 (*IsMeterVelAboveMaxLmt and AvgSndVelIsOutOfLimits*) Device Status Bit 1 and moved AO2Content to Device Status Bit 0 • Removed references to "Top Level screens and Detail screens in text and Table 7-1 and 7-2 headings • Added missing datapoints to Table 7-2 and Continuous Flow Analysis datapoints in Bytes/Bits 0-0,2-2, 2-1, 4-7, 5-1, 14-7, 14-6, 14-5, 14-4, 14-3, 15-7, 15-6, 15-5, 15-4, 15-3, 15-3 • Removed duplicate datapoint in table 7-2 Byte 4-0 (*PressHARTIsLoopCurrentFixed)* • Added Bytes 14 and 15 in Table 7-2
Section 8	• New section Alerts Resolutions
Section 9	• Changed Section 9.0 to 9.1 and re-numbered remaining sections • Re-pagination of section number was Section 8 Universal Commands • Table 9-1 added Command 6 Write polling address per FRS change 1.00 Draft AM
Section 10	• Changed Section 10.0 to 10.1 and re-numbered remaining sections • Re-pagination of section number was Section 9 Common-Practice Command • Changed title from HART Option Board to Expansion Board with HART

Page/Section	Description of Change
Section 11	• Changed Section 11.0 to 11.1 and re-numbered remaining sections • Re-pagination of section number was Section 10 Device-Specific Commands • Changed text from firmware v1.60 to v1.60 and later • Changed title from HART Option Board to HART® Option Board • Command 128 Request Data Bytes Byte 12 - added direct mapping AO*X*ActionUponInvalidContent data point • Command 128 Response Code 6 added Lower range value>Upper range value • Command 140 Byte 10 Bit 6 changed data point name from *AO2TrimCurrent* to *AO2Fixed* • Changed Command 141 IsAnyKeyAboutToExpire and IsAnyKeyExpired to not used and added Acknowledge latched alarm datapoints • Command 141 removed reference to external document • Changed Enum to Enum-8 throughout document • Changed reference to v1.60 of the the firmware to v1.60 and later • Added Commands 148-171 for Continuous Flow Analysis
Section 12	• Changed Section 12.0 to 12.1 and re-numbered remaining sections • Re-pagination of section was Section 11 Tables • Added Table 12-11 Decibel Units and Table 12-12 Voltage Units
Section 13	• Changed Section 13.0 to 13.1 and re-numbered remaining sections • Re-pagination of section was Section 12 Performance • Added link to Daniel website
Annex A	• Changed revision level from 1 to 2 • Changed number of Device-Specific Commands from 17 to 33 • Changed number of Additional-Status bytes from 6 to 15
Annex B	• Changed cross reference links to current pagination
Annex C	• Changed footer date from Sep 2007 to May 2009
Annex D	• Change to be compliant with Wave .5 formatting for AMS menu titles
Annex E	• Added Notice - Fast Key Sequences Menu Tree Diagrams valid for Revision 1
Annex F	• Added F-2 Updated manual revision history

F.3 CHANGES REV 2

Page/Section	Description of Change
Title Page	• Revision level 2 (no change) • Date from 09 September 2010 to 22 November 2010 • Added trademark to Daniel Measurement and Control
Table of Contents	• Deleted Section 8 Alert Resolutions section (Tokenizer 8 can display the length of the text) • Changed remaining Section Numbers/Titles
List of Figures	• Changed pagination and date
List of Tables	• Re-pagination of section titles after deleting Alert Resolutions
Sections	• Delete Section 8 Alert Resolutions and repaginate remaining sections • Changed footer date in sections to November 2010
Table 11-11 Section 12.8	• Changed Daniel CUI to Daniel MeterLink™
Annex E	• Updated Menu Tree information
Annex F	• Updated Revision history
Back Pages	• Updated RMA form

Note: The manual revision does not increment because the firmware did not change.

F.4 CHANGES REV 2

Page/Section	Description of Change
Title Page	• Revision level 2 (no change) • Date from 22 November 2010 to 20 December 2011
Table of Contents	• Updated TOC to add changes to Annex F • Changed footer date from November 2010 to December 2011
Sections	• Section 7 Changed Table 7-1 removed Device Status Bit references to Is1BitMemoryError and IsCorePresent • Section 10 Command 140 and 141 removed Device Status Bit references to Is1BitMemoryError and IsCorePresent shown as Reserved • Changed footer dates to December 2011
Annex E	• Updated Menu Tree information - changed Title on Sheets 1-5 to Gas USM from 3400 Series • Changed name of file from 3400_Series_Menu_pages_1-5_Rev_1.pdf to Gas USM Menu_pages_1-5_Rev_1.pdf • Changed footer date to December 2011
Annex F	• Updated Revision history - added Section F.4 • Changed footer date to December 2011

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DANIEL™ MEASUREMENT AND CONTROL, INC.
RETURNED MATERIAL AUTHORIZATION

REPAIR FORM FOR USED EQUIPMENT
INCLUDING DECONTAMINATION/CLEANING STATEMENT

A Return Material Authorization (RMA) number must be obtained prior to returning any equipment for any reason. Download the RMA form on the Daniel Measurement and Control, Inc. Support Services web page by selecting the link below.

Select the link below to open the Microsoft Excel® RMA request form:

http://www2.emersonprocess.com/EN-US/BRANDS/DANIEL/SUPPORT-SERVICES/Pages/Support-Services.aspx

1. Return Material Authorization (RMA) Number_____
2. Equipment to be returned:
   Model Number _____Serial Number_____
3. Reason for return:
   _____
   _____

Decontamination/Cleaning Fluids Process			
A. List each substance in which the equipment was exposed. Attach additional documents if necessary.			
Common Name	CAS# if Available	Used for Hazardous Waste (20 CFR 261)	EPA Waste Code if used for hazardous waste
		[ ] Yes [ ] No	
		[ ] Yes [ ] No	
		[ ] Yes [ ] No	
		[ ] Yes [ ] No	
		[ ] Yes [ ] No	
		[ ] Yes [ ] No	

B. Circle any hazards and/or process fluid types that apply:

Infectious	Radioactive	Explosive	Pryophoric	Poison Gas	
Cyanides	Sulfides	Corrosive	Oxidizer	Flammable	Poison
Carcinogen	Peroxide	Reactive-Air	Reactive-Water	Reactive-Other (list):	

Other Hazard Category (list):

C. Describe decontamination/cleaning process. Include MSDS description for substances used in decontamination and cleaning processes. Attach additional documents if necessary.

Shipping Requirements

Failure to comply with this procedure will result in the shipment being refused.

1. Write the RMA number on the shipping package.
2. Inside the package include one copy of this document and all required Material Safety Data Sheets (MSDS)
3. Outside of the package attach one copy of this document and all required Material Safety Data Sheets (MSDS).

THIS EQUIPMENT, BEING RETURNED "FOR REPAIR," HAS BEEN COMPLETELY DECONTAMINATED AND CLEANED. ALL FOREIGN SUBSTANCES HAVE BEEN DOCUMENTED ABOVE AND MSDS SHEETS ARE ATTACHED.

By_____ _____
(Signature) (Print name)

Title:_____ Date:_____

Company:_____

Phone: _____ Fax:_____

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