# HART® Field Device Specification Guide:

## HART® Field Device Specification Guide: Daniel Liquid Ultrasonic Meters revision 1

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

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- 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.
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- ALWAYS READ AND FOLLOW THE DANIEL® LIQUID ULTRASONIC 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.
# HART® Field Device Specification Guide: Daniel Liquid Ultrasonic Meters

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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).

### 1.0 Scope

The Daniel Measurement and Control, Inc. Division of Emerson Process Management HART® Field Device Specification Guide: Daniel Liquid Ultrasonic Meters, revision 1 complies with HART® Option Board Protocol Revision 5.10. This document specifies all the device specific features and documents HART® Option Board 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® Option Board capable Host Applications.

### 1.1 Purpose

This specification is designed to compliment other documentation (e.g., the *Daniel Liquid Ultrasonic Flow Meter Reference, Installation, and Operations Manual* P/N 3-9000-750) by providing a complete, unambiguous description of this field device from a HART® Option Board Communication perspective.

### 1.2 Who should use this document?

This specification is designed to be a technical reference for HART® Option Board 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 HART® Option Board Protocol requirements and terminology.

## 1.3 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 (HART® Option Board) |
| EDDL | Electronic Device Description Language (HART® Option Board) |
| FPGA | Field-Programmable Gate Array |
| HART® Option Board | 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 |

## 1.4 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® Option Board SMART Communications Protocol Specification (also includes the specifications listed below in italics) | HCF_SPEC 11, Rev. 5.10 (14-Dec-2000) |
| *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://www.emersonprocess.com/daniel/products/liquid/usonic/Model%203804%20Liquid%20Ultrasonic/Productdetail_1.htm*** |

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# DEVICE IDENTIFICATION

## 2. DEVICE IDENTIFICATION

### 2.0 HART® Option Board Identification

The HART® Field Device Specification Guide: Daniel Liquid Ultrasonic Meters indoctrination summary is shown in Table 2-1 below.

*Table 2-1 HART® Option Board Field Device Identification Summary*

| | | | |
|---|---|---|---|
| **Manufacturer Name:** | Daniel Measurement and Control, Inc. | **Model Name(s):** | HART® Option Board |
| **Manufacture ID Code:** | 13 (D Hex) | **Device Type Code:** | 40 (28 Hex) |
| **HART® Protocol Revision:** | 5.10 | **Device Revision:** | 1 |
| **Number of Device Variables:** | 3 (0, 6, 7) | | |
| **Physical Layers Supported:** | Bell 202 FSK | **Note: HART® Hardware Revision** | 1 |
| **Physical Device Category:** | Daniel Liquid Ultrasonic Flow Meter | | |

## 2.1 Physical Description

The HART® Option Board provides communication flexibility with Daniel Liquid Ultrasonic Flow Meters. The HART® Option Board enables the meter to easily communicate with other field devices, and ultimately, communicate key diagnostic information through PlantWeb® architecture.

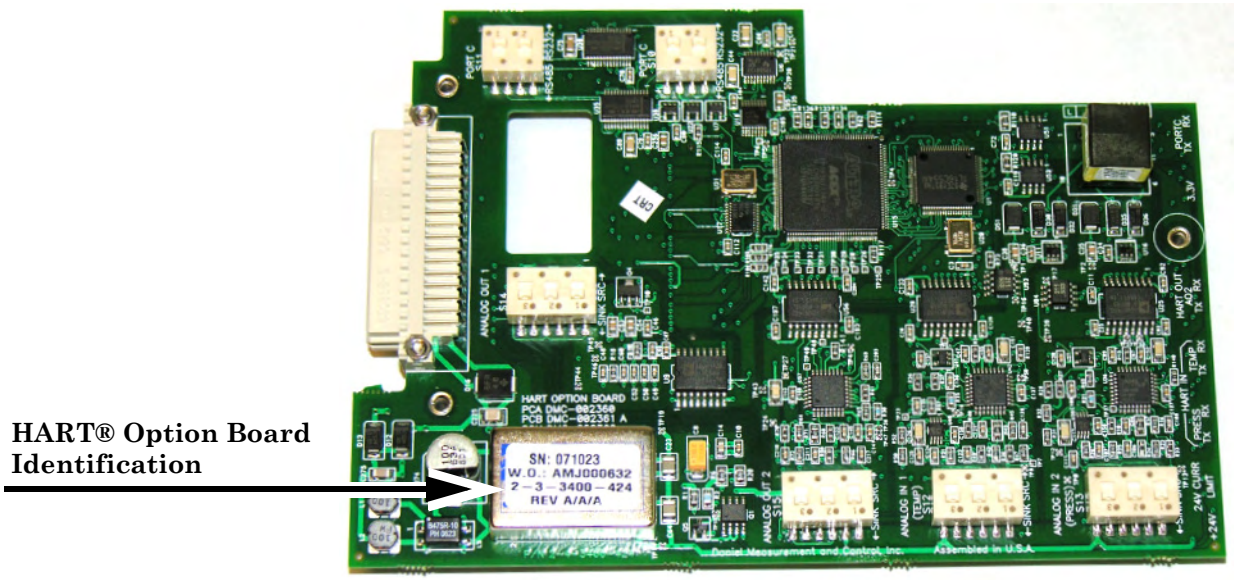


*Figure 2-1* HART® *Option Board*

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

# PRODUCT OVERVIEW

## 3. PRODUCT OVERVIEW

This section specifies the purpose and application of the HART® Option Board.

### 3.0 Device Function, Purpose and Features

The HART® Option Board 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.

### 3.1 Process Connections

The HART® Option Board is optionally used in place of the Series 100 Option Board. Thus, the HART® Option Board connects to the Daniel Liquid Ultrasonic Meter CPU and Field Connection boards in the same manner as the Series 100 Option Board and fits within the existing electronics housing.

### 3.2 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 HART® Option Board 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 HART® Option Board is compliant with Asset Management Solutions (AMS™) software applications that provides operator interface between the HART® Option Board 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**).

## 3.3 Other Required Equipment

The HART® Option Board is backward compatible with the Daniel Series 100 Option Board.

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

Any programmable device on the HART® Option Board (such as FPGA) is programmed via the CPU Board.

# PRODUCT INTERFACES

## 4. PRODUCT INTERFACES

This section discusses the HART® Option Board communications, electrical interface, and input and output requirements.

### 4.0 Process Interface

The HART® Option Board 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 HART® Option Board 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.

### 4.1 Sensor Input Channels

**NOTICE**

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

The HART® Option Board 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 firmware 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 HART® Option Board 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).

### 4.1.1 Communication Port(s)

An RS-232C/RS-485 (half duplex) serial communication port for Modbus communication is provided as Port C on the HART® Option Board. 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 |

### 4.1.2 HART® Option Board Analog Inputs

**NOTICE**

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

The HART® Option Board 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).

### 4.1.3 HART® Option Board Analog Outputs

Two 16 bit, 4-20 mA analog outputs are provided on the HART® Option Board. 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 HART® Option Board 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 HART® Option Board 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, Section 9 and 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. HART® OPTION BOARD DEVICE VARIABLES

The HART® Option Board does not use Device Family commands.

### 5.0 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<br>Volumetric Flow | **Unit Codes** | (see Table 11-1) |

## 5.1 Device Variable 6 - Pressure

When the HART® Option Board 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<br>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 11-9.

## 5.2 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 11-10) |

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 11-10.

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# HART® OPTION BOARD DYNAMIC VARIABLES

## 6. HART® OPTION BOARD DYNAMIC VARIABLES

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

### 6.0 Fixed Dynamic Variables

There are no fixed Dynamic Variables for this device.

### 6.1 Dynamic Variables with Configurable Mapping

The Daniel HART® Option Board allows the following user-configurable Dynamic Variables mapped to the Device Variables:

*Table 6-1 Dynamic Variables Configurable Mapping*

| Dynamic Variable | Device Variable Number | Name |
|---|---|---|
| PV | 0 | • 0 Uncorrected Flow Rate<br>• 6 Pressure<br>• 7 Temperature |
| SV | 0, 6, 7 | • 0 Uncorrected Flow Rate<br>• 6 Pressure<br>• 7 Temperature |
| TV | 0, 6, 7 | • 0 Uncorrected Flow Rate<br>• 6 Pressure<br>• 7 Temperature |
| QV | 0, 6, 7 | • 0 Uncorrected Flow Rate<br>• 6 Pressure<br>• 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. STATUS INFORMATION

This section documents the HART® Option Board 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 7.1)
- the device-specific command for reading detailed status information Command 140 (see Section 10.13).

Device-Specific Command 141 (see Section 10.14) is used to acknowledge status Boolean database points that require acknowledgement.

As shown in ( Annex E) the Failed, Maintenance, and Advisory screens (referred to as "top-level screens") each has its own related "Details" screen. The information indicated in the top-level screens is communicated via Universal Command 48 (see Section 7.1) unless it is indicated via the device status byte.

The database point mapping for the Device Status Byte is shown in Table 7-1. The Command 48 database point mapping is shown in Table 7-2. All "Details" screen information is communicated via Device Specific Command 140 (illustrated in the command definition in Section 10.13).

## 7.0 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*<br>• *IsCorePresent*<br>• *Is1BitMemoryError*<br>• *WatchDogReset*<br>• *IsElecVoltOutOfRange*<br>• *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*<br>*AO2IsFixed* |

*Table 7-1 Device Status Byte Database Point Mapping*

| DEVICE STATUS BIT | DEFINITION | EXPLANATION | RELATED DATABASE POINT(S) |
|---|---|---|---|
| 2 | **Loop Current Saturated** - The loop Current has reached its upper (or lower) endpoint limit and cannot increase (or decrease) any further. | | *AO2IsSaturated* |
| 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. | *FlowPressureIsOutOfLimits*<br>*FlowTemperatureIsOutOfLimits*<br>*(AO2Content)* |
| 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. | |

## 7.1 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 Top-Level 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>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></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>1</td><td>Bits</td><td>Maintenance Top-Level 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>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 Top-Level 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>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></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>3</td><td>Bits</td><td>Maintenance Top-Level 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>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 Top-Level 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>Invalid measurement indicator - logical OR'ing of the related database points</td><td>QFlowValidity (inverted)</td></tr>
<tr><td>6</td><td>* HART Pressure Input Device Status - logical OR'ing of the related database points<br><br>* Future availability</td><td>PressHARTIsCommErr<br>PressHARTIsDevMalfunction<br>PressHARTIsConfigChanged<br>PressHARTDidColdStart<br>PressHARTIsMoreStatusAvailable<br>PressHARTIsLoopCurrentFixed<br>PressHARTIsLoopCurrentFixed<br>PressHARTIsLoopCurrentSaturated<br>PressHARTIsNonPVOutOfLimits<br>PressHARTIsPVOutOfLimits</td></tr>
<tr><td>5</td><td>* HART Temperature Input Device Status - logical OR'ing of the related database points<br><br>* Future availability</td><td>TempHARTIsCommErr<br>TempHARTIsDevMalfunction<br>TempHARTIsConfigChanged<br>TempHARTDidColdStart<br>TempHARTIsMoreStatusAvailable<br>TempHARTIsLoopCurrentFixed<br>TempHARTIsLoopCurrentSaturated<br>TempHARTIsNonPVOutOfLimits<br>TempHARTIsPVOutOfLimits</td></tr>
<tr><td>4</td><td>Power failure indicator</td><td>DidPowerFail</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>5</td><td>Bits</td><td>Advisory Top-Level 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>One or more logs full indicator - logical OR'ing of the related database points</td><td>IsHourlyLogFull<br>IsDailyLogFull<br>IsAuditLogFull<br>IsAlarmLogFull<br>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<br>AO1IsFixed</td></tr>
<tr><td>3</td><td></td><td>AO1IsSaturated</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>IsElecTempOutOfRange</td></tr>
</table></td></tr>
<tr><td>6</td><td>Enum</td><td>Operating Mode #1 (set to 250 "Not Used")</td></tr>
<tr><td>7</td><td>Enum</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>
<tr><td>14-24</td><td>Bits or Enum</td><td>Device-Specific Status (not used at this time, not sent)</td></tr>
</table>

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# UNIVERSAL COMMANDS

## 8. UNIVERSAL COMMANDS

### 8.0 HART® Option Board Universal Commands

This section documents the HART® Option Board 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. |
| 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. |
| 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. COMMON-PRACTICE COMMANDS

This section documents the HART® Option Board additional device status optional Common-Practice Commands.

### 9.0 Supported Common-Practice Commands

This section lists the device features, functionality, and restrictions of Common-Practice Commands.

*Table 9-1 HART® Option Board 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. |

## 9.1 Burst Mode

This device does not support Burst Mode.

## 9.2 Catch Device Variable

This device does not support a Catch Device Variable.

# DEVICE-SPECIFIC COMMANDS

## 10. DEVICE-SPECIFIC COMMANDS

This section documents the Device-Specific Commands implemented for the HART® Option Board.

### 10.0 Public, Device-Specific Commands

This section lists the HART® Option Board 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

## 10.1 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 | 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* and *AOXMaxVel* |
| 7-10 | Float | Lower Range Value | Used to set *AOXMinVel*. Write is rejected if volumetric flow rate is selected as the device variable and the Lower Range Value is non-zero. |
| 11 | Enum | Flow direction to be represented by specified analog output | 0=Reverse, 1=Forward, 2=Absolute (indicates flow regardless of flow direction |
| 12 | Enum | 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. |

### 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 | 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 | Flow direction represented by specified analog output |
| 12 | Enum | 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 | Flow direction or alarm code selection 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. |

| Code | Class | Description | Explanation |
|---|---|---|---|
| 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 | |

## 10.2 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, 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 | |

## 10.3 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.<br><br>Used to set *Freq*X*Content*. |
| 2 | Enum | 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*, *and Freq*X*MaxVel*. This value corresponds to the maximum frequency (set below). |
| 7-10 | Float | Lower Range Value | Used to set *Freq*X*MinVel*. Write is rejected if any flow rate selected as the device variable and the Lower Range Value is non-zero. This value corresponds to zero frequency. |

| Byte | Format | Description | Explanation |
|---|---|---|---|
| 11-12 | Unsigned-16 | Maximum Frequency (Hertz) | Allowed values are 1000 and 5000 Hz. Used to set *Freq*X*MaxFrequency*. |
| 13 | Enum | Flow direction to be represented by Frequency Output Pair | • 0=Reverse<br>• 1=Forward<br>• 2=Absolute (indicates flow regardless of flow direction)<br>• 3=Bidirectional<br>(Phase A indicates forward direction flow, Phase B indicates reverse direction flow). Used to set *FreqXDir*. |
| 14 | Enum | Frequency B Phase zero-on-error configuration | 0=don't zero on error, 1=zero on error<br>Used to set *IsFreqXBZeroedOnErr*. |
| 15 | Enum | Frequency B Phase relative to Frequency A Phase configuration | • 0=Lag when forward flow, lead when reverse flow<br>• 1=Lead when forward flow, lag when reverse flow<br>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 *Freq*X*FeedbackCorrectionPcnt*. |
| 17 | Enum | Selected Digital Output A inverted polarity configuration | • 0=Normal polarity<br>• 1=Inverted polarity<br>This is used to set *DOXAIsInvPolarity* |
| 18 | Enum | Selected Digital Output A content selector | • 0=Corresponding Frequency Output Pair Validity<br>• 1=Flow Direction<br>This is used to set *DOXAContent* data point but it is NOT a direct mapping. |
| 19 | Enum | Selected Digital Output B inverted polarity configuration selector | • 0=Normal polarity<br>• 1=Inverted polarity<br>This is used to set *DOXBIsInvPolarity* |
| 20 | Enum | Selected Digital Output B content selector | • 0=Corresponding Frequency Output Pair Validity<br>• 1=Flow Direction<br>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 | 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 | Unsigned-16 | Maximum Frequency (Hertz) |
| 13 | Enum | Flow direction to be represented by Frequency Output Pair |
| 14 | Enum | Frequency B Phase zero-on-error configuration |
| 15 | Enum | Frequency B Phase relative to Frequency A Phase configuration |
| 16 | Unsigned-8 | Frequency feedback correction percentage |
| 17 | Enum | Selected Digital Output A inverted polarity configuration |
| 18 | Enum | Selected Digital Output A content |
| 19 | Enum | Selected Digital Output B inverted polarity configuration |
| 20 | Enum | 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 | |

## 10.4 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 | |

## 10.5 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 | Input Selector Code | • 0=None<br>• 1=Live 4-20 mA<br>• 2=Fixed (specified).<br>• *3=Live HART<br>Used to set *EnablePressureInput* and *PressureLiveInput* data points.<br><br>* The Live HART input selector code is not supported by v1.60 firmware. |
| 1 | Enum | 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. |

| Byte | Format | Description | Explanation |
|---|---|---|---|
| 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. |
| 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 | 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:<br>• 239 Hold Last Output Value → set *FlowPOrTSrcUponAlarm* to 0;<br>• 242 Used Fixed Value → set *FlowPOrTSrcUponAlarm* to 1 (Fixed value). |
| 23 | Enum | Absolute pressure input type indicator | • 0=gage<br>• 1=absolute<br>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 | Input Selector Code |
| 1 | Enum | 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 | Pressure and Temperature Alarm Selection Code (see Section 11) |
| 23 | Enum | 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.<br><br>* Also used for unsupported selector code, e.g. Live HART is not supported v1.60 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 | |

## 10.6 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 | |

## 10.7 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 | Input Selector Code | 0=None, 1=Live 4-20 mA, 3=Live HART, 2=Fixed (specified). Used to set *EnableTemperatureInput* and *TemperatureLiveInput* data points.<br><br>* The Live HART input selector code is not supported by v1.60 firmware. |
| 1 | Enum | 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 *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. |

| Byte | Format | Description | Explanation |
|---|---|---|---|
| 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 *MaxInputTemperature* 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 | 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:<br>• 239 Hold Last Output Value → set *FlowPOrTSrcUponAlarm* to 0<br>• 242 Used Fixed Value → set *FlowPOrTSrcUponAlarm* to 1 (Fixed value). |

### Response Data Bytes

| Byte | Format | Description |
|---|---|---|
| 0 | Enum | Input Selector Code |
| 1 | Enum | 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 | 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:<br>• lower alarm value > upper alarm value<br>• lower range value > upper range value<br>or<br>• a requested value is outside its sanity limits.<br>* Also used for unsupported selector code, e.g. Live HART is not supported v1.60 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 | |

## 10.8 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 | |

## 10.9 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 | Volume Units Code (see Table 11-7) |
| 1 | Enum | Flow Rate Time Units Code (see Table 11-8) |
| 2 | Enum | Pressure Units Code (see Table 11-9) |
| 3 | Enum | Temperature Units Code (see Table 11-10) |
| 4 | Enum | Velocity Units Code (see Table 11-6) |

### Response Data Bytes

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

## 10.10 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 | |

## 10.11 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 | Unsigned 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 | 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 | |
| 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 | |

## 10.12 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 | |

## 10.13 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) |

| Bit | Description | Related Database Point(s) |
|---|---|---|
| 7 (msb) | Indicates a diagnostic core file was generated. | *IsCorePresent* |
| 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). | *Is1BitMemoryError* |
| 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>
</table></td></tr>
</table>

<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>
</table></td></tr>
<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>
</table>

<table>
<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>AO2TrimCurrent</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>
<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>Average flow rate out-of-limits indicator.</td><td>AvgFlowIsOutOfLimits</td></tr>
<tr><td>6</td><td>Average sound velocity out-of-limits indicator.</td><td>AvgSndVelIsOutOfLimits</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 | |

## 10.14 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 | *IsCorePresent* |
| 1 | *Is1BitMemoryError* |
| 2 | *WatchDogReset* |
| 3 | *DidCnfgChksumChg* |
| 4 | *DidColdStart* |
| 5 | *DidPowerFail* |
| 6 | Reserved |
| 7 | Reserved |

The acknowledgeable alarm *DidCnfgChksumChg* is not acknowledged via Common Command 38 (Command 38 clears only the config changed flag in the Field Device Status Byte.). The *DidPowerFail* acknowledgeable alarm is automatically reset according to the HART® Device Status requirements (HART® Revision 5, HCF_SPEC-99 section 3.3). The meter also resets any *DidColdStart* alarm when the *DidPowerFail* alarm is automatically reset. However, this "automatic reset" only applies to HART® (for the Field Device Status byte) and does not clear the database point(s). Acknowledging *DidColdStart* or *DidPowerFail* via this command clears the specified database point.

### Request Data Bytes

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

### Response Data Bytes

| Byte | Format | Description |
|---|---|---|
| 0 | Enum | 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 | |

## 10.15 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 | Digital input selector | • 0=general purpose<br>• 1=used for calibration).<br>Used to set *IsDI1UsedForCal*. |
| 1 | Enum | General purpose polarity | • 0=normal<br>• 1=inverted<br>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 *DI1IsInvPolarity*. |
| 2 | Enum | Calibration input polarity | • 0=active high<br>• 1=active low<br>Applicable when the digital input is used for calibration. Specifies the digital input polarity for starting/stopping calibration. Used to set *IsDI1ForCalActiveLow*. |
| 3 | Enum | Calibrating gating type | • 0=edge gated<br>• 1=state gated<br>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 | Digital input usage selector (0=general purpose, 1=used for calibration) |
| 1 | Enum | (Bit 2) General purpose polarity (0=normal, 1=inverted) |
| 2 | Enum | (Bit 1) Calibration input polarity (0=active high, 1=active low) |
| 3 | Enum | (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 | |

## 10.16 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 | |

## 10.17 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

<table>
<tr><th>Byte</th><th>Format</th><th>Description</th></tr>
<tr><td>0</td><td>Enum</td><td>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.
<table>
<tr><th>Code</th><th>Description</th></tr>
<tr><td>0</td><td>Zero calibration process inactive</td></tr>
<tr><td>1</td><td>Zero calibration process in progress</td></tr>
<tr><td>2</td><td>Zero calibration process completed successfully</td></tr>
<tr><td>3</td><td>Zero calibration process failed due to chord failure during process</td></tr>
<tr><td>4</td><td>Zero calibration process failed due to too-large offset</td></tr>
<tr><td>5</td><td>Zero calibration process failed due to too-large estimated maximum deviation</td></tr>
</table></td></tr>
<tr><td>1</td><td>Unsigned 8</td><td>Zero calibration duration in minutes (for initial/default value displayed for user) (ZeroFlowCalReqDuration)</td></tr>
<tr><td>2</td><td>Unsigned 8</td><td>Zero calibration progress % (zero when status is 0) updated every 5 seconds</td></tr>
<tr><td>3</td><td>Enum</td><td>Zero flow velocity Units Code (see Section 11)</td></tr>
<tr><td>4-7</td><td>Float</td><td>Instantaneous zero flow velocity (DryCalVel) (included for display/charting purposes)</td></tr>
<tr><td>8-11</td><td>Float</td><td>Proposed zero calibration value ("zero flow velocity offset") (only relevant when the zero calibration process status is 2)</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 | |

## 10.18 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</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

<table>
<tr><th>Byte</th><th>Format</th><th>Description</th></tr>
<tr><td>0</td><td>Enum</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></tr>
<tr><td>1</td><td>Unsigned 8</td><td>Zero calibration duration (minutes) (ZeroFlowCalReqDuration)</td></tr>
</table>

### 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 HART® Option 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 (*Zero-FlowCalProgress*) 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

$\delta_{DryCalVel}$ 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.

## 10.19 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 | |

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# TABLES

## 11. HART® UNITS TABLES

### 11.0 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.

### 11.1 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 |

## 11.2 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.

## 11.3 Pressure Units

*Table 11-4 Pressure Units*

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

## 11.4 Temperature Unit Codes

*Table 11-5 Temperature Units*

| Unit Code | Description |
|---|---|
| 32 | Degrees Celsius |
| 33 | Degrees Fahrenheit |
| 35 | Kelvin |

## 11.5 Velocity Units

*Table 11-6 Velocity Units*

| Unit Code | Description |
|---|---|
| 20 | Feet per second |
| 21 | Meters per second |

## 11.6 Unit Conversion

*Table 11-7 Conversion Factors per Unit of Measurement*

| Conversion Factors | Unit of Measurement |
|---|---|
| (°F-32)x(5/9)–>°C<br>(°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)) |

## 11.7 Pressure and Temperature Tables

### Flow-Condition Pressure and Temperature

*Table 11-8 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 11-9 Data Points for Pressure Inputs*

| **Daniel CUI Display Name** | **Data Points, Options and Guidelines** |
|---|---|
| Is pressure gage or absolute? | Data points affected:<br>- **InputPressureUnit**<br>Options:<br>• Gage (FALSE)<br>• Absolute (TRUE) |
| Atmospheric pressure | Data points affected:<br>- **AtmosphericPress**<br>Options:<br>• Enter a value (KPaa or psia) within the range [30.0, 108.40 KPaa]<br>Guidelines:<br>• This data point is only applicable when the input pressure unit is specified as gage. |
| Live pressure, Min input | Data points affected:<br>- **MinInputPressure**<br>Options:<br>• 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:<br>- **MaxInputPressure**<br>Options:<br>• 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:<br>- **LowPressureAlarm**<br>Options:<br>• 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:<br>- **HighPressureAlarm**<br>Options:<br>• 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 11-10 Data Points for Temperature Inputs*

| **Daniel CUI Display Name** | **Data Points, Options and Guidelines** |
|---|---|
| Live temperature, Min input | Data points affected:<br>- **MinInputTemperature**<br>Options:<br>• 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:<br>- **MaxInputTemperature**<br>Options:<br>• 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:<br>- **LowTemperatureAlarm**<br>Options:<br>• 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:<br>- **HighTemperatureAlarm**<br>Options:<br>• 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. |

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# PERFORMANCE

## 12. PERFORMANCE

### 12.0 Sampling Rates

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

### 12.1 Power-Up

On power-up, when functioning correctly, the HART Option Board 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.

## 12.2 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.

## 12.3 Self Test

Refer to Section 5.10 in the *Daniel Liquid Ultrasonic Flow Meter Reference, Installation and Operations Manual* (P/N 3-9000-750 ( ***http://www.emersonprocess.com/daniel/products/liquid/usonic/Model%203804%20Liquid%20Ultrasonic/Productdetail_1.htm***) for self test details.

## 12.4 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 |

## 12.5 Busy and Delayed-Response

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

## 12.6 Long Messages

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

## 12.7 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 Daniel CUI. 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://www.emersonprocess.com/daniel/products/liquid/usonic/Model%203804%20Liquid%20Ultrasonic/Productdetail_1.htm)***.

## 12.8 Operating Modes

No alternative operating modes are available for this device.

## 12.9 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 and Section 3.4.6 for switch details.

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

## 12.10 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. 1** |
|---|---|
| Device type | Sensor |
| HART protocol revision | Rev. 8.0 |
| 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 | 17 |
| Bytes of additional device status | 6 (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<br>• Open (up position) write protection on<br>• Down (closed position) write protection off |
| Number of Response Preambles | • 5 minimum<br>• 20 maximum |

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# ANNEX C DEVICE VARIABLE CALCULATIONS

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://www.emersonprocess.com/daniel/products/liquid/usonic/Model%203804%20Liquid%20Ultrasonic/Productdetail_1.htm***

## C.1 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.2 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.3 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 4.0). 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**)

$\alpha$ = 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**)

$\pi$ = 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**)

$\mu$ = dynamic viscosity (Pa • s) (**Viscosity**)

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# ANNEX D AMS DEVICE OPERATIONS

## D.1 OVERVIEW

This section consists of the AMS™ Suite configuration and settings used by Daniel Liquid Ultrasonic Flow Meters and assumes the device is connected, power is applied and the device is functioning correctly.

**NOTICE**

**See Section E.2 375 Handheld communicator Menu tree for fast key selections.**

## D.2 AMS™ SUITE CONFIGURATION DATA

Review or change the default configuration (factory set) for Daniel Liquid Ultrasonic Meters using the AMS™ Suite software settings.

Right click on the device and select *Configuration Setup>Basic Setup* from the menu then select the tabs to review the default settings or change the configuration settings. Daniel Liquid Ultrasonic Flow Meters AMS™ tab selections include:

- Identification
- Units
- Analog Outputs 1 & 2
- Frequency and Digital Outputs 1 & 2
- Pressure
- Temperature
- Digital Input

## D.3 AMS™ SUITE DEVICE DIAGNOSTICS

Review or change the default configuration (factory set) for Daniel Liquid Ultrasonic Flow Meters using the AMS™ Suite Device Diagnostics.

Right click on the device and select *Device Diagnostics*. Click the tab from the provided selections:

- Acknowledge
- Failed
- Maintenance
- Advisory

## D.4 AMS™ SUITE PROCESS VARIABLES

Review or change the default configuration (factory set) for Daniel Liquid Ultrasonic Flow Meters using the AMS™ Suite Process variables.

Right click on the *Device Variable Mapping* menu and select the tab from the provided selections:

- Primary variable
- 2nd variable
- 3rd variable
- 4th variable
- All variables
- Identification

**NOTICE**

**The Device variable mapping for Daniel Liquid Ultrasonic Meters is the user configuration of Uncorrected Flow rate.**

## D.5 ZERO FLOW PROCEDURE

See Section 10.18 for the Velocity Zero Calibration process.

# 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.

## 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 | 1,1,3,1 |
| Analog Output 1 Direction | 1,1,3,2 |
| Analog Output 1 Lower Range | 1,1,3,3 |
| Analog Output 1 Upper Range | 1,1,3,4 |
| Analog Output 1 Alarm Action | 1,1,3,5 |
| Analog Output 2 Content | 1,1,4,1 |
| Analog Output 2 Direction | 1,1,4,2 |
| Analog Output 2 Lower Range | 1,1,4,3 |
| Analog Output 2 Upper Range | 1,1,4,4 |
| Analog Output 2 Alarm Action | 1,1,4,5 |
| Analog Output 2 Trim | 1,3,1,1 |
| Calibrate Zero Flow | 1,3,2 |
| Calibrate Zero Flow Velocity | 1,3,2,2 |
| Calibrate Velocity Zero Flow Duration | 1,3,2,3 |
| Calibrate Zero Flow Status | 1,3,2,4 |
| Calibrate Zero Flow Progress | 1,3,2,5 |
| Calibrate Start Zero Flow | 1,3,2,6 |
| Calibrate Abort Zero Flow | 1,3,2,7 |
| Device Variable Mapping | 1,2,1 |
| Device Variable Mapping PV | 1,2,1,1 |

*Table E-1 375 Fast Key Sequences*

| FUNCTION | FAST KEY INPUT SEQUENCE |
|---|---|
| Device Variable Mapping SV | 1,2,1,2 |
| Device Variable Mapping TV | 1,2,1,3 |
| Device Variable Mapping QV | 1,2,1,4 |
| Digital Input | 1,1,9 |
| Digital Input Usage | 1,1,9,1 |
| Digital Input General Polarity | 1,1,9,2 |
| Digital Input Calibration Polarity | 1,1,9,3 |
| Digital Input Calibration Gating | 1,1,9,4 |
| Digital Output 1 | 1,1,5,2 |
| Digital Output 1 CH A Content | 1,1,5,2,1 |
| Digital Output 1 CH A Polarity | 1,1,5,2,2 |
| Digital Output 1 CH B Content | 1,1,5,2,3 |
| Digital Output 1 CH B Polarity | 1,1,5,2,4 |
| Digital Output 2 | 1,1,6,2 |
| Digital Output 2 CH A Content | 1,1,6,2,1 |
| Digital Output 2 CH A Polarity | 1,1,6,2,2 |
| Digital Output 2 CH B Content | 1,1,6,2,3 |
| Digital Output 2 CH B Polarity | 1,1,6,2,4 |
| (Flow) Pressure | 1,1,8 |
| (Flow) Pressure Source | 1,1,8,1 |
| (Flow) Pressure Live | 1,1,8,2 |
| (Flow) Pressure Fixed | 1,1,8,3 |
| (Flow) Pressure Alarm Selection | 1,1,8,4 |
| (Flow) Pressure Alarm | 1,1,8,5 |
| (Flow) Temperature | 1,1,7 |
| (Flow) Temperature Source | 1,1,7,1 |
| (Flow) Temperature Live | 1,1,7,2 |
| (Flow) Temperature Fixed | 1,1,7,3 |
| (Flow) Temperature Alarm Selection | 1,1,7,4 |
| (Flow) Temperature Alarm | 1,1,7,5 |
| Frequency & Digital 1 | 1,1,5 |
| Frequency Output 1 | 1,1,5,1 |
| Frequency Output 1 Content | 1,1,5,1,1 |
| Frequency Output 1 Direction | 1,1,5,1,2 |

*Table E-1 375 Fast Key Sequences*

| FUNCTION | FAST KEY INPUT SEQUENCE |
|---|---|
| Frequency Output 1 B Zeroed on Error | 1,1,5,1,3 |
| Frequency Output 1 B Phase | 1,1,5,1,4 |
| Frequency Output 1 Max Frequency | 1,1,5,1,5 |
| Frequency Output 1 Lower Range | 1,1,5,1,6 |
| Frequency Output 1 Upper Range | 1,1,5,1,7 |
| Frequency Output 1 K-Factor | 1,1,5,1,8 |
| Frequency & Digital 2 | 1,1,6 |
| Frequency Output 2 | 1,1,6,1 |
| Frequency Output 2 Content | 1,1,6,1,1 |
| Frequency Output 2 Direction | 1,1,6,1,2 |
| Frequency Output 2 B Zeroed on Error | 1,1,6,1,3 |
| Frequency Output 2 B Phase | 1,1,6,1,4 |
| Frequency Output 2 Max Frequency | 1,1,6,1,5 |
| Frequency Output 2 Lower Range | 1,1,6,1,6 |
| Frequency Output 2 Upper Range | 1,1,6,1,7 |
| Frequency Output 2 K-Factor | 1,1,6,1,8 |

## E.2 375 FIELD COMMUNICATOR MENU TREE

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

- Figure 1 of 4 *Configuration Setup>Basic Setup*
- Figure 2 of 4 *Configuration Setup>Device and Configuration Setup>Calibrate*
- Figure 3 of 4 *Device Diagnostics*
- Figure 4 of 4 *Process Variables*

**1. Configuration Setup (Pages 1 and 2 of 4)**

2. Device Diagnostics (Page 3 of 4)

3. Process Variables (Page 4 of 4)

**1. Basic Setup**

2. Device (Page 2)

3.Calibrate (Page 2)

1. Identification
- 1. Tag
- 2. Manufacturer
- 3. Model
- 4. Dev id
- 5. Write protect
- 6. Date
- 7. Descriptor
- 8. Messages
- 9. Final Assembly
  - Poll addr
  - Num resp prems
  - Daniel Industries logo
  - Universal rev
  - Field dev rev
  - Software rev
  - Hardware rev
  - DD rev 1, build 022
  - 34XX Gas USM
  - EPM logo

2. Units
- 1. Volume units → Cum, L, bbl, gal
- 2. Flow rate time units → s, m, h, d
- 3. Velocity units → m/s, ft/s
- 4. Pressure units → Pa, kPa, MPa, psi
- 5. Temperature units → degC, Kelvin, degF

3. AO1
4. AO2 (HART)
- 1. Content → Uncorr volume flow rate
- 2. Direction → Reverse, Forward, Absolute
- 3. Lower range
- 4. Upper range
- 5. Alarm action → (Alarm Action) HIgh - 20mA, Low - 4mA, Hold Last Value, Very Low - 3.5mA, Very High 20.5mA, None

5. Freq & Digital 1
- 1. Frequency Output 1
- 2. Digital Output 1

1. Content → Uncorr volume flow rate; Reverse, Forward, Absolute, Bidirectional
2. Direction
3. B zeroed on error → Not Forced to Zero When Invalid, Forced to Zero When Invalid
4. B phase → Lag Fwd, Lead Rev, Lead Fwd, Lag Rev
5. Max frequency → 1000 Hz, 5000 Hz
6. Lower range
7. Upper range
8. Display K-Factor → K-Factor, Inverse K-Factor

1. CH A content.....Freq1 Validity → Freq1 Validity, Flow Direction → Normal, Inverted
2. CH A porarity.....Normal
3. CH B content.....Freq1 Validity → Freq1 Validity, Flow Direction → Normal, Inverted
4. CH B polarity.....Normal

6. Freq & Digital 2
- 1. Frequency Output 2
- 2. Digital Output 2

1. Content → Uncorr volume flow rate; Reverse, Forward, Absolute, Bidirectional
2. Direction
3. B zeroed on error → Not Forced to Zero When Invalid, Forced to Zero When Invalid
4. B phase → Lag Fwd, Lead Rev, Lead Fwd, Lag Rev
5. Max frequency → 1000 Hz, 5000 Hz
6. Lower range
7. Upper range
8. Display K-Factor → K-Factor, Inverse K-Factor

1. CH A content.....Freq1 Validity → Freq1 Validity, Flow Direction → Normal, Inverted
2. CH A porarity.....Normal
3. CH B content.....Freq1 Validity → Freq1 Validity, Flow Direction → Normal, Inverted
4. CH B polarity.....Normal

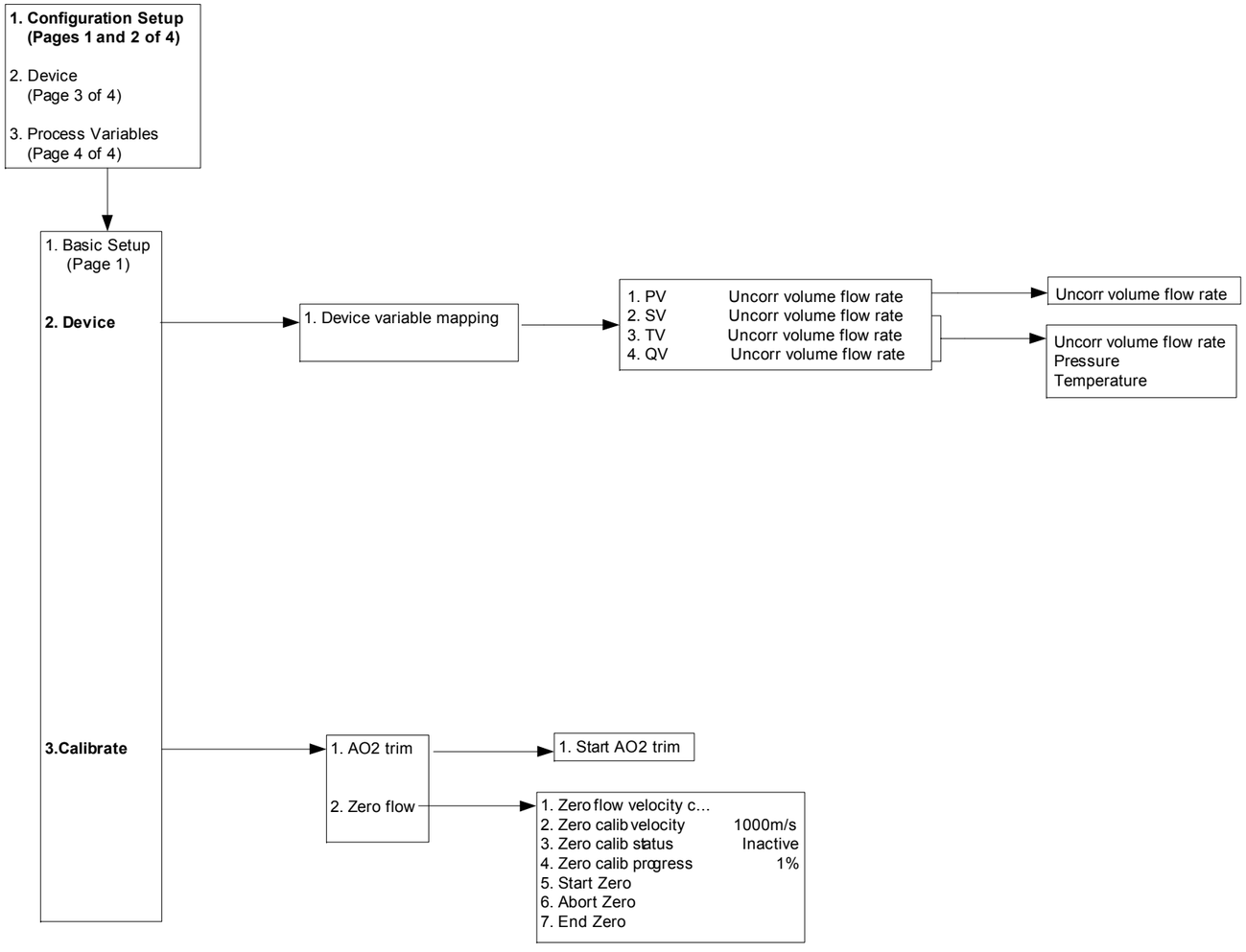
7. Temperature
- 1. Temperature source → Not Used, Live Analog, *Live HART, Fixed
- 2. Live Temperature → 1. Lower range, 2. Upper range
- 3. Fixed Temperature
- 4. Alarm selection → Hold Last Output Value, Use Fixed Value
- 5. Temperature alarm → 1. Low limit, 2. High limit

* Note: Live HART temperature and pressure based on future availability.

8. Pressure
- 1. Pressure source → Not Used, Live Analog, *Live HART, Fixed
- 2. Live Pressure → 1. Lower range, 2. Upper range
- 3. Fixed Pressure
- 4. Alarm selection → Hold Last Output Value, Use Fixed Value
- 5. Pressure alarm
- 6. Pressure type → 1. Gage or Absolute Pressure, 2. Atmospheric Pressure → Gage, Absolute

9. Digital Input
- 1. General Polarity → Normal, Inverted
- 2. Calibration Polarity → DI1 Cal Active High, DI1 Cal Active Low
- 3. Calibration Gating → DI1 Cal Edge Gated, DI1 Cal State Gated

**SHEET 1 0F 4**


1. Configuration Setup
(Pages 1 and 2 of 4)
2. Device
(Page 3 of 4)
3. Process Variables
(Page 4 of 4)
1. Basic Setup
(Page 1)
2. Device
3.Calibrate
1. Device variable mapping
1. PV Uncorr volume flow rate
2. SV Uncorr volume flow rate
3. TV Uncorr volume flow rate
4. QV Uncorr volume flow rate
Uncorr volume flow rate
Uncorr volume flow rate
Pressure
Temperature
1. AO2 trim
2. Zero flow
1. Start AO2 trim
1. Zero flow velocity c...
2. Zero calib velocity 1000m/s
3. Zero calib status Inactive
4. Zero calib progress 1%
5. Start Zero
6. Abort Zero
7. End Zero

1. Configuration Setup
(Pages 1 and 2 of 4)

**2. Device Diagnostics**
**(Page 3 of 4)**

3. Process Variables
(Page 4 of 4)

1. Configuration Setup
(Pages 1 and 2)

**2. Device Diagnostics**

3. Process Variables
(Page 4)

1. Acknowledge
2. Failed
3. Maintenance
4. Advisory

1. Failed
2. Advisory

1. Config lost
2. Core file present
3. Memory error
4. Watchdog Reset

1. A modification has.....OFF
2. Power failure.....OFF

1. Field device has mal.....OFF
2. Acquisition Mode.....OFF
3. Config lost.....OFF
4. View details.....OFF

1. Failed details

1. Device malfuncation

1. Core file present.....OFF
2. Acq board comm e.....OFF
3. Electronics voltage.....OFF
4. Memory error.....OFF
5. Watchdog reset.....OFF
6. Acq board rev unk.....OFF

1. Chord A hard failed
2. Chord B hard failed
3. Chord C hard failed
4. Chord D hard failed
5. PV analog output s...
6. PV analog output fi...
7. Clock invalid
8. Flow pressure inva...
9. Digital pressure inv...
Flow temperature i...
Digital temperature...
Reset required
Key(s) will expire
Key(s) expired
View Details

1. Maintenance Details

1. Chord A hard failed
2. Chord B hard failed
3. Chord C hard failed
4. Chord D hard failed

1. Chord *x* noise exc..
2. Chord x SNR belo...
3. Chord x measurem...
4. Chord x acquisitio...
5. Chord x delta time...
6. Chord x signal qual...
7. Chord x measurem...
8. Chord x detection
9. Chord *x* signal disc...

*Note:*
*x = Chord A, B, C, or D*

5. PV analog output fixed

1. Analog output 2 fixed
2. Analog output 2 tes...

1. A modification has...
2. Power failure
3. Process applied to...
4. Process applied to...
5. Frequency 1 test e...
6. Frequency 2 test e...
7. Measurement valid...
8. Electronics temper...
9. One Or More Logs Full
Analog output 1 fixed
Analog output 1 sat...
HART pressure devi...
HART temperature...
View details

Modification made to configuration
Power failure
PV process out of limits
Non-PV process out of limits
Frequency 1 test enabled
Frequency 2 test enabled
Measurement validity
Electronics temperature range
One or more logs full
Analog output 1 fixed
Analog output 1 saturated
HART pressure device status
HART temperature device status

1. Advisory details

1. Variable out of limits
2. Measurement validity
3. One or more logs full
4. HART pressure transmitter
5. HART temperature transmitter

1. Flow pressure out...
2. Flow temperature...

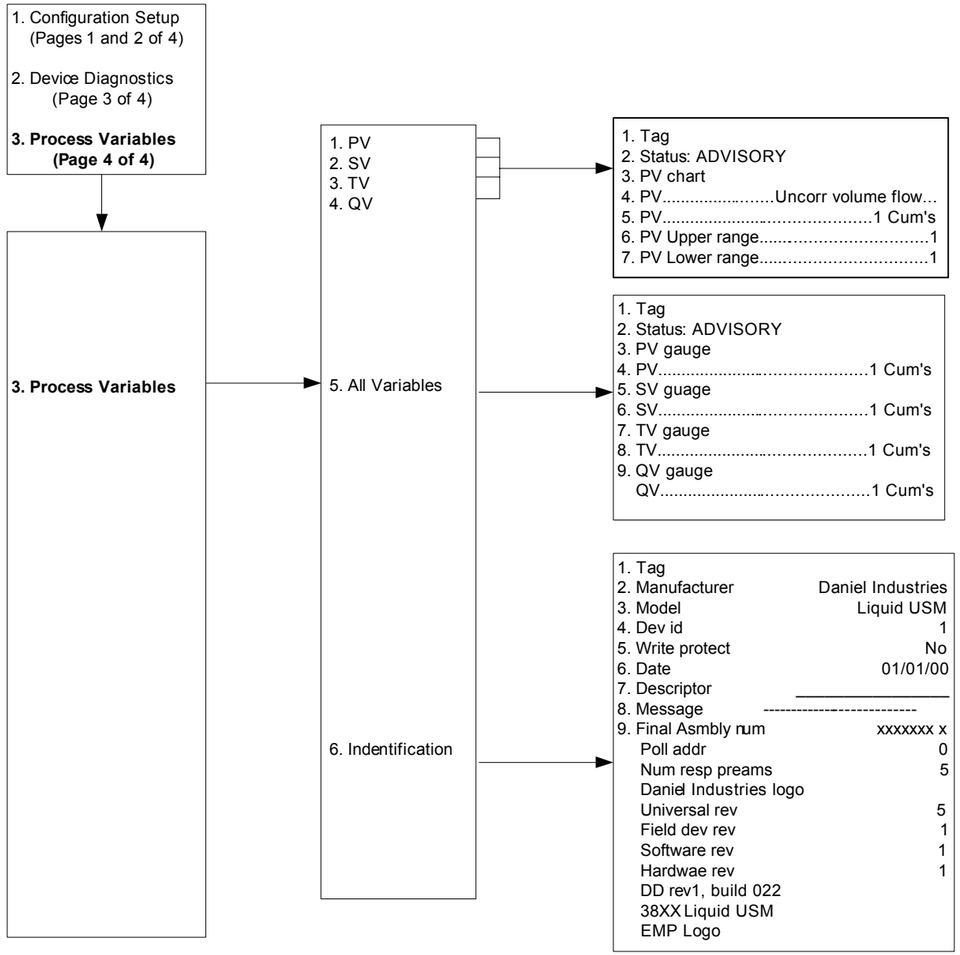
1. Hourly log full
2. Daily log full
3. Audit log full
4. Alarm log full
5. System log full

1. Pressure comm error
2. Pressure device m...
3. Pressure config ch..
4. Pressure cold started
5. Pressure more status
6. Pressure loop curr...
7. Pressure loop curr...
8. Pressure non-PV o...
9. Pressure PV out o...

Pressure loop currenr fixed
Pressure loop current saturated

1. Temperature comm error
2. Temperature device m...
3. Temperature config ch..
4. Temperature cold started
5. Temperature more status
6. Temperature loop curr...
7. Temperature loop curr...
8. Temperature non-PV o...
9. Temperature PV out o...

1. Flow condition vol...
2. Freq 1 validity
3. Freq 2 validity
4. AO1 validity
5. AO2 (HART) validity
6. HART AO2 SV valid...
7. HART AO2 TV valid...
8. HART AO2 QV valid...
9. HART slot 0 val...
HART slot 1 val...
HART slot 2 val...
HART slot 3 val...


1. Configuration Setup
(Pages 1 and 2 of 4)
2. Device Diagnostics
(Page 3 of 4)
3. Process Variables
(Page 4 of 4)
3. Process Variables
1. PV
2. SV
3. TV
4. QV
5. All Variables
6. Indentification
1. Tag
2. Status: ADVISORY
3. PV chart
4. PV.....Uncorr volume flow...
5. PV.....1 Cum's
6. PV Upper range.....1
7. PV Lower range.....1
1. Tag
2. Status: ADVISORY
3. PV gauge
4. PV.....1 Cum's
5. SV guage
6. SV.....1 Cum's
7. TV gauge
8. TV.....1 Cum's
9. QV gauge
QV.....1 Cum's
1. Tag
2. Manufacturer Daniel Industries
3. Model Liquid USM
4. Dev id 1
5. Write protect No
6. Date 01/01/00
7. Descriptor
8. Message
9. Final Asmbly num xxxxxxx x
Poll addr 0
Num resp preams 5
Daniel Industries logo
Universal rev 5
Field dev rev 1
Software rev 1
Hardwae rev 1
DD rev1, build 022
38XX Liquid USM
EMP Logo

# 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.

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# DANIEL MEASUREMENT AND CONTROL, INC. RETURN POLICY FOR WARRANTY AND NON-WARRANTY MATERIAL

Use the following procedure for returning equipment to the Daniel factory in the United States.

### Step 1 Obtaining a RMA Number

***A Return Material Authorization (RMA) number must be obtained prior to returning any equipment for any reason.***

To obtain a RMA number, call the Customer Service Department at 713-827-5033 between 8:00 a.m. and 5:00 p.m. (Central Standard Time), Monday through Friday, except holidays or email daniel.support@emersonprocess.com.

**NOTICE**

**No product returns will be accepted without a RMA number and will be returned at the customer's expense.**

**For warranty consideration, the product must be returned to Daniel within twelve (12) months of the date of original shipment or within eighteen (18) months of the date of original shipment of the product to destinations outside the United States. The Purchaser must prepay any shipping charges**

In addition, the Purchaser is responsible for insuring any product shipped for return, and assumes the risk of loss of the product during shipment.

- The following information is required at the time the RMA is issued:
  - Customer name
  - Contact name
  - Billing address
  - Contact Phone # and email address
  - Daniel SO #, PO #, or Invoice #
  - Item(s) to be returned
  - Reason for return
  - End user and final destination address
  - Consignee's complete name, address, contact name and phone number
- A RMA number is required for each original order. (Example: Two fittings purchased on two separate orders now being returned require two RMA numbers.)

***For product returns from locations outside the United States, Daniel Customer Service personnel will provide additional shipping requirements.***

### Step 2 Cleaning and Decontamination

Prior to shipment, thoroughly clean and decontaminate all equipment removing all foreign substances. This includes all substances used for cleaning the equipment. The cleaning and decontamination requirement applies to any part exposed to process fluids or cleaning substances.

Shipping equipment that has not been decontaminated may be in violation of U.S. Department of Transportation (DOT) regulations. For your reference, the requirements for packaging and labeling hazardous substances are listed in DOT regulations 49 CFR 172, 178, and 179.

If you suspect that a part has been contaminated, the part must be completely drained and flushed to remove contaminants.

**⚠WARNING**

**MAY CAUSE DEATH OR SERIOUS INJURY TO PERSONNEL**

**Contents may be under pressure or materials may be hazardous**

Follow appropriate handling instructions for accessing pressurized equipment. Avoid contact with hazardous materials or contaminated units and parts. Failure to do so may result in death or serious injury.

### Decontamination/Cleaning Statement

A blank Decontamination/Cleaning Statement is provided on the "Returned Material Authorization Repair Form for Used Equipment".

- A Decontamination/Cleaning Statement is required for each returned part.
- Fully complete each form and include a signature. If the decontamination statement is incomplete, the customer may be charged for decontamination and cleaning.

If the equipment has been exposed to a known hazardous substance with any characteristic that can be identified in the Code of Federal Regulations, 40 CFR 261.20 through 261.24, the chemical abstracts number and hazardous waste number/hazard code must be stated in the space provided on the form.

Two (2) copies of each Decontamination/Cleaning Statement must be provided:

- One (1) copy must be attached to the outside of the package.
- One (1) copy must be included inside the package.

### Step 3 Material Safety Data Sheets (MSDS)

Provide a Material Safety Data Sheet (MSDS) with the returned equipment for each substance that has come in contact with the equipment being returned, including substances used for decontamination and cleaning.

***A MSDS sheet is required by law to be available to people exposed to specific hazardous substances***, with one exception: if the equipment has only been exposed to food-grade substances or potable water, or other substances for which an MSDS is not applicable, the Decontamination/Cleaning Statement form alone is acceptable.

Two (2) copies of each MSDS must be provided:

- One (1) copy must be attached to the outside of the package.
- One (1) copy must be provided inside the package.

### Step 4 Packaging

#### Shipping a Device With Possible Contamination

To meet DOT requirements for identifying hazardous substances, ship only one device per package.

#### Shipping a Device Without Any Potential Contamination

Devices being returned may be shipped together in one package, if there is no potential of foreign substance contamination.

### Step 5 Shipping

Before returning used equipment:

- Mark each package clearly with a RMA number.
- Include a Decontamination/Cleaning Statement inside the package.
- Attach a duplicate Decontamination/Cleaning statement to the outside of the package.
- Include a MSDS for each substance that has come in contact with the equipment inside the package.
- Attach a duplicate MSDS to the outside of the package.

**NOTICE**

**No product returns will be accepted without a RMA number and will be returned at the customer's expense.**

**For warranty consideration, the product must be returned to Daniel within twelve (12) months of the date of original shipment or within eighteen (18) months of the date of original shipment of the product to destinations outside the United States. The Purchaser must prepay any shipping charges**

**Ship all * mechanical equipment to the following address:**

Daniel Measurement and Control, Inc.
Attn: Service Dept.
5650 Brittmoore Rd.
Houston, TX 77041
Ref: RMA#_____

*Mechanical equipment includes: Orifice Fittings, Parts, Plates, Seal Rings, Turbine Meters, Control Valves, Provers, Strainers, Meter Tubes, Ultrasonic Meters, Flow Conditioners, etc.

**Ship all * electronic equipment to the following address:**

Daniel Measurement and Control, Inc.
Attn: Service Dept.
11100 Brittmoore Park Drive
Houston, TX 77041
Ref: RMA#_____

*Electronic equipment includes: Gas Chromatographs, Petrocount Presets, Danload Preset, Ultrasonic Meter Electronics (CPU boards, transducers, etc.), 2403 Totalizer, MRT 97 Indicator, Preamps, Pick Up Coils, Prover Interface Boards, and the following Flow Computer Models: 2230, 2239, 2270, 2460, 2470, S100, 2100, and 3000.

# DANIEL MEASUREMENT AND CONTROL, INC.
# RETURNED MATERIAL AUTHORIZATION

## REPAIR FORM FOR USED EQUIPMENT
## INCLUDING DECONTAMINATION/CLEANING STATEMENT

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.**

4. Write the RMA number on the shipping package.

5. Inside the package include one copy of this document and all required Material Safety Data Sheets (MSDS)

6. 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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The sales and service offices of Daniel Measurement and Control are located throughout the United States and in major countries overseas.

Please contact Daniel Measurement Services at 11100 Brittmoore Park Drive, Houston, Texas 77041, or phone (713) 827-6314 for the location of the sales or service office nearest you.

Daniel Measurement Services offers both on-call and contract maintenance service designed to provide single-source responsibility for all Daniel products.



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