HART Protocol Specification

HART Field Communications

Pressure Device Family Specification

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Table of Contents

Table of Figures

1. SCOPE

This Device Family principally allows the configuration of a pressure measurement to be determined. The properties are common to many pressure applications including static pressure, differential pressure (e.g. to measure flow) and liquid level applications.

Pressure transmitters are widely used in the industry. They are very versatile in their application. Many other measurements like flow and level can be derived from pressure measurements. Since pressure transmitters vary from application to application the connection to the process is vital for the proper operation of a device. Therefore special features of the process connections are covered by this specification. This will allow the user to verify via HART whether the process connection of the device fits the requirements of the plant.

This specification does not cover the sensor interface to the electronics, the signal conditioning and the linearization to achieve a desired performance, i.e. accuracy or longterm stability.

The basic pressure configuration is done by Common Practice Commands. The Device Family specific commands deal with the properties of the sensor, the process connection or maximum observations of measurements.

This specification defines a set of Common Practice Commands that a pressure device must support (see Table 1 – Common Practice Commands for Pressure Device Variables for details). Some of these commands are related to the Primary Variable. These commands remain mandatory even if the Pressure Device Variable cannot be mapped to PV.

Another group of mandatory commands is related to the device in general, e.g. resetting the configuration changed flags, performing device reset, trimming the Analog Output Channel 0 or reading the Dynamic Variable assignment.

Command	Implementation
34 – Write PV Damping Value	M
35 – Write PV Range Values	M
36 – Set PV Upper Range Value	M
37 – Set PV Lower Range Value	M
38 – Reset Configuration Changed Flag	M
40 – Enter/Exit Fixed Current Mode	M (1)
42 – Perform Device Reset	M
43 – Set PV Zero	M
44 – Write PV Unit	M
45 – Trim Loop Current Zero	M (1)
46 – Trim Loop Current Gain	M (1)
47 – Write PV Transfer Function	M
50 – Read Dynamic Variable Assignment	M
51 – Write Dynamic Variable Assignment	M (2)
52 – Set Device Variable Zero	M (3)
53 – Write Device Variable Unit	M (3)

54 – Read Device Variable Information	M (3)
55 – Write Device Variable Damping Value	M (3)
80 – Read Device Variable Trim Points	M
81 – Read Device Variable Trim Guidelines	M
82 – Write Device Variable Trim Point	M
83 – Reset Device Variable Trim	M
'M' – Mandatory ; 'M (1)' – Mandatory, unless no Analog Output 0 exists; 'R' – Recommended; 'M (2) – Mandatory if Pressure is mappable; 'M' (3) – Mandatory if Pressure is mappable or not PV	

Table 1 – Common Practice Commands for Pressure Device Variables

The Pressure Device Family has mandatory and recommended commands. However, the developer is not completely free to choose from the recommended commands. There are certain groups of parameters. If one parameter of a group is supported, all other parameters of it become mandatory. If a developer wants that the device can report the number of remote seals connected to it he must also support all other commands and parameters that relate to remote seals. The groups of parameters are: Maximum measurement observation, remote seals and optional gasket materials. One Commands reads the capabilities of the supported features of the Device Family. This enables the host to display and load only the supported parameters.

The approach to write commands differs from the recommended practice in the Device Family Specification. The parameters are written in groups. There are not response codes for all possible wrong combinations of parameters. Instead there is one error response code for every parameter. This will not enable a operator to fix all possible problems in the combination of parameters. He has to fix one after the other. Since most of the parameters are only stored in a device and most pressure devices do not have a method to verify the parameters this will normally not cause problems.

For pressure transmitters that support this Device Family should implement all recommended commands besides the mandatory . This includes the write commands since these parameters can easily be changed by a user. See Table 2 – Pressure Device Family Commands for details. If a temperature or absolute pressure measurement for compensating the pressure value is not used or disclosed the maximum observations must not be supported.

Other devices that support this family as one of their measurements must only implement the mandatory commands though they are encouraged to implement the recommended commands if they are applicable.

Command	**Implementation**
1280 – Read Pressure Status	M
1281 – Read Capabilities	M
1282 – Read Supported Status Mask	M
1283 – Read Pressure Sensor Information	M
1284 – Read Process Connection	M
1285 – Read Associated Device Variables	M
1286 – Read Optional Gasket Material Data	R

1287 – Read Maximum Pressure Observation	R
1288 – Read Maximum Temperature Observation	R (1)
1289 – Read Maximum Static Pressure Observation	R (1)
1290 – Read Remote Seal Information	R
1408 – Write Process Connection	R
1409 – Write Optional Gasket Material Data	R
1410 – Write Remote Seal Information	R
'M' – Mandatory ; 'M (1)' – Mandatory, unless no Analog Output 0 exists; 'R' – Recommended; 'R (1)' – Recommended, unless no such measurement is taken	

Table 2 – Pressure Device Family Commands

Devices that measure multiple pressure values, e.g. measuring differential pressure and absolute pressure to compensate a flow measurement, would have multiple Pressure Device Family Variables. If the pressure is applied through the same process connection it is recommended that only one of the Device Variables uses the Pressure Device Family Commands. In the case of measuring differential pressure and absolute or gauge pressure to compensate flow or level calculations the differential pressure measurement must support the Device Family Commands.

If a developer wants that all pressure device variables belong to the Pressure Device Family but the pressure sensors share the same connection to the process only one of the Pressure Device Family Variables must support the write commands. In such a case the response code 8 – "Other Device Variable's Information updated/overwritten" is returned if the write command resulted in a change of parameters to indicate to a host that the data for other Pressure Device Family Variables have been changed.

2. REFERENCES

2.1 HART Field Communications Protocol Specifications

These documents published by the HART Communication Foundation are referenced throughout this specification:

HART Field Communications Protocol Specification. HCF_SPEC-12

Command Summary Specification. HCF_SPEC-99

Common Practice Command Specification HCF_SPEC-151

Device Families Command Specification. HCF_SPEC-160

Common Tables Specification. HCF_SPEC-183

Command Response Code Specification. HCF_SPEC-307

2.2 Related HART Documents

The HART Protocol Specifications frequently reference the manufacturers' device-specific document. Device-specific documents are developed and controlled by the respective manufacturer and should follow the requirements of the following HART Communication Foundation document:

Requirements for Device Specific Documentation. HCF_LIT-18

2.3 Related Documents

The following documents provide background information relevant to pressure measurement and this device family:

IEC 61518 - Mating, dimensions between differential pressure (type) measuring instruments and flanged-on shut-off devices up to 413bar (41,3MPa)

DIN EN 60770 - 1 - Transmitters for use in industrial process control systems – Part 1: Methods for performance evaluation (IEC 60770 – 1)

DIN EN 764 – Pressure equipment – Terminology

NE 80 – The Application of the Pressure Equipment Directive to Process Control Instruments (NAMUR recommendation)97/23/EG – Pressure Equipment Directive

97/23/EG – Pressure Equipment Directive

3. DEFINITIONS, SYMBOLS AND ACRONYMS

Terms used in this document and defined in *HART Field Communications Protocol Specification* include: Delayed Response, Delayed Response Mechanism, Device Variable, Busy, DR_CONFLICT, DR_DEAD, DR_INITIATE, DR_RUNNING, Floating Point, Request Data Bytes, Response Data Bytes, Response Message, Units Code

Device Family, or Device Family Specification — The definition of the properties, diagnostics and commands required to manage a Device Variable. The Device Family specification includes all the mandatory and optional properties necessary to configure the corresponding class of process connections.

4. PRESSURE DEVICE FAMILY - OVERVIEW

4.1 Pressure signal processing

Pressure is a important measurement in many different applications of the process industry. Often it is used to derive other quantities such as level, volume or flow. These secondary quantities are not covered in this document. Other Device Families will apply (e.g. hydrostatic level). If the device should be able to report them additional Device Families must be incorporated.

Figure 1 - Pressure Device Family Diagram illustrates a typical pressure device family diagram. It is a simplified view because the scope of this document is to use this diagram to show the benefits of using device family definitions for implementing of devices. But it can be used as a guideline for implementation of a pressure device. Other points should be considered when you are implementing a pressure device. It normally contains others modules like as an end-user characterization, ranging, current trim and converter, etc.

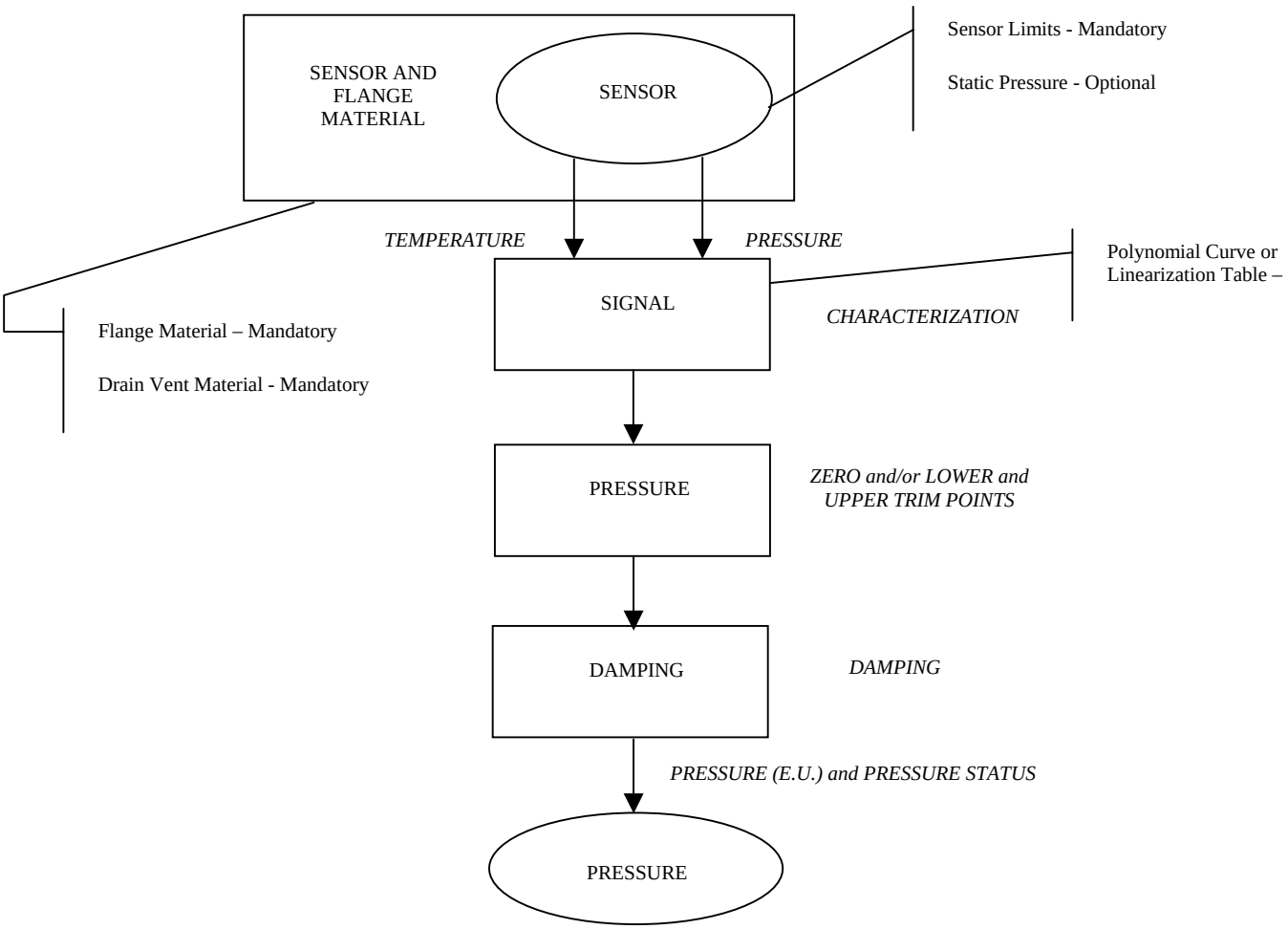

Figure 1 - Pressure Device Family Diagram

As you can see, the first module is the **Sensor** module. It contains information regarding to the transducer module like related parameters to sensor limit, static pressure and temperature.

Also there is an associated module called **Sensor and Flange Material** containing information about the technology and the sensor materials applied to the pressure transducer. It also might contain information related to flange, drain vent, fluid, diaphragm, remote seals, etc. This module describes specific parts related to the sensor type, range and application. These parts also are called dry and wet parts because they can be in contact with the process.

There are a lot of options in terms of materials that are described by tables and parameters included in this document.

The **Signal Conditioning** module should contain hardware and software components necessary for conditioning and filtering signals necessary for pressure measurement. It might contain optional and manufacture-specific parameters like coefficients for sensor's response characterization. It can be done by following a specific table (strapping table) or a polynomial curve. Basically, it generates a raw value proportional to pressure but corrects the sensor's non-linearity. It is normally a device-specific implementation and it should be configured at factory.

The **Pressure Trim** module corrects the transmitter pressure output by applying pressure references for Zero or Lower and Upper Trim Points. The trim adjust can also be used to correct the device response due long term drift, zero drift caused by installation problems, overpressure, aging, etc. Remember that it is very important to use a very accurate source reference for pressure.

The **Damping** module is a low pass filter with an adjustable time constant. It is used to smooth noisy signals. The Damping value is the time required for the output reaching 63.3% for a step input of 100%.

4.2 Pressure Transducer Module – Description

For illustration purpose only, we are using Figure 2 - Pressure Transducer Module - Exploded View to show a typical pressure transducer module. It represents a typical pressure transducer based on capacitive sensor technology. This illustration shows a conventional flange type configuration (without remote seals) for differential pressure measurement.

It might be necessary to keep some information about how each sensor configuration was assembled before it leaves the manufacturing facility. This information is kept in the sensor module or main board memory and it can be read or written by HART commands. Some of them are mandatory and others are optional. Also they can be implemented according to the device family standard

definitions. Other information like the sensor characterization or read only parameters like sensor technology will require device specific or factory commands to write them during manufacturing.

This document describes in details the commands and the parameters defined by the device family for pressure devices.

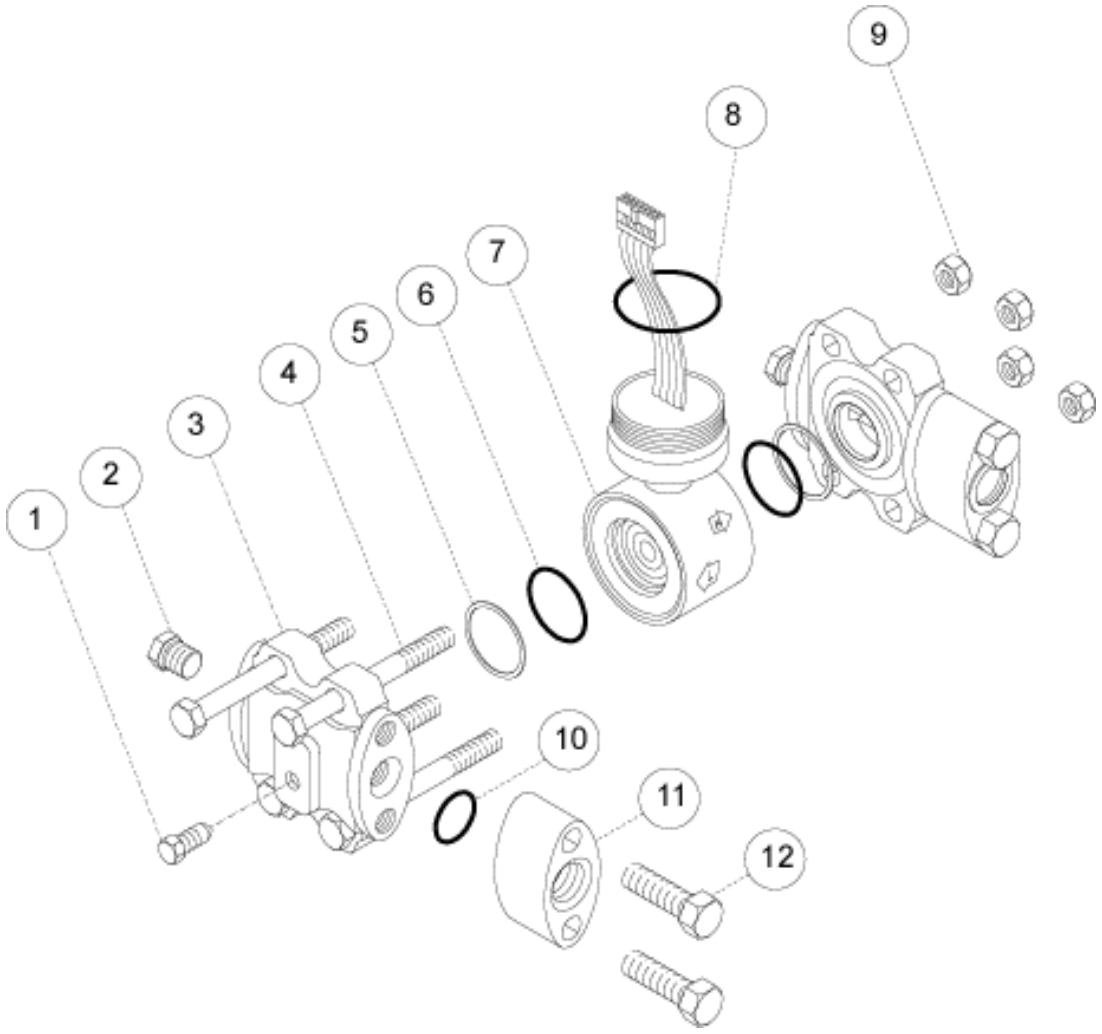

Figure 2 - Pressure Transducer Module - Exploded View

These parts are described by Table 3 - Pressure Transducer Module - Description of Parts. Each part listed below can be found in different materials and various options depending on the process, application and sensor type.

PARTS #	DESCRIPTION
1	Drain / Vent Screw
2	Flange Plug (Stopper)
3	Flange
4	Flange Bolt
5	Backup Gasket (typically an O'Ring, not necessary in some constructions)
6	Flange Gasket (typically an O'Ring)
7	Sensor
8	Neck Gasket (typically an O'Ring)
9	Flange Nut
10	Adapter Gasket (typically an O'Ring)
11	Adapter
12	Adapter Bolt
13	Process Connection Thread (normally only used in Gage Pressure Cells, see Table: Process Connection Thread)
14	Flange Mounting Thread (inside of Adapter 11 or Flange 3, see Table: Mounting Thread)

Table 3 - Pressure Transducer Module - Description of Parts

Devices that have more than one Pressure Device Variable connected through the same process connection and remote seals (variables readable with commands 1284, 1286 and 1290) shall have only one set of variables to store this information.

Shared process connections between different Device Variables are indicated with Command 1291. This reduces the memory requirement on simple hosts since it is not necessary for them to store the information twice or more. A host can also resolve the problem that arises if the process connection is identical for two device variables. If a host did not know that two variables are using the same process connection the consistency of its data base cannot be guaranteed. The host must either assume that there are two different process connections or must always reload all process connection data from all device variables after changing one item because the host does not know whether it changed another process connection. This command enables hosts to optimize their memory usage and to reduce the number of transactions used to keep their device data base up to date.

4.3 Ranging Commands for PV

If the Pressure Device Variable can be mapped to PV the Command 35 – Write PV Range Values, #36 Set PV Upper Range Value, #37 Set PV Lower Range Value and #47 - Write PV Transfer Function must be supported.

It must be possible that the Upper Range Value can be below the Lower Range Value. This will result in an inverse characteristic of the Analog Output.

It is also necessary that at least the Linear and the Square Root Transfer Function (Code 0x00 and 0x01) are supported. The Square Root Function is employed when a simple differential pressure transmitter is used to measure flow. The flow rate is proportional to the square root of the percent of range. If this function is activated the device will still report the pressure but the current will be proportional to the flow rate.

The Square Root Function shall be symmetric to the origin, i. e. the function is determined by the following formula: $y = \text{sgn}(x) * \sqrt{|x|}$. This definition prevents problems with a negative argument and enables a flow measurement in the opposite direction even though the accuracy might be reduced.

More sophisticated pressure transmitters will have additional function blocks that can compensate additional conditions such as temperature, density of the medium or totalize flow measurement. This is not part of the Pressure Device Family Specification.

HART Command #2 transmits the PV Percent of Range. For the purpose of flow measurements the Percent of Range is taken after applying the Transfer Function. In such an application the Percent of Range will reflect the Percent of Flow.

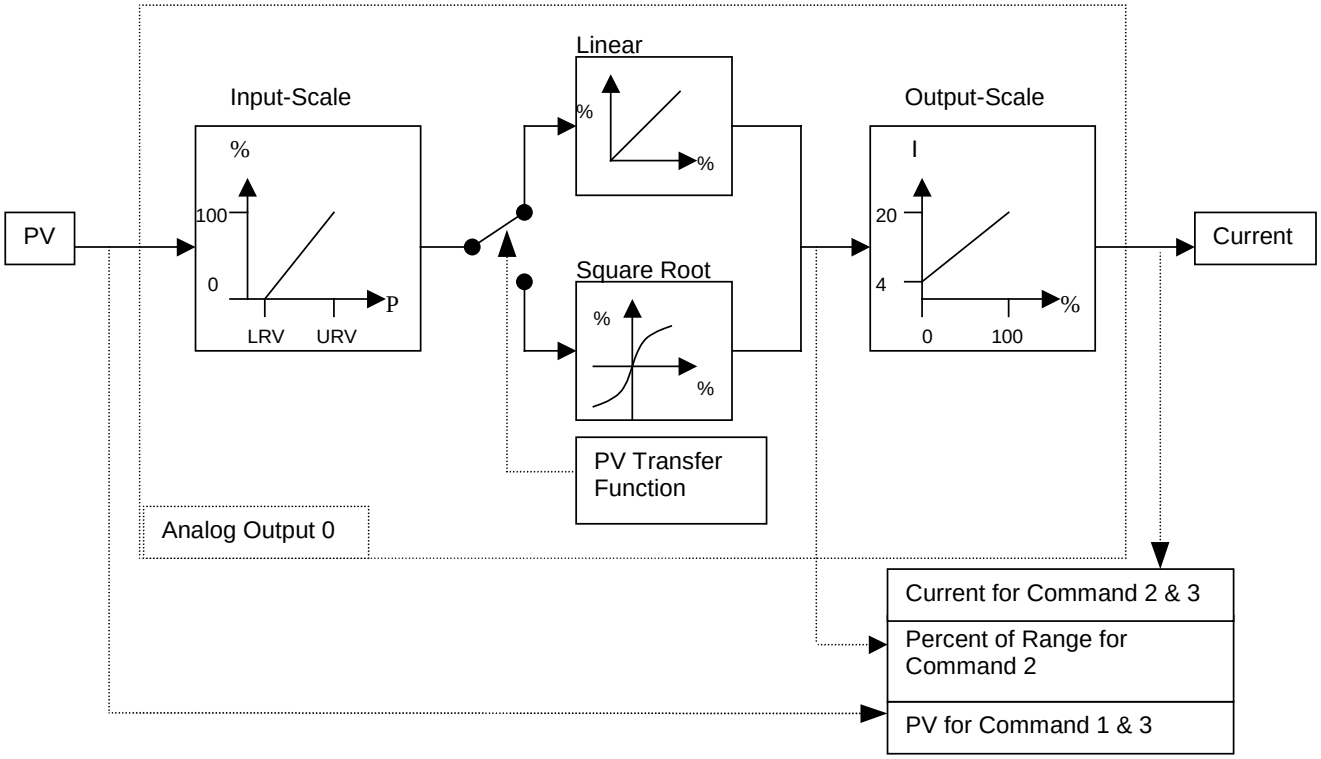

Figure 3 – Analog Output (4 – 20mA Example)

4.4 Example Pressure Devices

The following examples are intended to show the application of the Pressure Device Family. The form that is given shall not restrict the application of this Device Family. Device Developer might use the examples as guidelines.

4.4.1 Simple Pressure Transmitter

An example simple pressure transmitter contains a Device Variable Pressure that is mapped to PV and a cell temperature that is mapped to SV. The Device has a standard 4-20mA current loop connection to the DCS. The Transfer Function can be linear or square root. This simple pressure transmitter example will not record the maximum and minimum observations of either pressure or cell temperature or use additional gasket material information or remote seal information.

The block diagram of a simple pressure transmitter is shown in Figure 4 - Simple Pressure Transmitter.

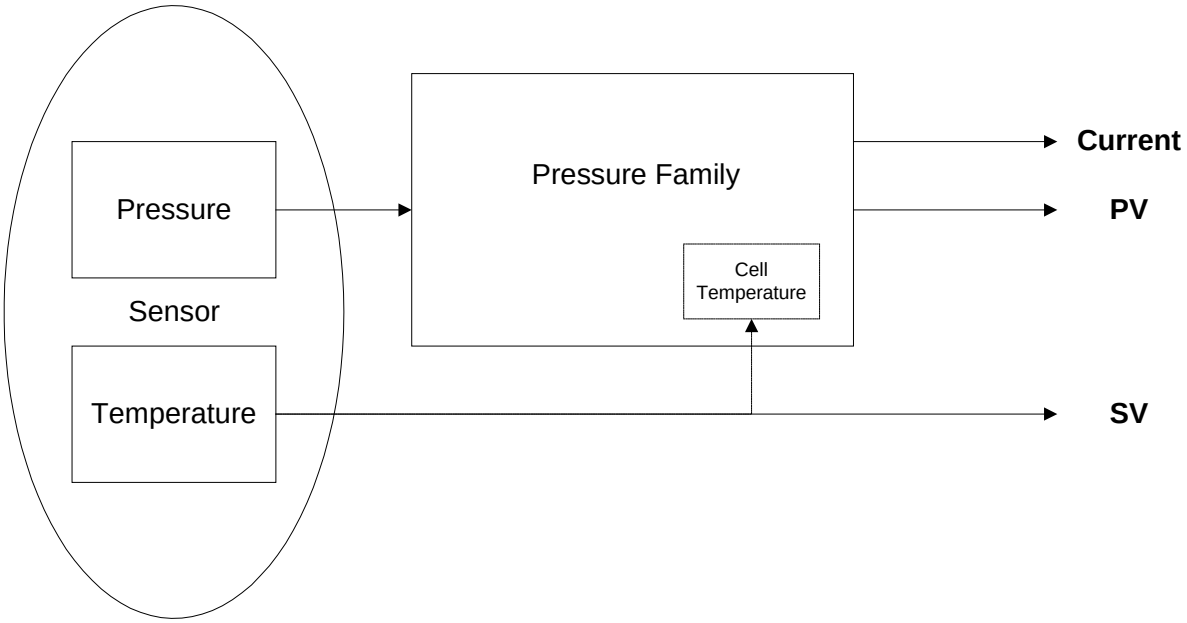

Figure 4 - Simple Pressure Transmitter

The cell temperature will usually not belong to the Temperature Device Family since the sensor and its properties are not configurable and cannot be changed by an end user because it is located in the measuring cell.

Device Variable Properties:

DV Code	Description	DV Class	DV Family	Mappable
0	Pressure	Pressure	Pressure	No
1	Cell Temperature	Temperature	None	No

Mandatory Commands (Universal Commands are not included since they are mandatory regardless of Device Families):

Common Practice Commands:

34, 35, 36, 37, 38, 40, 42, 43, 44, 45, 46, 47, 50, 80, 81, 82, 83 for DV Code 0.

Device Family Commands:

1280, 1281, 1282, 1283, 1284, 1285

Many pressure transmitters today offer this kind of support (some offer in addition an electronics temperature) along with gasket material and remote seal information. However, only device specific

commands are used. For such transmitters support for the Pressure Device Family should be fairly simple to implement.

4.4.2 Flow Transmitter using Pressure Device Family

A more complex example is a dP Pressure transmitter that measures the differential pressure, cell temperature and static pressure. It contains a function blocks for calculating flow and a totalizer. This example focuses on the use of the pressure device family in such a device. The device families for flow and totalizer are not covered by this spec. The block diagram of such a device is shown in Figure 5 - Flow Transmitter using Pressure Device Family.

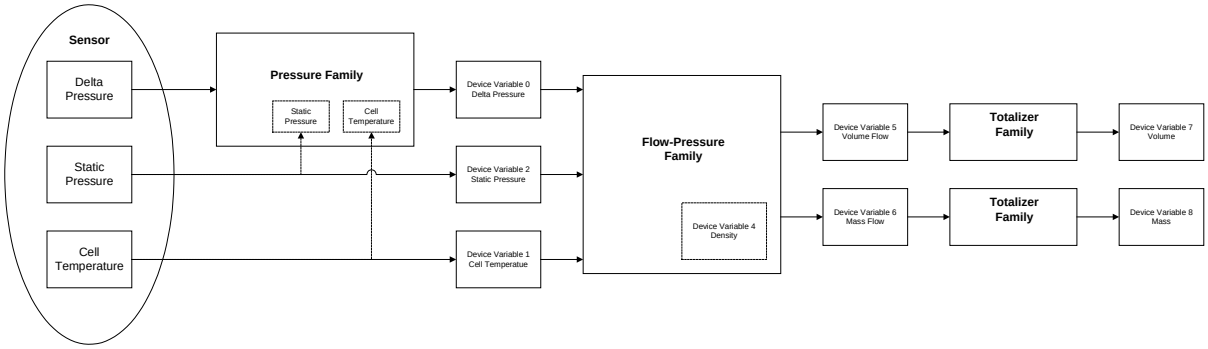

Figure 5 - Flow Transmitter using Pressure Device Family

The device uses the cell temperature and static pressure measurement to compensate the differential pressure at an orifice plate. All three measurements are then used by the flow function block to calculate the volumetric and mass flow. Both of them can then be totalized by seperate totalizer function blocks. Since such a device can either be used for pressure or flow measurements it should support the mapping mechanism for Device Variables. The end user can then configure the device for his application by remapping the Device Variable that is connected to Analog Channel 0. It is at least desirable to map Pressure, Volumetric or Mass Flow to PV.

A more complex device may also incorporate function blocks for Level and Volume measurement.

Device Variable Properties:

DV Code	Description	DV Class	DV Family	Mappable
0	Pressure	Pressure	Pressure	Yes
1	Cell Temperature	Temperature	None	Yes
2	Static Pressure	Pressure	Pressure	Yes
3	Volumetric Flow	Volumetric Flow	None	Yes

4	Mass Flow	Mass Flow	None	Yes
5	Volume	Volume	Totalizer	Yes
6	Mass	Mass	Totalizer	Yes

Mandatory Commands (Universal Commands are not included since they are mandatory regardless of Device Families):

Common Practice Commands:

34, 35, 36, 37, 38, 40, 42, 43, 44, 45, 46, 47, 50, 51, 52, 53, 54, 55 80, 81, 82, 83 for DV Code 0.

Device Family Commands:

1280, 1281, 1282, 1283, 1284, 1285, 1286, 1287, 1288, 1289, 1290, 1408, 1409, 1410

4.4.3 Valve with Pressure Transmitter

This is an example where a valve also incorporates a pressure measurement to control the flow in a pipe independent of a control system. The device can contain a PID controller (e.g. PID Device Family), a valve block and a Pressure Device Family variable.

The pressure cannot be mapped to PV. Such a device can be used for local flow control in a pipe. The flow is measured by the pressure sensor with a orifice plate. This is used as the measured value of the PID controller. The PID controller receives the setpoint from the current loop. The manipulated value – derived from the PID control algorithm – is internally connected to the target position of the valve controller which will open or close the valve that controls the flow through the pipe. Thus a closed loop control for the flow in the pipe is achieved locally.

Device Variable Properties:

DV Code	Description	DV Class	DV Family	Mappable
0	Setpoint for Flow	0	PID	No
1	Measured Value	0	PID	No
2	Manipulated Value	0	PID	No
3	Pressure	Pressure	Pressure	No
4	Flow	Volumetric Flow	None	No

5	Valve Setpoint	0	Positioner	No
6	Target Position	0	Positioner	No
7	Actual Position	0	Positioner	No
8	Back calculation	0	Positioner	No

Mandatory Commands (Universal Commands are not included since they are mandatory regardless of Device Families):

Common Practice Commands:

34, 35, 36, 37, 38, 40, 42, 43, 44, 45, 46, 47, 50, 52, 53, 54, 55, 80, 81, 82, 83 for DV Code 3.

Device Family Commands:

1280, 1281, 1282, 1283, 1284, 1285

5. COMMANDS

5.1 Response Code 8 in Write Commands

All Write Commands include the Response Code 8 – Other Device Variable's Information Updated / Overwritten. Field Devices will return this value if more than one Pressure Family Device Variable is available and shares the same information with others. Such a Field Device will only store one set of information (Process Connection, Optional Gasket Material, Remote Seal Information). It can be modified by all Pressure Device Family Commands for these Device Variables. If a Field Device has only one Pressure Device Family Variable it must never issue this response code.

If a host sees this response code for a write command it should update its database, i.e. it should reread the respective data items for every other Device Variable belonging to the Pressure Device Family.

5.2 Command 1280 Read Pressure Status (Mandatory)

All Device Families allow additional status information to be provided to host applications. This Device Family Status is in addition to the Device Variable Status information provided with all Device Variables and Dynamic Variables.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Bits	Device Family Device Variable Status (see Table: Pressure Device Family Device Variable Status)
2	Bits	Pressure Status 0 (see Table: Pressure Status 0)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3 – 4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7 – 15		Undefined

Code	Class	Description
16	Error	Access Restricted
17 -127		Undefined

5.3 Command 1281 Read Capabilities (Mandatory)

This command reads the capabilities of the optional parameters. Thus a master can know whether a device supports optional functions of this Pressure Device Family.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Unsigned-8	Family Definition Revision
2	Bits	Pressure Family Capabilities 0 (see Table: Pressure Family Capabilities 0)
3	Bits	Pressure Family Capabilities 1 (see Table: Pressure Family Capabilities 1)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3 - 4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7 - 15		Undefined
16	Error	Access Restricted
17 -127		Undefined

5.4 Command 1282 Read Supported Status Mask (Mandatory)

This command reports which bits of the Device Variable Status can be set by the device. It is possible that not all possible features are supported or are possible at all for certain implementations.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Bits	Supported Device Variable Family Status Bit Mask
2	Bits	Supported Pressure Status 0 Bit Mask (see Table: Pressure Status 0)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3 - 4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7 - 15		Undefined
16	Error	Access Restricted
17 -127		Undefined

5.5 Command 1283 Read Pressure Sensor Information (Mandatory)

Since the pressure Sensor Information is usually set by the manufacturer. No write command for these properties are defined in the Pressure Device Family. However, a manufacturer should be aware that it must be possible to set the values in the factory by means of Device Specific Commands.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Enum	Pressure Measurement type (see Table: Pressure Measurement Types)
2	Enum	Module Fill Fluid (see Table: Fill Fluids)
3	Enum	Diaphragm Material (see Common Tables Material Codes)
4	Unsigned-8	Sensor Hardware Revision
5	Enum	Sensor Technology (see Table: Sensor Technology)
6	Enum	Pressure Unit (see Common Tables Pressure Unit Code Table)
7 – 10	Float	Minimum Absolute Pressure
11 – 14	Float	Maximum Static Pressure

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3 - 4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7 - 15		Undefined
16	Error	Access Restricted
17 -127		Undefined

5.6 Command 1284 Read Process Connection (Mandatory)

This command reads the mandatory parameters for the process connection.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Enum	Flange Type (see Table: Flange Types)
2	Enum	Flange Material (see Common Tables Material Codes)
3	Enum	Flange Gasket Material (see Common Tables Material Codes)
4	Enum	Bolts Material (see Common Tables Material Codes)
5	Enum	Nuts Material (see Common Tables Material Codes)
6	Enum	Drain Vent Material (see Common Tables Material Codes)
7	Enum	Drain Vent Position (see Table: Drain Vent Position)
8	Enum	Process Connection Thread (see Table: Process Connection Thread)
9	Enum	Mounting Thread (see Table: Mounting Thread)
10	Enum	Pressure Measurement Application (see Table: Pressure Measurement Application)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3 - 4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7 - 15		Undefined
16	Error	Access Restricted
17 -127		Undefined

5.7 Command 1285 Read Associated Device Variables (Mandatory)

This command returns the Device Variable Codes for the measurements that are associated, i.e. that are necessary for the compensation, with the pressure. The typical measurements are sensor temperature and static pressure. If the associated measurement is not disclosed as Device Variable or is not necessary for the compensation 250 – none will be returned.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Unsigned-8	Associated Cell-Temperature Measurement (Device Variable No)
2	Unsigned-8	Associated Static Pressure Measurement (Device Variable No)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3 - 4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7 - 15		Undefined
16	Error	Access Restricted
17 -127		Undefined

5.8 Command 1286: Read Optional Gasket Material Data (Optional, Mandatory if supported feature)

This command reads the optional Gasket Material if they are supported.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Enum	Backup-Gasket-Material (see Common Tables Material Codes)
2	Enum	Adapter Gasket Material (see Common Tables Material Codes)
3	Enum	Neck Gasket Material (see Common Tables Material Codes)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3 - 4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7 - 15		Undefined
16	Error	Access Restricted
17 -127		Undefined

5.9 Command 1287: Read Min/Max Pressure Observation (Optional, Mandatory if supported feature)

These values are intended to show the maximum and minimum pressure the device experienced during its lifetime. They can be utilized by the customer, e.g. to optimize the process or diagnosis.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Enum	Pressure Unit
2 – 5	float	Minimum Pressure
6 – 9	Float	Maximum Pressure

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3 - 4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7 - 15		Undefined
16	Error	Access Restricted
17 -127		Undefined

5.10 Command 1288: Read Min/Max Temperature Observation (Optional, Mandatory if supported feature)

These values are intended to show the maximum and minimum temperature the device experienced during its lifetime. They can be utilized by the customer, e.g. to optimize the process or diagnosis.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Enum	Temperature Unit
2 – 5	float	Minimum Temperature
6 – 9	Float	Maximum Temperature

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3 - 4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7 - 15		Undefined
16	Error	Access Restricted
17 -127		Undefined

5.11 Command 1289: Read Min/Max Static Pressure Observation (Optional, Mandatory if supported feature)

These values are intended to show the maximum and minimum static pressure the device experienced during its lifetime. They can be utilized by the customer, e.g. to optimize the process or diagnosis.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Enum	Static Pressure Unit

Byte	Format	Description
2 – 5	float	Minimum static Pressure
6 – 9	Float	Maximum static Pressure

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3 – 4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7 – 15		Undefined
16	Error	Access Restricted
17 -127		Undefined

5.12 Command 1290: Read Remote Seal Information (Optional, Mandatory if supported feature)

This command reads the Remote Seal Information if they are supported.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Enum	Number of Remote Seals (see Table: Number of Remote Seals)
2	Enum	Remote Seal 1 Type (see Table: Seal Types)
3	Enum	Remote Seal 1 Diaphragm Material (see Common Tables Material Codes)

Byte	Format	Description
4	Enum	Remote Seal 1 Fill Fluid (see Table: Fill Fluids)
5	Enum	Remote Seal 2 Type (see Table: Seal Types)
6	Enum	Remote Seal 2 Diaphragm Material (see Common Tables Material Codes)
7	Enum	Remote Seal 2 Fill Fluid (see Table: Fill Fluids)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3 – 4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7 – 15		Undefined
16	Error	Access Restricted
17 –127		Undefined

5.13 Command 1408 Write Process Connection (Optional, Mandatory if supported feature)

Should a device check the configuration of the process connection it should start with parameter 1 (Flange Type) and work sequentially through the following parameters. This is supported by the response codes. Usually this is not checked since a customer can change the process connection even to types that are not shipped by a manufacturer.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)
1	Enum	Flange Type (see Table: Flange Types)
2	Enum	Flange Material (see Common Tables Material Codes)
3	Enum	Flange Gasket Material (see Common Tables Material Codes)
4	Enum	Bolts Material (see Common Tables Material Codes)

Byte	Format	Description
5	Enum	Nuts Material (see Common Tables Material Codes)
6	Enum	Drain Vent Material (see Common Tables Material Codes)
7	Enum	Drain Vent Position (see Table: Drain Vent Position)
8	Enum	Process Connection Thread (see Table: Process Connection Thread)
9	Enum	Mounting Thread (see Table: Mounting Thread)
10	Enum	Pressure Measurement Application (see Table: Pressure Measurement Application)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Enum	Flange Type
2	Enum	Flange Material
3	Enum	Flange Gasket Material
4	Enum	Bolts Material
5	Enum	Nuts Material
6	Enum	Drain Vent Material
7	Enum	Drain Vent Position
8	Enum	Process Connection Thread
9	Enum	Mounting Thread
10	Enum	Pressure Measurement Application (see Table: Pressure Measurement Application)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3 - 4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7		Undefined

Code	Class	Description
8	Warning	Other Device Variable's Process Connection Updated / Overwritten
9 – 15		Undefined
16	Error	Access Restricted
	Error	Illegal Flange Type
	Error	Illegal Flange Material
	Error	Illegal Flange Gasket Material
	Error	Illegal Bolts Material
	Error	Illegal Nuts Material
	Error	Illegal Drain Vent Material
	Error	Illegal Drain Vent Position
	Error	Illegal Process Connection Thread
	Error	Illegal Mounting Thread
17 -127		Undefined

5.14 Command 1409: Write Optional Gasket Material (Optional, Mandatory if supported feature)

This Command writes optional Gasket Material. The Manufacturer should only allow to change an item if a customer can change it.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code (see Device Variable Codes Table in appropriate device-specific document)
1	Enum	Backup Gasket Material (see Common Tables Material Codes)
2	Enum	Adapter Gasket Material (see Common Tables Material Codes)
3	Enum	Neck Gasket Material (see Common Tables Material Codes)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Enum	Backup Gasket Material (see Common Tables Material Codes)

Byte	Format	Description
2	Enum	Adapter Gasket Material (see Common Tables Material Codes)
3	Enum	Neck Gasket Material (see Common Tables Material Codes)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3 - 4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7		Undefined
8	Warning	Other Device Variable's Optional Gasket Material Data Updated / Overwritten
9 – 15		Undefined
16	Error	Access Restricted
	Error	Illegal Backup Gasket Material
	Error	Illegal Adapter Gasket Material
	Error	Illegal Neck Gasket Material
17 –127		Undefined

5.15 Command 1410: Write Remote Seal Information (Optional, Mandatory if supported feature)

This command writes the Remote Seal Information if they are supported. Note: A Device is not required to check whether the incoming data is correct, this is the responsibility of the configuration tool.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code

Byte	Format	Description
1	Enum	Number of Remote Seals (see Table: Number of Remote Seals)
2	Enum	Remote Seal 1 Type (see Table: Seal Types)
3	Enum	Remote Seal 1 Diaphragm Material (see Common Tables Material Codes)
4	Enum	Remote Seal 1 Fill Fluid (see Table: Fill Fluids)
5	Enum	Remote Seal 2 Type (see Table: Seal Types)
6	Enum	Remote Seal 2 Diaphragm Material (see Common Tables Material Codes)
7	Enum	Remote Seal 2 Fill Fluid (see Table: Fill Fluids)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code
1	Enum	Number of Remote Seals (see Table: Number of Remote Seals)
2	Enum	Remote Seal 1 Type
3	Enum	Remote Seal 1 Diaphragm Material
4	Enum	Remote Seal 1 Fill Fluid
5	Enum	Remote Seal 2 Type
6	Enum	Remote Seal 2 Diaphragm Material
7	Enum	Remote Seal 2 Fill Fluid

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
3 – 4		Undefined
5	Error	Too Few Data Bytes Received
6	Error	Device-Specific Command Error
7		Undefined
8	Warning	Other Device Variable’s Remote Seal Information Updated / Overwritten

Code	Class	Description
9 – 15		Undefined
16	Error	Access Restricted
	Error	Illegal Number of Remote Seals
	Error	Illegal Remote Seal 1 Type
	Error	Illegal Remote Seal 1 Diaphragm Material
	Error	Illegal Remote Seal 1 Fill Fluid
	Error	Illegal Remote Seal 2 Type
	Error	Illegal Remote Seal 2 Diaphragm Material
	Error	Illegal Remote Seal 2 Fill Fluid
17 –127		Undefined

6. PRESSURE DEVICE FAMILY TABLES

6.1 Table: Pressure Device Family Device Variable Status

The following table shows the assignment of the bits in the Pressure Device Family Device Variable Status:

Bit	Measurement
0x01	Reserved
0x02	Reserved
0x04	Reserved
0x08	More Device Variable Status Available
0x10	Limit Status:
0x20	11 Constant (i.e. value cannot be changed by the process)
	01 Low Limited (e.g. A/D Converter has reached its lower limit)
	10 High Limited (e.g. A/D Converter has reached its upper limit)
	00 Not limited
0x40	Process Data Status:
0x80	11 Good
	01 Poor accuracy (e.g. value is beyond rated pressure, temperature outside range)
	10 Manual / Fixed (e.g. value is simulated or forced)

6.2 Table: Pressure Status 0

Note: If a Pressure Sensor Break (0x01) is reported and the device has no backup the Pressure Device Variable Status must become “Bad”. If an Associated Device Variable (Temperature or Static Pressure) has a broken sensor (0x02 or 0x04) without backup the Pressure Device Variable Status can either become “Poor Accuracy” or “Bad”.

If any operating range of the measurements is exceeded it is up to the device manufacturer to decide whether the Pressure Device Variable is still accurate (Status: “Good”).

The Bits 0x10, 0x20 and 0x40 which report that a measurement is outside the rated operating range will be set and reset by the device according to current value of the respective variables.

Bit	Measurement
0x01	Pressure Sensor Break
0x02	Temperature Sensor Break
0x04	Static Pressure Sensor Break
0x08	Pressure Calibration Required

Bit	Measurement
0x10	Pressure Operating Range Exceeded
0x20	Temperature Operating Range Exceeded
0x40	Static Pressure Operating Range Exceeded
0x80	Reserved

6.3 Table: Pressure Family Capabilities 0

If a bit is set it indicates that a certain set of commands and parameters are supported by the device.

Bit	Capability
0x01	Maximum Pressure Observations: Command 1287: Read Min/Max Pressure Observation (Optional, Mandatory if supported feature) is supported
0x02	Maximum Temperature Observations: Command 1288: Read Min/Max Temperature Observation (Optional, Mandatory if supported feature) is supported
0x04	Maximum Static Pressure Observations: Command 1289: Read Min/Max Static Pressure Observation (Optional, Mandatory if supported feature) is supported
0x08	Optional Gasket Materials: Command 1286: Read Optional Gasket Material Data (Optional, Mandatory if supported feature) is supported
0x10	Remote Seal Information: Command 1290: Read Remote Seal Information (Optional, Mandatory if supported feature) is supported
0x20	Write Process Connection: Command 1408 Write Process Connection (Optional, Mandatory if supported feature) is supported
0x40	Write Optional Gasket Materials: Command 1409: Write Optional Gasket Material (Optional, Mandatory if supported feature) is supported
0x80	Write Remote Seal Information: Command 1410: Write Remote Seal Information (Optional, Mandatory if supported feature) is supported

6.4 Table: Pressure Family Capabilities 1

These bits are intended for future enhancements of the Pressure Device Family.

Bit	Measurement
0x01	Reserved

Bit	Measurement
0x02	Reserved
0x04	Reserved
0x08	Reserved
0x10	Reserved
0x20	Reserved
0x40	Reserved
0x80	Reserved

6.5 Table: Pressure Measurement Types

Code	Measurement Type
0	Differential (DP)
1	Gage (GP)
2	Absolute (AP) (derived from Differential Pressure)
3	Absolute (AgP) (derived from Gage Pressure)
4	
5	
6	
7	
230 – 249	For Device Specific Pressure Measurement Types

6.6 Table: Pressure Measurement Application

Code	Measurement Application
0	Pressure
1	Orifice Plate Flow Measurement
2	Hi Line Pressure (HP)

Code	Measurement Application
3	Liquid Level (LT|LLT)
4	Draft Range (DR)
5	Hydrostatic Tank Gauge
230 – 249	For Device Specific Pressure Measurement Types

6.7 Table: Flange Types

Flange Type- Hardware, adjacent to the sensor, that physically connects the process to the sensor.
Pressure- Pressure of the process measured with respect to a reference pressure.

Code	Flange Type
	Conventional
	Coplanar
	Flangeless
	Remote Seal
	Union
	Sanitary Clamp Fitting
	API 10000
	SMS
	DRD
	Varivent
	King Gage
	DIN 11851
	DIN 11864
	DIN15 PN40
	DIN20 PN40
	DIN25 PN40
	DIN25 PN400
	DIN40 PN40
	DIN50 PN16

Code	Flange Type
	DIN50 PN25
	DIN50 PN40
	DIN50 PN63
	DIN50 PN64
	DIN50 PN100
	DIN50 PN160
	DIN50 PN400
	DIN70 PN500
	DIN80 Table F
	DIN80 Table J
	DIN80 PN10
	DIN80 PN16
	DIN80 PN25
	DIN80 PN40
	DIN80 PN63
	DIN80 PN64
	DIN80 PN100
	DIN80 PN160
	DIN80 PN250
	DIN80 PN400
	DIN100 Table F
	DIN100 Table J
	DIN100 PN10
	DIN100 PN16
	DIN100 PN25
	DIN100 PN40
	DIN100 PN63
	DIN100 PN64
	DIN100 PN100
	DIN100 PN250
	DIN100 PN400
	DIN150 PN10
	DIN150 PN16
	DIN150 PN25

Code	Flange Type
	DIN150 PN40
	1 in, 150lb (ANSI)
	1 in, 300lb (ANSI)
	2in, 150lb (ANSI)
	2in, 250lb (ANSI)
	2in. 300lb (ANSI)
	2in 400/600lb (ANSI)
	2in 900lb (ANSI)
	2in 2500lb (ANSI)
	3in, 150lb (ANSI)
	3in, 300lb (ANSI)
	3in 400/600lb (ANSI)
	3in 600lb (ANSI)
	3in 900lb (ANSI)
	3in, 1500lb (ANSI)
	3in, 2500lb (ANSI)
	4in, 150lb (ANSI)
	4in, 300lb (ANSI)
	4in, 600lb (ANSI)
	4in, 900lb (ANSI)
	4in, 1500lb (ANSI)
	4in, 2500lb (ANSI)
	40 10K(JIS)
	40 20K(JIS)
	40 30K(JIS)
	40 40K(JIS)
	40 63K(JIS)
	50 10K(JIS)
	50 20K(JIS)

Code	Flange Type
	50 30K(JIS)
	50 40K(JIS)
	50 63K(JIS)
	80 10K(JIS)
	80 20K(JIS)
	80 30K(JIS)
	80 40K(JIS)
	100 10K(JIS)
	100 20K(JIS)
	100 30K(JIS)
	100 40K(JIS)
230 - 249	For Device Specific Flange Types
251	None

6.8 Table: Seal Types

Seal Types - Type of device that is capable of detecting and passing on the process pressure on to the module. This is only unambiguous if 1 remote seal is installed.

Code	Seal Type
	Chemical Tee Weld
	Extended Flanged Weld
	Pancake Flanged Weld
	Remote Flanged Weld
	Remote Threaded Weld
	Sanitary Tri-Clamp Weld
	Sanitary tank Spud Weld
	High Temperature
	Flush Flanged Weld

Code	Seal Type
	Union Connection Weld
	Thin Wall Tank Sanitary Spud Weld
	Flow-Through Saddle Seal
	Sanitary APC Style Seal
	Sanitary Cherry Burrell Seal
	Flange Mount
	Wafer
	DIN 11851
	TYPE 980.10
	Inline
	Off line Threaded
	Button
	Alimentary
	Aseptic
	Off-Line Flange Connection
	Urea Service
	Sandwich
	Compression Nut
	Flush diaphragm. ANSI 1"
	Flush diaphragm. ANSI 2"
	Extended diaphragm. ANSI 2"
	Flush diaphragm. ANSI 3"
	Extended diaphragm ANSI 3"
	Flush diaphragm DN 25
	Flush diaphragm DN 50
	Flush diaphragm DN 80
	Extended diaphragm DN 50
	Extended diaphragm DN 80
	Tube RS DN25/ANSI 1"/JIS25
	Tube RS DN40/ ANSI 1.5"/JIS40
	Tube RS DN50/ ANSI 2"/JIS50

Code	Seal Type
	Tube RS DN80/ ANSI 3"/JIS80
	RS with cap screw DN50
	RS clamp connection ANSI 2"
	Miniature RS G 1 A
	Miniature RS G 1/2 A
	Flush diaphragm JIS 25
	Flush diaphragm JIS 40
	Flush diaphragm JIS 50
	Flush diaphragm JIS 80
	Extended diaphragm JIS 50
	Extended diaphragm JIS 80
	Extended diaphragm JIS 100
230 - 249	For Device Specific Seal Types
251	None

6.9 Table: Fill Fluids

Sensor Fill Fluid- Fluid material in the module. Fill fluids are, typically, used by pressure transmitters.

Code	Fill Fluid
	Inert Fluid
	Food-Safe
	Distilled Water
	Mineral Oil
	Vegetable Oil
	High Temperature Oil

Code	Fill Fluid
	Silicone Oil
	Silicone Oil AK20
	Silicone Oil AK100
	Silicone Oil Fl13
	Silicone Oil Fl14
	Silicone Oil Fl17
	Silicone Oil Fl19
	Silicone Oil Fl21
	Silicone Oil Fl23
	Silicone Oil DC200
	Silicone Oil DC210H
	Silicone Oil DC550
	Silicone Oil DC704
	Silicone Oil M50
	Silicone Oil SH200
	Silicone Oil SH510
	Silicone Oil SH704
	Galden
	Fluorinated Oil
	Dioctyl Phthalate
	Daifloil
	Halo Carbon Oil
	Glycerin/H2O
	Propylene-Glycol/H2O
	Syltherm XLT
	Syltherm 800
	Therminol 66
	Neobee-M20
	Flourolube
	Voltalef 1A
	Paraffin
	Mineral Oil Sera5
230 - 249	For Device Specific Fill Types

Code	Fill Fluid
251	None

6.10 Table: Process Connection Thread

This table lists common thread types that are used for process connections

Code	Process Connection Thread
	G1/2A
	1/2in NPT-Female
	1/2in, 14NPT
	1/4in, 18NPT Female
230 – 249	For Device Specific Process Connection Threads
251	None

6.11 Table: Mounting Thread

This table lists common thread types that are used for mounting a pressure device to the process.

Code	Mounting Thread
	M10
	M12
	7/16-20 UNF
230 – 249	For Device Specific Mounting Threads
251	None

Code	Mounting Thread

6.12 Table: Sensor Technology

Code	Sensor Technology
	Capacitive
	Resistive
	Inductive
	Piezoresistive
	Ceramic (resistive)
	Ceramic (capacitive)
	Ceramic (resonative)
230 – 249	For Device Specific Sensor Technologies

6.13 Table: Drain Vent Position

Code	Drain Vent Position
	Opposite Process Connection
	At Side of Flange
230 – 249	For Device Specific Drain Vent Positions
251	None

6.14 Table: Number of Remote Seals

Code	Number of Remote Seals
1	One Remote Seal Connected
2	Two Remote Seals Connected

Code	Number of Remote Seals
230 – 249	For Device Specific Number of Remote Seals
251	None

ANNEX A. REVISION HISTORY

A1. Revision 1.0 a

Initial Revision.

A2. Revision 1.0 b to Revision 1.0 d

Changes according to Working Group results added.

A3. Revision 1.0 e

Added Seal and Flange Types. Minor Corrections. Added Process Connection Thread and Mounting Thread.

A4. Revision 1.0 f

Added Remote Seal Type Commands and Table Entries. Tables for Pressure Family Capabilities and Pressure Status added.

A5. Revision 1.0 h

Moved sections 4, 5 and 6 in one section (overview). Corrected copy and paste errors in tables. Table for mandatory and recommended Common Practice Commands moved to Scope.

A6. Revision 1.0 i

Added normative references and expanded use cases, added Command 1291.

A7. Revision 1.0 j

Changed mandatory common practice commands: Commands 52-55 are only mandatory if the Pressure Variable is not PV

Expanded use cases, added figures, deleted Command 1291, detailed Percent of Range in figure , added definition of square root function for negative values of Percent of Range, added use of Response Code 8 in Write Commands, Attribute Pressure Measurement Type (Command 1283) split into two: Pressure Measurement Type (Command 1283) and Pressure Measurement Application (Commands 1284 and 1408)

A8. Revision 1.0 k

Updated Related Document section with respective English descriptions.

A9. Revision 1.0 l

Corrected sentences and added Table for Pressure Device Family Device Variable Status.