STANDARD

Level Device Family Specification

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1 SCOPE

This Device Family defines the parameters of level measurement devices. Applicable technologies include Free wave (ultrasonic, radar, and laser), Guided wave, Capacitive, Hydrostatic, Radiometric, Magnetostrictive and Buoyancy. Other Level technologies may apply.

This Device family defines the mandatory parameters required to configure and operate Level measurement devices. Standardized Device Variables (as shown in Figure 1), commands and status are specified.

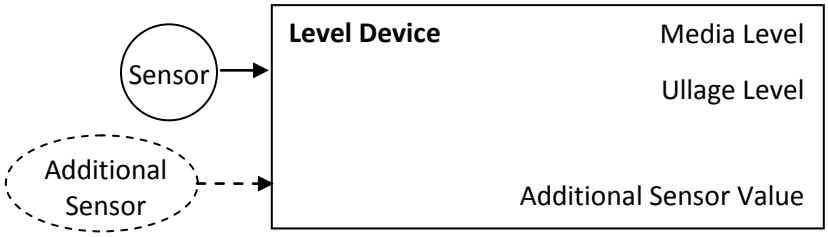

Figure 1. Level Device Variables

Any device variable from the level model can be used as the input to another device family. For example, Media Level can be the input to a volume block to produce a volume output.

This Device Family defines parameters that:

- Allow the Level Device to be Calibrated
- Allow the Level Device to indicate level in percent or length units
- Does not support any linearization function to convert level into, say, volume, contents or flow

This specification defines a set of common services that provide access to the configuration parameters for commissioning Level Devices and that provide continuous operational data and status in applications using Level Devices.

This ensures interoperability in terms of parameters and commands. It does not however always ensure interchangeability (the ability to exchange devices of different technologies, or devices of similar technologies but with different transducers).

Field Devices supporting this Device Family must:

- Comply with all requirements in this specification
- Support all mandatory Device Variables, commands and parameters
- When implementing Specific Level Device Family features, they must be implemented exactly as specified in Specific Technology Level Device Family documents
- Support Common Practice Commands that are defined in Annex B.

Implementations must support the optional features in this specification wherever possible. Implementations shall not claim support for this Device Family if capabilities similar to these optional features are implemented using device specific commands.

In this document we do not specify any mechanism for transferring large amount of data. Instead the Device should support block transfer Commands (HCF_SPEC-190).

A Linearization block is required to calculate volume using the Media Level as the input.

If a Level device is capable of producing two or more level values e.g. interface and bulk level, each level must be implemented by a separate level block.

2 REFERENCES

2.1 The HART Field Communications Protocol Specifications

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

HART Field Communications Protocol Specification. HCF_SPEC-13

Command Summary Specification. HCF_SPEC-99

Universal Command Specification. HCF_SPEC-127

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

Block Data Transfer Specification. HCF_SPEC-190

2.2 Related Documents

These documents provide background information applicable to Level devices:-

PROFIBUS-PA Profile for Process Control Devices, Version 3.0, Oct 1999 – Doc. No. 3.042

3 DEFINITIONS, SYMBOLS AND ACRONYMS

3.1 Definitions

3.1.1 General

Loop Current The value measured by a milli-ammeter in series with the field device. The Loop Current is a near DC analog 4-20mA signal used to communicate a single value between the field device and the control system. A digital counterpart of the loop current is defined as the percent range, i.e., 0% equals to 4mA and 100% equals to 20mA. Digital loop current value is accessible via Commands 2 and 3.

Sensor Reference Point The zero point of reference for the sensor value. In some technologies, the Sensor Reference Point is not a physical location because the sensor units are not Distance Units. In those cases, the Sensor Reference Point may be simply the zero or another defined value. When it is a physical location, this point is the Manufacturer-specific defined reference location on the device – typically either the face of the flange, the top of the thread, the bottom of the thread or the face of the sensor.

User Preferred Sensor Reference Point (UPSRP) The zero point of reference for the Sensor Points.

Level Reference Point The zero point of reference for the levels.

Dry Calibration A calibration performed by writing both the sensor value and the associated level value to the device

Wet Calibration A calibration performed by writing the level value to the device and having the device measure and store the associated sensor value.

Family Revision Specifies the Level Device Family revision to which the device complies.

Sensor Technology Code Identifies the sensor technology used in the device. Table 0 indicates the technology used for the sensor measurement.

Maximum Number of Calibration Points The maximum number of calibration points supported in the device. This value must be between 1 and 250.

Actual Number of Calibration The number of calibration points in use.

Points

Index of Calibration point	Identifies the calibration point position. Value must be from 0 to 249.
Calibration Function Code	Defines the calibration function. Table 8.9 indicates the calibration point function codes.

3.1.2 Level Parameters

All these Parameters are in Level Units. They are mandatory, except where marked as optional.

Level Unit Unit of level parameters. Mandatory m, cm, mm, ft, in, %.

Level Offset The value added to the Measured Level to give the Media Level. This value can be positive or negative.

Level Point N The Measured Level value corresponding to the Sensor Point N.

Level Point A The first valid Level Point in the calibration table. This corresponds to Sensor Point A.

Level Point B The last valid Level Point in the calibration table. This corresponds to Sensor Point B.

Measured Level The level of the product in the vessel before Level Offset

(Same unit of the Device Variables Media Level and Ullage Level.)

$$\text{Measured Level} = (\text{Sensor Value} - \text{Sensor Poin t B}) \times \left(\frac{(\text{Level Point A} - \text{Level Point B})}{(\text{Sensor Point A} - \text{Sensor Point B})} \right) + \text{Level Point B}$$

In N point Calibration, when the Sensor Value is within Sensor Point N and Point N-1 :

$$\text{Measured Level} = (\text{Sensor Value} - \text{Sensor Poin t N-1}) \times \left(\frac{(\text{Level Point N} - \text{Level Point N-1})}{(\text{Sensor Point N} - \text{Sensor Point N-1})} \right) + \text{Level Point N}$$

Media Level The level of the product in the vessel and is typically the Primary Variable.

(Same unit of the Device Variables Measured Level and Ullage Level.)

$$\textit{Media Level} = \textit{Measured Level} + \textit{Level Offset}$$

Ullage Reference Point The Level at which the Ullage Level is zero.

The default value is NaN. If NaN then Ullage Level is reported as NaN.

(optional)

Ullage Level (optional)

The amount of space left in the vessel once the Media level is calculated

(Same unit of the Device Variables Measured Level and Media Level.)

$$UllageLevel = Ullage\ Reference\ Point - Media\ Level$$

This formula assumes that Ullage Reference Point is the highest measurement point in the vessel. When it is not the case, an incorrect value for the free space in the tank may result.

Level Alarm Low Low

The Level below which the “Level below Level Alarm Low Low” status bit is set.

Level Alarm Low

The Level below which the “Level below Level Alarm Low” status bit is set.

Level Alarm High

The Level above which the “Level above Level Alarm High” status bit is set.

Level Alarm High High

The Level above which the “Level above Level Alarm High High” status bit is set.

3.1.3 Sensor Parameters

Sensor Offset

The value is in Sensor Units. See section 4.3 for details.

Sensor Compensation (optional)

A dimensionless value without units (unit code is 251(none)). See section 4.3 for details.

Sensor Unit

Units of Sensor parameters. The Sensor Unit depends on the classification of the Sensor Value.

Raw Sensor Value

The output of the sensor in Sensor Units associated with the material level. All parameters that are displayed in Sensor Units have to use the same unit table (referenced by the classification of Sensor Value).

Sensor Value

The result of the sensor correction with offset and compensation. Sensor Value is in Sensor Units which depends on the classification of the Sensor Value.

$$SensorValue = \left(\left(RawSensorValue - SensorOffset\right) * SensorCompensation\right)$$

Sensor Point N

The Sensor Value at Level Point N referenced to the UPSRP. Sensor Point N is in Sensor Units which depends on the classification of the Sensor Value. The Sensor Points must be different from each other and within the measurement

	range of the sensor. Their locations can be within the Blocking Distances as long as the measurement is possible at those points.
Sensor Point A	The first valid Sensor Point in the calibration table. This corresponds to Level Point A.
Sensor Point B	The last valid Sensor Point in the calibration table. This corresponds to Level Point B.
Additional Sensor Value (optional)	The additional output of the sensor in Additional Sensor Units.
Additional Sensor Unit (optional)	This unit depends on the classification of the Additional Sensor Value.

3.1.4 Distance Parameters

Distance Unit (optional)	Unit of Distance parameters. Mandatory m, cm, mm, ft, in.
Measurement Distance (optional)	The distance between the potential maximum measurement point of the device and the Sensor Reference Point.
Blocking Distance High (optional)	The distance from the Sensor Reference Point to the point at which the measurement becomes valid. Depending on the sensor technology used in the device, measurement may or may not be possible in this region. If measurement is possible in this region, the device may output the measured level, report the level at the edge of the bounding region, or declare the device to be in a fault state. In any case, by setting the Blocking Distance, the user can declare this region as “Not Valid”.
Blocking Distance Low (optional)	The distance from the end of the Measurement Distance up to the point at which the measurement becomes valid. Depending on the sensor technology used in the device, measurement may or may not be possible in this region. If measurement is possible in this region, the device may output the measured level, report the level at the edge of the bounding region, report the level as the Measurement distance, or declare the device to be in a fault state. In any case, by setting the Blocking Distance, the user can declare this region as “Not Valid”.

3.2 Symbols/Abbreviations

HCF HART Communication Foundation

LRP Level Reference Point

LSB Least Significant Byte. The LSB is always the last byte transmitted over a HART data link

MSB Most Significant Byte. The MSB is always the first byte transmitted over a HART data link.

NaN Not a Number.

SRP Sensor Reference Point

UPSRP User Preferred Sensor Reference Point

3.3 Data Format

In HART Protocol command specifications, the following key words are used to refer to the data formats. For more information about these formats refer to the *Command Summary Specificatio*n.

Bits Each individual bit in the byte has a specific meaning. Only values specified by the command may be used. Bit 0 is the least significant bit.

Enum An integer enumeration with each numeric value having a specific meaning. Only values specified in the Common Tables Specification may be used.

Float An IEEE 754 single precision floating point number. The exponent is transmitted first followed by the most significant mantissa byte.

Unsigned-nn An unsigned integer where nn indicates the number of bits in this integer. Multi-byte integers are transmitted MSB — LSB.

None A value of 251.

4 LEVEL DEVICE FAMILY

4.1 The Block Diagram

Figure 2 General Level Device Family Block Diagram overviews the inputs, processing blocks and outputs of the Level Device Family Block Diagram.

The Sensor provides the Raw Sensor Value in Sensor Units.

The Sensor Correction block applies the Sensor Offset to the Raw Sensor Value and scales the result by the Sensor Compensation to produce the Sensor Value. Sensor Compensation is a dimensionless value that may be derived from the Additional Sensor Value.

The Level Calibration block transforms the Sensor Value into Measured Level through a multi-point calibration. A minimum of 2 calibration points is required.

The Media Level is the sum of the Measured Level and the Level Offset.

The Ullage Level is the Ullage Reference Point minus Media Level.

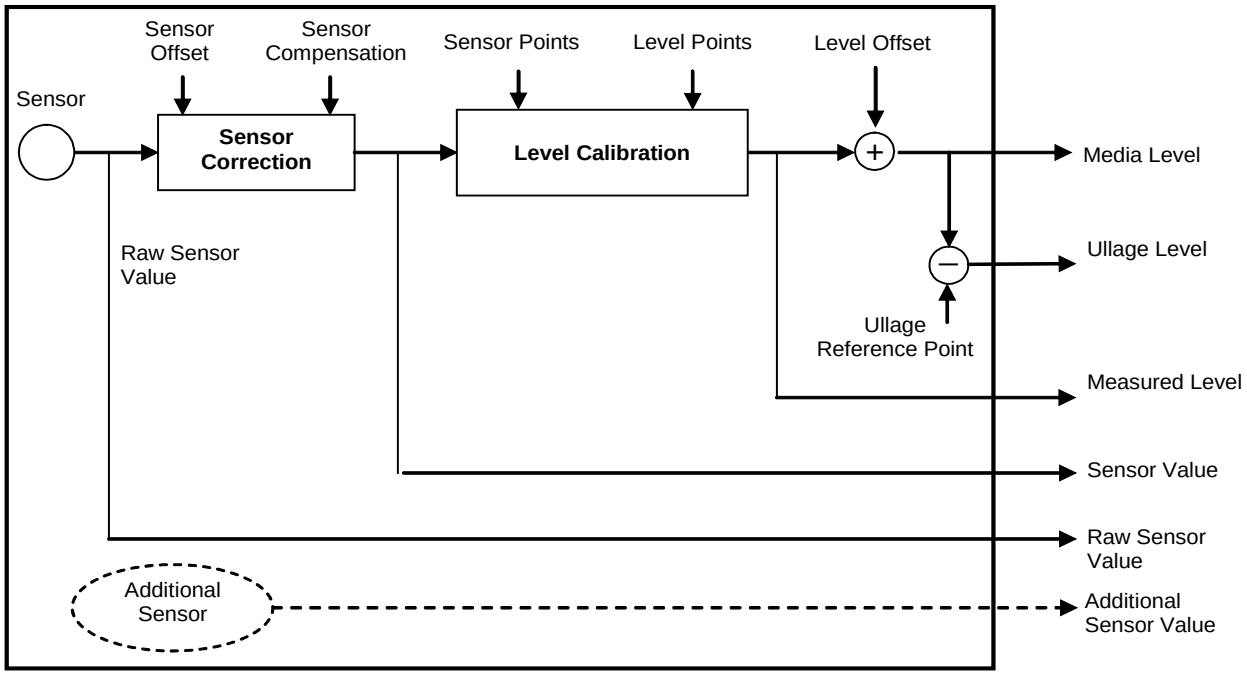

Figure 2. General Level Device Family Block Diagram

4.2 Device and Internal Variables of the Level Family

The following table shows the Level Family device variables that are used in Level devices.

Table 1. Level Family Device Variables

Device Variables	Classifications	Device Family	Description
Media Level	0- Not Classified	Level	Media Level is the Level in the vessel.
Ullage Level (optional)	0- Not Classified	Not Used	Ullage Level is the remaining distance available in the vessel.
Additional Sensor Value (optional)	See Table 8.3	Depends on the Sensor	A measured parameter which may be used for sensor compensation.

The following table shows the Level Family internal variables that are used in Level devices.

Table 2. Level Family Internal Variables

Internal Variables	Description
Measured Level	Same unit as Media Level l
Sensor Value	The result of Sensor correction with Sensor Offset and Sensor Compensation.
Raw Sensor Value	Same unit as Sensor Value Level l.

The manufacturer defines the order of the Device Variables. The main Device Variable is the Media Level and is used to reference the Device Family Command.

The Engineering Unit Codes that are indicated in the Common Tables in HCF_SPEC-183 should be used for the Level Classification.

4.3 Sensor Correction Calculation

Sensor Compensation Value and the Sensor Offset are used to compensate the Raw Sensor Value to provide a normalized Sensor Value. Sensor Compensation could be the result of a complex calculation, including temperature / density / time measurement. Sensor Offset is the difference between the User Preferred Sensor Reference Point (UPSRP) and the Sensor Reference Point (SRP). See Figure 3 for details.

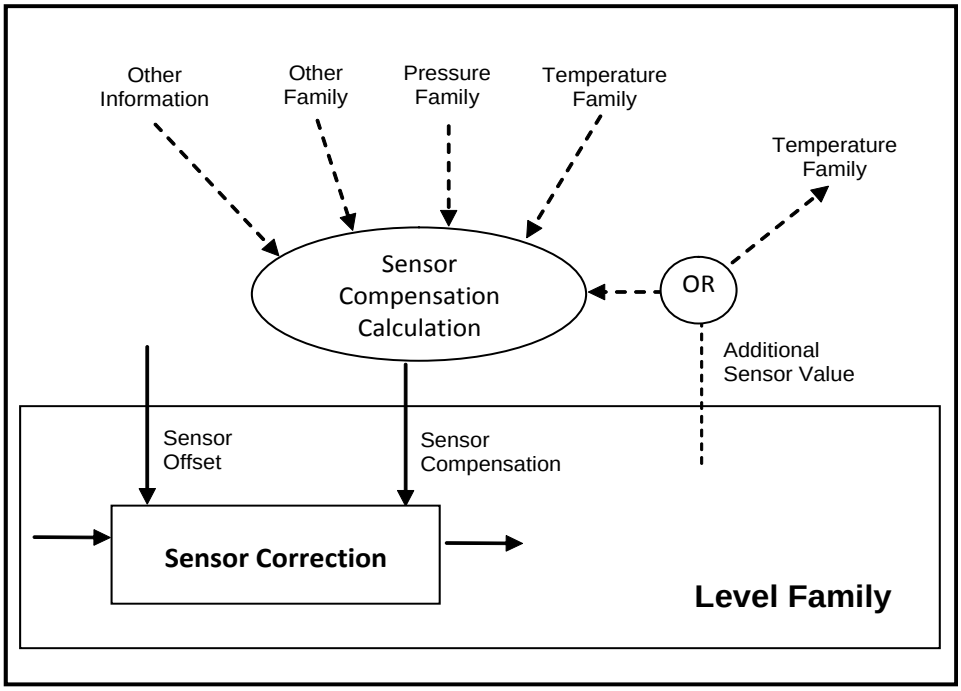

Figure 3. Sensor Compensation Calculation

4.4 Level Technology General Model

Presented here is the general description of the Level Device model and its parameters. Some points are clarified in the Technology Specific Diagrams that will be found in Section 5.

4.4.1 General Model

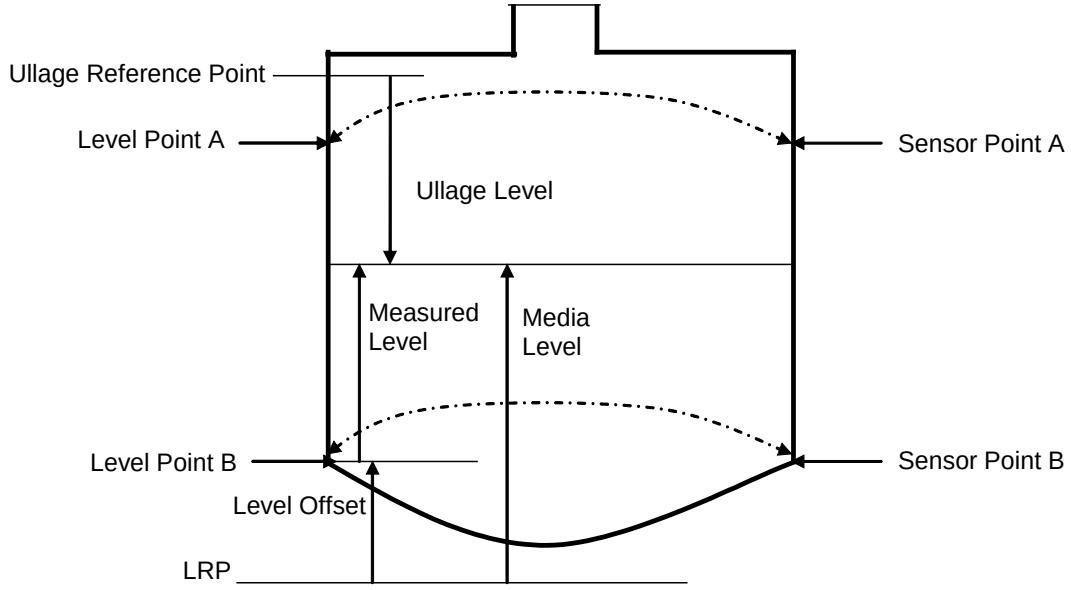

Figure 4. General Model

Sensor Points A and B in the above diagram are in Sensor or Distance Units. The rest of the parameters are in Level Units.

Level Points are always physical positions. Sensor Points are the sensor measured values according to the sensor technology. For example Sensor Units are Counts per Second in the Radiometric Technology model, thus Sensor Points cannot always be associated with physical positions.

The model has a distinct advantage from an engineering point of view in that all user parameters are referenced from the same point. The traditional model for some technologies has the 'span' measured from the 'Empty tank' point, which creates unneeded data coupling. The model still requires only 2 parameters as a minimum, but creates much more flexibility and allows other level technologies to be added.

Some technologies require that calibration be performed by moving or simulating the level of the material in the tank after the equipment is mounted on it. Other technologies are not constrained by this requirement. They can be calibrated outside the tank either by simulating the material movement in some way (Guided Wave, Free Wave, Magnetostrictive) or by just using the geometry of the tank and the characteristic of the media to determine the calibration parameters and then entering them (Free Wave).

A calibration performed by writing both the sensor value and the associated level value to the device by the user is called a dry calibration in this document. A calibration performed by writing the level value to the device and having the device measure and store the associated sensor value is called a wet calibration in this document. When the device is calibrated on a tank it is usually a wet calibration because the device can conveniently measure and store the sensor value and not require the user to take the unnecessary step of recording the sensor value and entering it himself.

A calibration performed on a tank can be either a full or partial calibration of the measurement range. A full calibration requires a calibration measurement at least where the level is at the top and at the bottom of the measurement range.

A partial calibration only requires a calibration measurement at one location within the measurement range. The device can either extrapolate the other point or another point can be simulated in some way. For example, the high level point can be simulated in the Radiometric Technology by closing the source housing thereby removing the radiation from the detector.

Dry calibration and Wet calibrations (partial, full) can be performed with 1, 2 or N point calibration.

4.4.2 Distance Parameters and Model

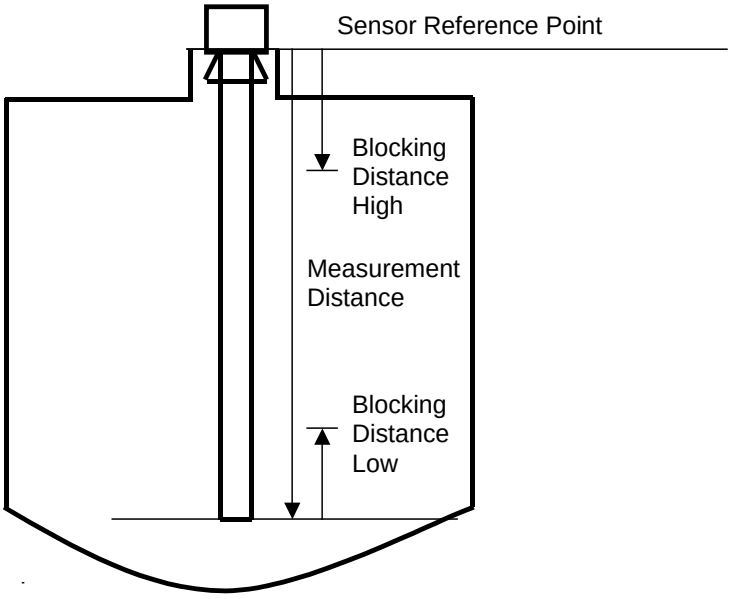

Figure 5. Distance Parameters and Model

These parameters are not required by the model to produce a Level value but are used by many technologies to give limits for it.

Their definitions are common to every Level Device but can have little or no benefit in some technologies.

All these parameters are in Distance Units.

5 TECHNOLOGY SPECIFIC DESCRIPTION OF MODEL AND PARAMETERS

5.1 Free Wave Technology Model and Parameters

This technology typically uses an ultrasonic wave (burst) or radar wave or light wave (laser) to determine the distance from the measurement point to the medium. This value is then converted into a level. The technology shares the following properties:

- The transmitted signal is a wave
- The wave is emitted from an antenna (e.g. radar) or transducer (e.g. ultrasonic)
- The wave must pass through a region (such as air or liquid) to a media interface (such as an air-liquid interface)
- The reflected signal from the media interface is measured to determine the level of the media.
- Temperature may be used for the Additional Sensor Value and may provide compensation for the Sensor Value.

A level device implementing a wave that adds a tube to the antenna/transducer to act as a "waveguide" for the signal is covered by this model. Other measurement methods may use this model if it is applicable.

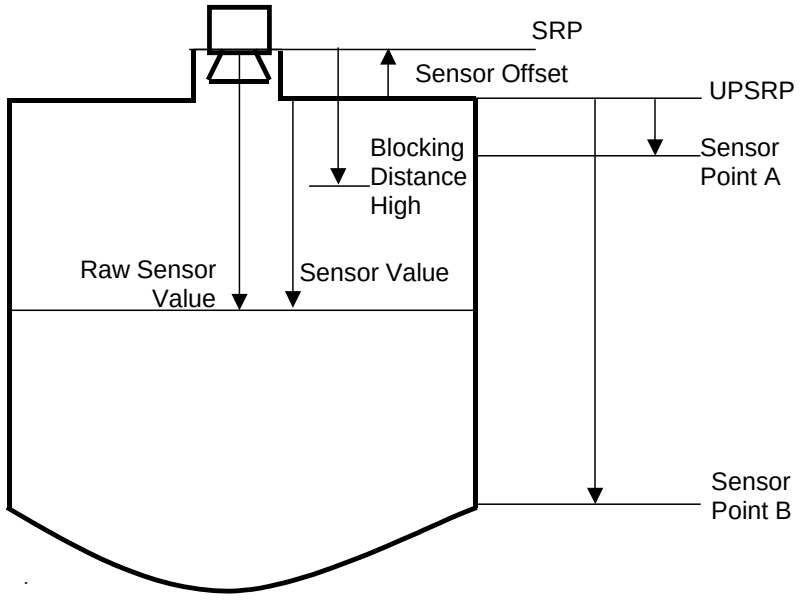

Figure 6. Free Wave Level Model

Table 3. Typical Implementation of Free Wave Parameters

Sensor Unit	Length
Additional Sensor Unit	Temperature (optional)
Sensor Reference Point	(see Diagram)
Sensor Offset	(see Diagram)
Sensor Compensation	Not Commonly Used (default 1.0)
Measurement Distance	Not Commonly Used
Blocking Distance High	Used (see Diagram)
Blocking Distance Low	Not Commonly Used

5.2 Guided Wave Technology Model and Parameters

The Guided Wave technology is very similar to the Free Wave, except in this case the wave is not in free air, but guided using a cable or other transmission line that makes contact with the medium.

- The transmitted signal is a wave
- The wave is transmitted down a transmission line.
- The wave is guided to a media interface (such as an air-liquid interface)
- The reflected signal from the media interface is measured to determine the level of the media.
- Temperature may be used for the Additional Sensor Value and may provide compensation for the Sensor Value.

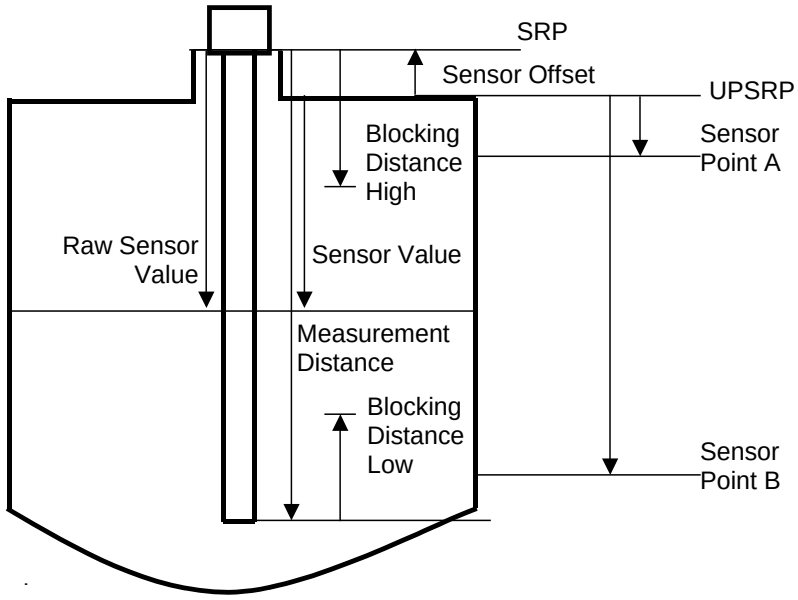

Figure 7. Guided Wave Level Model

Table 4. Typical Implementation of Guided Wave Parameters

Sensor Unit	Length
Additional Sensor Unit	Temperature
Sensor Reference Point	(see Diagram)
Sensor Offset	(see Diagram)
Sensor Compensation	Not Commonly Used (default 1.0)
Measurement Distance	Used (Probe Length)
Blocking Distance High	Used (see Diagram)
Blocking Distance Low	Used (see Diagram)

5.3 Capacitive Technology Model and Parameters

In the capacitive method of Level measurement, the probe and the container wall form a capacitor. Depending on the level in the container, there is either air (empty container) or medium (full container) in the space between the probe and container wall. Usually the impedance between the probe and the container wall is measured. This impedance depends not only on the level of the medium but also on the dielectric constants and the conductivity of the medium and on the geometry and materials of the Probe and the container. For these reasons, it is almost always necessary to perform a “wet calibration” of the sensor.

- The transmitted signal is a frequency
- The frequency signal is applied to a probe
- The signal must pass through a region (such as air or liquid).
- The change in signal due to the media is measured to determine the level of the media.

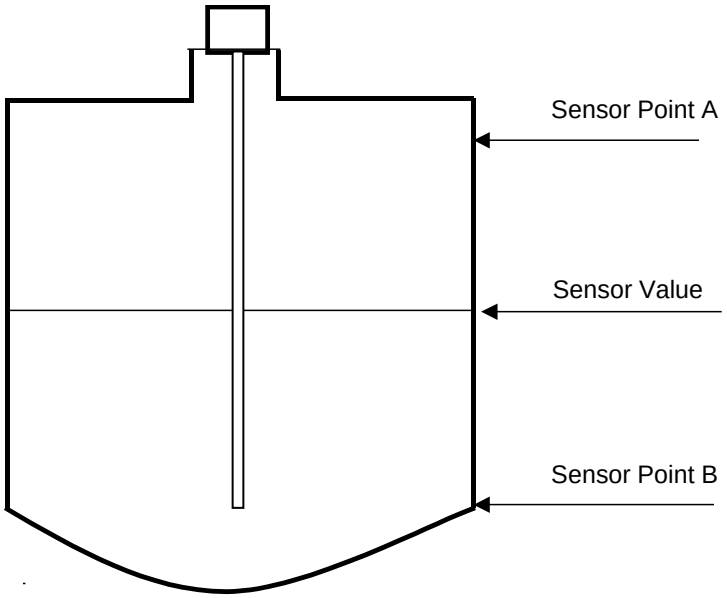

Figure 8. Capacitive Level Model

Table 5. Typical Implementation of Capacitive Parameters

Sensor Unit	Capacitance, frequency
Additional Sensor Unit	Not commonly used
Sensor Reference Point	Zero point of reference (usually zero)
Sensor Offset	Used to compensate some extension cable capacitance.
Sensor Compensation	Not Commonly Used (default 1.0)
Measurement Distance	Not Commonly Used
Blocking Distance High	Not Commonly Used
Blocking Distance Low	Not Commonly Used

5.4 Hydrostatic Technology Model and Parameters

Hydrostatic technology uses pressure to determine the media level so the Sensor Value is typically pressure, which would typically be the output of a pressure block from the pressure device family.

The Level Offset can be positive, if the sensor is placed higher than vessel bottom or negative, if the sensor is placed lower than the vessel bottom (see Figure 8 below).

- The change in signal due to the media is measured to determine the level of the media.
- Temperature may be used for the Additional Sensor Value and may provide compensation for the Sensor Value.

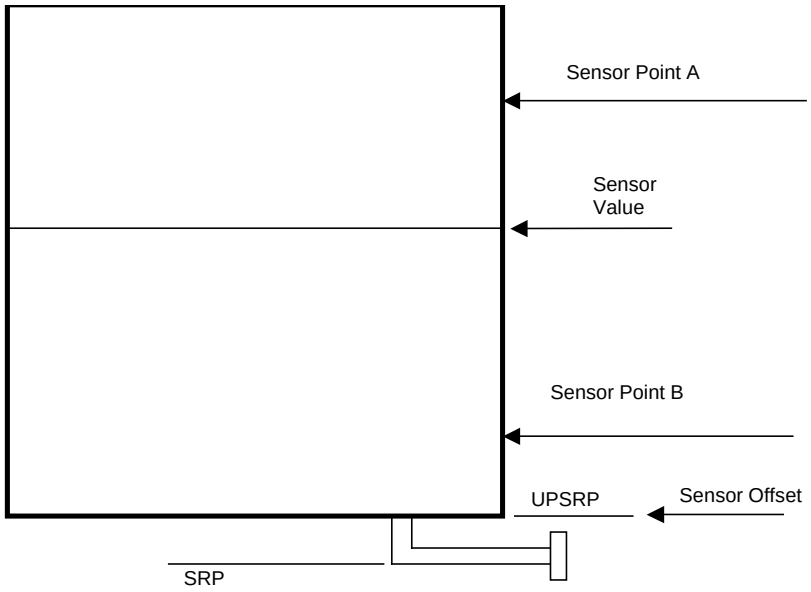

Figure 9. Hydrostatic Level Model

Table 6. Typical Implementation of Hydrostatic Parameters

Sensor Unit	Pressure
Additional Sensor Unit	Temperature
Sensor Reference Point	Zero point of reference (usually zero)
Sensor Offset	Used to compensate some installation drift.
Sensor Compensation	It is used if the density of the medium has changed from when the device was calibrated. The value is the density at calibration divided by the new density. The value must not be zero. The default value is 1.0 $Compensation = \frac{Density\ at\ calibration}{Density}$
Measurement Distance	Not Commonly Used
Blocking Distance High	Not Commonly Used
Blocking Distance Low	Not Commonly Used

5.5 Radiometric Technology Model and Parameters

This technology typically uses the radiation of a radioactive source to determine the level of the media in the vessel. The location of the radioactive source and sensor can be internal or external to the vessel, depending on the application and configuration of the source and sensor.

The technology shares the following properties:

- The radiated signal is emitted from the radioactive source and must pass through the media to the sensor.
- The remaining radiation reaching the sensor is the measure of the level.
- Temperature may be used for the Additional Sensor Value and may provide compensation for the Sensor Value.

This model covers a level device implementing an internal or external radioactive source with internal or external sensor, including absorption and back scatter techniques. Measurement of count rate when related to the model is independent of orientation between the sensor and the radioactive source.

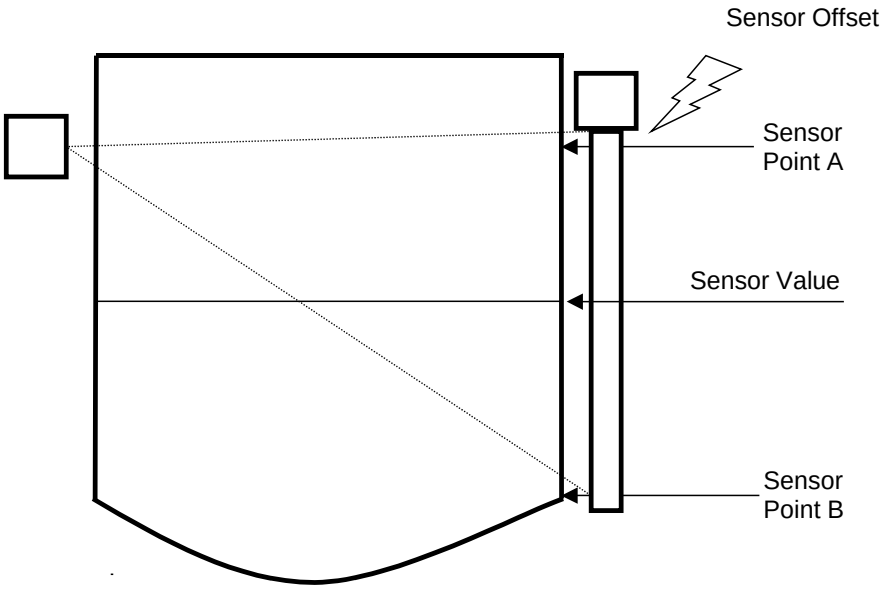

Figure 10. Radiometric Level Model

Table 7. Typical Implementation of Radiometric Parameters

Sensor Unit	Counts per second
Additional Sensor Unit	Temperature (optional)
Sensor Reference Point	Zero point of reference (usually zero)
Sensor Offset	Background Radiation
Sensor Compensation	It is used to compensate the decay rate of the radioactive source over time (Decay Factor).
Measurement Distance	Not Commonly Used
Blocking Distance High	Not Commonly Used
Blocking Distance Low	Not Commonly Used

5.6 Magnetostrictive Technology Model and Parameters

The Magnetostrictive technology uses a continuous sensing element which extends into the measured media. The sensor contains a wire having special magnetic properties and is fitted with a magnetic float which rides up and down with the product level.

- The sensor wire is repeatedly excited with a current pulse and the resulting instantaneous magnetic field created, interacts with the magnetic field of the float.
- This results in a torsional wave being produced at the float location.
- The torsional wave propagates from the float location, at the speed of sound, and travels towards the top end of the sensor tube, which is fitted with a special sensor.
- This torsional sensor converts the mechanical wave into an electrical pulse.
- The level calculation is done by measuring the time between the start pulse and the return pulse, and then applying the General Model using the Sensor Points.
- Blocking Distance Low may be used to account for Float immersion depth.
- Blocking Distance High may be used to account for unusable range at the top of the sensor.
- Temperature may be used for the Additional Sensor Value and may provide compensation for the Sensor Value.

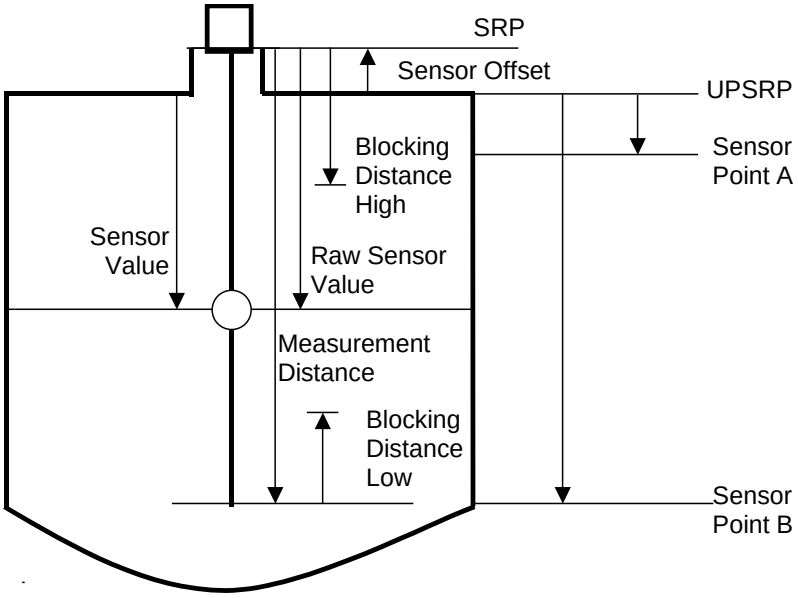

Figure 11. Magnetostrictive Level Model

Table 8. Typical Implementation of Magnetostrictive Parameters

Sensor Unit	Length
Additional Sensor Unit	Temperature (optional)
Sensor Reference Point	(see Diagram)
Sensor Offset	(see Diagram)
Sensor Compensation	Not Commonly Used (default 1.0)
Measurement Distance	Used (Probe Length)
Blocking Distance High	Not Commonly Used (see Diagram)
Blocking Distance Low	Not Commonly Used (see Diagram)

5.7 Buoyancy Technology Model and Parameters

The buoyancy technology uses a displacer sensing element which extends into the measured media.

- The buoyant force on the sensor varies with the media level.
- The buoyant force may be directly instrumented by a force-to-voltage transducer, or it may be mechanically converted to an intermediate signal such as linear or rotary spring displacement, before instrumentation.
- The force signal is compensated for temperature effects on the spring and density changes in the fluid(s).
- The force sensor may be calibrated independently of the media.

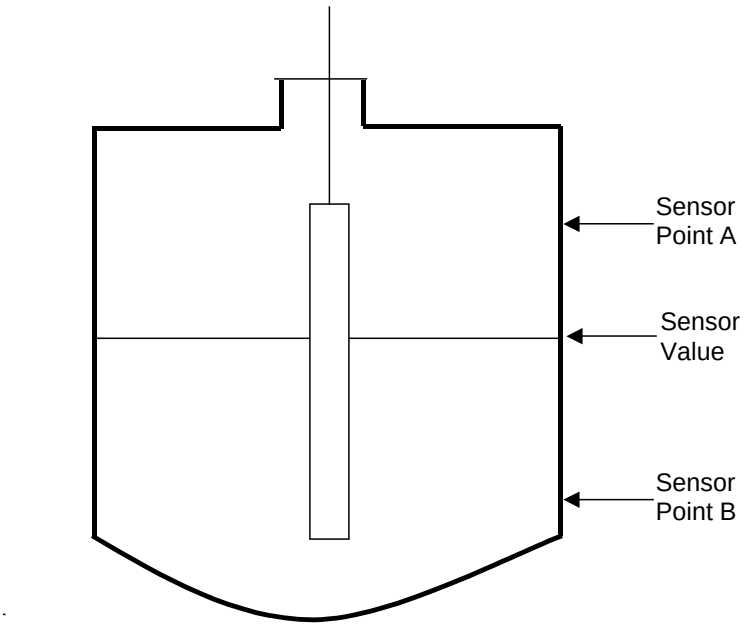

Figure 12. Buoyancy Level Model

Table 9. Typical Implementation of Buoyancy Parameters

Sensor Unit	Force, Length
Additional Sensor Unit	Temperature (optional)
Sensor Reference Point	Zero point of reference (usually zero)
Sensor Offset	Not Commonly Used (default 0.0).
Sensor Compensation	Not Commonly Used (default 1.0). A function of the Densities of upper and lower phases, temperature of transducer and Sensor Value.
Measurement Distance	Used (Displacer Length)
Blocking Distance High	Not Used
Blocking Distance Low	Not Used

6 LEVEL DEVICE FAMILY STATUS

6.1 Level Family Status

6.1.1 Sensor Status Definition

Table 10. Sensor Status Definition

Status	Definition	Example
Sensor defect	The sensor is not producing a valid sensor value	No sensor signal available
Sensor Unknown	The sensor is not recognized	The identification signal from the sensor is not in a valid range
Sensor Value Invalid	When the range limits of the sensor have been exceeded.	The Sensor value is less than 0% or greater than 100% of its measurement range.
Sensor Signal Lost	A sensor signal is being produced but the signal is not sufficient to generate a level value.	Free wave echo lost
Sensor Signal Interference	A sensor signal is being produced but the signal is of an unexpected or invalid value and not suitable to generate a level value.	Another radioactive source is corrupting the sensor signal
New Sensor Settings necessary	One or more of the Sensor Settings parameters is not suitable to produce a valid level value.	Sensor Offset too large
Critical Signal to Noise Ratio	The sensor value is valid but the signal quality is not good enough.	The difference between the valid sensor signal and the background is too small.

Note: For coding see section 8.2

6.1.2 Additional Sensor Status Definition

Table 11. Additional Sensor Status Definition

Status	Definition	Example
Additional Sensor defect	The Additional Sensor is producing an invalid Additional Sensor value	A valid Additional Sensor value can no longer be calculated from the Additional Sensor output.
Additional Sensor Value Invalid	When the range limits of the additional sensor have been exceeded.	The Additional Sensor value is less than 0% or greater than 100% of its measurement range.

Note: For coding see section 8.2

6.1.3 Level Status

6.1.3.1 Limits Variables Model

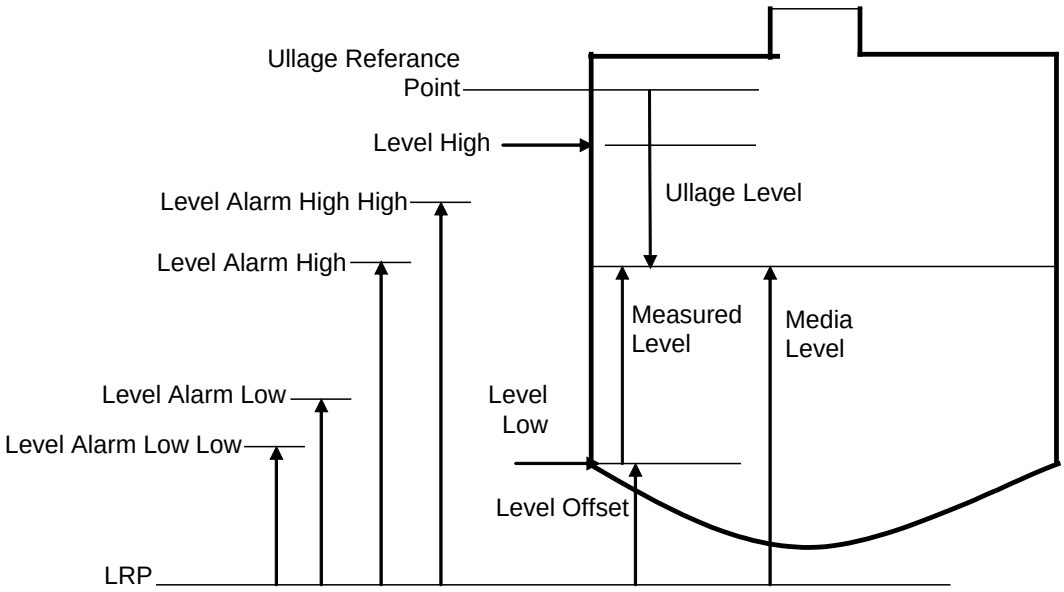

Figure 13. Limits Variables Diagram

6.1.3.2 Level Status Definition

Table 12. Level Status Definition

Status	Definition	Example
Level below Level Alarm Low Low (optional)	If the Media Level is below this level the “Level below Level Alarm Low Low” Status Bit is set. The Level Limits Exceeded bit is also set.	See diagram above
Level below Level Alarm Low (optional)	If the Media Level is below this level the “Level below Level Alarm Low” Status Bit is set. The Level Limits Exceeded bit is also set.	See diagram above
Level above Level Alarm High (optional)	If the Media Level is above this level the “Level above Level Alarm High” Status Bit is set. The Level Limits Exceeded bit is also set.	See diagram above
Level above Level Alarm High High (optional)	If the Media Level is above this level the “Level above Level Alarm High High” Status Bit is set. The Level Limits Exceeded bit is also set.	See diagram above
Distance in Blocking Distance Low (optional)	The level is within the Blocking Distance Low range and the level is valid but may not be trusted by the user.	See diagram in section 4.4.2
Distance in Blocking Distance High (optional)	The level is within the Blocking Distance High range and the level is valid but may not be trusted by the user.	See diagram in section 4.4.2
New Calibration necessary	The calibration is useable but through time or changes in process conditions a new calibration is required.	The density of the process fluid has changed
Incorrect Calibration	The calibration parameters do not make sense for a valid calibration.	Incorrect calibration parameters.
New Level Settings Necessary	One or more of the Level Settings parameters is not suitable to produce a valid level value.	Level Offset too large

Note: For coding see section 8.2

7 LEVEL DEVICE FAMILY COMMANDS

7.1 Read Commands

7.1.1 Command 2816 Read Level 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 of the Media Level

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1	Bits-8	Media Level Device Variable Status (see Level Family Table 1)
2	Bits-8	Sensor Status Byte 0 (see Level Family Table 4)
3	Bits-8	Sensor Status Byte 1 (see Level Family Table 5)
4	Bits-8	Level Status Byte 0 (see Level Family Table 6)
5	Bits-8	Level Status Byte 1 (see Level Family Table7)

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

7.1.2 Command 2817 Read Level Family Capability (Mandatory)

This command returns the Level Family Capability of this device including the Family Revision, the Sensor Technology, the maximum number of Calibration Points and whether or not there is an Additional Sensor Device Variable, an Ullage Device Variable, Sensor Compensation and High or Low Blocking Distances.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1	Unsigned-8	Family Revision
2	Enumeration	Additional Sensor Device Variable availability. (1-Available, 0- not available)
3	Enumeration	Ullage Device Variable availability. (1-Available, 0- not available)
4	Enumeration	Sensor Technology code (see Subsection 8.7)
5	Unsigned-8	Maximum number of Calibration Points
6	Enumeration	Sensor Compensation availability. (1-Available, 0- not available)
7	Enumeration	Blocking distances availability (see Subsection 8.8)

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

7.1.3 Command 2818 Read Level Family Device Variable Codes (Mandatory)

This command returns the Device Variable Codes for the device family variables.

If the variable is not implemented as a Device Variable, then 250 (none) will be returned.

Request Data Bytes

Byte	Format	Description
None		

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1	Unsigned-8	Device Variable Code of the Ullage Level (optional)
2	Unsigned-8	Device Variable Code of the Additional Sensor Value (optional)

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

7.1.4 Command 2819 Read Level Family Variable Classification (Mandatory)

This command returns the Device Variable Classification for the device family variables.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1	Unsigned-8	Device Variable Code of the Ullage Level (optional)
2	Unsigned-8	Device Variable Code of the Additional Sensor Value (optional)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1	Unsigned-8	Device Variable Classification of the Media Level
2	Unsigned-8	Device Variable Code of the Ullage Level (optional)
3	Unsigned-8	Device Variable Classification of the Ullage Level (optional)
4	Unsigned-8	Device Variable Code of the Additional Sensor Value (optional)
5	Unsigned-8	Device Variable Classification of the Additional Sensor Value (optional)
6	Unsigned-8	Classification of the Sensor Value (optional)
7	Unsigned-8	Classification of the Distance (optional)

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

7.1.5 Command 2820 Read Level Family Device Variable Values (Mandatory)

This command is used to read all device variable values. The unit tables are referenced by the classifications of the Device Variables. The Additional Sensor unit is obtained from the common table *Unit Codes*. For additional guidance, see Section 4.2.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1	Unsigned-8	Device Variable Code of the Ullage Level (send 250 if not supported)
2	Unsigned-8	Device Variable Code of the Additional Sensor Value (send 250 if not supported)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1-2	Enumeration 16	Media Level Units code
3-6	Float	Media Level Value
7	Unsigned-8	Device Variable Code of Ullage (send 250 if not supported)
8-9	Enumeration 16	Ullage Level Units code
10-13	Float	Ullage Level Value
14	Unsigned-8	Device Variable Code of Additional Sensor Value (send 250 if not supported)
15-16	Enumeration 16	Additional Sensor Unit code (see Common Table Unit Codes)
17-20	Float	Additional Sensor Value

Notes: When a Device Variable requested is not supported in the Field Device, then the corresponding Value must not be set to “0x7F. 0xA0, 0x00, 0x00”, and the Units Code must be set to “250”, Not Used.

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

7.1.6 Command 2821 Read Level Family Internal Variable Values (Mandatory)

This command is used to read all internal variable values. All values with sensor units have the same unit as the Sensor Value. All values with level units have the same unit as the Media Level. The unit tables are referenced by the classifications of the Device Variables. The Additional Sensor unit is obtained from the common table *Unit Codes*. For additional guidance, see Section 4.2.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1-2	Enumeration 16	Media Level Units code
3-6	Float	Measured Level Value
7-8	Enumeration 16	Sensor Unit code (see common table Unit Codes)
9-12	Float	Sensor Value
13-16	Float	Raw Sensor Value

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

7.1.7 Command 2822 Read Sensor Settings Values (Mandatory)

This command reads the Sensor setting parameters that are in Sensor Units. These include the Sensor Offset, Sensor Points A & B and Sensor Compensation.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1-2	Enumeration 16	Sensor unit code (for Sensor Offset & Sensor Points)
3-6	Float	Sensor Offset
7-10	Float	Sensor Compensation
11-14	Float	Sensor Point A
15-18	Float	Sensor Point B

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
32	Error	Busy
17-127		Undefined

7.1.8 Command 2823 Read Level Settings Values (Mandatory)

This command reads the Level setting parameters that are in Level Units. These include Level Points A & B and Level Offset.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1	Unsigned-8	Device Variable Code of the Ullage Level (send 250 if not supported)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1-2	Enumeration 16	Media Level unit code
3-6	Float	Level Offset
7-10	Float	Level Point A
11-14	Float	Level Point B
15	Unsigned-8	Device Variable Code of the Ullage Level (send 250 if not supported)
16-17	Enumeration 16	Ullage Level unit code
18-21	Float	Ullage Reference Point

Note: Command must return NaN for each parameter that is not supported.

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
32	Error	Busy
17-127		Undefined

7.1.9 Command 2824 Read Level Settings Alarm Limits (Optional)

This command reads the four Level Alarm parameters that are in Level Units.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1-2	Enumeration 16	Media Level unit code
3-6	Float	Level Alarm Low Low
7-10	Float	Level Alarm Low
11-14	Float	Level Alarm High
15-18	Float	Level Alarm High High

Note: Command must return NaN for each parameter that is not supported.

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
19-63		Undefined
65-127		Undefined

7.1.10 Command 2825 Read Distance Settings Values (Optional)

This command reads the Distance setting parameters that are in Distance Units. These include Blocking Distances High & Low and Measurement Distance. The distance classification code is always length (69).

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1-2	Enumeration 16	Distance Unit code
3-6	Float	Measurement Distance (return NAN if not supported)
7-10	Float	Blocking Distance Low (return NAN if not supported)
11-14	Float	Blocking Distance High (return NAN if not supported)

Note: Command must return NaN for each parameter that is not supported.

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
19-63		Undefined
32	Error	Busy
65-127		Undefined

7.1.11 Command 2826 Read Calibration Point (Mandatory)

This command reads one Calibration Point comprising one sensor point and one level point and their associated Units.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1	Unsigned-8	Index of Calibration Point (N), (Max : 249)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1	Unsigned-8	Index of Calibration Point (N), (Max : 249)
2-3	Enumeration 16	Sensor unit code
4-7	Float	Sensor Point N
8-9	Enumeration 16	Media Level unit code
10-13	Float	Level Point N

Note: Command must return NaN for each parameter that is not supported.

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
32	Error	Busy
17-127		Undefined

7.1.12 Command 2827 Read Calibration Information (Mandatory)

This command reads the actual number of Calibration Points in use.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1	Unsigned-8	Actual number of Calibration Points in use

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
32	Error	Busy
17-127		Undefined

7.2 Write Commands

7.2.1 Command 2944 Write Sensor Settings Sensor Offset (Mandatory)

This command is used for writing the Sensor Offset. The Sensor Offset must be in the same units and classification as the Sensor Value.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1-2	Enumeration 16	Sensor unit code
3-6	Float	Sensor Offset

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1-2	Enumeration 16	Sensor unit code
3-6	Float	Sensor Offset

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
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	Warning	Set to nearest possible value
9-15		Undefined
16	Error	Access Restricted
17-31		Undefined
32	Error	Busy (Delayed Response could not be initiated)
33	Error	DR Initiate
34	Error	DR Running
35	Error	DR Dead
36	Error	DR Conflict
37 - 127		Undefined

7.2.2 Command 2945 Write Sensor Settings Sensor Compensation (Optional)

This command is used for writing the Sensor Compensation.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1-2	Enumeration 16	Sensor unit code
3-6	Float	Sensor Compensation Value (default 1.0)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1-2	Enumeration 16	Sensor unit code
3-6	Float	Sensor Compensation Value

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
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	Warning	Set to nearest possible value
9-15		Undefined
16	Error	Access Restricted
17-31		Undefined
32	Error	Busy (Delayed Response could not be initiated)
33	Error	DR Initiate
34	Error	DR Running
35	Error	DR Dead
36	Error	DR Conflict
37 - 127		Undefined

7.2.3 Command 2946 Write Distance Settings Distance Unit (Optional)

This command is used for writing the Distance Unit. The classification code for Distance is always length. All variables for Distance must be the same unit.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1-2	Enumeration 16	Distance Unit code

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1-2	Enumeration 16	Distance Unit code

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	Error	In Write-Protect mode
8-15		Undefined
16	Error	Access Restricted
17		Undefined
18	Error	Invalid Units Code
19-31		Undefined
32	Error	Busy (Delayed Response could not be initiated)
33	Error	DR Initiate
34	Error	DR Running
35	Error	DR Dead
36	Error	DR Conflict
37 - 127		Undefined

7.2.4 Command 2947 Write Distance Settings Blocking (Optional)

This command is used for writing the two Blocking Distances (Upper and Lower).

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1-2	Enumeration 16	Distance Unit code
3	Enumeration 8	Blocking Distance Selection (0 - Low, 1 - High)
4-7	Float	Blocking Distance Value (default 0.0)

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1-2	Enumeration 16	Distance Unit code
3	Enumeration 8	Blocking Distance Selection (0 - Low, 1 - High)
4-7	Float	Blocking Distance Value (default 0.0)

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
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	Warning	Set to nearest possible value
9-15		Undefined
16	Error	Access Restricted
17		Undefined
18	Error	Invalid Units Code
19-31		Undefined
32	Error	Busy (Delayed Response could not be initiated)
33	Error	DR Initiate
34	Error	DR Running
35	Error	DR Dead
36	Error	DR Conflict
37 - 127		Undefined

7.2.5 Command 2948 Write Distance Settings Measurement Distance (Optional)

This command is used for writing the Measurement Distance.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1-2	Enumeration 16	Distance Unit code
3-6	Float	Measurement Distance Value

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1-2	Enumeration 16	Distance Unit code
3-6	Float	Measurement Distance Value

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
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	Warning	Set to nearest possible value
9-15		Undefined
16	Error	Access Restricted
17-31		Undefined
32	Error	Busy (Delayed Response could not be initiated)
33	Error	DR Initiate
34	Error	DR Running
35	Error	DR Dead
36	Error	DR Conflict
37 - 127		Undefined

7.2.6 Command 2949 Write Level Settings Alarm Limits (Optional)

This command is used for writing the Level Alarm limits. The Level Alarm units must be in the same units as Media Level.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1-2	Enumeration 16	Media Level Unit code
3	Enumeration 8	Level Alarm Limit Selection (see Subsection 8.11)
4-7	Float	Level Alarm

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1-2	Enumeration 16	Media Level Unit code
3	Enumeration 8	Level Alarm Limit Selection
4-7	Float	Level Alarm

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
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	Warning	Set to nearest possible value
9-15		Undefined
16	Error	Access Restricted
17		Undefined
18	Error	Invalid Units Code
19-31		Undefined
32	Error	Busy (Delayed Response could not be initiated)
33	Error	DR Initiate
34	Error	DR Running
35	Error	DR Dead
36	Error	DR Conflict
37 - 127		Undefined

7.2.7 Command 2950 Write Level Settings Level Trim (Mandatory)

This command is used for writing a Level Point during a wet calibration. The corresponding Sensor Point must be read and saved by the device at the same time. The Level Point unit must be in the same unit as Media Level.

Points may be unchanged, changed, inserted, appended or deleted. This is defined by the Calibration Function Code. (See Table 8.9 for specified function codes)

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1	Unsigned-8	Index of the Calibration Point (Max: 249)
2	Enumeration 8	Calibration Function Code (see Level Family Table 14)
3-4	Enumeration 16	Media Level Unit code
5-8	Float	Level value according to selection in byte 1

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1	Unsigned-8	Index of the Calibration Point (Max: 249)
2	Enumeration 8	Calibration Function Code
3-4	Enumeration 16	Media Level Unit code
5-8	Float	Level value according to selection in byte 1
9-10	Enumeration 16	Sensor Unit code
11-14	Float	Sensor value according to selection in byte 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	Error	In Write-Protect mode
8		Undefined
9	Error	Applied process too high
10	Error	Applied process too low
11	Error	Level Point too large
12	Error	Level Point too small
13	Error	Identical Sensor Point already specified
14		Undefined
15	Error	Non-Monotonic Calibration (Type Data Entry Error)
16	Error	Access Restricted
17-28		Undefined
29	Error	Delete calibration point not supported (Type Misc Error)
30		Undefined
32	Error	Busy (Delayed Response could not be initiated)
33	Error	DR Initiate
34	Error	DR Running
35	Error	DR Dead
36	Error	DR Conflict
37 - 127		Undefined

7.2.8 Command 2951 Write Level Settings Level Offset (Mandatory)

This command is used for writing the Level Offset. The Level Offset unit must be in the same unit as the Media Level.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1-2	Enumeration 16	Media Level Unit code
3-6	Float	Level Offset

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1-2	Enumeration 16	Media Level Unit code
3-6	Float	Level Offset

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
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	Warning	Set to nearest possible value
9-15		Undefined
16	Error	Access Restricted
17-31		Undefined
32	Error	Busy (Delayed Response could not be initiated)
33	Error	DR Initiate
34	Error	DR Running
35	Error	DR Dead
36	Error	DR Conflict
37 - 127		Undefined

7.2.9 Command 2952 Write Calibration Point (Mandatory)

This command is used for writing a Calibration Point (Sensor Point and Level Point) during a dry calibration. The Sensor Point Value unit must be in the same unit as the Sensor Value. The Level Point Value unit must be in the same unit as the Media Level.

Points may be changed, inserted, appended or deleted. This is defined by the Calibration Function Code. (See Table 8.9 for specified function codes)

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1	Unsigned-8	Index of the Calibration Point, (Max: 249)
2	Enumeration 8	Calibration Function Code (see Level Family Table 14)
3-4	Enumeration 16	Sensor Unit code
5-8	Float	Sensor Point Value according to selection in byte 1
9-10	Enumeration 16	Media Level Unit code
11-14	Float	Level Point Value according to selection in byte 1

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1	Unsigned-8	Index of the Calibration Point, (Max: 249)
2	Enumeration 8	Calibration Function Code
3-4	Enumeration 16	Sensor Unit code
5-8	Float	Sensor Point Value according to selection in byte 1
9-10	Enumeration 16	Media Level Unit code
11-14	Float	Level Point Value according to selection in byte 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	Error	In Write-Protect mode
8		Undefined
9	Error	Sensor Point too large
10	Error	Sensor Point too small
11	Error	Level Point too large
12	Error	Level Point too small
13	Error	Identical Sensor Point already specified
14		Undefined
15	Error	Non-Monotonic Calibration (Type Data Entry Error)
16	Error	Access Restricted
17-28		Undefined
29	Error	Delete calibration point not supported (Type Misc Error)
30		Undefined
32	Error	Busy (Delayed Response could not be initiated)
33	Error	DR Initiate
34	Error	DR Running
35	Error	DR Dead
36	Error	DR Conflict
37 - 127		Undefined

7.2.10 Command 2953 Write Ullage Reference Point (Optional)

This command is used for writing the Ullage Reference Point. The Ullage Reference Point unit must be in the same unit as the Media Level.

Request Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1	Unsigned 8	Device Variable Code of the Ullage Level
2-3	Enumeration 16	Ullage Level Unit code
4-7	Float	Ullage Reference Point

Response Data Bytes

Byte	Format	Description
0	Unsigned-8	Device Variable Code of the Media Level
1	Unsigned 8	Device Variable Code of the Ullage Level
2-3	Enumeration 16	Ullage Level Unit code
4-7	Float	Ullage Reference Point

Command-Specific Response Codes

Code	Class	Description
0	Success	No Command-Specific Errors
1		Undefined
2	Error	Invalid Selection
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	Warning	Set to nearest possible value
9-15		Undefined
16	Error	Access Restricted
17-31		Undefined
32	Error	Busy (Delayed Response could not be initiated)
33	Error	DR Initiate
34	Error	DR Running
35	Error	DR Dead
36	Error	DR Conflict
37 - 127		Undefined

8 LEVEL FAMILY TABLES

8.1 Level Family Table 1. Media Level Device Variable Status Byte

The following table indicates the Device Variable Status returned by all of the Level Device Variables. Media Level is the access point for Device Status even if the device is configured for Ullage Level.

Hex Code	Description
0xC0	Process Data Status
0x30	Limit Status
0x08	More Device Variable Status Available
0x04	Level Alarm Limits Exceeded (See Level Status Byte 0 for more details)

8.2 More Level Device Variable Status

The following tables indicate the More Device Variable Status returned by all of the Level Device Variables. When Level Device Variable Status equals 0x08 then Command 2816 Read Level Status is to be sent. When more than one Bit value is specified in the tables below the device manufacturer must select the appropriate value.

8.2.1 Level Family Table 2. System Status Byte 0

Hex Code	System Status (16 available)	Process Data Status (Bits)	Level Limits Exceeded (Bits)
0x01 – 0x80	Undefined	x	x

8.2.2 Level Family Table 3. System Status Byte 1

Hex Code	System Status (16 available)	Process Data Status (Bits)	Level Limits Exceeded (Bits)
0x01 – 0x80	Undefined	x	x

8.2.3 Level Family Table 4. Sensor Status Byte 0

Hex Code	Sensor Status (16 available)	Process Data Status (Bits)	Level Limits Exceeded (Bits)
0x01	Sensor defect	00	0
0x02	Sensor Unknown	00	0
0x04	Sensor Value Invalid	00	0
0x08	Sensor Signal Lost	00	0
0x10	Sensor Signal Interference	01	0
0x20	Critical Signal to Noise Ratio	01	0
0x40	New Sensor Settings necessary	01	0
0x80	Undefined	x	x

8.2.4 Level Family Table 5. Sensor Status Byte 1

Hex Code	Sensor Status (16 available)	Process Data Status (Bits)	Level Limits Exceeded (Bits)
0x01	Additional Sensor defect (optional)	00 or 01	0
0x02	Additional Sensor Value Invalid (optional)	00	0
0x04-0x80	Undefined	x	x

8.2.5 Level Family Table 6. Level Status Byte 0

Hex Code	Level Status (16 available)	Process Data Status (Bits)	Level Limits Exceeded (Bits)
0x01	Level below Level Alarm Low Low	11	1
0x02	Level below Level Alarm Low	11	1
0x04	Level above Level Alarm High	11	1
0x08	Level above Level Alarm High High	11	1
0x10	Distance in Blocking Distance Low	01	x
0x20	Distance in Blocking Distance High	01	x
0x40-0x80	Undefined	x	x

8.2.6 Level Family Table 7. Level Status Byte 1

Hex Code	Level Status (16 available)	Process Data Status (Bits)	Level Limits Exceeded (Bits)
0x01	New Calibration necessary	01	0
0x02	Incorrect Calibration	00	0
0x04	New Level Settings Necessary	01	0
0x08-0x80	Undefined	x	x

8.3 Level Family Table 8. Sensor Classification Code

Sensor Classification is used, for example, by Command 2819 to identify in which unit classification the Sensor measurement is performed. The Additional Sensor Value Classification code will also use this table.

Code	Sensor Classification
0	Device Variable not classified
1-63	Reserved
64	Temperature
65	Pressure
66-68	Reserved
69	Length
70	Time
71-79	Reserved
80	Frequency
81	Reserved
82	Capacitance
83-249	Reserved
250	Not Used
251	None
252	Unknown
253	Special

8.4 Level Family Table 9. Distance Classification Code

Distance Classification is used for example in Command 2819 to identify in which unit classification the Distance measurement is performed.

Code	Distance Classification
0	Device Variable not classified
1-68	Reserved
69	Length
70-249	Reserved
250	Not Used
251	None
252	Unknown

253	Special

8.5 Level Family Table 10. Level Classification Code

Level Classification is used for example in Command 2819 to identify in which unit classification the Level measurement is performed.

This list is used for MediaLevel, UllageLevel and MeasuredLevel

Code	Level Classification
92	Level

8.6 Level Family Table 11. Additional Sensor Classification Code

Additional Sensor Classification is used for example in Command 2819 to identify in which unit classification the Additional Sensor measurement is performed.

Code	Additional Sensor Classification
0	Device Variable not classified
64	Temperature

8.7 Level Family Table 12. Sensor Technology Code

Sensor Technology indicates the technology used for the sensor measurement.

Code	Sensor Technology
0	Free Wave
1	Guided Wave
2	Capacitive
3	Hydrostatic
4	Radiometric
5	Magnetostrictive
6	Buoyancy
7-251	Undefined
252	Unknown
253	Special

8.8 Level Family Table 13. Blocking Distance Code

Blocking Distance Code indicates which Blocking Distances are implemented in the device.

Code	Blocking Distance Supported
0	No Blocking Distance
1	Only Blocking Distance High
2	Only Blocking Distance Low
3	Both Blocking Distances
4-251	Undefined
252	Unknown
253	Special

8.9 Level Family Table 14. Calibration Function Code

Calibration Function Code indicates which Calibration function is to be executed.

Code	Calibration Points Function
0	Get
1	Add, Insert, Append
2	Delete
3	Change
4-255	Undefined

8.10 Level Family Table 15. Blocking Distance Selection Code

Blocking Distance Selection Code indicates which Blocking Distance is being accessed.

Code	Blocking Distance Selection
0	Blocking Distance Low
1	Blocking Distance High
2-255	Undefined

8.11 Level Family Table 16. Level Alarm Limit Selection Code

Level Alarm Limit Code indicates which Alarm Limit is being accessed.

Code	Alarm Limit Selection
0	Alarm Limit Low Low
1	Alarm Limit Low
2	Alarm Limit High
3	Alarm Limit High High
4-255	Undefined

ANNEX A. SUMMARY OF LEVEL COMMANDS

Command No.	Command Name	Implementation
2816	Read Level Status	Mandatory
2817	Read Level Family Capability	Mandatory
2818	Read Level Family Device Variable Codes	Mandatory
2819	Read Level Family Variable Classification	Mandatory
2820	Read Level Family Device Variable Values	Mandatory
2821	Read Level Family Internal Variable Values	Mandatory
2822	Read Sensor Settings Values	Mandatory
2823	Read Level Settings Values	Mandatory
2824	Read Level Settings Alarm Limits	Optional
2825	Read Distance Settings Values	Optional
2826	Read Calibration Point	Mandatory
2827	Read Calibration Information	Mandatory
2944	Write Sensor Settings Sensor Offset	Mandatory
2945	Write Sensor Settings Sensor Compensation	Mandatory
2946	Write Distance Settings Distance Unit	Optional
2947	Write Distance Settings Blocking	Optional
2948	Write Distance Settings Measurement Distance	Optional
2949	Write Level Settings Alarm Limits	Optional
2950	Write Level Settings Level Trim	Mandatory
2951	Write Level Settings Level Offset	Mandatory
2952	Write Calibration Point	Mandatory
2953	Write Ullage Reference Point	Optional

ANNEX B. SUMMARY OF COMMON PRACTICE COMMANDS

The following Common Practice Commands are applicable to all level devices.

Commands 52 and 54 must be implemented in all level devices and the other Common Practice Commands listed are strongly recommended.

Command No.	Command Name	Note
35	Write PV Range Values	Recommended, but optional
50	Read Dynamic Variable Assignments	
51	Write Dynamic Variable Assignments	
52	Set Device Variable Zero	Used for Sensor Point B in a wet calibration.
53	Write Device Variable Units	Used for Additional Sensor Unit
54	Read Device Variable Information	
79	Write Device Variable	Used to set a device variable in simulation mode.
83	Reset Device Variable Trim	It must reset all N pairs of Trim Points

ANNEX C. REVISION HISTORY

C.1 Initial revision.