Supplemental Manual for Brooks® EtherCAT® VDM300 DI Water Vapor Delivery Module

EtherCAT®

Brooks® VDM300 Series
with EtherCAT® Communications

BROOKS®
INSTRUMENT

Essential Instructions
Read before proceeding!

Brooks Instrument designs, manufactures and tests its products to meet many national and international standards. These products must be properly installed, operated and maintained to ensure they continue to operate within their normal specifications. The following instructions must be adhered to and integrated into your safety program when installing, operating and maintaining Brooks Instrument products.

- To ensure proper performance, use qualified personnel to install, operate, update, program and maintain the product.
- Read all instructions prior to installing, operating and servicing the product. If this instruction manual is not the correct manual, please see back cover for local sales office contact information. Save this instruction manual for future reference.
- ⚠ **WARNING: Do not operate this instrument in excess of the specifications listed in the Instruction and Operation Manual. Failure to heed this warning can result in serious personal injury and / or damage to the equipment.**
- If you do not understand any of the instructions, contact your Brooks Instrument representative for clarification.
- Follow all warnings, cautions and instructions marked on and supplied with the product.
- ⚠ **WARNING: Prior to installation ensure this instrument has the required approval ratings to meet local and national codes. Failure to heed this warning can result in serious personal injury and / or damage to the equipment.**
- Install your equipment as specified in the installation instructions of the appropriate instruction manual and per applicable local and national codes. Connect all products to the proper electrical and pressure sources.
- Operation: (1) Slowly initiate flow into the system. Open process valves slowly to avoid flow surges. (2) Check for leaks around the flow meter inlet and outlet connections. If no leaks are present, bring the system up to the operating pressure.
- Please make sure that the process line pressure is removed prior to service. When replacement parts are required, ensure that qualified people use replacement parts specified by Brooks Instrument. Unauthorized parts and procedures can affect the product's performance and place the safe operation of your process at risk. Look-alike substitutions may result in fire, electrical hazards or improper operation.
- Ensure that all equipment doors are closed and protective covers are in place to prevent electrical shock and personal injury, except when maintenance is being performed by qualified persons.
- ⚠ **WARNING: For liquid flow devices, if the inlet and outlet valves adjacent to the devices are to be closed for any reason, the devices must be completely drained. Failure to do so may result in thermal expansion of the liquid that can rupture the device and may cause personal injury.**

European Pressure Equipment Directive (PED)

All pressure equipment with an internal pressure greater than 0.5 bar (g) and a size larger than 25mm or 1" (inch) falls under the Pressure Equipment Directive (PED).
- The Specifications Section of this manual contains instructions related to the PED directive.
- Products described in this manual are in compliance with EN directive 2014/34/EU.
- All Brooks Instrument Flowmeters fall under fluid group 1.
- Products larger than 25mm or 1" (inch) are in compliance with PED category I, II or III.
- Products of 25mm or 1" (inch) or smaller are Sound Engineering Practice (SEP).

European Electromagnetic Compatibility (EMC)

The Brooks Instrument (electric/electronic) equipment bearing the CE mark has been successfully tested to the regulations of the Electro Magnetic Compatibility (EMC directive 2014/30/EU).
Special attention however is required when selecting the signal cable to be used with CE marked equipment.
Quality of the signal cable, cable glands and connectors:
Brooks Instrument supplies high quality cable(s) which meets the specifications for CE certification.
If you provide your own signal cable you should use a cable which is overall completely screened with a 100% shield.
"D" or "Circular" type connectors used should be shielded with a metal shield. If applicable, metal cable glands must be used providing cable screen clamping.
The cable screen should be connected to the metal shell or gland and shielded at both ends over 360 Degrees.
The shield should be terminated to an earth ground.
Card Edge Connectors are standard non-metallic. The cables used must be screened with 100% shield to comply with CE certification.
The shield should be terminated to an earth ground.
For pin configuration : Please refer to the enclosed Instruction Manual.

ESD (Electrostatic Discharge)

⚠ **CAUTION: This instrument contains electronic components that are susceptible to damage by static electricity. Proper handling procedures must be observed during the removal, installation or other handling of internal circuit boards or devices.**
Handling Procedure:
1. Power to unit must be removed.
2. Personnel must be grounded, via a wrist strap or other safe, suitable means before any printed circuit card or other internal device is installed, removed or adjusted.
3. Printed circuit cards must be transported in a conductive container. Boards must not be removed from protective enclosure until immediately before installation. Removed boards must immediately be placed in protective container for transport, storage or return to factory.
Comments
This instrument is not unique in its content of ESD (electrostatic discharge) sensitive components. Most modern electronic designs contain components that utilize metal oxide technology (NMOS, SMOS, etc.). Experience has proven that even small amounts of static electricity can damage or destroy these devices. Damaged components, even though they appear to function properly, exhibit early failure.

Dear Customer,

We recommend that you read this manual in its entirety as this will enable efficient and proper use of the EtherCAT® VDM300. Should you require any additional information concerning the EtherCAT VDM300, please feel free to contact your local Brooks Sales and Service Office; see back cover for contact information, or visit us on the web at www.BrooksInstrument.com. We appreciate this opportunity to service your fluid measurement and control requirements, and trust that we will be able to provide you with further assistance in the future.

Yours sincerely,

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1   General Information

1.1   Introduction

EtherCAT® is an Ethernet based communication system and is known for its high cycle time and cost efficient cabling and master application solutions. Brooks Instrument now introduces the EtherCAT interface on its VDM300 Series platform.

This manual is a supplement to the Brooks VDM300 Series installation and operation manual. It is assumed that the owner of this EtherCAT mass flow controller or meter is thoroughly familiar with the theory and operation of this device. If not, it is recommended that the owner read the installation and operation manual first before continuing with this supplement.

This manual assumes basic knowledge and understanding of EtherCAT (its topology and its method of logically accessing the data or parameters contained within the device). This manual is not intended to be a replacement to the EtherCAT specifications. It is recommended but not required for the purposes of this manual, that the user obtains a copy of the EtherCAT specifications (www.ethercat.org).

This manual does not make any assumptions about any particular manufacturer of equipment or custom software used by the user to communicate with the Brooks device, but assumes the user has thorough understanding of such equipment and any configuration software.

Application Notes and FAQ's are available at the Brooks Instrument web site (www.BrooksInstrument.com).

1.2   Definition of Terms

Abbreviation	Description
CDP	Common Device Profile
CoE	CAN Application Protocol over EtherCAT
ESC	EtherCAT Slave Controller
ESI	EtherCAT Slave Information (device description in XML format)
ETG	EtherCAT Technology Group
LA	Link Active
MFC/MFM	Mass Flow Controller/Mass Flow Meter
OD	Object Dictionary
PDO	Process Data Object
PreOp	Pre-Operational
RO	Read Only
RW	Readable and Writable
RXPDO	Receive PDO
SDP	Specific Device Profile
SI	Sub-Index
TXPDO	Transmit PDO
WO	Write Only

1.3 Numbers

Numeric values used throughout this manual will be clearly denoted as to the base numeric system it represents. All hexadecimal numbers (base 16) will be prefixed with a 0x, like 0xA4. All binary numbers (base 2) will be suffixed with a b, like 1001b. All other numbers not annotated this way will be assumed decimal (base 10).

2   Quick Start

This section assumes the owner of the device has a fully operational and trouble-free communications network with appropriate power supplies. This section also assumes that an EtherCAT master application is connected to the network capable of PDO and mailbox data communication. Both types of data communication modes are supported by the Brooks VDM300 EtherCAT device.

Brooks® VDM300Series conforms to the ETG.5003 Semiconductor Device Profile specification.
This specification consists of two parts:

Part 1: Common Device Profile
The Common Device Profile (CDP) specifies requirements applicable to all devices described in the Specific Device Profiles. Furthermore, it describes features and functionalities which shall be further defined in the Specific Device Profiles.

Part 2xxx: Specific Device Profiles
The Specific Device Profile (SDP) is based on Part 1 (CDP) and defines the data structure of the specific devices.
The Brooks VDM300 Series implementation of the Semi EtherCAT SDP conforms to the proposed specification for ETG.5003.2121 which is under review by ETG.
For a complete specification of a device used in the semiconductor manufacturing industry a SDP shall be read complementary with the CDP. Users may obtain a copy of the EtherCAT specifications at (www.ethercat.org).

2.1   Master Hardware

Various companies provide EtherCAT master applications, e.g. TwinCAT from Beckhoff, or offer EtherCAT master stacks to develop a master application, e.g. Acontis. A PC can be used to run most EtherCAT master applications but needs dedicated Ethernet hardware to support the high cycle times and kernel mode operation of the master application, see (www.beckhoff.com).

2.2   Physical Interface

The available physical interfaces on the EtherCAT device are listed below. Refer to the VDM300 Series Installation and Operation Manual for more details.

• 15 pin D-sub male connector for power and analog I/O, indicated by "PWR INPUT/OUTPUT"

• Micro USB for RS485 diagnostic port indicated by 'DIAG', refer to the VDM300 Series installation and operation manual for more details Twin RJ4 ports, indicated by "EtherCAT IN and OUT" Power Supply and Analog I/OPower needs to be supplied via the 15 pin D-sub connector. This connector also provides access to analog I/O signals, see Table 2-1
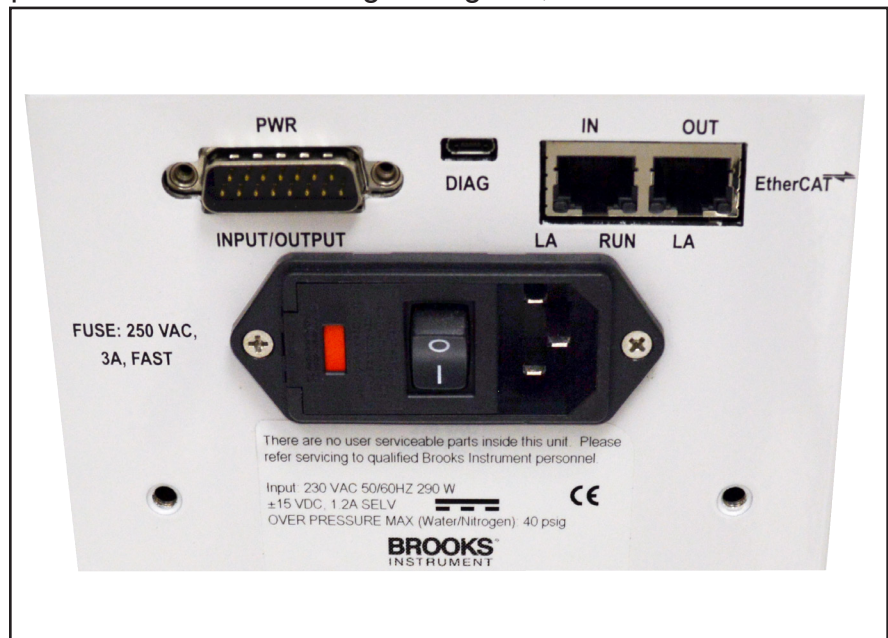
Figure 2-1 VDM300 Device Bottom Panel
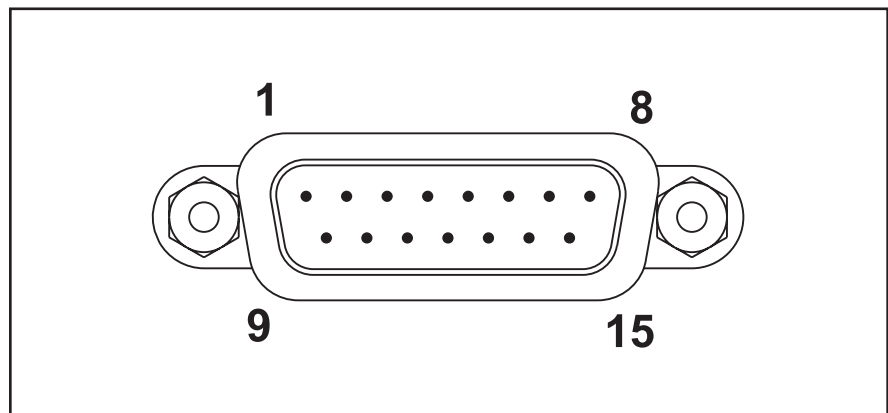
Figure 2-2 15-Pin D-sub Male Connector Pin Layout

Table 2-1 Pin Labelling of 15-Pin D-sub Connector

15-Pin Connector	Schematic Signal Name	Direction	Signal State (w/o Low Level Alarm Configuration)	Description
1	0-24Vdc Optional	Input	Digital output usage	Sets logic levels for digital I/O
2	Flow Signal Out	Output	0 to 5VDC	Scaled to vapor mass flow rate
3				Not functioning in EtherCAT device
4	Error Signal A	Output	+5 to 24VDC or Ground	This signal is user programmable. See Table 4-1a for device without Low Level Alarm configuration. See Table 4-1b for device with Low Level Alarm configuration
5	I/O Common	Input/ Output	N/A	Digital Ground Reference
6	-15 VDC	Input	-15 VDC	Negative rail for power supply circuitry
7	+15 VDC	Input	+15 VDC	Positive rail for power supply circuitry
8				Not functioning in EtherCAT device
9				Not functioning in EtherCAT device
10	Error Signal B	Output	+5 to 24VDC or Ground	This signal is user programmable. See Table 4-1a for device without Low Level Alarm configuration. See Table 4-1b for device with Low Level Alarm configuration
11	Analog Ground	Input/output	N/A	Ground reference for analog circuitry
12	Analog Ground	Input/output	N/A	Ground reference for analog circuitry
13	VDM 300 Status Indicator	Output	+5 to 24VDC or Ground	5-24 VDC indicates System is not ready, Ground indicates System ready- to-use. Oscillation between Ground and 5V at 1Hz indicates Drain Mode
14				Not functioning in EtherCAT device
15	Chassis Ground	Input	N/A	Reference ground for chassis

Table 2-1a: Error Logic for Devices Without Low Level Alarm Configuration
(Model Code: VDM3W3000AxAxNxxxx)

Pin 4	Pin 10	Indicates
Ground	Active	No Error
Active	Ground	High Tank Level
Ground	Ground	Either Low Tank Level or other System Error

Table 2-1b: Error Logic for Devices With Low Level Alarm Configuration
(Model Code: VDM3W3000AxAxLxxxx)

Pin 4	Pin 10	Indicates
Ground	Active	No Error
Active	Active	High Tank Level
Ground	Ground	Low Tank Level
Active	Ground	Other System Error

2.2.1 LEDs

The device supports RUN and LA LED indicators on the RJ45 jacks to indicate the status of network communication and the device mode.

The RUN LED will indicate the following:

Table 2-2 RUN LED Specification

Flash Code	Description
Off	The device is in INIT state
Blinking	The device is in PRE-OPERATIONAL state
Single Flash	The device is in SAFE-OPERATIONAL state
On	The device is in OPERATIONAL state
Flickering	The device Is booting and has not yet entered the INIT state.

The LA LED will indicate the following:

Table 2-3 LA LED Specification

Flash Code	Description
Off	No network detected
On	EtherCAT network detected

3 Slave Configuration

3.1 Introduction

Based on the information provided by the EtherCAT Slave Information file (ESI, device description in XML format) and/or EEPROM, master applications are able to configure the EtherCAT network. For the EtherCAT network configuration of the VDM300 Series devices, ESI files are provided on the Brooks website or contact Brooks Technical Support for more info.

The following table outlines the structure of the object dictionary and is divided into index areas as defined by ETG.5003. Not all index areas have object defined within them, as demonstrated in the sections to follow.

Table 3-1 Object Dictionary Structure

Index	Object
0x0000…0x0FFF	**Data Type Area**
0x1000…0x1FFF	**Communication Specific Data**
0x2000…0x5FFF	**Manufacturer Specific Data incl. Customer Requested Data**
0x2000 – 0x200B	Manufacturer Specific Inputs
0x200C – 0x200F	Customer Requested Inputs
0x3000 – 0x300B	Manufacturer Specific Outputs
0x300C – 0x300F	Customer Requested Outputs
0x4000 – 0x400B	Manufacturer Specific Configuration Data
0x400C – 0x400F	Customer Requested Configuration Data
0x5000 – 0x500B	Manufacturer Specific Information Data
0x500C – 0x500F	Customer Requested Information Data
0x6000…0xAFFF	**(SDP) Device Type Specific Data**
0x600x	Input Data of the Modules
0x700x	Output Data of the Modules
0x800x	Configuration Data of the Modules
0x900x	Information Data Modules
0xA00x	Diagnosis Data of the Modules
0xF0xx	**Semiconductor Device Profile Area**
0xF300	**Value Range Setting**
0xF38x…0xF3Ax	Exception Handling Data
0xF5xx	**Manufacturer Specific Device Data including Customer Requested Data**
0xF6xx	**SDP and CDP Device Specific Inputs**
0xF7xx	**SDP and CDP Device Specific Outputs**
0xF8xx	**SDP and CDP Device Specific Configuration Data**
0xF9xx	**SDP and CDP Device Specific Information Data**
0xFAxx	**SDP and CDP Device Specific Diagnosis Data**
0xFBxx	**SDP and CDP Command Objects**

3.2 Process Data Object (PDO) Mapping

Process Data Object mapping defines the data that is exchanged between the Master and the device using high speed data exchange. RxPDO mapping defines the data that is sent from the Master to the device and TxPDO mapping defines the data that is sent from the device to the Master. Note that the Master normally refers to RxPDO as Outputs and the TxPDO as Inputs.

During network configuration, the user must configure the data to be exchanged. The Brooks

VDM300 Series devices provide a default and a flexible PDO mapping object for each of the RxPDO and the TxPDO. The user may select either the default or the flexible PDO mapping, or both by using the PDO Assignment objects 0x1C12 and 0x1C13.

Rx flexible PDO mapping may be configured with up to 10 objects. Tx flexible PDO

mapping may be configured with up to 20 objects. Objects assigned to a PDO mapping must have the appropriate PDO access permission (see the Access column in the object definition tables). Mapping an object requires the user to specify the object's index, sub index, and size in bits in the PDO mapping object. Objects with a data type that is not a multiple of 8 bits may require that a Pad object be included so that the next object starts on an 8 bit boundary. An example of a datdoraa type that is not a multiple of 8 bits is the bool data type (1 bit). A pad object has an object number of 0x0000:00 with a non-zero bit size. The pad object counts as one of the 10 objects that can be configured. It is best practice to group objects that are not a multiple of 8 bits so that only 1 pad is required.

PDO mappings are sent from the Master to the device while the device is in PREOP state. If the PDO mappings are not properly configured, the device will return an error when re-quested to transition to the SAFEOP state. The Error LED will flash RED and the resulting device state will be ERRPREOP.

3.2.1 RxPDO Mapping

The Brooks VDM300 Series device supports one preconfigured, default RxPDO at 0x1600 and one user configurable RxPDO at 0x1601.

Table 3-2 Default RxPDO

PDO Index	PDO Sub Index	PDO Entry Index	PDO Entry Sub Index	Bit Length	Name
0x1600	0x01	0x7003	0x01	32	Flow SP [REAL]
	0x02	0x7009	0x01	8	Actuator Control

The default RxPDO is defined in the table below:

The following limitations apply to the flexible RxPDO (0x1601)

• Any PDO entry from the dynamic or the default PDO may only exist once. Setpoint (which can either be real or integer) can only be declared once. If an entry is declared more than once, or any other PDO definition fault exists (bad gap, invalid entry, etc.), the device will not exit pre-op.

• All objects assigned to active RxPDO will be Read-Only when accessed via COE Mailbox.

3.2.2 TxPDO Mapping

The Brooks VDM300 Series device supports one preconfigured, default TxPDO at 0x1A00 and one user configurable TxPDO at 0x1A01.

The default TxPDO is defined in the table below:

The following limitations apply to the flexible TxPDO (0x1A01):

Table 3-3 Default TxPDO

PDO Index	PDO Sub Index	PDO Entry Index	PDO Entry Sub Index	Bit Length	Name
0x1A00	0x01	0xF380	0x00	8	Active Exception Status
	0x02	0x6000	0x01	32	Flow Reading [REAL]
	0x06	0x6009	0x01	32	Position Set point [REAL]

3.3 Communication Specific Data

Table 3-4 Communication Specific Data

Index	Sub Index	Data Type	Access	Name	Description
0x1000		UDINT	RO	Device Type	5003. Sub-profile number is defined in 0xF010
0x1008		STRING(n)	RO	Manufacturer Device Name	Name of the device as non-zero terminated string, example: VDM300
0x1009		STRING(n)	RO	Manufacturer Hardware Version	Manufacturer Hardware Version
0x100A		STRING(n)	RO	Manufacturer Software Version	Manufacturer Firmware Version
0x100B		STRING(n)	RO	Manufacturer Bootloader Version	Manufacturer Bootloader Version
0x1018		IDENTITY	RO	Identity Object	
	0x01	UDINT	RO	Vendor ID	1538
	0x02	UDINT	RO	Product Code	300 = VDM300
	0x03	UDINT	RO	Revision Number	ESI Revision
	0x04	UDINT	RO	Serial Number	Numerical portion of the device serial number. For complete serial number see F9F0.
0x10F8		ULINT	RO	Timestamp Object	Local Timestamp of the device in ns. See ETG.1020
0x1600			RO	Default RxPDO Map	See Section 3.2
0x1601			RW	Flexible RxPDO Map	See Section 3.2
0x1A00			RO	Default TxPDO Map	See Section 3.2
0x1A01			RW	Flexible TxPDO Map	See Section 3.2
0x1C12			RW	RxPDO Assignment	See Section 3.2
0x1C13			RW	TxPDO Assignment	See Section 3.2
0x1C32		SCNC_PAR		Output SyncManager Parameter	
	0x01		R or RW	Synchronization Type	0x00: Free Run
	0x04		R	Synchronization Types supported	Bit 0: Free Run supported
0x1C33		SCNC_PAR		Input SyncManager Parameter	Sub-indexes shall be supported according to ETG.1020
	0x01		R or RW	Synchronization Type	0x00: Free Run
	0x04		R	Synchronization Types supported	Bit 0: Free Run supported

3.4 SDP Device Type Specific Data

3.4.1 Input Data

Table 3-5 Input Data

Index	Sub Index	Data Type	Access	Name	Description
0x6000				Sensor: Flow (floating)	
	0x01	REAL	RO TxPDO	Flow Reading	Current Flow Reading Units: Per Flow Data Unit
0x6004				Sensor: Flow (integer)	
	0x01	INT	RO TxPDO	Flow Reading	Current Flow Reading Units: COUNTS(-32768 to +32767, 24576=100%FS)
0x6009				Actuator	
	0x01	REAL	RO TxPDO	Position Set point	This is the read back of the Set point sent to the actuator. (e.g. valve voltage)
0x600F				Status	
	0x01	BOOL	RO TxPDO	Service in Progress	True if any command service has been started and currently active
	0x02	BOOL	RO TxPDO	Invalid Data Input	True if invalid input in RxPDO
	0x03	BOOL	RO TxPDO	Ramp Active	Ramp not supported
	0x04	BOOL	RO TxPDO	Valve Control Mode (fully-open)	True if device mode is set to fully-open
	0x05	BOOL	RO TxPDO	Valve Control Mode (fully-closed)	True if device mode is set to fully-closed

3.4.2   Output Data

Table 3-6 Output Data

Index	Sub Index	Data Type	Access	Name	Description
0x7003				**Controller: Flow SP (floating)**	
	0x01	REAL	WRITE_OP RxPDO	Flow SP	Sets MFC Flow Set point. Note: If this parameter is mapped in PDO, The "Flow SP [INT]" is excluded from PDO mapping. Units: Per Flow Data Unit
0x7007				**Controller: Flow SP (integer)**	
	0x01	INT	WRITE_OP RxPDO	Flow SP	Sets MFC Flow Set point Note: If this parameter is mapped in PDO, The "Flow SP [REAL]" shall be excluded from PDO mapping. Units: COUNTS(-32768 to +32767, 24576=100%FS)
0x7009				**Actuator**	
	0x01	USINT	WRITE_OP RxPDO	Actuator Control	0: Feedback (default) 1: Reserved 2: Fully Open 3: Fully Close 4: Freeze Position

3.4.3   Configuration Data

Table 3-7 Configuration Data

Index	Sub Index	Data Type	Access	Name	Description
0x8000				Sensor: Flow (floating)	
	0x01	UDINT	RW	Flow Data Unit	Data Unit for Flow Reading (Ref. ETG.1004) SCCM= 0x00A00000 SLM= 0x03A00000 This value is non-volatile
0x8009				Actuator	
	0x01	USINT	RW	Safe State	Specifies the behavior of the physical actuator while in safe state. MFC is in safe state while in INIT, BOOT, PREOP, or SAFEOP. 0: Valve unactuated (default) 1: Valve fully actuated 2: Hold last set point (flow or position) This value is non-volatile

3.4.4   Information Data

Table 3-8 Information Data

Index	SI	Data Type	Access	Name	Description
0x9000				Sensor: Flow (floating)	
	0x01	REAL	RO	Flow Reading Zero Offset	Stores Result of last Zero Offset service command executed. Units %FS
0x900A				Gas Parameter Instance 1	Gas Calibration Page 1
	0x01	USINT	RO	Gas Calibration Index	1
	0x02	UINT	RO	Gas Number	SEMI Number, 20
	0x03	STRING (128)	RO	Gas Symbol	Text Symbol, H2O
	0x04	STRING (128)	RO	Gas Name	Water Vapor
	0x05	REAL	RO	Minimum Full Scale	Minimum nominal value for this BIN and gas type in sub index 02 Units: SCCM
	0x06	REAL	RO	Nominal Full Scale	Maximum nominal value for this BIN and gas type in sub index 02 Units: SCCM
	0x07	REAL	RO	Configured Full Scale Range	Configured full scale range for the specified gas type in sub index 02 Units: SCCM
	0x08	REAL	RO	Minimum Flow SP	Manufacturer Defined, for this Gas and Bin with Configured Full Scale Range Units: %FS
	0x09	REAL	RO	Maximum Flow SP	Manufacturer Defined, for this Gas and Bin with Configured Full Scale Range Units: %FS
	0x0A	UINT	RO	Device Bin Number	Manufacturer defined
	0x0B	UINT	RO	Gas Calibration file revision number	Latest gas library revision stored in memory
	0x0C	UINT	RO	Revision of supported gas table	Revision number and description of update
	0x0D	STRING (10)	RO	Date of Factory Calibration	[DD/MM/YYYY]
	0x0E	STRING (10)	RO	Date of Last Calibration	[DD/MM/YYYY], date of cardinal points calibration. Note: VDM300 does not support cardinal point calibration adjustment.

3.5   Semi Device Profile Area

Table 3-9 Semi Device Profile

Index	Sub Index	Data Type	Access	Name	Description
0xF000				Semiconductor Device Profile	
	0x01	UINT	RO	Index Distance	Index offset between PDO entries of two consecutive modules (for ETG.5003 = 0x10), e.g. 0x7000, 0x7010
	0x02	UNIT	RO	Maximum Number of Modules	Up to 255 modules are possible. A device can support less than this. This entry described the supported number of modules
0xF010	0x01	UDINT	RO	Module Profile List	Each sub-index lists the profile-number of the corresponding module (hexadecimal representation, i.e. SDP 2121 is 0x0849)Bit 15…0: SDP Number Bit 31...16: 0x0000

3.6   Value Range Setting

Table 3-10 Value Range Setting

Index	Sub Index	Data Type	Access	Name	Description
0xF380		USINT	RO TxPDO	Active Exception Status	A condensed summary byte describing the collection of active device exceptions after corresponding masks (0xF3Ax) were applied. Bit 0: Device Warning Bit 1: Manufacturer Warning Bit 2: Device Error Bit 3: Manufacturer Error Bit 4...7: Reserved
0xF381	0x01	UDINT	RO TxPDO	Active Device Warning Details	Expanded details of the SDP specific device warning exceptions Bit 0-31 Reserved
0xF382	0x01	UDINT	RO TxPDO	Active Manufacturer Warning Details	Expanded details of the manufacturer warning exceptions specified by the manufacturer
0xF383	0x01	UDINT	RO TxPDO	Active Device Error Details	Expanded details of the SDP specific device error exceptions Bit 4 - Valve (malfunction) Bit 7-31 - Reserved
0xF384	0x01	UDINT	RO TxPDO	Active Manufacturer Error Details	Expanded details of the manufacturer error exceptions specified by the manufacturer
0xF390		USINT	RO TxPDO	Latched Exception Status	A condensed summary byte describing the collection of device exceptions after corresponding masks (0xF3Ax) were applied. Bit 0: Device Warning Bit 1: Manufacturer Warning Bit 2: Device Error Bit 3: Manufacturer Error Bit 4...7: Reserved
0xF391	0x01	UDINT	RO TxPDO	Latched Device Warning Details	Expanded details of the SDP specific device warning exceptions Bit 0-31 Reserved
0xF392	0x01	UDINT	RO	Latched	Expanded details of the manufacturer

Table continued on next page.

Table 3-10 Value Range Setting (Continued)

				TxPDO	Manufacturer Warning Details	warning exceptions specified by the manufacturer Mandatory if 0xF382 supported
0xF393	0x01	UDINT	RO TxPDO		Latched Device Error Details	Expanded details of the SDP specific device error exceptions Bit 4 - Valve (malfunction) Bit 7-31 - Reserved
0xF394	0x01	UDINT	RO TxPDO		Latched Manufacturer Error Details	Expanded details of the manufacturer error exceptions specified by the manufacturer. Mandatory if 0xF384 supported
0xF3A1	0x01	UDINT	RW		Device Warning Mask	Bitmask to include the corresponding device warning exception bits (as defined in the device warning details) in the active and latched exception status objects (0xF380 bit 0 and 0xF390 bit 0), if the corresponding bit is TRUE. Default of all bits TRUE (no masking).
0xF3A2	0x01	UDINT	RW		Manufacturer Warning Mask	Bitmask to include the corresponding manufacturer warning exception bits (as defined in the manufacturer warning details) in the active and latched exception status objects (0xF380 bit 1 and 0xF390 bit 1), if the corresponding bit is TRUE. Default of all bits TRUE (no masking).Mandatory if 0xF382 supported
0xF3A3	0x01	UDINT	RW		Device Error Mask	Bitmask to include the corresponding device error exception bits (as defined in the device error details) in the active and latched exception status objects (0xF380 bit 2 and 0xF390 bit 2), if the corresponding bit is TRUE. Default of all bits TRUE (no masking).
0xF3A4	0x01	UDINT	RW		Manufacturer Error Mask	Bitmask to include the corresponding manufacturer error exception bits (as defined in the manufacturer error details) in the active and latched exception status objects (0xF380 bit 3 and 0xF390 bit 3), if the corresponding bit is TRUE. Default of all bits TRUE (no masking). Mandatory if 0xF384 supported

3.7 Manufacturer Specific Device Data

Table 3-11 Manufacturer Specific Device Output Data

Index	Sub Index	Data Type	Access	Name	Description
0x2000				Sensor: VDM Specific	
	0x01	USINT	RO	Tank Level	Float level in the tank
	0x02	REAL	RO	Tank temperature, C	Tank temperature in degrees C
	0x03	REAL	RO	Block temperature, C	Block temperature in degrees C
	0x04	USINT	RO	VDM Status Indicator Pin	As described in the manual for the DB connector pin 13
	0x05	USINT	RO	Fill Valve Status	0 means closed, else open
	0x06	USINT	RO	Drain Valve Status	0 means closed, else open
	0x07	USINT	RO	Tank Overfill Alarm	0 means no alarm, else alarm
	0x08	USINT	RO	Tank Low Level Alarm	0 means no alarm, else tank level low while flowing
	0x09	USINT	RO	System Error Alarm Pin	0 means no error, else error
	0x0A	UDINT	RO	VDM Alarm Code	As described in the manual
	0x0B	USINT	RO	Drain Mode Status	0 means inactive, 1 means drain & 2 means complete
	0x0C	REAL	RO	Tank Heater Normalized	Normalized heater energy (tank)
	0x0D	REAL	RO	Block Heater Normalized	Normalized heater energy (MFC block)

Table 3-12 Manufacturer Specific Device Input Data

Index	Sub Index	Data Type	Access	Name	Description
0x3000				Commands: VDM Specific	
	0x01	USINT	WRITE_OP	Normal Pin	0 will prepare the system for vapor delivery if Drain is not 0, erp the manual for the Normal Pin 3.
	0x02	USINT	WRITE_OP	Drain Pin	0 will initiate a system drain if Normal is not 0, per the manual for the Drain pin 14.

3.8 SDP and CDP Device Specific Inputs

Table 3-13 SDP and CDP Device Specific Inputs

Index	Sub Index	Data Type	Access	Name	Description
0xF6F0	0x01	UDINT	RO TxPDO	Input Latch Local Timestamp	Local controller time corresponding to the input latch time in microseconds. It starts at zero on device power-up. If device has physical inputs: time of latching those inputs If device has no physical inputs: time immediately prior to writing to input SyncManager

3.9 SDP and CDP Device Specific Information Data

Table 3-14 SDP and CDP Device Specific Information Data

Index	Sub Index	Data Type	Access	Name	Description
0xF9F0		STRING(n)	RO	Manufacturer Serial Number	A string representing the manufacturer's serial number for the device. NOTE: This may have the same value as 0x1018:04.
0xF9F1	0x01	UDINT	RO	CDP Functional Generation Number	Common device profile functional generation number which this device supports.
0xF9F2	0x01	UDINT	RO	SDP Functional Generation Number	SDP functional generation number which this module supports. It shall be specified by each SDP.
0xF9F3		STRING(n)	RO	Vendor Name	String identifying the vendor text.
0xF9F4	0x01	STRING(n)	RO	Semiconductor SDP Device Name	String identifying the device type of this device, as defined by the SDP.
0xF9F5	0x01	USINT	RW RxPDO TxPDO	Output Identifier	The host (e.g. PLC application) increments this value each output change to verify the device has received the output(s). The slave shall not change the received value. Value shall be copied to the TxPDO if 0xF9F5 is mapped.
0xF9F6		UDINT	RO	Time since power on	Time since device has been powered on in seconds.
0xF9F7		UDINT	RO	Total time powered	Total time device has received power in seconds. It persists through power cycle.
0xF9F8		UDINT	RO	Firmware Update Functional Generation Number	FwUpdate Functional Generation Number supported by the device/module. Value shall be specified by the Firmware Update Profile (ETG.5003-2)0x00000000: FW Update according to ETG.5003-2 not supported

3.10   SDP and CDP Command Objects

Table 3-15 SDP and CDP Command Objects

Index	Sub Index	Data Type	Access	Name	Description
0xFB10		COMMAND _PAR		Zero Adjust for Flow Sensor	Service causes the device to modify flow reading offset [0x9nn0.01] such that flow reading [0x6nn0.01 and 0x6nn4.01] value equals zero as described in the operating manual.
	0x01	ARRAY [0..3] OF BYTE	WRITE_OP	Command	Send target reading [REAL]
	0x02	USINT	RO	Status	Supported values: 0: last command completed, no errors, no reply 1: Reserved 2: last command completed, error, no reply 3: Reserved 100-200: indicates how much of the command has been executed (in %, 100 = 0 %, 200 = 100 %) 255: command is executing (if the percentage display is not supported)
	0x03	ARRAY [0..1] OF BYTE	RO	Response	Byte 0: see Sub Index 2 Byte 1: unused (shall be 0)
0xFBF0		COMMAND _PAR		Device Reset Command	Execution of this command causes the device to emulate a complete power cycle. This includes an ESC reset. Some devices may require this reset to maintain a specific state not matching power cycle behavior for proper operation, per the SDP. NOTE: As consequence of an ESC reset all following devices are disconnected from the network. There are two versions of this command: Standard Reset: as described above Factory Reset: as described above, but

Table continued on next page.

Table 3-15 SDP and CDP Command Objects (Continued)

Index	Sub Index	Data Type	Access	Name	Description
					additionally, all parameters are restored to as-shipped defaults
	0x01	ARRAY [0…5] OF BYTE	RW	Command	A device reset is initiated when the following byte sequence is sent. Byte 0: 0x74 Byte 1: 0x65 Byte 2: 0x73 Byte 3: 0x65 Byte 4: 0x72 Byte 5: Standard Reset = 0x00
	0x02	USINT	RO	Status	Supported values: 0: Reserved 1: Reserved 2: last command completed, error, no response 3: Reserved 3-99: Reserved; shall be 0 100-200: indicates how much of the command has been executed (in %, 100 = 0%, 200 = 100%) 201-254: Reserved; shall be 0 255: command is executing (if the percentage display is not supported)
	0x03	ARRAY [0..1] OF BYTE	RO	Response	Byte 0: see Sub index 2
0xFBF1		COMMAND _PAR		Exception Reset Command	Execution of this command clears the latched exceptions
	0x01	ARRAY [0…4] OF BYTE	RW	Command	A Latched Exception Reset is initiated when the following byte sequence is sent. Byte 0: 0x74 Byte 1: 0x65 Byte 2: 0x73 Byte 3: 0x65 Byte 4: 0x72
	0x02	USINT	RO	Status	Supported values: 0: last command completed, no error, no response 1: Reserved 2: last command completed, error, no response 3: Reserved 3-99: Reserved; shall be 0 100-200: indicates how much of the command has been executed (in %, 100 = 0%, 200 = 100%) 201-254: Reserved; shall be 0 255: command is executing (if the

Table continued on next page.

Table 3-15 SDP and CDP Command Objects (Continued)

Index	Sub Index	Data Type	Access	Name	Description
					percentage display is not supported)
	0x03	ARRAY [0..1] OF BYTE	RO	Response	Byte 0: See Sub index 2
0xFBF2		COMMAND _PAR		Store Parameters Command	Execution of this command will store all parameters to non-volatile memory. If a device automatically saves all non-volatile parameters at the time they are written, this command will not take any action.
	0x01	ARRAY [0…4] OF BYTE	RW	Command	Read: Bit 0 = 1: slave saves the non-volatile parameters when writing 0xFBF2:01 with 0x65766173 Bit 1 = 1: slave saves the non-volatile parameters automatically when they are written Bit 2-31: reserved, shall be 0 Write: With the value 0x65766173 the non-volatile values will be stored in the non-volatile memory of the slave. If other values are written the Abort Code "0x06040043 Parameter is incompatible" shall be returned.
	0x02	USINT	RO	Status	Supported values: 0: last command completed, no error, no response 1: Reserved 2: last command completed, error, no response 3-99: Reserved; shall be 0 100-200: indicates how much of the command has been executed (in %, 100 = 0%, 200 = 100%) 201-254: Reserved; shall be 0 255: command is executing (if the percentage display is not supported)
	0x03	ARRAY [0..1] OF BYTE	RO	Response	Byte 0: See Sub index 2
0xFBF3		COMMAND _PAR		Calculate Checksum Command	Execution of this command will calculate a checksum for parameters stored in non-volatile memory. If the checksum cannot be calculated the Abort Code "0x08 00 00 21" shall be returned. All devices shall be able to calculate a checksum in PREOP without restriction.

Table continued on next page.

Table 3-15 SDP and CDP Command Objects (Continued)

Index	Sub Index	Data Type	Access	Name	Description
	0x01	ARRAY [0…3] OF BYTE	RW	Command	Read: Returns information about the supported checksum type Bit 0 = 0: no non-volatile parameters supported Bit 0 = 1: non-volatile parameters supported, at least 1 of the defined bits 1-7 shall be set Bit 1 = 1: CRC-32 Bit 2 = 1: MD5 Bit 3 = 1: SHA-1 Bit 4-6: Reserved, shall be 0 Bit 7 = 1: other algorithm Bit 8...31: Reserved, shall be 0 Write: Checksum Type Selection and Start Calculation A write access to this subindex shall only set one bit true in Bit[0...7]. If other values are written the Abort Code "0x06040043 Parameter is incompatible" shall be returned. Bit 0 = 1: Use default checksum algorithm of the slave Bit 1 = 1: CRC-32 Bit 2 = 1: MD5 Bit 3 = 1: SHA-1 Bit 4-6: Reserved, shall be 0 Bit 7 = 1: other algorithm Bit 8...31: Reserved, shall be 0
	0x02	USINT	RO	Status	Read: Returns information about the supported checksum type Bit 0 = 0: no non-volatile parameters supported Bit 0 = 1: non-volatile parameters supported, at least 1 of the defined bits 1-7 shall be set Bit 1 = 1: CRC-32 Bit 2 = 1: MD5 Bit 3 = 1: SHA-1 Bit 4-6: Reserved, shall be 0 Bit 7 = 1: other algorithm Bit 8...31: Reserved, shall be 0 Write: Checksum Type Selection and

Table 3-15 SDP and CDP Command Objects (Continued)

Index	Sub Index	Data Type	Access	Name	Description
					Start Calculation A write access to this subindex shall only set one bit true in Bit [0...7]. If other values are written the Abort Code "0x06040043 Parameter is incompatible" shall be returned. Bit 0 = 1: Use default checksum algorithm of the slave Bit 1 = 1: CRC-32 Bit 2 = 1: MD5 Bit 3 = 1: SHA-1 Bit 4-6: Reserved, shall be 0 Bit 7 = 1: other algorithm Bit 8...31: Reserved, shall be 0
	0x03	ARRAY [0..n] OF BYTE	RO	Response	Byte 0: see Subindex 2 Byte 1: Unused - Shall be zero Byte 2-n: Checksum return value. Size varies depending on checksum type used. The maximum length shall be 64 bytes.
0xFBF4			RO	Load Parameters Command	Execution of this command will load all parameters from non-volatile memory. If a device automatically saves all non-volatile parameters at the time they are written, this command will not take any action.
	0x01	ARRAY [0..3] OF BYTE	RW	Command	Read: Bit 1 = 1: slave saves the non-volatile parameters automatically when they are written Write: No action since slave saves the non-volatile parameters automatically
	0x02	USINT	RO	Status	"Supported values: 0: last command completed, no error, no response 1: Reserved 2: last command completed, error, no response
	0x03	ARRAY [0..1] OF BYTE	RO	Response	"Byte 0: see Subindex 2

4   Exceptions Implementation

The VDM300 EtherCAT detects exception conditions and reports these exceptions via Ether-CAT objects and on the display. Each exception is assigned to a category for EtherCAT reporting. Each exception is also assigned a severity classification. The severity classification defines how the exception is displayed and the action the device may take when the exception occurs.

The VDM300 supports 3 severity classifications:
• Failure
• Error
• Alert

An exception is assigned to the Failure classification if the exception is likely the result of a component failure or a configuration issue. Either of these results in the device being grossly inaccurate or otherwise unable to control flow. When an exception of this classification is detected, the device will be placed into safe state.

An exception is assigned to the Error classification when the cause of the exception may require action by the user. Exceptions of this type are typically process related and may affect flow accuracy.

Exceptions assigned to the Alert classification are informational and/or notifications to the user. The ETG.5003 Semiconductor Common Device Profile defines 4 categories for reporting of exceptions:
• Device Errors
• Device Warnings
• Manufacturer Errors
• Manufacturer Warnings

The assignment of exceptions to Device Errors and Device Warnings is specified by the Mass Flow Controller Specific Device Profile (SDP), ETG.5003.202x. (Specification 2121 is under review by ETG.) The assignment of exceptions to Manufacturer Errors and Manufacturer Warnings is specified by the manufacturer for each device type.

EtherCAT defines objects to report Exception information and objects to control the reporting of exceptions as shown in Table 1. In addition, the Brooks VDM300 defines 1 additional object to control the display of active errors and warnings.

Each error and warning condition can be enabled/disabled using the Mask objects 0xF3A1, 0xF3A2, 0xF3A3, and 0xF3A4. A set bit in the mask enables the error or warning. See Table 4-2, Table 4-3, and Table 4-4 for the appropriate mask object and bit for each error or warning condition.

Table 4-1 Objects for Reporting and Controlling Exceptions

Index	Sub Index	Data Type	Access	Name	Description
F380		USINT	RO	Active Exception Status	A condensed summary byte summarizing all active device and manufacturer defined exceptions: Bit 0 = Device Defined Warning Bit 1 = Manufacturer Defined Warning Bit 2 = Device Defined Error Bit 3 = Manufacturer Defined Error
F381	01	UDINT	RO	Active Device Warning Details	Bit mapped reporting of all Device defined Warnings. NOTE: There are no exceptions of this type defined by the Device Profile.
F382	01	UDINT	RO	Active Manufacturer Warning Details	Bit mapped reporting of all Manufacturer defined Warnings per Table 4-4
F383	01	UDINT	RO	Active Device Error Details	Bit mapped reporting of all Device defined Errors as described in Table 4-2
F384	01	UDINT	RO	Active Manufacturer Error Details	Bit mapped reporting of all Manufacturer defined Warnings as described in Table 4-3
F390		USINT	RO	Latched Exception Status	A latched version of the Active Exception Status, 0xF380. To clear latched bits see object 0xFBF1, Exception Reset Command.
F391	01	UDINT	RO	Latched Device Warning Details	A latched version of the Active Device Warning Details, 0xF381. To clear latched bits see object 0xFBF1, Exception Reset Command.
F392	01	UDINT	RO	Latched Manufacturer Warning Details	A latched version of the Active Manufacturer Warning Details, 0xF382. To clear latched bits see object 0xFBF1, Exception Reset Command.
F393	01	UDINT	RO	Latched Device Error Details	A latched version of the Active Device Error Details, 0xF383. To clear latched bits see object 0xFBF1, Exception Reset Command.
F394	01	UDINT	RO	Latched Manufacturer Error Details	A latched version of the Active Manufacturer Error Details, 0xF384. To clear latched bits see object 0xFBF1, Exception Reset Command.
F3A1	01	UDINT	RW	Device Warning Mask	A Bitmask to Enable/Disable the reporting of Device Warnings. NOTE: There are no exceptions of this type defined by the Device Profile.
F3A2	01	UDINT	RW	Manufacturer Warning Mask	A Bitmask to Enable/Disable the reporting of Manufacturer Warnings per Table 4-4. A bit defined as a 1 enables the corresponding exception.
F3A3	01	UDINT	RW	Device Error Mask	A Bitmask to Enable/Disable the reporting of Manufacturer Warnings per Table 4-2 A bit defined as a 1 enables the corresponding exception.
F3A4	01	UDINT	RW	Manufacturer Error Mask	A Bitmask to Enable/Disable the reporting of Manufacturer Warnings per Table 4-3. A bit defined as a 1 enables the corresponding exception

* Manufacturer defined

The VDM300 supports exceptions as defined in *Table 4-2*, *Table 4-3*, and *Table 4-4*.

Table 4-2 Device Errors

Condition Detected	Reported As	Severity	Exception Type
Valve Drive Failure, indicates that the valve drive circuit is outside of the normal operating range.	0x00000004	Error	Device Error

Table 4-3 Manufacturer Errors

Condition Detected	Reported As	Severity	Exception Type
Flow Sensor Failure, indicates that the flow sensor is outside of the normal operating ranges.	0x00000001	Failure	Manufacturer Error
Flow Sensor Block Temperature Sensor Failure, indicates that the temperature sensor is outside of the normal operating ranges.	0x00000002	Failure	Manufacturer Error
Tank Temperature Sensor Failure, indicates that the tank temperature sensor is outside of the normal operating ranges.	0x00000004	Failure	Manufacturer Error
Fill valve error	0x00000010	Failure	Manufacturer Error
Water level cannot be determined	0x00000020	Failure	Manufacturer Error
Sensor Flash not detected.	0x00000040	Failure	Manufacturer Error
Flash Data error.	0x00000080	Failure	Manufacturer Error
Flash Data error.	0x00000100	Error	Manufacturer Error
Calibration Failure.	0x00000200	Error	Manufacturer Error
Flow Sensor Block Temperature Stability Err, after the warmup period indicates that the sensor block temperature is out of control range.	0x00000400	Error	Manufacturer Error
Flow Zero Drift, indicates that the zero calibration has moved excessively from the factory zero.	0x00000800	Error	Manufacturer Error
Tank Temperature Stability Err, after the warmup period indicates that the tank temperature is out of control range.	0x00001000	Error	Manufacturer Error
Positive 12V out of spec.	0x00002000	Error	Manufacturer Error
Negative 12V out of spec.	0x00004000	Error	Manufacturer Error
3.3 Volt Supply out of spec.	0x00008000	Error	Manufacturer Error
5 Volt Supply out of spec.	0x00010000	Error	Manufacturer Error
Unable to achieve control, indicates that the unit took longer than 5 second to reach setpoint.	0x00020000	Error	Manufacturer Error
EtherCat Identity	0x00040000	Error	Manufacturer Error
Drain Valve Error	0x00080000	Error	Manufacturer Error
Tank Temperature out of operational limit. -Low	0x00100000	Error	Manufacturer Error
Tank Temperature out of operational limit. -High	0x00200000	Error	Manufacturer Error
Sensor Temperature Out of Operational Limit -High	0x00400000	Error	Manufacturer Error
Sensor Temperature Out of Operational Limit - Low	0x00800000	Error	Manufacturer Error
Vaporizing Chamber Overfilled	0x01000000	Error	Manufacturer Error
Tank has run dry.	0x02000000	Error	Manufacturer Error
Tank level sensor not detected	0x04000000	Error	Manufacturer Error
Failed to be Ready To Use in time	0x08000000	Error	Manufacturer Error

** Reserved for future implementation

Table 4-4 Manufacturer Warnings

Condition Detected	Reported As	Severity	Exception Type
Flow Sensor Block Temperature Stability Warning, after the warmup period indicates that the sensor block temperature is out of control range.	0x00000001	Alert	Manufacturer Warning
Flow Zero Drift, indicates that the zero calibration has moved excessively from the factory zero.	0x00000002	Alert	Manufacturer Warning
Tank Temperature Stability Warning, after the warmup period indicates that the tank temperature is out of control range.	0x00000004	Alert	Manufacturer Warning
Device not warmed up	0x00000008	Alert	Manufacturer Warning
Address switches differ from address read at power up.	0x00000020	Alert	Manufacturer Warning
Failure to drain	0x00000040	Alert	Manufacturer Warning

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