# EtherNet/IP™ Supplemental Manual

## SLA5800 & SLAMf Series Digital Mass Flow Controllers & Meters
### (Product revision 3.X)

**BROOKS®**
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*Beyond Measure*

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## Section 1: General Information

Many applications of Flow Controllers/Meters are moving to increase the use of automation. Automation comes in many forms: PLC's (Programmable Logic Controllers, like those from Allen/Bradley, DCS's (Distributed Control Systems, such as Emerson's DeltaV), PC-based solutions (National Instruments LabVIEW™), and Ethernet based field buses. Digital communications from these varied systems and the devices they measure and control, are a very effective means of not only accomplishing more effective and rapid system integration, but also providing greatly improved system diagnostics and maintainability.

EtherNet/IP™ is an Ethernet-based communications system for industrial automation applications built upon the IEEE 802.3 standards and TCP/IP communications standards. EtherNet/IP™ utilizes the Common Industrial Protocol (CIP™) as a top layer (application layer) of the TCP/IP protocol stack. This solution leverages the power of the internet and enterprise connectivity, combined with the functionality and comprehensive suite of messages and services for manufacturing automation applications. The EtherNet/IP™ interface is now available on SLA Series.

# Section 2: Definition of Terms

*Table 2-1 Definitions*

| Abbreviation | Description |
|---|---|
| Byte | A Byte refers to 8 consecutive bits. |
| CRC | Checksum (Cyclic Redundancy Check) |
| EIP | Ethernet/IP |
| EDS | Electronic Data Sheet |
| EtherNet/IP™ | Ethernet − Industrial Protocol |
| LSB | Least Significant Bit or Least Significant Byte |
| MAC | Media Access Control is responsible for address checking and is most often done in the hardware of a NIC. |
| Master | A Master is a unit which controls the Slaves, feeding them commands and receiving status reports in exchange. |
| MFC/MFM | Mass Flow Controller / Mass Flow Meter |
| MSB | Most Significant Bit or Most Significant Byte |
| MTU | Maximum Transmission Unit. The maximum payload that a standard Ethernet Frame can hold. The MTU is set at 1500 bytes (Not considering the Header and Checksum). |
| NIC | Network Interface Controller. A hardware component that connects a computer to a network. |
| NV | Non-Volatile |
| OSI Model | A standardized representation for how a communication system can be organized. (e.g., a protocol stack) The model is divided into layers, each responsible for a part of the communication. |
| RO | Read Only |
| RT | Real-time. A system that adheres to strict timing demands. |
| RW | Read / Write |
| Slave | A Slave is a unit (node) on the network (e.g., an MFC). The Slave is connected to a Master. |
| Stack | A synonym for the implementation of the layers of a protocol. |
| TCP/IP | Transport Control Protocol/Internet Protocol |
| Topology | The way a network (Master & Slaves) is inter-connected. The overall layout. (e.g., Star, Tree, Line Topology) |
| WO | Write Only |

## Section 3: Before Starting

### Background & Assumptions

This manual is a supplement to the SLA Series 5800 and MF/IP-66 Mass Flow Controller Installation and Operation Manuals. It is recommended that the owner read the Operations Manual first before continuing with this supplement.

This manual assumes a basic knowledge and understanding of the EtherNet/IP™ protocol, its topology and its method of logically accessing the data or parameters contained within a device. This manual also assumes basic knowledge and understanding regarding the operation of Mass Flow Controllers or Mass Flow Meters. This manual is not intended to be a replacement to the ODVA specification, which is still the authoritative definition and description of EtherNet/IP™ communications. It is recommended, but not required for the purposes of this manual, that the user obtain a copy of the EtherNet/IP™ specification from ODVA (http://www.odva.org/).

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

### Compliance

The SLA Series Mass Flow Controller (MFC) or Mass Flow Meter (MFM) conforms to the ODVA specified Device Profile for a Generic Device.

**Notations**

This section details notations and conventions used throughout the manual. It is recommended that the reader become very familiar with these conventions.

Hypertext links are used in the manual to assist in navigating.

A glossary is provided for reference in Section: 10 Glossary to aid in reviewing and/or to define any unfamiliar terms.

**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).

**EPATHS**

EPATH's will be denoted within brackets [] or braces {}, like [0x31, 1, 3], {0x31-1-3} which represents, left to right, the Class ID (hexadecimal or decimal), Instance ID (decimal), and Attribute ID (decimal)

## Section 4: Quick Start

This section assumes that the owner of the Digital Series device has a fully operational and trouble-free communications network with appropriate power supplies. This section also assumes that a master device or application is connected to the network, capable of Class 1 and Class 3 message communications. Both types of data communication modes are supported by the SLA Series EtherNet/IP™ device.

### Physical Interfaces

The available physical interfaces on the EtherNet/IP™ SLA5800 device are listed below:

- 5 pin M8 threaded male connector for power and Analog I/O, indicated by pwr.
- In and Out ports with RJ-45 connectors.
- 2.5mm female jack for RS485 diagnostic port indicated by 'DIAG', refer to the SLA Series Installation and Operation Manual for more details.

The available physical interfaces on the Ethernet/IP™ SLAMF/IP-66 Device are listed below:

- 5 pin M8 threaded Male (Nano Change) Connector for power and Analog I/O, indicated by pwr.
- In and Out ports with M12 connectors labeled "1" and "2".
- 2.5 mm female jack for RS485 diagnostic port, which is located under the top cover

**Communications**
**I/O SLAMF/IP-66**
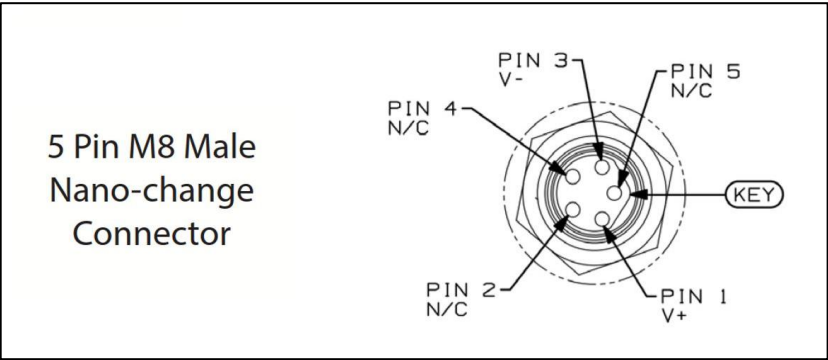


*Table 4.1: Pin Labeling of M12 Female "D"*
*Connectors (2 per device)*



| CONNECTOR | FUNCTION |
|-----------|----------|
| 1 | TD+ |
| 2 | RD+ |
| 3 | TD- |
| 4 | RD- |
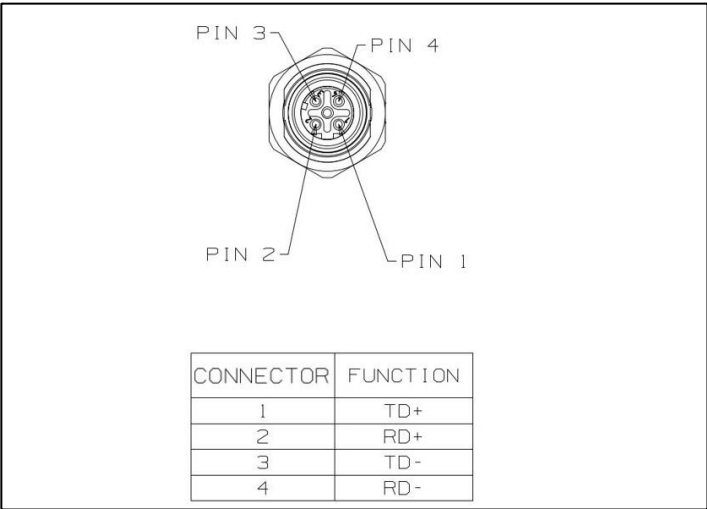
*Figure 4.1: 2 X M12, 4 POLE, FEMALE "D"*
*CODED CONNECTOR*



5-POLE

1 BROWN
2 WHITE
3 BLUE
4 BLACK
5 GREY

| Pin | Function |
|-----|----------|
| 1 | V + |
| 2 | N/C |
| 3 | V - |
| 4 | N/C |
| 5 | N/C |
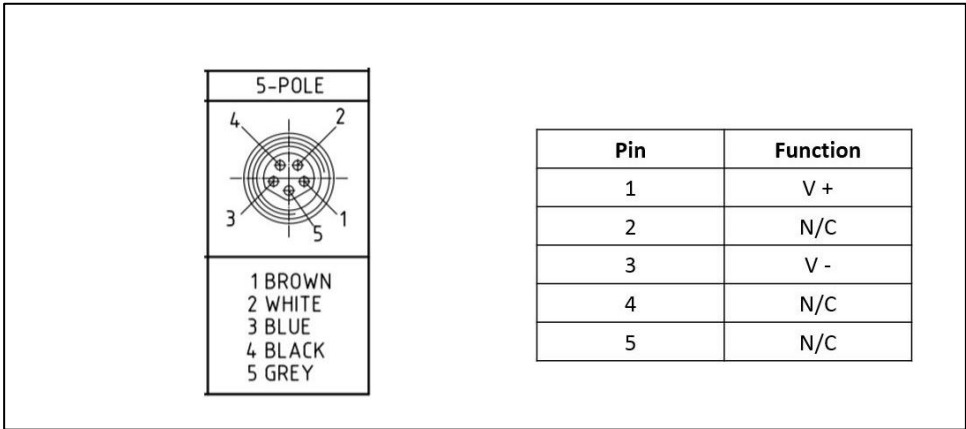
*Figure 4.2 Layout Under Top Cover*

**Power Supply SLA5800 & SLAMF/IP-66**

Power needs to be supplied via the M8 connector. This connector also provides access to analog I/O signals, see Table 4-2.



*SLA58xx Top Cover*
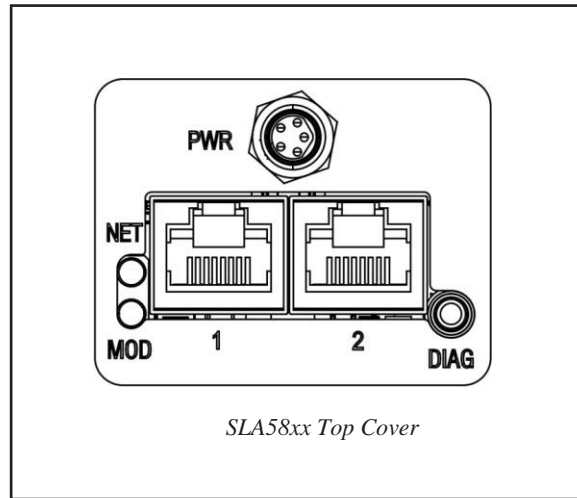
*Figure 4-2: EtherNet/IP Top Cover*



*SLA58xx*
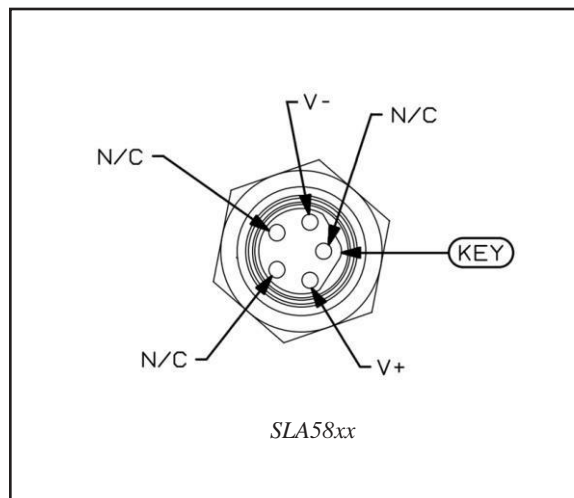
*Figure 4-3: M8 Male Device Connector Pin Layout, Pin Side View*

*Table 4-2: Pin Labeling of M8 Male Device and Female Mating Cable Connector*

| Pin Label | Function at Remote Connector |
|---|---|
| V+ | Positive Power Supply Voltage |
| V- | Power Supply Ground |
| N/C | Not Connected |

M8 mating cables can be purchased as a second line item, details given below.

*Figure 4-4: M8 Female Mating Cable*
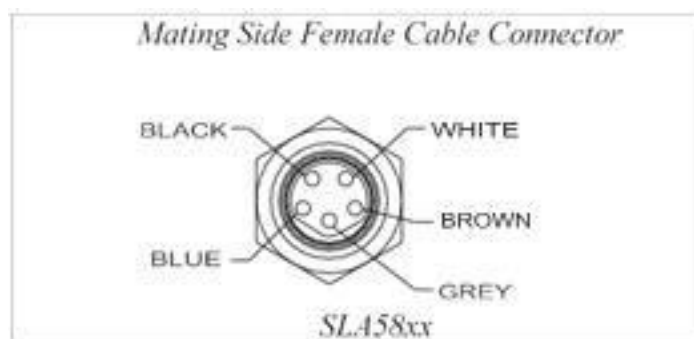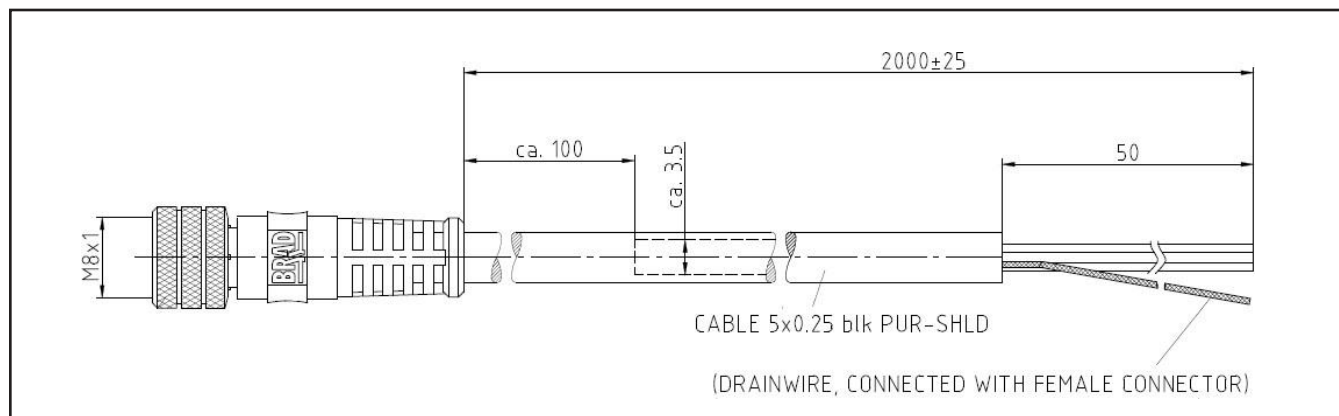


*Figure 4-5: M8 Female Mating Cable Connector Pin Layout*

## Network

*Table 4-3: Wire Labeling of M8 Female Mating Cable Connector*

| Wire Color | Wire Label | Function at Remote Connector |
|---|---|---|
| Blue | V | Power Supply Ground |
| Brown | V+ | Positive Power Supply Voltage |
| Black | N/C | Not Connected |
| White | N/C | Not Connected |
| Grey | N/C | Not Connected |

*Table 4-3: M8 Female Mating Cable Part Numbers*

| Supplier | Part Number | Description |
|---|---|---|
| Brooks Instrument | 124X049AAA | M8 Mating Cable 2m |
| | 124X050AAA | M8 Mating Cable 5m |
| | 124Z170AAA | ECAT to DB15 Male |

Each SLA Series EtherNet/IP™ device has (2) RJ-45 Ethernet Connection ports labeled 1 and 2. Network connections can be made to either or both ports, depending on the network topology. The SLA Series EtherNet/IP™ device will support star, linear and DLR topologies. Click the following reference for more detailed information on EIP topologies and their implementation EtherNet/IP Embedded Switch Technology.

The SLA Series EtherNet/IP™ device supports auto-negotiation of the communications link. Both ports support data rates of 10/100 Mbps and Half/Full duplex communications. The device may be directly connected to the Ethernet NIC on a desktop or laptop PC for configuration and commissioning activities

**MOD LED**

*Table 4-4: MOD LED Indicator Definitions*

| Indicator State | Summary | Requirement |
|---|---|---|
| Off | No power | No power is supplied to the device. |
| Green | Device Operational | Device is operating correctly. |
| Flashing Green | Standby | Device has not been configured. |
| Flashing Red | Major Recoverable Fault | The device has detected a Major Recoverable Fault (Alarm) |
| Red | Major Unrecoverable Fault | The device has detected a Major Unrecoverable fault (Error) |
| Flashing Green / Red | Self-test | The device is performing its power-up testing. |

**NET LED**

*Table 4-5: NET LED Indicator Definitions*

| Indicator State | Summary | Requirement |
|---|---|---|
| Off | Not powered, or no IP address | The device is powered off or is powered on but with no IP address configured. |
| Flashing Green | No connections | An IP address is configured, but no CIP connections are established with the device. |
| Steady Green | Connected | An IP address is configured, at least one CIP connection (any transport class) is established with the device. |
| Flashing Red | Connection timeout | An IP address is configured, and an Exclusive Owner connection has timed out. The NET indicator will return to steady green when the Exclusive Owner connection is reestablished. |
| Steady Red | Duplicate IP | The device has detected that its IP address is already in use. |
| Flashing Green / Red | Self-test | The device is performing its power-up testing. |

**TCP/IP Network Configuration**

The TCP/IP network settings can be configured using a web browser interface or through a variety of network utilities. By default, SLA Series EtherNet/IP™ MFC is shipped with DHCP enabled. If no DHCP server is available on the network, the device defaults to the following TCP/IP connections settings:

IP Address: 192.168.1.100

NET Mask: 255.255.255.0

Gateway Address: 0.0.0.0

DNS1: 0.0.0.0

DNS2: 0.0.0.0

To configure using a web browser, connect the device to the network that is configured with the same subnet as the device (192.168.1.xxx). Open the web browser and enter the IP address of the device as the URL

The Web Interface opens in read-only mode. To change the configuration, click the Login Tab. From the pulldown, select Configure or Control. The default password for Configure is 'configure'. The default password for Control is 'control'.

Click the Network Tab. By default, DHCP is selected. To manually configure the network settings, select the 'Store Value' radio button. The network configuration fields will become active. Click 'Submit' after setting the network configuration.

NOTE: Once the settings have been changed, the TCP/IP address will need to be reentered in the URL field of the browser to reconnect with the device and confirm the network settings.

## Class 1 Connection (Cyclic IO)

The following connection configuration can be used to create a Class 1 connection (also known as I/O Connection or Cyclic Data Connection). See Section 5 for more information on other Class 1 connection configurations.

See Appendix A for details on Class 1 Connection Types.

MFC

*Table 4-6: MFC Exclusive Owner Connection Configuration*

| Output[3] Assembly ID | 101 |
|---|---|
| Output Assembly Size | See Section 5.3 for Assembly 101 Size |
| Output Assembly RPI | > = 50 msec |
| Input[3] Assembly | 201 |
| Input Assembly Size | See Section 5.3 for Assembly 201 Size |
| Input Assembly RPI | >= 50 msec |
| Configuration Assembly[1] | 100 |
| Configuration Assembly Size[2] | See Section 5.3 for Configuration Assembly 100 Size |

1. If no configuration data is to be transferred to the device, set the configuration assembly ID to 0 with a data length of 0.
2. All field values in the configuration assembly data must have valid values or the assembly data will be rejected along with the connection open request.
3. The terms Input/Output are relative to the Master/Controller

<u>MFM</u>

*Table 4-7: MFM Input Only Connection Configuration*

| Output[3] Assembly ID | 102 |
|---|---|
| Output Assembly Size | See Section 5.3 for Assembly 102 Size |
| Output Assembly RPI | > = 50 msec |
| Input Assembly | 203 |
| Input Assembly Size | See Section 5.3 for Assembly 203 Size |
| Input Assembly RPI | >= 50 msec |
| Configuration Assembly[1] | 100 |
| Configuration Assembly Size[2] | See Section 5.3 for Configuration Assembly 100 Size |

1. If no configuration data is to be transferred to the device, set the configuration assembly ID to 0 with a data length of 0.
2. All field values in the configuration assembly data must have valid values or the assembly data will be rejected along with the connection open request.
3. The terms Input/Output are relative to the Master/Controller

## Class 3 Connection (Acyclic I/O)

The SLA Series EtherNet/IP™ devices support Class 3 connections. See Section 6 for details on supported objects and attribute definitions in the device.

## Section 5: Configuration

### Commonly Configured Attributes

EtherNet/IP™ provides several ways to configure a device. As noted in the previous sections, a configuration assembly can be used when establishing Class 1 connections, or alternatively, Class 3 connections can be used to set/get individual parameters

ODVA also defines Electronic Data Sheets (EDS) that specify the connections and parameters that are available in the device. The SLA Series EtherNet/IP™ device has EDS files available on the Brooks Instrument website. Your EIP network configuration tool may be able to read EDS files directly to facilitate the configuration process.

The SLA Series Ethernet/IP devices also contains an embedded web interface for configuration and troubleshooting. To access the web interface, see section '**TCP/IP Network Configuration**' in this manual.

The SLA Series MFC/MFM supports many different configurable attributes. The out-of-box defaults meet the needs of a great majority of applications, but some applications may require the device to report more information or behave differently than is configured with default settings, such as valve position, safe mode, flow and/or setpoint engineering units, etc.

This section covers the more common attributes that are configured to meet the unique needs of applications. The terms "attribute" and "parameters" can be used interchangeably and ultimately refer to the same data item within the MFC device. The term "parameter" is widely used within the EDS paradigm whereas "attribute" is used within the ODVA specification.

The following tables will reference both the EDS Parameter name (if the configuration software utilizes the EDS sheet) and the EPATH descriptor (class-instance-attribute) for those who are writing custom or have other types of configuration interfaces.

*Table 5-1: Commonly Configured Attributes/Parameters*

| Attribute | EDS Parameter | EPATH | Default | Semantics |
|---|---|---|---|---|
| Flow Meter Data Units | Flow_Unit | [0xA9-1-4] | 4103 (0x1007) | See Section 5.1.1 Data Units |
| Flow Controller Data Units | Ctrl_Units | [0x9E-1-4] | 4103 (0x1007) | See Section 5.1.1 Data Units |
| Temperature Meter Data Units | Temp_Units | [0xA4-1-4] | 4608 (0x1200) | See Section 5.1.1 Data Units |
| Selected Gas Calibration | Cal_Instance | [0xA9-1-35] | 1 | The instance of the Gas Calibration Object used to linearize the Flow Sensor |
| Valve Driver Safe State | Safe_State | [0x96-1-21] | 0 (Close) | The valve will close when the device is in its Safe State |
| Status Alarm Mask | Alarm_Mask | [0xB8-1-8] | 0x00000000 | All Alarm Bits are masked |
| Status Warning Mask | Warning_Mask | [0xB8-1-9] | 0x00000000 | All Warning Bits are masked |

## Data Units

The SLA Series MFC can report flow and accept setpoints in values associated to engineering units. This can simplify user interpretation of information from the device by letting the device perform the calculations necessary to interpret the flow signal from its internal sensor based upon information in the selected calibration.

*Table 5-2: Configurable Data Units Attributes*

| Parameter | EPATH | Applicable Units Table | Default |
|---|---|---|---|
| Flow Sensor Data Units | [0xA9-1-4] | Appendix C: Volumetric Flow Units Table | Percent |
| Flow Totalizer Data Units | [0xA9-1-125] | Appendix C: Volume Units Table | Liters |
| Flow Control Data Units | [0x9E-1-4] | Appendix C: Volumetric Flow Units Table | Percent |
| Temperature Data Units | [0xA4-1-4] | Appendix C: Temperature Units | deg C |

**Safe Mode**

All products in the SLA Series product line employ an internal State Machine to govern the operational mode of the device. One particular operational mode is the Safe Mode (a.k.a. the Safe State). For MFC(s), Safe Mode stops the controller and forces the valve actuator to a defined state (see section Valve Safe Mode). By default, the valve actuator will be closed. The state of the actuator in Safe Mode can be configured in the Valve Actuator object, parameters [0x96-1-21] and [0x96-1-22].

The device will be in Safe Mode when any of the following conditions exist:

- If any Error Status bit is set [0xB8-1-4]

- If no Class 1 connection is active

- If the Class 1 connection is closed or times out

- If a Class 1 connection is active and the Run/Idle flag is set to Idle[1]

**Valve Safe Mode**

The valve safe mode is the state the valve actuator will be in when the device is in Safe Mode. To configure the safe mode of the valve, use attribute 'Actuator Safe State' in the Valve Driver Object [0x96-1-21]. These states apply to both Normally Closed and Normally Open Valves.

*Table 5-3: Safe State*

| Value | State |
|-------|-------|
| 0 | Closed (default) |
| 1 | Open |
| 2 | Hold |
| 3 | Use Safe Value |

---

[1] The Class 1 Exclusive Owner connection message to the target device contains a header with certain flags required by the target device for proper operation. One of these flags is the Run/Idle flag. Setting of the Run/Idle flag is a function of the master/controller software. Consult your specific master/controller tools for setting this flag. One example would be changing the run mode of a PLC (run mode or program mode) would set/clear this flag. If the Run/Idle flag is set to Run, the device will be in the Executing State, otherwise the device will be in the Safe Mode.

**Process Gas Page Configuration**

If the MFC/MFM contains multiple calibrations, the selection of a particular calibration can be configured in attribute 'Calibration Instance' of the Flow Meter Object [0xA9-1- 35].

The value of this attribute is limited to the number of Flow Calibration Objects configured in the device. The minimum value is 1, which is also the default value.

Additionally, the calibration can be selected using the Calibration Instance field in output Assembly instance 101 for MFC's and Assembly instance 102 for MFM's. A value of 0 in this field is ignored by the device. If the field is set to an invalid value, calibration will not change and the 'Invalid Cal Page Selected' alarm status will be set.

## Class 1 Connections

The following tables describe the available Class 1 connection configurations in the device. See section 'Data Assemblies' for assembly sizes and details on the data fields within each assembly.

MFC

*Table 5-4: MFC Class 1 Connection Configurations*

| Name | Connection Type | Configuration Assembly | Output (Consume) Assembly | Input (Produce) Assembly |
|---|---|---|---|---|
| Ctrl/Mon XO | Exclusive Owner | - | 101 | 201 |
| Process Data 1 I/O | Input Only | - | 300 | 201 |
| Process Data 2 I/O | Input Only | - | 301 | 202 |
| Process Data 1 L/O | Listen Only | - | 302 | 201 |
| Process Data 2 L/O | Listen Only | - | 303 | 202 |
| Ctrl/Mon XO w/ Config | Exclusive Owner | 100 | 101 | 201 |
| Process Data 1 I/O w/ Config | Input Only | 100 | 304 | 201 |
| Process Data 2 I/O w/ Config | Input Only | 100 | 305 | 202 |
| Process Data 1 L/O w/ Config | Listen Only | 100 | 306 | 201 |
| Process Data 2 L/O w/ Config | Listen Only | 100 | 307 | 202 |
| Ctrl/Mon & Proc Data XO | Exclusive Owner | - | 101 | 204 |

MFM

*Table 5-5: MFC Class 1 Connection Configurations*

| Name | Connection Type | Configuration | Output (Consume) | Input (Produce) |
|---|---|---|---|---|
| Ctrl/Mon XO | Exclusive Owner | - | 102 | 203 |
| Process Data 1 I/O | Input Only | - | 300 | 202 |
| Process Data 2 I/O | Input Only | - | 301 | 203 |
| Process Data 1 L/O | Listen Only | - | 302 | 202 |
| Process Data 2 L/O | Listen Only | - | 303 | 203 |
| Ctrl/Mon XO w/ Config | Exclusive Owner | 100 | 102 | 203 |
| Process Data 1 I/O w/ Config | Input Only | 100 | 304 | 202 |
| Process Data 2 I/O w/ Config | Input Only | 100 | 305 | 203 |
| Process Data 1 L/O w/ Config | Listen Only | 100 | 306 | 202 |
| Process Data 2 L/O w/ Config | Listen Only | 100 | 307 | 203 |
| Ctrl/Mon & Proc Data XO | Exclusive Owner | - | 102 | 205 |

**Data Assemblies**

**Configuration Assembly**

The configuration assembly can be used to get or set configuration values in the device. Depending on the application tools for the master scanner, this configuration data can be sent to the device when Class 1 connections are created with the device. This data can also be accessed through message exchanges by reading or writing class 4, instance 100, attribute 3. If the configuration data is sent to the device using this assembly, all the data fields in the assembly must be a valid value otherwise all the data will be rejected. Refer to the object definitions for more information on parameter in this assembly.

**Configuration Assembly Instance ID: 100**

**Device Type: MFC**
**Assembly Size: 180 Bytes / 45 Words**

*Table 5-6: MFC Configuration Assembly Definition*

| Parameter | Class | Inst | ID | Data Type | Byte Offset | Data Size | Description |
|---|---|---|---|---|---|---|---|
| Flow Data Units | 169 | 1 | 4 | DINT | 0 | 4 | Flow Engineering Units |
| Totalizer Units | 169 | 1 | 125 | DINT | 4 | 4 | Totalizer Engineering Units |
| Calibration Instance | 169 | 1 | 35 | DINT | 8 | 4 | Selected Process Gas Instance |
| Flow Alarm Trip Point High | 169 | 1 | 17 | REAL | 12 | 4 | High Flow Alarm Trip Point |
| Flow Alarm Trip Point Low | 169 | 1 | 18 | REAL | 16 | 4 | Low Flow Alarm Trip Point |
| Flow Alarm Hysteresis | 169 | 1 | 19 | REAL | 20 | 4 | Flow Alarm Hysteresis. |
| Flow Alarm Settling Time | 169 | 1 | 20 | DINT | 24 | 4 | Flow Alarm Settling Time |
| Flow Warning Trip Point High | 169 | 1 | 21 | REAL | 28 | 4 | High Flow Warning Trip Point |
| Flow Warning Trip Point Low | 169 | 1 | 22 | REAL | 32 | 4 | |
| Flow Warning Hysteresis | 169 | 1 | 23 | REAL | 36 | 4 | |
| Flow Warning Settling Time | 169 | 1 | 24 | DINT | 40 | 4 | |
| Zero Operation Duration | 169 | 1 | 105 | DINT | 44 | 4 | Duration for Sensor Zero Operations |
| No Flow Threshold | 169 | 1 | 222 | REAL | 48 | 4 | No Flow Limit Threshold |
| No Flow Settling Time | 169 | 1 | 223 | DINT | 52 | 4 | No Flow Limit Settling Time |
| Choked Flow Threshold | 169 | 1 | 224 | REAL | 56 | 4 | Choked Flow Limit Threshold |
| Choked Flow Settling Time | 169 | 1 | 225 | DINT | 60 | 4 | Choked Flow Limit Settling Time |
| Zero Warning Time | 169 | 1 | 140 | DINT | 64 | 4 | Time since last zero warning limit |
| Zero Warning Settling Time | 169 | 1 | 141 | DINT | 68 | 4 | Delay time after zero setpoint to check zero quality |
| Zero Warning Band | 169 | 1 | 142 | REAL | 72 | 4 | Excessive drift warning band |
| Zero Success Band | 169 | 1 | 143 | REAL | 76 | 4 | Sensor zero operation success band |
| Back Stream Flow Limit | 169 | 1 | 228 | REAL | 80 | 4 | Backstream flow threshold |
| Back Stream Settling Time | 169 | 1 | 229 | DINT | 84 | 4 | Backstream flow settling time |
| Valve Warning Trip Point High | 150 | 1 | 18 | REAL | 88 | 4 | Valve High Warning Trip Point |
| Valve Warning Trip Point Low | 150 | 1 | 19 | REAL | 92 | 4 | Valve Low Warning Trip Point |
| Valve Warning Hysteresis | 150 | 1 | 20 | REAL | 96 | 4 | Valve Warning Hysteresis |
| Valve Safe State | 150 | 1 | 21 | DINT | 100 | 4 | Valve Safe State |
| Valve Safe Value | 150 | 1 | 22 | REAL | 104 | 4 | Valve Safe Value |

| Parameter | Class | Inst | ID | Data Type | Byte Offset | Data Size | Description |
|---|---|---|---|---|---|---|---|
| Controller Data Units | 158 | 1 | 4 | DINT | 108 | 4 | Flow Controller Engineering Units |
| Controller Warning Settling Time | 158 | 1 | 15 | DINT | 112 | 4 | Flow Controller Deviation Warning Settling Time |
| Controller Warning Error Band | 158 | 1 | 16 | REAL | 116 | 4 | Flow Controller Deviation Warning Error Band |
| Ramp Time | 158 | 1 | 19 | REAL | 120 | 4 | Flow Controller Ramp Time |
| Setpoint Limit | 158 | 1 | 194 | REAL | 124 | 4 | Flow Controller Setpoint Limit Value |
| Setpoint Limit Action | 158 | 1 | 201 | DINT | 128 | 4 | Flow Controller Setpoint Limit Behavior |
| Temperature Data Units | 164 | 1 | 4 | DINT | 132 | 4 | Temperature Engineering Units |
| Temperature Warning Trip Point High | 164 | 1 | 21 | REAL | 136 | 4 | High Temperature Warning Trip Point |
| Temperature Warning Trip Point Low | 164 | 1 | 22 | REAL | 140 | 4 | Low Temperature Warning Trip Point |
| Temperature Warning Settling Time | 164 | 1 | 24 | DINT | 144 | 4 | Temperature Warning Settling Time |
| Active Alarms Mask | 184 | 1 | 8 | DWORD | 148 | 4 | Alarms Bits Mask |
| Active Warnings Mask | 184 | 1 | 9 | DWORD | 152 | 4 | Warnings Bits Mask |
| Supply Voltage Warning Trip Point Low | 100 | 1 | 191 | REAL | 156 | 4 | Device power supply voltage high warning trip point |
| Supply Voltage Warning Trip Point High | 100 | 1 | 192 | REAL | 160 | 4 | Device power supply voltage warning low trip point |
| Supply Voltage Warning Settling Time | 100 | 1 | 193 | DINT | 164 | 4 | Device power supply voltage warning settling time |
| Zero Button Disable | 100 | 1 | 147 | DINT | 168 | 4 | Disables the zero button |
| Valve Control Warning Limit | 150 | 1 | 143 | REAL | 172 | 4 | Sets the threshold for the Valve Control Warning diagnostic |
| Valve Control Warning Settle Time | 150 | 1 | 144 | DINT | 176 | 4 | Sets the settling time for the Valve Control Warning diagnostic |

**Configuration Assembly Instance ID: 100**

**Device Type: MFM**
**Assembly Size: 112 Bytes / 28 Words**

*Table 5-7: MFM Configuration Assembly Definition*

| Parameter | Class | Inst | ID | Data Type | Byte Offset | Data Size | Description |
|---|---|---|---|---|---|---|---|
| Flow Data Units | 169 | 1 | 4 | DINT | 0 | 4 | Flow Engineering Units |
| Totalizer Units | 169 | 1 | 125 | DINT | 4 | 4 | Totalizer Engineering Units |
| Calibration Instance | 169 | 1 | 35 | DINT | 8 | 4 | Selected Process Gas Instance |
| Flow Alarm Trip Point High | 169 | 1 | 17 | REAL | 12 | 4 | High Flow Alarm Trip Point |
| Flow Alarm Trip Point Low | 169 | 1 | 18 | REAL | 16 | 4 | Low Flow Alarm Trip Point |
| Flow Alarm Hysteresis | 169 | 1 | 19 | REAL | 20 | 4 | Flow Alarm Hysteresis. |
| Flow Alarm Settling Time | 169 | 1 | 20 | DINT | 24 | 4 | Flow Alarm Settling Time |
| Flow Warning Trip Point High | 169 | 1 | 21 | REAL | 28 | 4 | High Flow Warning Trip Point |
| Flow Warning Trip Point Low | 169 | 1 | 22 | REAL | 32 | 4 | Low Flow Warning Trip Point |
| Flow Warning Hysteresis | 169 | 1 | 23 | REAL | 36 | 4 | Flow Warning Hysteresis |
| Flow Warning Settling Time | 169 | 1 | 24 | DINT | 40 | 4 | Flow Warning Settling Time |
| Zero Operation Duration | 169 | 1 | 105 | DINT | 44 | 4 | Duration for Sensor Zero Operations |
| Zero Warning Time | 169 | 1 | 140 | DINT | 48 | 4 | Time since last zero warning limit |
| Zero Warning Settling Time | 169 | 1 | 141 | DINT | 52 | 4 | Delay time after zero setpoint to check zero quality |
| Zero Warning Band | 169 | 1 | 142 | REAL | 56 | 4 | Excessive drift warning band |
| Zero Success Band | 169 | 1 | 143 | REAL | 60 | 4 | Sensor zero operation success band |
| Back Stream Flow Limit | 169 | 1 | 228 | REAL | 64 | 4 | Backstream flow threshold |
| Back Stream Settling Time | 169 | 1 | 229 | DINT | 68 | 4 | Backstream flow settling time |
| Temperature Data Units | 164 | 1 | 4 | DINT | 72 | 4 | Temperature Engineering Units |
| Temperature Warning Trip Point High | 164 | 1 | 21 | REAL | 76 | 4 | High Temperature Warning Trip Point |
| Temperature Warning Trip Point Low | 164 | 1 | 22 | REAL | 80 | 4 | Low Temperature Warning Trip Point |
| Temperature Warning Settling Time | 164 | 1 | 24 | DINT | 84 | 4 | Temperature Warning Settling Time |
| Active Alarms Mask | 184 | 1 | 8 | DWORD | 88 | 4 | Alarms Bits Mask |
| Active Warnings Mask | 184 | 1 | 9 | DWORD | 92 | 4 | Warnings Bits Mask |
| Supply Voltage Warning Trip Point Low | 100 | 1 | 191 | REAL | 96 | 4 | Device power supply voltage high warning trip point |

| Parameter | Class | Inst | ID | Data Type | Byte Offset | Data Size | Description |
|---|---|---|---|---|---|---|---|
| Supply Voltage Warning Trip Point High | 100 | 1 | 192 | REAL | 100 | 4 | Device power supply voltage warning low trip point |
| Supply Voltage Warning Settling Time | 100 | 1 | 193 | DINT | 104 | 4 | Device power supply voltage warning settling time |
| Zero Button Disable | 100 | 1 | 147 | DINT | 108 | 4 | Disables the zero button |

**Output Assemblies**

These assemblies are used to send data to the device. From the master scanner perspective these are outputs. Each assembly is defined to be used with a certain type of connection: Exclusive Owner, Input Only, and Listen Only. See Appendix A for more information on connection types. Refer to the object definitions for more information on parameter in this assembly.

**Process Control 1**
**Assembly Instance ID: 101**
**Device Type: MFC**
**Assembly Size: 24 Bytes / 12 Words**

*Table 5-8: Process Control 1 Assembly*

| Parameter | Class | Inst | ID | Data Type | Byte Offset | Data Size | Description |
|---|---|---|---|---|---|---|---|
| Setpoint | 158 | 1 | 6 | REAL | 0 | 4 | Flow controller setpoint |
| Valve Override | 150 | 1 | 5 | DINT | 4 | 4 | Valve Actuator Override Mode |
| Control Mode | 158 | 1 | 5 | DINT | 8 | 4 | Flow controller operational mode |
| Fixed Control Mode Value | 158 | 1 | 159 | REAL | 12 | 4 | Flow controller fixed controller mode actuator drive value |
| Custom Flow Totalizer Control | 169 | 1 | 131 | DINT | 16 | 4 | Sets the operational state of the custom flow totalizer |
| Calibration Instance | 169 | 1 | 35 | DINT | 20 | 4 | Selects the calibration page to be used by the flow meter |

**Null Data**
**Instance ID: 300 to 307**
**Device Type: MFC/MFM**
**Assembly Size: 0 Bytes / 0 Words**

Assembly Definition

Null Data assemblies are used for Listen Only or Input Only connections where no data is sent to the device, but an endpoint assembly must be defined when the connection is established.

**Input Assemblies**

These assemblies are used to retrieve data from the device. From the scanner perspective these are inputs. Each assembly is defined to be used with a certain type of connection: Exclusive Owner, Input Only, and Listen Only. See Appendix A for more information on connection types. Refer to the object definitions for more information on parameter in this assembly.

**Detailed Process Monitoring**
**Instance ID: 201**
**Device Type: MFC**
**Assembly Size: 28 Bytes / 14 Words**

*Table 5-9: Detailed Process Monitoring Assembly*

| Parameter | Class | Inst | ID | Data Type | Byte Offset | Data Size | Description |
|---|---|---|---|---|---|---|---|
| Flow | 169 | 1 | 6 | REAL | 0 | 4 | Flow sensor value |
| Valve Position | 150 | 1 | 6 | REAL | 4 | 4 | Valve actuator position |
| Live Setpoint | 158 | 1 | 202 | REAL | 8 | 4 | Active setpoint |
| Active Alarms | 184 | 1 | 4 | DWORD | 12 | 4 | Active Alarms |
| Active Warnings | 184 | 1 | 5 | DWORD | 16 | 4 | Active Warnings |
| Active Errors | 184 | 1 | 3 | DWORD | 20 | 4 | Active Errors |
| Device Status | 184 | 1 | 6 | DWORD | 24 | 4 | Device Status |

**Totalizers and Other Process Conditions**
**Instance ID: 202**
**Device Type: MFC and MFM**
**Assembly Size: 44 Bytes / 22 Words**

*Table 5-10: Totalizers and Other Process Conditions Assembly*

| Parameter | Class | Inst | ID | Data Type | Byte Offset | Data Size | Description |
|-----------|-------|------|-----|-----------|-------------|-----------|-------------|
| Flow Totalizer | 169 | 1 | 126 | REAL | 0 | 4 | Flow sensor totalizer |
| Flow Hours | 169 | 1 | 96 | DINT | 4 | 4 | Total flow hours |
| Custom Flow Totalizer | 169 | 1 | 130 | REAL | 8 | 4 | Custom flow sensor totalizer |
| Temperature | 164 | 1 | 6 | REAL | 12 | 4 | Temperature |
| Process Gas Full Scale | 102 | Active Instance[1] | 45 | REAL | 16 | 4 | Selected process gas page calibrated full scale |
| Process Gas Calibration Instance | 169 | 1 | 35 | DINT | 20 | 4 | Selected process gas page |
| Process Gas Standard Number | 102 | Active Instance[1] | 40 | DINT | 24 | 4 | Selected process gas page gas standard number |
| FAT Date | 102 | Active Instance[1] | 300 | DINT | 28 | 4 | Factory acceptance date |
| Device Input Supply Volts | 100 | 1 | 190 | REAL | 32 | 4 | Input voltage to MFC/MFM |
| Process Gas Data Units | 102 | Active Instance[1] | 42 | DINT | 36 | 4 | Selected process gas page calibration engineering units |
| Process Gas Flow Hours Totalizer | 102 | Active Instance[1] | 47 | REAL | 40 | 4 | Total flow hours for the selected process gas page |

[1] The Active Instance is selected by attribute Process Gas Calibration Instance [169-1-35]

**Flow and Detailed Device Status**
**Instance ID: 203**
**Device Type: MFM**
**Assembly Size: 20 Bytes / 10 Words**

*Table 5-11: Flow and Detailed Device Status Assembly*

| Parameter | Class | Inst | ID | Data Type | Byte Offset | Data Size | Description |
|---|---|---|---|---|---|---|---|
| Flow | 169 | 1 | 6 | REAL | 0 | 4 | Flow sensor value |
| Active Alarms | 184 | 1 | 4 | DINT | 4 | 4 | Active Alarms Status |
| Active Warnings | 184 | 1 | 5 | DINT | 8 | 4 | Active Warnings Status |
| Active Errors | 184 | 1 | 3 | DINT | 12 | 4 | Active Errors Status |
| Device Status | 184 | 1 | 6 | DINT | 16 | 4 | Active Device Status |

## Section 6: Detailed Configuration

### Overview

This section is recommended for advanced users of EtherNet/IP™ and Brooks Instrument MFC/ MFM products.

This section details all the Classes, Instances, Attributes and Services supported by the SLA58xx Series MFC/MFM. Differences between the MFC and MFM device types are noted as exceptions in each sub-section. The classes detailed in the following sections can be categorized into the following functional groups to indicate what aspect of the device is being configured:

*Table 6-1: Accessible Classes*

| Class | ID | Instances | MFC | MFM |
|---|---|---|---|---|
| Identity Object | 1 (0x01) | 1 | Y | Y |
| Assembly Object | 4 (0x04) | 5 | Y | Y |
| Device Management Object | 100 (0x64) | 1 | Y | Y |
| Process Gas Object | 102 (0x66) | 1-6 depending on the number of calibrations stored in the device | Y | Y |
| Valve Driver Object | 150 (0x96) | 1 | Y | N/A |
| Flow Controller Object | 158 (0x9E) | 1 | Y | N/A |
| Temperature Meter Object | 164 (0xA4) | 1 | Y | Y |
| Flow Meter Object | 169 (0xA9) | 1 | Y | Y |
| Status Object | 184 (0xB8) | 1 | Y | Y |

In the ODVA specification, Instance 0 of both attributes and services are referred to as Class Level attributes and services. Instance 1 and higher are referred to as Instance Level attributes and services. This document will refer to all Levels by their instance number to avoid possible confusion.

The following details the meaning of the table heading names:

**Attribute ID:** The ID number of the attribute.

**Name:** The ODVA Specification label for the attribute.

**Data Type:** The ODVA Data Type for this attribute. See Appendix B for the definition of each data type.

**Access Rule:** "Get" means that the value of this attribute is "Read Only". "Set" means that the value of this attribute can be read and/or written.

**NV:** "NV" = The value of the attribute is stored in non-volatile memory and its value will be retained after a power cycle.

**V:** "V" = The value of the attribute is in volatile memory and its value will be returned to default after a power cycle.

**Description:** A brief description of the meaning of the attribute.

**Notes:** Any additional notations of importance about the attribute. These notes will be found in the same section as the table.

**Services**

Services are operations or functions that can be invoked against an object. Services are invoked using Class 3 messaging (request/response). The services list in the table below are supported for all the objects define in this document. Other services specific to an object are included with the object description.

*Table 6-2: Common Services for all Objects*

| Service Code | Service Name | Service Description | Details |
|---|---|---|---|
| 0x0E | Get Attribute Single | Returns the contents of the specified attribute | Appendix D: Get Attribute Single |
| 0x10 | Set Attribute Single | Writes the contents of the specified attribute | Appendix D: Set Attribute Single |

## Identity Object [0x01]

Device Type(s): MFC and MFM

The Identity Object contains informational attributes that uniquely describe the device.

**Example:**
The use of attributes Vendor ID, Device Type, Product Code, and Serial Number together uniquely describe this device from any other device.

**Attributes**

*Table 6-3: Identity Instance Attributes*

| Attrib ID | Name | Data Type | Access Rule | NV | Description | Notes |
|---|---|---|---|---|---|---|
| 1 | Vendor ID | UINT | Get | NV | ID Number assigned to vendor by ODVA | Brooks Instrument ID = 246 |
| 2 | Device Type | UINT | Get | NV | Numeric identifier indicating the ODVA Device Profile implemented by the device | Device Type = 43 (0x2B) See 'Note: Device Type' below |
| 3 | Product Code | UINT | Get | NV | Identification of a product of an individual vendor. | MFC = 6, MFM = 7 |
| 4 | Revision | STRUCT of: | Get | NV | Revision of the device the Identity Object represents | See 'Note: Revision' below |
| | Major Revision | USINT | | | | |
| | Major Revision | USINT | | | | |
| 5 | Status | WORD | Get | V | Summary status of the device. | See 'Note: Status' below |
| 6 | Serial Number | UDINT | Get | NV | Serial number of device. | See 'Note: Serial Number' below |
| 7 | Product Name | SHORT STRING | Get | NV | Human readable Identification. | |

**Note: Device Type**

The device profile includes both an Identity and the Device Management Objects. Both objects contain an attribute that defines the kind of device this implementation supports. In this object the Device Type is assigned a numeric value of 0x2B. This number corresponds to the device profile ID contained in the ODVA specification. This attribute should not be confused with the Device Manager Device Type attribute [0x64, 1, 1] which is represented as a STRING (Short String) data type.

**Note: Revision**

The ODVA specification defines Major Revision as a significant change to the fit, form, or function of the product. Minor Revision is defined as changes that do not affect user configuration choices such as bug fixes, hardware component change, labeling change, etc.

**Note: Status**

The Status attribute of the Identity Object represents a summary status of the entire device. The definition of each bit in this attribute is defined by the ODVA EtherNet/IP™ specification. The Status Object (0xB8) provides detailed status of the operation of the MFC.

*Table 6-4: Identity Object Status*

| Bit | Label | Description |
|---|---|---|
| 0 | Owned | A Value of (1) indicates a Class 1 connection of type Exclusive Owner has been established with the device. Otherwise, this bit will have a value of (0) |
| 1-7 | Reserved | Always 0 |
| 8 | Minor Recoverable Fault | One or more Warning Status bits are set in the Status Object (184) attribute (5) |
| 9 | Reserved | Always 0 |
| 10 | Major Recoverable Fault | One or more Alarm Status bits are set in the Status Object (184) attribute (4) |
| 11 | Major Unrecoverable Fault | One or more Error Status bits are set in the Status Object (184) attribute (3) |
| 12-15 | Reserved | Always 0 |

**Note: Serial Number**

This Serial Number attribute differs from the Device Manager Serial Number attribute [0x64, 1, 9] whereby the Identity Object attribute [0x01, 1, 6] is strictly a numeric value that is guaranteed to be unique by the manufacturer across all …the manufacturer's products. The Device Manager attribute 'Serial Number' is a string value that should represent the manufacturer's method of defining serial numbers for its products.

**Services**

**Reset**

*Table 6-5: Identity Object Reset Service Arguments*

| Parameter Name | Data Type | Required | Parameter Value | Semantics |
|---|---|---|---|---|
| Type | USINT | N | 0 | Emulate as closely as possible cycling power on the item the Identity Object represents. This value is the default if this parameter is omitted (default). |
| | | | 1 | Return as closely as possible to the out–of–box configuration, then as closely as possible emulate cycling power. |

*Table 6-6: Identity Object Reset Service Response*

| Parameter Name | Data Type | Required | Parameter Value | Semantics |
|---|---|---|---|---|
| NO RESPONSE DATA | | | | |

## Assembly Object [0X4]

Device Type(s): MFC and MFM

The Assembly Object contains a list of attributes that data can be written to (sink) and read from (source) via the Data Buffer (3) attribute contained in this object. The Assembly Object is generally assigned as the endpoint of an I/O Connection object (assigned via the Path attributes in the Connection Object). In this way, multiple pieces of data can be moved to and from the device with a reduced number of network messages.
Assembly definitions supported by SLA Series MFC/MFM are defined in Section 5, 'Data Assemblies.'

### Attributes

*Table 6-7: Assembly Object Instance Attributes*

| Attrib ID | Name | Data Type | Access Rule | NV | Description | Notes |
|---|---|---|---|---|---|---|
| 3 | Data Buffer | ARRAY of BYTE | Conditional | NV | Zero or more attributes that comprise the Data Buffer | If the assembly is used as an endpoint in an active Class 1 connection, then this attribute will be Get only. Writing to this attribute will return a Device State conflict error |

### Services

No Object Specific Services

## Device Manager Object [0X64]

Device Types: MFC and MFM

The Device Manager Object contains product information about the SLA Series MFC/ MFM device such as serial number, model number, firmware revisions, etc. The object also captured device level operational parameters not specific to any other application object defined in the device.

### Attributes

*Table 6-8: Device Manager Instance Attributes*

| Attrib ID | Name | Data Type | Access Rule | NV | Description | Notes |
|---|---|---|---|---|---|---|
| 1 | Device Type | SHORT STRING | Get | NV | Device model name | Max. 8 Characters "MFC' or 'MFM |
| 3 | Manufacturer's Name | SHORT STRING | Get | NV | The name of the manufacturer of the device. | Max. 20 characters 'Brooks Instrument' |
| 4 | Manufacturer's Model Number | SHORT STRING | Get | NV | The manufacturer specified model number for the device | Max. 20 characters |
| 5 | Software Revision Level | SHORT STRING | Get | NV | Revision level of the firm- ware in the device. | Note: 'Revision Levels' below |
| 6 | Hardware Revision Level | SHORT STRING | Get | NV | Revision level of the hard- ware in the device. | |
| 7 | Manufacturer's Serial Number | SHORT STRING | Get | NV | Serial number of device assigned by the manufacturer | Max. 30 Characters |

| Attrib ID | Name | Data Type | Access Rule | NV | Description | Notes |
|---|---|---|---|---|---|---|
| 8 | Device Configuration | SHORT STRING | Get | NV | Any additional manufacturer specific information about the device | Max. 50 characters 'N/A' |
| 103 | Main Board Boot-loader Version | SHORT STRING | Get | NV | Revision level of the Main Board Bootloader firmware | Max. 8 Characters. See Section Revision Level |
| 104 | Device Configuration ID | DINT | Get | NV | Configuration Level of the device assigned by the manufacturer | |
| 147 | Zero Button Disable | DINT | Set | NV | Disables the ability to zero the device using the external button | |
| 190 | Supply Voltage | REAL | Get | V | Input supply voltage to the device in Volts | Volts |
| 191 | Supply Voltage Minimum Warning Limit | REAL | Set | NV | Minimum threshold, in Volts, to set the Supply Volts Low Warning bit | See Section Notes: Supply Voltage  See Section Notes: Status |
| 192 | Supply Voltage Maximum Warning Limit | REAL | Set | NV | Maximum threshold, in volts, to set the Supply Volts High Warning bit | See Section Note: Supply Voltage  See Section Note: Status |
| 193 | Supply Voltage Warning Settling Time | DINT | Set | NV | The amount of time, in milliseconds, the warning condition must exist be-fore the warning bit is set | See Section Note: Supply Voltage See Section Note: Status |
| 222 | Power On Hours | REAL | Get | NV | Power on time totalizer | Hours |
| 250 | Communications Board  Firmware Revision Level | SHORT STRING | Get | NV | Revision level of the communications board firmware | Max. 10 characters. See Section Revision Level |
| 251 | Communications Board  Hardware Revision Level | SHORT STRING | Get | NV | Revision level of the communications board hardware | Max. 10 characters. See Section Revision Level |
| 252 | Communications Board Bootloader Revision Level | SHORT STRING | Get | NV | Revision level of the communications bootloader firmware | Max. 10 characters. See Section Revision Level |

**Note: Status**

Status bits associated with this object are listed below. See section 7 for details on specific status and behavior.

- **[Active_Warnings]{184-1-5}, Bit 26:** Supply Voltage High
- **[Active_Warnings]{184-1-5}, Bit 27:** Supply Voltage Low

**Note Revision Level**

Attributes representing firmware revisions running in the device are comprised of the major and minor revision level, separated by a decimal point (for example, 1.04).

**Note Supply Voltage**

The Device Manager Object reports the input supply voltage to device. Warning status bits (See Status Object section) can be used to indicate high or low input voltage condition. Setting attributes 191 and 192 set the threshold values for setting the status flags. The statuses are self-clearing when the voltage returns within nominal range. Attribute 193 can be configured to delay the setting or clearing of the status to minimize spurious indications.

**Services**

No Object Specific Services

## Flow Meter Object [0xA9]

Device Types: MFC and MFM

The Flow Meter Object is responsible for reporting flow sensor values. The Flow Meter Object in conjunction with the selected Flow Meter Object can linearize the sensor values and convert measurements into engineering data units.

**Attributes**

*Table 6-9: Flow Meter Instance Attributes*

| Attrib ID | Name | Data Type | Access Rule | NV | Description | Notes |
|---|---|---|---|---|---|---|
| 4 | Data Units | ENGUNITS | Set | NV | Defines the Engineering Units context of Flow [6] and other attributes in this object. | See Note 'Data Units' below Default = Percent |
| 6 | Flow | REAL | Get | V | The amount of flow going through the sensor | This value is corrected, converted, and calibrated to report the actual value of flow. Data Units set by [4] |
| 17 | Alarm Trip Point High | REAL | Set | NV | Determines the Flow [6] value above which an Alarm Condition will occur | See 'Note: Status' below Data Units set by [4] |
| 18 | Alarm Trip Point Low | REAL | Set | NV | Determines the Flow [6] value below which an Alarm Condition Will occur | See 'Note: Status' below Data Units set by [4] |
| 19 | Alarm Hysteresis | REAL | Set | NV | The amount by which Flow [6] must recover past the Trip Point threshold ([17] and [18]) to clear the associated status condition | See 'Note: Status' below Data Units set by [4] |
| 20 | Alarm Settling Time | DINT | Set | NV | Determines the time that the Flow [6] value must exceed the Trip Point before the exception condition is generated. | See 'Note: Status' below Time in milliseconds |
| 21 | Warning Trip Point High | REAL | Set | NV | Determines the Flow [6] value above which a Warning Condition will occur | See 'Note: 'Status' below Data Units set by [4] |
| 22 | Warning Trip Point Low | REAL | Set | NV | Determines the Flow [6] value below which a Warning Condition will occur | See 'Note: Status' below Data Units set by [4] |
| 23 | Warning Hysteresis | REAL | Set | NV | The amount by which Flow [6] must recover past the Trip Point threshold ([21] and [22]) to clear the associated status condition | See 'Note: Status' below Data Units set by [4] |

| Attrib ID | Name | Data Type | Access Rule | NV | Description | Notes |
|---|---|---|---|---|---|---|
| 24 | Warning Settling Time | DINT | Set | NV | Determines the time that the Flow [6] value must exceed the Trip Point before the exception condition is generated. | See 'Note: Status' below Time in milliseconds |
| 35 | Gas Calibration Object Instance | DINT | Set | NV | Configures which S-Gas Calibration Object instance is currently active for this object. | See Note 'Gas Calibration Object Instance' below |
| 96 | Flow Hours | DINT | Get | NV | Total hours of flow through the device | |
| 105 | Zero Duration | DINT | Set | NV | The amount of time used by the device to perform a device zero operation | Time in milliseconds |
| 112 | Zero Enable | BOOL | Set | V | Starts a device sensor zero operation | Write '1' to this attribute starts a zero operation provided device status 'Zero Operation Inhibit' is not set<br><br>See Section 7.1.6 |
| 125 | Totalizer Units | DINT | Set | NV | The engineering units used to report the totalizer values in this object | See Note 'Data Units' and 'Totalizers' below |
| 126 | Flow Totalizer | REAL | Set | NV | Total gas flowed through the device. | See Note 'Totalizers' below Data Units set by [125] |
| 130 | Custom Flow Totalizer | REAL | Set | NV | Total gas flowed through the device since the last commanded 'Reset' through Custom Flow Totalizer Control [131] | See Note 'Totalizers' below Data Units set by [125] |
| 131 | Custom Flow Totalizer Control | DINT | Set | V | Commands start, stop and reset of Custom Flow Totalizer. | See Note 'Totalizers' below |
| 140 | Zero Recommend Time | DINT | Set | NV | Time limit since the last zero operations that will set the 'Zero Recommended' status. | See 'Note: Status' below and Section 7.1.5 Time in seconds 0 = Disabled |
| 141 | Zero Tolerance Settle Time | DINT | Set | NV | The number of seconds after 0% setpoint that the device will wait before checking 'Zero Recommend' status | See 'Note: Status' below and Section 7.1.5 MFC Only |

| Attrib ID | Name | Data Type | Access Rule | NV | Description | Notes |
|---|---|---|---|---|---|---|
| 142 | Zero Tolerance Band | REAL | Set | NV | The tolerance band for which the 'Zero Recommended' status will be set if when setpoint = 0% | See 'Note: Status' below and Section 7.1.5<br><br>0 = Disabled MFC Only |
| 143 | Zero Success Band | REAL | Set | NV | The error band for which the 'Bad Zero Warning' status will be set after completion of a zero operation and the resulting zero exceeds this band | See 'Note: Status' below and Section 7.2.5 |
| 144 | Zero Minimum Drift Time | DINT | Set | NV | The minimum time limit between two successful zero operations that must occur before an excessive zero drift diagnostic will be run. | See 'Note: Status' below and Section 7.2.4<br>0 = Disabled |
| 145 | Excessive Zero Drift Multiplier | REAL | Set | NV | A span adjustment to adjust/expand the Expected Drift rate | See 'Note: Status' below and Section 7.2.4 |
| 146 | Excessive Zero Drift Offset | REAL | Set | NV | An offset adjustment to adjust/expand the Expected Drift rate | See 'Note: Status' below and Section 7.2.4 |
| 148 | Total Drift | REAL | Get | NV | The total zero drift since flowing with current gas page. | See 'Note: Status' below and Section 7.2.4 |
| 149 | Zero History Table | STRUCT of: | Get | NV | Data collected on the last 128 zero operations | To retrieve data from the Zero History Table see Service Code 0x32 below |
| | Calibration Instance | UDINT | | | The Calibration Instance at the time of the zero operation | |
| | Zero Drift | REAL | | | The Zero Drift prior to commencing the zero operation | |
| | Temperature | REAL | | | The Temperature, in Celsius, prior to commencing the zero operation | |
| | Power On Hours | UDINT | | | Total power on hours at the time of the zero operation | |
| 222 | No Flow Limit | REAL | Set | NV | The percentage of setpoint by which if 'Flow' does not exceed will raise an 'Active_Alarms_No_Flow' status is raised | See 'Note: Status' below and Section 7.3.3<br><br>Units in percent MFC Only |

| Attrib ID | Name | Data Type | Access Rule | NV | Description | Notes |
|---|---|---|---|---|---|---|
| 223 | No Flow Settling Time | DINT | Set | NV | The time in which a No Flow condition must exists before a status is raised. | See 'Note: Status' below and Section 7.3.3<br>Time in milliseconds MFC Only |
| 224 | Choked Flow Limit | REAL | Set | NV | The percentage of setpoint by which if 'Flow' does not exceed will raise an 'ActiveWarnings_Choked_Flow' or 'Active_Alarms_Choked_Flow' status is raised | See 'Note: Status' below and Section 7.2.3 and 7.3.3<br>Units in percent MFC Only |
| 225 | Choked Flow Settling Time | DINT | Set | NV | The time in which a choke flow condition must exists before a status is raised. | See 'Note: Status' below and Section 7.2.3 and 7.3.3<br>Time in milliseconds MFC Only |
| 226 | Overhaul-Due | DINT | Set | NV | The time remaining in hours until device requires service. When this timer reaches 0, 'Overhaul Due Warning' status shall be set | See Note 'Timers' below |
| 227 | Calibration Due | DINT | Set | NV | The time remaining in hours until the device needs to be recalibrated. When this timer reaches 0, 'Calibration Due Warning' status shall be set | See Note 'Timers' below |
| 228 | Backstream Flow Limit | REAL | Set | NV | The threshold by which reverse flow must exceed to raise a backstream error status | See 'Note: Status' below and Section 7.4.1<br>Units in percent |
| 229 | Backstream Time Limit | DINT | Set | NV | The time in which a back-streaming flow condition must exist before a status is raised. | See 'Note: Status' below and Section 7.4.1<br>Time in milliseconds |
| 230 | Flow Totalizer Overflow Threshold | REAL | Set | NV | The threshold by which Flow Totalizer [126] must exceed before a 'Totalizer Overflow' status is raised | See 'Note: Status' below and Section 7.2.12 |

**Note: Data Units**

The value of this attribute is limited to the values specified in the Volumetric Flow Units Table in Appendix C - Data Units.

**Note: Status**

Status bits associated with this object are listed below. See section 7 for details on specific status and behavior.

- **[Active_Errors]{184-1-3}, Bit 2:** Back Streaming Error
- **[Active_Alarms]{184-1-4}, Bit 0:** Low Flow Alarm
- **[Active_Alarms]{184-1-4}, Bit 1:** High Flow Alarm
- **[Active_Alarms]{184-1-4}, Bit 2:** No Flow Alarm
- **[Active_Alarms]{184-1-4}, Bit 3:** Choked Flow Alarm
- **[Active_Alarms]{184-1-4}, Bit 15:** Invalid Process Gas Page Selected
- **[Active_Warnings]{184-1-5}, Bit 0:** Low Flow Warning
- **[Active_Warnings]{184-1-5}, Bit 1:** High Flow Warning
- **[Active_Warnings]{184-1-5}, Bit 3:** Choked Flow Warning
- **[Active_Warnings]{184-1-5}, Bit 4:** Excessive Zero Drift Warning
- **[Active_Warnings]{184-1-5}, Bit 5:** Bad Zero Warning
- **[Active_Warnings]{184-1-5}, Bit 17:** Calibration Due
- **[Active_Warnings]{184-1-5}, Bit 18:** Totalizer Overflow
- **[Active_Warnings]{184-1-5}, Bit 19:** Overhaul Due

**Note: Gas Calibration Object Instance**

The value of this attribute is limited to the number of Process Gas Object instances configured in the device. The minimum value is 1, which is also the default value.

**Note: Totalizers**

There are two totalizers: Flow Totalizer [126] and Custom Flow Totalizer [130]. The behavior of each totalizer is described in the following sections. The units of measure for both totalizers is set using Totalizer Units [125].

**Flow Totalizer**

Flow Totalizer [126] is a count-up flow totalizer. The attribute can be set to any value. If this totalizer value exceeds Totalizer Overflow Threshold [230], status Active_Warnings_Totalizer_Overflow {184-1-5} will be set. Setting this totalizer value below the overflow threshold will clear the status.

**Custom Flow Totalizer**

Custom Flow Totalizer [130] is a count-up flow totalizer. This totalizer value is controlled by Custom Flow Totalizer Control [131]. Options for controlling the totalizer are Run (1), Stop (2), and Reset (3). Reading Custom Flow Totalizer Control [131] will return the current operational state of the timer: Run (1) or Stop (2). When the Reset (3) command is written to Custom Flow Totalizer Control [131], the totalizer will reset to zero, and then return to its operational state prior to writing the reset command.

**Note: Timers**

There are two countdown timers, Overhaul Due [226] and Calibration Due [227], and one count-up timer Power On Hours [222].

**Countdown Timers**

Overhaul Due [226] and Calibration Due [227] are countdown timers. These timers can be utilized to raise preventative maintenance and calibration events. Counting down commences when the device is flowing gas. When the counters reach zero, their respective status' [Active_Alarms_Overhaul_Due] [184-1-5], and [Active_Alarms_Calibration_Due] [184-1-5] will be set. Writing a non-zero value to these timers will clear their respective status'. These timers can be written to at any time.

**Count-Up Timers**

Power On Hours [222] is a count-up timer that represents the total time, in hours, that the device has been powered on. This timer is not resettable.

**Services**

---

*Table 6-10: Flow Meter Instance Services*

| Service Code | Service Name | Service Description | Details |
|---|---|---|---|
| 0x32 | Get Zero History | Returns an entry in the Zero History Table [149] | See Service Details |

## Service Detail

*Table 6-11: Get Zero History Service Arguments*

| Parameter Name | Data Type | Required | Parameter Value | Semantics |
|---|---|---|---|---|
| Array Index | UDINT | Y | 1-128 | This parameter is the index into the Zero History Table. A value of 1 is the most recent entry in the table, a value of 128 is the oldest entry. |

*Table 6-12: Get Zero History Service Response*

| Parameter Name | Data Type | Required | Parameter Value | Semantics |
|---|---|---|---|---|
| Calibration Instance | UDINT | Y | 1-6 | The Calibration Instance at the time of the zero operation |
| Zero Drift | REAL | Y | - | The Zero Drift prior to commencing the zero operation |
| Temperature | REAL | Y | - | The Temperature prior to commencing the zero operation |
| Power On Hours | REAL | Y | - | Total power on hours at the time of the zero operation |

## Valve Driver Object [0x96]

Device Types: MFC

The Valve Driver is responsible for management of the actuator device controlling the process.

### Attributes

---

*Table 6-13: Valve Driver Object Instance Attributes*

| ID | Name | Data Type | Access Rule | NV | Description | Notes |
|---|---|---|---|---|---|---|
| 5 | Override | DINT | Set | V | Specifies a direct override of the physical actuator | See Note 'Override' below |
| 6 | Valve Position | REAL | Get | V | The value of the analog output signal used to drive the physical actuator | See Note 'Valve' below. Units in Percent |
| 18 | Warning Trip Point High | REAL | Set | NV | Determines the Value [6] above which a warning condition will occur | See Note 'Status' below. Units in Percent |
| 19 | Warning Trip Point Low | REAL | Set | NV | Determines the Value [6] below which a warning condition will occur | See Note 'Status' below. Units in Percent |
| 20 | Warning Hysteresis | REAL | Set | NV | Determines the Value [6] that must recover from a warning condition to clear the warning status | See Note 'Status' below. |
| 21 | Safe State | DINT | Set | NV | Specifies the behavior for the physical actuator in an Operational State other than Executing State | See Note 'Safe State' below |
| 22 | Safe Value | REAL | Set | NV | The analog output signal value that is indicated by Value [6] if the Safe State[21] is configured to 'Use Safe Value' | Default = 0% |
| 143 | Control Warning Threshold | REAL | Set | NV | The threshold above which the computed standard deviation of Valve Position [6] exceeds will raise the Valve Control Warning status. A value of 0.0 disables this diagnostic. | See Note 'Valve Control Warning' below<br><br>Units in Percent |
| 144 | Control Warning Settling Time | DINT | Set | NV | The time that standard deviation of 'Valve_Position' must exceed the Trip Point threshold before the Status Condition is raised. This value also sets the time that standard deviation of 'Valve_Position' has recovered from the Trip Point threshold before the associated status condition is cleared | See Note 'Valve Control Warning' below<br><br>Units in milliseconds |

**Note: Override**

The following table outlines the valid actuator override types.

*Table 6-14: Override*

| Value | State | Description |
|-------|-------|-------------|
| 0 | Normal | Actuator is under normal operational control |
| 1 | Closed | Actuator is driven fully closed |
| 2 | Open | Actuator is driven fully open |
| 3 | Hold | Actuator is held to last updated analog output signal prior to assertion of override |
| 4 | Safe State | Actuator is driven to the condition specified by the Safe State[21] attribute |

**Note: Valve**

To interpret the value of this attribute, it is important to understand the following terms:

**Operational Range:**

This is the range that is reported by Value [6]. The operational range of the actuator is full range that the actuator can be driven to move. This corresponds to Value [6] values of 0 to 100%.

**Nominal Control Range:**

The nominal control range is a set of values that the actuator is driven to that maps directly between no flow and full-scale flow. This set of values is a sub-range within the large operational range of the actuator.

Example, the nominal control range for a 0 to 100 SCCM device flowing nitrogen could be as follows:

at 0 SCCM Actuator = 20%

at 100 SCCM, Actuator = 30%

Under normal operational control (no override), the actuator generally operates in the nominal control range. The upper end of the control range is not an absolute limit under normal control. The controller will drive the actuator to whatever value is necessary to control flow. For example, if a restriction occurred upstream of the device resulting in reduced supply to the device, the controller will drive the actuator beyond the nominal control range to maintain control.

**Status**

Status bits associated with this object are listed below.

For details, see Section 7.

- **[Active_Warnings]{184-1-5}, Bit 8:** Valve High Warning
- **[Active_Warnings]{184-1-5}, Bit 9:** Valve Low Warning
- **[Active_Warnings]{184-1-5}, Bit 10:** Valve Control Warning

**Valve Control Warning**

Valve control warning is based upon a statistical computation by computing a rolling standard deviation on the valve position.  This diagnostic is disabled if the threshold value is set to 0.

**Safe State**

The following table outlines valid values for this attribute. This table applies for normally closed and normally open valves.

*Table 6-15: Safe State*

| Value | State | Description |
|-------|-------|-------------|
| 0 | Closed | The actuator will be driven closed (0%) |
| 1 | Open | The actuator will be driven open (100%) |
| 2 | Hold Last Value | The actuator will be driven to the last updated value of the analog output just prior to the entering of the safe state. |
| 3 | Use Safe Value | The actuator will be driven to the value configured in Safe Value [22] |

**Services**

No Object Specific Services

## Flow Controller Object [0x9E]

Device Types: MFC

The Flow Controller object is responsible for closing the loop between the measured process variable (via the Flow Meter Object) and the control variable (via the Valve Drive Object).

### Attributes

*Table 6-16: Flow Controller Object Instance Attributes*

| Attrib ID | Name | Data Type | Access Rule | NV | Description | Notes |
|---|---|---|---|---|---|---|
| 4 | Data Units | ENGUNITS | Set | NV | Defines the Engineering Units context of Setpoint [6] and other attributes in this object | See 'Note: Data Units' below |
| 5 | Control Override | DINT | Set | V | Overrides the automatic control of the flow controller | See 'Note: Control Override' |
| 6 | Setpoint | REAL | Set | V | The sensor value that the device will maintain a steady state condition. | Units set by [4] |
| 15 | Warning Settling Time | DINT | Set | NV | Time allowed for the control-loop to settle to within the error band | See 'Note: Status' below Time in milliseconds |
| 16 | Warning Error Band | DINT | Set | NV | The maximum deviation band by which Setpoint must equal the Process Variable before a status is indicated | See 'Note: Status' below Units set by [4] |
| 19 | Constant Time Ramp Rate | UDINT | Set | NV | The amount of time the controller will take to "ramp" flow from its current value to its final value as commanded in Setpoint [6] | Default = 0 [disabled] Time in milliseconds |
| 159 | Fixed Control Value | REAL | Set | V | Sets the valve actuator position when Control Override [5] is set to 'Fixed' | Units are % |
| 194 | Setpoint Limit | REAL | Set | NV | The maximum value for setpoint. If setpoint exceeds this value, the behavior of the controller is defined by Setpoint Limit Action[201] | Units set by [4] |
| 201 | Setpoint Limit Action | DINT | Set | NV | Sets the behavior of the controller when Setpoint [6] > Setpoint Limit[194] | See Note: Setpoint Limit Action |

| Attrib ID | Name | Data Type | Access Rule | NV | Description | Notes |
|---|---|---|---|---|---|---|
| 202 | Live Setpoint | REAL | Get | V | The actual setpoint to which the process variable Flow will be controlled | See section 7.2.10 for more information on Setpoint Limiting |

**Note: Data Units**

The value of this attribute is limited to the values specified in the Volumetric Flow Units Table and Mass Flow Units table in Appendix C - Data Units.

**Note: Status**

Status bits associated with this object are listed below. For details, see Section 7.

- **[Active_Warnings]{184-1-5}, Bit 11:** Setpoint Deviation
- **[Active_Warnings]{184-1-5}, Bit 13:** Setpoint Overrange
- **[Active_Warnings]{184-1-5}, Bit 14:** Setpoint Limited

**Note: Setpoint Limited Action**

See section 7.2.10 for more information on Setpoint Limiting

*Table 6-17: Setpoint Limiting Actions*

| Value | Description |
|---|---|
| 0 | Setpoint Limiting disabled |
| 1 | Raise 'Setpoint Over range' warning status, but do not actively limit the setpoint |
| 2 | Raise 'Setpoint Limited' status and actively limit the setpoint to Setpoint Limit [194] |

**Note: Control Override**

*Table 6-18: Setpoint Limiting Actions*

| Value | Description |
|---|---|
| 0 | Automatic Control |
| 1 | Control Override – Actuator Off |
| 2 | Control Override – Actuator Open 100% |
| 129 | Control Override – Set Actuator Position to the value in attribute 'Fixed Control Value' [159] |

**Services**

No Object Specific Services

## Process Gas Object [0x66]

Device Types: MFC and MFM

The Process Gas object defines characteristics associated with linearization/compensation of the gas flow sensor.

### Attributes

*Table 6-19 Process Gas Instance 0 Attributes*

| Attrib ID | Name | Data Type | Access Rule | NV | Description | Notes |
|---|---|---|---|---|---|---|
| 1 | Revision | UINT | Get | NV | Revision of the Process Gas object class definition upon which the implementation is based. | If updates require an increase in this value, then the value of this attribute increases by 1. Range 1– 65535 |
| 2 | Max Instance | UINT | Get | NV | The maximum instance ID of this object supported by the device | |
| 3 | Number of Instances | UINT | Get | NV | The number of instances of this object supported by the device | |

*Table 6-20: Process Gas Instance 1..n Attributes*

| ID | Name | Data Type | Access Rule | NV | Description | Notes |
|---|---|---|---|---|---|---|
| 37 | Reference Temperature | REAL | Get | NV | The gas temperature, in Celsius, under which this calibration was performed | |
| 38 | Reference Pressure | REAL | Get | NV | The gas pressure, in Pa, under which this calibration was performed | |
| 40 | Gas Standard Number | DINT | Get | NV | The gas type number assigned to this gas | See Note: 'Gas Standard Number' below<br>Default = 0, no gas type specified |
| 42 | Calibration Data Units | DINT | Get | NV | The engineering units of measure assigned to this gas | See Appendix C for units codes |
| 45 | Configured Range | REAL | Get | NV | The maximum calibrated flow value | |
| 47 | Total Flow Hours | REAL | Set | NV | The total number of hours flow through the device with this instance of the process gas page selected | |
| 200 | FAT Date | DATE | Set | NV | The factory acceptance date for this gas calibration | Number of days since 1972.<br>0 = 1/1/1972 |

### Note: Gas Standard Number

The Gas Standard Number as defined by SEMI publication SEMI E52-0298, "Practice for Referencing Gases Used in Digital Mass Flow Controllers."

### Services

No Object Specific Services

**Temperature Meter Object [0xA4]**

Device Type(s): MFC and MFM

The Temperature Meter object measures the temperature of the process gas.

**Attributes**

*Table 6-21: Temperature Meter Object Instance 1 Attributes*

| ID | Name | Data Type | Access Rule | NV | Description | Notes |
|---|---|---|---|---|---|---|
| 4 | Temperature Units | DINT | Set | NV | Sets the engineering units of measure of Temperature [6] and related attributes in this class | See Appendix C for unit codes |
| 6 | Temperature | REAL | Get | V | Temperature sensor value | Units set by [4] |
| 21 | High Temperature Warning Trip Point | REAL | Set | NV | Sets the threshold above which an High Temperature status will occur | See 'Note: Status' below Units set by [4] |
| 22 | Low Temperature Warning Trip Point | REAL | Set | NV | Sets the threshold below which an High Temperature status will occur | See 'Note: Status' below Units set by [4] |
| 24 | Warning Trip Point Settling Time | REAL | Set | NV | Sets the time that Temperature [6] must exceed the Trip Point thresholds before the Status Condition is raised. This value also sets the time that 'Temperature' has recovered from the Trip Point threshold before the associated status condition is cleared | See 'Note: Status' below Time in milliseconds |

**Status**

Status bits associated with this object are listed below. For details, see section 7.
- **[Active_Alarms]{184-1-4}, Bit 24:** Temperature Sensor Fail
- **[Active_Warnings]{184-1-5}, Bit 24:** High Temperature
- **[Active_Warnings]{184-1-5}, Bit 25:** Low Temperature

**Services**

No Object Specific Services

## Status Object [0xB8]

The Status Object contains all the status bits that can be indicated by the device. Details of how each status indication functions and their associated attributes for configure the status function can be reference in Section 7

### Attributes

*Table 6-22: Status Object instance 1..n Attributes*

| ID | Name | Data Type | Access Rule | NV | Description | Notes |
|----|------|-----------|-------------|----|-------------|-------|
| 3 | Active Errors | DWORD | Get | NV | Active Error Status Bits | See Note 'Active Errors' |
| 4 | Active Alarms | DWORD | Get | NV | Active Alarms Status Bits | See Note 'Active Alarms' |
| 5 | Active Warnings | DWORD | Get | NV | Active Warning Status Bits | See Note 'Active Warnings' |
| 6 | Device Status | DWORD | Get | NV | Device Status Bits | See Note 'Device Status' |
| 8 | Alarms Mask | DWORD | Get | NV | Active Alarms Mask Bits | See Note 'Mask Bits' |
| 9 | Warnings Mask | DWORD | Get | NV | Active Warnings Mask Bits | See Note 'Mask Bits' |

### Note: Active Errors

*Table 6-23: Active Error Bit Definitions*

| Bit(s) | Description |
|--------|-------------|
| 0-1 | Reserved |
| 2 | Back Streaming Error |
| 3-17 | Reserved |
| 18 | Internal Communications Error |
| 19-22 | Reserved |
| 23 | NV Memory Fail |
| 24-31 | Reserved |

### Note: Active Alarms

*Table 6-24: Active Alarms Bit Definitions*

| Bit(s) | Description |
|--------|-------------|
| 0 | Low Flow Alarm |
| 1 | High Flow Alarm |
| 2 | No Flow Alarm |

| Bit(s) | Description |
|--------|-------------|
| 3 | Choked Flow Alarm |
| 4-14 | Reserved |
| 15 | Invalid Process Gas Page Selected |
| 16-22 | Reserved |
| 23 | Using Backup NV Memory |
| 24 | Temperature Sensor Fail |
| 25-31 | Reserved |

## Note: Active Warnings

*Table 6-25: Active Warnings Bit Definitions*

| Bit(s) | Description |
|--------|-------------|
| 0 | Low Flow Warning |
| 1 | High Flow Warning |
| 2 | Reserved |
| 3 | Choked Flow Warning |
| 4 | Excessive Zero Drift Warning |
| 5 | Bad Zero Warning |
| 6-7 | Reserved |
| 8 | Valve High Warning |
| 9 | Valve Low Warning |
| 10 | Valve Control Warning |
| 11 | Setpoint Deviation |
| 12 | Reserved |
| 13 | Setpoint Overrange |
| 14 | Setpoint Limited |
| 15-16 | Reserved |
| 17 | Calibration Due |
| 18 | Totalizer Overflow |
| 19 | Overhaul Due |
| 20-23 | Reserved |
| 24 | High Temperature |
| 25 | Low Temperature |
| 26 | Supply Volts High |
| 27 | Supply Volts Low |
| 28-31 | Reserved |

**Note: Device Status**

*Table 6-26: Device Status Bit Definitions*

| Bit(s) | Description |
|--------|-------------|
| 0 | Device Is Executing |
| 1 | Flow Reading Valid |
| 2 | Temperature Reading Valid |
| 3 | Device Is Zeroing |
| 4 | Zero Recommended |
| 5 | Zero Operation Inhibit |
| 6-7 | Reserved |
| 8 | Device Error |
| 9 | Device Alarm |
| 10 | Device Warning |
| 11-31 | Reserved |

**Note: Mask Bits**

Active Alarms [4] and Active Warnings [5] can be masked by setting the corresponding bits in the mask attributes Alarms Mask [8] and Warnings [9]

**Services**

No Object Specific Services

## Section 7: Status

### Device Status {184-1-6}

There are four levels of status: Errors, Alarms, Warnings, and Device Status in decreasing order of severity. The corresponding tag names for the status attributes are:

- **[Active_Errors] {184-1-3}**
- **[Acitve_Alarms] {184-1-4}**,
- **[Active_Warnings] {184-1-5}**,
- **[Device_Status] {184-1-6}**

Each status word is an enumerated bitfield of type DWORD. These status bits are in the Status Class (Class ID 184) and are mapped to Produce Assemblies 201, 203.

**[Active_Alarms] {184-1-4}** and **[Active_Warnings] {184-1-5}** can be masked by setting the corresponding mask attributes **[Alarms_Mask] {184-1-8}** and **[Warnings_Mask] {184-1-9}**. A value of 0 for any mask bit blocks the correspond alarm or warning bit from being indicated. A value of 1 for any mask bit will allow the alarm or warning bit to be indicated.

**[Active_Errors] {184-1-3}** and **[Device_Status] {184-1-6}** cannot be masked. If any bit in **[Active_Errors] {184-1-3}** is set, it will force the flow controller into the Safe State. The device will require a reset to return to normal operation. A reset of the device can be achieved through a power cycle or by sending the Reset service (Service ID 5) to the Identity Class (Class ID 0x01).

### Bit 0: Device is Executing [Device_Status_Dev_Exec]

This status indicates the current execution state of the device

| Bit Value | Description |
|---|---|
| 1 | The device is Executing and controlling to setpoint |
| 0 | The device is in the Safe State |

The state of this status bit is dependent on **[Active_Errors]{184-1-3}** (see section 'Safe Mode') and the existence of a Class 1 connection.
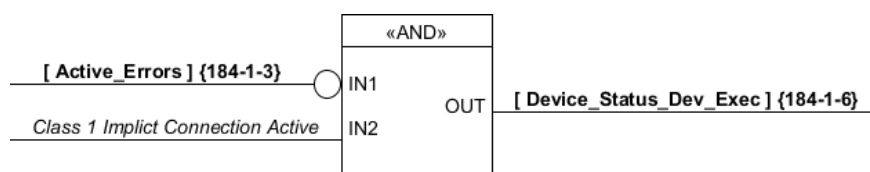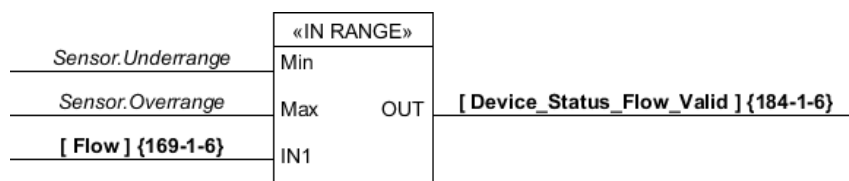
**Bit 1: Flow Reading Valid [Device_Status_Flow_Valid]**

This status indicates the quality of the flow sensor reading.

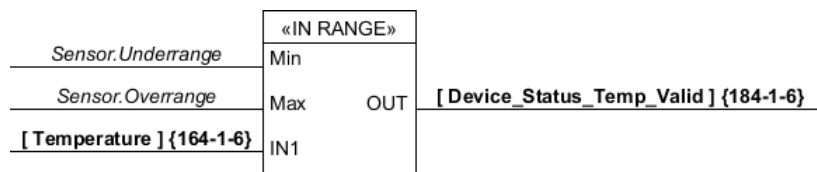| Bit Value | Description |
|---|---|
| 1 | The Flow Sensor operating nominally, and flow sensor readings are within normal range |
| 0 | Flow sensor reading is out of range and/or not operating nominally |

NOTE: *Sensor.Underrange* and *Sensor.Overrange* are internal variables

```
                           «IN RANGE»
   Sensor.Underrange  ───  Min
                                          [ Device_Status_Flow_Valid ] {184-1-6}
   Sensor.Overrange   ───  Max     OUT  ──
                           
   [ Flow ] {169-1-6}  ───  IN1
```

**Bit 2: Temperature Reading Valid [Device_Status_Temp_Valid]**

This status indicates the quality of the temperature sensor reading.

| Bit Value | Description |
|---|---|
| 1 | The temperature sensor operating nominally, and temperature sensor readings are within normal range |
| 0 | Temperature sensor reading is out of range and/or not operating nominally |

NOTE: *Sensor.Underrange* and *Sensor.Overrange* are internal variables

```
                             «IN RANGE»
   Sensor.Underrange   ───  Min
                                             [ Device_Status_Temp_Valid ] {184-1-6}
   Sensor.Overrange    ───  Max      OUT  ──
                           
   [ Temperature ] {164-1-6}  ───  IN1
```

**Bit 3: Device Is Zeroing [Device_Status_Dev_Zeroing]**

This status indicated the current state a sensor zero operation

| Bit Value | Description |
|---|---|
| 1 | The device is currently executing a Sensor Zero operation |
| 0 | Sensor Zero operation is complete |

**Bit 4: Zero Recommended [Device_Status_Zero_Recommend]**

This status indicates that the device should be zeroed (Sensor Zero operation is recommended). This status will be set when either of the following conditions is met:

**Condition 1: Zero Warn Time Expired**

Power on time since the last Successful Zero Operation > **[Zero_Recommend_Time {169-1-140}]**.

A Successful Zero Operation is defined as a completed Zero Operation that does not result in setting **[Device_Warn _Bad_Zero] {184-1-5}** or **[Device_Warn_Zero_Drift] {184-1-5}** warning status'.

This diagnostic is disabled when **[Zero_Recommend_Time] {169-1-140}** = 0.

**Condition 2: Zero Out of Tolerance**

If **[Ctrl_Setpoint {158-1-6}]** = 0 for > **[Zero_Tolerance_Settle_Time] {169-1-141}**

AND

Abs(**[Flow] {169-1-6}**) > 0.5 * **[Zero_Tolerance_Band] {169-1-142}**.

This diagnostic is disabled when **[Zero_Tolerance_Band] {169-1-142}** = 0.

| Bit Value | Description |
|---|---|
| 1 | When one of the two above conditions have been met |
| 0 | A successful Zero Operation has been completed |

**Bit 5: Zero Operation Inhibit [Device_Status_Zero_Op_Inhibit]**

This status indicates that device cannot perform a zero operation. A sensor zero operation *will be inhibited* when **any** of the following conditions are present:

- **[Ctrl_Setpoint] {158-1-6}** is not zero

- **[Valve_Override] {150-1-5}** is not set to 'Normal'

- The device is in the Safe State AND **[Valve_Safe_State] {150-1-21}** is not set to 'Closed'

- Any Alarm is Active **[Active_Alarms] {184-1-4}**

- Any Error is Active **[Acitve_Errors] {184-1-3}**

| Bit Value | Description |
|---|---|
| 1 | Device Zero Operations are inhibited |
| 0 | Device Zero operations can be performed |
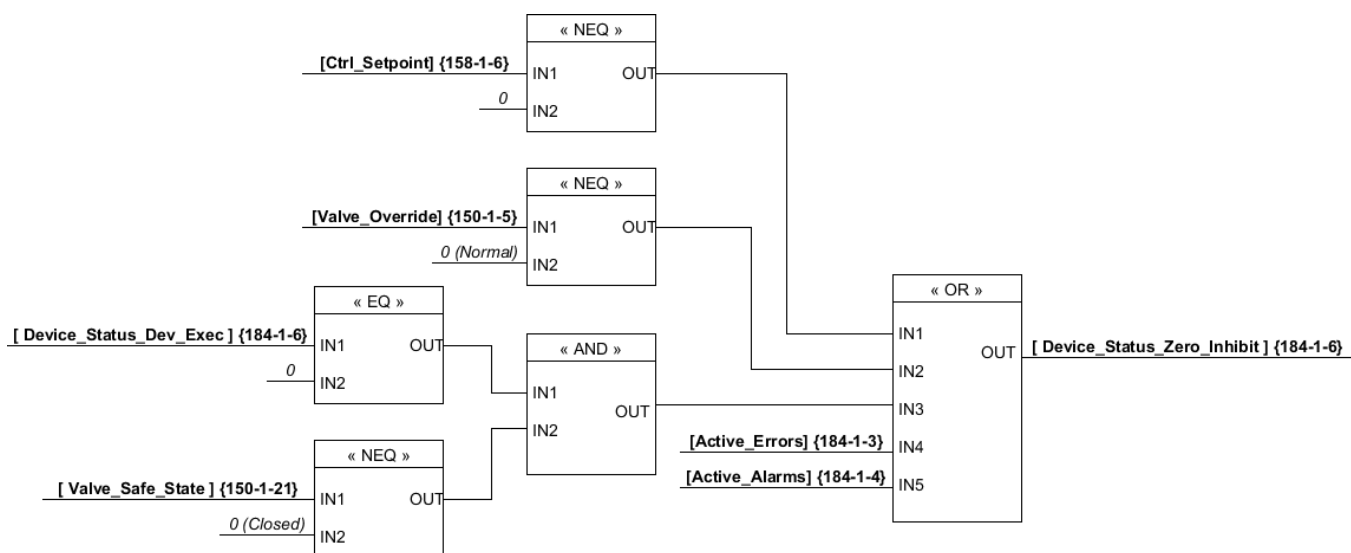


**Bit 6: Valve Override [Device_Status_Valve_Override]**

This status indicates the **[Valve_Override] {150-1-5}** is engaged

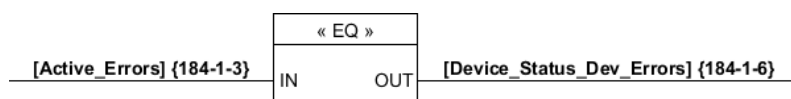| Bit Value | Description |
|---|---|
| 1 | Valve Override is Active (i.e. Off, Purge) |
| 0 | Valve Override is Normal |

**Bit 7: Control Override [Device_Status_Ctrl_Override]**

This status indicates if any **[Ctrl_Override] {158-1-5}** is engaged

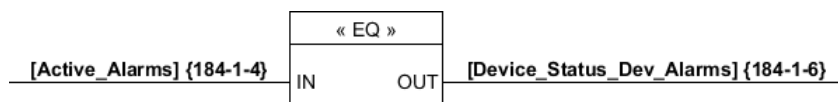| Bit Value | Description |
|---|---|
| 1 | Control Override is Active (i.e. Off, Purge, Fixed) |
| 0 | Control Override is Normal |

**Bit 8: Device Error [Device_Status_Dev_Error]**

This status indicates if any **[Active_Error] {184-1-3}** are present

| Bit Value | Description |
|---|---|
| 1 | One or more Errors are present |
| 0 | No Errors are present |

[Active_Errors] {184-1-3} — « EQ » IN OUT — [Device_Status_Dev_Errors] {184-1-6}

**Bit 9: Device Alarm [Device_Status_Dev_Alarm]**

This status indicates if any **[Active_Alarm] {184-1-4}** are present

| Bit Value | Description |
|---|---|
| 1 | One or more Alarms are present |
| 0 | No Alarms are present |

[Active_Alarms] {184-1-4} — « EQ » IN OUT — [Device_Status_Dev_Alarms] {184-1-6}

**Bit 10: Device Warning [Device_Status_Dev_Warning]**

This status indicates if any **[Active_Warnings] {184-1-5}** are present

| Bit Value | Description |
|---|---|
| 1 | One or more Warnings are present |
| 0 | No Warnings are present |

**Bit 11: Zero Button Disabled [Device_Status_Zero_Btn_Disabled]**

This status indicates if any **[Zero_Btn_Disable] {100-1-147}** is set

| Bit Value | Description |
|---|---|
| 1 | The zero button is disabled |
| 0 | The zero button is enabled |

**Bit 12: Control Ramping [Device_Status_Ctrl_Ramping]**

This status indicates that the controller is ramping to the new commanded setpoint.  This status becomes enabled when **[Ramp_Time] {158-1-19}** is set to a value other than 0

| Bit Value | Description |
|---|---|
| 1 | The controller is ramping to the new commanded setpoint |
| 0 | The controller has reached the new commanded setpoint |

**Warnings {184-1-5}**

**Bit 0: Low Flow Warning [Active_Warnings_Low_Flow]**

The status indicates a low flow warning condition exists.

This status is *disabled* when **[Device_Status_Flow_Valid] {184-1-6}** = 0

See Diagram in section Typical Status High/Low Processing for typical behavior of this status.

| Bit Value | Description |
|-----------|-------------|
| 1 | **[Flow] {169-1-6}** < **[Flow_Warn_TP_Low] {169-1-22}**<br>FOR<br>Time Period > **[Flow_Warn_Settling_Time] {169-1-24}** |
| 0 | **[Flow] {169-1-6}** > ( **[Flow_Warn_TP_Low] {169-1-22}** + **[Flow_Warn_Hyst] {169-1-23}** )<br>FOR<br>Time Period > **[Flow_Warn_Settling_Time] {169-1-24}** |

**Bit 1: High Flow Warning [Active_Warnings_High_Flow]**

This status indicates a high flow warning status condition.

This status is *disabled* when **[Device_Status_Flow_Valid] {184-1-6}** = 0

See Diagram in section Typical Status High/Low Processing for typical behavior of this status.

| Bit Value | Description |
|-----------|-------------|
| 1 | **[Flow] {169-1-6}** > **[Flow_Warn_TP_High] {169-1-21}**<br>FOR<br>Time Period > **[Flow_Warn_Settling_Time] {169-1-24}** |
| 0 | **[Flow] {169-1-6}** < ( **[Flow_Warn_TP_High] {169-1-21}** - **[Flow_Warn_Hyst] {169-1-23}** )<br>FOR<br>Time Period > **[Flow_Warn_Settling_Time] {169-1-24}** |

**Bit 3: Choked Flow Warning [Active_Warnings_Choked_Flow]**

This status indicates a choked flow alarm is imminent.

This status is *disabled* when *any* of the following conditions exist:

- **[Device_Status_Flow_Valid] {184-1-6}** = 0
- **[Active_Alarms_Choked_Flow_Alarm] {184-1-4}** = 1
- **[Ctrl_Setpoint] {158-1-6}** = 0.0
- **[Valve_Override] {150-1-5}** = 1 (Off)

| Bit Value | Description |
|---|---|
| 1 | **[Flow] {169-1-6}** < ( **[Choked_Flow_Lim] {169-1-224}** * **[Ctrl_Setpoint] {158-1-6}** ) <br> AND <br> **[Valve_Position] {150-1-6}** > [70% * Max Valve Position] <br> FOR <br> Time Period > ( 30% * **[Choked_Flow_Settling_Time] {169-1-225}** ) |
| 0 | **[Valve_Position] {150-1-6}** < [70% * Max Valve Position] <br> OR <br> **[Flow] {169-1-6}** > ( **[Choked_Flow_Lim] {169-1-224}** * **[Ctrl_Setpoint] {158-1-6}** ) |

This warning status is a function of Setpoint and Settling Time whereby the trip point is a percentage of the current setpoint for 10% of the settling time.

**Example**: If **[Choked_Flow_Limit]** = 30%, **[Choked_Flow_Settling_Time]** = 10 seconds, and the current setpoint **[Ctrl_Setpoint]** = 80%, then the status will be raised when [Flow] < (30% * 80%) ❼ 24% for (30% * 10 seconds) or 3 seconds.
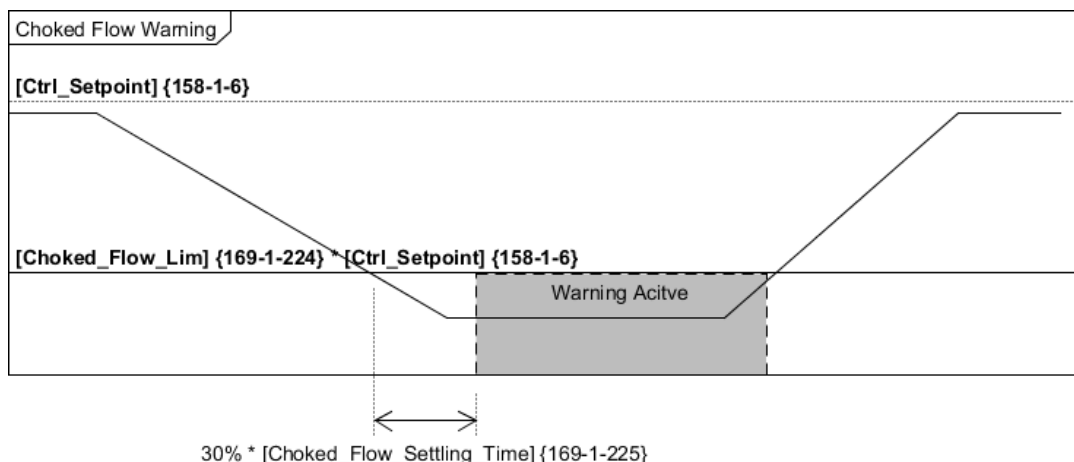
**Bit 4: Excessive Zero Drift Warning [Active_Warnings_Zero_Drift]**

This diagnostic indicates an excessive shift in zero since the last Zero Operation.

This diagnostic is run when **[Ctrl_Setpont] {158-1-6}** = 0 for **[Zero_Warn_Settle_Time] {169-1-141}**.

This diagnostic is *disabled* when **[Zero_Min_Drift_Time] {169-1-144}** = 0

| Bit Value | Description |
|---|---|
| 1 | The previous Zero Operation was successful<br>AND<br>Time since Last Zero Operation > **[Zero_Min_Drift_Time] {169-1-144}**<br>AND<br>The change in **[Flow] {169-1-6}** during the Zero Operation is:<br><br>> ( 0.2%FS/Year * **[Excess_Drift_Mult] {169-1-145}** + **[Excess_Drift_Add] {169-1-146}** ) |
| 0 | The selected calibration gas page is changed<br>OR<br>**[Zero_Min_Drift_Time] {169-1-144}** = 0 |

This diagnostic is detecting a drift in zero since the last time the device was zeroed. This is predicated upon two conditions:
1) the previous zero operation was successful and,
2) a sufficient amount of time has transpired since the last zero operation as defined by **[Zero_Min_Drift_Time] {169-1-144}**.

**Bit 5: Bad Zero Warning [Active_Warnings_Bad_Zero]**

---

This diagnostic indicates that the last Zero Operation was not successful.

This diagnostic is *disabled* when **[Zero_Sucess_Band] {169-1-143}** = 0

| Bit Value | Description |
|---|---|
| 1 | Zero Operation is Complete<br>AND<br>**[Ctrl_Setpoint] {158-1-6}** = 0<br>AND<br>**[Flow] {169-1-6}** > **[Zero_Success_Band] {169-1-143}** |
| 0 | Zero Operation is Started<br>OR<br>**[Zero_Success_Band] {169-1-143}** = 0 |

This diagnostic is performing a qualitative assessment on the result of the current zero operation based upon the flow signal after the zero. For this diagnostic to be as accurate as possible, a good process for zeroing the device should be in place and followed.



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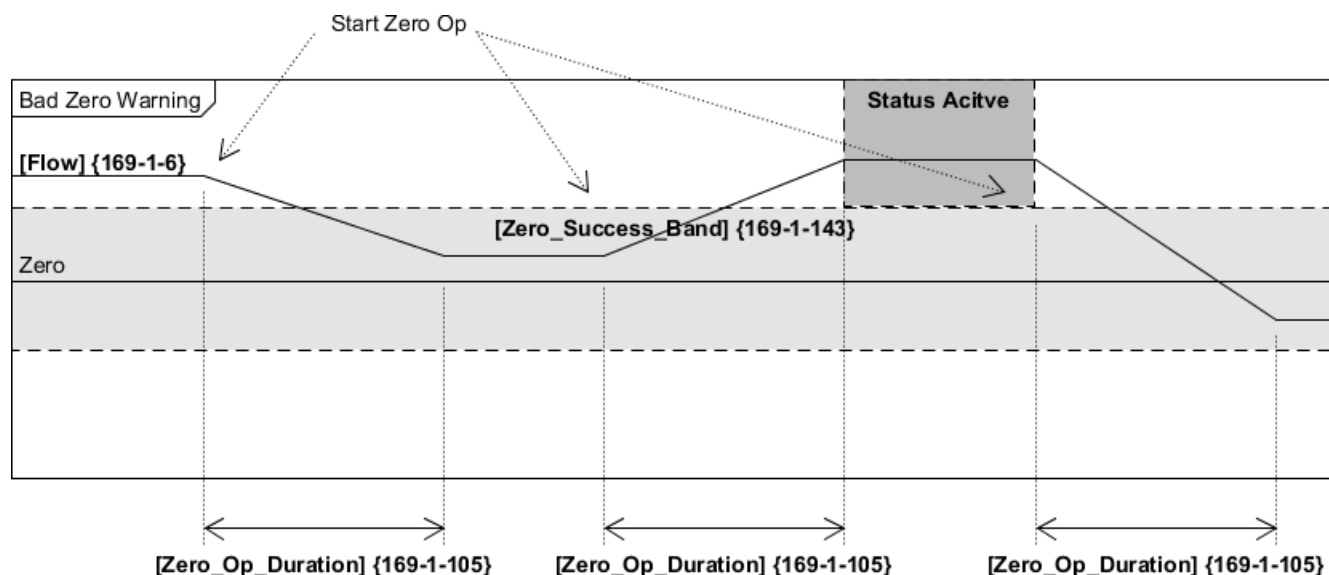
**Bit 8: Valve High Warning [Active_Warnings_Valve_High]**

The status indicates the valve position has exceeded a high position threshold

See Diagram in section Typical Status High/Low Processing for typical behavior of this status.

| Bit Value | Description |
|-----------|-------------|
| 1 | **[Valve_Position] {150-1-6}** > **[Valve_Warn_TP_High] {150-1-18}** |
| 0 | **[Valve_Position] {150-1-6}** < <br> ( **[Valve_Warn_TP_High] {150-1-18}** + **[Valve_Warn_Hyst] {150-1-20}** ) |

**Bit 9: Valve Low Warning [Active_Warnings_Valve_Low]**

The status indicates the valve position has exceeded a low position threshold

See Diagram in section Typical Status High/Low Processing for typical behavior of this status.

| Bit Value | Description |
|-----------|-------------|
| 1 | **[Valve_Position] {150-1-6}** < **[Valve_Warn_TP_Low] {150-1-19}** |
| 0 | **[Valve_Position] {150-1-6}** > <br> ( **[Valve_Warn_TP_Low] {150-1-19}** + **[Valve_Warn_Hyst] {150-1-20}** ) |

**Bit 10: Valve Control Warning [Active_Warnings_Valve_Ctrl]**

The Valve Control Warning diagnostic computes a rolling standard deviation of valve position and compares it to the threshold value set in attribute **[Valve_Ctrl_Warn_Limit] {150-1-143}**. This diagnostic is disabled when **[Valve_Ctrl_Warn_Limit] {150-1-143}** = 0.

See Diagram in section Typical Status High/Low Processing for typical behavior of this status.
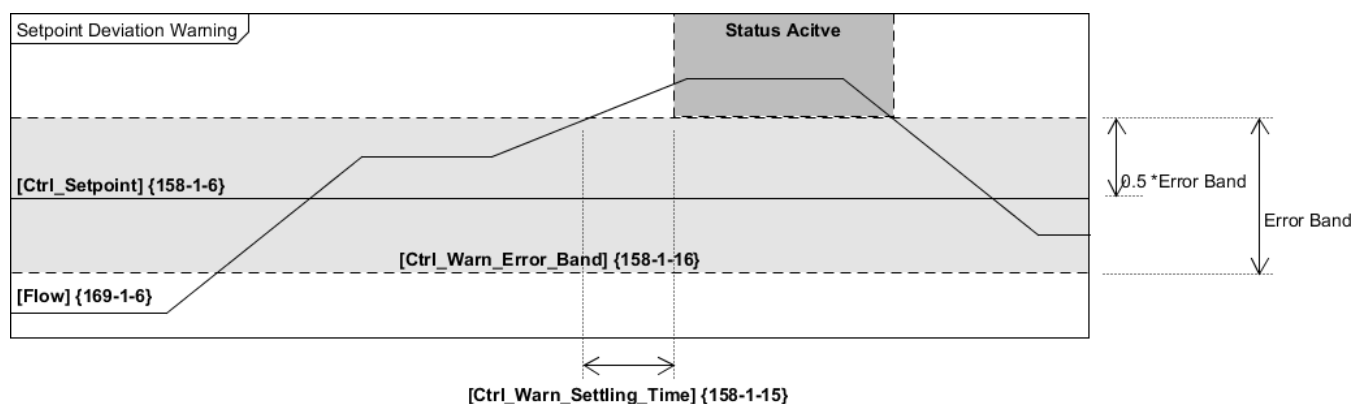
| Bit Value | Description |
|-----------|-------------|
| 1 | **STDDEV([Valve_Position] {150-1-6})** > **[Valve_Ctrl_Warn_Limit] {150-1-143}** <br> For <br> Time Period > **[Valve_Ctrl_Warn_Settling_Time] {150-1-144}** |
| 0 | **STDDEV([Valve_Position] {150-1-6})** <= **[Valve_Ctrl_Warn_Limit] {150-1-143}** <br> For <br> Time Period > **[Valve_Ctrl_Warn_Settling_Time] {150-1-144}** |

**Bit 11: Setpoint Deviation [Active_Warnings_SP_Deviation]**

---

The status indicates the controller cannot control flow to within the error band within a defined settling time. This diagnostic is ***disabled*** when ***any*** of the following conditions exists:

- **[Ctrl_Setpoint] {158-1-6}** = 0
- **[Device_Status_Flow_Valid] {184-1-5}** = 0

| Bit Value | Description |
|---|---|
| 1 | **[Flow] {169-1-6} > ( [Ctrl_Setpoint] {158-1-6} + ( 0.5 * [Ctrl_Warn_Error_Band] {158-1-16} ) )**<br>OR<br>**[Flow] {169-1-6} < ( [Ctrl_Setpoint] ] {158-1-6} - ( 0.5 * [Ctrl_Warn_Error_Band] {158-1-16} ) )**<br>FOR<br>Time Period > **[Ctrl_Warn_Settling_Time {158-1-15} ]** |
| 0 | **[Flow {169-1-6}] <= ( [Ctrl_Setpoint] ] {158-1-6} + ( 0.5 * [Ctrl_Warn_Error_Band] {158-1-16} ) )**<br>AND<br>**[Flow] {169-1-6} >= ( [Ctrl_Setpoint] ] {158-1-6} - ( 0.5 * [Ctrl_Warn_Error_Band] {158-1-16} ) )** |

**Bit 13: Setpoint Overrange [Active_Warnings_SP_Overrange]**

The status indicates the current setpoint has exceeded an upper threshold.

This diagnostic is *disabled* when **[Ctrl_SP_Lim_Action] {158-1-201}** = 0 (None)

| Bit Value | Description |
|---|---|
| 1 | **[Ctrl_SP_Lim_Action] {158-1-201}** = 1 (Raise Overrange Warning)<br>AND<br>**[Ctrl_Setpoint] {158-1-6}** > **[Ctrl_SP_Lim] {158-1-194}**<br>FOR<br>Time Period > 1 second |
| 0 | **[Ctrl_SP_Lim_Action] {158-1-201}** = 2 (Limit Setpoint) OR 0 (None)<br>OR<br>**[Ctrl_Setpoint] {158-1-6}** < **[Ctrl_SP_Lim] {158-1-194}**<br>FOR<br>Time Period > 1 second |
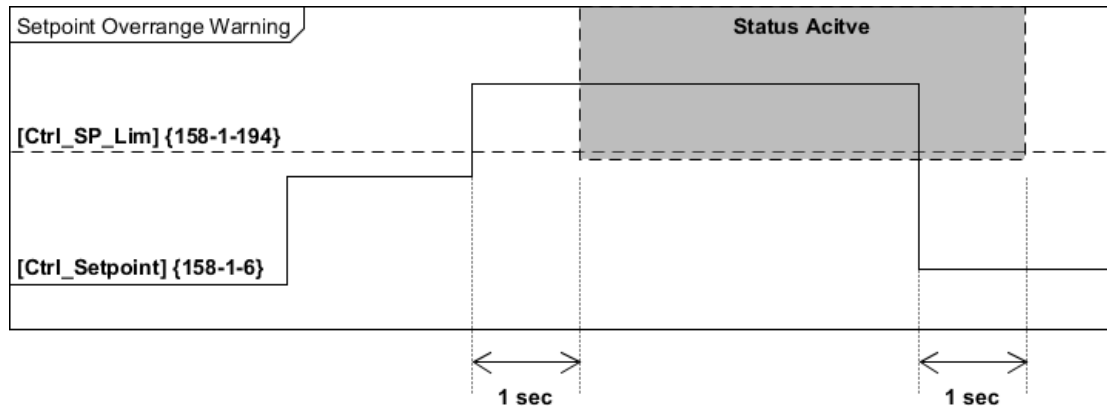
**Bit 14: Setpoint Limited [Active_Warnings_SP_Limited]**

---

The status indicates the **[Ctrl_Setpoint] {158-1-6}** has been limited by a **[Ctrl_SP_Lim] {158-1-194}**.

When **[Ctrl_Setpoint] {158-1-6}** < **[Ctrl_SP_Lim] {158-1-194}** then
**[Ctrl_Live_Setpoint] {158-1-202}** = **[Ctrl_Setpoint] {158-1-6}**.

When **{Crl_Setpoint} {158-1-6}** >= **[Ctrl_SP_Lim] {158-1-194}** then
**[Ctrl_Live_Setpoint] {158-1-202}** = **[Ctrl_SP_Limit] {158-1-6}**.

This diagnostic is *disabled* when **[Ctrl_SP_Lim_Action] {158-1-201}** = 0 (None)

| Bit Value | Description |
|---|---|
| 1 | **[Ctrl_SP_Lim_Action] {158-1-201}** = 2 (Limit Setpoint)<br>AND<br>**[Ctrl_Setpoint] {158-1-6}** > **[Ctrl_SP_Lim] {158-1-194}**<br>FOR<br>Time Period > 1 second |
| 0 | **[Ctrl_SP_Lim_Action] {158-1-201}** = 2 (Limit Setpoint) OR 0 (None)<br>OR<br>**[Ctrl_Setpoint] {158-1-6}** < **[Ctrl_SP_Lim] {158-1-194}**<br>FOR<br>Time Period > 1 second |
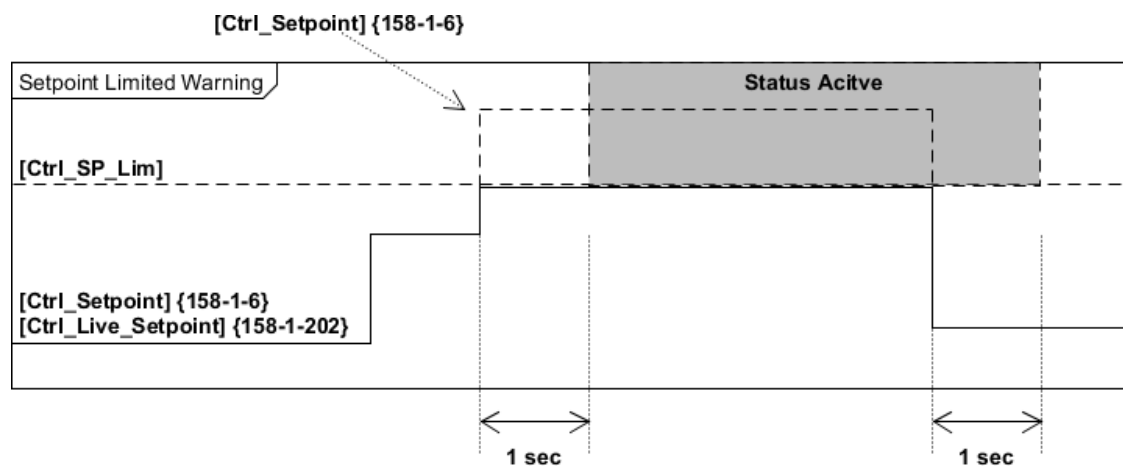
**Bit 17: Calibration Due [Active_Warnings_Cal_Due]**

This status indicates the devices needs to be calibrated.

See section Flow Meter Object, Section 6.x for details on Totalizers and Timers.

| Bit Value | Description |
|-----------|-------------|
| 1 | **[Cal_Due_Hours] {169-1-227}** = 0 |
| 0 | **[Cal_Due_Hours] {169-1-227}** > 0 |

**Bit 18: Totalizer Overflow [Active_Warnings_Total_Ovflow]**

This status indicates that **[Flow_Totalizer] {169-1-126}** has exceeded a defined overflow threshold.

See section Flow Meter Object, Section 6.x for details on Totalizers and Timers.

| Bit Value | Description |
|-----------|-------------|
| 1 | **[Flow_Totalizer] {169-1-126}** > **[Tot_Ovfl_Threshold] {169-1-230}** |
| 0 | **[Flow_Totalizer] {169-1-126}** <= **[Tot_Ovfl_Threshold] {169-1-230}** |

**Bit 19: Overhaul Due [Active_Warnings_Overhaul_Due]**

This status indicates that device requires maintenance.

See section Flow Meter Object, Section 6.x for details on Totalizers and Timers.

| Bit Value | Description |
|-----------|-------------|
| 1 | [Overhaul_Due_Hours] {169-1-226} = 0 |
| 0 | [Overhaul_Due_Hours] {169-1-226} > 0 |

**Bit 24: High Temperature Warning [Active_Warnings_High_Temp]**

The status indicates a high internal device temperature warning condition.

See Diagram in section Typical Status High/Low Processing for typical behavior of this status.

| Bit Value | Description |
|---|---|
| 1 | **[Temperature] {164-1-6}** > **[High_Temp_Warn_TP] {164-1-21}**<br>FOR<br>Time Period > **[Temp_Warn_Settling_Time] {164-1-24}** |
| 0 | **[Temperature] {164-1-6}** < **[High_Temp_Warn_TP] {164-1-21}**<br>FOR<br>Time Period > **[Temp_Warn_Settling_Time] {164-1-24}** |

**Bit 25: Low Temperature Warning [Active_Warnings_Low_Temp]**

This status indicates a low internal device temperature status condition.

See Diagram in section Typical Status High/Low Processing for typical behavior of this status.

| Bit Value | Description |
|---|---|
| 1 | **[Temperature] {164-1-6}** < **[Low_Temp_Warn_TP] {164-1-22}**<br>FOR<br>Time Period > **[Temp_Warn_Settling_Time] {164-1-24}** |
| 0 | **[Temperature] {164-1-6}** > **[Low_Temp_Warn_TP] {164-1-22}**<br>FOR<br>Time Period > **[Temp_Warn_Settling_Time]** |

**Bit 26: Supply Volts High [Active_Warnings_High_Supply_Volts]**

The status indicates the supply voltage is above the high warning trip point.

See Diagram in section Typical Status High/Low Processing for typical behavior of this status.

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| Bit Value | Description |
|---|---|
| 0 | **[Supply_V] {100-1-191}** < **[Supply_V_Max_Limit] {100-1-192}**<br>FOR<br>Time Period > **[Supply_V_Settle_Time] {100-1-193}** |
| 1 | **[Supply_V] {100-1-191}** > **[Supply_V_Max_Limit] {100-1-192}**<br>FOR<br>Time Period > **[Supply_V_Settle_Time] {100-1-193}** |

**Bit 27: Supply Volts Low [Active_Warnings_Low_Supply_Volts]**

The status indicates the supply voltage is below the low warning trip point.

See Diagram in section Typical Status High/Low Processing for typical behavior of this status.

.

| Bit Value | Description |
|---|---|
| 0 | **[Supply_V] {100-1-190}** > **[Supply_V_Min_Limit] {100-1-191}**<br>FOR<br>Time Period > **[Supply_V_Settle_Time] {100-1-193}** |
| 1 | **[Supply_V] {100-1-190}** < **[Supply_V_Min_Limit] {100-1-191}**<br>FOR<br>Time Period > **[Supply_V_Settle_Time] {100-1-193}** |

### Alarms {184-1-4}

**Bit 0: Low Flow Alarm [Active_Alarms_Low_Flow]**

The status indicates a low flow alarm condition.

See Diagram in section Typical Status High/Low processing for typical behavior of this status.

This diagnostic is *disabled* when **[Device_Status_Flow_Valid] {184-1-6}** = 0

| Bit Value | Description |
|---|---|
| 1 | **[Flow] {169-1-6}** < **[Flow_Alarm_TP_Low] {169-1-18}**<br>FOR<br>Time Period > **[Flow_Alarm_Settling_Time] {169-1-23}** |
| 0 | **[Flow] {169-1-6}** > ( **[Flow_Alarm_TP_Low] {169-1-18}** + **[Flow_Alarm_Hyst] {169-1-19}** )<br>FOR<br>Time Period > **[Flow_Alarm_Settling_Time] {169-1-23}** |

**Bit 1: High Flow Alarm [Active_Alarms_High_Flow]**

This status indicates a high flow alarm condition.

See Diagram in section Typical Status High/Low Processing for typical behavior of this status.

This diagnostic is *disabled* when **[Device_Status_Flow_Valid] {184-1-6}** = 0.

| Bit Value | Description |
|---|---|
| 1 | **[Flow] {169-1-6}** > **[Flow_Alarm_TP_High] {169-1-17}**<br>FOR<br>Time Period > **[Flow_Alarm_Settling_Time] {169-1-23}** |
| 0 | **[Flow] {169-1-6}** < ( **[Flow_Alarm_TP_High] {169-1-17}** - **[Flow_Alarm_Hyst] {169-1-19}** )<br>FOR<br>Time Period > **[Flow_Alarm_Settling_Time] {169-1-23}** |

**Bit 2: No Flow Alarm [Active_Alarms_No_Flow]**

This status indicates a no flow conditions exists.

This diagnostic is ***disabled*** when ***any*** of the following conditions exist:

- **[Device_Status_Flow_Valid] {184-1-6}** = 0
- **[Ctrl_Setpoint] {158-1-6}** = 0
- **[Valve_Override] {150-1-5}** = 1 (Off)

| Bit Value | Description |
|---|---|
| 1 | **[Flow] {169-1-6}** < ( **[No_Flow_Lim] {169-1-222}** * **[Ctrl_Setpoint] {158-1-6}** )<br>AND<br>**[Valve_Position] {150-1-6}** > [70% * *Max Valve Position*]<br>FOR<br>Time Period > **[No_Flow_Settling_Time] {169-1-223}** |
| 0 | **[Flow] {169-1-6}** > ( **[No_Flow_Lim] {169-1-222}** * **[Ctrl_Setpoint] {158-1-6}** )<br>OR<br>**[Valve_Position] {150-1-6}** < [70% * *Max Valve Position*]<br>FOR<br>Time Period > **[No_Flow_Settling_Time] {169-1-223}** |
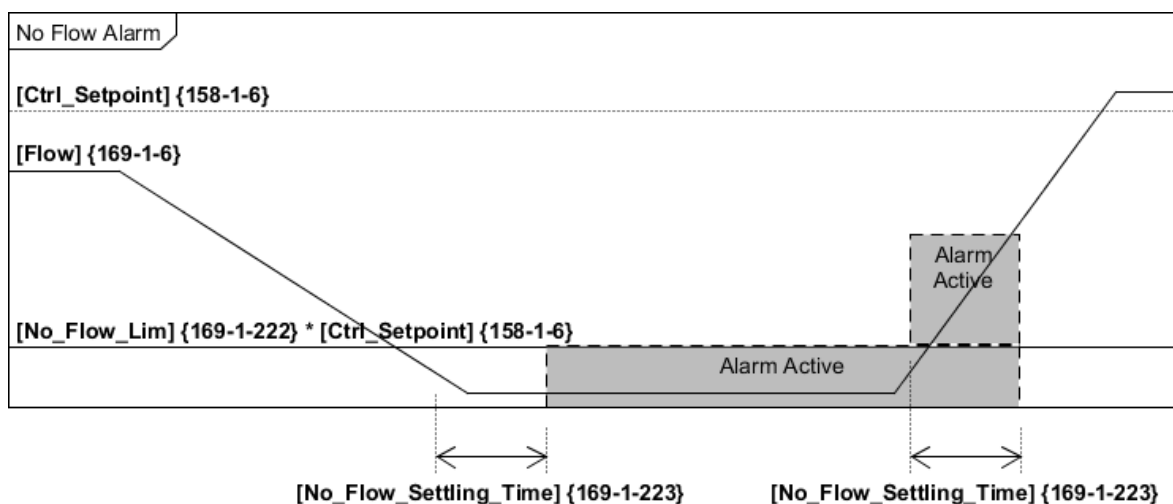
**Bit 3: Choked Flow Alarm [Active_Alarms_Choked_Flow]**

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This status indicates a choked flow condition exists.

This diagnostic is *disabled* when *any* of the following conditions exist:

- **[Device_Status_Flow_Valid] {184-1-6}** = 0
- **[Ctrl_Setpoint] {158-1-6}** = 0
- **[Valve_Override] {150-1-5}** = 1 (Off)

| Bit Value | Description |
|-----------|-------------|
| 1 | **[Flow] {169-1-6}** < ( **[Choked_Flow_Lim] {169-1-224}** * **[Ctrl_Setpoint] {158-1-6}** )<br>AND<br>**[Valve_Position] {150-1-6}** > [70% * Max Valve Position]<br>FOR<br>Time Period > **[Choked_Flow_Settling_Time] {169-1-225}** |
| 0 | **[Flow] {169-1-6}** > ( **[Choked_Flow_Lim] {169-1-224}** * **[Ctrl_Setpoint] {158-1-6}** )<br>OR<br>**[Valve_Position] {150-1-6}** < [70% * Max Valve Position]<br>FOR<br>Time Period > **[Choked_Flow_Settling_Time] {169-1-225}** |
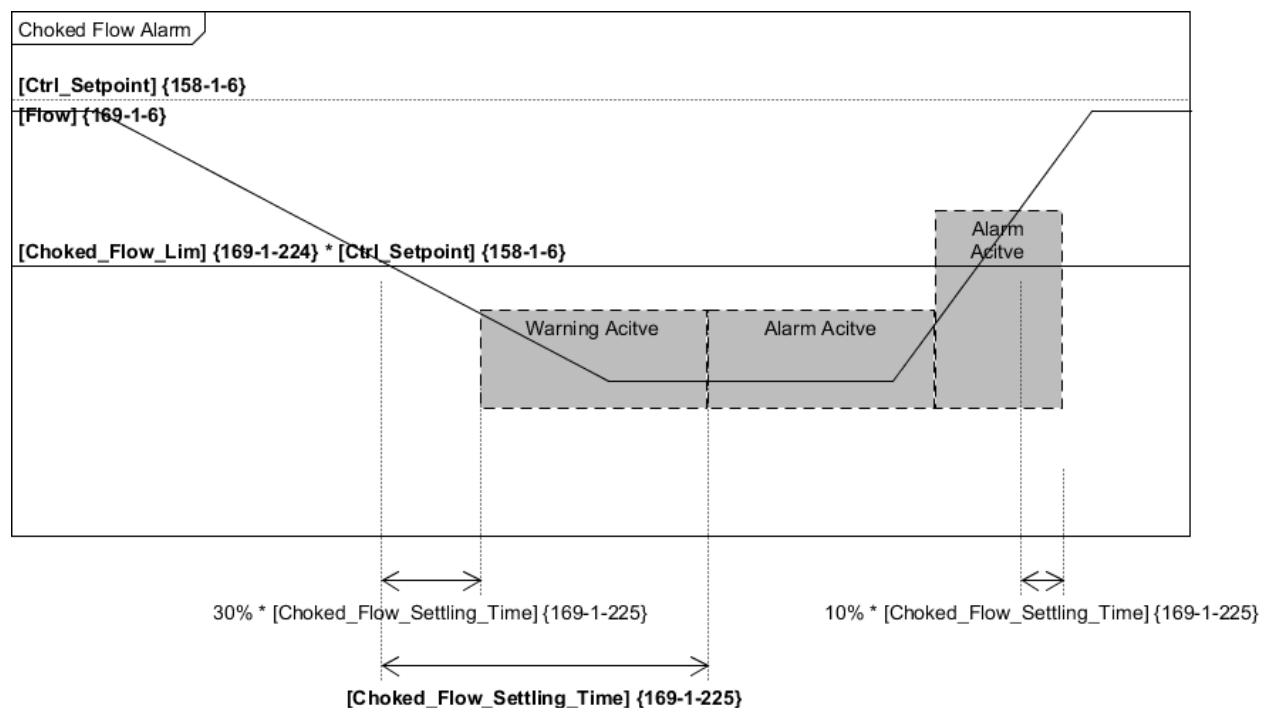
**Bit 15: Invalid Process Gas Page Selected [Active_Alarms_Invalid_Cal_Page]**

This status indicates that an invalid process gas page ID is being selected through output assembly 101 or assembly 102. This status will be set but the process gas page will not be changed.

| Bit Value | Description |
|---|---|
| 1 | This bit is set when an invalid process gas page ID is received by the device |
| 0 | The process gas page received by the device is valid |

**Bit 23: Using Backup NV Memory [Active_Alarms_NV_Mem]**

This status indicates that primary non-volatile memory has failed, and the device is using backup non-volatile memory.

| Bit Value | Description |
|---|---|
| 1 | This bit is set when NV Memory write failure has been detected |
| 0 | Indicates NV Memory write failure has not occurred |

**Bit 24: Temperature Sensor Fail [Active_Alarms_Temp_Sens_Fail]**

This status indicates the operational status of the temperature sensor

| Bit Value | Description |
|---|---|
| 1 | Indicates the temperature sensor is non-functional |
| 0 | Indicates the temperature sensor is functional |

## Errors {184-1-3}

**Bit 2: Back Streaming Error [Active_Errors_Bk_Stream]**

This status indicates that back stream condition exits.

This diagnostic is *disabled* when *any* of the following conditions exists:

- **[Valve_Override] {150-1-5}** = 2 (Purge)
- **[Device_Status_Dev_Zeroing] {184-1-6}** = 1
- **[Devcie_Status_Dev_Alarms] {184-1-6}** = 1
- **[Device_Status_Dev_Exec] {184-1-6}** = 0

| Bit Value | Description |
|-----------|-------------|
| 1 | [Flow] < [Bk_Stream_Flow_Lim]<br>FOR<br>Time Period > [Bk_Stream_Time_Lim] |
| 0 | This bit can only be cleared with a reset of the device |

**Bit 18: Internal Communication Error [Active_Errors_Int_Comms]**

This status indicates that a communications error between the Main Board and the EIP Adapter board has been detected.

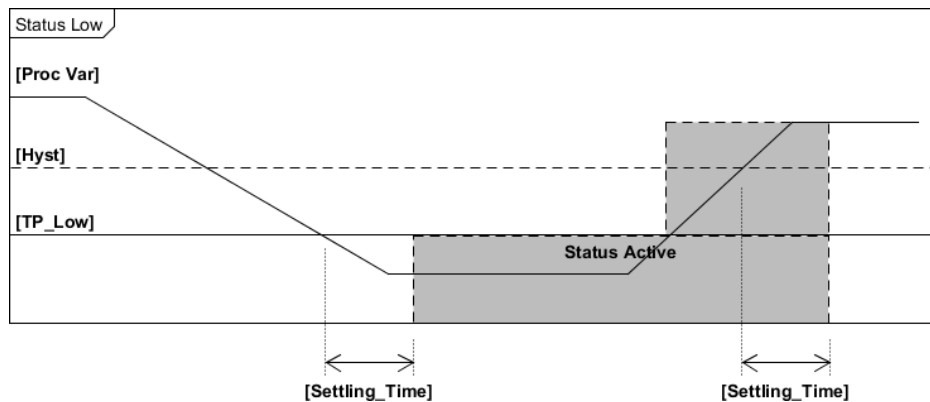| Bit Value | Description |
|-----------|-------------|
| 1 | Error Detected |
| 0 | This bit can only be cleared with a reset of the device |

**Bit 23: NV Memory Fail [Active_Errors_NV_Mem_Fail]**

This status indicates that both primary and backup non-volatile memories have had write failures detected

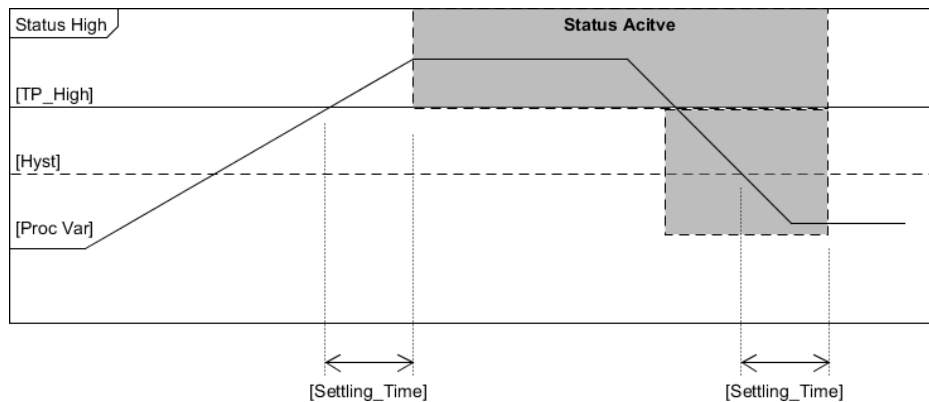| Bit Value | Description |
|-----------|-------------|
| 1 | Non-volatile memory fail detected |
| 0 | This bit can only be cleared with a reset of the device |

## Typical Status High/Low Processing

The following diagrams represent typical Status Low and Status High processing of signals. Several status definitions reference these diagrams.

### Status Low Processing



### Status High Processing

## Section 8: Troubleshooting

| Problem | Possible Causes |
|---|---|
| Scanner is actively scanning the network, but the NET LED is flashing green and MOD LED is solid green | The TCP/IP address for the device *is not* programmed into the scanner or does not match a device address already programmed in the scanner |
| | The TCP/IP address for the device *is* programmed into the scanner. Scanner cannot connect to the device because of one of the following: |
| | 1) The Produce/Consume/Config assembly data sizes are mismatched. The sizes programmed into the master/scanner do not match the connection configuration. See section 'Class 1 Connections' or reference the EDS file for the correct assembly sizes |
| | 2) The Input/Output/Config assembly IDs for the connection configuration are mismatched. See section 'Class 1 Connections' or reference the EDS file for the correct assembly ID's |
| | 3) The scanner is programmed to send data to the configuration assembly when the connection is established, however one or more of the data fields in the configuration data have invalid values. |
| Scanner is actively scanning the network and NET LED goes from solid green to flashing red and the MOD LED is solid green | The exclusive owner connection to the device has timed out and has not been re-established. |
| When power is applied to the device the NET LED goes solid red and the MOD LED is solid green | The IP address configured in the device conflicts with another device on the network. |
| When power is applied to the device the NET LED remains off and the MOD LED is solid green | An TCP/IP Address has not been assigned to the device. |
| When power is applied to the device, the MOD LED switches from flashing Red/Green to solid Red | Cycle power to the device. If problem persists, contact Brooks service. |
| The device never comes out of Self-Test (MOD LED continually flashes red/green). | Cycle power to the device. If problem persists, contact Brooks service. |
| A setpoint value is being sent to the device, but the MFC fails control flow (i.e. no actuator movement, low or no flow indication) | Check to make sure that the scanner is not setting the Run/Idle bit to Idle. This can occur if the scanner is put into a special program mode or the device in question has been placed into an "Idle" or "Inhibit" mode. |

## Section 9: Appendix

### Appendix A – Ethernet/IP Connections

SLA EIP MFC support Class 1 Messaging connections and Class 3 Messaging connections. Class 1 connections are used to pass a grouping of data continuously between the Master scanner and the target device at fast update rates. The grouping of data is defined by Assembly objects (see section 'Data Assemblies'). The Assemblies are defined to be used with certain connection types. The following sections discuss the following connections types and how they might be utilized on an Ethernet/IP network.

**Exclusive Owner Connection**

The terms Originator(O) and Target(T) are sometimes used to refer to the two devices respectively. With the Exclusive Owner connection, ownership of the device is established, and data is generally (not always) exchanged in both directions. The Owner-to-Target (O➐T) connection is usually point-to-point (unicast). The Target-to-Owner (T➐O) connection can be either unicast or multicast. Unicast restricts the data exchange between the two devices only. A multicast connection allows other devices to subscribe to the data being exchanged in the T➐O connection using Listen Only connections if the target device supports this type of connection for the data assembly.

**Input Only Connection**

The Input Only connection establishes and exchange of data, primarily from the Target to the Owner (T➐O). The Originator of this connection can be any device on the network including the Owner device. The T➐0 data is 0 length (NULL) and is used as a 'heartbeat' to keep the connection active. The Target-to-Owner (T➐O) connection can be either unicast or multicast. Unicast restricts the data exchange between the two devices only. A multicast connection allows other devices to subscribe to the data being exchanged in the T➐O connection using Listen Only connections if the target device supports this type of connection for the data assembly.

**Listen Only Connection**

The Listen Only connection allows devices to subscribe to a multicast connection stream from a target device provided that the data assembly used for the connection supports Listen Only. The Originator of this connection can be any device on the network including the Owner device. The pre-requisite to creating this connection is that a multicast connection from the Target must exist (see Exclusive Owner or Input Only connections). The T➐0 data is 0 length (NULL) and is used as a 'heartbeat' to keep the connection active. The Target-to-Owner (T➐O) connection is added to the subscription stream in the Target device and the Owner will begin to receive data from the multicast stream.

## Appendix B- Data Type Definitions

The following table list ODVA data types used throughout this manual and in the ODVA specification. The column C/C++ Encoding is given as a comparative common example reference.

*Table 9-1 Data Types*

| Data Type | Size (bytes) | Description | Range |
|---|---|---|---|
| BOOL | 1 | A true/false represented as 0 = false and 1 = true | 0 and 1 |
| SINT | 1 | An 8-bit signed integer value | -128 to 127 |
| USINT | 1 | An 8-bit unsigned integer value | 0 to 255 |
| INT | 2 | A 16-bit signed integer value | -32768 to 32767 |
| UINT | 2 | A 16-bit unsigned integer value | 0 to 65535 |
| DINT | 4 | A 32-bit signed integer value | -2147483648 to 2147483647 |
| UDINT | 4 | A 32-bit unsigned integer | 0 to 4294967296 |
| REAL | 4 | An IEEE single precision floating point number | 3.4E38 to -3.4E38 |
| DREAL | 8 | An IEEE double precision floating point number | |
| ENGUNIT | 1 | An enumerated value representing an engineering unit of measure | 4096 - 65535 |
| BYTE | 1 | An 8-bit Bitfield | N/A |
| SHORT STRING | Up to 128 bytes | A character array where the first byte is the number of characters in the array, and the subsequent bytes contain the ASCII characters. This is not a NULL terminated string. | N/A |

## Appendix C – Data Units

*Table 9-2: Volumetric Flow Units Table*

| Description | Symbol | Units Code | |
| --- | --- | --- | --- |
| | | **Decimal** | **Hex** |
| Percent | % | 4103 | 0x1007 |
| Barrels per Day | bbl/day | 2072 | 0x0818 |
| Barrels per Hour | bbl/hr | 2071 | 0x0817 |
| Barrels per Minute | bbl/min | 2070 | 0x0816 |
| Barrels per Second | bbl/sec | 2069 | 0x0815 |
| Cubic Centimeters per Day | cc/day | 2051 | 0x0803 |
| Cubic Centimeters per Hour | cc/hr | 2050 | 0x0802 |
| Cubic Centimeters per Minute | cc/min | 2049 | 0x0801 |
| Cubic Centimeters per Second | cc/sec | 2048 | 0x0800 |
| Cubic Foot per Day | cu ft/day | 2059 | 0x080B |
| Cubic Foot per Hour | cu ft/hr | 2058 | 0x080A |
| Cubic Foot per Minute | cu ft/min | 5122 | 0x1402 |
| Cubic Foot per Second | cu ft/sec | 2057 | 0x0809 |
| Gallons per Day | gal/day | 2064 | 0x0810 |
| Gallons per Hour | gal/hr | 5130 | 0x140A |
| Gallons per Minute | gal/min | 5129 | 0x1409 |
| Gallons per Second | gal/sec | 5128 | 0x1408 |
| Grams per Day | g/day | 2075 | 0x081B |
| Grams per Hour | g/hr | 2074 | 0x081A |
| Grams per Minute | g/min | 5135 | 0x140F |
| Grams per Second | g/sec | 2073 | 0x0819 |
| Imperial Gallons per Day | imp gal/day | 2068 | 0x0814 |
| Imperial Gallons per Hour | imp gal/hr | 2067 | 0x0813 |
| Imperial Gallons per Minute | imp gal/min | 2066 | 0x0812 |
| Imperial Gallons per Second | imp gal/sec | 2065 | 0x0811 |
| Cubic Inch per Day | cu in/day | 2063 | 0x080F |
| Cubic Inch per Hour | cu in/hr | 2062 | 0x080E |
| Cubic Inch per Minute | cu in/min | 2061 | 0x080D |
| Cubic Inch per Second | cu in/sec | 2060 | 0x080C |
| Kilograms per Day | kg/day | 2077 | 0x081D |
| Kilograms per Hour | kg/hr | 5136 | 0x1410 |
| Kilograms per Minute | kg/min | 2076 | 0x081C |
| Kilograms per Second | kg/sec | 5124 | 0x1404 |
| Pounds per Day | lbs/day | 2078 | 0x081E |
| Pounds per Hour | lbs/hr | 5133 | 0x140D |
| Pounds per Minute | lbs/min | 5132 | 0x140C |
| Pounds per Second | lbs/sec | 5131 | 0x140B |

| | | | |
|---|---|---|---|
| Liters per Day | L/day | 2053 | 805 |
| Liters per Hour | L/hr | 5140 | 0x1414 |
| Liters per Minute | L/min | 5139 | 0x1413 |
| Liters per Second | L/sec | 5126 | 0x1406 |
| Cubic Meters per Day | m3/day | 2056 | 0x0808 |
| Cubic Meters per Hour | m3/hr | 2055 | 0x0807 |
| Cubic Meters per Minute | m3/min | 2054 | 0x0806 |
| Cubic Meters per Second | m3/sec | 5125 | 0x1405 |
| Milliliters per Day | mL/day | 2052 | 0x0804 |
| Milliliters per Hour | mL/hr | 5138 | 0x1412 |
| Milliliters per Minute | mL/min | 5137 | 0x1411 |
| Milliliters per Second | mL/sec | 5127 | 0x1407 |
| Ounces per Day | oz/day | 2082 | 0x0822 |
| Ounces per Hour | oz/hr | 2081 | 0x0821 |
| Ounces per Minute | oz/min | 2080 | 0x0820 |
| Ounces per Second | oz/sec | 2079 | 0x081F |
| Standard Cubic Centimeters per Second | sccm | 5120 | 0x1400 |
| Standard Liters per Minute | SLPM | 5121 | 0x1401 |

*Table 9-3: Actuator Units*

| Description | Symbol | Units Code | |
|---|---|---|---|
| | | **Decimal** | **Hex** |
| Percent | % | 4103 | 0x1007 |

*Table 9-4: Temperature Units*

| Description | Symbol | Units Code | |
|---|---|---|---|
| | | **Decimal** | **Hex** |
| deg C | °C | 4608 | 0x1200 |
| deg F | °F | 4609 | 0x1201 |

*Table 9-5: Volume Units Table*

| Description | Symbol | Units Code | |
|---|---|---|---|
| | | **Decimal** | **Hex** |
| Liter | L | 11778 | 0x2E02 |
| Cubic Centimeter | $cm^3$ | 11793 | 0x2E11 |

## Appendix D – Service Summary Details

*Table 9-6: Get Attribute Single Service Parameters*

| Parameter Name | Data Type | Required | Description | Default |
|---|---|---|---|---|
| Attribute ID | USINT | Y | The attribute ID of the attribute to be read. | None |

*Table 9-7: Success Response Data*

| Return Value | Data Type | Description |
|---|---|---|
| Attribute Value | The Data Type of the Attribute being read | |

*Table 9-8: Set Attribute Single Service Parameters*

| Parameter Name | Data Type | Required | Description | Default |
|---|---|---|---|---|
| Attribute ID | USINT | Y | The attribute ID of the attribute to be read. | None |
| Attribute Value | (Equivalent to the data type of the Attribute) | Y | The value to which the attribute will be set | None |

*Table 9-9: Success Response Data*

| Return Value | Data Type | Description |
|---|---|---|
| NO SUCCESS RESPONSE DATA | | |

### Section 10: Glossary

This section is intended as a brief overview of Ethernet/IP™ terminology used throughout this manual.

**Assembly**

An Assembly is a Class that defines a collection of EPATH(s). This collection allows multiple attributes to be virtually accessed all at once. Each instance of an Assembly defines a unique set of EPATH(s).

**Attribute**

A Parameter or Data Item that may be read or written and is used for the purpose of configuration or is used to obtain information.

Example:

The attribute Data Units defines the engineering units flow will be reported in. The attribute Value indicates the current flow through the device. Attributes can be read/write or read only.

**Class**

A logical collection of related Attributes that define a particular function and/or behavior.

Example:

The class S-Analog Sensor contains information about configuring a sensor, the current status of the sensor, and/or the current value of what is being sensed.

**Connection**

A connection is a logical link between two devices by which messages are transferred. A device can have 1 or more simultaneous Connections.

**Device Profile**

A specification that defines a set of CIP objects that uniquely represents a particular device of that type or class. The device profile can further define attributes, services, assemblies, etc. that a device must support to be considered part of that type or class of device. These profiles are found in the ODVA specification, Vol. 1. The SLA Series MFC/MFM conforms to the Generic device profile.

**EDS**

The Electronic Data Sheet (EDS) is a specially formatted text description for a device that describes the connection characteristics and configurable parameters that are accessible via the Ethernet/IP™ network. EDS files can be read by configuration software used to configure Ethernet/IP™ networks.

**EPATH**

An EPATH is a unique identifier (sometimes referred to as a pointer) comprised of a Class ID, an Instance ID, and an Attribute ID. Some Classes have EPATH attributes that point to a particular data item. An example of this would be the Connection Class that contains two attributes, Produce Path and Consume Path. These attributes define where incoming data is sent to, and outgoing data comes from.

**Expected Packet Rate (EPR)**

The EPR is an attribute in the Connection Class that defines the maximum amount of time (in msec) messages should be received by the Connection (implementation of this value is dependent upon the Connection type, Class 1 or Class 3, but the behavior is the same in all Connection types). If the time between received messages for that connection exceeds the EPR, the Connection times out. This may result in the Connection being released by the device.

**Class 3 Connection**

A Class 3 Connection dictates a request and response exchange between two devices. The device sending the request must get a response from the device receiving the request message. Embedded in the Message is information about the Class, Instance, Attribute, Service, and any service data needed to process the message.

As a result, processing of Messages generally takes longer than Class 1 messaging. This is why Class 3 Connections are typically used for commissioning/configuration.

**Class 1 Connection**

Class 1 Connections are used for the exchange of data only. How a device processes the data and/or responds with data via an Connection is defined within the Connection(s) configurations.

**Instance**

An instance of a Class is a particular invocation of a Class (sometimes referred to as an Object). An Instance of a Class is unique in describing the behavior for a particular kind of object. Each instance of the class contains the same set of attributes defined by the class. The uniqueness of the instance is defined by the attribute values.

**Safe State (Safe Mode)**

An operational mode or state that is considered "safe" whereby the normal controller process is shut down and mechanical and sensing mechanisms are placed in a safe condition.

**Service**

A service is a pre-defined action that a Class provides. The most commonly used services are used to configure the device such as Get Attribute (0x0E) or Set Attribute (0x10). Other types of services may directly affect the behavior of a Class (or Object) such as Reset (0x5), Stop (0x6), or Start (0x7). There are many more services not listed here and each Class specifies which Services it supports.

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