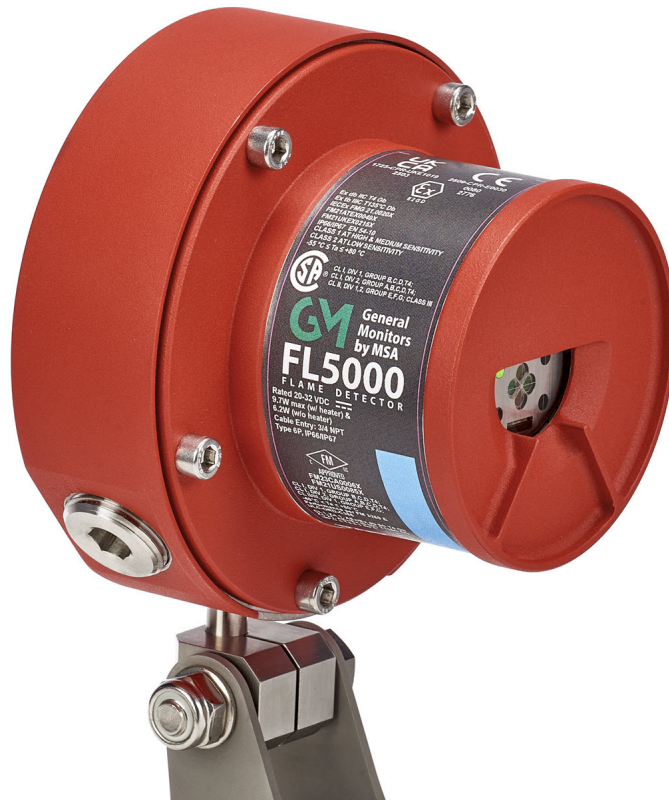




Safety Manual
FL5000
Flame Detector



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WARNING!

These instructions must be provided to users before use of the product and retained for ready reference by the user. Read this manual carefully before using or maintaining the device. The device will perform as designed only if it is used and maintained in accordance with the manufacturer's instructions. Otherwise, it could fail to perform as designed, and persons who rely on this device could sustain serious injury or death.

The warranties made by MSA with respect to the product are voided if the product is not installed and used in accordance with the instructions in this manual. Please protect yourself and your employees by following the instructions.

Please read and observe the WARNINGS and CAUTIONS inside. For additional information relative to use or repair, call 1-800-MSA-2222 during regular working hours.

For countries of Russian Federation, Republic of Kazakhstan and Republic of Belarus, the gas detector will be delivered with a passport document that includes valid approval information. On the CD with manual instruction attached to the gas detector the user will find the documents "Type Description" and "Test Method" - appendixes to Pattern Approval Certificate of Measuring instrument, valid in the countries of use.

The Declaration of Conformity can be found under the following link: <https://MSAsafety.com/DoC>.

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1 Introduction

This manual describes only the SIL related safety information for the FL5000 to support installations where SIL certification to IEC 61508 is required.

For complete information regarding performance, installation, operation, maintenance, safety information, warnings and specifications of the FL5000 Flame Detector, refer to the operating manual (PN 10238682).

The safety product you have purchased should be handled carefully, and installed and maintained in accordance with the associated product instruction manual. Remember, this product is for your safety.

WARNING!

- The FL5000 Flame Detector is certified as a SIL 2 or SIL 3 capable device under IEC 61508 and must be installed, used, and maintained in accordance with this manual if compliance with this IEC functional safety standard is desired. Failure to do so can result in a reduced safety level.
- Under no circumstances should this equipment be connected or disconnected when under power. This is contrary to hazardous area regulations and may also lead to serious damage to the equipment.

Failure to follow these warnings can result in serious personal injury or death.

2 Description

The FL5000 Flame Detector, hereafter also called the device, is a microprocessor based Multi-Spectral Infrared (MSIR) flame detector employing a state-of-the-art infrared (IR) detector to detect typical fires such as those produced by alcohol, n-heptane, gasoline, jet fuels, and hydrocarbons.

The FL5000 detector provides an isolated sink or source 0-20 mA analog output and relay outputs for Instant Alarm, Sustained Alarm and fault indication levels. The device contains an extensive set of self-diagnostic features with means of access and interrogation by means of the 0-20 mA analog output, HART, RS-485 Modbus and/or Bluetooth communications. The HART and Modbus communication protocols are non-interfering and can be used for diagnostics as part of SIL 2 or SIL 3 safety function operations. The Bluetooth communication disables the safety function and the operation is visually shown by a Blue LED (un-paired flashing or paired solid), 3.0 mA analog output, and Fault relay/LED active. The device is intended for integration with a fire alarm panel that can alert operations personnel to the presence of a fire.

The FL5000 Instruction Manual (PN 10238682) provides details on installation, operation and self-diagnostic features.

3 Safety and Precautionary Measures to be Adopted

Failure to follow the recommendations shown below can result in an unsafe condition and persons who rely on this product for their safety could sustain severe personal injury or loss of life.

WARNING!

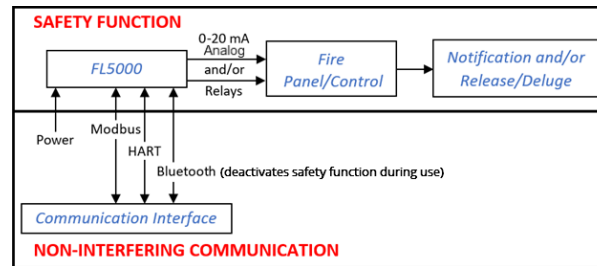
- The device described in this manual must be installed, operated and maintained in strict accordance with the labels, cautions, instructions and within the limitations stated.
- Protect the device from extreme vibration.
- Do not mount the device in extreme heat or sunlight as this may cause overheating. A sun shield is available to protect from extreme environments.
- Use only genuine MSA replacement parts when performing any maintenance procedures. Failure to do so may seriously impair device performance. Repair or alteration of the device beyond the scope of the product instructions or by anyone other than an authorized MSA service provider could cause the product to fail to perform as designed.
- Do not paint the device. If painting is done in an area where the device is located, exercise caution to ensure paint is not deposited on the device. Such paint deposits could interfere with the device operation.
- Before connection to a monitoring controller or fire panel (PLC, DCS, etc.), the user or installer must be properly trained with respect to the specific controller operation, input/output hardware, configuration and start-up procedures.

Failure to follow these warnings can result in serious personal injury or death.

4 Functional Safety Installation

4.1 Safety Function

The FL5000 detects fire and provides a 0-20 mA analog output and relay output for alarming. See diagram below for representation of the safety function and non-interfering communications.



HART, RS-485 Modbus and Bluetooth communications are typically used for field device setup, diagnostics, and troubleshooting. Carefully observe requirements for interfacing in hazardous locations. HART and Modbus communications are non-interfering functions and do not interrupt the safety critical functions of the device. The Bluetooth communication disables the safety function and the operation is visually shown by a Blue LED (un-paired flashing or paired solid), 3.0 mA analog output, and Fault relay/LED active.

4.2 Measurement Range

The FL5000 provides a NAMUR NE43 compliant analog 0-20 mA output. The 4-20 mA analog range is the normal measurement range with a 16 mA level representing Instant Alarm and a 20 mA level representing Sustained Alarm, and a 1.25 mA (default) level representing a fault condition. See the FL5000 Instruction Manual 10238682 for additional information.

The FL5000 analog 4-20 mA output signal safety function is by-passed during application of the TL105 Test Lamp and Bluetooth activation. An alternate means of safety protection must be applied on-site during these activities.

The FL5000 provides safety function instant and sustained alarm relays in addition to a fault relay. The instant and sustained alarm relays correspond to the 16 mA and 20 mA safety function analog outputs. The fault relay activates upon diagnostic fault response - see the FL5000 Instruction Manual 10238682 for details.

4.3 Diagnosis Response Time

The FL5000 monitors itself for many conditions and will report abnormalities to the user. All critical diagnostic functions are performed every second in addition to a Continuous Optical Path Monitor (COPM) check every 2 minutes. The Flash Memory Detection-to-Failure Reaction response time is less than or equal to 4 hours.

4.4 Safety-Relevant Parameters

The FL5000 has been subjected to rigorous reliability and functional safety assessments which have culminated in the device being certified to IEC 61508 (Ed. 2). It is assumed that the field devices will be installed in a Safety Instrumented System (SIS) in a Low Demand environment per IEC 61508. [Table 1](#) provides the SIL parameters for the device.

Table 1 FL5000 SIL Parameters

Safety Integrity Level (SIL)	SIL 2 (Relay and Analog Output) or SIL 3 (Analog Output)
Demand Mode	Low Demand Mode (LDM)
λ_{SD} , λ_{SU} , λ_{DD} , λ_{DU} , Safe Failure Fraction (SFF), Probability of Failure on Demand (PFD)	(see Table 2)
Hardware Fault Tolerance (HFT)	0
Type Classification	B
Mean Time to Restoration (MTTR)	SIL 2: 24 hours (MSA recommended)* SIL 3: 4 hours (MSA recommended)*
Proof Test Interval (PTI)	1-year recommended

*For SIL 2, a max. TTR of 67 hours is permitted with a PTI of 1 year. For SIL 3, a max. TTR of 7 hours is permitted with a PTI of 1 year.

4 Functional Safety Installation

Table 2 FL5000 with Analog Output

FL5000 Device	λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF
	FIT*	FIT*	FIT*	FIT*	%
Analog Output (SIL 2 or 3)	4088.2	208.4	131657	11.8	99.9913
Relay Output (SIL 2)	4096.7	197.5	131543.3	252.3	99.8146

*FIT = 1×10^{-9}

The FL5000 was designed with a very high level of reliability and fault detection. However, the possibility of an undetected fault still exists. Should an undetected fault occur, there is a chance that a fire condition will not be registered.

While the chance of an undetected fault cannot be completely eliminated, certain steps can be taken to minimize the probability. Regular maintenance is crucial to proper operation of the equipment. Frequent testing with the TL105 Test Lamp is an excellent means of ensuring proper operation of the equipment.

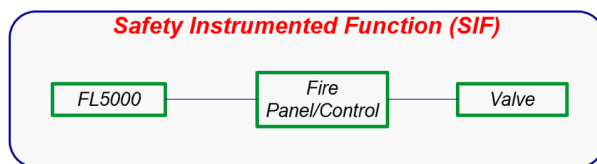
Refer to the instruction manual (PN 10238682) for full details.

Adhere to the proper installation, maintenance and operation to minimize the probability of undetected faults.

The useful lifetime is highly dependent upon device application, operating condition, environmental conditions, and other factors. The experience-based useful lifetime of the device is 8 – 12 years.

4.5 Integration

The FL5000 is designed to operate within a Safety Instrumented System. The device typically is integrated with a fire panel and notification and/or release equipment. This is an example of assessment of the Safety Instrumented Function (SIF), noting that detailed considerations and calculations are provided within IEC 61508-6 for further guidance:



$$PFD_{avg} = \Sigma (\lambda_{DU}(PTI/2 + MTTR) + \lambda_{DD} * MTTR)$$

PFD_{avg} **Average Probability of Failure on Demand** (hours)

PTI **Proof Test Interval** (hours)

λ_{DU} **Dangerous Undetected Failures** (hours)

λ_{DD} **Dangerous Detected Failures** (hours)

MTTR **Mean Time To Restoration** (hours)

Example SIL 2 Assessment for FL5000:

Assuming each device of the Safety Instrumented Function (SIF) has a 12-month (or 8,760 hour) Proof Test Interval (T_p) and a 24-hour Mean Time To Restoration (MTTR), the following simplified calculation applies for assessment:

$$PFD_{avg} = [(11.8 \times 10^{-9} * (8760 / 2 + 24) + 131657 \times 10^{-9} * 24) + PFD_{avg, \text{ Fire Panel}} + PFD_{avg, \text{ Valve}}]$$
$$= [0.00321 + PFD_{avg, \text{ Fire Panel}} + PFD_{avg, \text{ Valve}}]^*$$

*This total must be less than 0.01 for SIL 2.

5 Functional Safety Operation

5.1 Start-Up and Commissioning

The FL5000 should be commissioned by a qualified person with knowledge of flame detection equipment including device configuration. Digital communication by non-interfering HART/RS-485 Modbus communication, or deactivation of the safety function via Bluetooth communication, is necessary to monitor internal status and to modify the factory settings of the device. Upon completion of installation and commissioning, it is recommended to password-protect the device programming and setup function to prevent accidental or deliberate change of the device while in normal operation.

Performing Proof Tests is necessary at commissioning and on a periodic basis to ensure the Safety Instrumented Function (SIF) is maintained. Personnel performing the Proof Test procedures must be competent at performing the required tasks. The Proof Test results must be recorded and analyzed. Any corrective actions deemed necessary must be documented and communicated as part of safety functionality. The following Proof Test is required during start-up and commissioning:

- Flame Response Proof Test (see [6.1 Flame Response Proof Test](#) for detailed procedures)
- Output Response Proof Test (see [6.2 Output Response Proof Test](#) for detailed procedures)

5.2 Configuration

The FL5000 can be configured by HART, RS-485 Modbus, Dip Switch or Bluetooth digital communication methods. Refer to the instruction manual (PN 10238682) for operational details on HART, Modbus and Bluetooth operation.

Prior to device configuration, the system outputs must be inhibited. During configuration change using Bluetooth communication, the device will not be capable of performing the intended safety function. It is recommended that the password-protection feature be activated to prevent accidental or deliberate changes of the device configuration potentially affecting device operation.

There is a hierarchy of four access levels related to configuration change rights:

- Operator: Digital communication 'read' rights only.
- Supervisor: Digital communication configuration rights.
- Service: Digital communication configuration and device firmware update rights.
- MSA: Device firmware upload.

5.3 Accessories

The FL5000 list of accessories are provided within the instruction manual (PN 10238682). Use only original MSA listed accessories to ensure proper safety function operation.

6 Functional Safety Maintenance

6.1 Flame Response Proof Test

The Test Lamp (TL105) is recommended as a means of testing the operation of the device. To do this, activate and aim the Test Lamp directly at the device, this makes the device output rise to a specified value range as outlined in [Table 3](#).

Table 3 Typical Response Using the TL105 Test Lamp

Condition	Analog Output	Instant Alarm Relay	Sustain Alarm Relay
FL5000 placed in test mode	3.5 mA	no change	no change
TL105 pointed at FL5000	16 mA	engaged	no change
TL105 pointed at FL5000 (after preset FL5000 delay)	20 mA	engaged	engaged

Procedural Steps:

1. Set the FL5000 in test mode per the instruction manual.
NOTE: The Analog Output will change to 3.5 mA when test mode is entered.
2. Stand between 10 and 35 feet from the FL5000 and aim the Test Lamp (TL105) directly into the detector window.
3. Verify alarm indication via the LED's, analog output, HART, Modbus communication and record readings.
4. Exit the test mode per one of the methods detailed in the instruction manual 10238682.
5. Document successful Flame Response Proof Test in the Safety Instrumented Systems (SIS) logbook.

6.2 Output Response Proof Test

The Output Response Proof Test must be performed during commissioning and on an annual basis. If the Flame Response Proof Test successfully validated the 4-20 mA output with results recorded in the Safety Instrumented Systems (SIS) logbook, then the Output Response Proof Test outlined below can be waived.

A HART handheld communicator or a Test Lamp (TL105) is recommended as a means of testing the output response of the device.

Procedural Steps:

1. Disable alarm response at the control device.
2. Use a HART handheld communicator to perform a Alarm Test function at 20 mA, or use the Test Lamp (TL105).
3. Verify alarm indication and record readings.
4. Remove the Alarm Test function.
5. Verify the alarm indication clears.
NOTE: Reset action is required in alarm latching mode.
6. Enable alarm response at the control device.
7. Document successful Output Response Proof Test in the Safety Instrumented Systems (SIS) logbook.

6.3 Repair

Any FL5000 repairs must be conducted at the factory to ensure high reliability of the safety instrument. Firmware upgrades must be performed by MSA. All failures that are detected by internal diagnostics or by the Proof Tests must be reported to MSA.

6.4 Replacement

The Safety Instrumented System (SIS) calculations are based on a sufficient number of spare replacement parts to achieve a 24-hour (SIL 2) or 4-hour (SIL 3) mean time to repair.

7 Terms and Definitions

FMEDA	Failure Mode Effects and Diagnostics Analysis
HART	Highway Addressable Remote Transducer
HFT	Hardware Fault Tolerance
LFL	Lower Flammable Limit
PFD	Probability of Failure on Demand (Probability of Dangerous Failure)
PFD_{avg}	Average Probability of Failure on Demand
SFF	Safe Failure Fraction
SIF	Safety Instrumented Function
SIL	Safety Integrity Level
SIS	Safety Instrumented System
FIT	Failure in Time

