SAFETY MANUAL

Intelligent Sensors for Combustible Gas Applications

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Safety Manual **04-09**

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This manual describes the safety related information for the installation, operation, configuration, and maintenance of the following field devices:

- S4000CH Intelligent Sensor with HART Communication for Combustible Gas Detection
- S4000C Intelligent Sensor for Combustible Gas Detection
- S4100C Intelligent Sensor for Combustible Gas Detection for European Applications

For complete information regarding performance, installation, operation, maintenance and specifications of the above products, please refer to the associated product manual.

General Monitors' mission is to benefit society by providing solutions through industry-leading safety products, services and systems that save lives and protect capital resources from the dangers of hazardous flames, gases and vapors.

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

WARNING: TOXIC, COMBUSTIBLE, AND FLAMMABLE GASES AND VAPORS ARE VERY DANGEROUS. USE EXTREME CAUTION WHEN THESE HAZARDS ARE PRESENT.

INTRODUCTION

General Description

The Models S4000CH, S4000C, and S4100C Intelligent Sensors for combustible gas detection are microprocessor-based transmitters designed for use with General Monitors' catalytic bead sensors. They monitor combustible gases and vapors within the lower explosive limit (LEL) and transmit a 4-20 mA analog output proportional to the gas concentration. Optional Warn and Alarm relays can be programmed to trip when gas concentrations reach a percentage of the LEL. All detectors are regarded as Type B field devices per IEC 61508. The S4000CH, S4000C, and S4100C can each connect to Safety Integrity Level (SIL) suitable TA102A Trip Amplifiers.

The safety function of the S4000CH detector does not include:

- HART communication
- RS-485 Modbus communication

The safety function of the S4000C and S4100C detectors do not include:

- RS-485 Modbus communication

HART and Modbus communication are typically used for field device setup, diagnostics, and troubleshooting. Carefully observe requirements for interfacing in hazardous locations. HART and Modbus communication are non-interfering functions and do not interrupt the safety critical function of the detectors.

INSTALLATION

NOTE: Power should remain disconnected until all other wiring connections are made.

For complete installation information for the S4000CH, S4000C, and S4100C, refer to the product instruction manual for each of these field devices.

Detector Location Considerations

There are no standard rules for detector placement, since the optimum detector location varies with the application. The customer must evaluate conditions at the facility to make this determination. To the greatest extent possible, the Models S4000CH, S4000C, and S4100C detectors should be installed in a manner that provides accessibility to conduct occasional calibration checks.

The sensors used in the Models S4000CH, S4000C, and S4100C should be mounted pointing down to prevent water build-up on the sensor head. Furthermore, the sensor should not be placed where contaminating substances may coat it or where excessive vibration is possible.

Although the S4000CH, S4000C, and S4100C are Radio Frequency Interference (RFI) resistant, the units should not be mounted close to radio transmitters, high magnetic or electrical fields, or in areas with similar interference.

Locate the S4000CH, S4000C, and S4100C where prevailing air currents contain the maximum concentration of gas. Also, locate the detectors as near as possible to the likely source of a gas leak. Observe the temperature range of the field device and locate the unit away from concentrated sources of heat. Do not locate the intelligent sensors in areas that exceed the maximum operating temperature of the unit, such as locations with gas turbine exhaust.

No special or additional mounting, wiring, power, or tool requirements exist beyond the standard installation practices documented in the product instruction manuals for the S4000CH, S4000C, and S4100C.

Sensors may be adversely affected by prolonged exposure to certain materials. Loss of sensitivity or corrosion may be gradual if such materials are present in low concentrations, or it may be rapid at high concentrations. The more important materials adversely affecting sensors are as follows:

- Constant presence of high concentrations of hydrogen sulfide (H_2S) gas
- Silicones (often contained in greases and aerosols)
- Halides, compounds containing fluorine, chlorine, bromine, and iodine
- Heavy metals, e.g., tetraethyl lead
- Caustic and acidic liquids and vapors

The presence of poisons and contaminants in an area does not necessarily preclude the use of an S4000CH, S4000C, and S4100C intelligent sensor. The feasibility of using a sensor in such areas must be determined by an analysis of the specific factors in each

application and General Monitors should be consulted before attempting any such installation.

Sensors used in these areas usually require more frequent calibration checks than normal, and typically have a shorter life. In many such applications, the standard two-year warranty would not apply.

WARNING: Under NO circumstances should 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. Equipment damaged in this manner is not covered under warranty.

OPERATION, CONFIGURATION AND MAINTENANCE

For complete information on the operation, configuration, and maintenance of the S4000CH, S4000C, and S4100C, refer to the product instruction manual for each of these field devices.

General Monitors recommends that the S4000CH, S4000C, and S4100C be calibrated one hour after start-up, and that the calibration be checked every ninety (90) days to ensure system integrity. More frequent calibration checks are recommended for environments that have a greater likelihood of mud collecting on the sensor head, sensors accidentally being painted over, or other conditions that may adversely impact the sensor.

General Monitors recommends that a calibration schedule be established and followed. A logbook should also be kept, showing calibration dates and dates of sensor replacement.

The S4000CH, S4000C, and S4100C are intelligent sensors performing internal diagnostics on critical faults every second and respond with 0 mA at the Analog Output upon detection of a fault. In addition, depending on configuration, the S4000CH may also respond with a fault signal of 1.25 mA or 3.5 mA at the Analog Output.

Refer to the Troubleshooting Section in the appropriate product instruction manual in the event of a calibration or operational fault. In addition, spare parts should be on-hand as described in the Spare Parts Section of the product instruction manual.

NOTE: Entering Gas Check or Calibration mode sends a 1.5 mA output signal and disables the Warning and Alarm relay circuits. The S4100C output for these modes is selectable (0 mA, 1.5 mA, or 2 mA) with 1.5 mA as the default.

WARNING: Disconnect or inhibit external devices such as Trip Amplifiers, Programmable Logic Controllers (PLC), or Distributed Control Systems (DCS) before performing any maintenance.

SPECIFICATIONS

Table 1 and Table 2 list specifications for the S4000CH, S4000C, and S4100C. For a complete list of specifications, refer to the instruction manual of each respective model.

	S4000CH	S4000C	S4100C
Instruction Manual P/N	MANS4000CH	MANS4000C	MANS4100C-EU
Temp. Range (Electronics)*			
Operating:	CSA/FM: -40°F to 167°F (-40°C to +75°C) ATEX: -40°F to 158°F (-40°C to +70°C)	-40°F to 167°F (-40°C to +75°C)	-50ºC to +70ºC
Storage:	-58°F to 185°F (-50°C to +85°C)	-58°F to 185°F (-50°C to +85°C)	-50ºC to +70ºC
Humidity Range:	5% to 100% RH, non-condensing	5% to 100% RH, non-condensing	5% to 100% RH, non-condensing
Atmosphere:	Will not operate in <5% oxygen	Will not operate in <5% oxygen	Will not operate in <5% oxygen
Input Power:			
Absolute min:	20 VDC	20 VDC	10 VDC
Nominal:	24 VDC	24 VDC	
Absolute max:	36 VDC	36 VDC	35 VDC

Table 1 – Environmental/Electrical Specifications

* For operating temperature range of sensors see instruction manual

Mode	S4000CH HART Disabled	S4000CH HART Enabled	S4000C	S4100C*
Fault	0 mA	3.5 mA/ 1.25 mA**	0 mA	0 mA
Calibration, Gas Check, Setup Mode	1.5 mA	3.5 mA/ 1.5 mA**	1.5 mA	0 mA, 1.5 mA***, or 2 mA
0 – 100 % LEL	4 – 20 mA	4 – 20 mA	4 – 20 mA	4 – 20 mA
Over range	20 – 21.7 mA	20 – 21.7 mA	20 – 22 mA	20.1 – 21.7 mA

Table 2 – Analog Output Specifications (Max Load: 650 ohms)*

* For S4100C max load is 750 ohms.
** S4000CH HART Enabled units may have Analog Output modified to output 3.5 mA or 1.25mA for a malfunction and 3.5 mA or 1.5 mA for calibration, gas check and setup modes. The default is 3.5mA.
*** User selectable on the S4100C for these modes. Default is 1.5 mA.

CERTIFICATIONS AND FAILURE RATE DATA

The S4000CH, S4000C, and S4100C field devices have gone through rigorous reliability and functional safety assessments, which have resulted in each of these products being certified to IEC 61508 Parts 1, 2, and 3, by FM Approvals. The reliability assessment is a failure rate prediction that assumes an average temperature of 40ºC and an environmental factor equivalent to Ground Fixed. It is assumed that the field devices will be installed in a Safety Instrumented System (SIS) operating in a Low Demand environment per IEC 61508. The tables below list the SIL parameters for each field device.

	S4000CH (4-20 mA Output)	S4000CH (Relay Output)	S4000C (4-20 mA Output)
FM Certificate	3034949-S4000CH	3034949-S4000CH	3034949-S4000C
Product Life (Years)*	22	22	21
λ_{DD} (Fails per hour)	1.14E-5	1.16E-5	1.1E-5
λ_{DU} (Fails per hour)	8.8E-8	3.26E-7	1.2E-7
Safe Failure Fraction (SFF)	>99%	97%	>99%
Safety Integrity Level (SIL)**	3	2	3
Diagnostic Test Interval	1 sec	1 sec	1 sec
Response Time (with 100% LEL methane applied)	T_{50} < 10 sec	T_{50} < 10 sec	T_{50} < 10 sec
Average Probability of Failure on Demand PFD_{avg}1oo1***	1.4E-4	4E-4	1.75E-4

Table 3A – SIL Parameters for S4000CH and S4000C (Clean Environment)

* Catalytic bead sensor life is typically 3-5 years.
** Hardware Fault Tolerance (HFT) = 0
*** PFD_{avg}1oo1 assumes a 4 hour repair time and 90 day proof test interval.

	S4000CH (4-20 mA Output)	S4000CH (Relay Output)	S4000C (4-20 mA Output)
FM Certificate	3034949-S4000CH	3034949-S4000CH	3034949-S4000C
Product Life (Years)*	22	22	21
λ_{DD} (Fails per hour)	1.6E-5	1.6E-5	1.55E-5
λ_{DU} (Fails per hour)	1.7E-6	1.9E-6	1.7E-6
Safe Failure Fraction (SFF)	91%	90%	92%
Safety Integrity Level (SIL)**	2	2	2
Diagnostic Test Interval	1 sec	1 sec	1 sec
Response Time (with 100% LEL methane applied)	T_{50} < 10 sec	T_{50} < 10 sec	T_{50} < 10 sec
Average Probability of Failure on Demand PFD_{avg}1oo1***	1.9E-3	2.15E-3	2E-3

Table 3B – SIL Parameters for S4000CH and S4000C (Contaminated Environment)

* Catalytic bead sensor life is typically 3-5 years.
** Hardware Fault Tolerance (HFT) = 0
*** PFD_{avg}1oo1 assumes a 4 hour repair time and 90 day proof test interval.

S4100C (4-20 mA Output)	Clean Environment	Contaminated Environment
FM Certificate	3034949-S4100C	3034949-S4100C
Product Life (Years)*	21	21
λ_{DD} (Fails per hour)	1.1E-5	1.63E-5
λ_{DU} (Fails per hour)	3.34E-8	1.83E-6
Safe Failure Fraction (SFF)	>99%	92%
Safety Integrity Level (SIL)**	3	2
Diagnostic Test Interval	1 sec	1 sec
Response Time (with 100% LEL methane applied)	T_{50} < 10 sec	T_{50} < 10 sec
Average Probability of Failure on Demand PFD_{avg}1oo1***	3E-4	2.4E-3

Table 4 – SIL Parameters for S4100C

* Catalytic bead sensor life is typically 3-5 years.
** Hardware Fault Tolerance (HFT) = 0

*** PFD_{avg}1oo1 assumes a 24 hour repair time and 90 day proof test interval.

Agency Approvals

The S4000CH, S4000C, and S4100C have the following approvals:

S4000CH	S4000C	S4100C
CSA	CSA	ATEX
FM Approvals	FM Approvals	BV
ATEX	ATEX	Approved for Russia
HART Registered	Approved for Russia	Approved for Kazakhstan
Approval for Russia Pending	IEC 61508 per FM Approvals	IEC 61508 per FM Approvals
IEC 61508 per FM Approvals		

Table 5 – Approvals