MSA
The Safety Company

User Instructions

ULTIMA®X5000

Order No.: 10177362/02
Print Spec: 10000005389 (EO)
CR: 800000070115

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

NOTE: This manual describes only the SIL related safety information for the ULTIMA X5000 to support installations where SIL certification to IEC 61508 is required.

The MSA ULTIMA X5000 Gas Monitor, hereafter also called the device, is designed to monitor the environment where mounted and alert the user to potentially dangerous levels of target gas. The ULTIMA X5000 uses various detection methods, depending on the gas of interest. Detection methods include electrochemical, infrared, catalytic bead or other technologies.

The ULTIMA X5000 is capable of communicating with and displaying information for two sensors at a time. The device generates two discrete analog outputs; one for each sensor connected to the transmitter. Each analog output is a standard 4 to 20 mA sourcing output. The analog output associated with Sensor 1 has HART (Highway Addressable Remote Transducer) communication encoded on it. If two sensors are connected, the HART communication on output 1 carries information for both sensors.

Relays and other communication protocols are available as an option.

The ULTIMA X5000 is suitable for installation in hazardous locations. It is intended for integration with a control system that can alert operations personnel to the presence of a gas alarm. The ULTIMA X5000 Gas Monitor is regarded as Type B field device per IEC 61508.

⚠ WARNING!

- For complete information regarding performance, installation, operation, maintenance, safety information, warnings and specifications of the ULTIMA X5000 Gas Monitor, refer to the operating manual (PN 10177361).
- This safety product must be handled carefully, and installed and maintained in accordance with the associated product instruction manual.
- Toxic, combustible, and flammable gases and vapors are very dangerous. Use extreme caution when these hazards are present.
- The ULTIMA X Series Gas Monitor is certified as a SIL 2 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. It is, however, permissible to disconnect and replace sensors without removing power in a class I (combustible gas) area.

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

2 Safety and Precautionary Measures

⚠ WARNING!

- The user should read and understand the instruction manual, including all cautions and warnings, before using the device.
- The device described in this manual must be installed, operated and maintained in strict accordance with the labels, cautions, warnings, instructions and within the limitations stated.
- Protect the device from extreme vibration.
- 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.
- XIR Plus sensors should be mounted horizontally. Non XIR Plus sensors should be mounted vertically facing down. This will help ensure that environmental particulates will not block the gas path to the sensor. It is recommended to periodically perform a visual inspection of the sensor gas inlet as part of normal maintenance. Failure to follow this recommendation can lead to degraded performance.
- Before connection to a monitoring controller (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.
- Do not mount the device in extreme heat or sunlight as this may cause overheating. A sunshield is available to protect from extreme environments.
- 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. Solvents in the paint may also cause an alarm condition to occur.
- Do not use a high pressure wash on the device. Forced water entry to some sensor inlets can obstruct the gas path leading to degraded performance
- Do not use silicone type lubricants in assembling the device and do not allow silicone vapors to be drawn into the flow system while in operation. Silicone can desensitize the combustible gas sensor thereby giving incorrect readings.

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

3 Operational Safety Concerns

For additional operational information refer to the product instruction manual (P/N 10177361).

3.1 Calibration

The ULTIMA X5000 allows the user a method for sensor calibration. This typically includes a zero and span operation with target gas. Refer to the instruction manual for full details on calibration methodology for each sensor type.

The frequency of calibration gas testing depends on the operating time, chemical exposure and type of sensor. Especially in new installations or applications, it is recommended that the first sensors be calibrated more often to establish the sensor performance in this particular environment. For the purposes of compliance to IEC 61508 a proof test interval is required and is shown in this manual under the section titled “Certifications and Failure Rate Data”.

3.2 Changing or Replacing Sensors

SafeSwap

The ULTIMA X5000 comes with patented SafeSwap technology, which allows users to change or replace XCell sensors without needing to power down the instrument. For non-XIR Plus sensors, the main transmitter unit will accept different sensor modules. When a sensor is changed in the field, the main transmitter unit will communicate with the sensor module and identify its target gas type and calibration information. The gas type will show on the main transmitter display. When replacing a sensor, verify that the correct sensor has been installed by viewing the gas type shown on the instrument display. In addition, it is recommended that proper installation be verified by applying the gas of interest to the sensor to ensure a proper response.

⚠ WARNING!

Refer to the associated product manual (P/N 10177361) for warnings and instructions for changing or replacing sensors under power.

Failure to follow this warning can result in serious personal injury or death.

Swap Delay

For added convenience, all sensors with SafeSwap also have a Swap Delay which is enabled by default and may be disabled by the user. This feature gives users a 2 minute window to change sensors without triggering a fault condition. Once a sensor is disconnected from the transmitter, the user will have 2 minutes to reconnect a sensor. During this time, the device analog output will go to its Maintenance level. If a sensor is reconnected or replaced during the 2 minute window, the new sensor’s countdown sequence will begin and the analog output will remain at the Maintenance level. After the sensor countdown is complete, the analog output will return to reporting a live gas reading. If a sensor is not reconnected after the 2 minute window, the ULTIMA X5000 will enter a “Sensor Missing” fault condition.

3.3 System Faults

The ULTIMA X5000 monitors itself for many conditions and will report abnormalities to the user. Refer to Section 8 Troubleshooting for a list of potential faults and troubleshooting recommendations.

3.4 Minimizing Undetected Faults

The ULTIMA X5000 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 potentially dangerous gas reading will not be registered.

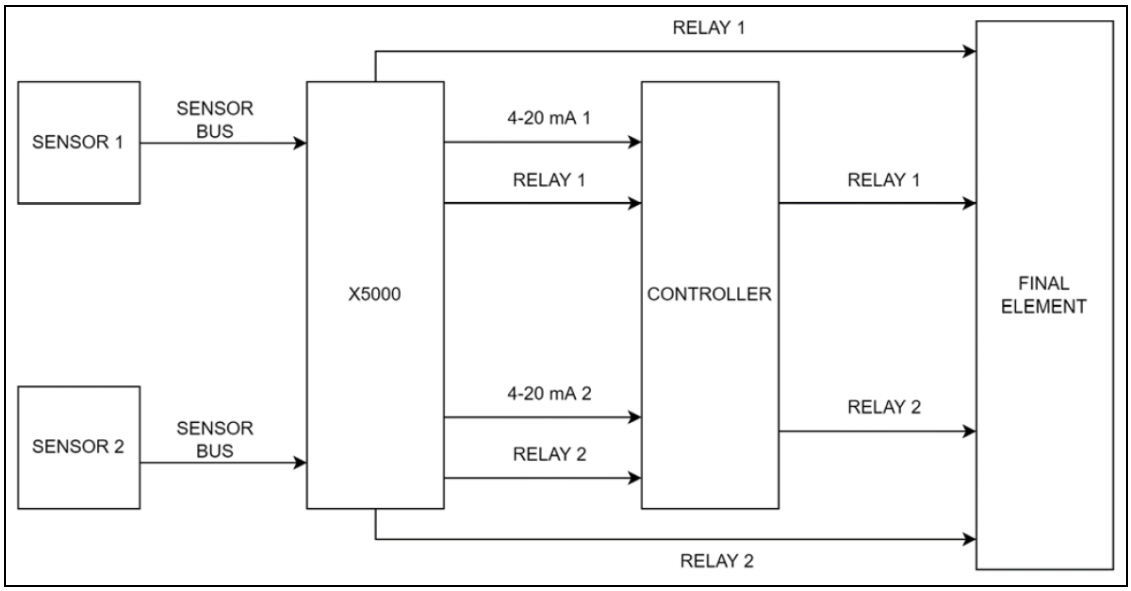
While the chance of an undetected fault cannot be completely eliminated, certain steps can be taken to minimize the probability. Regular maintenance is crucial to proper operation of the equipment. Frequent gas application is also an excellent means of insuring proper operation of the equipment.

Refer to the instruction manual for full details. Adherence to the proper installation, maintenance, calibration and operation will minimize the probability of undetected faults.

4 Functional Safety Installation

4.1 Safety Function

The Ultima X5000 detects hydrocarbon, toxic, and oxygen gas atmospheres and provides a 4-20 mA output depending on the concentration in air, see user manual for additional information. See diagram below for representation of the safety function and non-interfering communications.



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

4.2 Measurement Range

The X5000 provides an analog 4-20 mA output that is proportional to hydrocarbon vapor, toxic, or oxygen concentrations. The X5000 output measurement provides defined fault condition current levels below 3.6 mA or above 20.5 mA as outlined in the Instruction Manual.

4.3 Diagnosis Response Time

The X5000 monitors itself for many conditions and will report abnormalities to the user. All critical diagnostic functions are performed within 24 hours as the worst case diagnostic detection time.

4.4 Proof Test Steps

1. Bypass the safety function and take appropriate action to avoid a false trip.
2. Use HART communications to retrieve any diagnostics and take appropriate action.
3. Inspect the transmitter for any visible damage or any other communication.
4. Perform sensor calibration per the instructions provided in user manual 10177361.
5. Remove any safety function bypass and restore normal operation.

4.5 Safety-Relevant Parameters

The X5000 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 or High Demand environment per IEC 61508. The following table provides the SIL parameters for the Transmitter and Receiver devices:

Safety Integrity Level (SIL)	SIL 1		SIL 2		SIL 3	
Low Demand Mode (LDM) / High Demand Mode (HDM)	LDM	HDM	LDM	HDM	LDM	HDM
Structure 1oo1	X	X	X			
Structure 1oo2	X	X	X	X	X	X
λSD, λSU, λDD, λDU	See the table in 4.6 Application Specific Restrictions					
Hardware Fault Tolerance (HFT)	SIL 2 HFT = 0, SIL 3 HFT = 1					
Type Classification	B					
Mean Time to Restoration (MTTR)	4 hours					
Proof Test Interval (PTI)	3 months					
Systematic Capability	SC 2					

4.6 Application Specific Restrictions

The following application specific restrictions are applicable to the X5000 and have been considered during the Failure Modes, Effects and Diagnostic Analysis of the X5000. These restrictions shall be included in the safety manual for the X5000.

- The failure rates for the Xcell sensor sections do not include the sensor failure rates, which must be added to obtain the complete metrics.
- If the relay board option is used the Fault Relay output must be monitored by the logic solver.

Sample PFDavg Calculations:

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

PFD_{avg}	**A**verage **P**robability of **F**ailure on **D**emand (hours)
PTI	**P**roof **T**est **I**nterval (hours) = 2190 (3 months)
λ_{DU}	**D**angerous **U**ndetected Failures (hours)
λ_{DD}	**D**angerous **D**etected Failures (hours)
MTTR	**M**ean **T**ime **T**o **R**estoration (hours) = 4
Structure	1oo1

Safety Relevant Parameters

Device	λSD	λSU	λDD	λDU	PFDavg
Common	484	153	380	170	1.88E-04
Xcell 1	3	0	37	14	1.54E-05
Xcell 2	3	0	41	15	1.65E-05
mA Output 1	0	12	87	12	1.32E-05
mA Output 2	0	12	37	0	1.50E-07
Relay Output	93	79	69	80	8.79E-05
Cat Bead	477	167	605	1978	2.17E-03

Echem Toxic	385	385	457	1825	2.01E-03
Echem Oxygen	386	1814	454	407	4.47E-04
Xcell Toxic	417	385	417	1830	2.01E-03
Xcell Oxygen	418	1812	417	402	4.42E-04
Life & Health	1679	155	2654	735	8.08E-04
Diffusion Supervision	1106	866	2017	1453	1.60E-03
XIR Plus	223	66	267	80	8.79E-05

λ_{SD} = Fail Safe Detected * 10^{-9}

λ_{SU}= Fail Safe Undetected * 10^{-9}

λ_{SD} = Fail Dangerous Detected * 10^{-9}

λ_{DU} = Fail Dangerous Undetected * 10^{-9}

Sample Configuration 1:

X5000 Transmitter (Common)

XIR Plus sensor (add mA output 1)

Life & Health sensor (add mA output 2)

Relay boards

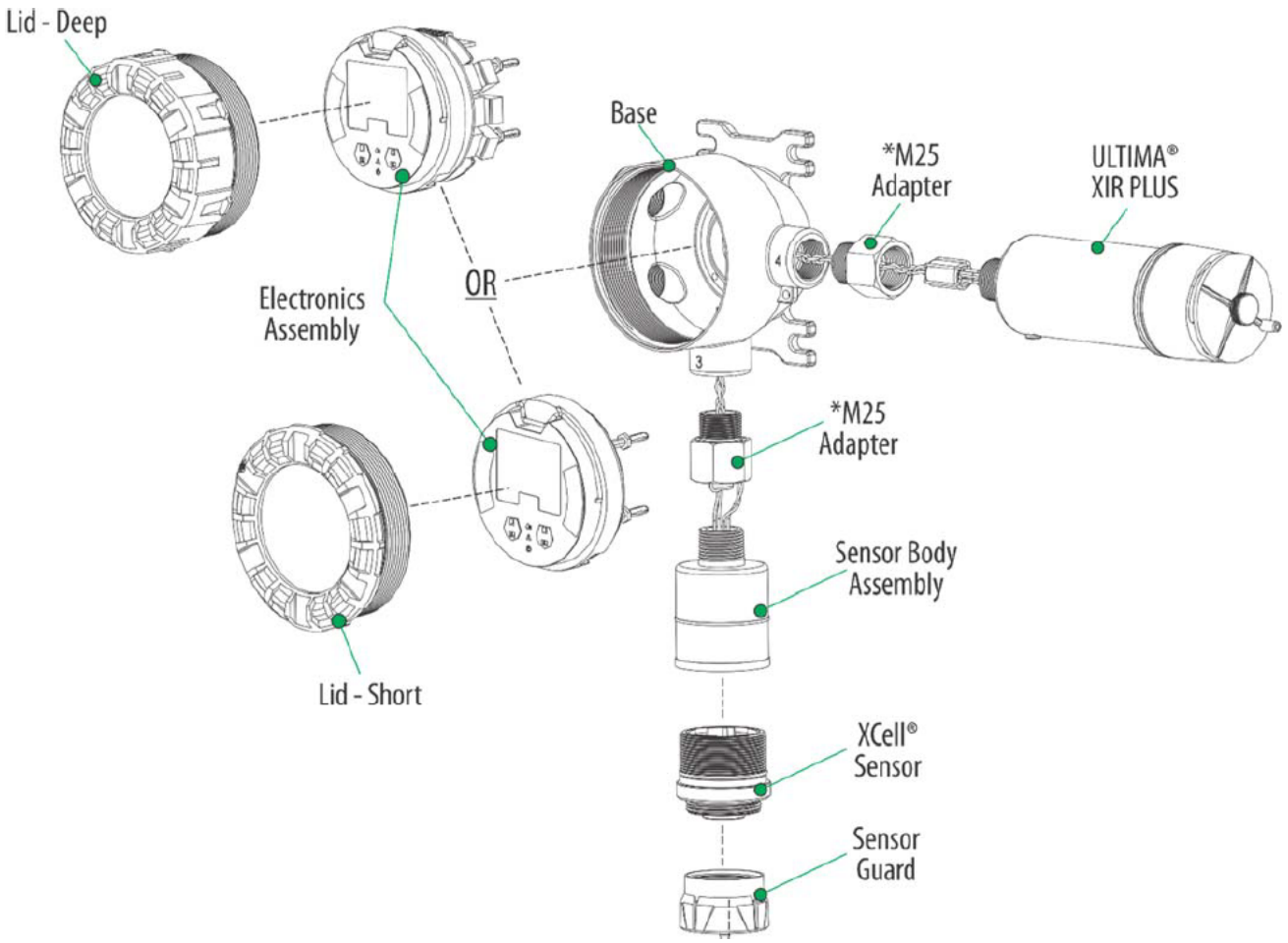
PFD_{avg}= 1.88 * 10^{-4} + 8.79 * 10^{-5} + 1.32 * 10^{-5} + 8.08 * 10^{-4} + 0.0 + 8.79 * 10^{-5} = 1.19 * 10^{-3}

PFD_{avg}Sample 1**= 1.19 * 10^{-3}**

NOTE: Total system calculation is required to determine final PFDavg, these calculations do not account for final elements e.g. safety valves or logic solvers.

5 Unit Identification

5.1 Component Overview

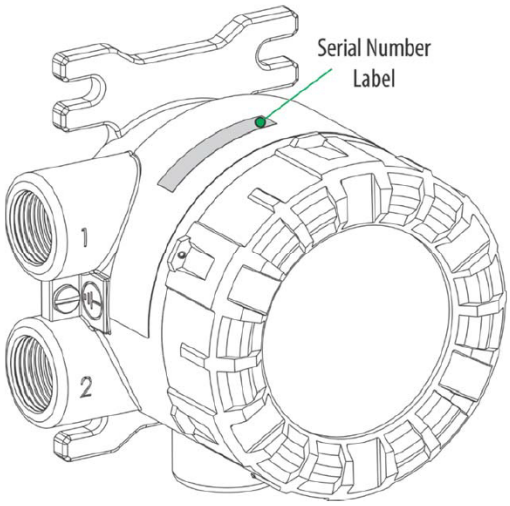


* Only used with M25 bases

5.2 Label Overview

Serial number is located where shown (highlighted in green on label below). Actual number of digits may be different.

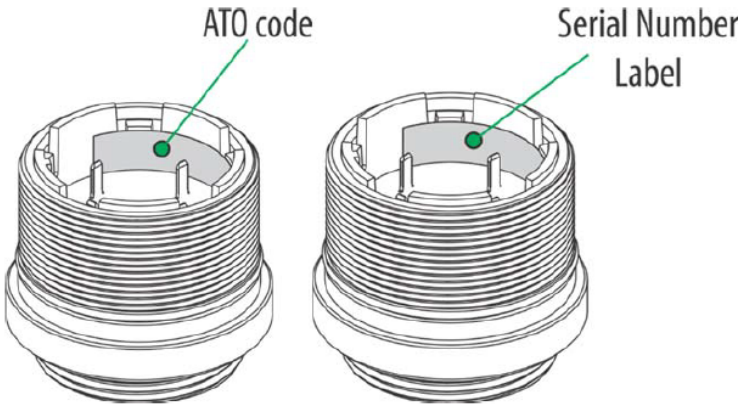
Transmitter - Position of Labels



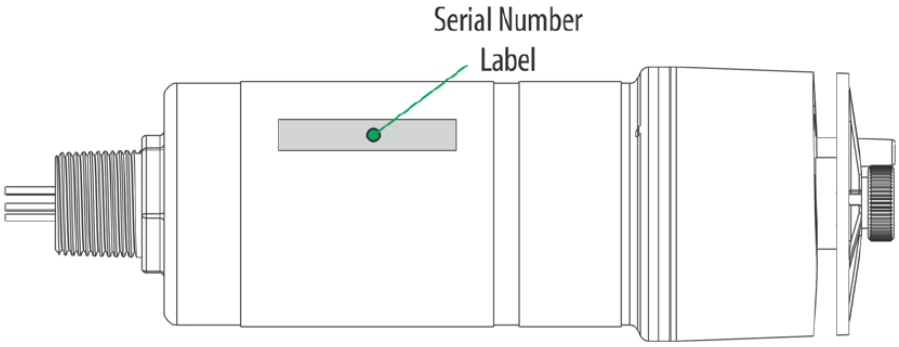
Board Stack - Position of Labels



Digital Sensor - Position of Labels



XIR Plus - Position of Labels



Label

PN: A-X5000-X-X-X-X-X-XX-XX-X
MM/YYYY
SN: 1234567891234

5.3 Software

Software information can be read using the display see user manual 10177361 for additional information.

6 Specifications

The tables below list specifications for the ULTIMA X5000 Gas Monitor. For a complete list of specifications refer to the product instruction manual.

Environmental/Electrical Specifications

	Toxics & Oxygen	Combustible Catalytic	XIR PLUS
Operating temperature range	-40°C to +60°C	-40°C to +60°C	-40°C to +60°C
Storage temperature range	-40°C to +60°C	-40°C to +60°C	-40°C to +60°C
Humidity range	10-95% RH	5-95% RH	5-95% RH
Input voltage min	11 VDC		
Input voltage nominal	24 VDC		
Input voltage max	30 VDC		

Analog Output Default Values

Output Setting (mA)	Custom 1	Custom 2	3.5 mA with HART	1.25 mA with HART
Fault	2.0	2.0	3.5	1.25
Calibration (excl. O_2)	3.0	3.0	3.5	1.25
Calibration – O_2 only	3.0	21.7[3]	3.5	1.25
Ready	4.0	4.0	4.0	4.0
WARN[1] Signal	5.6	5.6	5.6	5.6
ALARM[2] Signal	8.8	8.8	8.8	8.8
Over Range	21.7	21.7	21.7	21.7

[1] Assumes alarm level of 10% full scale.
[2] Assumes alarm level of 30% full scale.
[3] For an O2 sensor, 21.7 mA is the default Custom 2 setting and is not configurable.

7 Safety Function

The ULTIMA X5000 sensor head, utilizes oxygen, combustible and toxic sensors to monitor and alarm to dangerous and explosive atmospheres.

The element safety functions of the ULTIMA X5000 are defined as follows:
To provide the host system with a predefined 4-20 mA alarm signal output and to de-energize a relay (if included) in the event of a dangerous or explosive atmosphere depending on the sensor type configuration.

⚠ WARNING!

The low and high alarm relays must be configured to de-energize to trip for proper SIL function. See the user manual 10177361 for additional information.

Failure to follow this warning can result in serious personal injury or death.

See the Analog Output Default Values table in Section 6 Specifications for 4-20 mA alarm signal details in different operation modes.

The analog output range is 0-22 mA. It is normal operation within minimum to maximum detection range is 4 mA to 20 mA respectively. Refer to Analog Output Default Values table in Section 6 Specifications for more details on specific analog output conditions.

NOTE: It is recommended to use password protection to prevent unauthorized users from changing configurations.

NOTE: The analog indications below 4 mA are configurable by the user in the range (0-3.75 mA). Refer to operating manual for specific configuration details.

Fault Reporting Time (refer to Section 8 Troubleshooting)

Fault	Minimum time	Maximum time
Integrated circuit memory	0.050 seconds	24 hours
Sensor w/o Swap Delay	3 seconds	4 seconds
Sensor w/ Swap Delay	120 seconds	121 seconds
Negative Drift	120 seconds	121 seconds
Life and Health Fault	6 hours	6 hours + 1 second
Other	1 second	8 seconds

When ordered the ULTIMA X5000 comes with three SPDT (single pole double throw) relays which include normally open, common and normally closed contact terminals. Two of the relays correlate to gas reading and can be configured for either de-energized or energized operation and also may be configured as latching or non-latching. The third relay is a dedicated fault relay. The fault relay is configured as normally energized, non-latching. This normally energized default setting is for fail-safe operation and cannot be reconfigured. In the event of a failure, including loss of power, the fault relay will change state to indicate a fault condition.

The safety function of the ULTIMA X5000 Gas Monitor does not include:

- HART Communication
- RS-485 Modbus communication
- Bluetooth communication

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

8 Troubleshooting

The following table lists all fault messages, their priority levels, and corrective actions required to resolve them. The faults are listed in alphabetical order. Lower priority messages are output only after the highest priority message is cleared. In all cases, MSA must be contacted for any failures observed and repairs performed.

NOTE: The lower the priority number in the table below, the higher the priority.

Fault Messages and Resolutions

Priority	Display Message	Status LEDs (G/Y/R)	Description	Resolution
35	“ACT Fault”	ON/ON/OFF	Indicates an out of range measurement.	Replace the sensor.
24	“Beads Off Fault”	ON/ON/OFF	Indicates that the combustible sensors beads are OFF.	Acknowledge or cycle power to the sensor. Let the sensor warmup, then recalibrate the sensor. If this does not resolve the issue, replace the sensor.
23	“Calibration Required”	ON/ON/OFF	Indicates the sensor requires calibration.	Calibrate the sensor(s) attached to the instrument.
25	“Channel Error”	ON/ON/OFF	Indicates that there is an error in the mA output system.	Reset the sensor. Verify sensor configurations (if different from default values). Then recalibrate the sensor. If the issue persists, replace the sensor.

Priority	Display Message	Status LEDs (G/Y/R)	Description	Resolution
7	“Configuration Fault”	ON/ON/OFF	Indicates that an incorrect configuration was detected.	Select Reset Main Unit from Instrument menu. Verify the customer settings. Replace the main PCBA.
4	“EEPROM Fault”	ON/ON/OFF	Indicates there is an error with the EEPROM.	Typically this is a unit with both sensors disabled and no sensor attached. Attach one sensor to the unit.
29	“External Memory Access Error”	ON/ON/OFF	Indicates that an error occurred communicating to the EEPROM.	Select Reset Main Unit from Instrument menu. Verify the customer settings. Replace the main PCBA.
30	“External Memory Checksum Error”	ON/ON/OFF	Indicates the EEPROM memory is not valid.	Select Controller Data Reset from Instrument menu.Verify any custom settings and re calibrate the instrument.
3	“Flash Checksum Fault”	ON/ON/OFF	Indicates there is something incorrect with the main PCBA’s program.	Replace the main PCBA.
8	“General System Error”	ON/ON/OFF	Indicates one of the internal power supplies is out of range.	Adjust the input power supply voltage to within range for the sensor configuration. Replace the main PCBA.
5	“Internal Circuit Fault”	ON/ON/OFF	Indicates a hardware failure on the main PCBA.	Replace the main PCBA.
33	“Lamp Fault”	ON/ON/OFF	Indicates the sensors lamp is not operating properly. (XIR PLUS sensors only)	Replace the sensor.
15	“Life and Health Fault”	ON/ON/OFF	Indicates the sensor is at the end of life.	Recalibrate the sensor to get additional life. If error does not clear after recalibration, replace the sensor.
36	“Low Signal Failure”	ON/ON/OFF	This indicates the sensors output is low.	Clean the optics on the sensor or replace the sensor.
1	“Supply Voltage Fault”	ON/ON/OFF	The input power supply is out of the operating range. It may be too low or too high.	Check the input power supply is within range for the sensor configuration.
17	“Negative Drift”	ON/ON/OFF	This indicates the sensor is reading downscale.	Recalibrate the sensor.
26	“Negative Supply Fault“	ON/ON/OFF	Indicates the negative power supply is out of range.	Check the input power supply. If this is within range, then replace the sensor.
N/A	“Over Range”	ON/ON/OFF	An over scale gas reading is present.	Verify the area is clear of gas first then recalibrate the sensor.
31	“Parameter out of range”	ON/ON/OFF	Indicates that a setting is improperly set in the unit.	Select Controll Data Reset from Instrument menu. Verify any customer settings. Then recalibrate the sensor.
2	“RAM Checksum Fault”	ON/ON/OFF	Indicates a bad RAM memory location was detected.	Replace the main PCBA.
34	“Reference Failure”	ON/ON/OFF	Indicates an out of range measurement.	Replace the sensor.

Priority	Display Message	Status LEDs (G/Y/R)	Description	Resolution
6	“Relay Fault”	ON/ON/OFF	Indicates that a problem with the relays was detected.	Replace the relay options PCBA.
22	“Sensor Configuration Reset”	ON/ON/OFF	Indicates the sensor datasheet was reset.	Calibrate the sensor.
12	“Sensor Element Error”	N/A	Indicates the sensor is broken.	Replace the sensor.
38	“Sensor End of Life Fault”	ON/ON/OFF	Indicates the sensor is at the end of life. (excl. TruCal Sensors)	Recalibrate the sensor/replace the sensor.
27	“Sensor FLASH Error”	ON/ON/OFF	Indicates there is something wrong with the sensors program.	Replace the sensor.
13	“Sensor Heater Fault”	ON/ON/OFF	Indicates the sensors heater is not working properly.	Replace the sensor.
25-40	“Sensor Internal Fault”	ON/ON/OFF	Indicates the detection of a hardware issue in the sensor.	Replace the sensor.
9	“Sensor Missing”	ON/ON/OFF	Indicates the sensor is no longer detected.	Replace the sensor.
28	“Sensor RAM Error”	ON/ON/OFF	Indicates a bad RAM memory location was detected.	Replace the sensor.
10	“Sensor Supply Voltage Fault”	ON/ON/OFF	Indicates the sensors input voltage is out of range.	Check the input power supply voltage and check the wiring to the sensor module for damage. If this does not resolve the issue, replace the sensor.
20	“Span Calibration Fault”	ON/ON/OFF	Indicates the sensor did not pass the Span calibration operation.	Acknowledge the fault by pressing and holding both EZ touch buttons at the same time for up to 5 seconds. The unit will revert to the previous calibration so that the unit can continue to detect gas while troubleshooting fault. Causes for this fault include: (1) Span gas is not applied within the calibration time-out period. (2) The incorrect span gas is applied or the span value is not set correctly in the Sensor Settings. (3) The sensor is at its end of life. Check the span gas concentration and the sensor span value setting to ensure that the correct span gas is being used. Go through the calibration process again after verifying. If fault persists, replace the sensor.
14	“TEDS CRC-16 Error”	ON/ON/OFF	Indicates the sensors datasheet is invalid.	Reset the sensor. Verify the sensor settings (if different from default), then recalibrate the sensor.

Priority	Display Message	Status LEDs (G/Y/R)	Description	Resolution
40	“Unknown Error”	ON/ON/OFF	Indicates that a sensor is returning an unknown error condition.	Replace the sensor or update the main PCBA software.
19	“Zero Calibration Fault”	ON/ON/OFF	Indicates the sensor did not pass the Zero calibration operation.	Acknowledge the fault to revert to the previous calibration. This fault can be caused by (1) A bad sensor (2) The sensor is trying to zero while span gas is being applied. Check the zero gas cylinder is correct and within expiration date. If not using zero gas, ensure that there is not a background concentration of the target gas in the atmosphere. Go through the calibration process again after verifying. If fault persists, replace the sensor
N/A	Full scale value and “LOC” displayed on the lower display areas per each sensor	ON/ON/OFF	Indicates a combustible sensors over range condition was measured.	Acknowledge the sensor, wait for the warmup time period and recalibrate the sensor.
11	Parameter Fault (Sensor)	ON/ON/OFF	Indicates that a setting is improperly set in the unit.	Reset the sensor's datasheets. Verify any customer settings. Then recalibrate the sensor.
N/A	Gas value is still shown	Both side green LEDs blinking	Indicates that calibration is recommended. (TruCal sensors only)	Calibrate the sensors attached to the unit.