Ultima® X Series Gas Monitor

Safety Manual
SIL 2 Certified

The Ultima X Series Gas Monitor is qualified as an SIL 2 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.

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This manual is available on the internet at www.msasafety.com.
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Chapter 1,
Purpose and Scope

Purpose

In order to maintain the designed safety level (SIL 2) for installation and operation of the MSA Ultima X Series Gas Monitors, this safety manual provides the specific requirements of user responsibilities in the following areas:

- proof testing
- transmitter repair and replacement
- reliability data
- product life
- environmental and application limits
- parameter settings.

Scope

This manual applies to the following analog output (4-20 mA) models:

- general-purpose Ultima XA monitor
- explosion-proof Ultima XE monitor
- explosion-proof Ultima XIR monitor.

Chapter 2,
Using the Ultima X Series Gas Monitors

Safety Function

The safety function of the Ultima X Gas Monitor is to:

- monitor gas concentration
- update outputs based on this monitoring.
  - The outputs consist of:
    - an analog output that reflects the gas concentration
    - three alarm relay outputs
    - one fault relay output.
  - The analog output is a scaled 4-20 mA output value where:
    - 4 mA represents 0% of range and
    - 20 mA represents 100% of range.
  - The alarm relay outputs allow for three independent, configurable alarms which energize or de-energize the coil when gas concentration exceeds the configurable threshold values.

Safety Integrity Level

The Ultima X Gas Monitor is certified to meet the requirements of Safety Integrity Level (SIL) 2 according to IEC 61508: 2010 for use in low demand applications only.

- Oxygen, catalytic combustible and IR gases are SIL 2 w/ HFT = 0 (Hardware Fault Tolerance).
- Toxic gases are SIL 2 w/ HFT = 1 and SIL 1 w/ HFT = 0.

Safety Accuracy

The Ultima X Gas Monitor has a safety accuracy of 10%. This means that internal component failures are listed in the device failure rate if these failures cause an error of 10% or greater.

Diagnostic Response Time

The Ultima X Gas Monitor has a diagnostic response time of 24 hours. This means that any detectable hardware failure is detected and reported within 24 hours of fault occurrence. This time is equal to the sum of the diagnostic test interval and the fault response time.

Gas Detection Times

The amount of time it takes to detect the presence of a gas varies based on sensor type.

- Refer to this information in TABLE 3-1 of the Ultima X Series Gas Monitor Instruction Manual (P/N 10036101).

Update Time

The state of the analog output and the relay outputs is updated every second or sooner.

Setup

Installation

For installation, refer to instructions given in chapter 1 of the Ultima X Series Gas Monitor Instruction Manual (P/N 10036101).

Configuration and Calibration

After installing the Ultima X Gas Monitor, a calibration must be done to ensure proper operation. Perform the INITIAL Calibration procedure given in chapter 2 of the Ultima X Series Gas Monitor Instruction Manual (P/N 10036101).

No gas monitor configuration is required for the analog output. However, configuration may be required to use the alarm outputs.

- Alarm relays are factory-enabled as non-latching, de-energized.
- Alarm relays activate when the monitor detects a gas concentration level that exceeds setpoints.
- Factory configuration of alarms 1, 2, and 3 is generally to set the alarms when 10%, 20%, and 30% of full scale reading is exceeded, respectively.

NOTE: these settings are sensor-specific and may vary depending on the sensor installed.

- The following sensor settings may be changed:
  - setpoints
  - direction of the alarm
  - latching or nonlatching
  - enabled or not enabled.
- If necessary, these items can be configured using the HART or the Ultima X Controller. For details on how to make these changes, refer to the Ultima/Ultima X Controller and Calibrator manual (P/N 813379).
- When using HART, ensure safety function is not affected by utilizing password protection or other security measures to prevent unvalidated changes to instrument parameters.
- If alarm outputs will be used for safety-related functions, they must be tested prior to system operation. Once alarm outputs are configured, apply and remove gas to and from the system to ensure that alarms:
  - are set when the thresholds are exceeded
  - latch if configured to do so, or clear if they are not.

Proof Testing

The recommended proof test for the Ultima X Gas Monitor is given in TABLE 2-1. This is a periodic test recommended to help detect the majority of any dangerous, undetected failures. The proof test coverage for this test depends on sensor type. The details may be found in the FMEDA report, which is available upon request.

Perform this test periodically at intervals known as the proof test interval, which must be chosen to meet the probability of failure on demand requirements for SIL 2.

Table 2-1. Proof Test for Ultima X Series Gas Detectors

TEST	EXPECTED OUTCOME
1. Bypass the safety function or take appropriate action to avoid a false trip. Note that calibration output signal must be disabled so the analog output can be measured during the test.	None
2. Perform a zero and span calibration as defined in the regular calibration section of the Ultima X Series Gas Monitor instruction manual. While performing calibration, measure the analog output when the device has zero gas or span gas connected. If alarm relays are used, check relay output	Analog output should read 4mA when zero gas is connected. Analog output should be scaled between 4 mA and 20 mA when span gas is applied. Exact analog output value depends on span gas concentration. (e.g., if span gas concentration is 50% LEL, analog output should be 12 mA Reaction of external relays varies, based on configuration. See TABLE 2-2 for detailed relay reaction based on configuration. Any activated relays should remain activated when gas is removed if they are configured to latch; otherwise,. relays deactivate when gas is removed If calibration is successful, the display shows “END” after the zero and the span calibration steps
3. If using alarm relays, and any alarm relay did not activate in the step 2 because the alarm setpoint was higher than the span gas concentration, the relay should be activated in this test. Change the setpoint for any such alarms to a value just below the span gas concentration. Now apply the span gas as it was done during calibration	Relay should activate when span gas is applied. When span gas is removed, alarm should remain active if it is configured to latch; otherwise, it should become inactive
4. Remove the span gas	When span gas is removed, the alarm should remain active if it is configured to latch; otherwise, it should become inactive
5. Change the setpoint back to the desired value	None
6. Remove the bypass or otherwise reverse the action taken in step 1	None

Table 2-2. Expected Alarm Relay States Gas Type

SETPOINT	ALARM SETTING	ALARM RELAY STATE WITH ZERO GAS APPLIED	ALARM RELAY STATE WITH SPAN GAS APPLIED
Lower than span gas concentration	Above Set-point	Not active	Activated
Lower than span gas concentration	Below Set-point	Activated	Not Active (NOTE: If alarm relays are configured as latching, the alarm must be cleared after the zero gas is removed for this state to be correct)
Higher than span gas concentration	Above Set-point	Not Active	Not Active
Higher than span gas concentration	Below Set-point	Activated	Activated

NOTE: Personnel performing the Ultima X proof test should be trained in SIS operations, including bypass procedures, Ultima X Monitor maintenance and company management of change procedures.

Routine Maintenance

Besides proof testing, the following three maintenance procedures that must be performed on the Ultima X gas monitors.

Periodic Calibration

To ensure accuracy and detect any sensor problems, calibrate the:

- XE and XA monitors a minimum of every three months
- XIR monitor according to the requirements as documented in the Ultima X Series Gas Monitor instruction manual (P/N 10036101).

Calibrate monitors with catalytic combustible sensors when they have been exposed to non-combustible chemicals known to reduce sensor sensitivity (Silanes, Silicates, Silicones and Halides). Use the regular calibration method given in the Ultima X Series Gas Monitor instruction manual (P/N 10036101).

After calibration, read all messages on the LCD display and correct any errors. Change the sensor immediately if the following messages occur:

- "SENSOR WARNING"
- "REPLACE SENSOR".

Refer to the "Limitations Associated with Toxic Gas and Combustible Gas Monitoring" section later in this chapter.

Periodic Sensor Replacement for Oxygen, Toxic, and Catalytic Combustible sensors

These sensors have a limited lifetime and must be replaced periodically to ensure proper operation. Unless historical calibration records show that sensors consistently last longer:

- replace oxygen and toxic sensors once per year
- replace catalytic combustible sensors every 18 months.

Due to environmental conditions, these sensors may require replacement more or less frequently. If supported by calibration records:

- toxic sensors can be replaced as infrequently as every two years
- combustible sensors can be replaced as infrequently as every three years.
    - Do not exceed this replacement schedule.

Immediately replace sensors if the "SENSOR WARNING" or "REPLACE SENSOR" messages occur after calibration.

Cleaning Monitor Windows on the XIR Sensor

NOTE: This does not apply to sensors other than the XIR sensor.

If the monitor windows on this sensor are dirty, the sensor may produce erroneous readings. Whereas diagnostics detect this condition, the user should also perform a periodic visual inspection of the windows. The window is easily inspected after removing the environmental guard. Frequency of required inspection is environmentally dependent.

In typical environments, windows never require cleaning due to the:

- environmental guard protection
- heating elements that prevent water condensation.

However, regular cleaning may be needed under severe conditions. Adjust the inspection rate to match your particular environment. Initially, perform inspections every six months at a minimum. Increase the inspection frequency if:

- the unit requires cleaning at every inspection
- diagnostics report that cleaning is required more frequently than the inspection rate.

Conversely, if the inspections rarely show that cleaning is required, the inspection rate may be decreased. A good practice is to perform inspections at twice the rate that cleaning is historically required. If the windows appear dirty during the inspection, perform the XIR cleaning procedure given in Chapter 4 of the Ultima X Series Gas Monitor instruction manual (P/N 10036101).

NOTE: Personnel performing Ultima X proof test should be trained in SIS operations, including bypass procedures, Ultima X Monitor maintenance and company management of change procedures.

Repair and Replacement

Fault Conditions

The Ultima X has numerous self diagnostics that are run periodically to detect problems in the device. When problems are found:

- messages appear on the LCD display
- depending on the severity of the problem, the analog output may be set to 3.0 mA and the fault relay de-energized.
    - The analog output or fault relay must be connected to equipment that alerts the user that a problem exists or takes action to move the system into a safe state.

When a fault is indicated:

- observe the LCD display for fault details.
- fix faults within the system repair time (the repair time used in probability of failure calculations according to IEC 61508)
    - Actions to correct a fault are given in TABLE 4-3 of the Ultima X Series Gas Monitor instruction manual (P/N 10036101).

NOTE: Personnel performing Ultima X repair or replacement should be trained in SIS operations, including bypass procedures, Ultima X Monitor maintenance and company management of change procedures.

NOTE: Any field failure of the Ultima X Series Gas Monitor should be reported to MSA.

Modification

Any modifications [allowed per the Ultima X Monitor Manual (P/N 10036101)] made to the Ultima X Monitor configuration after the system is commissioned must be validated to ensure they were made properly. Executing the Proof Test procedure given earlier in this chapter may be used for this validation.

Reliability Data

A detailed Failure Mode, Effects, and Diagnostics Analysis (FMEDA) report with all failure rates and failure modes is available from MSA. The Ultima X Gas Monitor is certified for low demand mode applications up to SIL2 for use in a simplex (1oo1) configuration, depending on the PFD_{avg} or PFH calculation of the entire Safety Instrumented Function.

Lifetime Limits

Expected Ultima X lifetime is approximately 10 years.

- Reliability data listed in the FMEDA report is only valid for this period.
- Ultima X failure rates may increase after this period.
- Reliability calculations based on the data listed in the FMEDA report for Ultima X lifetime beyond 10 years may yield results that are too optimistic (i.e., calculated Safety Integrity Level will not be achieved).

Environmental Limits

Ultima X environmental limits are given in TABLE 3-1 of the Ultima X Series Gas Monitor instruction manual (P/N 10036101). If these limits are exceeded, reliability data listed in the FMEDA report are not valid.

Application Limits

Required Output Load

Current output in the 3-wire operation mode is designed for loads between 0 to 500 ohms when operated from power supply voltage greater than 24 V.

Required Compliance Voltage

To ensure proper operation, the transmitter in 2-wire current output operation mode must have access to a minimum of 8 V at the maximum current output level. Available voltage is calculated by subtracting the impact of all sources of voltage drop (such as intrinsic safety barriers and total loop resistance) from the loop voltage.

Use of Wireless IR interface

The wireless IR interface allows the Ultima Controller and Ultima Calibrator to communicate with the monitor. This interface should only be used for configuration, maintenance and proof test activities.

Use of LCD Interface

The LCD interface:

- should only be used for:
  - configuration
  - maintenance and
  - proof test activities
- should not be relied upon as the primary method to monitor the gas concentration.

The analog output or alarm relays must be hard wired to a device that alerts the user to an alarm condition and/or takes action to mitigate the condition and move the system into a safe state.

Limitations Associated with Oxygen Monitoring

Limit the use of the oxygen monitoring capability to situations where detection of oxygen-deficient situations is required.

Limitations Associated with Toxic Gas and Combustible Gas Monitoring

Limit use of combustible gas monitoring using catalytic measurement or

IR technology and toxic gas monitoring to environments where the monitored gas is not expected to be normally present.

- Continuous presence of such gas may shorten sensor life and impedes the negative drift diagnostic.
- If monitored gas is found to be in the environment for an extended period of time, recalibrate the sensor to ensure proper operation.

Chapter 3,
Terms and Definitions

FMEDA
Failure Mode Effect and Diagnostic Analysis

SIF
Safety Instrumented Function

SIL
Safety Integrity Level

SIS (Safety Instrumented System)
Implementation of one or more Safety Instrument Functions composed of any combination of sensor(s), logic solver(s), and final element(s)

SLC
Safety Life Cycle

Safety
Freedom from unacceptable risk of harm

Functional Safety
Systems's ability to perform actions necessary to achieve or maintain a defined safe state for the equipment / machinery / plant / apparatus under control of the system

Basic Safety
Equipment must be designed and manufactured so it protects against risk of damage to persons by electrical shock and against resulting fire and explosion. The protection must be effective under all normal operating conditions and under single fault condition

Verification
Demonstration for each phase of the life-cycle that the (output) deliverables of the phase meet the objectives and requirements specified by the inputs to the phase. The verification is usually executed by analysis and/or testing

Validation
Test that demonstrates safety-related system(s) or combination of safety-related system(s) and external risk reduction facilities meet the Safety Requirements Specification

Safety Assessment
Investigation determining the safety achieved by safety-related systems

Further definitions of terms used for safety techniques and measures