

Operating Manual  
**ULTIMA<sup>®</sup> X-Series**  
Gas Monitors



MSA AUER GmbH  
Thiemannstrasse 1  
D-12059 Berlin

Germany

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## EC Declaration of Conformity

Manufactured by: Mine Safety Appliances Company  
1000 Cranberry Woods Drive  
Cranberry Township, PA 16066 USA

The manufacturer or the European Authorized Representative:  
MSA AUER GmbH, Thiemannstrasse 1, D-12059 Berlin

declares that the **ULTIMA XE Main**  
product **ULTIMA XE Main with HART Module**

based on the EC-Type Examination Certificate: **DMT 02 ATEX E 202 X**  
complies with the ATEX directive 94/9/EC, Annex III. Quality Assurance Notification  
complying with Annex IV of the ATEX Directive 94/9/EC has been issued by  
Ineris of France, Notified Body number: 0080.

The product is in conformance with the EMC directive 2004 / 108/ EC,  
EN 50270 :2006 Type 2 \*, EN 61000 - 6 - 4 : 2007

\* EN 61000-4-6 : Ultima XE MAIN HART MODULE : occasional transmission error can appear at the  
2-wire version. A fault check has to be used at the receiver unit.

The product complies with the directive 96/98 / EC (MarED),  
based on the EC-Type Examination Certificate : **SEE BG 213.038**  
The quality surveillance is under the control of SEE BG, Notified Body number: 0736

We further declare that the product complies with the provisions of  
LVD Directive 2006 / 95/ EC, with the following harmonised standard:  
EN 61010-1 :2002

*Dr. A. Schubert*

MSA AUER GmbH

Dr. Axel Schubert

R&D Instruments

Berlin, October 2008



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product

**ULTIMA SENSOR XE**

based on the EC-Type Examination Certificate: **DMT 02 ATEX E 202 X**  
complies with the ATEX directive 94/9/EC, Annex III. Quality Assurance Notification  
complying with Annex IV of the ATEX Directive 94/9/EC has been issued by  
Ineris of France, Notified Body number: 0080.

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EN 50270:2006 Type 2, EN 61000-6-4:2007

The product complies with the directive 96/98/EC (MarED),  
based on the EC-Type Examination Certificate: **SEE BG 213.038**

The quality surveillance is under the control of SEE BG, Notified Body number: 0736

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MSA AUER GmbH  
Dr. Axel Schubert  
R&D Instruments

Berlin, October 2008



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declares that the  
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### **ULTIMA XE SENSOR OX/TOX**

based on the EC-Type Examination Certificate: **DMT 02 ATEX E 202 X**  
complies with the ATEX directive 94/9/EC, Annex III. Quality Assurance Notification  
complying with Annex IV of the ATEX Directive 94/9/EC has been issued by  
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The manufacturer or the European Authorized Representative:  
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declares that the  
product

### **ULTIMA XIR SENSOR**

in combination with ULTIMA XE MAIN or  
ULTIMA X Junction Box

based on the EC-Type Examination Certificate: **DMT 02 ATEX E 202 X**  
complies with the ATEX directive 94/9/EC, Annex III. Quality Assurance Notification  
complying with Annex IV of the ATEX Directive 94/9/EC has been issued by  
Ineris of France, Notified Body number: 0080.

The product is in conformance with the EMC directive 2004/108/EC,  
EN 50270:2006 Type 2, EN 61000-6-4:2007

The product complies with the directive 96/98/EC (MarED),  
based on the EC-Type Examination Certificate: **SEE BG 213.038**

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1000 Cranberry Woods Drive  
Cranberry Township, PA 16066 USA

The manufacturer or the European Authorized Representative:  
MSA AUER GmbH, Thiemannstrasse 1, D-12059 Berlin

declares that the  
product **ULTIMA XI**

based on the EC-Type Examination Certificate: **DMT 02 ATEX E 202 X**  
complies with the ATEX directive 94/9/EC, Annex III. Quality Assurance Notification  
complying with Annex IV of the ATEX Directive 94/9/EC has been issued by  
Ineris of France, Notified Body number: 0080.

The product is in conformance with the EMC directive 2004/108/EC,  
EN 50270:2006 Type 2, EN 61000-6-3:2007

The product complies with the directive 96/98/ EC (MarED),  
based on the EC-Type Examination Certificate: **SEE BG 213.039**

The quality surveillance is under the control of SEE BG, Notified Body number: 0736

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Dr. Axel Schubert  
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Berlin, October 2008



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1000 Cranberry Woods Drive  
Cranberry Township, PA 16066 USA

The manufacturer or the European Authorized Representative:  
MSA AUER GmbH, Thiemannstrasse 1, D-12059 Berlin

declares that the product **ULTIMA X Junction Box with Sensor type**  
**ULTIMA XE** or  
**ULTIMA XIR** or  
**ULTIMA XE OX/TOX**

based on the EC-Type Examination Certificate: **DMT 02 ATEX E 202 X**

complies with the ATEX directive 94/9/EC, Annex III. Quality Assurance Notification complying with Annex IV of the ATEX Directive 94/9/EC has been issued by Ineris of France, Notified Body number: 0080.

We further declare that the product complies with the EMC directive 2004/108/EC:  
EN 50270:2006 Type 2, EN 61000-6-4:2007

*Dr. A. Schubert*  
MSA AUER GmbH  
Dr. Axel Schubert  
R&D Instruments

Berlin, October 2008





## EC Declaration of Conformity

Manufactured by: Mine Safety Appliances Company  
1000 Cranberry Woods Drive  
Cranberry Township, PA 16066 USA

The manufacturer or the European Authorized Representative:  
MSA AUER GmbH, Thiemannstrasse 1, D-12059 Berlin

declares that the product **ULTIMA XA (24V no relays)**

complies with the EMC directive 2004/108/EC

EN 50270:2006 Type 2, EN 61000-6-4:2007

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Dr. Axel Schubert  
R&D Instruments

Berlin, October 2008



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1000 Cranberry Woods Drive  
Cranberry Township, PA 16066 USA

The manufacturer or the European Authorized Representative:  
MSA AUER GmbH, Thiemannstrasse 1, D-12059 Berlin

declares that the  
product **HART MODULE**

based on the EC-Type Examination Certificate: **DMT 02 ATEX E 202 X**

complies with the ATEX directive 94/9/EC, Annex III. Quality Assurance Notification complying with Annex IV of the ATEX Directive 94/9/EC has been issued by Ineris of France, Notified Body number: 0080.

We further declare that the product complies with the EMC directive 2004/108/EC:  
EN 50270:2006 Type 2, EN 61000-6-4:2007

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MSA AUER GmbH  
Dr. Axel Schubert  
R&D Instruments

Berlin, October 2008

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# 1 Safety Regulations

## 1.1 Correct Use

The ULTIMA X<sup>®</sup> Series Gas Monitors are fixed Gas Monitors for measuring toxic and combustible gases as well as oxygen. They are suitable for outdoor and indoor applications without limitations, e.g. offshore industry, chemical and petrochemical industry, water and sewage industry. Using sensors, the instruments test the ambient air and trigger the alarm as soon as the gas exceeds a specific concentration level.

It is imperative that this operating manual be read and observed when using the product. In particular, the safety instructions, as well as the information for the use and operation of the product, must be carefully read and observed. Furthermore, the national regulations applicable in the user's country must be taken into account for a safe use.



### **Danger!**

This product is supporting life and health. Inappropriate use, maintenance or servicing may affect the function of the device and thereby seriously compromise the user's life.

Before use the product operability must be verified. The product must not be used if the function test is unsuccessful, it is damaged, a competent servicing/maintenance has not been made, genuine MSA spare parts have not been used.

Alternative use, or use outside this specification will be considered as non-compliance. This also applies especially to unauthorised alterations to the product and to commissioning work that has not been carried out by MSA or authorised persons.

## 1.2 Liability Information

MSA accepts no liability in cases where the product has been used inappropriately or not as intended. The selection and use of the product are the exclusive responsibility of the individual operator.

Product liability claims, warranties also as guarantees made by MSA with respect to the product are voided, if it is not used, serviced or maintained in accordance with the instructions in this manual.

### 1.3 Safety and Precautionary Measures to be Adopted

**Attention!**

The following safety instructions must be observed implicitly. Only in this way can the safety and health of the individual operators, and the correct functioning of the instrument, be guaranteed.

- The ULTIMA X<sup>®</sup> Series Gas Monitors described in this manual must be installed, operated and maintained in strict accordance with their labels, cautions, instructions, and within the limitations stated.
- The ULTIMA X<sup>®</sup> Series Gas Monitor is designed to detect gases or vapours in air. The concentration of gases or vapours in steam or inerted and oxygen-deficient atmospheres cannot be measured with this instrument. For oxygen deficiency measurements, use the oxygen sensor.
- For oxygen deficiency or enrichment measurements use the 0-25 % oxygen sensor for oxygen measurement during inerting use the 0-10 % oxygen sensor.
- The ULTIMA XIR Infrared Combustible Gas Monitor detects the presence of most combustible gases by measuring the infrared light absorbed during the presence of these gases. This monitor however, does NOT detect the presence of hydrogen gas and must never be used to monitor for hydrogen gas.
- The ULTIMA XIR Combustible Gas Monitor does not detect the presence of acetylene gas and the presence of acetylene gas will degrade the sensor performance.
- Protect the ULTIMA X<sup>®</sup> Series Gas Monitor from extreme vibration. Do not mount the sensing head in direct sunlight as this may cause overheating of the sensor.
- Electrochemical sensors are sealed units which contain a corrosive electrolyte. Should a sensor develop leakage, it must be immediately removed from service and disposed of properly. Caution must be exercised so that the electrolyte does not contact skin, clothing or circuitry otherwise personal injury [burns] and/or equipment damage may result.
- The only absolute method to ensure proper overall Operation of an ULTIMA X<sup>®</sup> Series Monitor is to check it with a known concentration of the gas for which it has been calibrated. Consequently, calibration checks must be included as part of the routine inspection of the System. When calibration gas is applied via the gas inlet of a SensorGard, a calibration cap shall be used for prevention against influence of the surrounding atmosphere.




- As with all Gas Monitors of these types, high levels of, or long exposure to, certain compounds in the tested atmosphere could contaminate the sensor. In atmospheres where the ULTIMA X<sup>®</sup> Series Gas Monitor may be exposed to such materials, calibration must be performed frequently to ensure that the operation is dependable and display indications are accurate.
- The ULTIMA X<sup>®</sup> Series Gas Monitor must not be painted. If painting is done in an area where a monitor is located, care must be exercised to ensure that paint is not deposited on the sintered metal flashback arrestor in the gas sensor inlet, if so equipped. Such paint deposits would interfere with the gas diffusion process.
- Use only genuine MSA replacement parts when performing any maintenance procedures provided in this manual. Failure to do so may seriously impair instrument performance. Repair or alteration of the ULTIMA X<sup>®</sup> Gas Monitor, beyond the scope of these maintenance instructions or by anyone other than an authorised MSA service personnel, could cause the product to fail to perform as designed.
- The ULTIMA X<sup>®</sup> Series is designed for applications in hazardous areas under atmospheric conditions.
- For correct measurements, the ULTIMA XE and XA combustible gas sensors require an oxygen concentration greater than 10 Vol%. Oxygen enriched atmospheres, greater than 21 Vol%, can affect the measurement and the electrical safety of the Gas Monitor.
- ULTIMA XE and XA combustible: When the ULTIMA XE and XA monitor the surrounding atmosphere, the measuring gas reaches the sensors by diffusion. In this case the measuring values are smaller than the measuring values if the same gas concentration is applied via SensorGard during calibration. If the air speed during monitoring the surrounding atmosphere is higher than 1m/s the deviations of the measuring values are within the limits stated by EN 60079-29-1:2007.
- ULTIMA XE and XA combustible: The difference of air pressure between operation and calibration shall not be greater than 10 kPa.
- The response time of the ULTIMA XIR will be increased by significant dust deposits on the XIR SensorGard. Checks for dust deposits must be done at regular intervals.
- If a relay version of the ULTIMA X<sup>®</sup> Series Gas Monitor is used, the highest alarm used shall be set for latching.

- Catalytic combustible gas sensors may produce low or zero response to combustible gas after exposure to substances as Silicon, Silane, Silicate, Halide and compounds containing Fluorine, Chlorine, Iodine or Bromine.
- ATEX applications
  - ▷ HART shall only be used for ULTIMA configuration, calibration or diagnostics. For safety relevant applications, the 4-20 mA analogue output shall be used for measuring values.
  - ▷ The Alert option shall be set to "ON"

## 2 Description

### 2.1 Marking, Certificates and Approvals according to the Directive 94/9/EC [ ATEX ]

#### HART Module

Manufacturer:	Mine Safety Appliances Company 1000 Cranberry Woods Drive Cranberry Township, PA 16066 USA
Product:	<b>HART Module</b>
Type of protection:	EN 60079-0:2006, EN 60079-1:2004, EN 60079-11:2007
Performance:	only in combination with ULTIMA XE MAIN
Marking:	HART MODULE  II 2G Ex d [ib] IIC T5 $-40^{\circ}\text{C} \leq T_a \leq +60^{\circ}\text{C}$ $U_o = 6,14 \text{ V}$ , $I_o = 170 \text{ mA}$ , $C_o = 34 \text{ uF}$ , $L_o = 1,3 \text{ mH}$ $P_o = 260 \text{ mW}$ , $U_m = 250 \text{ VAC}$
EC-Type Examination Certificate:	DMT 02 ATEX E 202 X
Quality Assurance Notification:	0080
Year of Manufacture:	see Serial Number
Serial Nr.:	see Label

**EMC Conformance according to the Directive 2004/108/EC**  
 EN 50270:2006 Type 2, EN 61000-6-4:2007

**ULTIMA XE Main**

Manufacturer: Mine Safety Appliances Company  
1000 Cranberry Woods Drive  
Cranberry Township, PA 16066 USA

Product: ULTIMA XE Main with:  
ULTIMA XE SENSOR ,ULTIMA XIR SENSOR  
ULTIMA XE SENSOR OX/TOX  
ULTIMA XE SENSOR OX/TOX ia

ULTIMA XE Main with HART Module and with:  
ULTIMA XE SENSOR ,ULTIMA XIR SENSOR  
ULTIMA XE SENSOR OX/TOX

Type of protection: EN 60079-29-1:2007, EN 60079-11:2007

Performance: EN 60079-29-1:2007, EN 50104:2002 , EN 50271:2001  
Int.Relais +LEDs , UB=19 V-30 V, Ia= 4-20 mA, 3-Wire

Gas Oxygen: 0 -10 Vol %  
0 - 25 Vol % PFG-Nr: 41301103

Gas: Measure range : 0-100% LEL

ULTIMA XE: Methane, Propane,2-Butanone, Acetone, Acetylene, 1,3-Butadiene, Diethyl ether, Ethane, Ethanol, Ethylene, Ethyl acetat, Ethylene oxide, (FAM-) Standard mineral spirit 65/95, n-Butane, n-Hexane, n-Pentane, 2-Propanol, Propene, Propylene oxide, Hydrogen, Cyclo pentane, Allyl alcohol, i-Butene, i-Butane, Methanol, Cyclohexane.

ULTIMA X IR: Methane, Propane,2-Butanone, Acetone, 1,3-Butadiene, Diethyl ether, Ethane, Ethanol, Ethyl acetat, Ethylene oxide, (FAM-) Standard mineral spirit 65/95, i-Butyl acetate, n-Butyl acetate, n-Butane, n-Hexane, n-Nonane, n-Pentane, 2-Propanol, Propene, Propylene oxide, Toluene, Xylene, Cyclo pentane, Allyl alcohol, i-Butene, i-Butane, Methanol.

Marking:

**ULTIMA XE MAIN**

II 2G Ex d IIC T5

-40°C ≤ Ta ≤ +60°C

if equipped with HART MODULE and XP port

II 2G Ex d [ib] IIC T5

Uo = 6,14 V , Io = 170 mA , Co = 34 uF , Lo = 1,3 mH

Po = 260 mW , Um = 250 VAC

**assembled with the following components:****ULTIMA XE**

II 2G Ex d IIC T4

-40°C ≤ Ta ≤ +60°C

**ULTIMA X IR**

III 2G Ex d IIC T5

-40°C ≤ Ta ≤ +60°C

only mounted with XE MAIN

**ULTIMA XE Ox/Tox ia**

II 2G Ex ia IIC T4

-40°C ≤ Ta ≤ +60°C

only together with the ia barrier

Special conditions for safe use:

Some of the flameproof joints have widths that are bigger and gaps that are smaller than the values required in table 2 of IEC 60079-1. In case of repair or exchange of parts forming these flameproof parts the widths and the gaps of these joints have to comply with the values of commercial specification no. 10000012327 signed 04.05.2005 and drawing no. 10000017784 signed 04.05.2005.

EC-Type Examination Certificate: DMT 02 ATEX E 202 X

Quality Assurance Notification: 0080

Year of Manufacture: see Serial Number

Serial Nr.: see Label

**EMC Conformance according to the Directive 2004 / 108 / EC**

EN 50270:2006 Type 2, EN 61000-6-4:2007

EN 61000-4-6 : Ultima XE MAIN HART MODULE : occasional transmission error can appear at the 2-wire version. A fault check has to be used at the receiver unit.

**MarED Conformance according to the Directive 96/98 EC**

SEE BG 213.038, Notified Body number: 0736

**LVD Conformance according to the Directive 2006/95/EC**

DIN EN 61010-1:2002-08

**ULTIMA XI**

Manufacturer: Mine Safety Appliances Company  
1000 Cranberry Woods Drive  
Cranberry Township, PA 16066 USA

Product: MSA ULTIMA XI

Type of protection: EN 60079-0:2006, EN 60079-1:2004

Performance: EN 60079-29-1:2007, EN 50271:2001

Gas: Measure range : 0-100% LEL

ULTIMA XE: Methane, Propane, 2-Butanone, Acetone, 1,3-Butadiene, Diethyl ether, Ethane, Ethanol, Ethyl acetat, Ethylene oxide, (FAM-) Standard mineral spirit 65/95, i-Butyl acetate, n-Butyl acetate, n-Butane, n-Hexane, n-Nonane, n-Pentane, 2-Propanol, Propene, Propylene oxide, Toluene, Xylene, Cyclo pentane, Allyl alcohol, i-Butene, i-Butane, Methanol

Marking: **ULTIMA XI**



II 2G Ex d IIC T5

$-40^{\circ}\text{C} \leq T_a \leq +60^{\circ}\text{C}$

$U_m = 30 \text{ V DC}$  ,  $P_{\text{nom}} = 4,2 \text{ W}$

EC-Type Examination Certificate: DMT 02 ATEX E 202 X

Special conditions for safe use connected only to a connection box without any other electronic components inside of the enclosure:

**ULTIMA XI equipped with a tapered NPT thread for use with an flameproof enclosure „d“ , which is certified for these use:**

In case of mounting the gas monitor to an enclosure of protection type flameproof enclosure „d“ the reference pressure of the separate enclosure for the connection must not exceed 20 bar. The test of the mechanical strength of the separate enclosure for the connection and the test of the connecting thread with respect to explosion hazards must be ensured within the framework of the type test of the electrical apparatus, that is attached to the gas monitor ULTIMA XI. The threaded hole to which the gas monitor is attached to must meet the requirements of section 5.3 (Table 3/4) DIN EN 60079-1.

**ULTIMA XI equipped with a metric thread for use with an increased safety enclosure „e“, which is certified for these use:**

In case of mounting the gas monitor to enclosures in type of protection increased safety "e" the mechanical resistance and the IP protection of the mounted enclosure has to be ensured by the type test of the electrical apparatus being mounted to the gas monitor. After mounting of the gas monitor onto an enclosure in type of protection increased safety "e" the clearances and creepage distances must meet the requirements of 4.3 (Table 1) of EN 60079-3. The non-sheathed cables of the gas monitor must be routed and connected so as to be mechanically protected and corresponding to the temperature resistance of the cables as per 4.2, 4.5.1 and 4.8 of EN 60079-3.

The gas monitor ULTIMA XI must be screwed into the housing wall such that it is secured against self-loosening. The specified minimum thread depth of the add-on housing has to be observed.

The gas monitor ULTIMA XI must be included into the earthing and equipotential bonding of the complete unit including the enclosure for connecting.

Quality Assurance Notification: 0080

Year of Manufacture: see Serial Number

Serial Nr.: see Label

**EMC Conformance according to the Directive 2004/108/EC**  
EN 50270:2006 Type 2, EN 61000-6-3:2007

**MarED Conformance according to the Directive 96/98 EC**  
SEE BG 213.039, Notified Body number: 0736

**ULTIMA X Junction Box**





Manufacturer: Mine Safety Appliances Company  
1000 Cranberry Woods Drive  
Cranberry Township, PA 16066 USA

Product: ULTIMA X JUNCTION BOX with sensor type:  
ULTIMA XE SENSOR or  
ULTIMA XIR SENSOR or  
ULTIMA XE SENSOR OX/TOX

Type of protection: EN 60079-0: 2006, EN 60079-1: 2004

Performance: only in combination with ULTIMA XE MAIN

Marking:

	<b>ULTIMA X JUNCTION BOX</b>	
	II 2G Ex d IIC T5 -40°C ≤ Ta ≤ +60°C	
	<b>ULTIMA XE</b>	<b>ULTIMA X IR</b>
	II 2G Ex d IIC T4 -40°C ≤ Ta ≤ +60°C	 III 2G Ex d IIC T5 -40°C ≤ Ta ≤ +60°C
	<b>ULTIMA XE Ox/Tox</b>	
	II 2G Ex d IIC T4 -40°C ≤ Ta ≤ +60°C	

EC-Type Examination Certificate: DMT 02 ATEX E 202 X

Quality Assurance Notification: 0080

Year of Manufacture: see Serial Number

Serial Nr.: see Label

**EMC Conformance according to the Directive 2004/108/EC**  
EN 50270:2006 Type 2, EN 61000-6-4:2007



## 2.2 Overview

The ULTIMA X<sup>®</sup> Series instruments are housed in a flameproof enclosure and are calibrated at the factory ready for installation.

The instrument components vary somewhat depending on the particular model.

All models are provided with ¾" NPT or M25 x 1.5 cable entries.

The following instrument types are available:

### ULTIMA XE

Gas monitor with electronic display in a 316 stainless steel flameproof enclosure [→ Fig. 1]. For combustible gases a catalytic sensor is used and for toxic gases and oxygen an electrochemical sensor is used. The ULTIMA XE can be ordered with the standard 4 to 20mA analogue output or with an optional HART [Highway Addressable Remote Transducer] protocol, which is superimposed on the 4 to 20 mA signal.

### ULTIMA XA

Gas monitor with electronic display in a rugged plastic general purpose enclosure. The ULTIMA XA can be ordered with the standard 4 to 20mA analogue output or with an optional HART [Highway Addressable Remote Transducer] protocol, which is superimposed on the 4 to 20mA signal.

### ULTIMA XIR

Gas monitor with electronic display in a 316 stainless steel flameproof enclosure, based on infrared absorption technology [→ Fig. 2]

### ULTIMA XI

Gas monitor without display unit in a flameproof enclosure made of stainless steel, based on infrared absorption technology. The sensors generate an output signal which is transmitted directly or via a connection box to an appropriate control unit [→ separate Operating Manual for ULTIMA XI].

### ULTIMA<sup>®</sup> X3 TM

Gas monitor with electronic display in a flameproof enclosure made of stainless steel. There are three connection options for microprocessorcontrolled gas sensors and transmitters [→ separate Operating Manual for ULTIMA<sup>®</sup> X3<sup>TM</sup> Addendum].

All models in the ULTIMA® X Series can be equipped with remote sensors  
[→ Fig. 3].

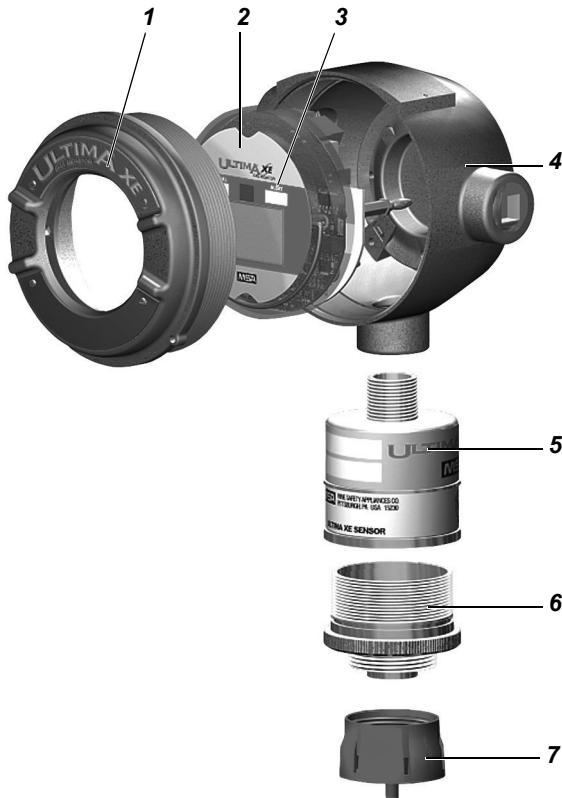


Fig. 1 ULTIMA – Gas monitor [ULTIMA XE shown here]

- 1 Enclosure with viewing window
- 2 Sensor electronics with optional LEDs and display
- 3 Display
- 4 Flameproof enclosure
- 5 Sensor housing
- 6 Sensor module
- 7 SensorGard



Fig. 2 ULTIMA – XIR Gas monitor



Fig. 3 ULTIMA – Remote sensor module reactive gas



Fig. 4 ULTIMA – Remote sensor module non reactive gas



Fig. 5 ULTIMA XA

### 3 Installation

The ULTIMA X<sup>®</sup> Series of Gas Monitors should be installed where gas leaks are expected. The installation is carried out depending on the gas density either in the upper area of the room under the ceiling or lower down close to the ground. The display on the front of the instrument must always be clearly visible, the view must not be obstructed.



Before beginning the installation, with the help of the shipping documents and the sticker on the shipment carton, check that the delivered components are complete and correct.

---

#### 3.1 Instructions for Installation

- ULTIMA XE and XA type instruments must be installed with the sensor inlet pointing downwards to avoid clogging of the gas inlet by particles or liquids.
- ULTIMA XIR type instruments must be installed with the sensor inlet fitting extending horizontally from main enclosure [→ Fig. 2]. This helps prevent the build-up of particulate or liquid on the optical surfaces of the sensor.
- Instruments from the ULTIMA X<sup>®</sup> Series must not be painted. When painting, always make sure that no paint falls on the sensor inlet fitting. Paint deposits can prevent the gas diffusion process where gas from the atmosphere diffuses into the sensor. In addition, any solvents in the paint may activate the alarm.
- Instruments from the ULTIMA X<sup>®</sup> Series must be protected from external vibrations and direct sunlight.



For details of the instrument cabling and the electrical connection refer the installation drawings in addition to this manual [→ Chapter 9].

---

### 3.2 Installation with ULTIMA® X Series Mounting Kit

Instruments from the ULTIMA X® Series are installed at the place of installation on a mounting plate.

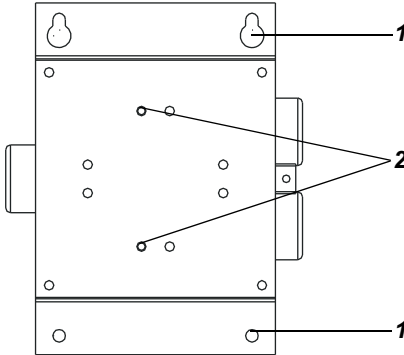


Fig. 6 Mounting plate for ULTIMA XE and XIR

- 1 Wall mounting fixing holes
- 2 Instrument fixing holes



Use M6 x 20 mm screws and suitable plugs for attaching the mounting plate to the wall.

M6 x 20 screws will also be required for fixing the mounting plate to the ULTIMA X Series enclosure.



When preparing the assembly, make sure that the mounting arrangement is correct for the particular device.

Mount the instrument as follows:

- (1) Using the mounting plate as a template, mark the holes for the four fixing screws.
- (2) Drill four holes of appropriate diameter.
- (3) Attach mounting plate to the Gas Monitor enclosure with M6 x 20 screws.
- (4) Attach Gas Monitor with mounting plate, using four M6 x 20 screws, at the place of installation.



During the assembly, the ULTIMA XE Gas Monitor enclosure can be rotated 360°, to ensure easy access to any of the four cable entries. For correct positioning of the display, the electronics assembly can be installed in any of the four self-aligning positions.

### 3.3 Installing the ULTIMA XA Gas Monitor

- (1) Remove lid and drill enclosure for power, signal and optional relay cable entry.

Use one of the following methods to mount the general purpose ULTIMA XA Gas Monitor/Less Sensor or the ULTIMA XA Gas Monitor:

- (2) Use mounting holes in the corners of the ULTIMA XA enclosure to mount directly to a wall.

The ULTIMA XA gas sensor is not shipped attached to the main enclosure.

- (3) Ensure the sensor wiring harness is through the entry and the sensor is pointed downward.

### 3.4 Electrical Connection for the ULTIMA® X Series Instruments



#### **Attention!**

ULTIMA® X Series instruments must be installed only in compliance with the applicable regulations, otherwise the safe operation of the instrument is not guaranteed.

During installation, use the internal earth connection to ground the instruments.

If an external earth connection is permitted or demanded by the local authorities, it serves merely as additional earthing.

**Instructions for electrical connection**

- Twisted cable pair of a quality suitable for measuring instruments is recommended. Use shielded cable if there are any electromagnetic or other sources of interference [such as motors, welding appliances, heating appliances, etc.].
- Always observe maximum cable lengths and cross-section [→ Chapter 9.14 and 9.15].
- Water or impurities can penetrate the instrument through the cable. In hazardous areas, it is recommended to install the cable in a loop just before entry into the instrument or to slightly bend it to prevent water from entering.
- Details on the correct input voltage are given under power supply in the "Various technical data" table in chapter 7.

The connections for the power supply, earthing and signal output are marked on the back of the Gas Monitor electronics assembly.

2-wire cable is suitable for:

- Models for detecting toxic gases with 4-20-mA output  
Models for detecting oxygen with 4-20-mA output

3-wire cable is required for all:

- Models for detecting combustible gases  
Models for detecting toxic gases and oxygen with 4-20-mA output, which must be operated with additional functions [relay etc.].

Instruments from the ULTIMA X<sup>®</sup> Series are installed at the place of installation on a mounting plate.



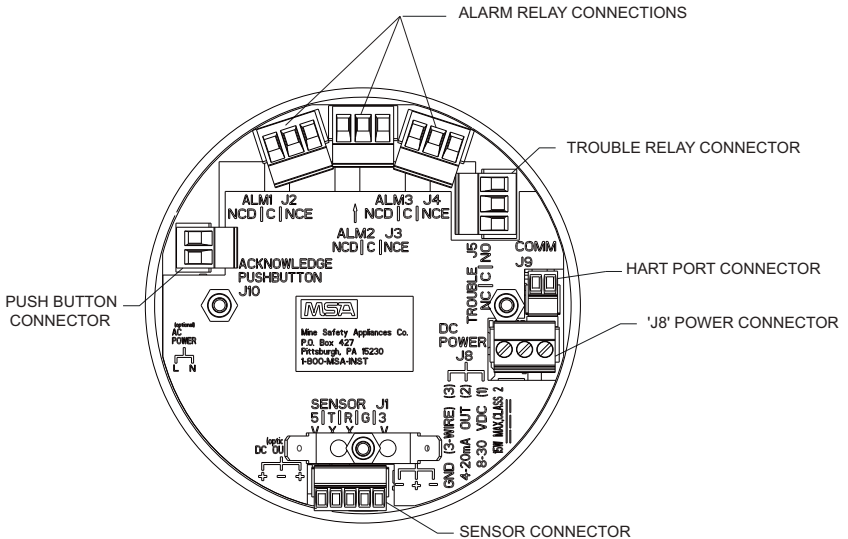


Fig. 7 Connections on the instrument board

This shows all possible ULTIMA XE connections, three wire with 4-20 mA output and HART Protocol.



If using the HART signal terminate the 4-20 mA line with 230 to 500 Ohms

ULTIMA X<sup>®</sup> Series Gas Monitors can be connected to all control units that process 4-20 mA analogue signals [such as SUPREMA, 9010/9020, DCS etc.]

The power supply requirements are given in chapter 7. In addition, refer to:

- installation drawings [→ Chapter 9.1 to 9.5]
- cable lengths and cross-sections [→ Chapter 9.14 and 9.15]
- connection drawings for controllers [→ Chapter 9.10 to 9.14]



### Attention!

When using any of the ULTIMA X<sup>®</sup> Series options [such as relays] with 4-20 mA output signal, a 3-wire connection must be used. Failure to use a 3-wire connection could damage the electronics in the ULTIMA X<sup>®</sup> Series Gas Monitor.

## Connecting the Cable in a Typical Gas Monitor from the ULTIMA® X Series



The following procedure applies for 2-wire 4-20 mA Gas Monitors with control circuit and 3-wire Gas Monitors with separate power supply. Refer to ULTIMA® X Series addendum "Gas Monitors with X3 Technology" for ULTIMA® X3™ connection details.



Fig. 8 PCB

### 1 PCB Identification

- (1) Unscrew instrument enclosure and remove instrument electronics assembly.
- (2) Read the label on the side of the instrument electronics assembly.
  - A-ULTX-PCB-E-1 is a two-wire unit, 4-20 mA output
  - A-ULTX-PCB-E-2 is a two-wire unit with HART protocol on the 4-20 mA output
  - A-ULTX-PCB-E-3 is a three-wire unit, 4-20 mA output
  - A-ULTX-PCB-E-4 is a three-wire unit with HART protocol on the 4-20 mA output.
- (3) Connect +24 V DC to contact 1 of the J8 plug.
- (4) Connect 4-20-mA input of remote system to contact 2 of J8 plug.



If using the HART signal terminate the 4-20 mA line with 230 to 500 Ohms

- (5) For 3-wire instruments, connect the instrument earth [signal earth] to contact 3 of the J8 plug [contact 3 is not used in 2-wire instruments].

- (6) Connect sensor module cable to J1 plug.
- (7) If necessary, connect cable for optional relay and/or the RESET button [→ Chapter 12].
- (8) Insert instrument electronics assembly into enclosure.
- (9) Screw cover onto enclosure.

### 3.5 ULTIMA® X Series Remote Sensor Module Installation



#### Attention!

The ULTIMA X® Series remote sensor module must be installed only in compliance with the applicable regulations, otherwise safe operation of the instrument is not guaranteed.

Disconnect the power source to the ULTIMA X monitor before connecting the cable.

The remote sensor module is used in conjunction with the ULTIMA X® Series without sensor. It can be installed similarly to the Gas Monitor bearing in mind the maximum separation distance [→ Chapter 9.15].

- (1) Permanently attach a tube with an inner diameter of 6 mm to the SensorGard.
- (2) Route the tube to the ULTIMA X Gas Monitor ensuring there are no kinks, leaks or obstructions.
- (3) Secure the tube close to the monitor; it is used to deliver calibration gas to the sensor.



Some installations require metal pipe or metallic conduit. In these cases, separate conductors or unshielded cable may be used.

In the case of unprotected wiring, screened conductors or cables must be used to minimise the possibility of electrical interference or contact with other voltages.

The screened cable used must comply with applicable regulations.

The following are required for assembling the remote sensors:

- 5 conductors for instruments from the ULTIMA X® Series
- 4 conductors for instruments of the ULTIMA XIR type.

ULTIMA X® Series instruments contain a terminal strip for 5 conductors of up to 2.5 mm<sup>2</sup> cross-section.

- (4) Remove cover from the remote sensor module.

- (5) For ULTIMA X<sup>®</sup> Series [XE or XIR] instruments, feed the cable from the Gas Monitor through the wire entry provided in the remote housing and connect to the terminal strip.
- (6) Attach remote sensor module cover.



Incoming power and signal cable shield should be connected to earth ground at the power source. Connect power and remote sensor cable shields to the main printed circuit board shield terminals.

Connect the shield inside the sensor housing according to the installation drawings for remote sensors [installation drawings → Chapter 9.1 to 9.10].

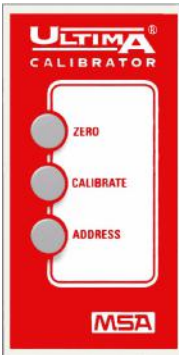
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## 4 Operation

### 4.1 Hand-held Controller and Calibrator

The intrinsically safe ULTIMA/ULTIMA X Controller and Calibrator can be used to calibrate and change or view the configuration of ULTIMA X<sup>®</sup> Series Gas Monitors.

#### ULTIMA/ULTIMA X Calibrator



A simple to use three button device with a non-invasive IR interface to the ULTIMA X<sup>®</sup> Series Gas Monitors to perform the following functions:

- Zero
- Calibration [zero and span]
- Address change [for specific models]

[→ ULTIMA/ULTIMA X Series Controller and Calibrator Operating Manual].

#### ULTIMA/ULTIMA X Controller



The ULTIMA/ULTIMA X Series Controller with a non-invasive IR interface provides all the functions of the Calibrator plus access to the following features:

- Three alarm levels and relays
- Date of last successful calibration
- Change the factory-set test gas value
- Change the upper measuring range limit
- Display of minimum, maximum and average gas concentration

[→ ULTIMA/ULTIMA X Series Controller and Calibrator Operating Manual].



All firmware versions of the Calibrator will work with the ULTIMA<sup>®</sup> X<sup>3</sup> TM Gas Monitors but the Controller must have firmware version 3.03 or later.

## 4.2 HART Compatible Communications Interface

The hand-held HART Communicator, such as the Emerson 375 Field Communicator, must be HART revision 7 compliant and can be obtained from a HART-authorized supplier. See chapter 13 for command definitions.

## 4.3 Commissioning

ULTIMA X<sup>®</sup> Series instruments are calibrated at the factory and are immediately ready for use.

After power is applied to the instrument, the LCD shows a test of all display words.

The software version is then displayed, followed by a 30 second countdown for sensor stability. During this time, the output signal corresponds to the calibration output signal (3.75mA for combustible or toxic, 21mA for oxygen).

[more information → chapter 5, "Calibration Output Signal in ULTIMA<sup>®</sup> X Series Gas Monitors"]. See 10.1 "Instrument Operation for Fault Relay behaviour during power-up".

For instruments with LEDs, the red alarm LED is ON steady during the 30 second countdown.

After 30 second countdown, check whether the gas type and gas concentration [ppm, % gas or % LEL] are displayed alternately.

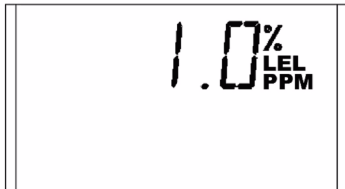


Fig. 9 Display of gas concentration

For instruments with LEDs, the green normal LED is ON steady after completing the 30 second countdown. For more information, see "List of instrument functions" in chapter 10.1.

During normal operation, the ULTIMA X monitor displays the gas concentration of the area surrounding the sensor. The corresponding output signal can be transmitted to a controller or read directly from the optional HART port with an HCF (HART Communications Foundation) approved communicator.



The ULTIMA X<sup>®</sup> Series catalytic model for detecting combustible gases can detect certain combustible gases in concentrations above 100 % LEL. When exposed to these concentrations the ULTIMA X<sup>®</sup> Series Gas Monitors will display one of the following two modes.

In this case, the ULTIMA X Series Gas Monitor switches to one of the following operating modes:

- +LOC % LEL:** The ULTIMA X<sup>®</sup> Series Gas Monitor has been exposed to a high gas concentration [above the LEL], and there is a possibility that the over-range condition may still exist.
- OVER % LEL:** The ULTIMA X<sup>®</sup> Series Gas Monitor has been exposed to a high gas concentration [above the LEL], and the over-range condition definitely still exists.



#### Attention!

In both cases, rectify the cause of the excessively high gas concentration and ventilate the area before attempting the following.

- In the **+LOC % LEL** mode, the output signal will also be locked at full-scale. If this condition occurs the ULTIMA X must be unlocked by performing a “Zero Function” with the Calibrator or Controller. This prevents ambiguous values from being displayed when the sensor is exposed to a gas concentration of more than 100 % LEL.
- In the **OVER % LEL** mode, the combustible gas exceeds the 100 % LEL range. The ULTIMA X returns to normal operation, as soon as the gas concentration drops below 100 % LEL.

## 5 Calibration

The ULTIMA<sup>®</sup> X Gas Monitor calibration must be checked at regular intervals [at least every 6 months] in accordance with EN 60079-29-2 and EN 45544-4 and any applicable national regulations.



Before the actual calibration, completely read all the calibration instructions and the ATEX performance information in the Technical Data chapter of this manual.

Identify all calibration components and become familiar with them.

It is recommended that all calibration components are connected before starting a calibration as it is necessary to apply test gas to the instrument during a 30 second countdown.

## 5.1 Calibration Basics

ULTIMA X<sup>®</sup> Series Gas Monitors are calibrated at the factory. Nevertheless, it is recommended to recalibrate the instrument after installation. The frequency of calibration depends on the duration of use and the chemical exposure of the sensor. New sensors must be calibrated frequently until it is clear from the calibration data that they have stabilised. From then onwards, the frequency of calibration can be reduced and adapted to the plan stipulated by the safety officer or plant manager.



Connect power to the ULTIMA X Gas Monitor at least one hour before attempting a calibration.

Carry out the calibration during commissioning as well as at regular intervals. This ensures optimum operation of the sensor.

If the XE SensorGard is used during calibration of the combustible sensor a calibration factor 1.2 times higher than the calibration gas concentration must be used.

For calibration, some of the following accessories are required [→ chapter 8]:

ULTIMA X Controller  
 ULTIMA X Calibrator  
 ULTIMA XIR SensorGard \*)



ULTIMA XE Flow Block [flow rate 0.5 l/min]



ULTIMA XE SensorGard \*)  
 ULTIMA XIR Flow Cap



\*) see ULTIMA Controller and Calibrator manual





For pump application the flow rate must be within 0.5 and 5 l/min. At the gas outlet a tube of at least 30 cm shall be used.

---

### **Non-combustible Chemical Substances that cause Reduced Sensitivity of the Catalytic Sensor**

Catalytic sensors for combustible gases in areas where non-combustible chemical substances can escape must be calibrated after such an exposure. This is especially applicable when the user is aware that some substances reduce the sensitivity, such as Silanes, Silicates, Silicones and Halides [compounds containing Fluorine, Chlorine, Iodine or Bromine].



A list of interfering gases for electrochemical sensors is given in the "Response characteristics of sensors" tables in chapter 10.2.

---

### **Resetting Latched Alarms**

If a latched alarm was triggered at a ULTIMA X Gas Monitor [flashing display]:

- The alarm can be reset with an infrared remote control [such as an ULTIMA Calibrator or Controller].
- The latched alarm is reset by the next infrared signal received from a Calibrator or Controller [as long as the alarm threshold is no longer exceeded].

The actual infrared command is ignored and interpreted as "Alarm-Reset". When the latching alarm function is inactive, other valid IR commands may be used.

### **Calibration Output Signal in ULTIMA® X Series Gas Monitors**

The ULTIMA® X Series Gas Monitor is shipped with the calibration output signal disabled so the output signal will correspond to the gas concentration value during the calibration process. In some applications it may be desirable to enable the calibration output signal or lock the output to a pre-determined output value to prevent activation of alarm devices. The calibration signal can be enabled using HART command #187 or the ULTIMA X Controller [-> chapter 10.1 "Instrument Operation"].

When the calibration output signal is enabled, the output signal is 3.75 mA for the 4-20-mA models.



For the 25 % oxygen range the calibration output signal is 21 mA. If required this can be changed to 3.75 mA.

[→ ULTIMA/ULTIMA X Series Controller and Calibrator Operating Manual and HART Commands #141 and #181].



Calibration kits are available for ULTIMA X<sup>®</sup> Series Instruments.

The recommended calibration kits are listed in the ULTIMA/ULTIMA X Series Controller and Calibrator Operating Manual.

### **ULTIMA<sup>®</sup> X Series Gas Monitor Calibration Procedure**

Read all calibration instructions before attempting an actual calibration. Also, identify and become familiar with all of the calibration components.

During the calibration, it is necessary to quickly apply the span gas to the unit. Prior connection of the calibration components will aid in the ease of unit calibration.

The only true check of any Gas Monitor's performance is to apply gas directly to the sensor. The calibration procedure must be performed regularly.

### **Span Gas Values**

The Ultima X Series Gas Monitor is factory-shipped with a preset span gas value - → **Factory-set Span Values.**

This span gas value can be changed using the MSA Ultima Controller or a HART controller; otherwise, the span gas must correspond to the preset concentration. See the Controller/Calibrator Manual for instructions to change the span gas value. See Appendix, Chapter 13, HART Specific Information for the equivalent HART command.

Specific span gas values for combustible gases and vapours are listed in Chapter 7.4 and 7.5, "ATEX Performance Approval".

### Factory-set Span Values

Gas Type	Range	SPAN Gas Preset Values
Carbon Monoxide	0-100 ppm;	60 ppm
	0-500 ppm	300 ppm
	0-1000 ppm	400 ppm
Sulfur Dioxide	0-25 ppm	10 ppm
	0-100 ppm	10 ppm
Hydrogen Sulfide	0-10 ppm	5 ppm
	0-50 ppm	40 ppm
	0-100 ppm	40 ppm
	0-500 ppm	250 ppm
Nitric Oxide	0-100 ppm	50 ppm
Nitrogen Dioxide	0-10 ppm	5 ppm
Chlorine	0-5 ppm	2 ppm
	0-10 ppm	2 ppm
	0-20 ppm	10 ppm
Hydrogen Cyanide	0-50 ppm	10 ppm
Hydrogen Fluoride <sup>6</sup>	0-10 ppm	10 ppm
Chlorine Dioxide <sup>3</sup>	0-3 ppm	1 ppm
Oxygen	0-10%	5%
	0-25%	20.8%
Natural Gas <sup>2</sup>	0-100% LEL	25% LEL <sup>1</sup>
Petroleum Vapours <sup>2</sup> [Gasoline]	0-100% LEL	40% LEL <sup>1</sup>
General Solvents <sup>2</sup>	0-100% LEL	55% LEL <sup>1</sup>
Non-Methane IR <sup>2</sup>	0-100%	29% LEL <sup>1</sup>
Methane IR <sup>2</sup>	0-100% LEL	50% LEL <sup>4</sup>
Phosphine	0-2 ppm	0.5 ppm
Arsine	0-2 ppm	1.0 ppm
Germane	0-3 ppm	2.5 ppm
Silane	25 ppm	5 ppm
Diborane	50 ppm	15 ppm
Fluorine	0-5 ppm	4.0 ppm

Gas Type	Range	SPAN Gas Preset Values
Bromine	0-5 ppm	2.5 ppm
Ammonia	0-100 ppm	25 ppm
	0-1000 ppm	300 ppm
Hydrogen	0-1000 ppm	500 ppm
Ethylene Dioxide <sup>5</sup>	0-10 ppm	4.0 ppm
Carbon Dioxide IR	0-5000 ppm	3300 ppm
	0-2%	1.5%
	0-5%	3.3%
Hydrogen Chloride	0-50 ppm	40 ppm

<sup>1</sup> Calibrated with Propane (0.6% gas by volume)

<sup>2</sup> For ATEX safety related applications see Chapter 7.4 and 7.5 'ATEX Performance Approval'

<sup>3</sup> ClO<sub>2</sub> is calibrated with Cl<sub>2</sub>

<sup>4</sup> Methane IR is calibrated with 50% LEL Methane

<sup>5</sup> Ethylene Oxide is calibrated with SO<sub>2</sub>.

<sup>6</sup> Hydrogen Fluoride (HF) is calibrated with Hydrogen Chloride (HCL)

### ULTIMA XE/XA Combustible

When the ULTIMA XE monitors the surrounding atmosphere, the measuring gas reaches the sensor by diffusion. In this case the measuring values are smaller than the measuring values if the same gas concentration is applied via the SensorGard during calibration.

If the air speed when monitoring the surrounding atmosphere is higher than 1 m/s, the deviations of the measuring values are within the limits stated by EN 60079-29-1:2007.

If the air speed is lower than 1 m/s, the limits stated by EN 60079-29-1:2007 will only be met, if the SensorGard is removed after calibration.

The difference in air pressure between diffusion operation and calibration shall not be greater than 10 kPa.

## 5.2 Initial Calibration

When a new sensor is placed in the ULTIMA Gas Monitor, an INITIAL Calibration must be performed. This procedure enables the unit to gather data about the sensor to make accurate decisions for the CHANGE SENSOR function and the CAL

FAULT function to work properly. Additionally, INITIAL Calibration should only be used when a regular calibration will not clear a fault condition due to use of incorrect cal gas or other similar situation.

Initial calibration is accomplished by:

- **Push-Button** - using the optional push-button as outlined in [→ chapter 12.6 "Calibration with RESET button"]
- **HART Communicator** - [→ chapter 13.12]
- **ULTIMA/ULTIMA X Calibrator** - pressing the **ZERO** and **CALIBRATE** buttons simultaneously while aiming the Calibrator at the ULTIMA X
- **ULTIMA/ULTIMA Controller** - pressing and holding the **SPAN** button until the Controller display shows "**Do Init Cal 1=y**"
- Press 1 while pointing the Controller at the ULTIMA/ULTIMA X Series display.
  - ▷ The ULTIMA® X Series display should show a 30-second countdown and "**APPLY ZERO GAS**"
  - ▷ The remainder of the procedure is now the same as that for a regular calibration.
  - ▷ The word "**iCAL**" on the ULTIMA X® Series display distinguishes INITIAL Calibration from a regular calibration. If the word "**iCAL**" does not appear, the user may abort the calibration by pressing the ZERO, CAL or ADDRESS button on the Calibrator while aiming at the unit; then, retry the above procedure.



The calibration process can be aborted at any time during the 30-second countdown simply by pressing the ZERO, CAL or ADDRESS button on the Controller/Calibrator while aiming at the ULTIMA X or by pressing and releasing the push-button if fitted.

This procedure should be initiated only when a new sensor is installed otherwise, the sensor end-of-life indication may not be accurate.

---

The display leads the user through the zero and span calibration routines as in a regular calibration.

### 5.3 Regular Calibration

A regular calibration includes "zero" and "span" as described in the following procedures.

#### Zeroing Using the Zero Cap



This method is only suitable when the atmosphere contains no traces of the gas to detect.

Otherwise, use zero gas.

---

- (1) Place the zero cap of the corresponding calibration kit over the SensorGard and wait two minutes.
- (2) Continue zeroing from point [7] below.

#### Zeroing Using the Zero Gas Cylinder

- (1) Remove zeroing gas cylinder and flow controller from the calibration kit.
  - (2) Screw the flow controller onto the top of the zero gas cylinder.
  - (3) Push the smaller end of the tube from the calibration kit over the flow controller gas outlet.
  - (4) When using cal-kit 40, push the other end of the tube over the SensorGard inlet.
  - (5) When using cal-kit 41, use the calibration cap [which has a hole for the tube].
    - push the tube through the hole in the bottom of the cap,
    - push the end of the tube over the sensor inlet and slide the calibration cap fully over the entire sensor inlet.
  - (6) Turn on the zero gas flow by turning the knob on the flow controller.
  - (7) Point the Calibrator/Controller at the ULTIMA X Gas Monitor display and press the CALIBRATE button.
- 



The zero or calibration procedure can be aborted at any time during the 30 second countdown by pointing the Calibrator/Controller at the Gas Monitor display and pressing any key or by pressing and releasing the push-button if available.

---



There is no 30 second countdown for oxygen instruments; zeroing is done electronically.

---

The display shows:

- A countdown from 30 to 0 seconds
- the APPLY ZERO GAS indicators [→ Fig. 10].

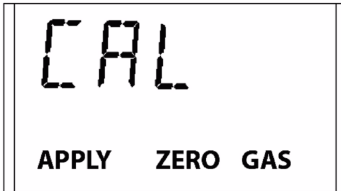


Fig. 10 Prompt for supplying zeroing gas

- (8) After the 30 second countdown:
  - CAL and a numeric value will be displayed alternately on the display, which is the actual reading of the gas concentration the sensor is detecting.
  - After the gas reading has stabilised, the alternating display stops and if the calibration is successful, the display will show END.
- (9) If using the zero cap, remove it.
- (10) When using a zero gas cylinder, close the valve on the flow regulator and remove the tube from the SensorGard.



If the calibration output signal is enabled during calibration, it will remain at the SENSOR CAL value for another two minutes after END is displayed.

If CAL FAULT is displayed, this indicates the following:

- The zeroing of the ULTIMA X<sup>®</sup> Series Gas Monitor has failed.
- The ULTIMA X<sup>®</sup> Series Gas Monitor is operating with the calibration parameters, which were defined before beginning the calibration [→ chapter 11.3 "Instructions for troubleshooting"].

To remove the CAL FAULT message, a complete successful calibration procedure must be performed.

The ULTIMA X Series Monitor allows automatic zero adjustment only within a pre-defined range. Outside this range, no corrections can be made, e.g. when an empty or wrong gas cylinder is connected or the gas flow did not start within the 30 seconds countdown period.

- If only a zero was carried out, the procedure is complete and the user should return the calibration equipment to the calibration kit.
- If a calibration was carried out, the ULTIMA will continue to the "span" procedure, which is described below.

### Span Calibration

During a regular calibration, the ULTIMA® X Series Gas Monitor automatically begins the span countdown after a successful zeroing.

The span countdown is 30 seconds [→ Fig. 11].



During the 30 second countdown, the span procedure can be cancelled at any time by pointing the Calibrator/Controller at the ULTIMA display and pressing any key. Alternatively, if the ULTIMA is fitted with a push-button press and release it.

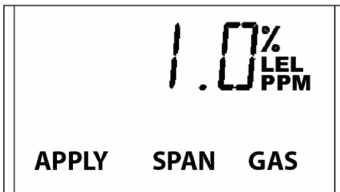


Fig. 11 Prompt for supplying test gas

- (1) Remove test gas cylinder and flow controller from the calibration kit
- (2) Attach the flow controller to top of the span gas cylinder.
- (3) Push the small end of the tube from the calibration kit over the flow controller gas outlet.
- (4) When using cal-kit 40, push the other end of the tube over the SensorGard inlet.



- (5) When using cal-kit 41, use the calibration cap which has a hole for the tube.
  - push the tube through the hole in the bottom of the cap,
  - connect the tube end over the sensor inlet and
  - push the calibration cap over the entire sensor inlet.
- (6) Start the span gas flow by turning the knob on the flow controller.
  - The calibration gas must be applied during the 30 seconds countdown period.
  - If the CAL FAULT message is displayed on the ULTIMA X Monitor before the span gas is applied, a steady state gas reading was reached, causing the monitor to use a false measured value as a span indication.
  - To clear this fault, restart the calibration process.

After the 30 second countdown:

- The display alternates between CAL and a numeric value, which corresponds to the actual gas concentration the sensor is detecting.
- After the gas value has stabilised, the alternating display stops. If the calibration is successful, END is displayed for approximately 2 seconds [→ Fig. 12].

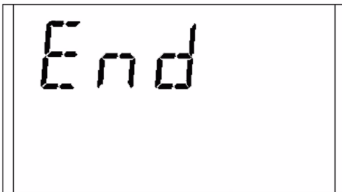


Fig. 12 Calibration completed



No user adjustments are required.

The display will show the span gas value while the span gas is flowing to the ULTIMA X Monitor.

---

- (7) Turn off the gas flow by turning the knob on the flow controller.



If the calibration output signal is enabled during calibration, it will remain at the SENSOR CAL value for another two minutes after END is displayed.

---

- The displayed value must correspond to that of the ambient conditions.

If CAL FAULT is displayed, this indicates:

- The calibration of the ULTIMA® X Series Gas Monitor has failed.
- The ULTIMA X Series Gas Monitor is operating with the calibration parameters which were determined before beginning the calibration [→ chapter 11.3 "Instructions for troubleshooting"].

To remove the CAL FAULT message, the complete calibration process must be successful.

- (8) After successful calibration, remove the tubing from the flow controller, unscrew it from the test gas cylinder and stow the components in the calibration kit.

### XIR Calibration

Although a full calibration, zero and span, can be performed on the ULTIMA XIR Gas Monitor, a no-gas calibration is sufficient to properly calibrate the monitor.

Typically, a zero adjustment is all that is required as any degradation of the sensors performance is normally associated with slight drifts in its zero response which in turn will adversely affect its span performance.

Restoring the sensor's zero is typically sufficient to restore its span performance.

- (1) A zero adjustment is performed by pressing the ZERO button on the Calibrator or Controller [or by using the optional push-button calibration as outlined in chapter 12.6, "Calibration with RESET Button"] and following the Zeroing instructions in chapter 5.3.
- (2) After completing the zero adjustment, perform a span check to ensure correct operation. If the span check is unsuccessful, perform a full calibration.



For calibration of an XIR sensor with a flow cap, temporarily replace the flow cap with the calibration cap [included with the instrument] and carry out the calibration.

---



#### **Attention!**

The calibration cap must be removed from the XIR climatic protection cap after completing the zeroing and/or test gas process, otherwise the sensor will not function correctly.

### Calibration record

The date of the last successful calibration is stored by the ULTIMA® X Series monitor. The ULTIMA/ULTIMA X Controller can be used to display this date on the monitor LCD.

## 6 Maintenance

ULTIMA X<sup>®</sup> Series Gas Monitors constantly perform a self check. If a problem is detected, the appropriate error message is displayed [→ chapter 11.3 "Instructions for troubleshooting"].

When a critical error is detected, the output signal goes to a fault condition.

- For models with 4-20-mA output, the fault output signal is 3.0 mA.
- The "CHANGE SENSOR" message is not an error and does not affect the output signal.



Messages that the user may see are shown in 11.1 and 11.2.



### Attention!

Use only genuine MSA replacement parts when performing any maintenance procedures provided in this manual. Repair or alteration of the ULTIMA X<sup>®</sup> Series Gas Monitor, beyond the scope of these instructions or by anyone other than authorised MSA service personnel may seriously impair instrument performance.

### 6.1 ULTIMA XIR Cleaning Procedure



Before cleaning the ULTIMA XIR sensor window disable the alarm relays using the ULTIMA/ULTIMA X Controller. This prevents activation of the alarm during the cleaning.

Response time will be increased by significant dust deposits on the XIR SensorGard. Checks for dust deposits have to be done at regular intervals.

---

**Attention!**

Do not place foreign objects in the sensor's analytical region [except per the "ULTIMA XIR Cleaning Procedure" as described above]; otherwise, the infrared beam can be partially blocked, causing the sensor to generate false readings. All objects must be removed from the sensor's analytical region for it to function properly. Similarly, if water or isopropyl alcohol is used to clean the sensor's windows, any residue from the cleaning procedure must be completely dissipated before returning the unit to service. Checking the sensor's response to zero gas is the best way to purge residual cleaning materials from the sensor and to make sure that sensor's reading is stable before zeroing or calibrating the sensor [→ chapter 5, "Calibration"]

- (1) Remove the environmental or flow cap.
- (2) Place an opaque object [piece of paper, cardboard, etc.] between the light source window and the mirror to completely obscure the light path for two to three seconds.
  - ▷ The ULTIMA XIR Monitor enters the Cleaning Mode for two minutes.



While in the Cleaning Mode, the sensor will not respond to the presence of gas.

- ▷ The analogue current output is 3.0 mA during this time.
  - ▷ The display indicates "low signal".
- (3) While both windows are made of a highly durable material that is not easily scratched, avoid excessive pressure when cleaning them. Clean, cotton-tipped applicators are the most convenient tool to remove material collected on the windows.
  - Use a dry applicator or one moistened with distilled water to wipe the window and remove dust.
  - Use an additional clean, dry applicator to remove any residual water.
  - Use an applicator moistened with isopropyl alcohol to remove heavy deposits of solids, liquids or oil films. Clean the window again with a second applicator moistened with distilled water; then, dry the window with a final applicator.
  - Avoid using excessive amounts of water or alcohol in the cleaning procedure, and inspect the window to ensure that the entire surface is clean.

- The unit remains in the Cleaning Mode for a minimum of two minutes. If active cleaning is still in progress at the end of this period, the sensor detects the motion of this object in its light path and automatically extends the Cleaning Mode for 15 seconds. Further 15-second Cleaning Mode extensions continue until no motion is detected.



When the cleaning process is complete, be sure to remove all objects from the light path.

- (4) When exiting the Cleaning Mode, the unit returns to normal operation. If water or isopropyl alcohol was used, allow the unit to operate for 15 minutes to completely dry before replacing the environmental guard and continuing to monitor for combustible gas.
- (5) Replace the environmental or flow cap.
- (6) After cleaning the windows, it is advisable to check the sensor's response to both zero and calibration gas.

## 6.2 Replacing the ULTIMA XE/XA Sensor

The only routine maintenance item is the sensing element itself, which has a limited lifetime. If the "CHANGE SENSOR" message [→ Fig. 13] appears, the life of the sensor has almost expired. The sensor must be replaced with another one of the same type.

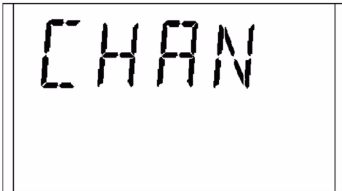


Fig. 13 "CHANGE SENSOR" scrolls across the display



### Attention!

Handle the sensor carefully; the electrochemical version is a sealed unit which contains a corrosive electrolyte.

Any leaked electrolyte must not come into contact with the skin, eyes or clothes, thus avoiding burns.

If any contact with the electrolyte does occur, immediately rinse with a large quantity of water. On contact with the eyes, rinse thoroughly with water for 15 minutes and consult a doctor.



A leaking sensor must not be installed in the sensor housing. Dispose of leaking sensors in accordance with local regulations.

Replacement sensors can be ordered from MSA [Order details → chapter 8.2].



### Attention!

For ULTIMA XE/XA Gas Monitors, first unscrew the sensor by rotating it at least three full turns [maximum four turns from its tightly closed position], wait for 10 seconds and unscrew the sensor completely. Failure to follow this warning could result in ignition of a hazardous atmosphere.



The output signal delay is activated on delivery of ULTIMA X<sup>®</sup> Series Gas Monitors.

This means that an error message is suppressed for 60 seconds. Thus, the sensor can be replaced without an ERROR being displayed.

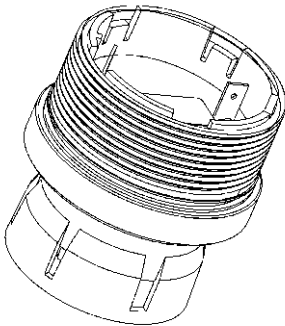


Fig. 14 Sensor and SensorGard

- (1) Unscrew the sensor unit from the bottom of the ULTIMA X<sup>®</sup> Series Gas Monitor [→ Fig. 14].
- (2) Identify and obtain the sensor unit needed.
- (3) Replace sensor unit.



Alarm setpoints and relay functions [energised/de-energised] will not change when changing a sensor from its current type to the same gas type.

Alarm setpoints and the upscale/downscale relay function will change to the new sensor' settings when changing a sensor module from its current type to a different gas type.

- (4) The ULTIMA X<sup>®</sup> Series Gas Monitor is shipped with the Sensor Swap Delay enabled. This means that the 4-20 mA output signal and the FAULT relay will hold off a fault indication for 60 seconds after the missing sensor indication is displayed on the instrument. This setting allows the operator to exchange sensor modules without a FAULT indication.
- (5) Refer to Chapter "Calibration".

## 7 Technical Data

### 7.1 Dimensions, Weight

Gas types		Combustible gases, oxygen and toxic gases	
XE	Dimensions	W x H x D [mm]:	162 x 262 x 100
	Weight	approx.	5 kg
XIR	Dimensions	W x H x D [mm]:	320 x 150 x 100
	Weight	approx.	4.75 kg
XA	Dimensions	W x H x D [mm]:	130 x 240 x 76
	Weight	approx.	0.7 kg

## 7.2 Performance Specifications

Gas types		Combustible gases, oxygen and toxic gases		
Temperature range	Toxic gases and oxygen	Operating range	0 °C to 40 °C	
		Extended range *)	-20 °C to +50 °C	
		Operating range NH <sup>3</sup>	0 °C to 30 °C	
		Extended range NH <sup>3</sup> ; CL <sub>2</sub> ; ClO <sub>2</sub> *)	-10 °C to 40 °C	
		Calibrate within operating temperature range.		
	Combustible gas, catalytic	Single module	-40 °C to +60 °C	
		Dual module		
	Combustible gas, IR	Single module	-40 °C to +60 °C	
		Dual module		
	Drift	Zero drift	Less than 5 % per year, typically XIR Ethylene: ≤ 4 % per 3 months	
Span drift		Less than 10 % per year, typically		
Noise		Less than 1 % FS		
Warm up time		Less than 45 sec		
Storage temperature		-40 °C to +60 °C or limits of the sensor		
Step change response	Time to reach 20 % of scale - Toxics	Less than 12 sec	[typically 6 sec]	
		Less than 20 sec		
	Time to reach 50 % of scale - Toxic	Less than 30 sec	[typically 12 sec]	
		Less than 45 sec		
Response time with sensor	Gas	ULTIMA XE Oxygen		
		t20	t90	
	Oxygen	≤ 10 sec	≤ 40 sec **)	

\*) In the extended temperature range, the sensor may not meet all the specified parameters

\*\*\*) Response time t90 may increase up to 50 seconds when used with SensorGard.



Gas types		Combustible gases, oxygen and toxic gases			
	Gas	ULTIMA XE combustible		ULTIMA XIR	
Response time with sensor guard/ environmental guard		t50	t90	t50	t90
	Methane	≤ 15 sec	≤ 35 sec	≤ 15 sec	≤ 35 sec
	Propane	≤ 25 sec	≤ 55 sec	≤ 15 sec	≤ 45 sec
	Ethylene			≤ 15 sec	≤ 40 sec
	n-Pentane	≤ 30 sec	≤ 65 sec	≤ 15 sec	≤ 45 sec
Pressure	80 – 120 kPa	XE: = 8 % LEL Propane			
Air velocity	0 – 6 m/s	XE: = 9 % LEL			
Real time clock and parameter memory		Lithium backup battery life time = 8 years			
Humidity	Toxic gases and oxygen	15 % to 95 % rel. humidity, non-condensing, max. 24 hours [15 to 60% RH (SO <sub>2</sub> **)]			
		35 % to 95 % rel. humidity, non-condensing, long-term			
	Combustible	5 % to 95 % rel. humidity			
Sensor life from date of manufacture	Combustible gases, catalytic	3 years, typically			
	Toxic gases and oxygen NH <sub>3</sub> Sensor***	2 years, typically			
	Full replacement warranty	XE 1 year; XIR 2 years; XIR source 10 years			
Wiring requirements	mA output	Toxic gases and oxygen	2 or 3 wire		
		Combustible gases	3 wire		

\*\*SO<sub>2</sub> sensor should not be used in dirty or humid environments.

\*\*\*0-100 ppm NH<sub>3</sub> sensor is consumable at a rate of 10% for every 200 ppm/hours of exposure.

0-1000 ppm NH<sub>3</sub> sensor is consumable at a rate of 10% for every 1500 ppm/hours of exposure.

Gas types		Combustible gases, oxygen and toxic gases		
Power input (for instruments with internal relays - see chapter 12)	mA versions	Toxic gases and oxygen	19 - 30 V DC	max. 24 mA at 24 V DC
		Combustible gases, catalytic	19 - 30 V DC	max. 160 mA at 24 V DC
		Combustible gases, IR	19 - 30 V DC	max. 200 mA at 24 V DC
Signal output	4 – 20 mA	Combustible gases	3 wire, current-source	
		Toxic gases and oxygen	2 wire, current-sink or 3 wire, current-source	

### 7.3 Measuring Accuracy

Gas	Linearity	Repeatability
Carbon monoxide	±2 % FS	±1 % FS or 2 ppm
Oxygen	0 - 25 % V/V ±2 % FS	±1 % FS
Hydrogen sulphide	0 - 10 % V/V ±3 % FS	±1 % FS or 2 ppm
Chlorine	±10 % FS or 2 ppm	±5 % FS or 1 ppm
Sulphur dioxide	±10 % FS or 2 ppm	±1 % FS or 2 ppm
Nitric oxide	±10 % FS or 2 ppm	±1 % FS or 2 ppm
Nitrogen dioxide	±10 % FS or 2 ppm	±4 % FS or 1 ppm
Hydrogen chloride	±10 % FS or 2 ppm	±10 % FS or 2 ppm
Hydrogen cyanide	±10 % FS or 2 ppm	±4 % FS or 2 ppm
Combustible gas, catalytic	< 50 % LEL ±3 % FS > 50 % LEL ±5 % FS	±1 % FS
Combustible gas, IR Methane, Propane	< 50 % LEL ±2 % FS > 50 % LEL ±5 % FS	±2 % FS
Chlorine dioxide	±10 % FS or 2 ppm	±5 % FS or 1 ppm
Ethylene oxide	±10 % FS	±5 % FS
Ammonia	±10 % FS	±5 % FS
Hydrogen	± 5 % FS	±5 % FS
Phosphine	±10 % FS	±10 % FS

Gas	Linearity	Repeatability
Arsine	±10 % FS	±10 % FS
Germanium	±10 % FS or 2 ppm	±10 % FS
Silane	±10 % FS or 2 ppm	±1 % FS or 2 ppm
Diborane	±10 % FS or 2 ppm	±1 % FS or 2 ppm
Fluorine	±10 % FS or 2 ppm	±5 % FS or 2 ppm
Bromine	±10 % FS or 2 ppm	±5 % FS or 2 ppm

## 7.4 ULTIMA XE – ATEX Performance Approval



When monitoring flammable gas in safety related applications the ULTIMA XE must be calibrated with a known concentration of the gas being monitored.

The lower explosive limits [LEL] of the gases and vapours in following table were taken from EN 60079-29-1:2007. For gases and vapours not listed in EN 60079-29-1:2007, the lower explosive limits [LEL] were taken from the Chem-safe [Dechema, Frankfurt] data base. Local regulations may specify different LEL values; always ensure the correct values are used.

It is recommended that the ULTIMA XE zero is calibrated using clean air, free of flammable gas, and calibration gas of approximately 50 % LEL in air of the gas being monitored. The table shows the ULTIMA XE flammable gas sensor relative response to various gases and vapours when calibrated using 50 % LEL Propane in air. For non-safety related applications the ULTIMA XE flammable gas sensor may be calibrated using the relative response factors shown in the table and 50 % LEL Propane in air. When using relative response factors for gas calibration, deviations of up to ±20 % of the true gas concentration can be expected.

### Reference Calibration Example for 50 % Methanol:

- (1) Relative response factor for Methanol from the table in this chapter = 0.79
  - (2) Propane calibration gas concentration being used = 0.89 Vol% C<sub>3</sub>H<sub>8</sub>
  - (3) Propane volume concentration for 100 % LEL = 1.7 Vol%
  - (4) Propane calibration gas concentration in % LEL
- $$\% \text{ LEL} = 0.89 \text{ Vol\% C}_3\text{H}_8 \times \frac{100 \% \text{ LEL}}{1.7 \text{ Vol\% C}_3\text{H}_8} = 52.4 \% \text{ LEL}$$
- (5) Gas calibration set point = 52.4 % LEL x 0.79 = **41.4 % LEL**

**ULTIMA XE - Relative Response Factors**

Relative response factors of tested gases for 0.89 Vol% Propane calibration gas.

Measuring gas	100 % LEL in Vol%	Relative re- sponse factor	Response time [t50] *)	Response time [t90] *)
Acetone	2.5 Vol%	0.94	≤ 19 s	≤ 49 s
Acetylene	2.3 Vol%	0.73	≤ 12 s	≤ 25 s
Allyl alcohol [50 °C]	2.5 Vol%	0.81	≤ 14 s	≤ 52 s
[FAM-] Benzine 65/ 95	1.1 Vol%	1.28	≤ 12 s	≤ 33 s
1,3-Butadiene	1.4 Vol%	0.96	≤ 16 s	≤ 34 s
i-Butane	1.5 Vol%	1.07	≤ 17 s	≤ 36 s
n-Butane	1.4 Vol%	1.13	≤ 16 s	≤ 38 s
2-Butanon	1.8 Vol%	1.19	≤ 12 s	≤ 46 s
i-Butylene	1.6 Vol%	0.92	≤ 16 s	≤ 37 s
Cyclohexane	1.2 Vol%	1.25	≤ 13 s	≤ 30 s
Cyclopentane	1.4 Vol%	1.15	≤ 19 s	≤ 47 s
Diethyl Ether	1.7 Vol%	1.13	≤ 18 s	≤ 41 s
Ethane	2.5 Vol%	0.79	≤ 14 s	≤ 30 s
Ethanol	3.1 Vol%	0.90	≤ 10 s	≤ 27 s
Ethylene	2.3 Vol%	0.77	≤ 13 s	≤ 27 s
Ethyl Acetate	2.2 Vol%	1.07	≤ 19 s	≤ 59 s
Ethylene Oxide	2.6 Vol%	0.94	≤ 15 s	≤ 37 s
n-Hexane	1.0 Vol%	1.48	≤ 12 s	≤ 28 s
Methanol	5.5 Vol%	0.79	≤ 16 s	≤ 41 s
n-Pentane	1.4 Vol%	1.13	≤ 19 s	≤ 46 s
Propane	1.7 Vol%	1.00	≤ 11 s	≤ 26 s
2-Propanol	2.0 Vol%	1.07	≤ 11 s	≤ 34 s
Propene	2.0 Vol%	0.76	≤ 14 s	≤ 30 s
Propylene Oxide	1.9 Vol%	1.03	≤ 18 s	≤ 43 s
Hydrogen	4.0 Vol%	0.56	≤ 8 s	≤ 15 s

\*) ULTIMA XE response times with flow block and a flow rate of 1 l/min.

## 7.5 ULTIMA XIR – ATEX Performance Approval



When monitoring flammable gas in safety related applications the ULTIMA XIR must be calibrated with a known concentration of the gas being monitored.

The lower explosive limits [LEL] of the gases and vapours in the following tables were taken from EN 60079-29-1:2007. For gases and vapours not listed in EN 60079-29-1:2007, the lower explosive limits [LEL] were taken from the Chem-safe [Dechema, Frankfurt] data base. Local regulations may specify different LEL values; always ensure the correct values are used.

It is recommended that the ULTIMA XIR zero is calibrated using clean air, free of measuring gas, and calibration gas of approximately 50 % LEL in air of the measuring gas. If it is not possible to calibrate with the same gas as the measuring gas then the Propane [ $C_3H_8$ ] reference gas concentration together with the relative response factors shown in the table can be used. When using this calibration method deviations of up to  $\pm 20$  % of the true gas calibration can be expected.

These relative response factors only apply at ambient temperatures of 20 °C and unless otherwise indicated.

### Reference Calibration Example for Methanol when Using Propane:

- |  |                      |
|--|----------------------|
| (1) Relative response factor for Methanol from the table in this chapter | = 0.70               |
| (2) Propane calibration gas concentration being used                     | = 0.89 Vol% $C_3H_8$ |
| (3) Propane volume concentration for 100 % LEL                           | = 1.7 Vol%           |
| (4) Propane calibration gas concentration in % LEL                       |                      |

$$\% \text{ LEL} = 0.89 \text{ Vol\% } C_3H_8 \times \frac{100 \% \text{ LEL}}{1.7 \text{ Vol\% } C_3H_8} = 52.4 \% \text{ LEL}$$

- |                               |                     |                     |
|-------------------------------|---------------------|---------------------|
| (5) Gas calibration set point | = 52.4 % LEL x 0.70 | = <b>36.7 % LEL</b> |
|-------------------------------|---------------------|---------------------|

**ULTIMA XIR - Relative Response Factors for Propane Calibration Gas**

Measuring gas	100 % LEL in Vol%	Linearisation curve	Reference Gas Concentration [Propane]	Relative response factor
Acetone	2.5 Vol%	(8) Ethylene	0.25 Vol%	3.31
Allyl alcohol [50 °C]	2.5 Vol%	(2) Propane	0.25 Vol%	3.31
[FAM-] Benzine 65/95	1.1 Vol%	(2) Propane	0.89 Vol%	1.10
1,3-Butadiene	1.4 Vol%	(8) Ethylene	0.25 Vol%	5.97
i-Butane	1.5 Vol%	(4) Butane	0.89 Vol%	1.08
n-Butane	1.4 Vol%	(4) Butane	0.89 Vol%	1.08
2-Butanon	1.8 Vol%	(2) Propane	0.41 Vol%	2.06
i-Butyl Acetate	1.3 Vol%	(2) Propane	0.89 Vol%	1.46
n-Butyl Acetate [50 °C]	1.3 Vol%	(2) Propane	0.89 Vol%	1.41
i-Butylene	1.6 Vol%	(6) Hexane	0.41 Vol%	1.95
Cyclopentane	1.4 Vol%	(7) Cyclopentane	0.89 Vol%	0.94
Diethyl Ether	1.7 Vol%	(2) Propane	0.89 Vol%	1.22
Ethane	2.5 Vol%	(3) Ethane	0.89 Vol%	0.90
Ethanol	3.1 Vol%	(6) Hexane	0.89 Vol%	1.06
Ethyl Acetate	2.2 Vol%	(2) Propane	0.61 Vol%	1.52
Ethylene Oxide	2.6 Vol%	(6) Hexane	0.41 Vol%	1.91
n-Hexane	1.0 Vol%	(6) Hexane	0.89 Vol%	1.27
Methanol	5.5 Vol%	(3) Ethane	0.89 Vol%	0.70
n-Nonane	0.7 Vol%	(2) Propane	0.89 Vol%	1.37
n-Pentane	1.4 Vol%	(2) Propane	0.89 Vol%	0.99
Propane	1.7 Vol%	(2) Propane	0.85 Vol%	1.00
2-Propanol	2.0 Vol%	(6) Hexane	0.61 Vol%	1.30
Propylene	2.0 Vol%	(2) Propane	0.41 Vol%	2.32
Propylene Oxide	1.9 Vol%	(2) Propane	0.61 Vol%	1.44

Measuring gas	100 % LEL in Vol%	Linearisation curve	Reference Gas Concentration [Propane]	Relative response factor
Toluene	1.1 Vol%	(8) Ethylene	0.25 Vol%	3.75
Xylene	0.96 Vol%	(2) Propane	0.41 Vol%	2.56

Response time with measuring gas when using the ULTIMA XIR Flow Cap [flow rate 1 l/min.]: 50 = 10 s, t<sub>90</sub> = 30 s.

### ULTIMA XIR - Relative Response to 50 % LEL

The ULTIMA XIR response to 50 % LEL of the measuring gas, when configured to linearisation curve number 2 [Propane] and calibrated in clean air and 50 % LEL Propane, is shown below for various flammable gases and vapours.

When using relative response factors for gas calibration, deviations of up to  $\pm 20$  % of the true measuring gas concentration can be expected.

Measuring gas	100 % LEL in Vol%	Response to 50 % LEL of the measuring gas
Acetone	2.5 Vol%	15 % LEL
Acetylene	2.3 Vol%	0 % LEL
Allyl alcohol [50 °C]	2.5 Vol%	16 % LEL
Ammonia	15 Vol%	0 % LEL
[FAM-] Benzine 65/95	1.1 Vol%	46 % LEL
1,3-Butadiene	1.4 Vol%	7 % LEL
i-Butane	1.5 Vol%	49 % LEL
n-Butane	1.4 Vol%	47 % LEL
2-Butanon [MEK]	1.8 Vol%	25 % LEL
i-Butyl Acetate	1.3 Vol%	34 % LEL
n-Butyl Acetate	1.3 Vol%	36 % LEL
i-Butylene	1.6 Vol%	25 % LEL
Cyclohexane	1.2 Vol%	31 % LEL
Cyclopentane	1.4 Vol%	53 % LEL
Diethyl Ether	1.7 Vol%	42 % LEL
Acetic Acid [50 °C]	4.0 Vol%	78 % LEL
Acetic Anhydride [50°C]	2.0 Vol%	2 % LEL
Ethane	2.5 Vol%	56 % LEL

Measuring gas	100 % LEL in Vol%	Response to 50 % LEL of the measuring gas
Ethanol	3.1 Vol%	48 % LEL
Ethylene	2.3 Vol%	8 % LEL
Ethyl Acetate	2.2 Vol%	33 % LEL
Ethylene Oxide	2.6 Vol%	27 % LEL
n-Hexane	1.0 Vol%	40 % LEL
Methanol	5.5 Vol%	73 % LEL
n-Nonane	0.7 Vol%	37 % LEL
n-Pentane	1.4 Vol%	51 % LEL
Propane	1.7 Vol%	50 % LEL
2-Propanol	2.0 Vol%	40 % LEL
Propylene	2.0 Vol%	22 % LEL
Propylene Oxide	1.9 Vol%	35 % LEL
Toluene	1.1 Vol%	15 % LEL
Hydrogen	4.0 Vol%	0 % LEL
Xylene	0.96 Vol%	20 % LEL

## 8 Ordering Information

### 8.1 Gas Monitors, Accessories

Description	Part No.
<b>LED/Relay Options</b>	
ULTIMA XE/IR PCB, no Relays, no LEDs, 2-wire	10044388
ULTIMA XE/IR PCB, no Relays, with LEDs, 3 wire	10044385
ULTIMA XE/IR PCB, with Relays, with LEDs, 3 wire	10044384
ULTIMA XE/XIR with HART, no Relays, no LEDs, 2-wire	10097872
ULTIMA XE/XIR with HART, no Relays, with LEDs, 3-wire	10097873
ULTIMA XE/XIR with HART, with Relays, with LEDs, 3-wire	10097874



Description	Part No.
<b>Accessories</b>	
ULTIMA XE Calibration Cap	10020030
ULTIMA XE SensorGard	10028904
ULTIMA XIR SensorGard	10041265
ULTIMA XIR Calibration Cap	10041533
ULTIMA XE Flow Cap	10041866
ULTIMA XIR Flow Cap	10042600
ULTIMA Controller	10044459
ULTIMA Calibrator	10044470
Cable Gland M25 EEx d	10045619
Cable Gland M20 EEx d	10045880
Reducer M25 to M20 EEx de	10045881
ULTIMA XE Mounting Bracket	10047561
ULTIMA remote sensor mounting bracket	10047562
RESET push button [external]	10074014
Duct mount kit	on request

Enclosures	¾" NPT	25 mm
ULTIMA XE/XIR enclosure without terminal strips	10044380	10044382
ULTIMA XE/XIR enclosure with terminal strips	10044381	10044383
ULTIMA XE, reactive local sensor + HART module	10097875	10097879
ULTIMA XE/XIR, non-reactive local sensor+ HART port	10097876	10097880
ULTIMA XE, reactive remote sensor + HART port	10097877	10097921
ULTIMA XE/XIR non-reactive remote sensor	10098926	10098925
ULTIMA XE/XIR HART module	10098928	10098927
ULTIMA XE/XIR, non-reactive remote sensor + HART port	10097878	10097922
ULTIMA XE/XI, Remote Sensor Housing, EExe, M25	---	10044458
ULTIMA XE/XI, Remote Sensor Housing, EExd, 3/4"	10044457	---

## 8.2 Replacement Parts

Description	Part No.	
Carbon Monoxide, 0 – 100 ppm	10044471	
Carbon Monoxide, 0 – 500 ppm	10044472	
Oxygen, 0 – 10 % - compensated	10044473	
Oxygen, 0 – 25 % - compensated	10044474	
Hydrogen Sulfide, 0 – 10 ppm	10044475	
Hydrogen Sulfide, 0 – 50 ppm	10044476	
Hydrogen Sulfide, 0 – 100 ppm	10044477	
Nitric Oxide, 0 – 100 ppm	10044478	
Nitrogen Dioxide, 0 – 10 ppm	10044532	
Hydrogen Cyanide, 0 – 50 ppm	10044479	
Hydrogen Chloride, 0 – 50 ppm	10044533	
Chlorine, 0 – 5 ppm	10044531	
Chlorine Dioxide, 0 – 3 ppm	10044534	
Combustible Gas, 0 – 100% LEL, Gas Group 1	10044480	
Combustible Gas, 0 – 100% LEL, Gas Group 2	10044481	
Comb Gas IR - Gas Group 4	10044483	
Phosphine, 0 – 2 ppm	10044486	
Arsine, 0 – 2 ppm	10044487	
Silane, 0 – 25 ppm	10044488	
Germane, 0 – 3 ppm	10044489	
Diborane, 0 – 50 ppm	10044500	
Bromine, 0 – 5 ppm	10044535	
Fluorine, 0 – 10 ppm	10044537	
Ammonia, 0 – 50 ppm	10044538	
Ammonia, 0 – 100 ppm	10056993	
Hydrogen, 0 – 1000 ppm	10044501	
	¾" thread	25 mm thread
IR-sensor, 0 – 100 % LEL, Group 3	10044482	10044484
IR-sensor, 0 – 100 % LEL, Group 4	10044483	10044485

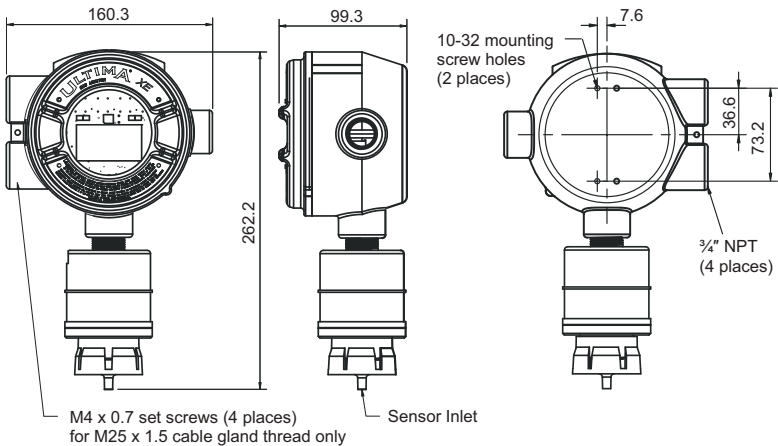
## 9 Appendix: Electrical Installation



The cabling and electrical installation must be carried out based on the instrument types used.

Electrical installation details are given in appropriate drawings.

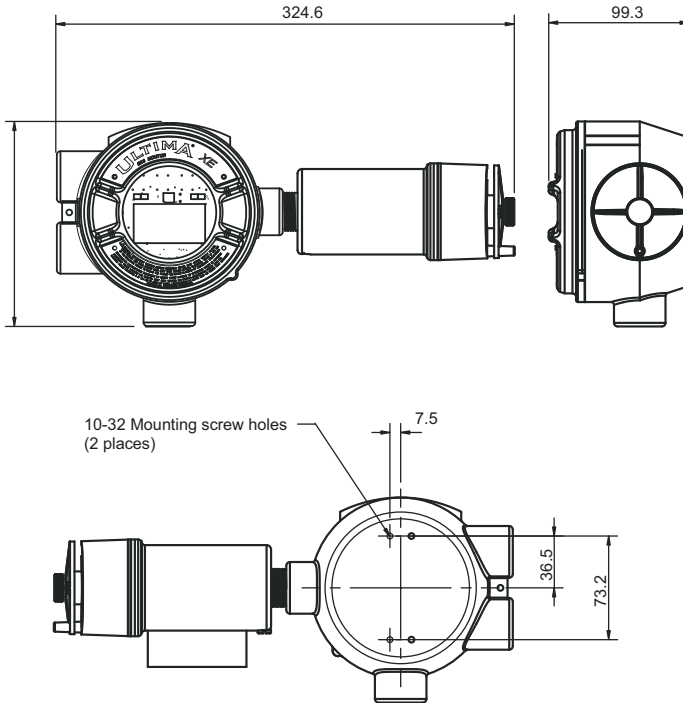
### 9.1 Installation Outline Drawing [CE] - ULTIMA XE



#### Notes:

- Instrument weight: 4.72 kg
- Instrument housing: 316 St.St.
- Dimensions shown in millimetres.
- Install ULTIMA XE with sensor inlet pointing down.
- Certified cable glands or blanking plugs shall be installed at all cable entries during installation.
- All cable shields to be terminated to ground earth at one end only.
- NPT threads shall conform to the requirements of ANSI/ASME B1.20.1, and shall be made-up wrench tight.

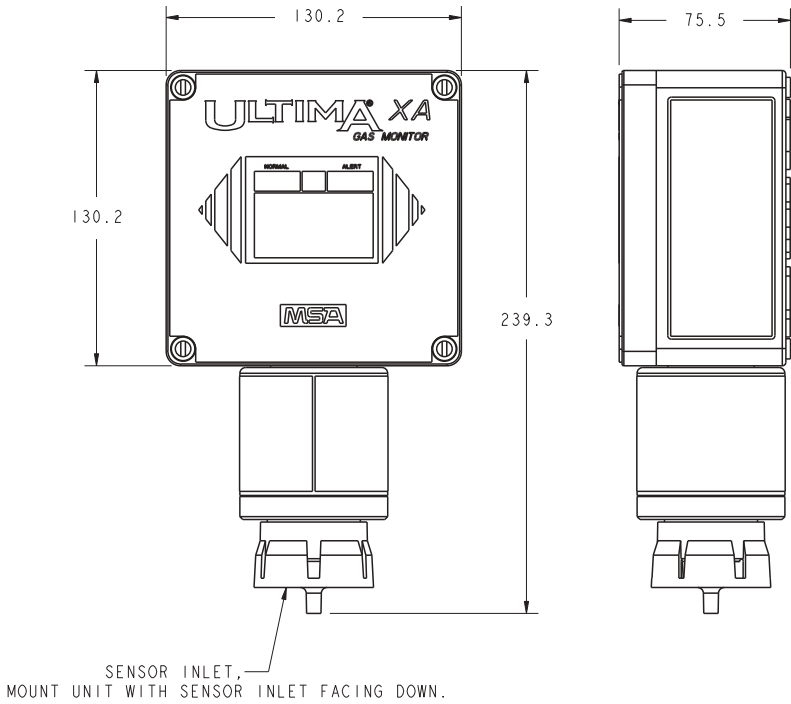
## 9.2 Installation Outline Drawing [CE] - ULTIMA XE with XIR Sensor



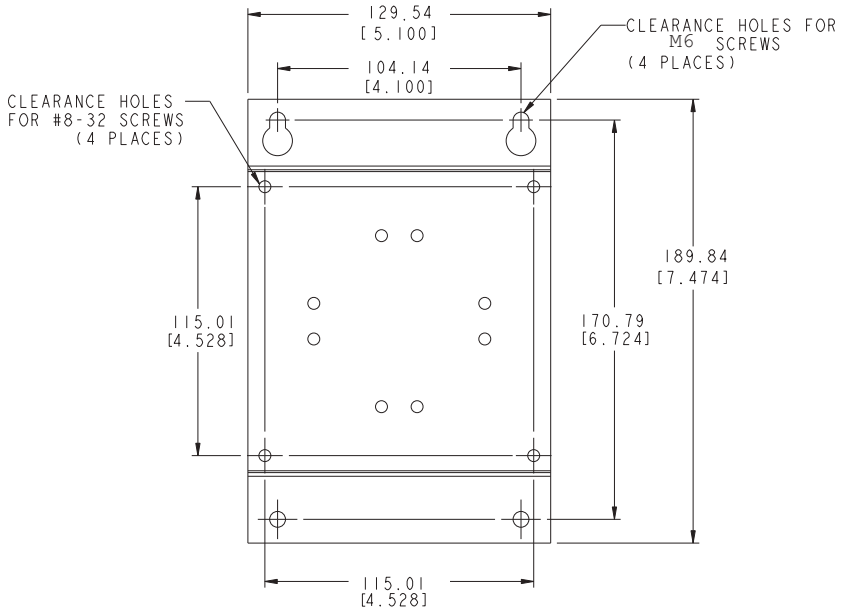
### Notes:

- Instrument weight: 4.8 kg
- Dimensions shown in millimetres.
- Install XIR sensor horizontal as shown.
- Cable gland threads are M25 x 1.5 mm OR 3/4" NPT x 14
- Instrument housing: 316 St.St.
- All cable shields to be terminated to ground earth at one end only.
- Certified cable glands or blanking plugs shall be installed at all cable entries during installation.
- NPT threads shall conform to the requirements of ANSI/ASME B1.20.1, and shall be made-up wrench tight.

### 9.3 Installation Outline Drawing [CE] - ULTIMA XA

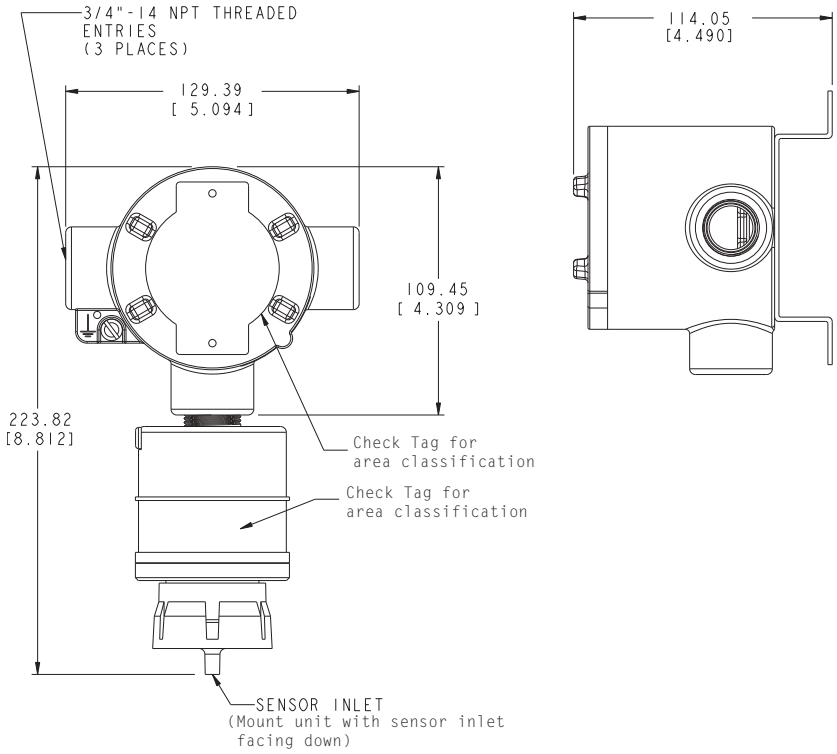


### 9.4 Installation - Mounting Bracket

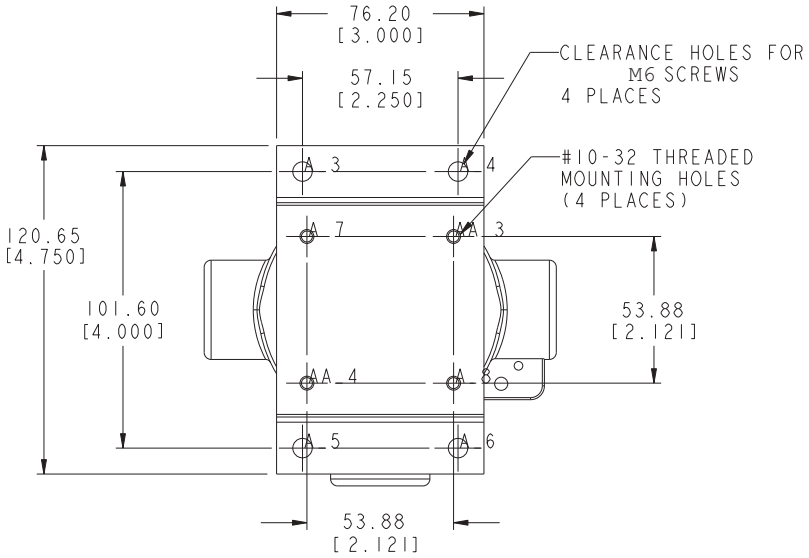


Optional ULTIMA XE and XA Mounting Bracket

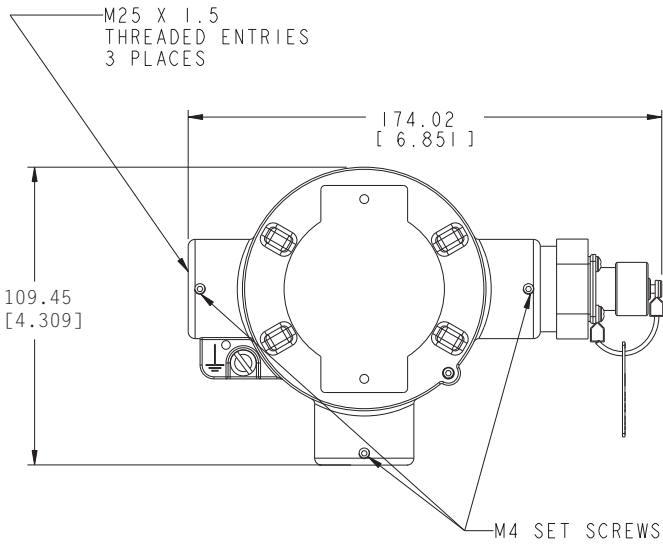
9.5 Remote non-reactive sensor and mounting bracket



3/4"-14 NPT THREADED ENTRIES SHOWN  
 WEIGHT = 7.12 LBS (3.23 KG.)

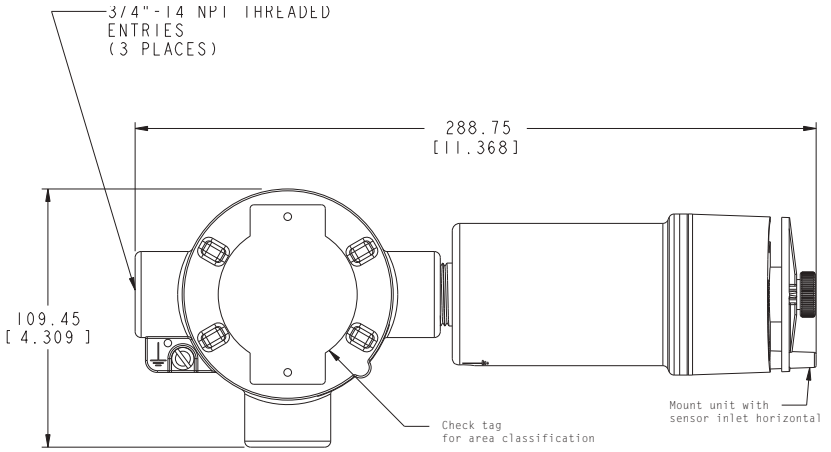


### 9.6 HART module

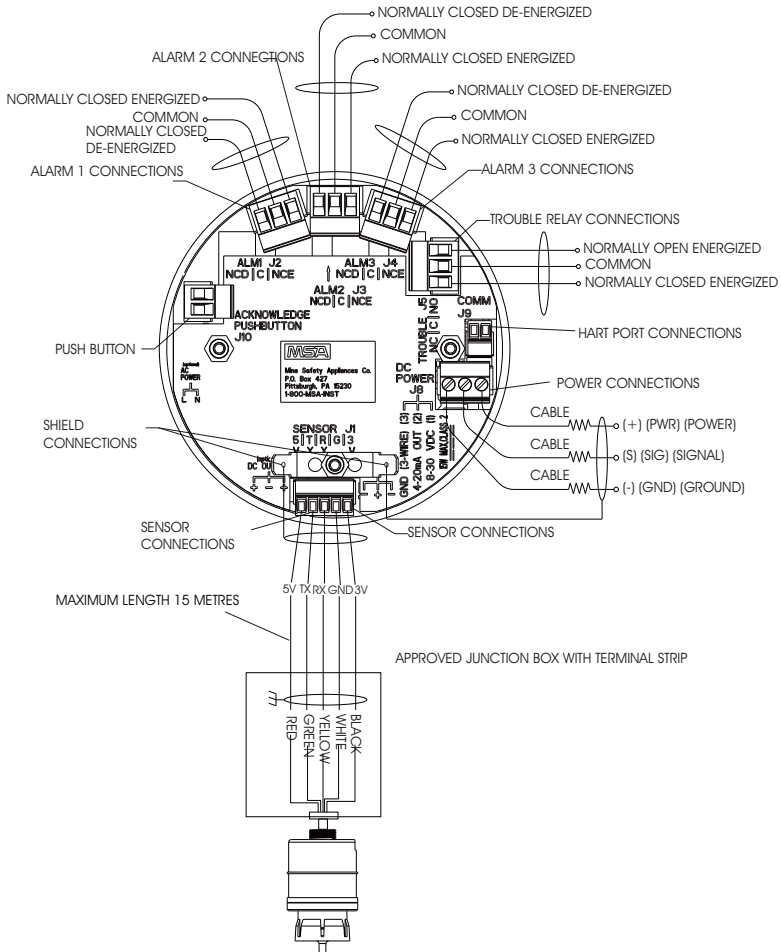




### 9.7 ULTIMA XIR Remote Sensor



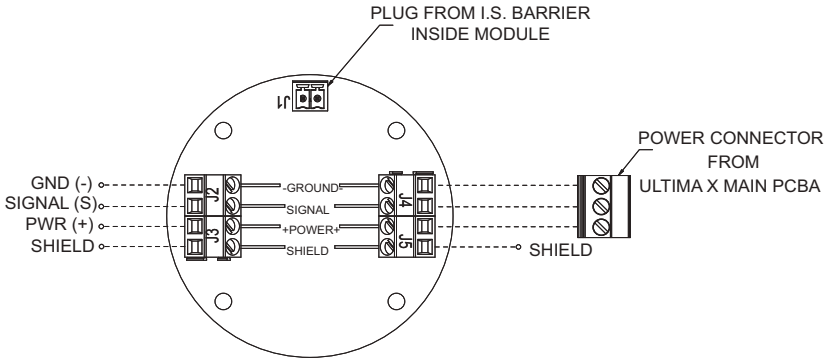
### 9.8 Installation Outline Drawing [CE] - ULTIMA XE Wiring Connections



**Notes:**

- Shield to be connected to earth ground at one end only.
- Customer installed normally open push button switch. SWITCH MUST BE APPROVED HAZARDOUS AREA USE.
- Certified cable glands or blanking plugs shall be installed at all cable entries during installation.

## 9.9 HART Module Connections



## 9.10 Connection to MSA Controllers

Maximum cable lengths in metres for cable with 1.5 mm<sup>2</sup>

ULTIMA X Type	SUPREMA	E292 VP	9010/20 [12 VA]	Gasgard XL	V-Factor *)
OX-TOX [2 wire]	1600	1500	1200	1000	--
OX-TOX [3 wire]	2000	1800	1500	1200	1.2
Catalytic [3 wire]	800	700	600	500	1.2
IR [3 wire]	500	350	300	250	1.2

\*) Cable extension factors for ULTIMA X without relay and LED. Use the following factors for different cable cross-sections:

$$1.0 \text{ mm}^2 = 0.66$$

$$1.5 \text{ mm}^2 = 1.00$$

$$2.5 \text{ mm}^2 = 1.45$$

### 9.11 Connection Drawings - SUPREMA

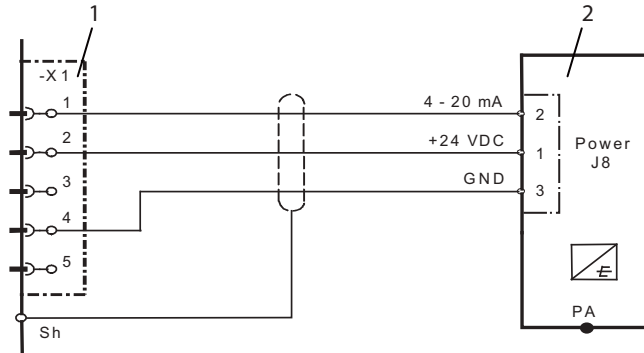


Fig. 15 Connection drawing - ULTIMA X [3-wire] to SUPREMA

1 SUPREMA

2 ULTIMA X

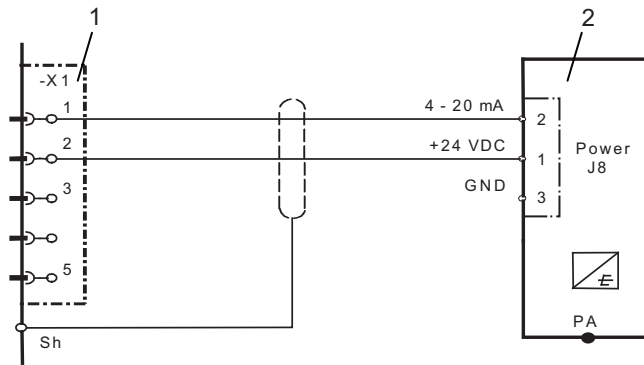


Fig. 16 Connection drawing - ULTIMA X [2-wire] to SUPREMA

1 SUPREMA

2 ULTIMA X

## 9.12 Connection Drawings - 9010/9020

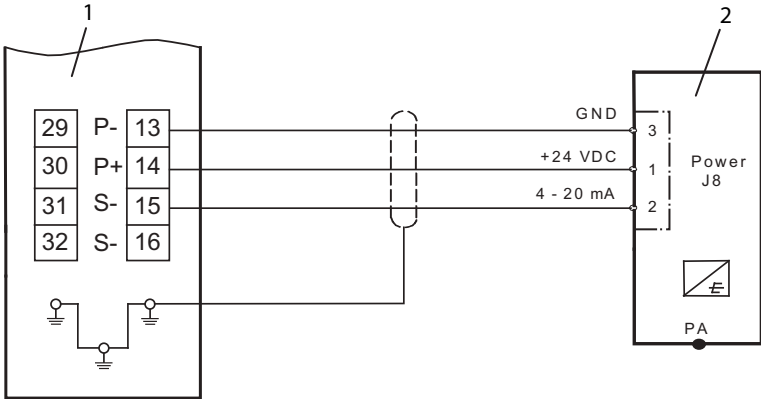


Fig. 17 Connection drawing - ULTIMA X [3-wire] to 9010/20 LCD

1 Terminal block 9010/9020

2 ULTIMA X

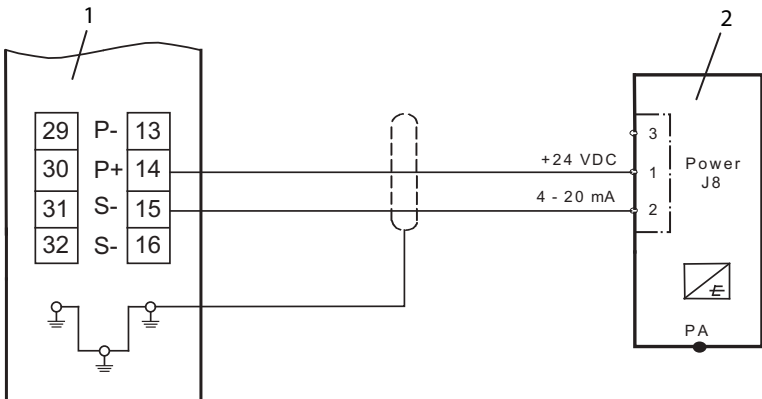


Fig. 18 Connection drawing - ULTIMA X [2-wire] to 9010/20 LCD

1 Terminal block 9010/9020

2 ULTIMA X

### 9.13 Connection Drawings - Gasgard

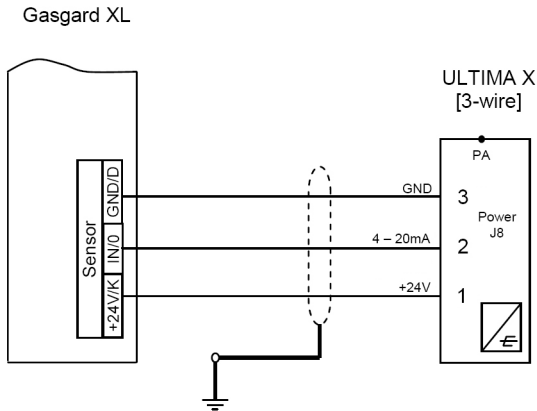


Fig. 19 Connection drawing - ULTIMA X [3-wire] to Gasgard XL

- 1 Channel card - Gasgard XL      2 ULTIMA X

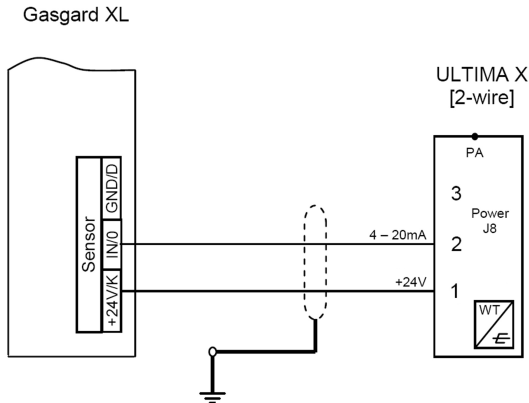


Fig. 20 Connection drawing - ULTIMA X [2-wire] to Gasgard XL

- 1 Channel card - Gasgard XL      2 ULTIMA X

## 9.14 Cable Lengths and Cross-section - Gas Monitors

### Toxic Gases and Oxygen Sensors with 4-20 mA Signal Output [2- wire Sensor]

Cross-section	Max. length at 24 V DC	Max. load resistance
1.0 mm <sup>2</sup>	2134 m	500 Ohm

### Catalytic Combustible Gas Sensor with 4-20 mA Signal Output [3- wire Sensor]

Power supply	24 V DC	
Configuration	without relay	with relay
Cross-section 1.0 mm <sup>2</sup>	762 m	640 m
Cross-section 1.5 mm <sup>2</sup>	1280 m	914 m
Max. load resistance at signal output	500 Ohm	

### Toxic Gases and Oxygen Sensors with 4-20 mA Signal Output [3- wire Sensor]

Cross-section	Max. length at 24 V DC	Max. load resistance
1.0 mm <sup>2</sup>	3658 m	500 Ohm

### Catalytic Combustible Gas Sensor with 4-20 mA Signal Output [3- wire Sensor]

Power supply	24 V DC	
Configuration	without relay	with relay
Cross-section 1.0 mm <sup>2</sup>	610 m	457 m
Cross-section 1.5 mm <sup>2</sup>	1067 m	762 m
Max. load resistance at signal output	500 Ohm	

## 9.15 Cable lengths and Cross-section - Remote Sensor Module \*)

	Minimum cross-section	Maximum length
Toxic gases and oxygen	1.00 mm <sup>2</sup>	30 m
Combustible gases, catalytic	1.00 mm <sup>2</sup>	15 m
	1.50 mm <sup>2</sup>	30 m
Combustible gases, IR	1.50 mm <sup>2</sup>	15 m
	2.50 mm <sup>2</sup>	30 m

\*) For instruments with CE mark, the maximum length is 15 metres.

# 10 Appendix: Instrument Specifications

## 10.1 Instrument Operation

Operating mode	LED		4 – 20 mA	Fault relay
	GREEN	RED		
No alarm	ON	OFF	Gas value	Energised
Alarm	OFF	Flashes	Gas value	Energised
Fault	OFF	ON	3.0 mA	De-energised
Power up [HART version]	OFF	ON Steady	< 3.75 mA	De-energised
Power up [Non-HART version]	OFF	ON Steady	< 3.1 mA	De-energised
Count-down [all versions]	OFF	ON Steady	Alarm option <sup>1)</sup> disabled: 21.0 mA for 02 , 3.75 mA for others	Energised if ALERT option disabled <sup>1)</sup>
			Alarm option <sup>1)</sup> enabled: 3.75 mA for all	De-energised if ALERT option enabled <sup>1)</sup>



Operating mode	LED		4 – 20 mA	Fault relay
	GREEN	RED		
Sensor missing / Countdown	OFF	ON	3.0 mA if SWAP delay time-out expired <sup>2)</sup> , SWAP delay disabled or FAULT	De-energised if SWAP delay timeout <sup>2)</sup> expired, SWAP delay <sup>3)</sup> disabled or FAULT
			Last gas value, if SWAP delay enabled and SWAP delay <sup>3)</sup> timeout not expired	Energised, if SWAP delay <sup>3)</sup> enabled and SWAP delay timeout has not expired <sup>2)</sup> .
Sensor calibration	OFF	ON	3.75 mA if calibration signal enabled and ALERT option <sup>1)</sup> enabled; gas value if calibration signal is disabled	Energised if ALERT option disabled
			21.0 mA for O <sub>2</sub> if calibration signal enabled and ALERT option <sup>1)</sup> disabled	De-energised if ALERT option enabled <sup>1)</sup>
Calibration 4-20	OFF	ON	4 mA, if 4 mA calibration selected	Energised if ALERT option disabled
			20 mA, if 20 mA calibration selected	De-energised if ALERT option enabled <sup>1)</sup>
Calibration fault	OFF	ON	Gas value	De-energised two seconds every minute
Under-range	OFF	ON	3.0 mA	De-energised
Overrange/LOC	ON <sup>4)</sup>	OFF <sup>4)</sup>	21 mA	Energised

<sup>1)</sup>See Calibrator/Controller manual for ALERT option.

<sup>2)</sup>SWAP delay signal is 60 s if enabled, otherwise 0 s.

<sup>3)</sup>See Calibrator/Controller manual for SWAP delay options.

<sup>4)</sup>Alarm operation will follow if the alarms are enabled.

## 10.2 Sensor Response to Interferants

Interferant	Concentration [ppm]	CO filtered	H <sub>2</sub> S	Cl <sub>2</sub>	SO <sub>2</sub> filtered	NO	NO <sub>2</sub>
Acetone	1000	0	0	0	0	No Data	0
Acetylene	12000	0	0	0	0	No Data	No Data
Ammonia	25	0	0	0	0	No Data	0
Arsine	1	0	0	0	0	0	No Data
Benzene	20	0	0	0	0	No Data	No Data
Bromine	2	0	0	2.5	No Data	0	0
Carbon Dioxide	5000	0	0	0	0	0	0
Carbon Disulfide	15	0	0	0	0	0	No Data
Carbon Monoxide	100	100	0.3	0	0.2	No Data	0
Chlorine	5	0	-3	5	0	0	0
Diborane	20	0	0	0	0	No Data	No Data
Ethylene	50	100	0.1	0	0	No Data	0
Ethyl Alcohol	100	115	0	0	0	No Data	No Data
Ethyle Oxide	10	No Data	No Data	No Data	0	No Data	No Data
Ether	400	3	0	0	0	No Data	0
Fluorine	5	0	0	2.5	0	0	No Data
Freon 12	1000	0	0	0	0	0	0
Germane	1	0	0	0	0	0	No Data
Hexane	500	0	0	0	0	No Data	0
Hydrogen	500	200	0.5	0	15	No Data	-10
Hydrogen Chloride	50	0	0	0	0	4	0
Hydrogen Cyanide	10	0	0	0	0	0	0
Hydrogen Fluoride	10	0	0	0	0	No Data	No Data

Interferant	Concentration [ppm]	CO filtered	H <sub>2</sub> S	Cl <sub>2</sub>	SO <sub>2</sub> filtered	NO	NO <sub>2</sub>
Hydrogen Sulfide	10	1	10	-0.1	0	1	-8
MEK	200	0	0	0	0	0	0
Mercaptan [Methyl]	5	0	4.5	-0.1	0	1	No Data
Methane	5000	0	0	0	0	0	0
Nitric Oxide	100	0	2	0	2	100	No Data
Nitrogen Dioxide	5	-1	-4	0.5	-5	1.5	5
Phosphine	0.5	No Data	0	0	No Data	0	No Data
Silane	5	0	0	0	0	0	No Data
Sulfur Dioxide	10	0	0.3	0	10	0.5	No Data
Tichloro-ethylene	1000	0	0	0	0	0	No Data

Interferant	Concentration [ppm]	HCN	HCL	ClO <sub>2</sub>	HF	PH <sub>3</sub>	ASH <sub>4</sub>	SIH <sub>4</sub>
Acetone	1000	No Data	No Data	0	No Data	No Data	No Data	No Data
Acetylene	12000	No Data	No Data	0	No Data	No Data	No Data	No Data
Ammonia	25	0	0	0	0	No Data	No Data	No Data
Arsine	1	No Data	1	0	No Data	0.7	1	1
Benzene	20	0	No Data	0	No Data	No Data	No Data	No Data
Bromine	2	0	No Data	1	No Data	No Data	No Data	No Data
Carbon Dioxide	5000	0	0	0	No Data	No Data	No Data	No Data

Interferant	Concentration [ppm]	HCN	HCL	ClO <sub>2</sub>	HF	PH <sub>3</sub>	ASH <sub>4</sub>	SIH <sub>4</sub>
Carbon Disulfide	15	0.1	0	0	No Data	0	0	0
Carbon Monoxide	100	0	0	0	No Data	0	1	0
Chlorine	5	-0.2	0	2.5	5	No Data	No Data	No Data
Diborane	20	No Data	0	0	No Data	3.5	5	4
Ethylene	50	-0.3	No Data	0	No Data	0.5	1	1
Ethyl Alcohol	100	0	No Data	0	No Data	No Data	No Data	No Data
Ethyle Oxide	10	No Data	No Data	0	No Data	No Data	No Data	No Data
Ether	400	No Data	No Data	0	No Data	No Data	No Data	No Data
Fluorine	5	0	0	1	No Data	No Data	No Data	No Data
Freon 12	1000	0	0	0	0	0	0	0
Germane	1	No Data	1	0	No Data	0.7	1	1
Hexane	500	0	No Data	0	No Data	No Data	No Data	No Data
Hydrogen	500	0	0	0	No Data	0	0	0
Hydrogen Chloride	50	No Data	50	0	30	No Data	No Data	No Data
Hydrogen Cyanide	10	10	0	0	0	No Data	No Data	No Data
Hydrogen Fluoride	10	No Data	No Data	0	No Data	No Data	No Data	No Data
Hydrogen Sulfide	10	50	40	0	No Data	No Data	No Data	No Data

Interferant	Concentration [ppm]	HCN	HCL	ClO <sub>2</sub>	HF	PH <sub>3</sub>	ASH <sub>4</sub>	SiH <sub>4</sub>
MEK	200	No Data	No Data	0	No Data	No Data	No Data	No Data
Mercaptan [Methyl]	5	6	No Data	0	No Data	No Data	No Data	No Data
Methane	5000	0	0	0	No Data	No Data	No Data	No Data
Nitric Oxide	100	-3	40	0	2	No Data	No Data	No Data
Nitrogen Dioxide	5	No Data	0	0.2	2.5	No Data	No Data	No Data
Phosphine	0.5	No Data	2	0	No Data	0.5	1	0.7
Silane	5	No Data	7	0	No Data	0.1	0.2	5
Sulfur Dioxide	10	-0.3	0	0	2.7	0.5	1	2
Tichloro-ethylene	1000	No Data	No Data	0	No Data	No Data	No Data	No Data

Interferant	Concentration [ppm]	GeH <sub>3</sub>	B <sub>2</sub> H <sub>6</sub>	Br <sub>2</sub>	F <sub>2</sub>	NH <sub>3</sub>	NH <sub>2</sub>	EtO
Acetone	1000	No Data	No Data	0	0	No Data	No Data	No Data
Acetylene	12000	No Data	No Data	0	0	No Data	No Data	No Data
Ammonia	25	No Data	No Data	0	0	25	No Data	0
Arsine	1	1	5	0	0	No Data	No Data	No Data
Benzene	20	No Data	No Data	0	0	No Data	No Data	No Data
Bromine	2	No Data	No Data	2	12	No Data	No Data	No Data

Interferant	Concentration [ppm]	GeH <sub>3</sub>	B <sub>2</sub> H <sub>6</sub>	Br <sub>2</sub>	F <sub>2</sub>	NH <sub>3</sub>	NH <sub>2</sub>	EtO
Carbon Dioxide	5000	No Data	No Data	0	0	0	0	No Data
Carbon Disulfide	15	0	0	0	0	No Data	No Data	No Data
Carbon Monoxide	100	0	0	0	0	0	2	No Data
Chlorine	5	No Data	No Data	4	10	0	0	0
Diborane	20	5	20	0	0	No Data	No Data	No Data
Ethylene	50	1	2	0	0	0	40	No Data
Ethyl Alcohol	100	No Data	No Data	0	0	No Data	No Data	0
Ethyle Oxide	10	No Data	No Data	No Data	No Data	No Data	No Data	10
Ether	400	No Data	No Data	0	0	No Data	No Data	No Data
Fluorine	5	No Data	No Data	2	5	No Data	No Data	No Data
Freon 12	1000	0	0	0	0	0	0	0
Germane	1	1	5	0	0	No Data	No Data	No Data
Hexane	500	No Data	No Data	0	0	No Data	No Data	No Data
Hydrogen	500	0	0	0	0	No Data	500	0
Hydrogen Chloride	50	No Data	No Data	0	0	0	0	No Data
Hydrogen Cyanide	10	No Data	No Data	0	0	0	3	0
Hydrogen Fluoride	10	No Data	No Data	0	0	No Data	No Data	No Data

Interferant	Concentration [ppm]	GeH <sub>3</sub>	B <sub>2</sub> H <sub>6</sub>	Br <sub>2</sub>	F <sub>2</sub>	NH <sub>3</sub>	NH <sub>2</sub>	EtO
Hydrogen Sulfide	10	No Data	No Data	0	-0.2	0.5	1	No Data
MEK	200	No Data	No Data	0	0	0	No Data	3
Mercaptan [Methyl]	5	No Data	No Data	0	-0.2	No Data	No Data	No Data
Methane	5000	No Data	No Data	0	0	No Data	No Data	No Data
Nitric Oxide	100	No Data	No Data	0	0	0	3	No Data
Nitrogen Dioxide	5	0.5	No Data	0.4	1	No Data	No Data	0
Phosphine	0.5	1	3	0	0	0	0	0
Silane	5	0.2	15	0	0	No Data	No Data	No Data
Sulfur Dioxide	10	3	6	0	0	0	0	No Data
Tichloroethylene	1000	No Data	No Data	No Data	0	No Data	No Data	No Data

## 11 Appendix: Instrument Messages

### 11.1 Messages during Instrument Operation

Messages	Meaning
MM/DD/YY	Date format
VER	Software version
TIME	Time
DATE	Date
MIN	MINIMUM value of interval
MAX	MAXIMUM value of interval
AVG	Average gas concentration of interval
Adr	Instrument address
End	Calibration cycle ends
Err	Error code
HR	Hour display [one or two character]
OVER	Gas value exceeds the set range

### 11.2 Messages during Instrument Configuration

Messages	Meaning
CAL SIG ON	Instrument issues calibration signal during calibration
CAL SIG OFF	Instrument issues gas value during calibration
LTCH/	Latching relay
UNLTCH/	Non-latching relay
INCR/	Increasing alarm relay operation
DECR/	Decreasing alarm relay operation
ENER/	Operating with energised relay
DENER/	Operating with de-energised relay
CAL	Normal calibration or 4-20 calibration cycle
iCAL	Initial calibration
OFF	Alarm is OFF
ON	Alarm is ON
RNGE	Instrument full-scale
PCAL	Date of last calibration



Messages	Meaning
TBLE	Instrument gas table selection [if applicable]
ALERT OP ON	Instrument output will follow ALERT mode
ALERT OP OFF	Instrument will not follow ALERT mode
SWAP DELAY ON	60 second delay after sensor missing before fault
SWAP DELAY OFF	Fault occurs at sensor missing condition

### 11.3 Instructions for Troubleshooting

Message	Meaning	Remedy
MN FLASH FAULT	Main printed circuit board program memory is invalid	- Replace main printed circuit board.
MN RAM FAULT	Main printer circuit board shows defective RAM memory segment	- Replace main printed circuit board.
MN EEPROM FAULT	Main printed circuit board EEPROM is invalid	- Replace main printed circuit board.
SENSOR MISSING	Instrument has lost data communication with the sensor module	- Connect sensor or replace sensor.
SNSR FLASH FAULT	Sensor module program memory is invalid	- Replace sensor module.
SNSR RAM FAULT	There is a RAM-memory segment defect in the sensor module	- Replace sensor module.
SNSR DATA FAULT	Sensor module data sheet is invalid	- Send the reset data sheet command from the controller or - if error persists replace sensor.
INVALID SENSOR	The connected sensor module is not compatible with the instrument	- Replace it with the correct sensor type.
+SUPPLY FAULT	Power supply of main printed circuit board is outside permissible range	- Check sensor wiring or replace main printed circuit board.

Message	Meaning	Remedy
RELAY FAULT	An error has occurred in the internal relays	- Disconnect instrument from power supply and connect again or - replace printed board.
SNSR POWER FAULT	Power supply of sensor module outside permissible range	- Correct wiring fault replace printed circuit board or sensor module.
IR SOURCE FAULT	A fault has occurred in the IR source	- Replace IR source or contact manufacturer.
“FIXED CURRENT MODE”	4-20mA is at a set level and will not change when gas is applied or under fault conditions	- Exit Fixed Current Mode using the HART controller
-SUPPLY FAULT	The sensor module negative supply is outside the permissible range	- Check wiring or replace sensor module.
REF SIG FAULT	A fault has occurred in the IR reference detector	- Replace IR reference detector or contact manufacturer.
ANA SIG FAULT	A fault has occurred in the analytical IR detector	- Replace IR detector or contact manufacturer.
LOW SIGNAL	The IR signal is too low	- Clean optics or replace sensor module.
PARAM FAULT	An operating parameter is outside the permissible range or the sensor has failed the internal test	- Restart instrument or replace.
CONFIG RESET	Main EEPROM memory was reset	- Use Controller to reset all configurations [e.g. alarm levels, calibration signal on or off].
CHANGE SENSOR	Sensor life expired	- Replace sensor.

Message	Meaning	Remedy
ZERO CAL FAULT / SPAN CAL FAULT	Instrument did not calibrate successfully	- Repeat calibration - Check if the correct cali- bration gas was used . - Check flow system for blockage
SENSOR WARN- ING	Sensor life has almost ex- pired	- Prepare to replace sen- sor.
CHECK CAL	Check calibration	- Carry out bump test or calibration.
+LOC	Instrument is locked in over- range condition	- Calibrate or reset sensor.
OVER % LEL	Sensor is exposed to a gas concentration above the LEL	- The instrument will return to normal operation when the gas concentration drops below 100 % LEL.
Und	Underrange condition - slow -	- Calibrate or replace sen- sor.
und	Underrange condition - fast -	- Calibrate or replace sen- sor.

The highest priority message is displayed first. Lower priority messages are output only after the highest priority message is cleared. A manual selected scanning of low-priority messages is not possible.

## 12 Appendix: Optional Internal Relays and RESET Button

### 12.1 General

The internal relays are designed to enable ULTIMA® X Series Gas Monitors to control other equipment. The four optional relays are located under the display module and provide the following functions:

- three alarm relays and
- one fault relay.

After configuration, the relays activate when an alarm condition is detected. Similarly, the fault relay is de-energised when a fault is detected.

The alarm relays are set to "non-latching" and "de-energised" at the factory.

To disable or configure the alarms, use the ULTIMA/ULTIMA X Controller.

The fault relay is normally energised so that it is de-energised and is switched to a fail-safe condition in case of a fault or power failure. Information on this is given in chapter D-3 of this appendix.

To prevent false alarms, the alarms/relays are temporarily disabled in the following cases:

- During the first minute after connecting to the power supply
- During calibration
- For two minutes after the calibration

### 12.2 Mounting and Wiring of instruments

Mount and wire the ULTIMA X® Series according to the instructions in chapter 3, "Installation".

All electrical connections to the ULTIMA X® Series Gas Monitor can be made via the clearly marked board mounted connections.

For complete configuration instructions [→ ULTIMA/ULTIMA X Series Controller and Calibrator Operating Manual].



To avoid problems due to electrical interference, do not run AC cables from relays in the same conduit or cable tray as the DC signal cable.

---

### Permissible Cable Length for the ULTIMA X<sup>®</sup> Series with Internal Relays [4-20 mA models]

The permissible cable length varies for models with or without internal relays.

Sensor type	Supply voltage	Wire cross-section	Max. cable length	Max. load resistance [mA output]
Combustible gases, catalytic	24 V DC	1.5 mm <sup>2</sup>	800 m	500 Ohm
Combustible gases, IR	24 V DC	1.5 mm <sup>2</sup>	500 m	500 Ohm
Toxic gases and oxygen	24 V DC	1.5 mm <sup>2</sup>	2000 m	500 Ohm



Screened cable is recommended for the installation.

### Specifications for Relays in the ULTIMA X<sup>®</sup> Series Gas Monitor with Internal Relays

Temperature range		-40 °C to +60 °C	
Humidity		15 % to 95 % RH non-condensing	
Relays	3 alarms	SPDT [single pole, double throw]	
	Fault relay [normally energised]	SPDT [single pole, double throw]	
Relay Ratings	At 125 V AC or 250 V AC, non-inductive	5.0 A or 5 A at 75 W	
	At 30 V DC, non-inductive	5.0 A or 5 A at 75 W	
Power consumption [instrument with relay]	Toxic gases and oxygen	At 24 V DC	max. 80 mA
	Combustible gas, catalytic	At 24 V DC	max. 200 mA
	Combustible gas, IR	At 24 V DC	max. 250 mA

## 12.3 Alarm Relays

[→ Fig. 7 in chapter 3.4]

There are three alarm relays and one fault relay in the ULTIMA X<sup>®</sup> Series Gas Monitors.

The three alarm relays will be activated if the sensor detects a gas concentration that lies outside the limit values. The adjustment range of the alarm set-points is 0 – 60 % full scale. By default, the alarms 1, 2 and 3 are set at 10 %, 20 % and 30 % of the full scale reading and will be activated when the gas reading is above these values. The oxygen model is an exception in the following cases:

- Alarm 1 is set at 19 % oxygen and is activated when the oxygen reading falls below this setpoint.
- Alarm 2 is set at 18 % oxygen and is activated when the oxygen reading falls below this setpoint.
- Alarm 3 is set at 22 % oxygen and is activated when the oxygen reading rises above this setpoint.
- The adjustment range of oxygen alarm set-points is 0 - 25 Vol%.

These default setpoints can be changed or verified with the ULTIMA/ULTIMA X Controller [→ ULTIMA/ULTIMA X Series Controller and Calibrator Operating Manual]. In addition, the "latching alarm" option can be enabled with the Controller.

Each alarm relay has one set of change over contacts [single pole double throw – SPDT]. They are marked as follows:

- NCD [normally closed when relay is de-energised]
- C [common] or
- NCE [normally open, when relay is energised].

ULTIMA X Series Gas Monitors are delivered with the alarm relays factory set to the de-energised [no-alarm] position and the fault relay is set to energised [no-fault] position.

Upon activation, the relay contacts change state and remain in this state as long as the alarm condition exists within the ULTIMA<sup>®</sup> X Series Gas Monitor or latching mode is selected. These defaults can be verified or changed with the ULTIMA/ULTIMA X Controller.

[→ "Instructions for resetting alarms" with the Calibrator/Controller in chapter 5.1].

## 12.4 Fault Relay [Trouble]

[→ Fig. 7 in chapter 3.4]

It is a normally-energised, single-pole, double throw [SPDT] relay. During normal operation, the normally closed [NC] contacts are closed. When a fault is detected or the power is disconnected the relay contacts will change as follows:

- the normally closed contacts [NC] will open
- the normally open contacts [NO] will close

and the relay switches to a fault condition.

The relay can remain STEADY ON or PULSED. These two different modes can communicate different information to a PLC or DCS connected to the Fault Relay.

### "STEADY ON" indicates:

- The ULTIMA X<sup>®</sup> Series sensor is not correctly connected or
- There is a fault in the ULTIMA X<sup>®</sup> Series Gas Monitor or
- a relay has failed.

### PULSED [once per minute] indicates:

- The calibration of the ULTIMA X<sup>®</sup> Series Gas Monitor is invalid or
- The CHECK CAL or CAL FAULT message appears on the ULTIMA X<sup>®</sup> Series Gas Monitor.

## 12.5 Optional RESET Button

The optional RESET button is to allow latching relays to be reset at the Gas Monitor location.

The RESET button must be a normally open type with a momentary contact when pressed and have electrical ratings of at least 1 amp at 250 V AC.



The RESET push button must be installed remotely and not directly into the ULTIMA X cable gland entry. The switch must be fitted in an approved junction box and be ATEX approved for hazardous area use.

---

Latching relays can be configured using the ULTIMA/ULTIMA X Series Controller.

In the "latching" configuration, when the RESET button is pressed, any latched alarm will be reset providing the gas concentration that activated the alarm is below the alarm set-point. In the "non- latching" configuration, the RESET button has no effect on the alarms.



The RESET function can also be executed by an infrared command from the ULTIMA/ULTIMA X Series Controller [→ ULTIMA/ULTIMA X Series Controller and Calibrator Operating Manual].

## 12.6 Calibration with RESET Button

To calibrate the instrument using the RESET button, proceed as follows:

- (1) Press and hold RESET button until the heart symbol appears on the display.
- (2) Release RESET button.
  - ▷ At this point any latched alarms will be reset.
- (3) Press the RESET button again within 3 seconds of releasing it and hold until the required calibration is displayed [→ table below].

Type of calibration	Display	Holding time for RESET button
Zero calibration	CAL ZERO	5 seconds
Span calibration	CAL SPAN	10 seconds
Initial calibration	iCAL	20 seconds

- (4) Release RESET button when the desired type of calibration is displayed.



During the 30 seconds countdown, the zeroing or span calibration can be aborted at any time by pressing and holding the RESET push button until the heart symbol is displayed.

When the push button is released the calibration will be aborted.

- (5) For details of the calibration procedure [→ chapter 5.3].

## 12.7 Relay Connections

All electrical connections to the internal relays can be made directly on the printed board [→ Figure 7]. When connecting the relays to motors, fluorescent lamps or other inductive loads, it is necessary to suppress any sparks or inductive feedback that may occur at the relay contact. These effects may damage the instrument and make it inoperative.

One way to reduce these effects is to install a “Quencharc”, available from MSA as part number 630413, across the load being switched.



**Attention!**

Before connecting the cable to ULTIMA® X Series Gas Monitors, disconnect or isolate the monitor power source otherwise there is danger of electric shock.

To connect the relay, the ULTIMA® X Series Gas Monitor must be opened. Proceed as described below:

- (1) Remove the ULTIMA X® Series Gas Monitor enclosure cover.



To enable correct connection of all plugs note their location before removing them.

- (2) Pull the terminal plugs to release them from the now accessible printed board.
- (3) Feed the cable [not included] into the enclosure and connect it to the appropriate terminal plugs.
- (4) Make sure that each cable conductor is connected correctly to ensure proper functioning of the Gas Monitor.
- (5) If installing a RESET push-button:
  - Feed a 2-wire cable to the J10 terminal plug [Figure 4].
  - Connect the 2-wire cable to the two connections of the J10 terminal plug.
  - Identify the cable to allow proper connection at the push-button.
  - Route the cable to the push-button switch and connect the cable to it.



Route the 2-wire cable to avoid electrical interference from relay wiring.

- (6) Re-install the connector plugs to the correct printed circuit board locations. Make sure the connector terminal plugs are completely pushed in to the printed circuit board sockets.
- (7) Pull the cable from the instrument to remove any excess slack.



To avoid unwanted electrical noise it is important not to have any excess wire or cable inside the enclosure.

- (8) Replace the ULTIMA® X Series Gas Monitor cover.

## 13 Appendix: HART Specific Information

### 13.1 HART Field Device Specification

The ULTIMA X Series Gas Monitor is available with an optional HART [Highway Addressable Remote Transducer] output communications protocol. With this option, the ULTIMA X Series Gas Monitor complies with HART Protocol Revision 7 and uses the 16-bit manufacturer and device codes. This document specifies all the device specific features and documents HART Protocol implementation details [e.g., the Engineering Unit Codes supported]. These specifications assume the reader is somewhat familiar with HART Protocol requirements and terminology.

This specification is a technical reference for HART-capable HOST Application Developers, System Integrators and knowledgeable End Users. It also provides functional specifications [e.g., commands, enumerations and performance requirements] used during Field Device deployment, maintenance, testing, and operations. It is recommended that the 4-20 mA output be the primary gas monitoring signal. The HART signal can be the secondary method.



#### ATEX applications

HART shall only be used for ULTIMA configuration, calibration or diagnostics. For safety relevant applications, the 4-20 mA analogue output shall be used for measuring values.



The two-wire units' HART protocol does not comply fully with Immunity Standards EN61000-4-3 [2006] and EN61000-4-6 [2007].

Manufacturer Name	MSA	Model Name	ULTIMA
Manufacture ID Code	0X6008	Device Type Code	0xE09F
HART Protocol Revision	7	Device Revision	1
Number of Device Variables	1	Notes:	
Physical Layers Supported	FSK, 4-20 mA		
Physical Device Category	Current Output		

## Host Interface

### Analogue Output

The three-wire 4-20 mA current loop is connected on terminals marked 8-30 VDC [1], 4-20 mA OUT[2], and GND [3-wire] [3]. The two-wire 4-20 mA current loop is connected on the 8-30 VDC[1] and 4-20 mA OUT[2] terminals. Refer to the installation outline drawings for details.

This is the main output from this transmitter, representing the process gas measurement, linearised and scaled according to the configured instrument range. This output corresponds to the Primary Variable [PV]. HART communications are supported on this loop. This device has a Capacitance Number [CN] of 1.

An inoperative device can be indicated by down-scale or up-scale current, depending on the sensor type. Current values are shown in the following table:

### Current Values

	Direction	Values [% of Range]	Values [mA or V]
Linear over-range	Down	0%	4.00 mA
	Up	+105.0% +1.0%	20.64 to 20.96 mA
Device malfunction indication	Down: less than		3.5 mA
	Up: greater than		20.96 mA
Maximum current			22.0 mA
Multi-drop Current draw			3.5 mA
Lift-off voltage, 3-wire PCBA			8 VDC
Lift-off voltage, 2-wire PCBA			13 VDC at 250 Ohms

**Device Variables Exposed by the ULTIMA Monitor**

<b>Variable</b>	<b>Description</b>	<b>Variable</b>	<b>Description</b>
Gas Type	Sensor gas type description	Last Cal Date	Date sensor was last calibrated
Alarm Setpoints	Gas value at which an alarm status bit is set	Auto Zero comp	Amount of compensated below zero drift
Alarm Action	increasing or decreasing alarm type, latching or non latching	Alert option status	See next chapter
Alarm Status	Indication of alarm setpoint exceeded	Swap Delay status	See next chapter
Input Voltage	Device input voltage level		
Min/Max/Avg	Minimum, maximum and avg. value of PV over time	Sensor Temp	
Avg Interval	Time interval for min, max, avg [1, 8 or 24 hr]	Sensor Status	Status returned by sensor
Gas Table	Linerisation table selection	Relay EN/De-eng	Relay EN/De-eng
Cal Sig	Cal Signal Status		
RTC Date	Device real time clock date		
RTC Min	Device real time clock minutes		
RTC Hrs	Device real time clock hours		

**Dynamic Variable implemented by ULTIMA Monitor**

	<b>Meaning</b>	<b>Units</b>
PV	Gas Value	%, %LEL, PPM

## Status Information

### Device Status

Bit 4 ["More Status Available"] is set when any failure is detected. Command #48 gives further details.

### Extended Device Status

The ULTIMA Monitor can predict when certain maintenance will be required. This bit is set if a sensor fault or maintenance warning is detected. "Device Variable Alert" is set if the PV is out of limit.

### Additional Device Status [Command #48]

Command #48 returns 5 bytes of data, with the following status information:

0	0	Configuration Reset	Error	4,7
	1	Main ram fault	Error	4,7
	2	Main flash fault	Error	4,7
	3	EEProm write error	Error	4,7
	4	Incompatible sensor	Error	4,7
	5	Sensor quick under range	Error	4,7
	6	Sensor UNDER range	Error	4,7
	7	Calibration fault	Error	4,7
1	0	Sensor Missing	Error	4,7
	1	Sensor Overrange	Warning	
	2	Overrange Lock	Warning	
	3	Parameter Fault	Error	4,7
	4	Sensor Warm up	Warning	
	5	Sensor Config Reset	Warning	
	6	Sensor Power Fault	Error	
	7	5V Power Fault	Error	
2	0	Zero Countdown	Info	
	1	Apply Zero Gas	Info	
	2	Span Countdown	Info	
	3	Apply Span Gas	Info	
	4	Cal Aborted	Info	
	5	Zero Fault	Info	

	6	Span Fault	Info	
	7	Cal OK	Info	
3	0	End of Life Warning	Warning	4,7
	1	Sensor Swap Delay	Info	
	2	Change Sensor Fault	Error	
	3	Sensor Power Fault	Error	4,7
	4	Internal Comm Fault	Error	
	5	Cal Sig Enable	Info	
	6	Alert Option Enable	Info	
	7	Relay Fault	Error	
4	0	Alarm 1 Set	Warning	
	1	Alarm 2 Set	Warning	
	2	Alarm 3 Set	Warning	
	3			
	4			
	5			
	6			
	7			

"Not used" bits are always set to 0.

Some bits used in this transmitter indicate device or sensor failure and, therefore, also set bit 7 and bit 4 of the Device Status byte.

These bits are set or cleared by the self-test executed at power up, or following a reset. They are also set [but not cleared] by any failure detected during continuous background self-testing.

## 13.2 Universal Commands

All Universal commands have been implemented in the ULTIMA Gas Monitor. The ULTIMA Gas Monitor returns a 7 in the Universal rev to indicate the device is using the expanded 16-bit manufacturer and device codes.

## 13.3 Common-Practice Commands

The following Common Practice commands have been implemented in the ULTIMA device:

### Supported Commands

Command #	Description
35	Write Range Values
38	Reset "Configuration Changed" flag
40	Enter/Exit Fixed Current Mode
See <b>Warning</b> below	
42	Perform Master Reset
45	Trim DAC Zero
46	Trim DAC Gain
48	Read Additional Device Status
59	Write Number of Response Preambles
71	Lock Device
72	Squawk
80	Read Device Variable Trim Point

### Burst Mode

This device supports burst mode.

### Catch Device Variable

This Field Device does not support Catch Device Variable.



#### Warning!

The gas monitor will NOT register gas concentration changes on the 4-20 mA signal line if the operator places the unit in Fixed Current Mode. Implement alternate protection measures when the unit is placed in this mode. Make sure the unit is returned to Standard Operational Mode prior to use for gas detection.

### Device-Specific Commands

The following device-specific commands are implemented in the ULTIMA Monitor:

Command #	Description
129	Read Sensor Gas Type
130	Read Device RTC
131	Read Alarm Setpoints
132	Read Alarm Control Actions
133	Read Min/Max/Average Values
134	Read Last Cal Date
135	Read Gas Table
136	Read Input Voltage
137	Read Auto Zero Comp
139	Read Sensor Status
140	Read Swap Delay Status
141	Read Cal Signal Status
142	Read Alert Option Status
143	Read Sensor Temperature
144	Read Relay Normal State
173	Write Device RTC
174	Write Alarm Setpoints
175	Write Alarm Control Actions
176	Write Average Interval
177	Write Upper Trim Point
178	Write Gas Table
179	Write Sensor Data sheet Reset
180	Write Sensor Swap Delay Enable
181	Write Cal Signal Enable
182	Write Calibration Mode
183	Write Calibration Abort
184	Write Calibration Step
185	Write Alarm Acknowledge
186	Write Protect Mode
187	Write Alert Option



Command #	Description
188	Write Relay Normal State

**Command #129: Read Sensor Gas Type**

Reads the Gas Type of the sensor currently connected to the ULTIMA Gas Monitor.

**Request Data Bytes**

None.

**Response Data Bytes**

Byte	Format	Description
0-3	ASCII	Sensor gas type description [→ Table 13.8]

**Command #130: Read Device Real Time Clock**

Reads the Real Time clock hours and minutes from the ULTIMA X Gas Monitor.

**Request Data Bytes**

None.

**Response Data Bytes**

Byte	Format	Description
0	Unsigned	RTC Hours
1	Unsigned	RTC Minutes

**Command #131: Read Alarm Setpoints**

Reads the ULTIMA X Alarm Setpoint values.

**Request Data Bytes**

None.

**Response Data Bytes**

Byte	Format	Description
0-3	Float	Alarm 1 Setpoint Value
4-7	Float	Alarm 2 Setpoint Value
8-11	Float	Alarm 3 Setpoint Value

**Command #132: Read Alarm Control Actions**

Reads the ULTIMA X Alarm Control Actions.

**Request Data Bytes**

None.

**Response Data Bytes**

Byte	Format	Description
0	Bit Enum	Alarm 1 Control Actions [→ Table 13.5]
1	Bit Enum	Alarm 2 Control Actions [→ Table 13.5]
2	Bit Enum	Alarm 3 Control Actions [→ Table 13.5]

**Command #133: Read Min, Max, Avg Values**

Returns the ULTIMA minimum, maximum and average values recorded over an average interval. The average interval can be a value of 1, 8, or 24 hours. For a one-hour interval, the value is updated at the top of each hour. For an eight-hour interval, the values are updated at 800, 1600 and 2400 hours.

**Request Data Bytes**

None.

**Response Data Bytes**

Byte	Format	Description
0-3	Float	Minimum Value
4-7	Float	Maximum Value
8-11	Float	Average Value
12	Unsigned	Average interval [1, 8, or 24]

**Command #134: Read Last Cal Date**

Returns the ULTIMA last calibration date of the currently connected sensor.

**Request Data Bytes**

None.

**Response Data Bytes**

Byte	Format	Description
0-2	Unsigned	Last sensor calibration date

**Command #135: Read Gas Table**

This command returns the ULTIMA sensor Gas Table currently in use. The Gas Tables are linearisation reference tables used with certain sensors to provide accurate response for different gases from the same sensor.

**Request Data Bytes**

None.

**Response Data Bytes**

Byte	Format	Description
0	Unsigned	Gas Table Number [→ Table 13.8]

**Command #136: Read Input Voltage Value**

Returns the ULTIMA input supply voltage value. This number should be in the range of 8-30 volts DC.

**Request Data Bytes**

None.

**Response Data Bytes**

Byte	Format	Description
0-3	Float	Input Voltage Value

**Command #137: Read Auto Zero Comp Value**

Returns the ULTIMA Automatic Zero Compensation value. This value is accumulated by the device when the sensor reading attempts to drift below zero. This value is used to compensate the actual Zero calibration. The device will attempt to compensate up to 10 counts [display units] before setting the under-range bit.

**Command #139: Read Sensor Status message**

Returns the ULTIMA X sensor status message. This is a single byte containing hex codes. This byte is sent from the sensor module to the main processor and passed to the HART communications processor.

**Request Data Bytes**

None.

**Response Data Bytes**

Byte	Format	Description
0	Enum	Sensor Status message [→ Table 13.7]

**Command #140: Read Swap Delay Status**

This command returns the ULTIMA X sensor swap delay status. This is a single byte containing a 0 if disabled or 1 if enabled. If enabled, the swap delay will hold off a sensor missing error for 1 minute. This hold-off allows a sensor module to be swapped out with a calibrated sensor module without triggering a "sensor missing" alarm and dropping the 4-20 mA to the trouble level.

**Request Data Bytes**

None.

**Response Data Bytes**

Byte	Format	Description
0	Enum	Sensor Swap Delay Status [0 - disabled, 1 - enabled]

**Command #141: Read Cal Signal Status**

This command returns the ULTIMA X Cal Signal status. This is a single byte containing a 0 if disabled or 1 if enabled. If enabled, the output will be set to 3.75 mA during calibration [21 mA for oxygen]. If disabled, the output will track the gas concentration.

**Request Data Bytes**

None.

**Response Data Bytes**

Byte	Format	Description
0	Enum	Sensor Cal Signal [0 –disabled, 1 - enabled]

**Command #142: Read Alert Option Status**

This command returns the ULTIMA X Alert Option Status status. This is a single byte containing a 0 if disabled or 1 if enabled. If enabled, the Alert Option will cause the 4-20 mA to be set to 3.75 mA during calibration of an Oxygen sensor [if the Cal Signal Option is also enabled]. If the Alert Option is disabled and the Cal Signal enabled, the output will be set to 21 mA during Oxygen sensor calibration.

**Request Data Bytes**

None.

**Response Data Bytes**

Byte	Format	Description
0	Enum	Alert Option Status [0 - disabled, 1 - enabled]

**Command #143: Read Sensor Temperature**

This command returns the ULTIMA X Sensor Temperature. This is a single byte containing an integer value representing the temperature returned by the gas sensor. Not all gas sensors have an on-board temperature sensor.

**Request Data Bytes**

None.

**Response Data Bytes**

Byte	Format	Description
0	Unsigned	Sensor temperature [°C]

**Command #144: Read Relay Normal State**

This command returns the ULTIMA X to the Normal relay state. This is a single byte containing a bit map of the three alarm relays' non alarm states. Not all gas sensors have on-board relays.

**Request Data Bytes**

None.

**Response Data Bytes**

Byte	Format	Description
0	Bit 0	Alarm #1 0 = normally de-energised, 1 = normally energised
0	Bit 1	Alarm #2 0 = normally de-energised, 1 = normally energised
0	Bit 2	Alarm #3 0 = normally de-energised, 1 = normally energised

**Command #173: Write RTC**

Writes the ULTIMA Real Time Clock hours and minutes values. The real time clock is used to compute the minimum, maximum and average values and to date stamp the last sensor calibration date.

**Request Data Bytes**

Byte	Format	Description
0	Unsigned	RTC hours [0-23]
1	Unsigned	RTC minutes [0-59]

**Response Data Bytes**

Byte	Format	Description
0	Unsigned	RTC hours [0-23]
1	Unsigned	RTC minutes [0-59]

**Command-Specific Response Codes**

Code	Class	Description
0	Success	No Command-specific errors
1 - 2		Undefined
3	Error	Parameter too large
4		Undefined
5	Error	Too few data bytes
6		Undefined
7	Error	In write protect mode
8 - 15		Undefined
16	Error	Access Restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

**Command #174: Write Alarm Setpoints**

Writes the ULTIMA Alarm Setpoint values. The ULTIMA Gas Monitor uses alarm setpoint values to set alarm status bits in the device. The alarms can be enabled or disabled, set to increasing or decreasing and can be set to latching. The alarm adjustment range is greater than zero and less than full-scale [see "Command 175: Write Alarm Setpoint Control Actions"].

**Request Data Bytes**

Byte	Format	Description
0	Unsigned	Alarm Number [1, 2, or 3]
1-4	Float	Alarm Setpoint Value

**Response Data Bytes**

Byte	Format	Description
0	Unsigned	Alarm Number
1-4	Float	Alarm Setpoint Value

**Command-Specific Response Codes**

Code	Class	Description
0	Success	No Command-specific errors
1 - 2		Undefined
3	Error	Parameter too large
4	Error	Parameter too small
5	Error	Too few data bytes
6		Undefined
7	Error	In write protect mode
8-15		Undefined
16	Error	Access Restricted
17-18		Unrestricted
19	Error	Invalid device variable index
20 - 31		Undefined
32	Error	Busy
33 - 127		Undefined



**Command #175: Write Alarm Setpoint Control Actions**

Writes the ULTIMA X Alarm Setpoint Control Actions. The ULTIMA X Gas Monitor uses alarm setpoint Control Actions to enabled or disabled, set to increasing or decreasing and to set the alarm to latching or non latching.

**Request Data Bytes**

Byte	Format	Description
0	Unsigned	Alarm Number [1, 2, or 3]
1	Bit Enum	Alarm Control Action Value [→ Table 13.5]

**Response Data Bytes**

Byte	Format	Description
0	Unsigned	Alarm Number [1, 2, or 3]
1	Bit Enum	Alarm Control Action Value [→ Table 13.5]

**Command-Specific Response Codes**

Code	Class	Description
0	Success	No Command-specific errors
1 - 4		Undefined
5	Error	Too few data bytes
6		Undefined
7	Error	In write protect mode
8 -15		Undefined
16	Error	Access Restricted
17 -18		Undefined
19	Error	Invalid device variable index
20 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

**Command #176: Write Average Interval**

Writes the ULTIMA Average Interval. This interval is in hours and is used by the device to determine the collection interval for Minimum, Maximum and Average values. The Average collection interval can be for 1, 8 or 24 hours.

**Request Data Bytes**

Byte	Format	Description
0	Unsigned	Average Interval

**Response Data Bytes**

Byte	Format	Description
0	Unsigned	Average Interval

**Command-Specific Response Codes**

Code	Class	Description
0	Success	No Command-specific errors
1		Undefined
2	Error	Invalid Selection
3 - 4		Undefined
5	Error	Too few data bytes
6		Undefined
7	Error	In write protect mode
8 - 15		Undefined
16	Error	Access restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

**Command #177: Write Upper Trim Point**

Writes the ULTIMA X Upper Trim or Span point value. The ULTIMA Gas Monitor uses the Upper trim point value to perform Span calibration. When a Span calibration is performed, the device automatically sets the highest reading obtained to this Span value. The adjustment range of the Upper Trim Point is from one display unit to the full scale limit.

**Request Data Bytes**

Byte	Format	Description
0-3	Float	Upper Trim Point [Span] Value

**Response Data Bytes**

Byte	Format	Description
0-3	Float	Upper Trim Point [Span] Value

**Command-Specific Response Codes**

Code	Class	Description
0	Success	No Command-specific errors
1 - 2		Undefined
3	Error	Parameter too large
4	Error	Parameter too small
5	Error	Too few data bytes
6		Undefined
7	Error	In write protect mode
8 - 15		Undefined
16	Error	Access restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

**Command #178: Write Gas Table**

Writes the ULTIMA X Gas Table selection. The ULTIMA Gas Monitor uses the Gas Table value to select a reference table of linearisation values for certain sensors.

**Request Data Bytes**

Byte	Format	Description
0	Unsigned	Gas Table selection number [→ Table 13.8]

**Response Data Bytes**

Byte	Format	Description
0	Unsigned	Gas Table selection number

**Command-Specific Response Codes**

Code	Class	Description
0	Success	No Command-specific errors
1 - 2		Undefined
3	Error	Parameter too large
4	Error	Parameter too small
5	Error	Too few data bytes
6		Undefined
7	Error	In write protect mode
8 - 15		Undefined
16	Error	Access restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

**Command #179: Write Sensor Data Sheet Reset Control**

Writes a data sheet reset command to ULTIMA X Gas Monitor. This command causes the ULTIMA Monitor to reset the current sensor data sheet to factory default settings. This command will set certain device warning status bits and require the user to re-calibrate the sensor. At present, the only valid number for this command is 1.

**Request Data Bytes**

Byte	Format	Description
0	Unsigned	Sensor reset control

**Response Data Bytes**

Byte	Format	Description
0	Unsigned	Sensor reset control

**Command-Specific Response Codes**

Code	Class	Description
0	Success	No Command-specific errors
1 - 2		Undefined
3	Error	Parameter too large
4	Error	Parameter too small
5	Error	Too few data bytes
6		Undefined
7	Error	In write protect mode
8 - 15		Undefined
16	Error	Access restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

**Command #180: Write Sensor Swap Delay Enable**

This command writes command number to the ULTIMA X Gas Monitor to enable or disable the two-minute swap delay feature. This device feature enables a two-minute hold-off of the sensor missing fault, allowing the user to “Swap” or change sensor modules without having the 4-20 mA set to the fault condition. The configuration change bit will be set, and the configuration change counter will be incremented.

**Request Data Bytes**

Byte	Format	Description
0	Enum	Swap Delay 1 = Enable 0 = Disable

**Response Data Bytes**

Byte	Format	Description
0	Enum	Swap Delay 1 = Enable 0 = Disable

**Command-Specific Response Codes**

Code	Class	Description
0	Success	No Command-specific errors
1 - 2		Undefined
3	Error	Parameter too large
4		Undefined
5	Error	Too few data bytes
6		Undefined
7	Error	In write protect mode
8 - 15		Undefined
16	Error	Access restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

**Command #181: Write Cal Signal Enable**

This command writes command number to the ULTIMA X Gas Monitor to enable or disable the Cal signal output. Without the Cal Signal enabled, the 4-20 mA output will follow the gas reading during calibration. With the Cal Signal enabled, the 4-20 mA output will be set to 3.75 mA during calibration and be held there for one minute after calibration has ended to allow the sensor to re-stabilise. Status group 3 indicates the current setting of this mode.

**Request Data Bytes**

Byte	Format	Description
0	Enum	Cal Signal 1 = Enable 0 = Disable

**Response Data Bytes**

Byte	Format	Description
0	Enum	Cal Signal 1 = Enable 0 = Disable

**Command-Specific Response Codes**

Code	Class	Description
0	Success	No Command-specific errors
1 - 2		Undefined
3	Error	Parameter too large
4		Undefined
5	Error	Too few data bytes
6		Undefined
7	Error	In write protect mode
8 - 15		Undefined
16	Error	Access restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

**Command #182: Write Calibration Mode**

This command writes a calibration mode number to the ULTIMA Gas Monitor. The mode commands initiate a calibration sequence in the device. Device status byte 2 can be monitored to determine the progress of the calibration.

**Request Data Bytes**

Byte	Format	Description
0	Enum	Calibration Mode Number [→ Table 13.6]

**Response Data Bytes**

Byte	Format	Description
0	Enum	Calibration Mode Number[→ Table 13.6]

**Command-Specific Response Codes**

Code	Class	Description
0	Success	No Command-specific errors
1 - 2		Undefined
3	Error	Parameter too large
4		Undefined
5	Error	Too few data bytes
6		Undefined
7	Error	In write protect mode
8 - 15		Undefined
16	Error	Access restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined



**Command #183: Write Calibration Abort**

This command writes a calibration Abort command to the ULTIMA Gas Monitor. The calibration abort command instructs the device to suspend the calibration sequence initiated by the calibration mode command. Valid number for this command is 1.

**Request Data Bytes**

Byte	Format	Description
0	Unsigned	Calibration Abort Command number

**Response Data Bytes**

Byte	Format	Description
0	Float	Calibration Abort Command number

**Command-Specific Response Codes**

Code	Class	Description
0	Success	No Command-specific errors
1 - 2		Undefined
3	Error	Parameter too large
4	Error	Parameter too small
5	Error	Too few data bytes
6		Undefined
7	Error	In write protect mode
8 - 15		Undefined
16	Error	Access restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

**Command #184: Write Calibration Step**

This command writes a calibration Step Command to the ULTIMA Gas Monitor. The Step command instructs the device to advance to the next step during a manual calibration sequence. Device status byte 2 can be monitored to determine the progress of the calibration. Valid number for this command is 1.

**Request Data Bytes**

Byte	Format	Description
0	Unsigned	Calibration Step Number

**Response Data Bytes**

Byte	Format	Description
0	Float	Calibration Step Number

**Command-Specific Response Codes**

Code	Class	Description
0	Success	No Command-specific errors
1 - 2		Undefined
3	Error	Parameter too large
4	Error	Parameter too small
5	Error	Too few data bytes
6		Undefined
7	Error	In write protect mode
8 - 15		Undefined
16	Error	Access restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

**Command #185: Write Alarm Acknowledge**

This command writes an Alarm Acknowledge command to the ULTIMA X Gas Monitor. The alarm acknowledge command instructs the device to clear any latched alarms in the device, provided the setpoint level for the alarm has receded. Valid command number is on 1.

**Request Data Bytes**

Byte	Format	Description
0	Unsigned	Alarm Acknowledge command number

**Response Data Bytes**

Byte	Format	Description
0	Float	Alarm Acknowledge command number

**Command-Specific Response Codes**

Code	Class	Description
0	Success	No Command-specific errors
1 - 2		Undefined
3	Error	Parameter too large
4		Parameter too small
5	Error	Too few data bytes
6 - 15		Undefined
16	Error	Access restricted
17 - 31		Undefined
32	Error	Busy
33 - 127		Undefined

**Command #186: Write Protect Mode**

This command sends a single, unsigned byte to the device. Sending a 1 puts the device in write protect mode. In write protect mode, all writes and commands are ignored except a command to disable the write protect. Only reads to the device can be made. Sending a disable, releases the device from write protect mode. During write protect mode, all local [Pushbutton] controls are locked out as well.

**Request Data Bytes**

Byte	Format	Description
0	Enum	Write protect Mode [0 = disable, 1 = Enable]

**Response Data Bytes**

Byte	Format	Description
0	Enum	Write protect Mode [0 = disable, 1 = Enable]

**Command-Specific Response Codes**

Code	Class	Description
0	Success	No Command-Specific Errors
2	Error	Invalid Selection
3-4		Undefined
5	Error	Too few data bytes
6		Undefined
7	Error	In write protect mode
8-15		Undefined
16	Error	Access Restricted
17-31		Undefined
32	Error	Busy
33-127		Undefined

**Command #187: Write Alert Option**

This command disables or enables the Alert Option on the ULTIMA X unit. This is a single byte containing a 0 if disabled or 1 if enabled. If enabled, the Alert Option will cause the 4-20 mA to be set to 3.75 mA during calibration of an Oxygen sensor [if the Cal Signal Option is also enabled]. If the Alert Option is disabled and the Cal Signal enabled, the output will be set to 21 mA during Oxygen sensor calibration.

	Alert Options	
	ON	OFF
Calibration	Alert relay de-energised	Alert relay energised
Power on RESET (Countdown)	Alert relay de-energised	Alert relay energised
4 – 20 CAL mA (Oxygen)	3.75 mA	21 mA
4 – 20 POR mA (Oxygen)	3.75 mA	21 mA

**Request Data Bytes**

Byte	Format	Description
0	Enum	Alert Option Mode [0 - disabled, 1 - enabled]

**Response Data Bytes**

Byte	Format	Description
0	Enum	Alert Option Mode [0 - disabled, 1 - enabled]

**Command-Specific Response Codes**

<b>Code</b>	<b>Class</b>	<b>Description</b>
0	Success	No Command-Specific Errors
2		Undefined
3	Error	Parameter too large
4		Undefined
5	Error	Too few data bytes
6		Undefined
7	Error	In write protect mode
8-15		Undefined
16	Error	Access Restricted
17-31		Undefined
32	Error	Busy
33-127		Undefined

**Command #188: Write Relay Normal State**

This command sets the ULTIMA X Normal relay state. This is a single byte containing a bit map of the three alarm relays' non alarm states. Not all gas sensors have on-board relays.

**Request Data Bytes**

Byte	Format	Description
0	Bit 0	Alarm #1 0 = normally de-energised, 1 = normally energised
0	Bit 1	Alarm #2 0 = normally de-energised, 1 = normally energised
0	Bit 2	Alarm #3 0 = normally de-energised, 1 = normally energised

**Response Data Bytes**

Byte	Format	Description
0	Bit 0	Alarm #1 0 = normally de-energised, 1 = normally energised
0	Bit 1	Alarm #2 0 = normally de-energised, 1 = normally energised
0	Bit 2	Alarm #3 0 = normally de-energised, 1 = normally energised

**Command-Specific Response Codes**

Code	Class	Description
0	Success	No Command-Specific Errors
1-4		Undefined
5	Error	Too few data bytes
6		Undefined
7	Error	In write protect mode
8-15		Undefined
16	Error	Access Restricted
17-31		Undefined
32	Error	Busy
33-127		Undefined

### 13.4 Gas Type Descriptions

Gas Type	Description
CO	Carbon Monoxide
O <sub>2</sub>	Oxygen
COMB	Combustible-pellistor
XIR	Infrared Combustible
H <sub>2</sub> S	Hydrogen Sulfide
Cl	Chlorine
Cl <sub>2</sub>	Chlorine Dioxide
NH <sub>3</sub>	Ammonia

### 13.5 Alarm Control Actions

Bit 0	Alarm Enable	1 = enabled, 0 = disabled
Bit 1	Alarm Direction	1 = increasing, 0 = decreasing
Bit 2	Alarm Latch Status	1 = latching, 0 = non-latching
Bit 3-7	Unused	

### 13.6 Calibration Modes

Mode #	Description
0	Initiate Zero Sensor sequence
1	Initiate Standard calibration sequence
2	Initiate Initial calibration sequence
3	Initiate Manual [stepped] calibration sequence



### 13.7 Sensor Status Codes

<b>Code</b>	<b>Description</b>
0x01	Flash Fault
0x05	Ram Fault
0x07	Pellement Fault
0x0A	Data Sheet Fault
0x1E	Power Fault
0x1F	IR Factory Mode
0x20	IR Lamp Fault
0x28	EEPROM R/W Fault
0x2D	EEPROM Checksum Fault
0x2F	Sensor Missing Fault
0x3A	Negative Power Supply Fault
0x3B	IR Reference Fault
0x3C	Temperature Fault
0x3D	IR Analyte Fault
0x3E	IR Low Signal Fault
0x3F	IR Parameter Fault
0x40	Calibration Fault
0x41	Zero Mode
0x42	Span Mode
0x7C	Sleep Mode
0x7D	Warm Up Mode
0x7E	Power On Reset Mode
0x7F	Sensor OK

### 13.8 Gas Table Values

Table	Description
1	Methane
2	Propane
3	Ethane
4	n-Butane
5	n-Pentane
6	n-Hexane
7	Cyclopentane
8	Ethylene
21	Acetylene
47	5000 PPM CO <sub>2</sub>
48	5% CO <sub>2</sub>
49	2% CO <sub>2</sub>
50	Custom
250	Unused

### 13.9 Performance

Typical sampling rates are shown in the following table.

#### Sampling Rates

Gas Samples	4 per second
PV digital value calculation	5 per second
Analogue output update	5 per second

#### Power-Up

On power-up, the transmitter goes through a self-test procedure, and a sensor warm up and initialisation period which takes approximately 30 seconds. During this period, the device will not respond to HART commands, and the analogue output is set at 3.75 mA.

When the self-test is satisfactorily completed, and the sensor initialised, the PV value is set, and the analogue output moves to a value representing the measurement. The rate of this calculation is limited by an internal filter damping time. Only after the PV and SV are correctly set, will the device respond to HART commands. If the self-test fails, all live measurement data [PV, current and percent of range] are set to "Not A Number", and the analogue output is set to the configured malfunction-indicating current. The device will attempt to respond to HART commands.

Fixed-current mode is cancelled by power loss.

#### Reset

Command 42 ["Device Reset"] causes the device to reset its microprocessor. The resulting restart is identical to the normal power-up sequence.

### Self-Test

The self-test procedure is executed at power-up or following Command 42 ["Device Reset"]. Some self-test procedures are continuously run in a background mode. The self-test includes:

- Microprocessor
- RAM
- Program ROM
- Configuration storage EEPROM
- Sensor communications
- Data sheet integrity
- Internal communications.

This self-test takes about 10 seconds. During self-test, following power-up or reset, the analogue output is set to 3.75 mA and the device does not respond to HART commands.

During self-test run in background mode, the analogue output updates continuously and the device responds normally to HART commands.

Continuous self-testing is part of the normal device operation. The same checks are made, but over a longer period between measurement function cycles.

### Command Response Times

Minimum	20 ms
Typical	50 ms
Maximum	100 ms*

\*During self-test following a power up reset or reset command, the device may take up to 10 seconds to respond.

### Busy and Delayed-Response

The transmitter may respond with "busy" status if a further command is received while self-test or certain command functions are underway.

Delayed-response is not used.

### Long Messages

The largest data field used is in the response to Command 21: 34 bytes including the two status bytes.

### Non-Volatile Memory

EEPROM is used to hold the device's configuration parameters. Both the main board and sensor module contain EEPROM devices. New data is written to this memory on execution of certain write commands, during calibration operations and during normal operation.

### Modes

Fixed current mode is implemented, using Command 40. This mode is cleared by power loss or reset.

### Write Protection

Write-protection is provided by command 186. When in the Write Protect mode, all read commands are available, no "write" or "command" commands are accepted.

### Damping

Damping is internally-fixed, affecting only the PV and the loop current signal. There is no user-settable damping control.

## 13.10 Capability Checklist

Manufacturer, model and revision	MSA, ULTIMA, rev. 2
Device type	Transmitter
HART revision	7
Device Description available?	Yes
Number and type of sensors	1
Number and type of actuators	0
Number and type of host side signals	1: 4 - 20 mA analog
Number of Device Variables	13
Number of Dynamic Variables	1
Mappable Dynamic Variables?	No
Number of common-practice commands	11
Number of device-specific commands	31
Bits of additional device status	32
Alternative operating modes?	No
Burst mode?	Yes
Write-protection?	Yes

### 13.11 Default Configuration

Parameter	Default Value
Lower Range Value	0
Upper Range Value	Sensor dependent
PV Units	Sensor dependent
Sensor type	various
Number of wires	3
Damping time constant	N/A
Fault-indication jumper	Sensor dependent
Write-protect mode	write enabled
Number of response preambles	5
Alarms	Enabled

### 13.12 Calibration Using a HART® Communicator

#### Sensor Zero Selection Menu

#### Select Sensor Calibration from the "Sensor Trim" Menu

Sensor calibration or "trim" functions are available from several locations in the menu structure. See → Fig. 30 for a view of this selection menu.

**First warning screen**

Once the sensor calibration feature is selected, a warning message displays to indicate that the 4-20 mA output should be disabled from any automatic control loop to prevent false action during calibration. The user must acknowledge this screen to continue. See → Fig. 27 for a view of this warning screen. Optionally, the user may abort the process at this screen.

**Second warning screen**

After acknowledgement of the control loop message, a second warning message displays, informing the user that sensor calibration will be changed. The user can abort the procedure at this time or acknowledge the screen to proceed. → Fig. 29 for a view of this screen.

**Zero Sensor function select screen**

Upon acknowledgement of the calibration change warning screen, a calibration function selection screen appears. To zero the sensor, select the "Sensor Zero" function and acknowledge the screen. → Fig. 30 for a view of this screen.

**Calibration initiated screen**

Once a calibration selection function is selected, the command is sent to the device. A status message is then returned to indicate the progress. The first status message should indicate that the calibration sequence has started. This screen also shows the sensor value, units and type information. No action is required as it is only a five-second information screen and advances automatically. The user may abort the process at this time. → Fig. 32 for a view of this screen.

**Selection confirmation screen**

After the initiating screen displays for five seconds, a second information screen displays. This screen displays for five seconds and provides the user confirmation of the current calibration selection. No action is required at this screen, but the user may press the ABORT button to stop the process. → Fig. 34 for a view of this screen.

### **Sensor Zero countdown screen**

Once the information screens are displayed, the device should start sending back a status byte to indicate calibration progress. The first status message should be the 30-second device countdown message. This message prompts user to start applying Zero gas if necessary. This screen also displays the current gas reading from the sensor. [This screen is skipped for the Oxygen sensor as it uses an electronic Zero]. This message displays during the 30-second countdown and the user can abort the process at any time. → Fig. 36 for a view of this screen message.

### **Zero Adjustment screen**

After the 30-second countdown screen [or the selection confirmation screen for an Oxygen sensor], the device should send back a status message indicating that the device is attempting to adjust the internal calibration. The user is instructed to apply Zero gas at this time. The device waits for a stable reading to occur and then saves the zero calibration data automatically. The user can abort the process at any time by selecting the ABORT button. → Fig. 38 for a view of this screen.

### **Calibration completion message**

Following a successful zero calibration, an information screen displays, indicating the calibration process has completed. This is a five-second, timed message and requires no user input. → Fig. 45 for a sample view of this information screen.

### **Calibration gas reminder screen**

Once the device has performed a successful Zero function and stored the calibration information, it returns a calibration OK message. This causes a series of calibration closure messages to appear. The first closure message is a reminder to disconnect any calibration gases from the device. → Fig. 47 for a sample view of this message screen. The user can abort this screen, but the only affect at this time would be that the last information screen will not display.

### **Loop control reminder message**

The final information screen following a calibration procedure is a reminder to return the loop to automatic control. → Fig. 49 for a sample of this screen.

## **13.13 Standard Calibration Procedures**

### **Standard Zero/Span Calibration Selection Menu**

#### **Select Sensor Calibration from the Sensor Trim Menu**

Sensor calibration or “trim” functions are available from several locations in the menu structure. → Fig. 30 for a view of this selection menu.

#### **First warning screen**

Once the sensor calibration feature is selected, a warning message displays to indicate that the 4-20 mA output should be disabled from any automatic control loop



to prevent false action during calibration. The user must acknowledge this screen to continue. → Fig. 26 for a view of this warning screen. Optionally, the user may abort the process at this screen.

### **Second warning screen**

After acknowledgement of the control loop message, a second warning message displays, informing the user that sensor calibration will be changed. The user can abort the procedure at this time or acknowledge the screen to proceed. → Fig. 28 for a view of this screen.

### **Standard Calibration function select screen**

Upon acknowledgement of the calibration change warning screen, the user is presented with a calibration function selection screen. To perform a standard Zero/ Span of the sensor, select the “Zero/Span” function and acknowledge the screen. → Fig. 30 for a view of this screen.

### **Calibration initiated screen**

Once a calibration selection function is selected, the command is sent to the device. A status messages is then returned to indicate the progress. The first status message should indicate that the calibration sequence has started. This screen also shows the sensor value, units and type information. No action is required as it is only a five-second information screen and advances automatically. The user may abort the process at this time. → Fig. 32 for a view of this screen. The red and green LEDs on the main board blink momentarily to indicate the device has begun the procedure.

**Selection confirmation screen**

After the initiating screen displays for five seconds, a second information screen displays. This screen displays for five seconds and provides the user confirmation of the current calibration selection. No action is required at this screen, but the user may press the ABORT button to stop the process. → Fig. 34 for a view of this screen.

**Sensor Zero countdown screen**

Once the information screens are displayed, the device should start sending back a status byte to indicate the progress of the calibration. The first status message should be the 30-second device countdown message prompting the user to start applying Zero gas if necessary. This screen also displays the current gas reading from the sensor. [This screen is skipped for the Oxygen sensor, as it uses an electronic Zero]. This message displays during the 30-second countdown; the user can abort the process at any time. → Fig. 36 for a view of this screen message. The red LED is OFF and the green LED is blinking on the main circuit board to indicate the start of the Zero procedure.

**Zero Adjustment screen**

After the 30-second countdown screen [or the selection confirmation screen for an Oxygen sensor], the device should send back a status message indicating that the device is attempting to adjust the internal calibration. The user is instructed to apply Zero gas at this time. The device waits for a stable reading to occur and then saves the zero calibration data automatically. The user can abort the process at any time by selecting the ABORT button. → Fig. 38 for a view of this screen.

**Sensor Span countdown screen**

After successful completion of the sensor Zero procedure, the device automatically steps to the Span routine and displays an information screen indicating the Span procedure has started. This is a 30-second countdown wait for gas connection and transport. The user is prompted to start applying the Span calibration gas at this time. [For a 0-25% Oxygen sensor, the sensor can be spanned using room air.] → Fig. 40 for a sample view of this screen. The red LED is ON solid and the green LED is blinking on the main board to indicate the start of the Span procedure.

### **Adjusting Span screen**

After the 30-second Span initialisation, a Span adjustment screen displays and continually updates with the gas [PV] reading, units and type information. Once the device detects a stable reading, the data is stored automatically and the user is notified of the completion status. → Fig. 42 for a sample view of the Span adjustment screen. The user can abort the procedure at any time and the prior calibration data is restored.

### **Calibration completion message**

Upon successful completion of the SPAN procedure, an information screen displays. → Fig. 44 for a sample completion screen. This is a five-second information screen; no user action is required.

### **Calibration gas reminder screen**

Following the Calibration completion screen, another information screen is presented to inform the user to disconnect any calibration gas from the device. This is a five-second timed message; no user acknowledgement is required. → Fig. 46 for a view of this information screen.

### **Loop control reminder message**

The final calibration screen is an information screen prompting the user to reconnect the sensor output to any automatic control process that was disconnected at the start of the procedure. The user is required to acknowledge this screen. → Fig. 48 for a sample view of this screen.

## 13.14 Initial Calibration Procedures

### Initial Calibration Selection Menu

Initial calibration is selected in a manner similar to the standard Zero/Span calibration procedure and the steps are similar [except the function selection should be "Initial Cal"]. Initial calibration should be run when a new sensor is connected to the unit or when a standard Zero/Span procedure will not clear a fault condition [such as when the wrong Span gas is used]. The Initial Calibration function allows the device to make accurate decisions for the CHANGE SENSOR and CAL FAULT functions.

### Initial Calibration Function Select Screen

Upon acknowledgement of the calibration change warning screen [see "Second warning screen" earlier in this chapter], a calibration function selection screen appears. To perform an Initial Calibration of the sensor, select the "Initial Cal" function and acknowledge the screen. → Fig. 21 for a view of this screen. Refer back to "Standard Calibration Procedures" for the complete calibration procedure.

## 13.15 User [Stepped] Calibration Procedures

### User Calibration Selection Menu

User calibration is selected in a manner similar to the standard Zero/Span calibration procedure; the steps are similar, except the function selection should be "User Cal". Normal calibrations are performed and stepped automatically by the device while prompting the user to apply the required calibration gas.

This is a timed function and, if the calibration gas is not applied in time or the reading does not stabilise within the given timeout period [windy conditions, duct mount, high sensitivity sensor modules, extended gas sample lines, etc.], it will timeout and send a "Cal Fault" status. User calibration allows the user to manually step through the Zero and Span calibrations and decide when the reading has reached optimum stability.

### User Calibration Step Screens

User calibration is similar to the standard procedures provided earlier under "Standard Calibration Procedures", except that the automatic adjustment screens described in "Zero Adjustment screen" and "Adjusting Span screen" chapters are replaced with a Step/Refresh screen allowing the user to review the readings and decide when to advance the procedure [→ Fig. 21 and → Fig. 23].

### Zero Cal Step Screen

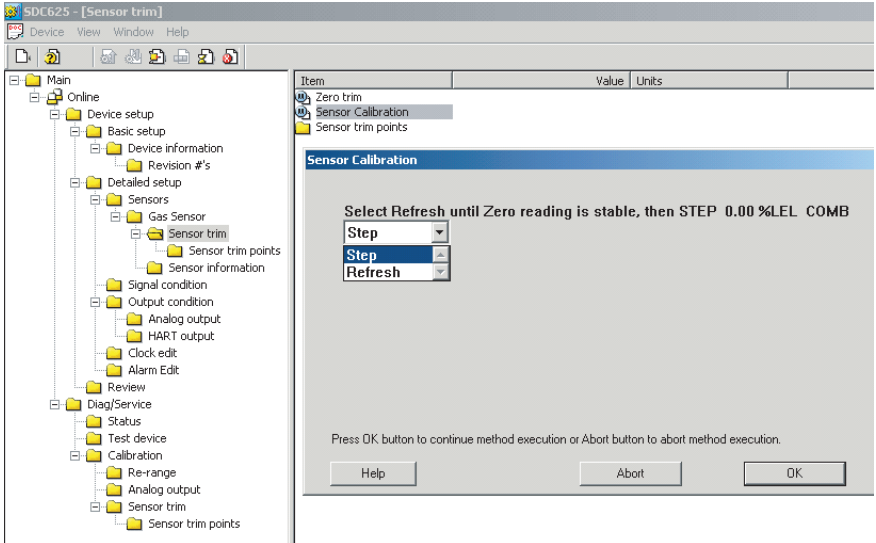


Fig. 21 Zero cal step screen

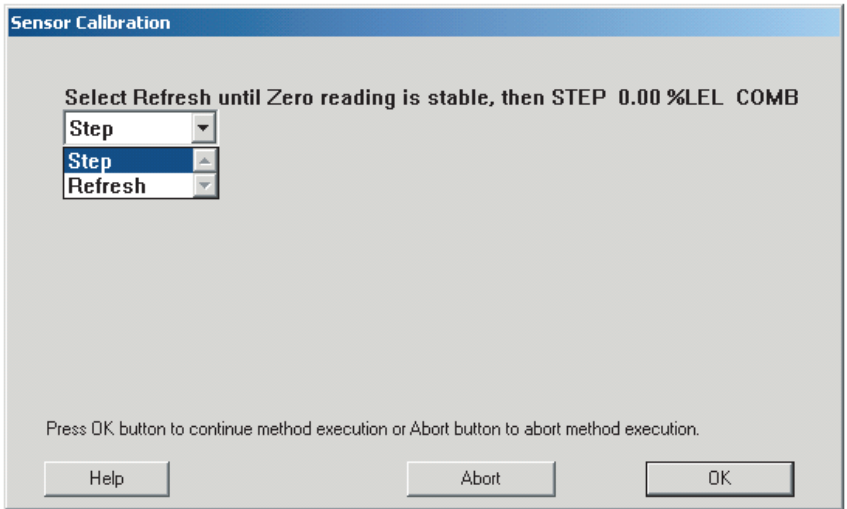


Fig. 22 Zero cal step screen

### Span Cal Step Screen

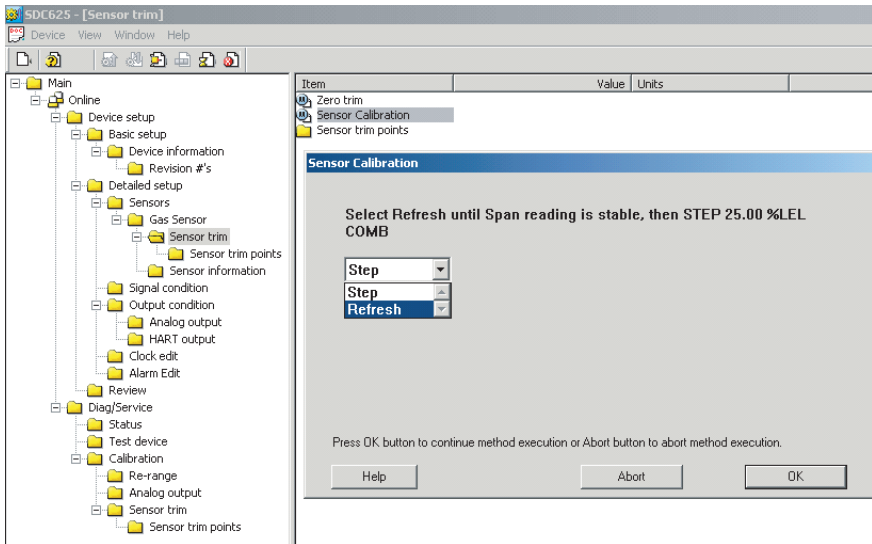


Fig. 23 Span cal step screen

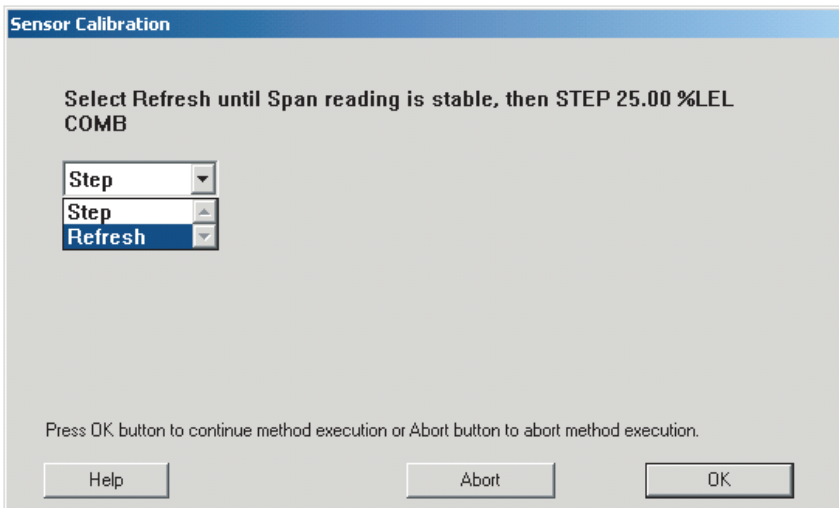


Fig. 24 Span cal step screen

## 13.16 Sample Calibration Display Screens

### HART DDL-based Calibration Display Screens

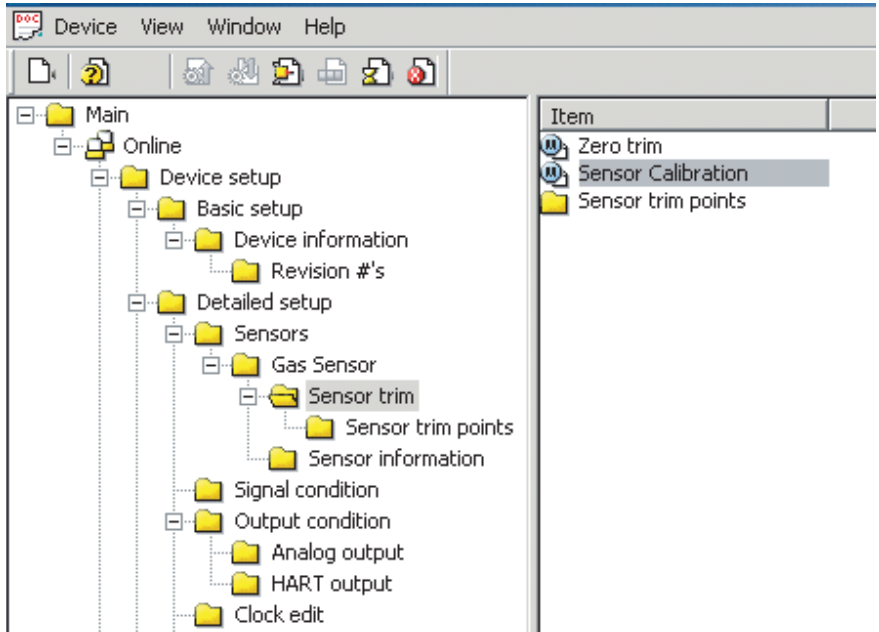


Fig. 25 Select Sensor Calibration from the Sensor Trim Menu

### First Warning Screen

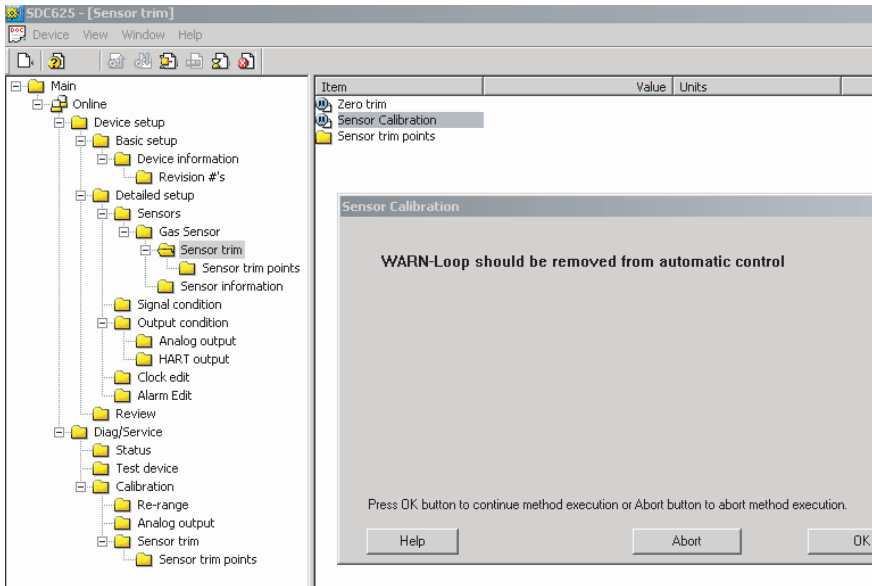


Fig. 26 First warning screen

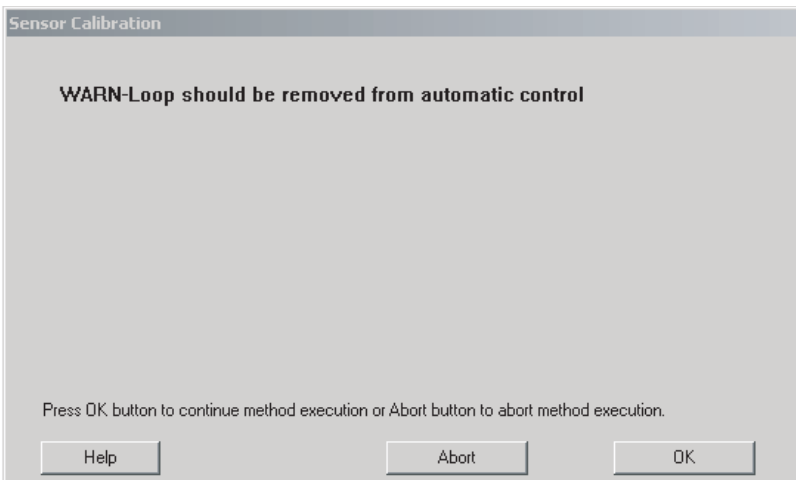


Fig. 27 First warning screen



### Second Warning Screen

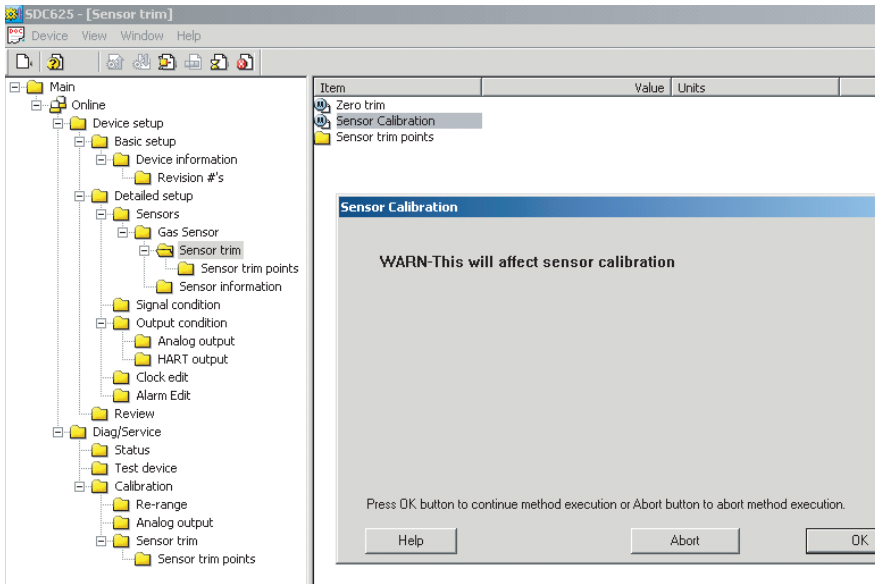


Fig. 28 Second warning screen

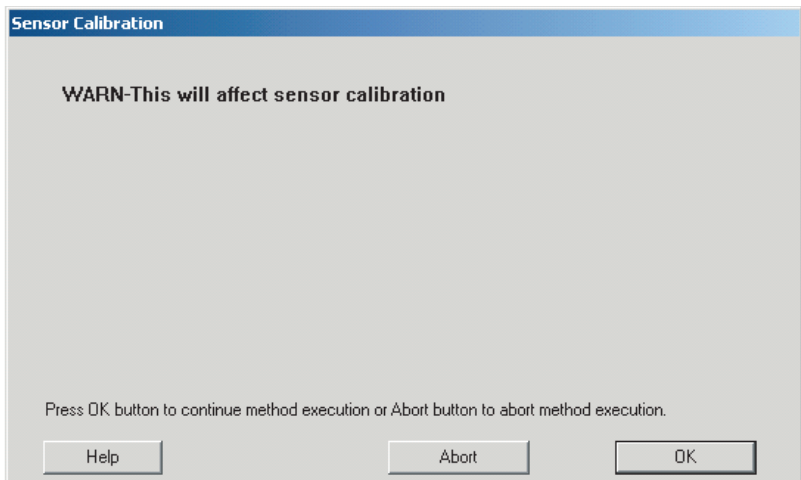


Fig. 29 Second warning screen

Standard Calibration Function Select Screen

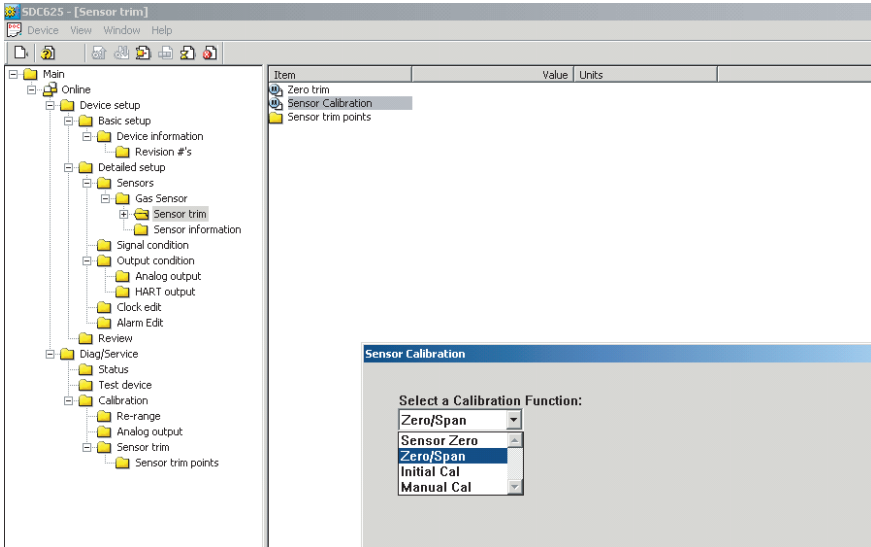


Fig. 30 Standard calibration function select screen

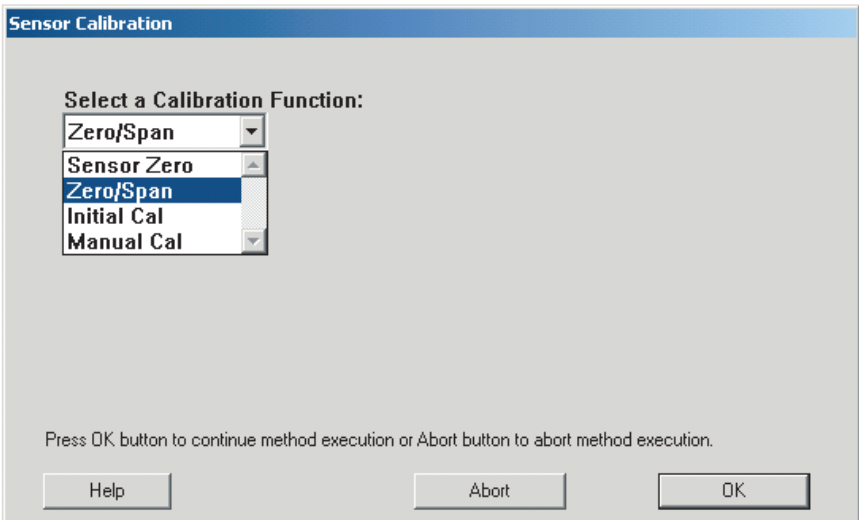


Fig. 31 Standard calibration function select screen

## Calibration Initiated Screen

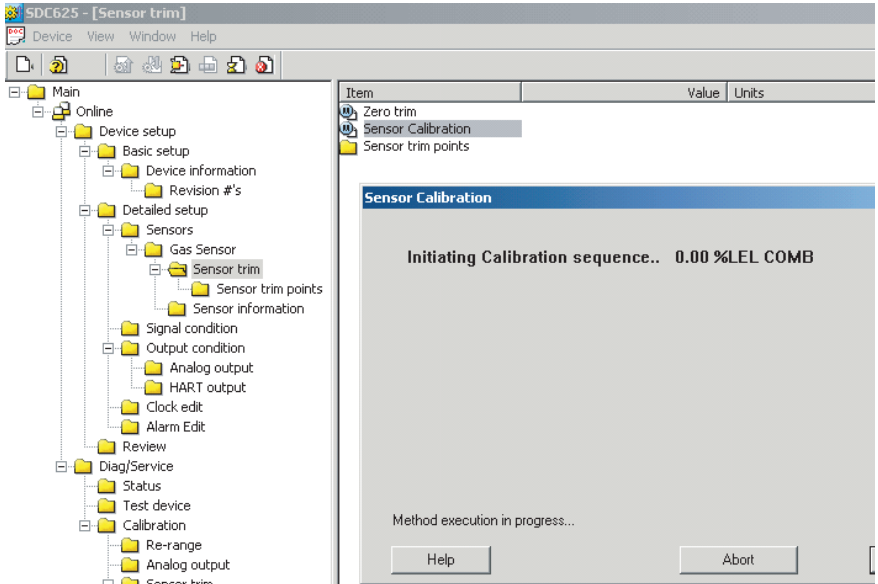


Fig. 32 Calibration initiated screen

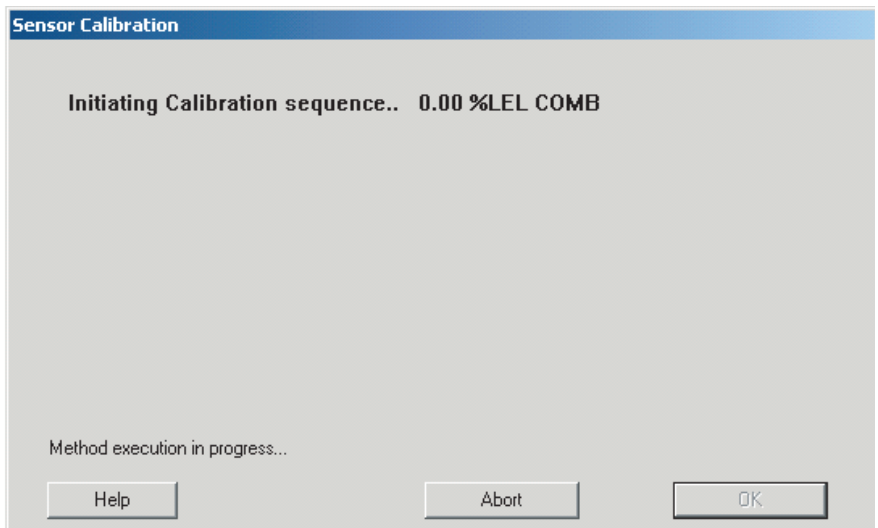


Fig. 33 Calibration initiated screen

**Selection Confirmation Screen**

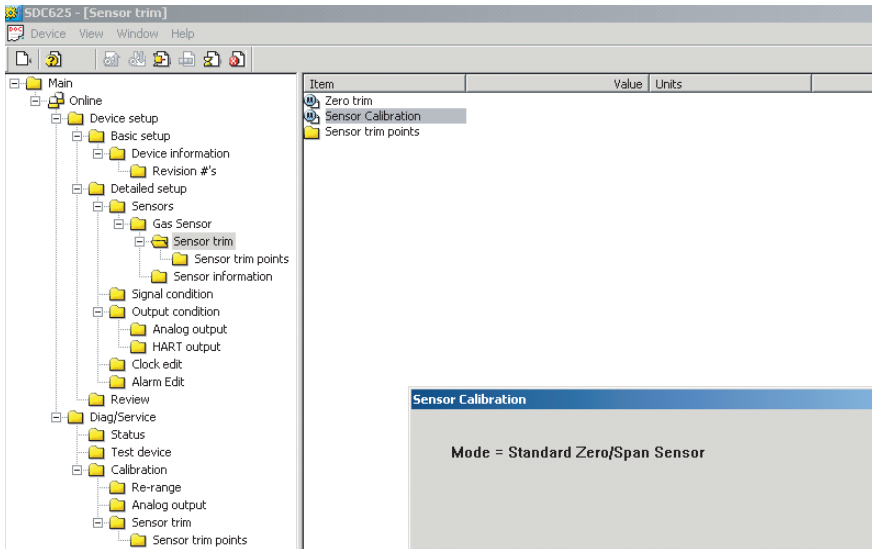


Fig. 34 Selection confirmation screen

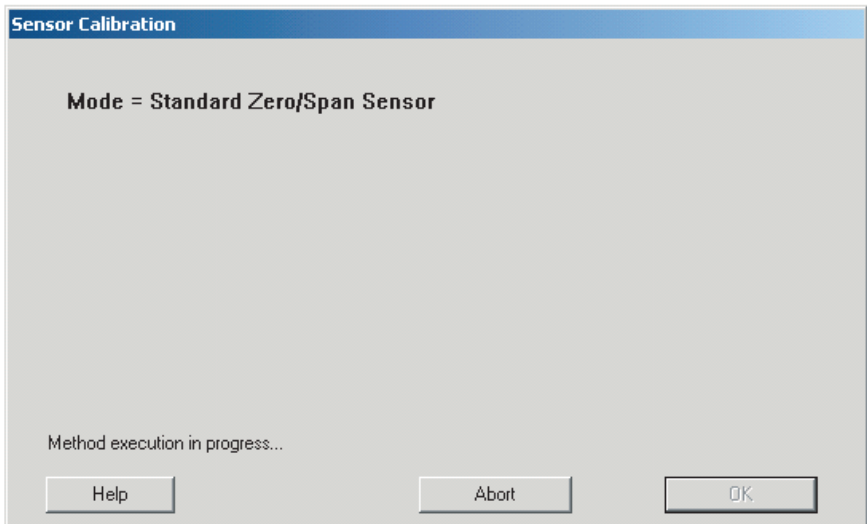


Fig. 35 Selection confirmation screen

### Sensor Zero Countdown Screen

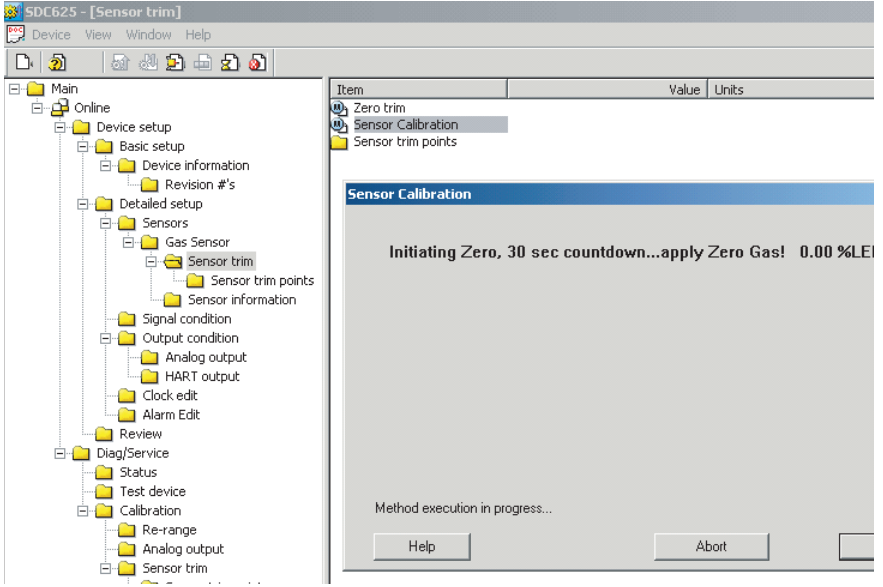


Fig. 36 Sensor zero countdown screen

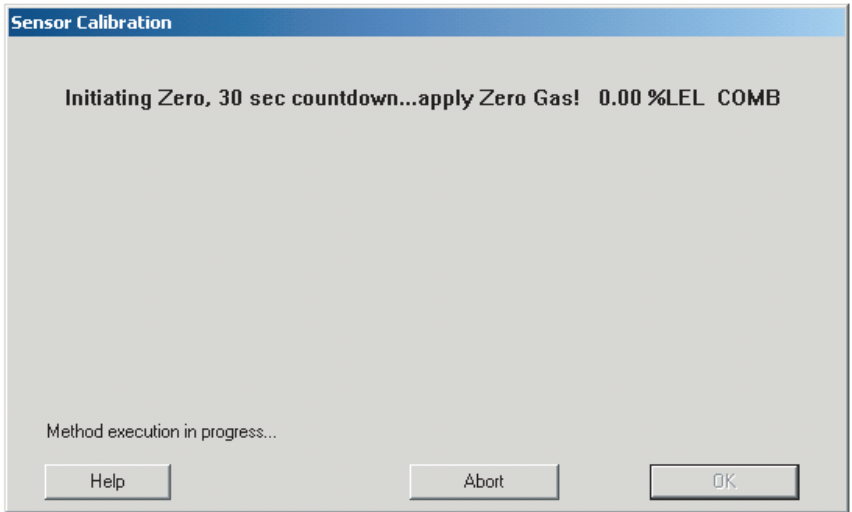


Fig. 37 Sensor zero countdown screen

### Zero Adjustment Screen

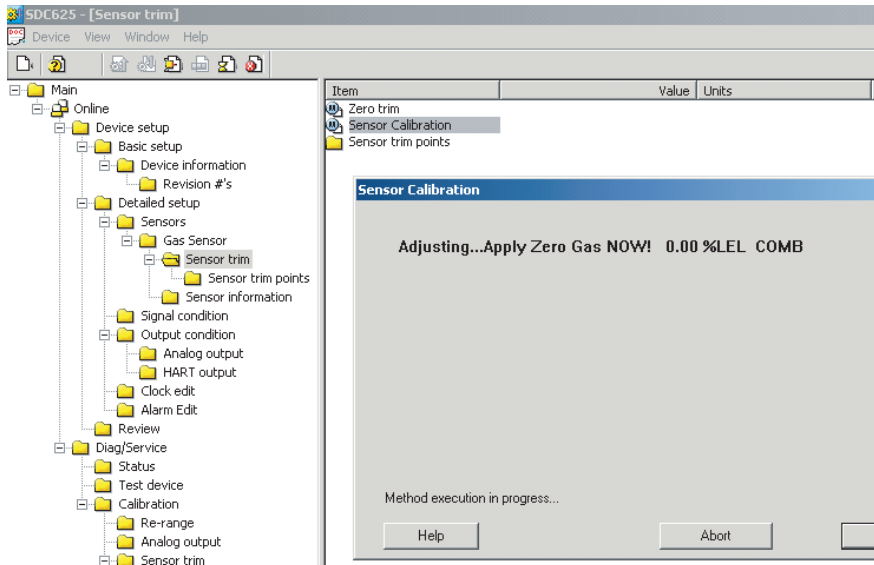


Fig. 38 Zero adjustment screen

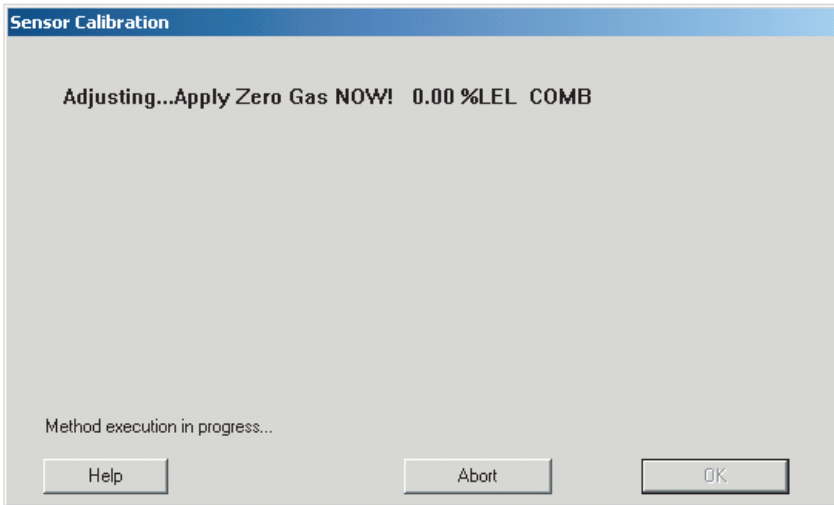


Fig. 39 Zero adjustment screen

### Span Countdown Screen

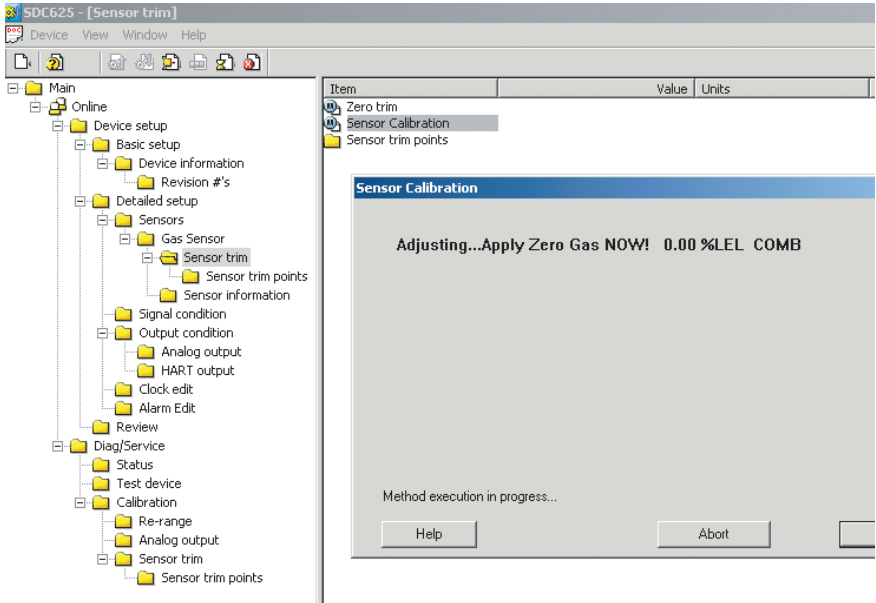


Fig. 40 Span countdown screen

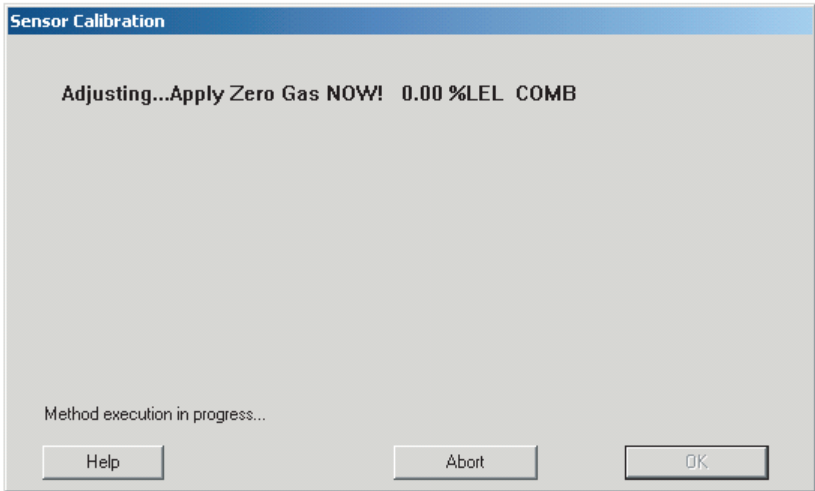


Fig. 41 Span countdown screen

### Adjusting Span Screen

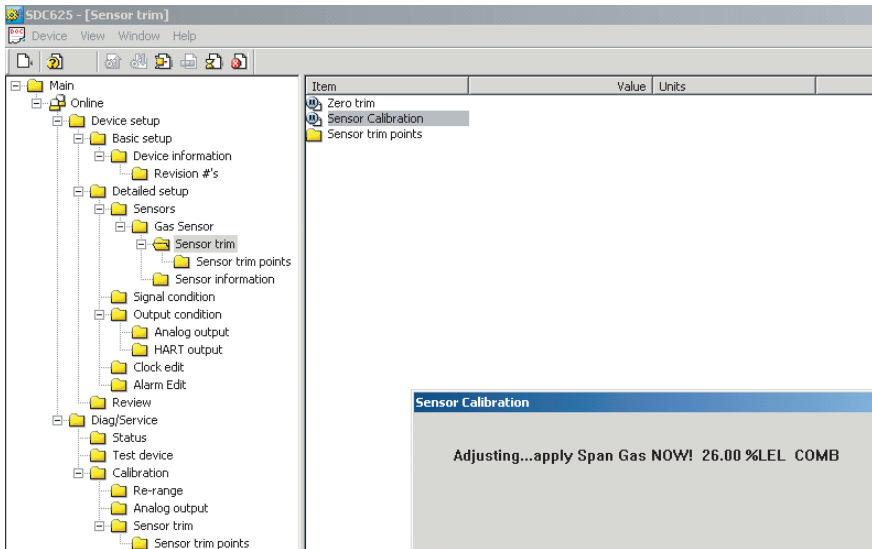


Fig. 42 Adjusting span screen

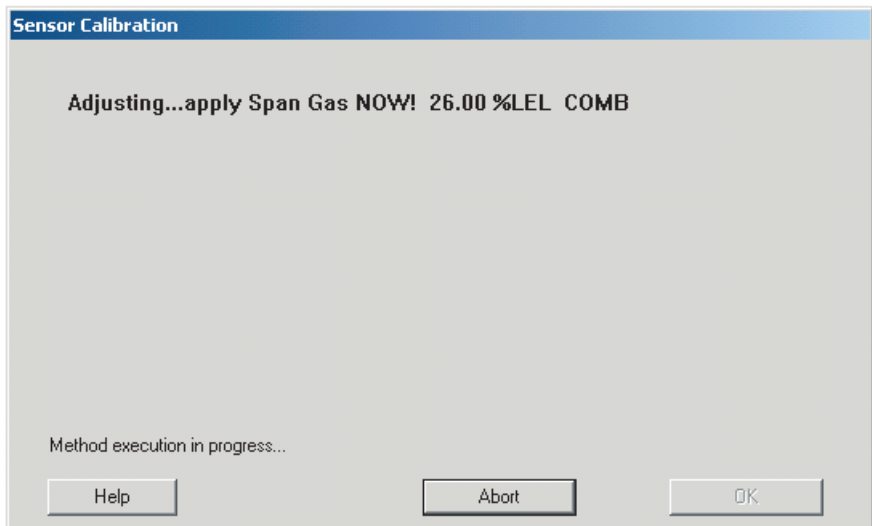


Fig. 43 Adjusting span screen



## Calibration Completion Message

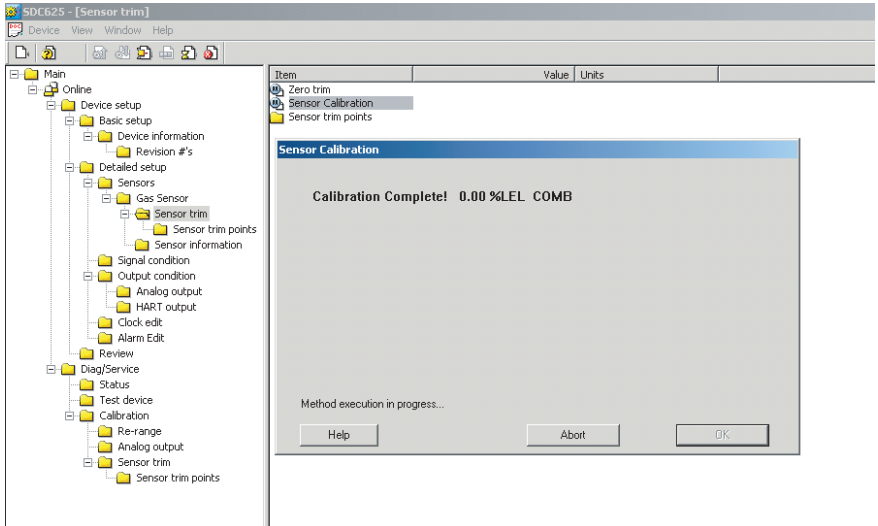


Fig. 44 Calibration completion message

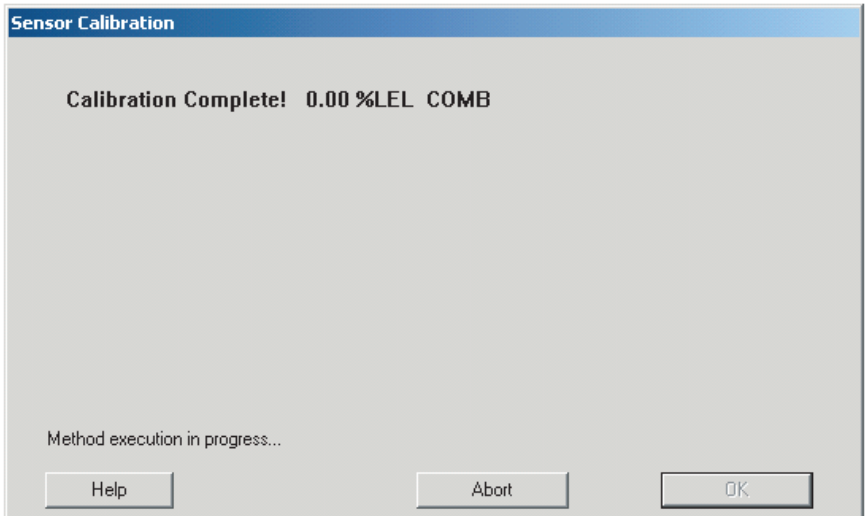


Fig. 45 Calibration completion message

### Calibration Gas Reminder Screen

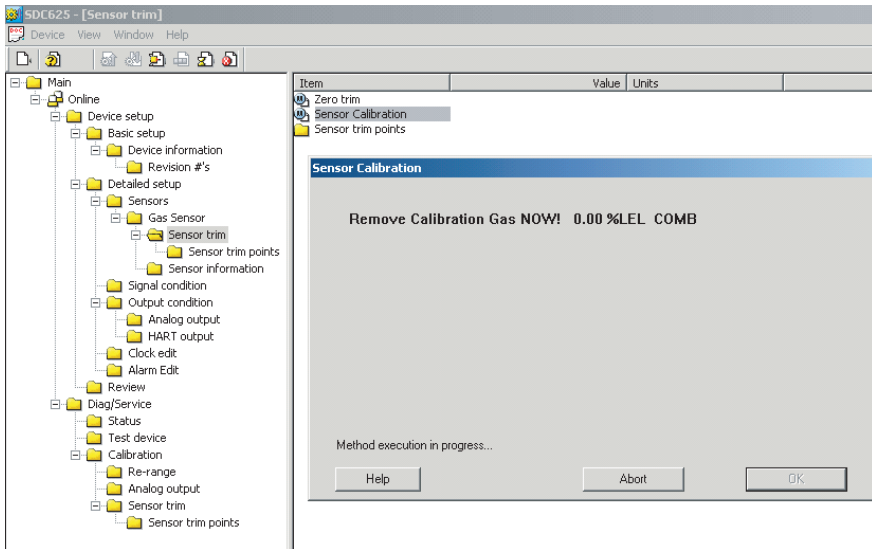


Fig. 46 Calibration gas reminder screen

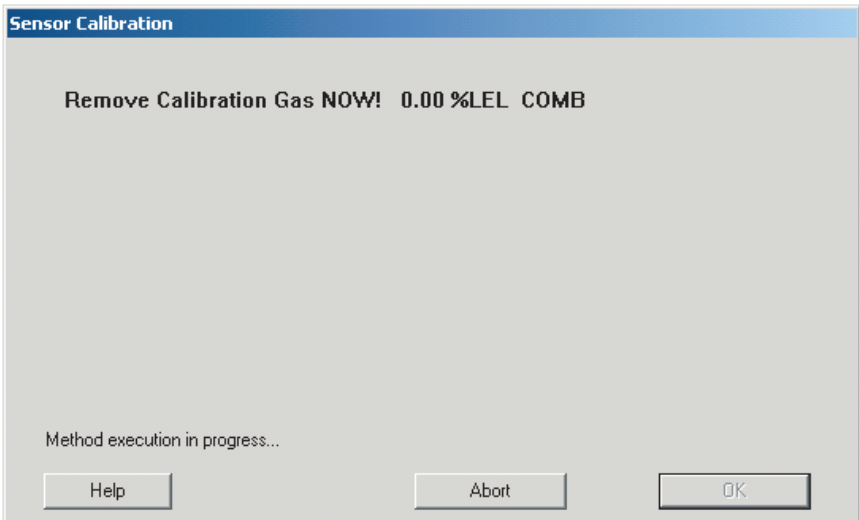


Fig. 47 Calibration gas reminder screen

### Loop Control Reminder Message

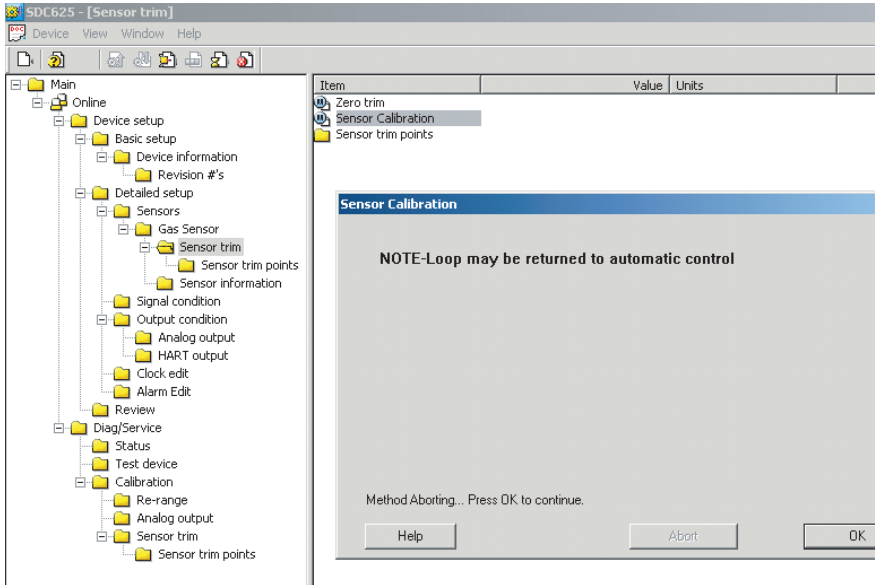


Fig. 48 Loop control reminder message

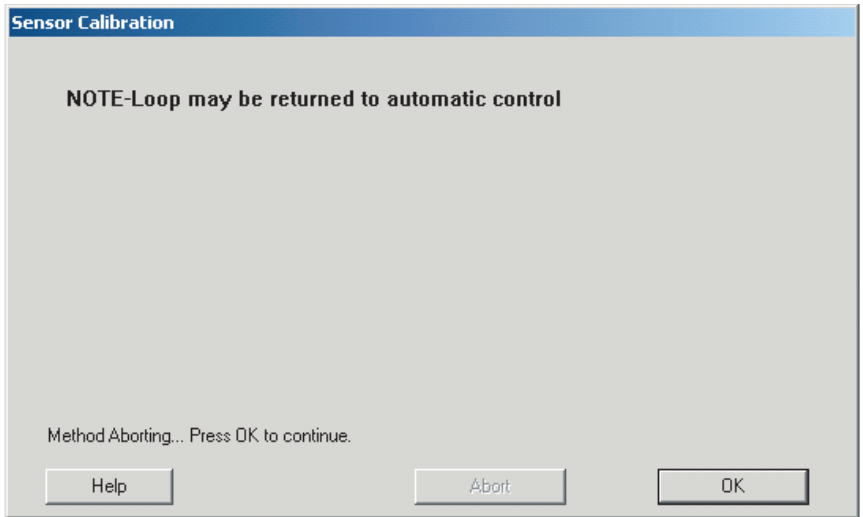


Fig. 49 Loop control reminder message

## 13.17 Troubleshooting

### Fault Indications

#### Span Fault

This fault can occur if the sensor is in cal mode and the required SPAN gas is not applied to the sensor at the indicated time or within the timeout period. The 4-20 mA returns the measured gas value. This fault sets several status flags in the digital output to indicate that an error has occurred. The current calibration status can be observed by right-clicking on status group 2 to expand it as shown in → Fig. 50.

Other possible cause for a Span Fault could be the use of an incorrect Span gas or improperly set PV Upper Trim point [Span] setting. The Trim [calibration] point information can be viewed from the sensor trim points menu as shown in → Fig. 52.

Span faults can also be caused by a bad sensor, sensor at end-of-life, or a sensor that is too far out of calibration for the Standard Zero/ Span procedure to make the adjustment. An attempt to Initial Cal the sensor may be able to correct the calibration; otherwise, the sensor must be replaced. Additional sensor status can be obtained by right-clicking on status group 3 to expand it as shown in → Fig. 53.

## Calibration Status Screen

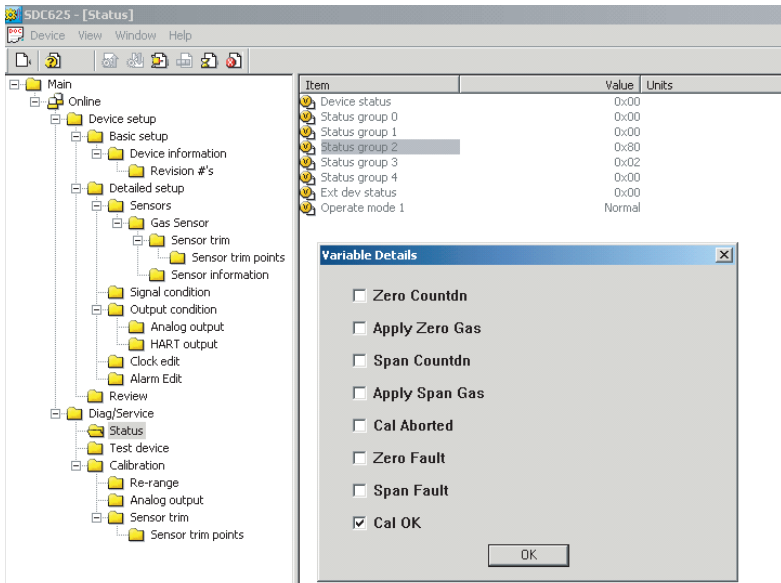


Fig. 50 Calibration status screen

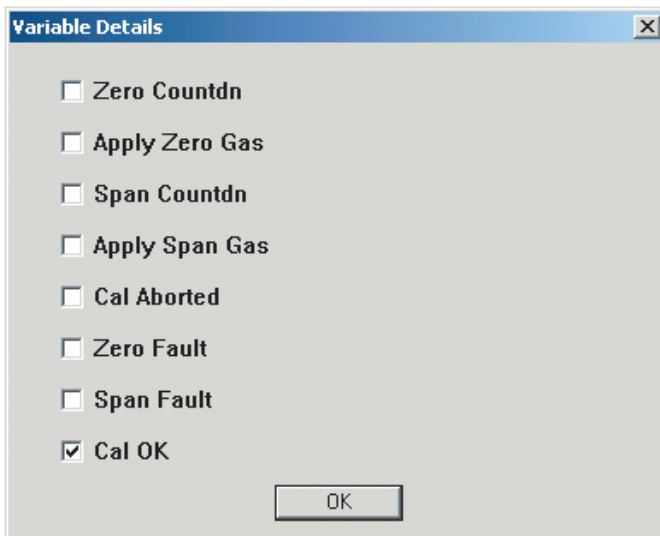


Fig. 51 Calibration status screen

### Sensor Trim Point Screen

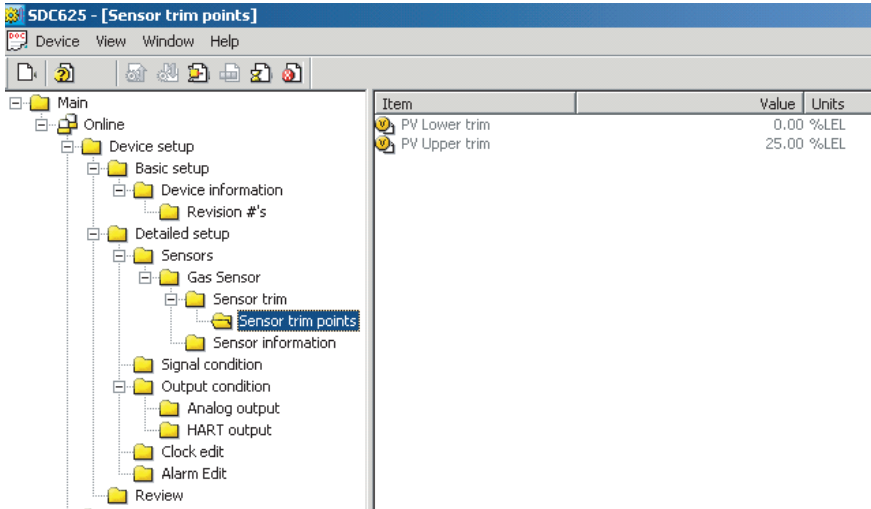


Fig. 52 Sensor trim point screen

**Additional Sensor Status Screen**

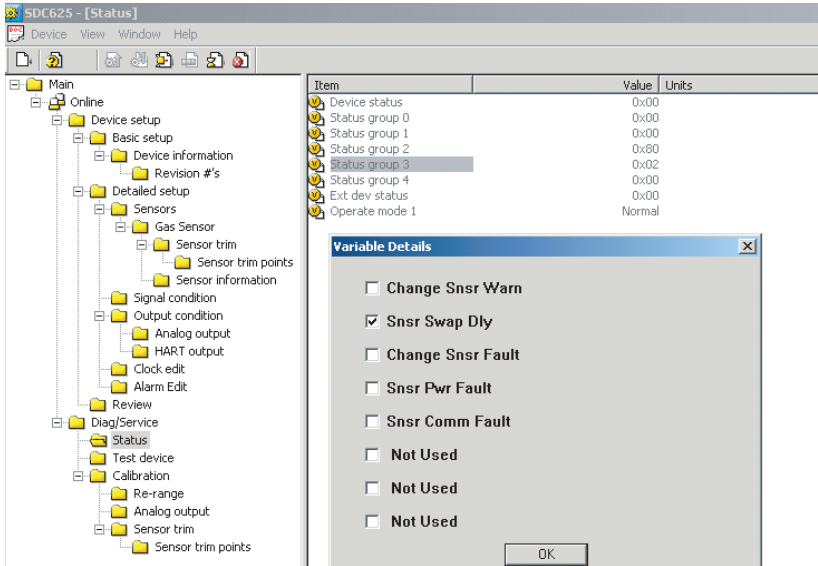


Fig. 53 Additional Sensor status screen

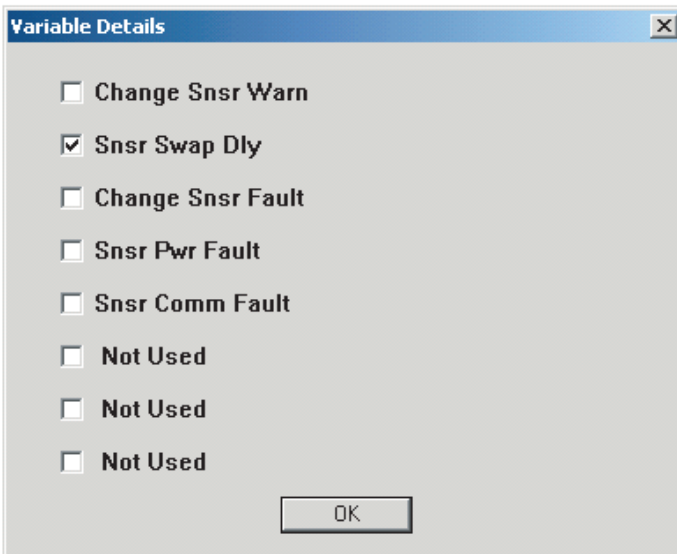


Fig. 54 Additional Sensor status screen

**Zero Fault**

The Zero Fault can be caused by a faulty sensor, calibration out of the Standard Zero/Span calibration range, sensor in change, sensor fault or attempting to zero the sensor with Span gas applied. The application of Zero gas should be checked and the sensor status [as defined in → Fig. 50 and → Fig. 54] verified if this fault occurs.

**Calibration Aborted**

User calibration abort or sensor calibration faults can cause a calibration process to abort. Status group 2 as shown in → Fig. 50 can be viewed to determine if the abort was caused by a cal fault. Status group 2 can be expanded by right-clicking the selection as shown in → Fig. 55 to provide additional information [also → Fig. 50]:



**Device Status Screen**

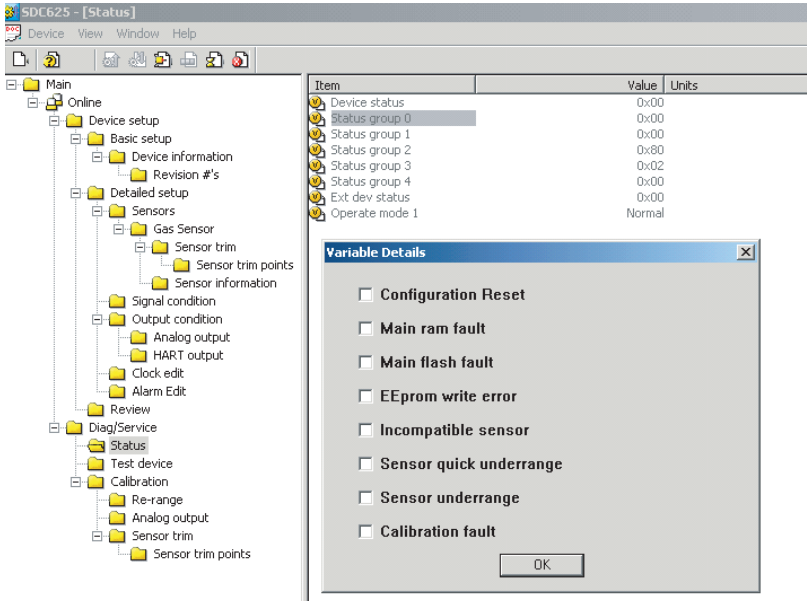


Fig. 55 Device status screen

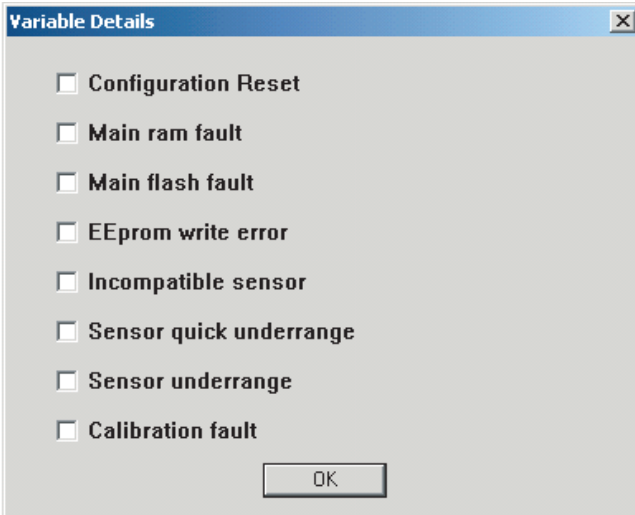


Fig. 56 Device status screen

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