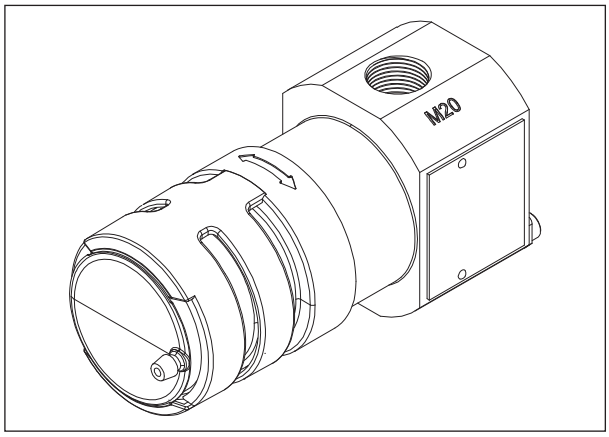
IRmax

Infrared hydrocarbon gas detector



Installation, operating and maintenance instructions
Instructions d'installation, d'utilisation et de maintenance
Installations-, Bedienungs- und Wartungsanleitung
Instrucciones de instalación, operación y mantenimiento
Istruzioni d'installazione, uso e manutenzione
Installatie-, bedienings- en onderhoudsinstructies
Instrukcje montażu, obsługi i konserwacji
Instruções de instalação, funcionamento e manutenção

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CROWCON
Detecting Gas Saving Lives

Contents

IRmax concept

IRmax is an ultra-compact infrared (IR) gas detector, which delivers rapid, fail-safe detection of hydrocarbon gases and vapours.

Featuring dual-wavelength IR sensor technology in a rugged 316 stainless steel package, **IRmax** is designed to operate in the harshest conditions. Unlike conventional IR gas detectors, **IRmax** does not incorporate heaters to prevent condensation on windows and mirrors. The STAY CLIR coating on optical components prevents condensation forming while the detector is operating.

IRmax is compatible with any 4-20mA control system, and can also be installed in an RS485 Modbus addressable network (see Section 7).

IRmax requires only 1 Watt of power, typically 75-90% lower than conventional IR gas detectors.

IRmax features a compact diffusion gas chamber, which in combination with an effective weatherproof cap provides excellent speed of response. The weatherproof cap has been designed using flow modelling software to enable remote gassing and calibration of the **IRmax** without requiring a special calibration cap.

The **IR Display** makes it possible to monitor readings from the **IRmax** both locally and remotely. An **IR Display** can be fitted directly to **IRmax**. Alternatively, **IRmax** may be supplied with an Intrinsically Safe (IS) Barrier module attached. An **IR Display** can then be connected to the IS Barrier Module via temporary or permanent cabling. The available options are illustrated on Diagram 3, page 5.

For further information about other accessories for the **IRmax** see Diagram 3 on page 5 and Section 5, page 16.

Concept and safety

Safety information

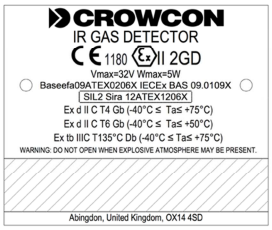
- **IRmax** gas detectors must be installed, operated and maintained in strict accordance with these instructions, warnings, label information, and within the limitations stated.
- The rear nut on **IRmax** must be kept tightly closed during operation. Do not attempt to remove the rear nut until power to the detector is isolated - otherwise ignition of a flammable atmosphere can occur. Before removing the nut for maintenance, calibration or servicing, check that the surrounding atmosphere is free of flammable gases or vapours. Do not open until several minutes after the power has been removed.
- Maintenance and calibration operations must only be performed by qualified service personnel.
- Only genuine **Crowcon** replacement parts must be used; substitute components may invalidate the certification and warranty of the **IRmax**.
- **IRmax** must be protected from extreme vibration, and direct sunlight in hot environments as this may cause the temperature of the **IRmax** to rise above its specified limits and cause premature failure.
- **IRmax** will not detect hydrogen, ammonia or carbon dioxide.
- The equipment must be earthed using the cable gland and steel armoured cable.
- Certification for Zone 21/22 dust environments: **IRmax** basic (without **IR Display** or **IS Barrier** module) may be used in environments that may contain hazardous dusts (Zones 21 or 22).
- **IRmax** with an **IS Barrier** module may be used in Zones 21 or 22 provided the ambient temperature remains below 40°C and a remote **IR Display** or Hand-Held IR Displays are installed/used outside the hazardous area only.
- **IRmax** with a Fixed **IR Display** cannot be installed in a Zone 21 or 22 area.

Product overview

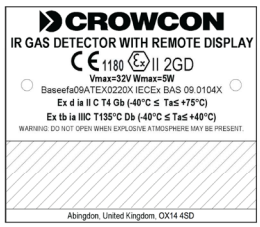
IRmax is an infrared gas detector designed for detecting common hydrocarbon gases in the range 0 to 100%LEL (Lower Explosive Limit: the minimum concentration in air at which ignition can occur).

IRmax is a certified Flameproof (Exd) detector suitable for use in ATEX Zone 1 or Zone 2 hazardous areas. Please refer to the certification label on the side of the Detector to identify the type of certification that relates to the product supplied.

Note: if no certification label is fitted to the* IRmax*, the detector is not certified for use in hazardous areas.



IRmax Basic certification label



IRmax with *IS Barrier* certification label

IRmax with Fixed *IR Display* certification label

Detectors certified for use in Brazil

Diagram 1: *IRmax* certification labels

1. Introduction

English

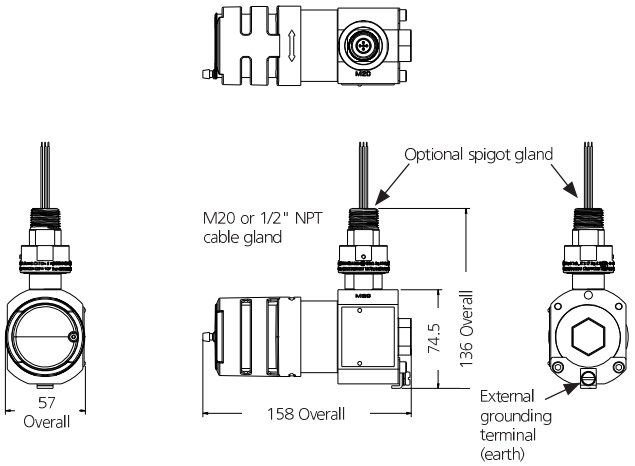
1.1 General

The configuration of each **IRmax** is identified by a label fitted on the main body. Please quote the product name, part number and serial number when contacting **Crowcon** for advice or spares.

1.2 Product description

IRmax consists of a main body of 316 stainless steel, an antistatic weatherproof cover over the optics and gas measurement chamber and an electronics assembly. An **IR Display** Module can also be fitted. Instructions for fitting the **IR Display** appear in the **IR Display** manual (M07061).

An optional connection spigot gland can be supplied to allow **IRmax** to be fitted directly to auxiliary junction boxes with either M20 or ½" NPT cable entries.



All dimensions in millimetres

Diagram 2: *IRmax* dimensioned view

Note: The* IRmax *body is supplied with two cable entries; one is M20, one is 1/2" NPT. The cable entry not specified when ordering an* IRmax *will be sealed using a certified plug. The* IRmax *must be installed with both cable entries sealed: one with a cable gland, the other with a certified IP66 rated stopping plug.

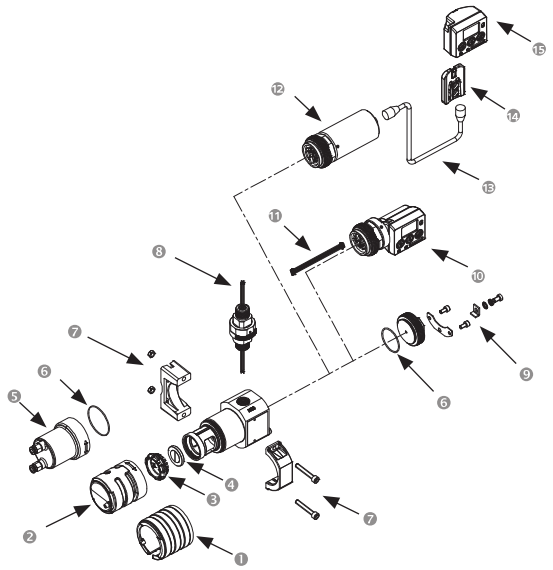


Diagram 3: *IRmax* exploded view (part numbers shown where applicable)

❶ Calibration cap M041007
❷ Weatherproof cap M04995
❸ Mirror retainer } Supplied together as 'mirror replacement kit' C011206
❹ Mirror
❺ Flow adaptor S012996
❻ O-ring for back-nut, **IS Barrier** Module or **Fixed IR Display** Module: M040077
❼ Mounting bracket as complete assembly S012130
❽ Spigot gland M20 or 1/2"NPT versions : M20 ATEX: S012147, 1/2" NPT ATEX: S012190
❾ Retaining plate and bolts for rear plug, **Fixed IR Display** and **IS Barrier** module
❿ **IR Display** fixed version
⓫ **IR Display** to **IRmax** connector E07987
⓬ IS Barrier Module
⓭ **IR Display** connecting lead
⓮ **Remote IR Display** mounting bracket M03833
⓯ **Remote IR Display**

2. Installation

English

WARNING

- **This detector is designed for use in Zone 1 and Zone 2 hazardous areas. Certification is dependent upon the accessories fitted and ambient operating temperature. Please refer to the specifications table on page 15 for certification details. Installation must be in accordance with the recognised standards of the appropriate authority in the country concerned.**
- **For further information please contact Crowcon. Prior to carrying out any installation work ensure local regulations and site procedures are followed.**
- **The equipment must be earthed using the cable gland and steel armoured cable.**
- **Do not attempt to fit an IR Display to an IRmax not supplied for the purpose. Detectors supplied for use with a display are certified Exd ia, and must be operated either with a Fixed Display containing an IS barrier, or with a Remote IR Display or IS Hand-Held Calibrator connected via a Crowcon IS Barrier module.**
- **Detectors supplied without a display are certified Exd IIC and cannot be retro-fitted for use with an IR Display.**

2.1 Location

The **IRmax** should be mounted where the gas to be detected is most likely to be present. The following points should be noted when locating gas detectors:

- To detect gases which are lighter than air, such as methane, detectors should be mounted at high level. To detect heavier-than-air gases, such as flammable vapours, detectors should be mounted at low level.
- When locating detectors consider the possible damage caused by natural events e.g. rain or flooding. For detectors mounted outdoors in very hot regions **Crowcon** recommend the use of a sunshade (see Section 5, Accessories and spare parts, on page 16).
- Consider ease of access for functional testing and servicing.
- Consider how the escaping gas may behave due to natural or forced air currents. Mount **IRmax** in ventilation ducts if appropriate (see Section 5, Accessories and spare parts, on page 16).
- Consider the process conditions. For example, butane is normally heavier than air, but if released from a process which is at an elevated temperature and/or pressure, the gas may rise rather than fall.

The placement of sensors should be determined following advice of experts having specialist knowledge of gas dispersion and the plant processing equipment as well as safety and engineering issues. The agreement reached on the locations of sensors should be recorded.

2.2 Mounting

IRmax can be mounted in three ways:

1. Using the **Crowcon** mounting bracket with direct field cable connection (4-20mA operation only).
2. Using a spigot gland to connect to an existing Exe or Exd certified junction box. **Crowcon** supplies a suitable spigot gland as an optional extra (see 3 below).
3. Using the optional **Crowcon** auxiliary junction box and spigot gland.

Optional parts are listed in Section 5 on page 16.

IRmax should be installed at the designated location with the sensor barrel horizontal +/- 15° (orientation shown on Diagram 2 on page 4). This ensures that dust or water will not collect on the optical components.

2.3 Cabling directly to IRmax

This option is suitable for 4-20mA operation only. A **Crowcon** mounting bracket is required to retain the detector to a wall or 2" (50 mm) pipe.

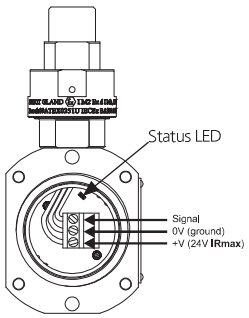
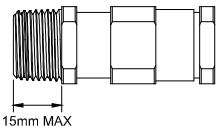


Diagram 4: Field cable connections on the *IRmax*

Connect field cables using a certified gland via the chosen cable entry on the **IRmax** body (M20 or 1/2" NPT), as indicated in Diagram 4. **Crowcon** recommends cable glands are installed pointing downwards.



Ensure that cable glands with the appropriate Exd certification are used, and that the thread length does not exceed the length specified in the diagram (left).

2. Installation

English

2.3.1 Terminal designation

With the **IRmax** oriented as shown in Diagram 2 on page 4 (M20 cable entry at the top), the 3-core field cable should be terminated using the removable connector as follows:

+24V at the bottom, 0V in the middle, Signal at the top.

The 6-pin connector on the right of the PCB is for servicing and/or connection of an **IR Display** module

+ve terminal:	+ve supply from the control card.
Sig terminal:	Signal/Sense from control card.
0 V terminal:	-ve supply from the control card.

2.3.2 Installing IRmax using a mounting bracket

a. **IRmax** can be supplied with a mounting bracket (S012130) rather than a spigot gland so that it can be directly connected to field cables (see Diagram 5).

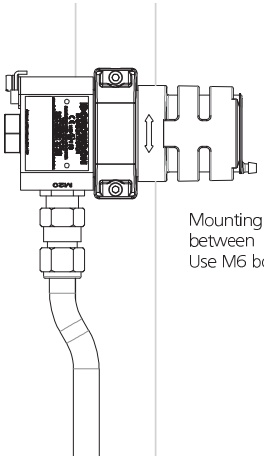


Diagram 5: *IRmax* with a mounting bracket and cable gland

b. If the **IRmax** is to be mounted on a flat surface, mark and drill two holes using the mounting bracket as a template. Loosely fix two parts of the bracket using fixings suitable for the wall/surface.

c. Remove the weatherproof cap from the **IRmax**, and slide the body of the **IRmax** through the bracket. It is recommended that the **IRmax** body is installed with the cable entry facing downwards.

d. Secure the two bracket fixings so that the **IRmax** is held firmly in place. Re-fit the weatherproof cap.

e. Once the **IRmax** is securely fixed in place, remove the **IRmax** rear nut to enable access to the cable terminals.

f. Prepare the field cable – **Crowcon** recommends 1.5 mm^2 Steel Wire Armoured (SWA) cable. Other cable types may be used provided they are compatible with Exd certified glands. Fit a suitably certified Exd cable gland, pass the cable conductors through the body of the **IRmax** and screw in the cable gland. Secure the gland and ensure the cable armour is grounded to the cable gland and the **IRmax** body. **NB.** Don't forget to re-fit the rear nut after installing the cable.

g. The retaining plate (item 9 on Diagram 3, page 5) must be securely fitted to prevent any risk of the rear nut (or F**ixed IR Display** or **IS Barrier** module accessory) vibrating loose.

2.4 Installing using a spigot gland and auxiliary junction box

This option is required where **IRmax** is to be connected to an existing Exd or Exe certified auxiliary junction box.

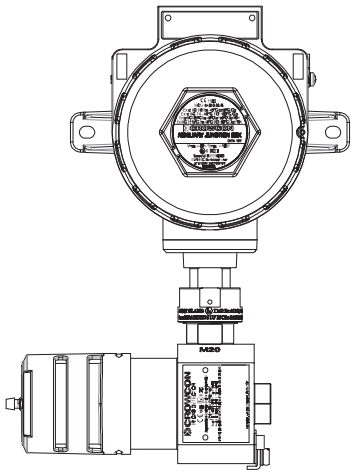


Diagram 6: *IRmax* connected to the auxiliary junction box

2. Installation

2.4.1 To fit IRmax to an auxiliary junction box:

a. Carefully remove the outer section of the spigot gland (item 8 in Diagram 3 on page 5).

b. Screw the narrow end of the spigot gland into the auxiliary junction box.

c. Raise the **IRmax** to the auxiliary junction box and pass the wires through the assembly and into the auxiliary junction box. Secure the **IRmax** by screwing the collar tightly to the cable gland. Tighten grub screw.

d. The main body of the **IRmax** can be swivelled horizontally at any angle, provided it is mechanically secure, does not interfere with other equipment and is accessible for maintenance.

e. Refer to Section 2.6 for instructions on wiring. See also Diagram 4 on page 7.

2.5 Cabling requirement

Cabling to **IRmax** must be in accordance with the recognised standards of the appropriate authority in the country concerned and meet the electrical requirements of the **IRmax**.

Crowcon recommends the use of steel wire armoured (SWA) cable and suitable explosion proof glands must be used. Alternative cabling techniques, such as steel conduit, may be acceptable provided appropriate standards are met.

The maximum recommended cable length is 3.4 km (see Table 1).

IRmax requires a dc supply of 12-30Vdc. Ensure there is a minimum of 12V at the **IRmax** from the control panel, taking into account the voltage drop due to cable resistance at a peak current of 0.1A.

A 1.5mm^2 cable will typically allow cable runs up to 3.0km. Table 1 below shows the maximum cable distances for typical cable parameters.

C.S.A.	Resistance	Max. Distance >20 V	Max. Distance 18 to 20 V
mm^2	(Ohms per km)	(km)	(km)
1.0	18.4	2.2	1.6
1.5	13.0	3.0	2.3
2.5	11.5	3.4	2.6

Table 1: Maximum cable distances for typical cables

2.6 Connections and settings

All connections described are with reference to the terminal block mounted within **IRmax** connector main body. The terminals on the **IRmax** connector PCB are marked '+', 'sig' and '0 V'. Correct polarity should be observed when connecting the **IRmax** to control equipment.

IRmax is factory set as a 'current sink' device unless otherwise specified when ordering. To reset to 'current source', remove the back nut and move the two links on the terminal PCB from the 'sink position to the 'source' position, as shown in Diagram 7.

Note: ***The external grounding terminal is only to be used where local authorities permit or require such a connection. Where possible, to limit radio frequency interference, the auxiliary junction box and cable armour should be grounded at the control panel (safe area) only to avoid earth loops.***

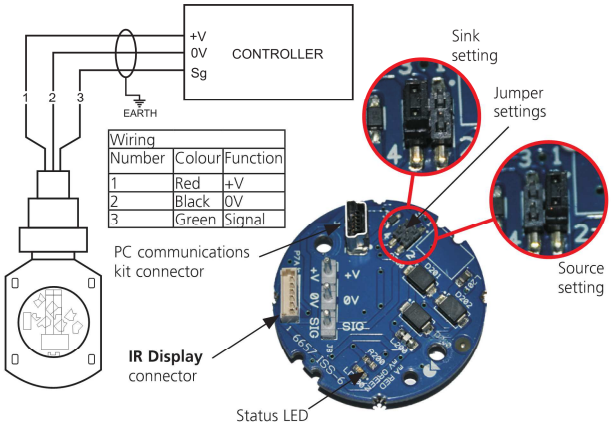


Diagram 7: Sink/source jumper location

The 4-20mA signal can be set to current 'Sink' or 'Source' using the pins and jumper link shown in Diagram 7. Set to current 'Sink' by fitting the jumper link to pins 3 and 4 as shown on the left-hand photograph. Set to current 'Source' by fitting the jumper link to pins 1 and 2 as shown on the right-hand photograph. **IRmax** will be set to current 'Sink' unless specified otherwise when ordering.

LED indication: an LED is fitted to the terminal PCB to indicate the current operating status. Refer to Section 6 on page 17 for more information.

3. Operation

English

WARNING

Prior to carrying out any work ensure local regulations and site procedures are followed. Never attempt to open the IRmax or auxiliary junction box when flammable gas is present. Ensure that the associated control panel is inhibited so as to prevent false alarms.

3.1 Commissioning procedure

1. Check that:
    a. The cable connections are correct
    b. The supply voltage is set at the control card as 18 to 30 V. The voltage measured at the **IRmax** terminals (within the Exe auxiliary junction box if used, or at the **IRmax** terminal PCB) and must be set between 12 and 30 V.
    c. The links are set for 4-20 mA sink or source as appropriate to control card.
2. Once powered up leave **IRmax** for 30 minutes before attempting zero/cal. This delay is to ensure thermal stability. (***Note: IRmax will be fully operational from 30 seconds after power is applied.***)
3. Ensure clean air (i.e. no hydrocarbon gas) before zeroing. Zero reading at control card (refer to control card instructions).
4. Fit a calibration cap over weatherproof cover to isolate measurement chamber from ambient air. Such a cap is available from **Crowcon** (M041007). Connect calibration gas (50% LEL nom) and apply at 1 litre-per-minute flow.
5. After 30 seconds adjust cal/span on control card so that display reads 50% LEL, or matches concentration of calibration gas applied. The **IRmax** itself should not require calibration.
6. Remove gas and calibration cap. Re-check zero.
7. At installation, or after the mirror has been changed, the **IRmax** can be zeroed and calibrated either using an **IR Display** accessory (see page 1) or via a PC communications kit (see the **IRmax Accessories manual**).

Note: ATEX Certified* IRmax *will be supplied calibrated for compliance with EN61779 (where, for example 100% LEL Methane = 4.4% volume).

Note: It is recommended that the calibration cap is used for initial commissioning. Subsequent calibrations may be conducted by applying gas to the weatherproof cap remotely via the pipe spigot (thus avoiding the need to directly access the* IRmax*). Calibration without the calibration cap (i.e. directly via the weatherproof cap) can be performed provided local windspeed is below 2 metres/second. The flow rate of the gas must be greater than 2.0 litre/minute.

3.2 Routine maintenance

Site practices will dictate the frequency with which detectors are tested. **Crowcon** recommends that **IRmax** is gas tested at least every 6 months and re-calibrated as necessary. To re-calibrate an **IRmax** follow the steps given in Section 3.1.

In the event of an electronic failure please consult your local **Crowcon** representative.

Calibration interval:	**Crowcon** recommend calibration every 12 months.
Remote calibration via pipe:	Wind speed should be less than 2.0 metres per second. If greater, use the calibration cap to prevent gas dilution.
Cleaning of optics:	Is **not** recommended unless the **IRmax** is in obscuration fault. If the window or mirror become contaminated, clean carefully with the IPA impregnated wipes and/or the soft cloth supplied in the mirror cleaning kit (see Section 5, **Accessories and spare parts** on page 16).
Mirrors:	If the mirror is damaged, obtain a mirror replacement kit (see Section 5, **Accessories and spare parts** on page 16). The **IRmax** must always be re-zeroed and re-calibrated after mirror replacement. If condensation starts to cause faults replace mirror (optical coating may be damaged). **Crowcon** recommends replacing mirror every 5 years.

3.3 Changing gas types

Each **IRmax** is supplied pre-calibrated for a particular type of gas (for example methane or propane). If re-calibration for a different gas type is required, the **IRmax** can be re-configured using the PC communications kit (see Section 5, **Accessories and spare parts** on page 16), and then calibrated.

3.4 Relative responses of gas types

The graph below shows the relative responses to other gas types for an **IRmax** calibrated on methane.

Note: many hydrocarbon gases and vapours are more easily detected by IR detectors than methane. The response of IRmax (and other IR gas detectors) will be linear across the 0-100%LEL range for the target gas (ie methane in this example), but non-linear for other hydrocarbons that may also be present.

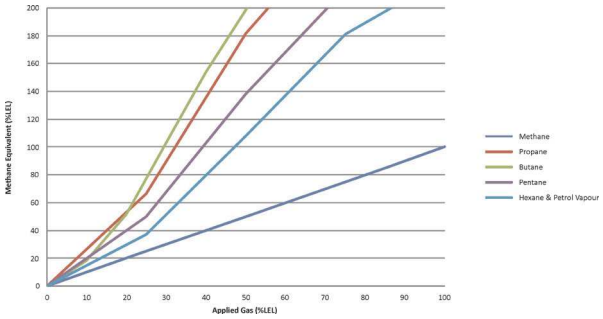


Diagram 8

The diagram shows the approximate response of the gases mentioned above: from left to right, butane, propane, pentane, hexane & petrol vapour and methane.

Other gas types and ranges are available. Please contact **Crowcon** for further details.

4. Specification

Enclosure material	316 Stainless Steel
Dimensions (Detector only)	158mm x 75mm x 57mm (6.2 x 2.9 x 2.3 ins) (without spigot)
Weight	**IRmax** 1.58kg (3.5lbs) **IRmax** with Fixed **IR Display** 2kg (4.4lbs) **IRmax** with IS Barrier Module 2.4kg (5.3lbs) Remote **IR Display** 0.2kg (0.4lbs)
Operating voltage	12Vdc to 30V dc
Power	< 1 W
Output	3-wire 4-20 mA (Sink or Source)
Fault signal	<1 mA
Maximum cable loop resistance	80 Ohms (relative to –ve terminal)
Operating temperature	-40°C to +75°C (-40°F to +167°F)
Humidity	0–100% Relative Humidity
Degree of protection	IP66
Explosion protection	Flameproof
Approval code ATEX	**IRmax** (without **IR Display**) II 2 GD Exd IIC T6 Gb Tamb = -40°C to +50°C II 2 GD Exd IIC T4 Gb Tamb = -40°C to +75°C II 2 GD Ex tb IIIC T135°C Db (-40°C ≤ Ta≤ +75°C) **IRmax** with **IS Barrier module** (remote display) II 2 GD Exd ia IIC T4 Gb Tamb = -40°C to +75°C Ex tb ia IIIC T135°C Db Tamb = -40°C to +40°C **IRmax** (with **Fixed IR Display**) II 2 G Exd ia IIC T4 Gb (Tamb = -40°C to +75°C)
Safety certificate no. ATEX and IECEx	**IRmax** (without **IR Display**): Baseefa 09ATEX0206X and IECEx BAS.09.0109X **IRmax** (with **IR Display**): Baseefa 09ATEX0220X and IECEx BAS.09.0104X
Functional Safety	Certified for use in a SIL 2 system. Certificate number: Sira 12ATEX1206X
Standards	EN60079-0:2006, EN60079-1:2004, EN60079-29-1: 2007, EN61779, IEC61508: 2010, EN50402: 2005
Zones	Certified for use in Zone 1 or Zone 2
EMC	EN50270

5. Accessories and spare parts

English

Part Numbers	Name	Description
M041007	Calibration cap	Fits over the standard weathercap to enable calibration where local air speed exceeds 2 metres per second.
S012130	Mounting bracket kit	Enables mounting to a wall or 2" (50 mm) pipe. Not required if **IRmax** is being fitted to an existing auxiliary junction box.
S012152	Sun shade/Collector cone	Can be fitted to **IRmax** to protect against elevated temperatures due to direct sunlight and/or to extend the detectors footprint for detecting lighter than air gases (e.g. methane).
S012169	Duct mounting kit	Enables monitoring of ducts from 300 mm to 3000 mm, and air-flow between 2 m/s and 20 m/s.
S012996	Flow adaptor	For gas sampling applications.
S012827	PC communications kit	Communications module, software and lead to enable configuration of the detector.
M20: S012295 ½" NPT: S012296	Auxiliary junction box	Mounting option for **IRmax** for use in hazardous environments.
C011210	Mirror cleaning kit	Contains IPA impregnated wipes and microfibre cloth

IRmax Spares

Refer to Diagram 3 on page 5 for details of spare parts.

6. Fault finding

6.1 Errors signalled by LED

The LED fitted to the terminal PCB can help identify faults. Its position is shown on Diagram 7 on page 11. The table below shows how to interpret what is wrong for each pattern of flashes.

LED Pattern	Detector Status	Action
Regular flash each second.	Healthy.	
On with short blips off.	Detector in start-up mode.	Wait 10 seconds.
Fast flash on and off or irregular flash pattern.	Supply voltage too low or too high.	Ensure the **IRmax** supply voltage is correctly set. Ensure measurement is made directly at the detector terminals.
Permanently on.	Fault, host or i-module error.	Power-cycle the **IRmax**, if fault persists, return to **Crowcon**.
Two long flashes followed by a short flash.	Fatal error; lamp or detector fault.	Return to **Crowcon**.
Fast double flash each second.	Fatal error, module or configuration fault.	Check the detector configuration using PC communications kit software. Check power supply. If fault persists, return to **Crowcon**.
Short blip each second.	Optics obscured.	Check window and mirror, clean if necessary. Re-zero **IRmax** and check calibration.

Any other faults can only be rectified by returning the **IRmax** to **Crowcon** or authorised service agent.

6.2 Analogue Output

IRmax will remain in Fault state and "Service required" will also be shown on the **IR Display** (if fitted) if the analogue output signal has failed or is not connected to a control system or load resistor. **IRmax** actively monitors the 4-20mA analogue output signal to verify it is in range. If the signal is out of range the detector will go into fault and the output will be set to 1mA. Thus, when testing a detector it is essential that it is either connected to a control panel or a 100Ω load resistor is connected between the '0V' and 'Sig' terminals (detector set to 'Source' mode) or between the '0V' and '+V' terminals (detector set to 'Sink' mode).

7. RS485 Modbus configuration

English

7.1 General

This section explains how to use **IRmax** detectors in a Modbus configuration. An RS485 enabled version is available for such applications. Up to 32 **IRmax** detectors can be linked in star or bus configurations as described below.

Connections to the RS485 version of the **IRmax** must be made via a spigot gland to an auxiliary junction box (see Section 5 on page 16), rather than by cabling directly into the detector.

Please note that the **IR Display** cannot be used with RS485 enabled **IRmax**.

The RS485 enabled version of the **IRmax** has five field terminals . The terminals are:

1	Positive supply	12 V to 30 V above 0 V
2	0 V	Return and RS485 reference
3	4-20 mA signal	Source or Sink signal (optional)
4	RS485 B	RS485 differential signal
5	RS485 A	RS485 differential signal

The signals on the RS485 terminals conform to the EIA/TIA-485 standard, which means that the common mode range is -7V to +12V with respect to the 0V terminal.

Note that not all RS485 manufacturers agree on the polarity of the A and B signals. If the wiring does not work one way, users should switch the RS485 A&B wires. There is no risk in making the wrong connection.

The communication settings are 9600 bps, two stop bits and no parity.

When compiling an interface for a control system, it is important to consider the amount of time it takes for the system to collect information from each detector in turn. The fastest speed at which multiple detectors can be polled is 14 detectors per second; practical conditions may reduce this to 7 per second. Users must ensure that the arrangement allows alarm signals to be registered within acceptable time limits.

It is also important to ensure that the system can supply enough power to keep all the detectors working. To calculate the amount of power required in a linear bus connection, see Section 7.3, Cabling requirements, on page 20.

For full Modbus instructions, contact **Crowcon** (see addresses on back cover).

7.2 Wiring topology

The two common wiring topologies in use are the star connection and the linear bus.

7.2.1 Star connection

In a star-connected topology all detectors are wired to a central point, which is usually the control panel. No cables are required to have more than 5 cores as all the 4-20mA signal connections are taken directly to the control panel.

The RS485 A and B signals can then all be connected together at the star point. The bus should then be terminated at the star point with a single 110 ohm termination resistor.

The length of each arm of the star may not exceed 750 metres.

7.2.2 Linear bus connection

In a bus-connected topology all **IRmax** are wired to a linear arrangement, usually with the control panel at one end. A classic situation is a tunnel installation, with **IRmax** installed at regular intervals (see Diagram 9 below).

To wire the installation, two 110 ohm-terminating resistors should be fitted: one at each physical end of the bus.

As the 4-20mA signals cannot be shared, an additional conductor is required on each wiring hop. If none of the 4-20mA signals are being used, then only four conductors are required.

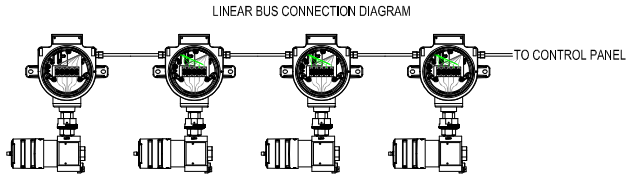


Diagram 9

7. RS485 Modbus configuration

7.3 Cabling requirements

7.3.1 Calculating the minimum level of power required

The more **IRmax** detectors connected to the linear bus, the greater the power required to run the system. To calculate the power required for a particular setup, it is necessary to know the cable resistance between each pair of **IRmax** detectors. A current of at least 0.1mA must be allowed for each 'hop' between **IRmax**. The voltage to be applied can be calculated by estimating the voltage drop across each 'hop' – at the end at least 12V must remain to ensure that the last **IRmax** functions correctly.

Contact **Crowcon** for advice in specific cases. Alternatively, follow the steps outlined below and the sample calculation shown in the next section.

1. The voltage must not fall below 12V, so start the calculation by setting the voltage at the last **IRmax** in the line at that value.
2. Each **IRmax** may draw up to 0.1 A. Calculate the cable voltage loss of the first 'hop' between detectors by taking the 'aggregate current' to be 0.1A, and multiply this by the cable resistance of the 'hop' between the last and the last but one **IRmax**.
3. Add this voltage drop to the initial 12V to get the lowest acceptable voltage at the last but one **IRmax**. Add 0.1A to the value for the 'aggregate current' to get to 0.2mA, the minimum current running through the last but one 'hop' of the bus. Multiply this by the cable resistance for the last but one 'hop' to get the next voltage drop.
4. Repeat this process for each **IRmax**, accumulating the voltage losses that will occur between each **IRmax**.
5. The maximum detector voltage of 30V must not be exceeded.

7.3.2 Sample calculation

As an example, here are the results of the calculation for six **IRmax** detectors spaced equally 250 m apart on cable with cross-sectional area of 1mm^2. Each hop has a resistance of 4.6 ohms.

Station	Supply voltage	Supply current
1	12	0.1 A
2	12.46	0.2 A
3	13.38	0.3 A
4	14.76	0.4 A
5	16.6	0.5 A
6	18.9	0.6 A
Panel supply	21.66	0.6 A

8. Functional Safety Manual

8.1 Introduction

The following sections provide detail on the certification of **IRmax** in accordance with the IEC 61508 and EN 50402 Functional Safety standards. Information is given on the features considered in the safety case, maintenance requirements and data to enable **IRmax** to be integrated into Safety Instrumented System (SIS).

8.2 IRmax and IRmax Modbus Safety Function

To measure the concentration of flammable gas and indicate the measurement by means of a 4-20mA output.

Failures in respect of the safety function will be detected by the hardware and associated firmware. They will be revealed as an output signal of less than 3.6mA or more than 21mA.

8.3 Functional Safety Data

Parameter name	Symbol	Equation / source	IRmax
Proof Test Interval	T1	As defined by Crowcon.	8,760 hours (annual)
Mean Time To Repair	MTTR	As defined by Crowcon.	8 hours
Type A/B	Type A	As defined by Crowcon.	Type B
Total failures:	λ	From FMEDA	1.04E-05
Safe diagnosed failures:	λ_{SD}	From FMEDA	1.95E-08
Safe undiagnosed failures:	λ_{SU}	From FMEDA	8.59E-08
Dangerous diagnosed failures:	λ_{DD}	From FMEDA	9.74E-06
Dangerous undiagnosed failures:	λ_{DU}	From FMEDA	5.06E-07
Safe no-effect failures:	λ_{NE}	From FMEDA	3.21E-09
Diagnostic coverage:	DC	λ_{DD} / (λ_{DU} + λ_{DD})	95.06%
Safe Failure Fraction:	SFF	(λ_{SD} + λ_{SU} + λ_{DD}) / λ	95.11%
Channel equivalent down time	t_{CE}	(λ_{DU} / λ_D)(T/2 + MTTR) + (λ_{DD} / λ_D) MTTR	2.24E+02
PFDAVG (using 61508-6 equation)	PFD_{AVG}	(λ_{DU} + λ_{DD}) t_{CE}	2.30E-03
PFDAVG (using simplified equation)	PFD_{AVG}	λ_{DU} (T / 2+MTTR) + (λ_{DD} MTTR)	2.30E-03
PFDAVG (using IEC 61508-6 equation)	PFD_{AVG}	$1-\varepsilon^{-(\lambda dd+\lambda du)\ tce}$	2.30E-03
SIL capability (Low demand mode)			**SIL2**
SIL capability (High demand mode)			**SIL2**

For low demand applications, in respect of random hardware failures and safe failure fraction, all variants of the system are suitable for use in **SIL 2** applications.