INSTRUCTION MANUAL
Model CX-IR

Infrared Combustible Gas Sensors
Operator's Installation and Instruction Manual
Covers all Model CX-IR Sensors

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1. Introduction

1.1 Description

Teledyne Detcon Model CX-IR combustible gas sensors are non-intrusive "Smart" sensors designed to detect and monitor combustible hydrocarbon gases in the air with a detection range of 0-100% LEL (Lower Explosive Limit). The sensor features an LED display of current reading, fault and calibration status. A primary feature of the sensor is its method of automatic calibration, which guides the user through each step via fully scripted instructions illustrated on the LED display.

The microprocessor-supervised electronics are enclosed in an encapsulated module and housed in an explosion proof casting. The infrared detector is mounted in an intrinsically safe stainless steel housing and includes a Splash Guard Cal Adapter.

Non-Dispersive Infrared (NDIR) Optical Sensor Technology

The sensor technology is designed as a miniature plug-in replaceable component, which can easily be changed out in the field.

The NDIR sensor consists of (Figure 1);

- one infrared lamp source,
- two pyroelectric detectors (active and reference),
- and one optical gas sample chamber.

The lamp source produces infrared radiation, which interacts with the target gas as it is reflected through the optical gas sample chamber. The infrared radiation contacts each of the two pyroelectric detectors at the completion of the optical path. The active pyroelectric detector is covered by a filter specific to the part of the IR spectrum where the target gas absorbs light. The reference pyroelectric detector is covered by a filter specific to the non-absorbing part of the IR spectrum. When the target gas is present, it absorbs IR radiation and the signal output from the active detective decreases accordingly. The reference detector output remains unchanged. The ratio of the active and reference detector outputs are then used to compute the target gas concentration.

The technique is referred to as non-selective and may be used to monitor most any combustible hydrocarbon gas. Unlike catalytic bead type sensors, Teledyne Detcon IR sensors are completely resistant to poisoning from corrosive gases and can operate in the absence of an oxygen background. The sensors are characteristically stable and capable of providing reliable performance for periods exceeding 5 years in most industrial environments.

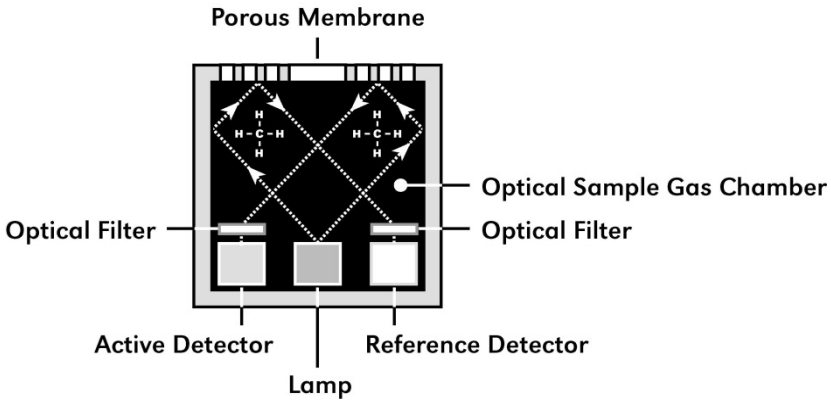

Figure 1 Sensor Cell Construction

Principle of Operation

The target gas diffuses through a stainless steel screen and into the volume of the sample gas optical chamber. An alternating miniature lamp provides a cyclical IR radiation source, which reflects through the optical gas sample chamber and terminates at the two pyroelectric detectors. The active and reference pyroelectric detectors each give an output which measures the intensity of the radiation contacting their surface. The active detector is covered by an optical filter specific to the part of the IR spectrum where the target gas absorbs light. The reference detector is covered by a filter specific to the non-absorbing part of the IR spectrum. When present, the target gas absorbs a fraction of the IR radiation and the signal output from the active detector decreases accordingly. The signal output of the reference detector remains unchanged in the presence of the target gas. The ratio of the active/reference signal outputs is then used to compute the target gas concentration. By using the ratio of the active/reference signal outputs, measurement drift caused by the changes in the intensity of the IR lamp source or changes in the optical path's reflectivity is prevented (Figure 2).

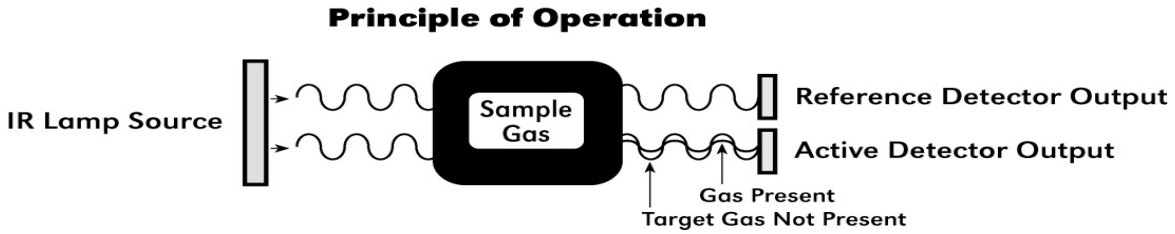

Figure 2 Principle of Operation

Performance Characteristics

The IR sensor maintains strong sensitivity to most all combustible hydrocarbon gases within the LEL range. When compared with the typical catalytic bead LEL sensor, the IR sensor exhibits improved long-term zero and span stability. Typical zero calibration intervals are quarterly to semi-annual and typical span intervals are semi-annual to annual.

NOTE	Actual field experience is always the best determination of appropriate calibration intervals.

NOTE	The CX-IR sensor will not respond to combustible gases that are not hydrocarbons, such as H_2, NH_3, CO, H_2S….etc. It can only be used to measure hydrocarbon type gases.

The IR sensor generates different signal sensitivity levels for different combustible hydrocarbon target gases. Unless otherwise specified the CX-IR sensor will be factory calibrated for methane service. If the target hydrocarbon gas is other than methane, then the unit will have to be span calibrated and configured in accordance with this CX-IR sensor instruction manual.

1.2 Modular Design

The CX-IR sensor assembly is completely modular and is composed of four parts (Figure 3).

1. CX-IR Intelligent Transmitter Module (ITM)
2. Plug-in Infrared Sensor
3. CX Series Bottom Housing
4. Rain Shield

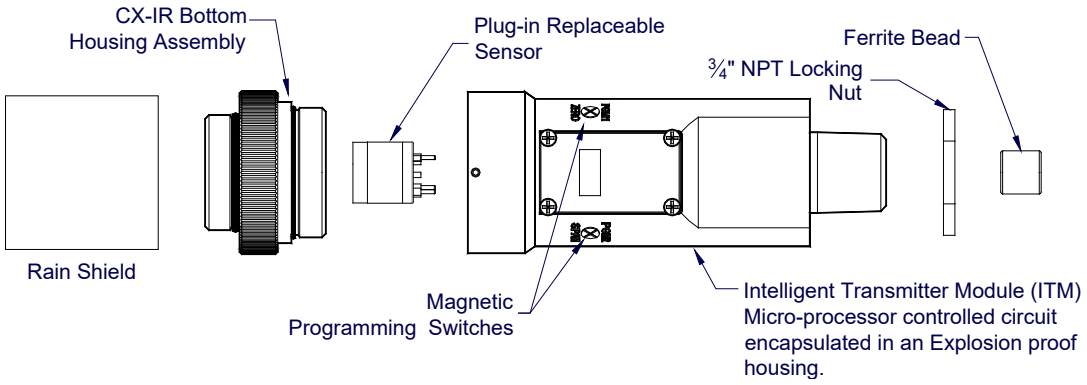

Figure 3 Sensor Assembly Breakaway

NOTE	All metal components are constructed from electro polished 316 Stainless Steel to maximize corrosion resistance in harsh environments.

CX-IR Intelligent Transmitter Module

The transmitter module is microprocessor-based and attached to the explosion proof junction box. Circuit functions include an intrinsically safe barrier, on-board power supply, microprocessor, magnetic programming switches, and a linear 4-20mA DC output. Magnetic program switches (located on either side of the ITM) are activated by a hand-held magnetic programming tool, allowing non-intrusive operator interface with the transmitter module. Electrical classifications are Class I, Div 1, Groups B, C, and D.

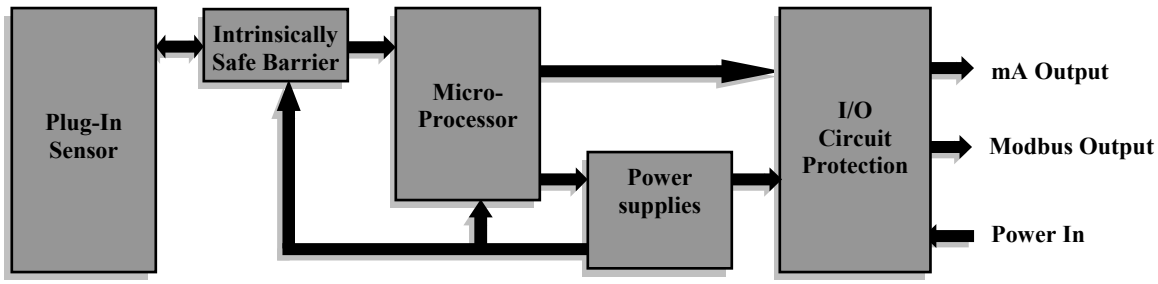

Figure 4 Functional Block Diagram

Field Replaceable Sensor

Teledyne Detcon's infrared gas sensors are field proven, plug-in sensors with over-sized gold-plated connections that eliminate corrosion problems. The sensor can be accessed and replaced in the field easily by releasing the locking screw and unthreading the splashguard adapter assembly.

Figure 5 Plug-in Sensor

2. Installation

2.1 Hazardous Locations Installation Guidelines for Safe Use

1. Install the sensor only in areas with classifications matching the approval label. Follow all warnings listed on the label.

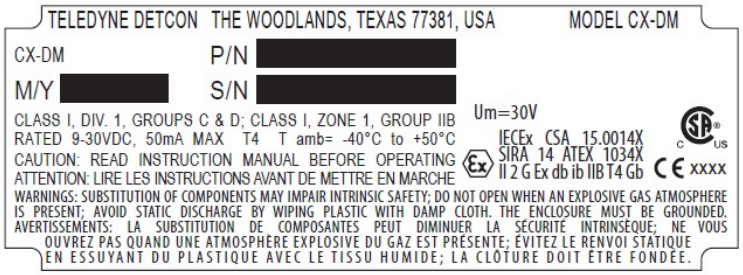

Figure 6 Approval Label

2. Do not remove the junction box cover while in the classified are unless it is conformed the there is no explosive gas levels in the area.

3. A good ground connection should be verified between the sensor's metal enclosure and the junction box. If a good ground connection is not made, the sensor can be grounded to the junction box using the sensor's external ground lug. Verify a good ground connection between the junction box and earth ground.

4. Proper precautions should be taken during installing and maintenance to avoid the build-up of static charge on the plastic components of the sensor (Rain Shield) Wipe with damp cloth on plastic components to avoid static discharge.

5. Do not substitute components. Substitution of components may impair the intrinsic safety rating.

6. Do not operate the sensor outside of the stated operating temperature limits.

7. Do not operate the sensor outside the stated operating limits for voltage supply.

8. These sensors meet ATEX standards EN60079-0:2012. EN60079-1:2007 and EN60079-11:2012.

9. These sensors have a maximum safe location voltage of Um=30V.

10. The CX-IR apparatus is not capable of withstanding the 500V insulation test required by clause 6.3.12 of IEC/EN 60079-11:2007 (and by clause 6.8.1 of CSA Std. 142); thus, the enclosure must be grounded.

11. The CXT-IR must only be combustible sensing cell model 371-IR1II1-000.

2.2 Sensor Placement

Sensor location is critical to the overall safe performance of the product. Confirm that the following five factors are verified during sensor placement.

1. Density of the gas to be detected
2. Most probable leak sources within the industrial process
3. Ventilation or prevailing wind conditions
4. Personnel exposure
5. Maintenance access

Density

Sensor placement should be relative to the density of the target gas. For the detection of heavier than air gases, sensors should be located within 4 feet of grade since heavy gases typically settle in low lying areas. For gases lighter than air, sensor placement should be 4 to 8 feet above grade in open areas or in pitched areas of enclosed spaces.

Leak Sources

The most leak sources in an industrial process are flanges, valves, and tubing connections where seals may either fail or wear. Other leak sources are best determined by facility engineers with experience in similar processes.

Ventilation

Normal ventilation or prevailing wind conditions can dictate efficient location of gas sensors in a manner where the movement of gas clouds is quickly detected.

Personnel Exposure

The undetected migration of gas clouds should not be allowed to approach concentrated personnel areas such as control rooms, maintenance or warehouse buildings. Selecting sensor location should combine leak source and perimeter protection in the best possible configuration.

Maintenance Access

Consideration should be given to providing easy access for maintenance personnel and the consequences of close proximity to contaminants that may cause the sensor to wear prematurely.

NOTE	In all installations, the gas sensor should point straight down. Improper sensor orientation may result in false readings and permanent sensor damage.

Additional Placement Considerations

The sensor should not be positioned where it might be sprayed or coated with surface contaminating substances. Painting sensor assemblies is prohibited.

Although the sensor is designed to be RFI resistant, it should not be mounted in close proximity to high-powered radio transmitters or similar RFI generating equipment.

When possible mount in an area void of high wind, accumulating dust, rain, splashing from hose spray, direct steam releases, and continuous vibration. If the sensor cannot be mounted away from potentially damaging conditions then use the Teledyne Detcon's Harsh Location Dust Guard accessory.

Do not mount in locations where temperatures will exceed the operating temperature limits of the sensor. Use a sunshade to maintain correct operating temperature if mounted in direct sun light.

2.3 Sensor Mounting

Vertically position the CX-IR so the sensor points straight down. The explosion-proof enclosure or junction box is typically mounted on a wall or pole. Teledyne Detcon provides a selection of standard junction boxes in aluminum and stainless steel.

NOTE	If wall mounting without a mounting plate, make sure to use at least $^{1}/_{2}$" spacers underneath the aluminum junction boxes $^{1}/_{4}$" mounting holes to move the sensor assembly away from the wall and to allow access to the sensor assembly.

NOTE	Metal-on-metal contact must be maintained to provide a solid electrical ground path. Only use Teflon Tape or other pipe thread material on the $^{3}/_{4}$" threads if the sensor is mounted in a severe or harsh environment. If Teflon Tape is used the Sensor ***must*** be externally grounded using a ground strap.

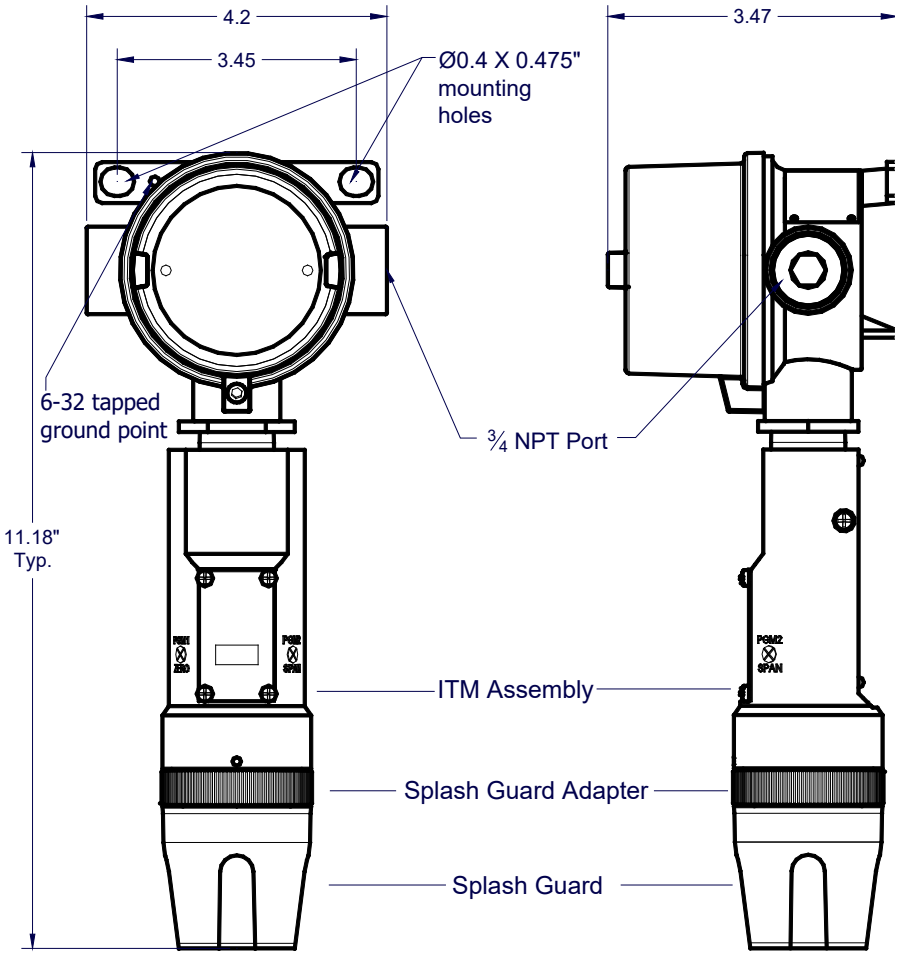

Figure 7 CX-IR Sensor with Mini Stainless Steel Junction Box

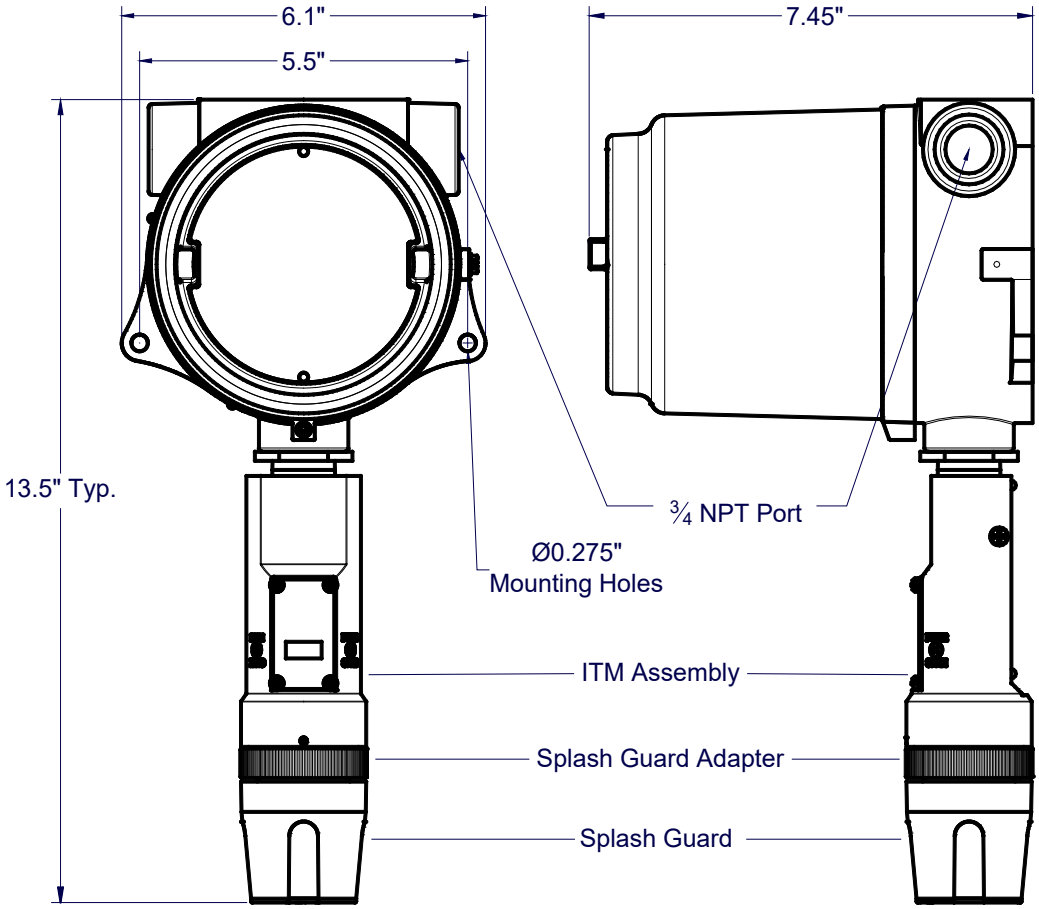

Figure 8 CX-IR Sensor with Rechargeable Battery Pack

When mounting on a pole, secure the junction box to a suitable mounting plate and attach the mounting plate to the pole using U-Bolts. (Pole-Mounting brackets for Teledyne Detcon junction boxes are available separately.)

2.4 Electrical Installation

The sensor assembly wiring should be installed in accordance with local electrical codes. Proper electrical installation of the gas sensor is critical for conformance to electrical codes and to avoid damage due to water leakage.

If a conduit run exists, a drain should be incorporated. The drain allows condensation inside the conduit run to drain safely away from the sensor assembly. Electrical seals act as a secondary seal to prevent water from entering the wiring enclosure. However, electrical seals are not designed to provide an absolute watertight seal, especially when used in the vertical orientation. The electrical seal fitting is required to meet the National Electrical Code per NEC Article 500-3d (or Canadian Electrical Code Handbook Part 1 Section 18-154). Requirements for locations of electrical seals are covered under NEC Article 501-5.

NOTE:	For products utilizing the aluminum junction box option, the conduit seal shall be placed at the entry to the junction box (see Figure 9 as an example). For products utilizing the stainless steel junction box option, the conduit seal shall be placed within 18" of the enclosure. Crouse Hinds type EYS2, EYD2 or equivalent are suitable for this purpose.

NOTE	Water damage from water leaking into the enclosure is not covered by the Teledyne Detcon warranty.

NOTE	Unused ports should be blocked with suitable $^{3}/_{4}$" male NPT plug. Teledyne Detcon supplies one $^{3}/_{4}$" NPT male plug with each J-box enclosure. If connections are other than $^{3}/_{4}$" NPT, use an appropriate male plug of like construction material.

CAUTION	Do not apply system power to the sensor until all wiring is properly terminated (Section 2.6).

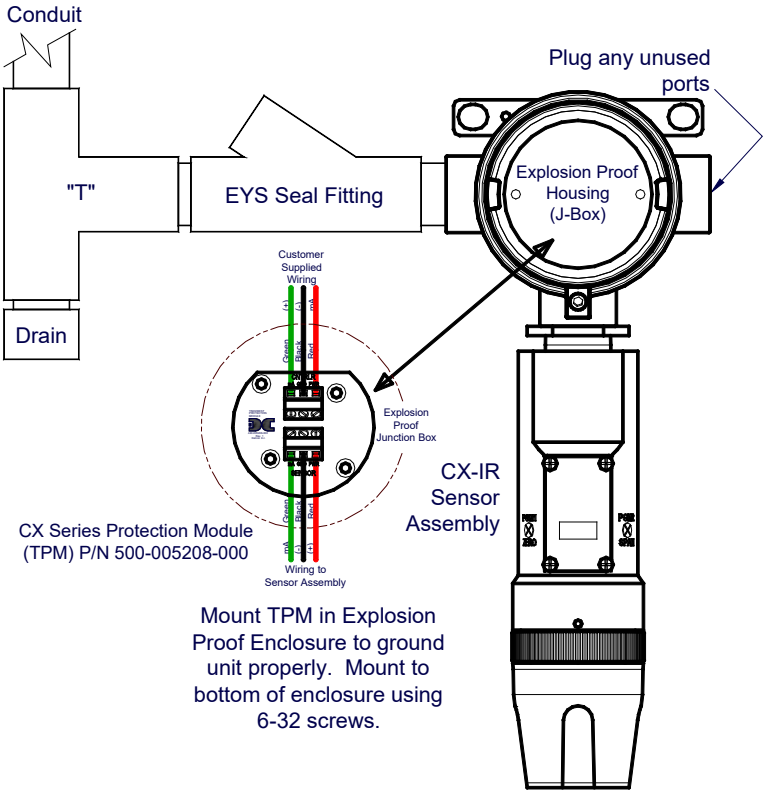

Figure 9 Typical Installation

2.5 Field Wiring

Teledyne Detcon Model CX-IR sensor assemblies require three conductor connections between power supplies and host electronic controller's 4-20mA output. Wiring designations are + (DC), – (DC), and mA (sensor signal. Maximum wire ohmic resistance between sensor and 24VDC source is defined below. Maximum wire size for termination in the Teledyne Detcon J-Box accessory is 14 gauge.

Max Resistance drop on red and black wire is 10 ohms. This considers wire diameter, wire length and maximum operation temperature.

Max loop load resistance between green and black wire is 500 ohms. Minimum loop load resistance between green and black wire is 100 ohms. This is considers wire diameter, wire length, max operating temperature and selected termination resistor.

AWG	Wire Dia.	Over-Current Protection
22	0.723mm	3A
20	0.812mm	5A
18	1.024mm	7A
16	1.291mm	10A
14	1.628mm	20A

Table 1 Protection vs. Wire Gauge

NOTE 1: Wiring table is based on stranded tinned copper wire and is designed to serve as a reference only.

NOTE 2: Shielded cable is required for installations where cable trays or conduit runs include high voltage lines or other possible sources of induced interference. Separate conduit runs are highly recommended in these cases.

NOTE 3: The supply of power should be from an isolated source with over-current protection as stipulated in table.

2.5.1 Terminal Connections 3-Wire 4-20mA

CAUTION: Do not apply System power to the sensor until all wiring is properly terminated. Refer to Section 2.5 Initial Start Up

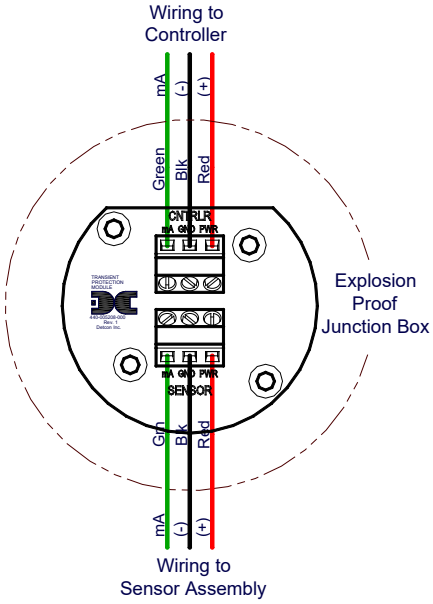

Figure 10 Sensor Wire Connections

a) Remove the junction box cover. Identify the terminal blocks for customer wire connections.

b) Observing correct polarity, terminate the 3-conductor 4-20mA field wiring (+, -, mA) to the sensor assembly wiring in accordance with the detail shown in **Figure 10**.

c) Replace the junction box cover.

2.5.2 Terminal Connections 4-20mA and RS-485

1. Remove the junction box cover.

2. Connect the incoming 24V to the terminal labeled "+" and 24V return to the terminal labeled "–". Connect the mA output to the “mA” terminal and the Modbus signals (if used) to the “A” and “B” terminals. Note: the “Y” terminal is not used.

3. Replace the junction box cover after Initial Start Up (Section 2.6).

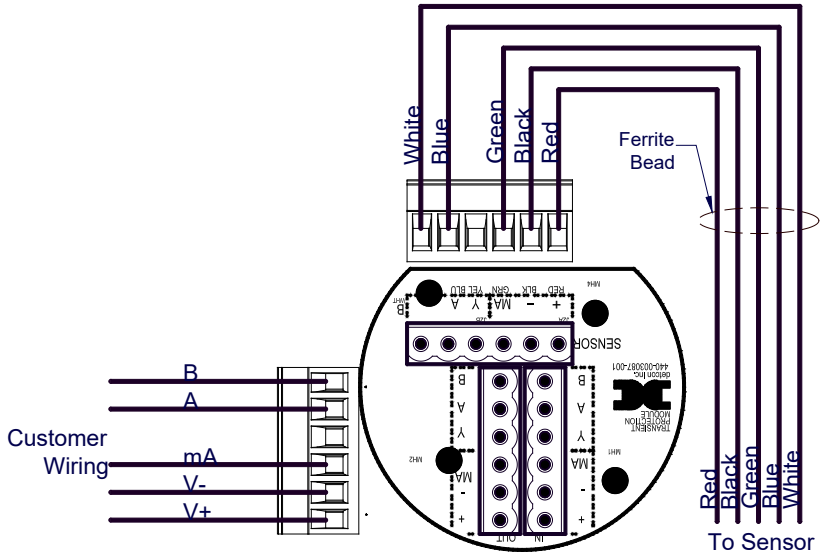

Figure 11 Terminal Interconnect

NOTE	A 6-32 or 8-32 threaded exterior ground point is provided on most junction boxes for an external ground. If the sensor assembly is not mechanically grounded, an external ground strap ***must*** be used to ensure that the sensor is electrically grounded.

2.5.3 Terminal Connections 4-20mA, RS-485, and Alarm Outputs

1. Remove the junction box cover.

2. The wires from the sensor connect to J5, J6, and J7. The connections for the sensor wires are labeled with their corresponding colors. Connect the red, black, white/black, white/brown, violet, and orange wires to J5. Connect the green wire to the J6 terminal labeled “SEN. GRN”. Connect the blue and white sensor wires to the J7 terminals labeled “SEN. BLU” and “SEN. WHT”.

3. J1 has normally open, common, and normally closed connections for the Alarm 1 relay. The Alarm 2 relay connections are located on J4.

NOTE	The Alarm Relays are rated for 5A @ 30VDC/240VAC. Exceeding these rating will damage the sensor assembly.

4. A solar panel (for battery recharge) may be connected J1 and J4. The positive lead of the panel should be connected to the SOLAR terminal on J4. The negative lead of the panel should be connected to GND on J1.

5. A PLC or RTU may be used to monitor the Modbus output from the sensor. The Modbus connections can be made on MODBUS A and MODBUS B on J7 and GND on J6.

NOTE	A DC common wire from the PLC/RTU must be connected to GND on J6.

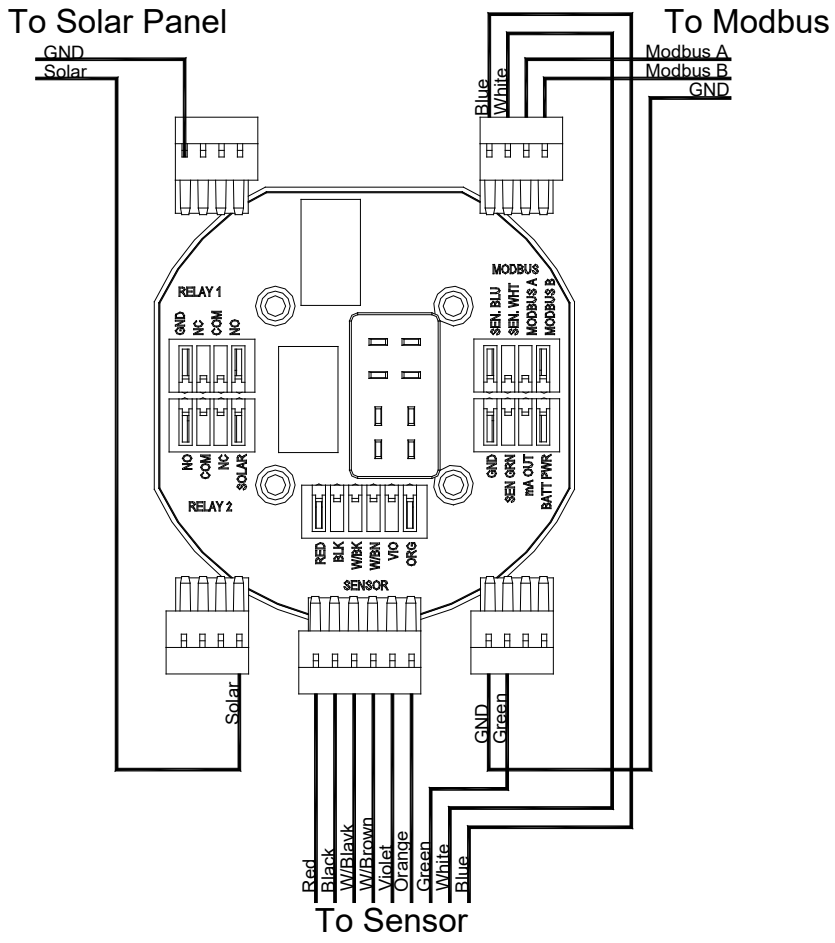

Figure 12 Battery Term Board Wiring

2.6 Initial Start Up

Combustible Gas Sensors

Upon completion of all mechanical mounting and field wiring, apply power to the unit. If the unit is equipped with the optional power switch, power is applied by pushing the switch. Observe the following normal conditions:

1. Upon power up, the sensor will scroll **CX-IR** and will then display the current reading for approximately 5 seconds. A temporary upscale reading may occur as the sensor stabilizes. This upscale reading will decrease to 0% LEL within 1 to 2 minutes of power-up, assuming there is no gas in the area of the sensor.

2. After the initial power up, the sensor display will turn off. Thereafter the display will come on once every 10 seconds and will display the current reading for about 2 seconds, and will return to a blank display to conserve battery power.

NOTE	In normal operation the display will come on once every 10 seconds, will display the current reading for about 2 seconds, and will return to a blank display to conserve battery power.

Initial Operational Tests

After a warm up period of 1 hour (or when zero has stabilized), the sensor should be checked to verify sensitivity to the target gas.

Material Requirements

- Splash Guard with integral Cal Port and with Wind Guard (Detcon PN 613-120000-700) -*or*-
- Threaded Calibration Adapter (Detcon PN 943-000006-132) - *or* -
- Teflon Calibration Adapter for highly reactive gases (Detcon PN 943-01747-T05)
- Detcon Span Gas; 50% of range target gas in balance N2 or Air at fixed flow rate between 200-500cc/min (500cc/min is preferred)

12. Attach the calibration adapter to the Splashguard Adapter Assembly or connect tubing to integral cal port. It is recommended that the Wind Guard (Detcon PN 943-000000-000) is installed over the Splash Guard during calibration.

13. Apply the test gas at a controlled flow rate of 200 - 500cc/min (500cc/min is the recommended flow). Observe that the ITM display increases to a level near that of the applied calibration gas value.

NOTE	Wind Guard must be used when calibrating with the integral cal port to ensure proper calibration.

14. Remove test gas and observe that the display decreases to 0.

15. If a calibration adapter was used during these tests, remove it from the unit, and re-install the Splash Guard.

16. If the wind guard was used, remove the wind guard.

Initial operational tests are complete.

CX-IR Combustible gas sensors are factory calibrated prior to shipment, and should not require significant adjustment on start up. However, it is recommended that a complete calibration test and adjustment be performed 16 to 24 hours after power-up. Refer to calibration instructions in Section 3.3.

3. Operation

The operator interface of the CX Series gas sensors is accomplished with two internal magnetic switches located to either side of the LED display (Figure 14). The two switches, labeled **PGM1** and **PGM2**, allow for complete calibration and configuration, eliminating the need for area de-classification or the use of hot permits.

Figure 13 Magnetic Programming Tool

The magnetic programming tool (Figure 13) is used to operate the magnetic switches. Switch action is defined as momentary contact (a swipe), a 3-second hold, and a 10-second hold. (Hold times are defined as the time from the point when the arrow prompt appears. Swiping the magnet does not display the arrow prompt.) For momentary contact use, the programming magnet is briefly held over a switch location, or swiped. For 3-second hold, the programming magnet is held in place over the switch location for three seconds. For 10-second hold, the programming magnet is held in place over the switch location for 10 seconds. The 3 and 10 second holds are generally used to enter calibration/program menus and save new data. The momentary contact is generally used to move between menu items and to modify set-point values. Arrows (◄ and ►) are used on the LED display to indicate when the magnetic switches are activated. The location of **PGM1** and **PGM2** are shown in Figure 14.

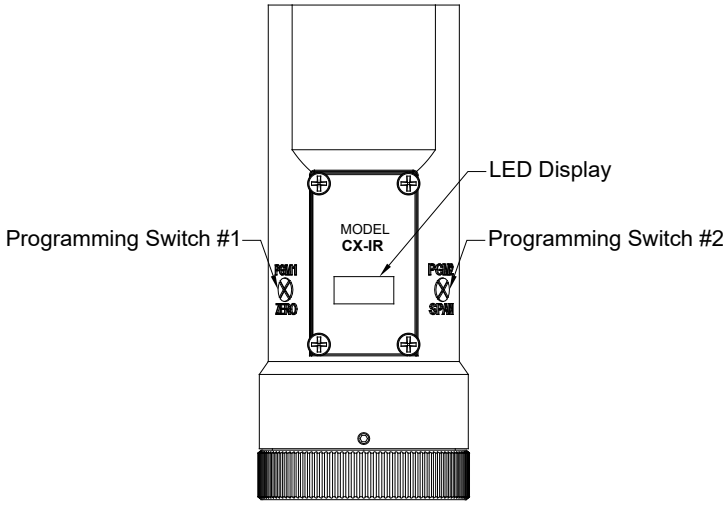

Figure 14 Magnetic Programming Switches

NOTE	While in Program Mode, if there is no magnetic switch interaction after 4 consecutive menu scrolls, the sensor will automatically revert to normal operating condition. While changing values inside menu items, **if there is no magnet activity after 3 to 4 seconds the sensor will revert to the menu scroll.** If the sensor is in Bump Test mode, the display will remain active.

3.1 Operator Interface

The operating interface is menu-driven via the two magnetic program switches located under the target marks of the sensor housing. The two switches are referred to as **PGM1** and **PGM2**. The menu list consists of three menu items that include sub-menus:

Normal Operation

Concentration reading is displayed once every 10 seconds.

Calibration Mode

AutoZero
AutoSpan

Program Mode

View Sensor Status
- CX-IR ##.##
- Serial Number
- Range ###
- Autospan Level ##
- Modbus ID ##
- Last Cal ## Days
- Sensor Life ###%
- Temperature ##C
- Alarm 1 Level
- Alarm 2 Level
- Fault

Set Gas Type
Set Autospan Level
Set Gas Factor
Set Modbus ID
Bump Test
Restore Defaults
Alarm Settings

Software Flowchart

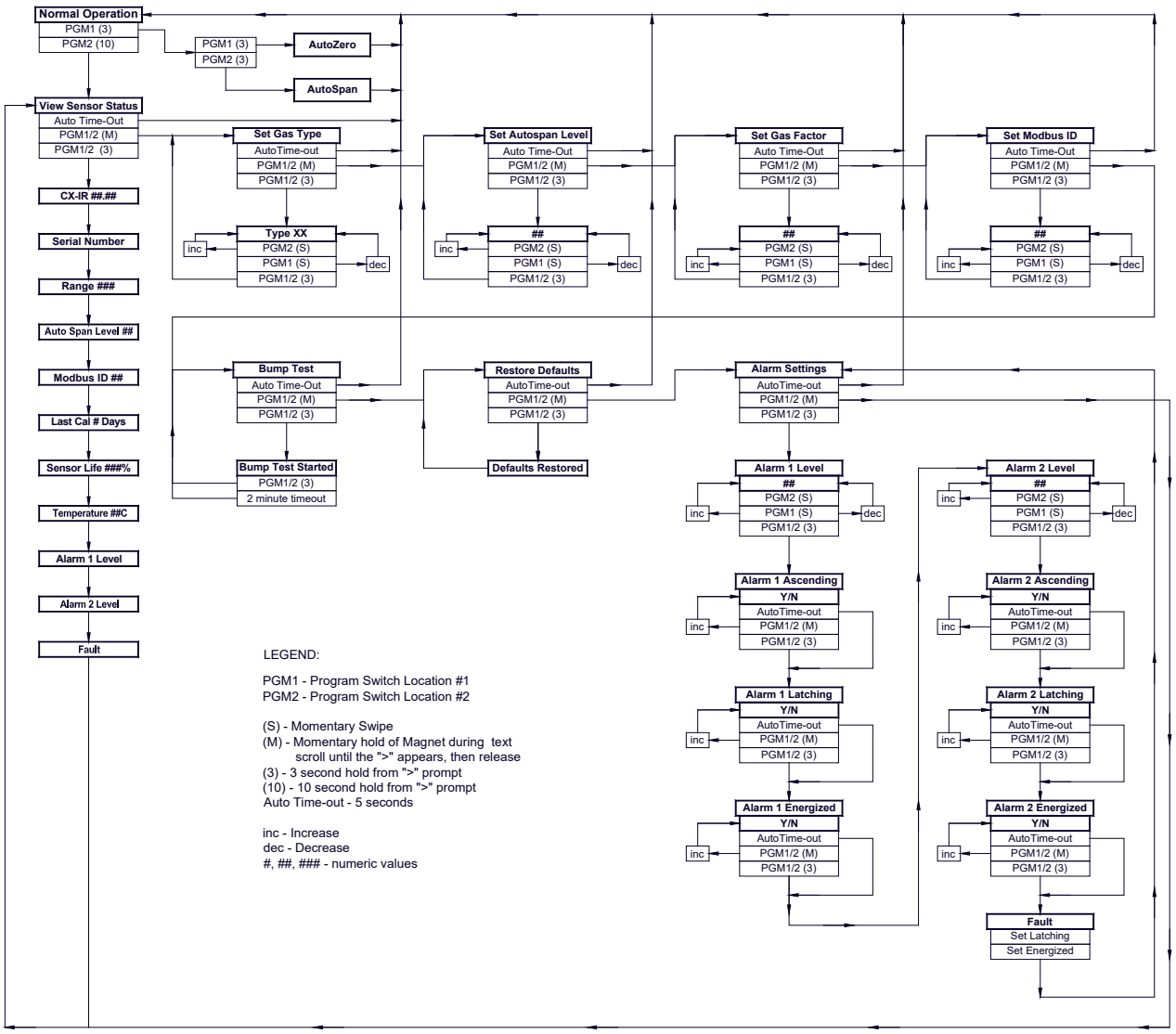

Figure 15 Software flow chart

3.2 Normal Operation

In normal operation, the Intelligent Transmitter Module (ITM) display will be blank and will display the gas reading once every 10 seconds for about 2 seconds (normally appear as "0"). At any time, swiping a magnet across either **PGM1** or **PGM2** will cause the ITM to display the range and gas type (i.e. "ppm H2S"). If the sensor is actively experiencing any diagnostic faults, a swipe of the magnet will cause the display to scroll the fault condition. Refer to Section 5 Service and Maintenance for more information on fault conditions.

3.3 Calibration Mode

Zero and span calibration should be performed on a routine basis (quarterly minimum is advised) to ensure reliable performance. If a sensor has been exposed to any de-sensitizing gases, or to very high over-range combustible gas levels, re-calibration should be considered. Unless otherwise specified, span adjustment is recommended at 50% of the full scale range.

To enter calibration mode hold the magnet over **PGM1** for 3 seconds. If the sensor is experiencing a fault condition the "►" prompt will not appear until the fault(s) have been displayed. When the ITM enters calibration mode the display will scroll **Pgm1=Zero Pgm2=Span** twice before returning to normal mode (about 5 seconds).

NOTE	Upon entering calibration mode, the Modbus™ status register bit 14 is set to signify the sensor is in-calibration mode. This bit will remain set until the program returns to normal operation.

3.3.1 AutoZero

The AutoZero function is used to zero the sensor. AutoZero should be performed periodically or as required. AutoZero should be considered after periods of over-range target gas exposure. Local ambient air can be used to zero calibrate a combustible gas sensor as long as it can be confirmed that it contains no target or interference gasses. If this cannot be confirmed then a zero air or N_2 cylinder should be used.

Material Requirements:

- DetconMicroSafe™ Programming Magnet (PN 327-000000-000)
- Splash Guard with integral Cal Port (Detcon P/N 613-120000-700) and Calibration Wind Guard (Detcon PN 613-120000-700) -or-
- Threaded Calibration Adapter (Detcon PN 943-000006-132)
- Detcon Zero Air cal gas (PN 942-001123-000) (or use ambient air if no target gas is present)
- Detcon Nitrogen 99.99% (PN 942-640023-100)

NOTE	The zero gas source may be zero air or N_2 if local ambient air contains target or interference gases.

NOTE	The Calibration Wind Guard must be used when the Splashguard Adapter with integral Cal Port is used. Failure to use the Calibration Wind Guard may result in an inaccurate AutoZero calibration.

a) For combustible gas sensors, if the ambient air is known to contain no target gas content, then it can be used for zero calibration. If a zero gas cal cylinder is going to be used, attach the calibration adapter and set flow rate of 200-500cc/min (500cc/min is the recommended flow rate) and let sensor purge for 1 to 2 minutes before executing the **AutoZero**.

b) From normal operation, enter calibration mode by holding the programming magnet over **PGM1** for 3 seconds The display will then scroll **Pgm1=Zero Pgm2=Span**. Hold the programming magnet over **PGM1** for 3 seconds once the "◄" prompt appears to execute **AutoZero** (or allow to timeout in 5 seconds if AutoZero is not desired).

NOTE	The "◄" prompt will show that the magnetic switch is activated during the 3 second hold period.

NOTE	Upon entering calibration mode, the Modbus™ status register bit 14 is set to signify the sensor is in-calibration mode. This bit will remain set until the program returns to normal operation.

c) The ITM will display the following sequence of text messages as it proceeds through the **AutoZero** sequence:

Zero Cal . . . Setting Zero . . . Zero Saved (each will scroll twice)

d) Remove the zero gas and calibration adapter, if applicable.

3.3.2 AutoSpan

The AutoSpan function is used to span calibrate the sensor. AutoSpan should be performed periodically or as required. AutoSpan should be considered after periods of over-range target gas exposure. Unless otherwise specified, span adjustment is recommended at 50% of range.

NOTE	Before performing AutoSpan calibration, verify that the AutoSpan level matches the span calibration gas concentration as described in Section 3.4.3 Set AutoSpan level.

Material Requirements:

- Detcon MicroSafe™ Programming Magnet (PN 327-000000-000)
- Splash Guard with integral Cal Port (Detcon P/N 613-120000-700) and Calibration Wind Guard (Detcon PN 613-120000-700) *-or-*
- Threaded Calibration Adapter (Detcon PN 943-000006-132)
- Detcon Span Gas. Recommended span gas is 50% of range with target gas. Other suitable span gas sources containing the target gas in air or N_2 balance are acceptable.

NOTE	Contact Teledyne Detcon for ordering information on span gas cylinders.

NOTE	A target gas concentration of 50% of range is strongly recommended. This should be supplied at a controlled flow rate of 200 to 500cc/min, with 500cc/min being the recommended flow rate. Other concentrations can be used if they fall within allowable levels of 5% to 100% of range.

NOTE	The Calibration Wind Guard must be used when the Splashguard Adapter with integral Cal Port is used. Failure to use the Calibration Wind Guard may result in an inaccurate AutoZero calibration.

NOTE	It is generally not advised to use other gasses to cross-calibrate for span. Cross-calibration by use of other gasses should be confirmed by Teledyne Detcon.

 ***CAUTION***	Verification that the calibration gas level setting matches the calibration span gas concentration is required before executing **AutoSpan** calibration. These two numbers must be equal.

AutoSpan consists of entering calibration mode and following the displayed instructions. The display will ask for the application of span gas in a specific concentration. The applied gas concentration must be equal to the calibration gas level setting. The factory default setting and recommendation for span gas concentration is 50% of range. If a span gas containing the recommended concentration is not available, other concentrations may be used as long as they fall between 5% and 95% of range. However, any alternate span gas concentration value must be programmed via the **Set AutoSpan Level** menu before proceeding with AutoSpan calibration.

a) Verify that the AutoSpan level is equal to the calibration span gas concentration. (Refer to View Sensor Status in Section 3.4.1.) If the AutoSpan level is not equal to the calibration span gas concentration, adjust the AutoSpan level as instructed in Section 3.4.3.

b) From normal operation, enter calibration mode by holding the programming magnet over **PGM1** for 3 seconds.

NOTE	The "◄" prompt will show that the magnetic switch is activated during the 3 second hold period.

c) The display will scroll **'PGM1=Zero PGM2=Span'**. Hold the programming magnet over **PGM2** for 3 seconds to execute **AutoSpan** (or allow to timeout in 5 seconds if AutoSpan is not intended). The ITM will scroll **'Apply XX % Gas'**.

d) Apply the span calibration test gas for combustible gas sensors at a flow rate of 200-500cc/min (500cc/min is the recommended flow rate). As the sensor signal begins to increase the display will switch to flashing **XX** reading as the ITM shows the sensor's **as found** response to the span gas presented. If it fails to meet the minimum in-range signal change criteria within 2 minutes, the display will report **Range Fault** twice and the ITM will return to normal operation, aborting the AutoSpan sequence. The ITM will continue to report a **Range Fault** until a successful calibration is completed.

e) Assuming acceptable sensor signal change, after 1 minute the reading will auto-adjust to the programmed AutoSpan level. The ITM then reports the following messages: **'Remove Gas'**.

f) Remove the span gas source and calibration adapter. The ITM will report a live reading as it clears toward 0. When the reading clears below 10% of range, the ITM will display **'Span Complete'** and will revert to normal operation. If the sensor fails to clear to less than 10% in less than 5 minutes, a **'Clearing Fault'** will be reported twice and the ITM will return to normal operation, aborting the AutoSpan sequence. The ITM will continue to report a **Clearing Fault** until a successful calibration is completed.

g) AutoSpan calibration is complete.

NOTE	If the sensor fails the minimum signal change criteria, a **Range Fault** will be declared and the Range Fault bit will be set on the Modbus™ output.

NOTE	If the sensor fails the clearing time criteria, a **Clearing Fault** will be declared and the Clearing fault bit will be set on the Modbus™ output.

3.4 Program Mode

Program Mode provides menus to check and set operational and configuration parameters of the sensor. Program Mode provides for adjustment of the AutoSpan Level, Gas Factor, Gas Type and Range, and Serial ID. Program mode includes the diagnostic function bump test and restores defaults.

The Program Mode menu items appear in the order presented below:

View Sensor Status
Set Gas Type
Set AutoSpan Level
Set Gas Factor
Bump Test
Set Modbus™ ID
Restore Defaults
Alarm Settings

Navigating Program Mode

From normal operation, enter program mode by holding the magnet over **PGM2** for 3 seconds. The "►" prompt will verify that the magnetic switch is activated. If the sensor is experiencing a fault condition the "►" prompt will not appear until the fault(s) have been displayed.

NOTE	The arrow prompts (◄ and ►) will show that the magnetic switch is activated during the 3 second hold period.

The ITM will enter program mode and the first menu item **View Sensor Status** will be displayed. Hold the magnet over **PGM1** or **PGM2** while the current menu text is scrolling to advance to the next menu item.

At the conclusion of the text scroll the arrow prompt ("►" for PGM2 or "◄" for PGM1) will appear, immediately remove the magnet. The ITM will advance to the next menu item. Repeat this process until the desired menu item is displayed.

NOTE	PGM1 moves the menu items from right to left and PGM2 moves the menu items from left to right.

To enter a menu item, hold the magnet over **PGM1** or **PGM2** while the menu item is scrolling. At the conclusion of the text scroll the "►"prompt ("►" for PGM2 or "◄" for PGM1) will appear, continue to hold the magnet over **PGM1** or **PGM2** for an additional 3 to 4 seconds to enter the selected menu item. If there is no magnet activity while the menu item text is scrolling (typically 4 repeated text scrolls), the ITM will automatically revert to Normal Operation.

3.4.1 View Sensor Status

View Sensor Status displays all current configuration and operational parameters including:

- CX-IR ##.##
- Serial Number
- Range ###
- Autospan Level ##
- Modbus ID ##
- Last Cal ## Days
- Sensor Life ###%
- Temperature ##C
- Alarm 1 Level
- Alarm 2 Level
- Fault

From the **View Sensor Status** text scroll, hold the magnet over **PGM1** or **PGM2** until the arrow prompt appears and continue to hold the magnet in place for an additional 3 to 4 seconds (until the display starts to scroll **Status Is**). The display will scroll the complete list of sensor status parameters sequentially.

When the status list sequence is complete, the ITM will revert to the **View Sensor Status** text scroll.
The user can either:

- review list again by executing another 3 to 4 second hold,
- move to another menu item by executing a momentary hold over **PGM1** or **PGM2**, or
- return to normal operation via automatic timeout of about 15 seconds (the display will scroll **View Sensor Status** four times and then return to normal operation).

3.4.2 Set Gas Type

The IR sensor has a slightly different linearization requirement for different groupings of target gases. The two selections are;

- %LEL and
- %VOL.

The Set Gas Type menu function is a simple choice between these two gas type groupings.

NOTE	The default value for Gas Type is methane (%LEL).

The menu item appears as: **Set Gas Type**.

From the Set Gas Type and Range text scroll, hold the magnet over **PGM1** or **PGM2** until the arrow prompt appears and continue to hold the magnet in place for an additional 3 to 4 seconds (until the display starts to scroll **%LEL / %VOL**). Swipe the magnet momentarily over **PGM2** or **PGM1** to change the selection until the correct choice is displayed. Hold the magnet over **PGM1** or **PGM2** for 3 seconds to accept the new value. The display will scroll **Type Saved**, then **Set Range** followed by the currently selected Range. Momentarily hold the magnet over **PGM1** or **PGM2** to change the Range Selection until the correct value is displayed. Hold the magnet over **PGM2** for 3 seconds to accept the new value.

Move to another menu item by executing a momentary hold, or, return to normal operation via automatic timeout of about 15 seconds (the display will scroll **Set Gas Type** 4 times and then return to normal operation).

3.4.3 Set AutoSpan Level

Set AutoSpan Level is used to set the span gas concentration level used to calibrate the sensor. This level is adjustable from 5% to 95% of range. The current setting can be viewed in **View Program Status**.

The menu item appears as: **Set AutoSpan Level**.

From the **Set AutoSpan Level** text scroll, hold the magnet over **PGM1** or **PGM2** until the "►" prompt appears and continue to hold the magnet in place for an additional 3-4 seconds (until the display starts to scroll **Set Level**). The display will switch to **XX** (where XX is the current gas level).

Swipe the magnet momentarily over **PGM2** to increase or **PGM1** to decrease the AutoSpan Level until the correct level is displayed. When the correct level is achieved, hold the magnet over **PGM2** for 3 to 4 seconds to accept the new value. The display will scroll **Level Saved**, and revert to **Set AutoSpan Level** text scroll.

Move to another menu item by executing a momentary hold, or return to normal operation via automatic timeout of about 15 seconds (the display will scroll **Set AutoSpan Level** 4 times and then return to normal operation).

3.4.4 Set Gas Factor

Because of the CX-IR sensor's almost universal response to combustible hydrocarbon gases, the CX-IR sensor can be configured and calibrated to detect a variety of combustible gases. The detected gas is referred to as the "target gas" and the span calibration gas is referred to as the "cal gas". In cases where the cal gas is different from the target gas, the Set Gas Factor menu function is used to maintain accuracy. This feature allows for a significant degree of flexibility in the detection and span calibration process.

NOTE	The default value for Gas Factor is 1.0. This would be used when the target gas is the same as the cal gas.

Set Gas Factor is used to make the appropriate signal sensitivity adjustment when the target gas is different from the cal gas. This is necessary because the IR sensor has different signal strengths for each combustible hydrocarbon gas. The Gas Factor value is adjustable from 0.2 to 5.0. It represents the translation between the target gas and the cal gas when they are different.

The menu item appears as: **Set Gas Factor**.

To calculate the correct Gas Factor (Table 2), take the Gas Factor of the target gas and divide by the Gas Factor of the cal gas. The calculated value is the correct number to enter into the menu as the Gas Factor.

For example, if calibrating with methane when propane is the target gas, the correct Gas Factor to enter would be 0.63/1.0 = 0.63.

For example, if calibrating with butane when ethane is the target gas, the correct Gas Factor to enter would be 0.38/0.72=0.53.

Table 2 shows the Gas Factors of most combustible hydrocarbon gases that will be measured. Find the gas of interest for the cal gas and the target gas and follow the above instruction. If there is a mixture of target gases, use a weighted approach to determine the correct Gas Factor.

For example, if the target gas was 50% butane and 50% pentane and the cal gas was methane, the correct Gas Factor would be calculated and entered as ((0.5 x 0.77) + (0.5 x 0.77)) / 1.0 = 0.77.

Table 2 Gas Factors

Gas	Factor	Gas	Factor	Gas	Factor
Acetic Acid	2.00	Decane	1.53	Naphthalene	
Acetone	1.21	Ethyl Alcohol	0.35	n-Nonane	1.53
Benzene	1.00	Ethane	0.38	n-Octane	1.34
1,3-Butadiene	1.80	Ethyl Benzene	1.07	n-Pentane	0.77
Butane	0.77	Ethylene	2.39	Propane	0.63
Iso-Butane	0.72	n-Heptane	0.98	iso-Propyl Alcohol	0.54
Butene-1	0.67	n-Hexane	1.00	Propylene	0.80
n-Butyl Alcohol	0.63	Dimethyl Ether	0.40	Toluene	1.00
iso-Butyl Alcohol	0.63	Methane	1.00	Vinyl Acetate	1.43
Cyclohexane	0.89	Methanol	0.41	Vinyl Chloride	
Cyclopropane	0.45	Methyl Ethyl Ketone	0.77	Xylene	1.00

From the Set Gas Factor text scroll, hold the magnet over **PGM1** or **PGM2** until the arrow prompt appears and continue to hold the magnet in place for an additional 3 to 4 seconds (until the display starts to scroll **Set Factor**). The display will then switch to **X.XX** (where X.XX is the current gas factor). Swipe the magnet momentarily over **PGM2** to increase or **PGM1** to decrease the gas factor level until the correct value is displayed. Hold the magnet over **PGM2** for 3 seconds to accept the new value. The display will scroll **Factor Saved**, and revert to **Set Gas Factor** text scroll.

Move to another menu item by executing a momentary hold, or, return to normal operation via automatic timeout of about 15 seconds (the display will scroll **Set Gas Factor** four times and then return to normal operation).

3.4.5 Set Modbus™ ID

The CX-IR sensor can be polled serially via RS-485 Modbus™ RTU. **Set Modbus ID** is used to set the Modbus™ serial ID address. The Modbus™ is adjustable from 01 to 256 in hexadecimal format (01-FF) hex. Each sensor must have a unique Modbus address to operate correctly on the network. The current serial ID can be viewed in View Sensor Status.

The menu item appears as: **Set Modbus™ ID**.

From the **Set Modbus ID** scroll, hold the programming magnet over **PGM1** or **PGM2** until the "►" prompt appears and continue to hold the magnet in place for an additional 3 to 4 seconds (until the display starts to scroll **Set ID**). The display will then switch to **XX** (where **XX** is the current ID address).

Swipe the magnet over **PGM2** to increase or **PGM1** to decrease the hexadecimal number until the desired ID is displayed. Hold the magnet over **PGM2** for 3 to 4 seconds to accept the new value. The display will scroll **ID Saved**, and revert to **Set Modbus ID** text scroll.

Move to another menu item by executing a momentary hold or, return to normal operation by automatic timeout of about 15 seconds (the display will scroll **Set Serial ID** 5 times and return to normal operation).

3.4.6 Bump Test

Bump test checks the response of the sensor with the indication of response limited to the display only. The bump test mode allows the performance of the sensor to be checked without firing the alarms of any attached control systems. The results of the bump test will not affect the reading register on the Modbus™ output.

The menu item appears as: **Bump Test**

From the **Bump Test** text scroll, hold the magnet over **PGM1** or **PGM2** until the "►" prompt appears and continue to hold the magnet in place for an additional 3 to 4 seconds (until the display starts to scroll **Bump Test Started**).

Apply span gas to the sensor in accordance with Section 0. The sensor will respond to the gas testing the sensor response while the current Modbus gas reading (Modbus register 0002) remains unchanged. Remove the gas before the bump test time expires (2 minutes).

The display will return to normal operation alternating between the live gas reading and showing **Bump** until 2 minutes expires or the execution of a momentary hold over **PGM1** or **PGM2**, when the display will scroll **Bump Test Ended**.

3.4.7 Restore Defaults

Restore Factory Defaults clears the current user configuration and calibration data from memory and reverts back to factory default values. Returning to a factory default is common when settings have been configured improperly and a known reference point needs to be re-established to correct the problem.

This menu item appears as: **Restore Defaults**.

NOTE Restoring factory defaults should only be used when absolutely necessary. All previously existing configuration inputs will have to be re-entered if this function is executed. A full 10 second magnet hold on PGM2 is required to execute this function.

From the **Restore Defaults** scroll, hold the programming magnet over **PGM2** until the "►" prompt appears and continue to hold for 3 to 4 seconds. The display will scroll **Defaults Restored**, and revert to **Restore Defaults** text scroll.

Move to another menu item by executing a momentary hold or, return to normal operation by the automatic timeout of about 15 seconds (the display will scroll **Restore Defaults** 4 times and return to normal operation).

Following the execution of **Restore Defaults**, the CX-IR will revert to its factory default settings. The default settings are as follows:

NOTE	The following must be performed in order before the sensor can be placed in operation.

- **Gas Type:** The Gas Type default is %LEL. If the gas type was changed the gas type will need to be reset by the user (Section)3.4.2
- **AutoSpan Level** = 50% of range. AutoSpan level must be set appropriately by the operator (Section3.4.3).
- **Gas Factor**: The default Gas Factor is 1. If the units was set to a different gas factor it will need to be reset by the user (Section 3.4.4).
- **Modbus ID** = 01. The Modbus ID must be set appropriately by the user (Section **Error! Reference source not found.**).
- **AutoZero**: AutoZero Settings are lost and user must perform new AutoZero (Section 3.3.1).
- **AutoSpan**: AutoSpan Settings are lost and user must perform new AutoSpan (Section 3.3.2).

3.4.8 Alarm Settings

The CX-IR includes two open collector alarm relay drivers. These relay driver outputs can be used to drive external relays. The can also be connected to Teledyne Detcon 's CX Relay Term board (p/n 500-005223-000) and used to create dry contact outputs. These outputs can be configured to change state when the concentration exceeds a set level. The outputs can be configured to operate in either energized or non-energized mode. In non-energized mode, the relay driver is floating (deactivated) if the alarm level has not been reached. In energized mode, the relay driver is connected to ground (activated) if the alarm level has not been reached. Energized mode provides for fail-safe operation since a loss of power or cable failure will cause the output to be deactivated.

The alarm driver outputs can be configured as either latching or non-latching. In non-latching mode, the output is deactivated as soon as the sensor alarm condition is cleared. In latching mode, the output remains active even after the alarm condition has cleared. Once activated, the output can only be deactivated by swiping a magnetic programming tool above the PGM1 or PGM2 mark on the CX-IR ITM.

The alarm driver outputs can be configured for ascending or descending mode. In ascending mode the output will be activated when the concentration is *above* the alarm threshold. This is the most common mode of operation for the CXT-IR. The alarm output can also be activated in descending mode. In this mode, the alarm output will activate when the concentration is *below* the alarm threshold. This is the most common mode of operation for an O_2 detector.

The menu item appears as: "**Alarm Settings**"

From the "**Alarm Settings"** text scroll, hold the programming magnet over PGM1 or PGM2 until the "►" prompt appears and continue to hold the magnet in place for an additional 3-4 seconds until the display starts to scroll "**Alarm 1 Set Level**". The display will then switch to "XX" (where XX is the current alarm level in ppm). Swipe the magnet momentarily over PGM2 to decrease or PGM1 to increase the Alarm 1 Level until the desired level is displayed. When the correct level is displayed, hold the magnet over PGM1 or PGM2 for 3 seconds to accept the new value. The display will scroll "**Level Saved**".

The display will scroll "**Ascending**", and then switch to "**Yes**" or "**No**". "Yes" indicates the output is in ascending mode and "No" indicates the output is in descending mode. Swipe the magnet momentarily over PGM2 or PGM1 until the correct value is displayed. Hold the magnet over PGM2 for three seconds to save the setting. The display will scroll "**Saved**".

The display will scroll "**Latching**", and then switch to "**Yes**" or "**No**". "No" indicates the output is non-latching and "Yes" indicates the output is latching. Swipe the magnet momentarily over PGM2 or PGM1 until the correct value is displayed. Hold the magnet over PGM2 for three seconds to save the setting. The display will scroll "**Saved**".

The display will scroll "**Energized**", and then switch to "**Yes**" or "**No**". "No" indicates the output is normally non-energized and "Yes" indicates the output is normally energized. Swipe the magnet momentarily over PGM2 or PGM1 until the correct value is displayed. Hold the magnet over PGM2 for three seconds to save the setting. The display will scroll "**Saved**".

The display will scroll "**Alarm 2 Set Level**". The display will then switch to "XX" (where XX is the current alarm level in ppm). Swipe the magnet momentarily over PGM2 to decrease or PGM1 to increase the Alarm 2 Level until the desired level is displayed. When the correct level is displayed, hold the magnet over PGM1 or PGM2 for 3 seconds to accept the new value. The display will scroll "**Level Saved**".

The display will scroll "**Ascending**", and then switch to "**Yes**" or "**No**". "Yes" indicates the output is in ascending mode and "No" indicates the output is in descending mode. Swipe the magnet momentarily over PGM2 or PGM1 until the correct value is displayed. Hold the magnet over PGM2 for three seconds to save the setting. The display will scroll "**Saved**".

The display will scroll "**Latching**", and then switch to "**Yes**" or "**No**". "No" indicates the output is non-latching and "Yes" indicates the output is latching. Swipe the magnet momentarily over PGM2 or PGM1 until the correct value is displayed. Hold the magnet over PGM2 for three seconds to save the setting. The display will scroll "**Saved**".

The display will scroll "**Energized**", and then switch to "**Yes**" or "**No**". "No" indicates the output is normally non-energized and "Yes" indicates the output is normally energized. Swipe the magnet momentarily over PGM2 or PGM1 until the correct value is displayed. Hold the magnet over PGM2 for three seconds to save the setting. The display will scroll "**Saved**".

Move to another menu item by executing a momentary hold, or, return to Normal Operation via automatic timeout of about 15 seconds (the display will scroll "**Alarm Settings**" 4 times and then return to Normal Operation).

3.5 Fault Diagnostic/Failsafe Feature

If the ITM should incur a fault, the Global Fault bit will be set on the Modbus™ output. This can occur if the ITM detects a problem with the sensor, detects that there is no sensor connected, if the ITM has an internal fault, or other fault condition. The Global Fault bit will be set on the Modbus™ output until the problem is resolved. The display will show the Fault when a magnetic programming tool is swiped across either PGM1 or PGM2. The error codes are defined in Section 6 Troubleshooting.

4. Modbus™ Communications

Model CX-IR sensors feature Modbus™ compatible communications protocol and are addressable via the operator interface. Communication is two wire, half duplex 485, 9600 baud, 8 data bits, 1 stop bit, and no parity. If a multi-point system is being utilized, each sensor should be set for a different address. Typical address settings are: 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B, 0C, 0D, 0E, 0F, 10, 11…etc.

Sensor RS-485 ID numbers are factory default to 01 and can be changed in the field using the operator interface (Section 3.5.5).

4.1 General Modbus™ Description

The Modbus™ communication uses the RTU transmission mode per the Modbus™ specification. The basic frame format for Modbus™ consists of a Modbus™ address, function code, data and CRC.

Address Field	Function Code	Data	CRC

Figure 16 Modbus™ Frame Format

The Modbus ID Field is the unique Modbus™ address of each device on the network. The Function Code is the function to be performed. The Data contains read or write data and is formatted according to the function being performed. The CRC (Cyclic Redundancy Code) is used to detect errors in the frame. Frames with errors are invalid and ignored.

Modbus™ transactions consist of a request by the controller and response from the device being addressed so there are two frames transferred for every transaction. Every request is evaluated by the CX-IR to determine if it is addressed, and if it falls within the register address range. If these two conditions are true, the CX-IR will then verify a valid Function Code. Function Codes supported by the CX-IR are as follows:

- Function Code 03 (03h) – Read Holding Registers
- Function Code 06 (06h) – Write Single Register
- Function Code 16 (10h) – Write Multiple Registers

If an invalid function code is performed, the CX-IR will ignore the request.

4.2 Modbus™ Register Map & Description

When the CX-IR is assigned a Modbus™ address, the following registers become available to the controller for access. All CX-IR sensors implement this register set. Some registers are Read Only (R) and others are Read/Write (R/W) as shown by the R/W column. This equates to specific function codes where Read is function code 03 and Write is function code 06 or 16.

NOTE	A write to a Read Only register is allowed and returns a response, but it does not change the value of the register.

Table 3 is the register map for the CX-IR sensor and gives a brief description each register or register set.

Table 3 CX-IR Register Map

Register	Name	R/W	Meaning	Units
40000	CX-IR Device Type	R	= 42	
40001	Range	R/W	Detectable Range	%LEL
40002	Reading	R	Current Gas Reading	%LEL
40003	Calibration Level	R/W	Auto Span Level	%LEL
40004	Life	R	Sensor Life	%
40005	Sensor Faults	R	See Section 4.2.1	
40006	Sensor Model	R	IR (set to 3)	
40007	Days since Calibration	R		days
40008	Reserved	R		
40009	Reserved	R		
40010	Sensor Temperature	R		°C
40011	Gas Factor	R/W	See Section 3.4.4	
40012	Reserved	R		
40013	Reserved	R		
40014	Range Divisor	R		
40015	Calibration Enable/Status	R/W		
40016	Gas Type/Units String	R	ASCII Text (set at factory)	
40017	Gas Type/Units String	R	ASCII Text (set at factory)	
40018	Gas Type/Units String	R	ASCII Text (set at factory)	
40019	Gas Type/Units String	R	ASCII Text (set at factory)	
40020	Gas Type/Units String	R	ASCII Text (set at factory)	
40021	Gas Type/Units String	R	ASCII Text (set at factory)	
48199	Battery Life in Percent	R	Smart Battery Life remaining in percent	%
48200	Battery Life in Minute	R	Smart Battery Life remaining in minutes	minutes
48204	Status	R	Wireless Status	
48205	Input Voltage	R	Smart Battery voltage or Input Voltage to A/D	volts
48206	Battery Error Count	R/W	Smart Battery read error count if detected	

4.2.1 Sensor Faults – Register 40005

The sensor fault status register consists of High and Low Status Bits. These bits are set/reset as faults occur or are cleared. Each Bit has a particular meaning and displayed as follows:

Register # 40005	High Byte Status Bits	Low Byte Status Bits

NOTE Bits read as 0 are FALSE, bits read as 1 are TRUE.

Status Bits High Byte:
Bit 15 – Reserved
Bit 14 – Calibration Mode
Bit 13 – Reserved
Bit 12 – Zero Fault
Bit 11 – Range Fault
Bit 10 – Reserved

Bit 9 – Clearing Fault
Bit 8 – Reserved

Status Bits Low Byte:
Bit 7 – Sensor Fault
Bit 6 – Processor Fault
Bit 5 – Memory Fault
Bit 4 – Reserved
Bit 3 – Reserved
Bit 2 – Temperature Fault
Bit 1 – Auto Span Fault
Bit 0 – Global Fault

4.2.2 Battery Info – Multiple Registers

If a Teledyne Detcon smart battery pack is connected to the CX, there are five registers associated with information about that battery. The CX utilizes the I^2C interface to read battery status and only one Teledyne Detcon battery pack can be read per CX.

The controller can determine if a battery is present by reading the Status Register (register 48204). There are two bits in this sixteen bit register pertaining to the battery, Battery Detect – bit 4 (lowest bit is 0) and Battery Fault – bit 5. Both bits default to a value of 0. Battery Detect will be set once the first read of the battery over the I^2C interface was successful. Battery Fault will be set if a battery was detected but the last read failed. Battery Fault is re-evaluated upon every read of the battery which is set to approximately every 60 seconds. Register 48206 (I^2C Batt Read Fails) will increment by 1 each time there is a failure. This register can be cleared by writing a 0 to it at any point.

Once the battery has been detected the controller can read the battery life (registers 48199 and 48200). The battery adjusts these values based upon the average current usage. If this usage varies widely over time it will take some time to re-adjust the battery life readings. For instance an Alarm Station with no alarms will consume a very small amount of battery but when Alarms are active this will jump to a much higher level of usage. So in this case battery life may go from several weeks down to several hours.

The battery life is presented in two forms, life remaining in percentage (register 48199) and life remaining in minutes (register 48200). The battery Life remaining is percentage is a value between 0 and 100 and battery life in minutes is an unsigned value between 0 and 65535. Both readings are generally necessary to provide appropriate feedback to the user. Life in minutes is the best for determining when to change the battery. For example if the user wanted to be notified a day before the battery needed to be changed, the user could set a threshold in the controller to be notified of low battery after 1440 minutes (1 day).

Since 65535 is the maximum value for life remaining in minutes, this represents a maximum of 45.5 days. The battery life for an application can be much greater than this value and will remain at a reading of 65535 until it drops below this. Life in percentage was added for this reason. Percentage will track starting at 100 percent and drop down as battery life decreases. The controller can therefore use both registers, one to represent usage in percentage to present to the user and then use the life in minutes to set a threshold on when a low battery condition exists for changing the battery.

The output voltage of the battery in volts can be read in register 48205. This register is useful when using a non-rechargeable battery pack without an internal fuel gauge. In this case the battery voltage can be used to give an indication of when the batteries need to be replaced.

5. Service and Maintenance

Calibration Frequency

In most applications, monthly to quarterly span calibration intervals will assure reliable detection. With industrial environments varying, after initial installation and commissioning close frequency tests should be performed, weekly to monthly. Test results should be recorded and reviewed to determine a suitable calibration interval.

Visual Inspection

The Sensor should be inspected annually for the following:

- Inspect the sensor for signs of corrosion, pitting, and water damage.
- Remove the Splash Guard and inspected it for blockage, broken, cracked, or missing pieces.
- For H2S Sensor assemblies, inspect CX-IR Series Splashguard Adapter Assembly with integral filter (P/N 602-003803-200) for blockage of filter material.
- Inspect inside of the Junction Box for signs of water accumulation, signs of corrosion.
- Check wiring to ensure there are no loose or pinched wires and all connections are clean and tight.

Condensation Prevention Packet

A moisture condensation packet should be installed in every explosion proof junction box. The packet will prevent the internal volume of the J-Box from condensing and accumulating moisture due to day-night humidity changes. This packet provides a critical function and should be replaced annually.

5.1 Replacement of Plug-in Sensor

NOTE	It is not necessary to remove power while changing the plug-in toxic gas sensor in order to maintain area classification. The sensor is intrinsically safe.

NOTE	Only replace the plug-in sensor with an authorized CX-IR family of gas sensors.

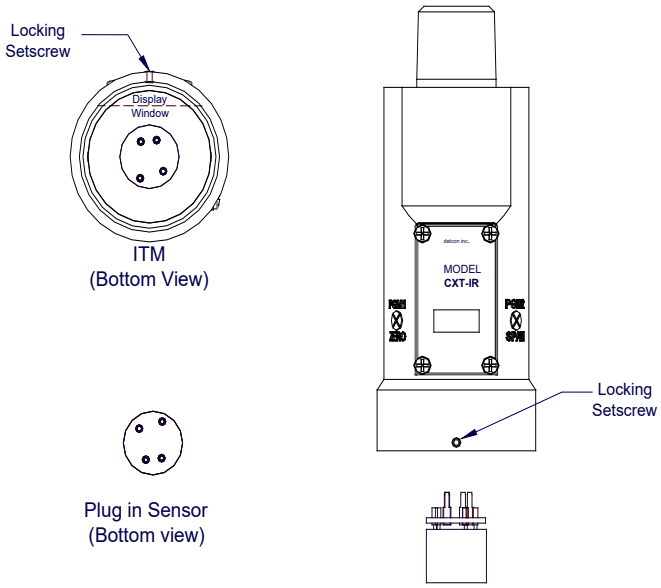

Figure 17 Sensor Cell and ITM Mating

1. Use a $^{1}/_{16}$" Allen wrench to release the locking setscrew that locks the ITM and splashguard adapter assembly together.

NOTE	One turn of the setscrew will suffice - Do not remove setscrew completely.

2. Remove the splashguard. Unthread and remove the splashguard adapter assembly from the ITM.

3. Gently pull the plug-in sensor out of the ITM. Verify that the gas type and range of the new sensor cell is correct. Orient the new plug-in sensor so that it matches with the female connector pins. When properly aligned, press the sensor in firmly to make the proper connection.

4. Thread the splashguard adapter assembly onto the ITM to a snug fit and tighten the locking setscrew using the $^{1}/_{16}$" Allen wrench. Reinstall the splashguard.

5. Check and perform zero calibration and span calibration in accordance with Section 3.3.

5.2 Replacement of ITM – Aluminum J-Box

1. Remove the power source to the sensor assembly. Disconnect all sensor wire connections at the junction box terminal board, taking note of the wire connections.

NOTE	It is necessary to remove power to the junction box while changing the ITM in order to maintain area classification.

2. Use a wrench at the top section of the ITM and unthread the ITM until it can be removed.

3. Use a $^{1}/_{8}$" Allen wrench to release the locking cap head screw that locks the ITM and splashguard adapter assembly together.

NOTE	One turn of the setscrew will suffice - Do not remove setscrew completely.

4. Unthread and remove the splashguard adapter assembly and splash guard from the ITM. These will be re-used with the new ITM.

5. Gently remove the plug-in toxic gas sensor from the old ITM and install the sensor in the new ITM. Orient the plug-in sensor so it matches the female connector pins on the new ITM and press the sensor in firmly to make proper connection.

6. Thread the splashguard adapter assembly onto the new ITM until snug, tighten the locking cap head screw and reinstall splash guard.

7. Feed the sensor assembly wires through the $^{3}/_{4}$" female NPT port and thread the assembly into the J-box until tight and the ITM faces toward the front access point. Use the locking nut to secure the ITM in this position. Re-connect the sensor assembly wires to the terminal board inside the junction box.

8. Check and/or perform Zero Calibration and Span Calibration in accordance with Section 3.3.

5.3 Replacement of ITM – Stainless Steel Mini Condulet

NOTE	It is necessary to remove power to the Junction box while changing the ITM in order to maintain area classification.

1. Disconnect the sensor wire connections from the terminal board, taking note of the wire connections.
2. Use a wrench at the top section of the ITM and unthread the ITM until it can be removed.
3. Use a $^{1}/_{8}$" Allen wrench to release the locking cap head screw that locks the ITM and splashguard adapter assembly together.

NOTE	One turn of the setscrew will suffice - Do not remove setscrew completely.

4. Unthread and remove the splashguard adapter assembly and splash guard from the ITM. These will be re-used with the new ITM.
5. Gently remove the plug-in toxic gas sensor from the old ITM and install it in the new ITM. Orient the plug-in sensor so it matches the female connector pins on the new ITM and press the sensor in firmly to make proper connection.
6. Thread the splashguard adapter assembly onto the new ITM until snug, tighten the locking cap head screw and reinstall splash guard.
7. Feed the sensor assembly wires through the $^{3}/_{4}$" female NPT port and thread the assembly into the J-box until tight and the ITM faces toward the front access point. Use the locking nut to secure the ITM in this position.
8. Re-connect the sensor assembly wires to the terminal board inside the junction box.
9. Check and/or perform Zero Calibration and Span Calibration in accordance with Section 3.3.

5.4 Replacement of the Smart Battery Pack

The CX-IR Sensor incorporates a ‘Low battery’ fault message which will appear as an alternating display between the current gas reading and ‘VOLT’ on the sensor display. This fault will appear when the battery voltage drops below 7.5 volts. When the voltages drops below 7.2 volts the display will change to a steady ‘VOLT’ display, the sensor will then enter into ‘Fault’ mode, and the sensor will no longer provide a valid gas reading.

NOTE	The safety approvals require removing entire sensor assembly to a non-hazardous area before installing or changing out the batteries or battery pack.

1. Remove the cover from the J-box.
2. Unscrew battery bracket lid, and swing the lid away from the battery pack.
3. Remove the battery pack from the J-box, and replace with new battery pack.
4. Swing the lid back over the battery pack, and re-tighten screws in battery bracket lid.
5. Replace the cover on the J-box.

6. Troubleshooting Guide

If the ITM detects any functional errors the ITM will display the fault. If the sensor is experiencing a fault condition a momentary swipe of the magnet will cause the ITM to scroll the fault condition(s) across the display before the "◄" or "►" prompt will appear.

The Display Error Codes are:
Auto Span Fault
Temperature Fault
Memory Fault
Processor Fault
Clearing Fault
Range Fault
Sensor Fault
Zero Fault
Sensor Fault 2

Some faults are self-explanatory, and if these faults occur and cannot be cleared the ITM should be replaced first to see if the fault will clear. Other faults may need further investigation. Some of the sensor problems, associated error codes, and resolutions are listed below.

6.1 Under-Range problems

Probable Cause: Sensor Baseline drifted lower, Interference gases,

- Perform Zero Calibration. Use Zero Air or N_2 source. (Section3.3.1 AutoZero)
- Allow more time for zero stabilization if this is a biased sensor type.
- If using Splashguard with Integral Cal Port, must use Calibration Wind Guard or air movement can compromise span gas delivery.
- Execute successful Span Calibration. (Section 3.3.2 AutoSpan)
- Replace plug-in toxic sensor if error continues.

6.2 Stability problems

Probable Causes: Failed Sensor, empty or close to empty Cal Gas Cylinder, problems with cal gas and delivery

- Check validity of span gas using pull tube or other means (check MFG date on cal gas cylinder).
- Use proper cal gas regulators and tubing for highly corrosive gases
- If using Splashguard with Integral Cal Port, must use Calibration Wind Guard or air movement can compromise span gas delivery.
- Check for obstructions affecting cal gas hitting sensor face (including being wet, blocked, or corroded). H2S sensors assemblies use CX-IR Series Splashguard Adapter Assembly with integral filter. Clean or replace if necessary.
- Replace the plug-in toxic sensor.

6.3 Clearing problem

Probable Causes: Failed Sensor, Cal Gas not removed at appropriate time, problems with cal gas and delivery, Background of Target Gas.

- The sensor must recover to < 5% of range in < 5 min after Span calibration is complete
- Use bottled air (zero air or N_2) if there is a known continuous background level.
- Check validity of span gas using pull tube or other means (check MFG date on cal gas cylinder).
- Use proper cal gas regulators and tubing for highly corrosive gases

- Check for obstructions affecting cal gas hitting sensor face (including being wet, blocked, or corroded). H2S sensors assemblies use CX_IR Series Splashguard Adapter Assembly with integral filter. Clean or replace if necessary.
- Replace the plug-in toxic sensor.

6.4 Poor Calibration Repeatability

Probable Causes: Failed Sensor, use of wrong Cal Gas or problems w/ cal gas and delivery, Interference Gases

- Check validity of span gas with regulator and sample tubing in place using pull tube or other means (check MFG date on cal gas cylinder).
- Use proper cal gas regulators and tubing for highly corrosive gases (HF, HCI, Cl2, NH3, HBR, F2, etc.)
- Check for obstructions affecting cal gas hitting sensor face (including being wet, blocked, or corroded). H2S sensors assemblies use CX-IR Series Splashguard Adapter Assembly with integral filter. Clean or replace if necessary.
- Replace the plug-in toxic sensor.

6.5 Unstable Output/ sudden spiking

Possible Causes: Unstable power supply, inadequate grounding, or inadequate RFI protection.

- Verify Power source is stable.
- Verify field wiring is properly shielded and grounded.
- Contact Teledyne Detcon to optimize shielding and grounding.

6.6 Nuisance Alarms

- Check condulet for accumulated water and abnormal corrosion on terminal board.
- If nuisance alarms are happening at night, suspect condensation in condulet.
- Add or replace Teledyne Detcon ’s Condensation Prevention Packet P/N 960-202200-000.
- Investigate the presence of other target gases that are causing cross-interference signals.
- Determine if cause is RFI induced.

6.7 Intelligent Transmitter Module (ITM) not responding

- Verify condulet has no accumulated water or abnormal corrosion.
- Verify required batteries are installed and have enough charge to power the sensor.
- Swap with a known-good ITM to determine if ITM is faulty.

Contact the Teledyne Detcon Service Department for further troubleshooting assistance at 713-559-9200.

7. Customer Support and Service Policy

Teledyne Detcon Headquarters
Shipping Address: 4055 Technology Forest Blvd, The Woodlands, Texas 77381
Mailing Address: P.O. Box 8067, The Woodlands Texas 77387-8067
Phone: 713.559.9200

• www.teledynegasandflamedetection.com
• detcon-service@teledyne.com
• detcon-sales@teledyne.com

All Technical Service and Repair activities should be handled by the Teledyne Detcon Service Department via phone or email (contact information given above). RMA numbers should be obtained from the Teledyne Detcon Service Department prior to equipment being returned. For on-line technical service, have the model number, part number, and serial number of product(s) in question available.

All Sales activities (including spare parts purchase) should be handled by the Teledyne Detcon Sales Department via phone or email (contact information given above).

NOTE	All additional parts must be supplied by Teledyne Detcon. Use of parts from a third party will void warranty and safety approvals.

NOTE	CX-IR should only be repaired by Teledyne Detcon personnel or a Teledyne Detcon trained representative.

7.1 Warranty Notice

Teledyne Detcon Inc. warrants the Model CX-IR gas sensor to be free from defects in workmanship of material under normal use and service for one year from the date of shipment on the transmitter electronics. See Warranty details in the CX-IR Sensor Warranty (Section 7.2).

Teledyne Detcon Inc. will repair or replace without charge any such equipment found to be defective during the warranty period. Full determination of the nature of, and responsibility for, defective or damaged equipment will be made by Teledyne Detcon Inc. personnel.

Defective or damaged equipment must be shipped to the Teledyne Detcon Inc. factory or representative from which the original shipment was made. In all cases, this warranty is limited to the cost of the equipment supplied by Teledyne Detcon Inc. The customer will assume all liability for the misuse of this equipment by its employees or other contracted personnel.

All warranties are contingent upon the proper use in the application for which the product was intended and does not cover products which have been modified or repaired without Teledyne Detcon Inc. approval, or which have been subjected to neglect, accident, improper installation or application, or on which the original identification marks have been removed or altered.

Except for the express warranty stated above, Teledyne Detcon Inc. disclaims all warranties with regard to the products sold. Including all implied warranties of merchantability and fitness and the express warranties stated herein are in lieu of all obligations or liabilities on the part of Teledyne Detcon Inc. for damages including, but not limited to, consequential damages arising out of, or in connection with, the performance of the product.

7.2 CX-IR Sensor Warranty

Plug-in Sensor Warranty

Teledyne Detcon, Inc., as the manufacturer, warrants under intended normal use each new CX-IR sensor to be free from defects in material and workmanship for a period of one year from the date of shipment to the original purchaser. Should the sensor fail to perform in accordance with published specifications within the warranty period, return to Teledyne Detcon, Inc., for necessary repair or replacement. All warranties and service policies are FOB the Teledyne Detcon facility located in The Woodlands, Texas

Terms & Conditions

- The original serial number must be legible on each sensor element base.
- Shipping point is FOB the Teledyne Detcon factory.
- Net payment is due within 30 days of invoice.
- Teledyne Detcon, Inc. reserves the right to refund the original purchase price in lieu of sensor replacement.

ITM Electronics Warranty

Teledyne Detcon Inc. warrants, under intended normal use, each new CX-IR Sensor ITM to be free from defects in material and workmanship for a period of one year from the date of shipment to the original purchaser. All warranties and service policies are FOB the Teledyne Detcon facility located in The Woodlands, Texas.

Terms & Conditions

- The original serial number must be legible on each ITM.
- Shipping point is FOB the Teledyne Detcon factory.
- Net payment is due within 30 days of invoice.
- Teledyne Detcon, Inc. reserves the right to refund the original purchase price in lieu of ITM replacement.

8. Appendix

8.1 Specifications

System Specifications

Sensor Type:	Continuous diffusion/adsorption type NDIR Non-Disperse Infrared Sub-miniature plug-in replaceable type
Sensor Life:	5 years typical
Measuring Ranges:	0-100% LEL, 0-100% by volume
Accuracy/ Repeatability:	± 3% LEL in 0-50% LEL range, ± 5% LEL in 51-100% LEL range
Response Time:	T50 < 10 seconds, T90 < 30 seconds
Warranty:	1 year

Environmental Specifications

Operating Temperature:	-40°C to +75°C
Storage Temperature:	-40°C to +75°C
Operating Humidity:	0-100% RH (Non-condensing)
Operating Pressure:	±10% atmospheric pressure

Electrical Specifications

Input Voltage:	7-30VDC
Power Consumption:	25mW (typical), 420mW (max)
RFI/EMI Protection:	Complies with EN61326
Cable Requirements:	Power/Analog: 3-wire shielded cable Maximum distance is 4000 feet with 14 AWG Power/RS-485: 4-wire two twisted pair shielded cable

Mechanical Specifications

Length:	ITM - 5.165 inches (131 mm), 8.5 inches (215mm) with Splash Guard
Width:	2.2 inches (55 mm)
Weight:	2.5 lbs (1.2 Kg)
Mechanical Connection:	¾” Male NPT threaded connection with locking nut
Electrical Connection:	five 18 gauge wire leads - 5.5” long

8.2 Spare Parts, Sensor Accessories, Calibration Equipment

Part Number	Spare Parts
92C-IR0405-000	CX-IR Intelligent Transmitter Module
371-IR1II1-000	Replacement Plug-in toxic gas sensor
Part Number	**Sensor Accessories**
6130	Sensor Rain Shield
602-003803-100	CX-IR Splashguard Adapter Assembly
327-000000-000	Programming Magnet
Part Number	**Calibration Accessories**
943-000000-000	Calibration Wind Guard
943-000006-132	Threaded Calibration Adapter
943-050000-132	Span Gas Kit: Includes calibration adapter, span gas humidifier, 500cc/min fixed flow regulator, and carrying case. (Not including gas).
See Detcon	Span Gases – various
943-05AM00-000	500 cc/min Fixed Flow Regulator for span gas bottle
Part Number	**Optional Accessories**
897-860000-316	316SS Mini Condulet w/Solid Cover
960-202200-000	Condensation prevention packet (For condulet, replace annually)

8.3 Revision Log

Revision	Date	Changes made	Approval
1.0	3/27/2013	Release	LBU
1.1	01/29/14	Update wiring, calibration and other corrections	LBU
1.2	05/29/14	Added Section 2.1, Updated Approvals Label	BM
1.3	09/08/24	Added Section 2.1, Updated Approvals Label	BM
1.4	10/14/15	Updated wiring, Section 2.5, added information about battery pack and alarm outputs	LBU
1.5	06/06/18	Added conduit seal in Section 2.4	MM
1.6	12/20/19	Updated Company Information	MM