

# Operation and Maintenance Manual

Bently Nevada\* Asset Condition Monitoring

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## 3500/63 Hazardous Gas Detection System

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## Top Installation and Commissioning Issues for BN Haz Gas System

Read this manual for more detailed information

1. Confirm wiring prior to power up. Do not short any sensor leads to earth ground. If replacing sensors while under power, assure no gas is present and always **disconnect the black lead last** (the PWR<sup>-</sup> connection at the I/O) when removing sensor and **connect the black lead first** when installing sensor.
2. Power sensors for at least 30 minutes prior to calibration.
3. Sensors mounted in or near ducts should be facing into the air flow.
4. Do not coil the excess sensor lead lengths inside housings or junction boxes. Cut leads to length required.
5. Do not expose sensors to poisons such as silicone-based RTV, paint, or welding fumes.
6. Do not allow water or liquids to enter the sensor face.
7. If sensors were shipped before Aug 10, 2011, follow TIL 61446345.
8. Be sure to use correct regulator:
  - a. Manual calibration: 169039, 0.5 L/min, CGA600 connection to bottle
  - b. Remote calibration: 284357-01, 2-stage, 10psi, 2 L/min, CGA600 connection to bottle
9. Use BN recommended calibration gas. Calibration gas uses balance of air (N<sub>2</sub> and O<sub>2</sub>), not balance of nitrogen alone. Bottles have a CGA600 connection.
10. For manual calibrations use correct BN specified calibration cup that comes in calibration kit 168868-01.
11. You cannot calibrate a channel that is NotOK without setting the channel bypass software switch.
12. You cannot calibrate a channel that is in Alarm state without clearing the gas and the latched alarm first.
13. If using remote calibrator,
  - a. Tubing should be 1/8" diameter. If it is not expect more use of calibration gas, increase time required to calibrate, and possibly even failure to calibrate depending on length of tubing.
  - b. Leave the shutoff valve open (if one exists at the interface panel) when prompted to remove the calibration gas. Closing the valve at this point in the calibration will leave pressure in the line that may cause the bleed off timer to fail. After completion of the calibration, close the valve.
14. Systems come shipped from BN with valid configurations. If you install a new spare monitor or I/O in the field, you must first download a valid configuration before you can calibrate any channels.
15. Understand that voting logic is employed in GE haz gas protection systems. Faulted channels are part of this voting logic and care must be taken to avoid false trip. For example, placing a channel in bypass will reduce logic of a group from 2oo4 to 1oo3. Correct a NotOK or channel in Alarm before calibrating another channel in the group.
16. Understand that changes in temperature or air flow at the sensor location from the time of calibration to the time of operation can appear as small positive or negative gas readings.

## Additional Information

### Notice:

This manual does not contain all the information required to operate and maintain the product. Refer to the following manuals and documents for other required information.

#### **3500 Monitoring System Rack Installation and Maintenance Manual (129766-01)**

- general description of a standard system
- general description of a Triple Modular Redundant (TMR) system
- instructions for installing and removing the modules from a 3500 rack
- drawings for all cables used in the 3500 Monitoring System

#### **3500 Monitoring System Rack Configuration and Utilities Guide (129777-01)**

- guidelines for using the 3500 Rack Configuration software for setting the operating parameters of the module
- guidelines for using the 3500 test utilities to verify that the input and output terminals on the module are operating properly

#### **3500 Field Wiring Diagram Package (130432-01)**

- diagrams that show how to hook up a particular sensor
- lists of recommended wiring

#### **350800 Hazardous Gas Sensor Pamphlet (168724-01)**

- diagrams and instructions for installing the sensor

#### **3500 Rack Interface Module Manual (129768-01)**

- diagrams and instructions for installing the RIM

#### **3500 Transient Data Interface Manual (161580-01)**

- diagrams and instructions for installing the TDI

#### **3500 4-channel Relay Module Manual (141533-01)**

- diagrams and instructions for installing and configuring the 4-channel relay card

### **3500 4-channel TMR Relay Module Manual (129771-01)**

- diagrams and instructions for installing and configuring the 4-channel TMR relay card

### **3500 16-channel Relay Module Manual (162291-01)**

- diagrams and instructions for installing and configuring the 16-channel relay card

### **EC Declaration of Conformity for Hazardous Gas Detection System (178462)**

#### **Product Disposal Statement**

Customers and third parties, who are not member states of the European Union, who are in control of the product at the end of its life or at the end of its use, are solely responsible for the proper disposal of the product. No person, firm, corporation, association or agency that is in control of product shall dispose of it in a manner that is in violation of any applicable federal, state, local or international law. Bently Nevada, Inc. is not responsible for the disposal of the product at the end of its life or at the end of its use.



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# 1. Receiving and Handling Instructions

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## 1.1 Receiving Inspection

Visually inspect the modules for obvious shipping damage. If shipping damage is apparent, file a claim with the carrier and submit a copy to Bently Nevada, Inc.

## 1.2 Handling and Storing Considerations

Circuit boards contain devices that are susceptible to damage when exposed to electrostatic charges. Damage caused by obvious mishandling of the board will void the warranty. To avoid damage, observe the following precautions in the order given.

<b>Application Advisory</b>
Gas detection will be disabled when this module is removed from the rack.

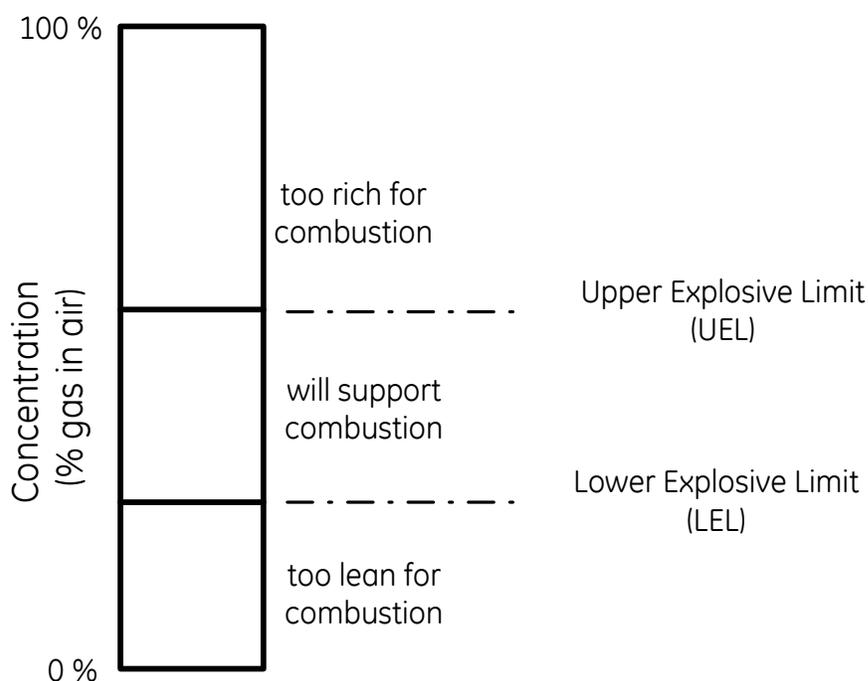
- Do not discharge static electricity onto the circuit board. Avoid tools or procedures that would subject the circuit board to static damage. Some possible causes include ungrounded soldering irons, and nonconductive plastics and similar materials.
- Personnel must be grounded with a suitable grounding strap (see Section 12.11 for ordering information, on page 138) before handling or maintaining a printed circuit board.
- Transport and store circuit boards in electrically conductive bags or foil.
- Use extra caution during dry weather. Relative humidity less than 30% tends to multiply the accumulation of static charges on any surface.



## 2. System Overview

The hazards of gas exposure are generally categorized as combustible, toxic, or oxygen deficient. In many industrial facilities methane and hydrogen are the combustible gases of concern. The Hazardous Gas Detection System detects the presence of these combustible gases, protecting property and personnel.

The lower concentration at which a particular gas will support combustion is called the Lower Explosive Limit (LEL). Below this concentration, the gas is too lean to support combustion. There is a corresponding Upper Explosive Limit above which the concentration is too rich to support combustion. See Figure 2-1.



**Figure 2-1: Explosive Limits**

The concentration at which a gas will explode depends on the gas. For example, the LEL of methane is approximately 5.0 percent by volume in air at 20 °C, whereas the LEL of hydrogen is approximately 4.0 percent by volume in air at 20 °C. Note that “% LEL” is a common reference when discussing the concentration of explosive gases. If a gas concentration reaches 100% LEL, the gas is at its lower explosive limit and will explode if an ignition source and oxygen are both present.

The Hazardous Gas Detection System consists of a sensor, a monitor (with input/output (I/O) module) and an external power supply and is part of a 3500 Monitoring System. One monitor provides six channels of gas detection. You can screw sensors directly into conduit, or use the sensor with the flameproof

enclosure to simplify sensor replacement and field wiring termination. Refer to Figure 2-2.

The hazardous gas detection system requires an external power supply because of the large amount of current that each gas sensor requires (300 mA each, which exceeds what the rack power supplies can provide). The external supply interfaces to each I/O card. The 3500/63 monitor regulates the current and sends out the regulated current to each of the six sensors via the I/O card.

The system can also include relay module(s) that you can program to change state to enable trip or shutdown of machines or processes, produce audible and/or visible alarms, or otherwise protect both human life and machine assets.



**Figure 2-2: Hazardous Gas Detection Monitor, Sensor, and Sensor with Flameproof Housing**

## 2.1 Monitor

The 3500/63 Hazardous Gas Detection monitor measures % LEL as well as number of days since last calibration for each channel, as illustrated in Figure 2-3. The system provides protection by continuously comparing combustible gas concentrations in the area of the sensors against configured setpoints for each channel. The Cal Status Danger alarm is always set at 90 days and cannot be changed by the user, although the user can disable the alarm. The user can both configure and disable the Cal Status Alert alarm.

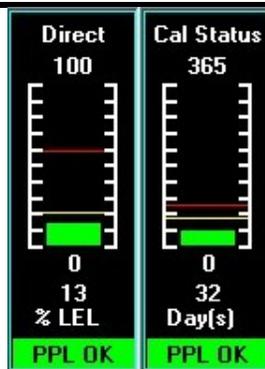


Figure 2-3: Monitor Bargraphs

## 2.2 Sensor

The Hazardous Gas Detection System uses the approved 350800 hazardous gas sensor. This sensor consists of a catalytic bead and a reference bead that form a Wheatstone bridge when connected to the 3500/63 Hazardous Gas Detection Module, as shown in Figure 2-4. The catalytic bead of the sensor (labeled  $R_{\text{reac}}$  in Figure 2-4) is impregnated with a catalyst that promotes oxidization, while the reference bead is treated to inhibit oxidization. Electrical current from the monitor heats the beads to a temperature at which gas will oxidize at the catalytic bead. This oxidation, when gas is present, raises the temperature of the catalytic bead above the temperature of the reference bead, which increases its resistance and unbalances the bridge. The imbalance is proportional to the concentration of combustible gas.

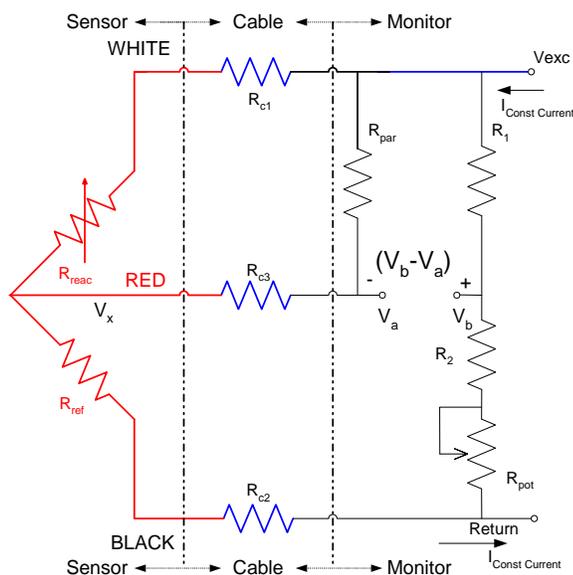


Figure 2-4: Monitor and Sensor Front End

The 350800 sensor is available in five different lead lengths and can be ordered with or without a flameproof housing.

## 2.3 Flameproof Housing

The sensor has an ordering option for a flameproof housing, as shown in Figure 2-5. The housing has 3/4" NPT threads on both ends, so that the sensor connects to one entry and conduit connects to the other entry. The lid of the housing is threaded and simplifies sensor replacement. The sensor and field wiring connect inside the housing, which contains a terminal strip. The housing and internal terminal strip are rated to 200 °C. Refer to Section 4.8 for more information about hazardous area installations.



Figure 2-5: Sensor with Flameproof Housing

## 2.4 Remote Calibrator

The 350810 Remote Haz Gas Calibrator (see Figure 2-1) may only be used in conjunction with the 350800 Hazardous Gas Sensor. If a 350800 Sensor is located in a Zone 1 area, or any area that is difficult to access, the Remote Haz Gas Calibrator will allow calibration of the sensor from a remote location away from the hazardous or confined area.

The 350810 Remote Haz Gas Calibrator is operated pneumatically. There are no electronics associated with the calibrator itself. The line pressure from the calibration gas is used to operate a slide that when closed blocks surrounding air from reaching the 350800 Sensor. The trapped air in front of the sensor is then purged with a metered flow of calibration gas. Turning off the flow of calibration gas allows the slide to return to its original position, which permits surrounding air to reach the sensor and resume online monitoring.



Figure 2-6 Remote Calibrator mounted on Haz Gas Sensor



## 3. System Performance and Hazardous Area Approvals

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Application Advisory
<p>The 3500/63 Hazardous Gas Detection System is a component that may be used in a safety shutdown system. The overall performance of the shutdown system is dependent on other components in the system. All of these components need to be incorporated into a working system by a System Integrator who is familiar with safety shutdown systems. The System Integrator and the End User are ultimately responsible for proper functioning of the safety shutdown system.</p>

Hazardous gas detection systems must conform to specific standards. These standards relate not only to general safety and hazardous areas that other Bently Nevada\* Asset Condition Monitoring systems meet, but also to strict performance requirements that are unique to hazardous gas detection systems. This section presents some of those unique performance requirements as well as hazardous area information.

### 3.1 Performance Certification

Hazardous gas detection systems are performance certified as a group which consists of a sensor (detector head), a monitor, and a means of alarm indication. The certified system consists of all of the following:

- 3500/05 instrument rack, and
- 1 or 2 3500/15 power supply(ies), and
- 3500/22 TDI (Transient Data Interface) or 3500/20 RIM (Rack Interface Module), and
- 3500/63 hazardous gas detection monitor, and
- 350800 hazardous gas sensor(s) with or without Ex d flameproof junction box, and
- 3500/01 Configuration Software
- Optional 350810 Remote Calibrator

AND at least one of the following means of providing latched alarming:

- a 3500/32, 3500/33, or 3500/34 Relay Module
- an approved control system<sup>1</sup> receiving data from the 3500 system via:
  - 4-20 mA outputs from the rack, or
  - Modbus® through the 3500/92 Communications Gateway Module.

Additional acceptable accessories are:

- 3500/02 Data Acquisition Software
- 3500/03 Operator Display Software
- 3500/94 Display
- 3500/95 Display w/ Integrated Computer

<sup>1</sup> This approval does not include or imply approval of apparatus to which the subject instrumentation may connect. In order to maintain a performance approved system, the Approvals Agencies must also approve the apparatus to which this instrument connects.

The system approved by Bently Nevada, Inc. meets the following Performance Standards specific to combustible gas detection:

FM 6320 Approval Standard for Combustible Gas Detectors

CSA C22.2 No. 152 Combustible Gas Detection Instruments

IEC 60079-29-1 Gas Detectors – Performance Requirements of Detectors for Flammable Gases

ANSI / ISA—12.13.01 - Performance Requirements, Combustible Gas Detectors

Some of the important criteria associated with the above standards are:

- A unique state called “Over Range” (greater than 100% LEL reading) must be latching and requires user intervention to clear the latch.
- A fault indication must be given by the time the reading drops to -10% LEL. The agencies require this safety mechanism because of the inherent effects of temperature on the catalytic bead technology. If the resistance of the reference bead exceeds the resistance of the catalytic bead as the temperature rises the measurement will appear as a negative gas reading. If the sensor gets hot enough and the bridge becomes unbalanced enough, the system will indicate a fault as

required by the performance standards. For the Bently Nevada system the negative reading is displayed to aid with troubleshooting until it reaches the -9 % LEL Level, at which point it indicates a fault. Note that the 4-20 mA recorder output will clamp at 4 mA (0 %LEL) and not indicate negative gas readings in HMIs that use the recorder outputs. The negative gas readings are only displayed via Bently protocol such as in BN Display and System1.

- Accuracy at Room Temperature: The sensing head is exposed to five different gas concentrations over the full scale range (0 to 100% LEL) and the system shall not vary from the known test gas by more than  $\pm 3\%$  of full-scale gas concentration for 0-50 %LEL and  $\pm 5\%$  of the full-scale gas concentration for above 50 %LEL.

- Accuracy over Temperature: Meets the following when exposed to 50 %LEL after having been calibrated with 50 %LEL at room temperature:

-40 °C	50 % LEL +/- 10 %LEL
-25 °C	50 % LEL +/- 5 %LEL
22 °C	50 % LEL +/- 3 %LEL
75 °C	50 % LEL +/- 5 %LEL
200 °C	50 % LEL +/- 10 %LEL

Shift at 200 °C with no gas present is 0 %LEL +/-5 %LEL after having been calibrated with 50 %LEL at room temperature.

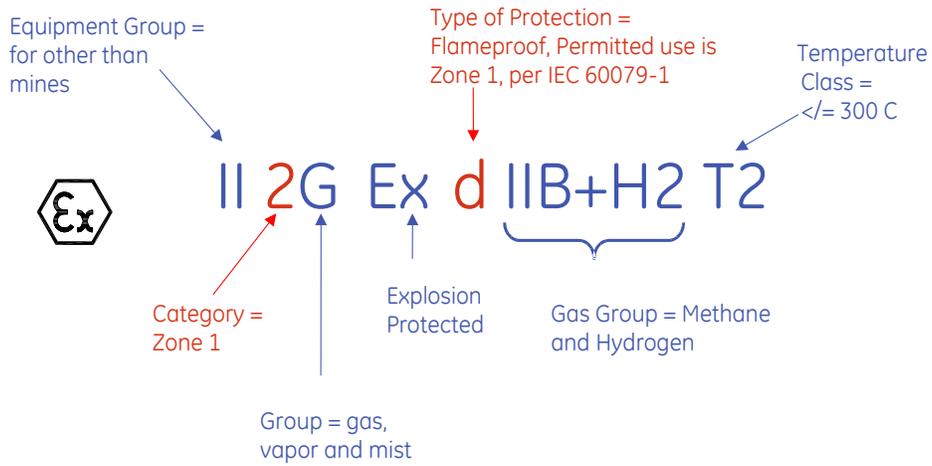
- Long-term stability: IEC test is a 60-day test with intermittent spans of time being exposed to calibration gas. Readings must be within  $\pm 7\%$  of the measuring range or  $\pm 20\%$  of the indication, whichever is greater.
- Step Change Response Time: When suddenly exposing the sensor head to 100% LEL the system will read 50% LEL within 10 seconds and 90% LEL within 30 seconds.

In addition, to the above criteria, the Bently Nevada system has met the requirements for humidity variation, calibration to methane or hydrogen, air velocity variation, supply voltage variation, vibration, drop test, as well as general construction, markings, and documentation requirements with regard to the above listed standards.

## 3.2 Hazardous Area Certification

### Sensor:

The 350800 sensor is approved for use at ambient temperature in the range of  $-40\text{ °C} \leq T_a \leq +200\text{ °C}$ . The sensor is ATEX and IEC marked for hazardous areas as shown in Figure 3-1.



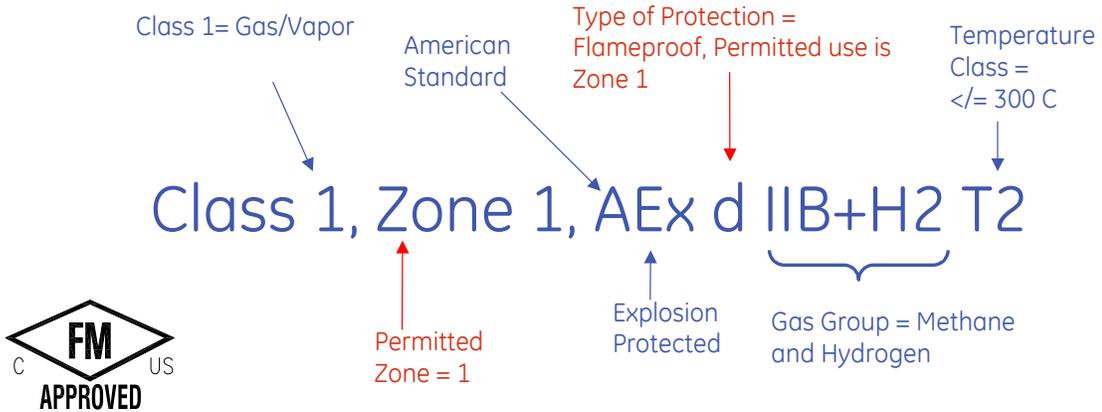
Label Legend:

- II: Equipment group is for other than mines
- 2: Category is Zone 1
- G: Group is for gas, vapor, and mist
- E: European Standard
- Ex: Explosion protected
- d: Type of protection is flameproof, permitted use is Zone 1 per IEC 60079-29-1
- IIB+H2: Gas group is methane and hydrogen
- T2: Temperature class is  $\leq +300$  °C

**Figure 3-1: Sensor ATEX Haz Area Marking Key**

## Section 3 - System Performance and Hazardous Area Approvals

The sensor is also North America marked as shown in Figure 3-2.



Label Legend:

- Class 1: Class 1 is for gas/vapor
- Zone 1: Permitted zone is 1
- A: American Standard
- Ex: Explosion protected
- d: Type of protection is flameproof, permitted use is Zone 1
- IIB+H2: Gas group is methane and hydrogen
- T2: Temperature class is  $\leq +300\text{ }^{\circ}\text{C}$

**Figure 3-2: Sensor North American Haz Area Marking Key**

The complete marking on the sensor also includes the temperature range and the agency certification numbers as shown below:

ATEX



II 2 G Ex d IIB+H2 T2  
 SIR A 06ATEX1173X  
 $-40\text{ }^{\circ}\text{C} \leq T_a \leq +200\text{ }^{\circ}\text{C}$   
 $(-40\text{ }^{\circ}\text{F} \leq T_a \leq +392\text{ }^{\circ}\text{F})$

IEC

II 2 G Ex d IIB+H2 T2  
 IECEx SIR 06.0053X  
 $-40\text{ }^{\circ}\text{C} \leq T_a \leq +200\text{ }^{\circ}\text{C}$   
 $(-40\text{ }^{\circ}\text{F} \leq T_a \leq +392\text{ }^{\circ}\text{F})$

North America

CLASS 1, ZONE 1  
AEx d IIB+H2 T2  
FM 3021960  
 $-40\text{ }^{\circ}\text{C} \leq T_a \leq +200\text{ }^{\circ}\text{C}$   
 $(-40\text{ }^{\circ}\text{F} \leq T_a \leq +392\text{ }^{\circ}\text{F})$

**Monitor:**

The 3500/63 monitor is approved for Zone 2 / Class 2.

AEx nA IIC  
Class I, Zone 2  
Class I, Div 2, Groups A, B, C, D  
T4 @  $-20\text{ }^{\circ}\text{C} \leq T_a \leq +65\text{ }^{\circ}\text{C}$  ( $-4\text{ }^{\circ}\text{F}$  to  $+150\text{ }^{\circ}\text{F}$ )

**Flameproof Housing:**

The housing is a flameproof housing for use with the 350800 sensor in Zone 1 areas and can be used for ease of sensor replacement. The flameproof housing is not required to meet Zone 1 or 2.

**Remote Calibrator:**

The Remote Calibrator is for use with the 350800 sensor. It is approved for use in the same environments for which the sensor is approved.

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## 4. Special Sensor Considerations

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There are several characteristics of catalytic bead technology that you must understand to ensure that you install and use the hazardous gas sensor properly.

### 4.1 Exposure to Gas

Catalytic bead sensors will last for many years if used within their specified operating conditions. When exposed to gas the catalyst is used, or spent. Therefore, if the sensor is exposed to gas above the Lower Explosive Level (LEL) for more than a few minutes you should recalibrate the sensor. See Section 9 for calibration procedures.

### 4.2 Poisons and Inhibitors

Certain chemicals will poison, or deactivate, the sensor so that it will lose sensitivity and eventually become totally non-responsive. The most common chemicals that can poison catalytic sensors are those that contain silicon. These include the common oil and lubricants with silicon compounds that plants use as additives in machinery. Sulfur compounds that are often released with gases, chlorine, and heavy metals can also poison the sensor. The exact cause of this poisoning is very difficult to identify. Very small concentrations of some chemicals may severely degrade the sensor's response to gas. There have been instances in which a first firing heated a turbine casing and caused lube oil dripped on the turbine casing to outgas silicones, poisoning the sensors. Even hand lotions with silicones can cause problems with a sensor. Always exercise care when handling, installing, and working around catalytic bead sensors.

Other chemicals, such as some halogen compounds, will inhibit the sensor so that it temporarily loses the ability to function correctly. Normally, after 24 to 48 hours of exposure to "clean" ambient air, the sensor will start to function normally again.

Below is a list of poisons and inhibitors. Many compounds fall into both categories—inhibitors and poisons. For a commercial product, which may contain a mixture of components, consult a relevant material safety data sheet or contact the manufacturer of the suspect product to determine whether the product contains any likely poisons or inhibitors.

#### Poisons

- Organic silicones (e.g. silanes and siloxanes)

- Hydrogen sulfide in percentage concentrations

- CFC's

Halogens and hydrogen halides (i.e. fluorine, chlorine, bromine, iodine, and hydrogen chloride)

Compounds that form barriers on beads from solutions (e.g. sodium chloride mists and spray)

Metal and non-metal hydrides (e.g. phosphine, arsine)

#### Inhibitors

Hydrogen sulfides in ppm concentrations

Chlorinated hydrocarbons (e.g. carbon tetrachloride, chloroform)

Organo-metallic compounds (e.g. tetra-ethyl lead compounds)

High concentrations of heavy hydrocarbons, especially those of high molecular weight (e.g. naphthalene, styrene)

Sulfur containing hydrocarbons in ppm levels (e.g. mercaptans in concentration  $\geq 10$ ppm)

Acid sprays and mists (e.g. sulphuric acid)

Oxides of sulfur and nitrogen

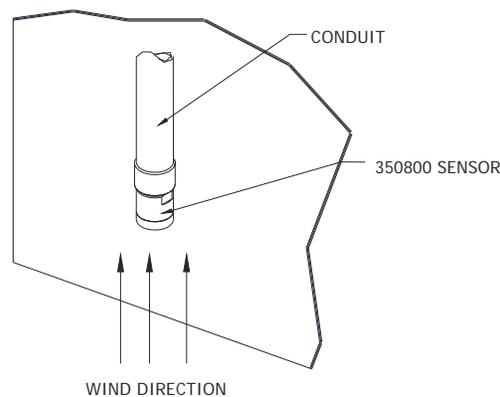
If you know that the sensor has been exposed to poisons or inhibitors you should use the procedures in Section 10.1 to verify the sensor's functionality. Often you may be unaware that the sensor has been exposed to a poison or inhibitor. Additionally, even when not exposed to poisons or inhibitors, catalytic bead sensors may show loss of sensitivity with time. Because one cannot tell if the sensor has ceased to operate due to inadvertent poisoning or inhibitors without actually exposing the sensor to a test gas, you should regularly verify or recalibrate catalytic bead sensors. We recommend that you recalibrate sensors for gas turbine installations, including turbine compartments, gas fuel modules and hydrogen-cooled generator compartments, at least every 90 days. The remote calibrator can be extremely advantageous for meeting the recalibration requirement, especially for hard to reach environments. See Section 2.4.

### 4.3 Sensor Location and Orientation

Determining the ideal placement of the sensors is the responsibility of the end user. Many factors should be considered, depending on the application. Be aware of the specific gravity of the gas to be detected. A leak may create a non-homogeneous mixture. A light gas will concentrate along the ceiling, whereas a heavy gas will concentrate along the floor.

Additionally, you should consider ventilation systems that can affect the gas concentration stratum when determining placement of the sensors. If the 350800 Sensor is mounted in a location with an air velocity of 2 m/s or more, the Sensor

must be mounted facing into the wind. (Refer to Figure 4-1). This will provide the least amount of wind-induced sensor variation.



**Figure 4-1: Sensor orientation in high air flow**

If moisture is a concern, you may orient the sensor with the head pointing downward to prevent moisture from accumulating on the sensor head if the gas density and ventilation situation permit it.

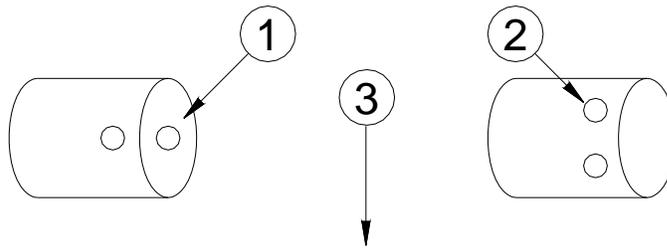
Often system designs include redundant sensors. These systems locate a number of sensors in a given area in a given orientation and use voting logic to analyze the measurements in the monitoring system before annunciating alarms or changing relay states. There are companies that specialize in computerized fluid dynamic analyses to determine the best location for hazardous gas sensor placement based on the application.

#### 4.4 Sensor Power-Up Stabilization

The detection technology of a catalytic bead sensor assumes that the temperatures of catalytic and reference beads are high enough to oxidize the gas at the catalytic bead. Before you begin the calibration process, the beads should be at their operating temperature. Electric current to the sensor generates this heat. Therefore, you should power up the sensor and allow the temperature to stabilize for at least 30 minutes before calibrating the sensor.

#### 4.5 Sensor Bead Orientation

Because the sensing technology relies on temperature variation (seen as resistance changes) between the catalytic and reference bead, use the same orientation to calibrate the sensor as that under which the sensor will be used to detect gas. The relationship of one bead to the other is important. Calibrating the sensor in one orientation and then tightening down the sensor resulting in a new orientation may inadvertently cause overheating of one of the beads with respect to the other (for example, due to convection as shown in Figure 4-2). This will appear as a gas reading when no gas is present.



1. Beads beside each other on a horizontal plane
2. One bead above the other, vertically
3. Gravity

**Figure 4-2: Relationship of one bead to the other**

Best practice is to have the sensor installed exactly as it will be during normal operation before calibration is performed.

## 4.6 Temperature Effects

During calibration the sensor is “zeroed” in known clean air and a reading is taken under exposure to 50% LEL calibration gas. This establishes the scale factor or sensitivity for the given sensor. Following calibration, changes in the resistance of the catalytic bead with respect to the reference bead will result in a gas reading, whether positive or negative. When exposed to combustible gas, the resistance of the catalytic bead increases due to the temperature rise caused by the burning combustible gas at the catalytic bead. This rise in resistance of the catalytic bead compared to that of the reference bead results in a positive gas reading and is proportional to the concentration of combustible gas present.

Other factors that cause a change in resistance between the two beads can also appear as a gas reading. For example, calibration of the sensor at an ambient temperature of 23C and then operation of the sensor at an ambient temperature of 200C can appear as a small gas reading even when no gas is present if the catalytic bead and reference bead and associated field wiring do not track each other identically over the change in ambient temperature. The small reading can appear as a negative or positive value depending on which bead has changed more in resistance over the temperature change. This undesirable side-effect of the technology has been minimized by the design to ensure that the sensor meets the performance criteria required by the approvals agencies.

Similarly, if the sensor is calibrated and then a high air flow is applied causing one bead to cool with respect to the other, it can appear as a positive or negative gas reading. This is one reason why it is recommended to orient sensors in high air flow areas or any duct regions such that the air is flowing directly into the sensor face, evenly distributed across both beads so as not to cool one bead with respect to the other.

Similarly, because the field wiring and the monitor electronics are also part of the Wheatstone bridge, temperature effects related to field wiring and the monitor must be considered, too. The cabinet that houses the BN rack should be closed during calibration to allow the monitoring system to be at operational temperatures. Excess lead lengths in field wiring or of the sensor itself should not be coiled inside housings that are located in hot areas. Lead lengths should be trimmed for the length needed for the installation.

## 4.7 Sensor Wiring Color Code

Use Table 4:1 to identify which sensor lead connects to which terminal on the monitor I/O and/or terminal block. Refer to Section 6, for I/O and block terminal names. Refer also to the Field Wiring Diagrams at the back of this manual.

**Table 4:1: Sensor Wire Color Chart**

Sensor Lead Color	Terminal Name
WHITE	PWR+
RED	CNTR
BLACK	PWR-

## 4.8 Installation in Hazardous Areas

The sensor is approved for Zone 1. The method of protection is flameproof, which means that the method must contain an explosion and quench the flame. The face of the sensor serves as the flame arrestor in the form of a porous sintered metal disk. The catalytic bead and reference bead are behind the sinter, so that if an explosion were to occur internal to the body of the sensor the sinter would prevent any flame from igniting gases in front of the face of the sensor. Because the method of protection is flameproof the installation must also be flameproof. One method of obtaining a flameproof installation is to use rigid metal conduit.

Flameproof conduit installations require that:

- Terminations in the hazardous area must be in flameproof housings
- All conduit fittings must be flameproof
- The installation must use conduit seals within a certain distance of flameproof housings (refer to local area and the governing agency standards)
- The installation must use conduit seals at the boundary between the hazardous area and the safe area

The sensor can be installed directly into conduit and still meet Zone 1 requirements as long as Zone 1 flameproof wiring techniques and local area codes are followed. This generally means:

- Pull back the leads to a flameproof terminal housing in the hazardous area, or
- Pull back the leads to the safe area for termination and employ conduit seals where required.

When using the flameproof terminal housing for terminations in a hazardous area conduit seals may be required within a certain distance of the housing (refer to local area and the governing agency standards). The sensor itself serves as the seal at one entrance to the Bently Nevada flameproof housing. The other conduit entrance to the housing may require a conduit seal after the field wiring is pulled and terminated to the terminal strip in the housing. Additionally, the field-wiring conduit run may also need a conduit seal at the boundary between the hazardous and the safe area.

The sensor leads may be pulled all the way back to the safe area (without the need for a termination housing in the hazardous area). Such an installation may still require a conduit seal at the boundary of the hazardous area and the safe area.

In all cases, after wires are pulled, conduit seal fittings must be potted to prevent a flame front from traveling down the conduit.

Even if the sensor is installed in a Zone 2 area, **flameproof wiring techniques must be used** because the sensor is a Zone 1 approved sensor whose method of protection is flameproof. Flameproof is generally the method of protection for catalytic bead sensors because of the high current requirements for the beads to function properly. The method of limiting the energy as in non-incendive or intrinsically safe methods of protection is not an option that can be used with catalytic bead technology.

Zone 2 areas are areas in which gas is present only under abnormal or fault conditions and then only for a very short amount of time. Agencies do not approve catalytic bead sensors for combustible gas detection for Zone 2 applications because the intent of the sensor is to function when gas *is* present. In fact, the use of a combustible gas detection system can be used to derate a Zone 1 area to a Zone 2 area when the system is used to ensure that hazardous gas will only be present for a limited amount of time should a fault scenario (leak) develop.

## 4.9 Sensor Replacement

	<b>DANGER</b>
EXPLOSION HAZARD. De-energize the system before opening the flameproof housing or replacing a sensor or independently confirm that no gas is present.	

Catalytic bead sensors are expendable and will likely need replacement over time or if the sensor is ever exposed to combustible gas, poisons, or inhibitors.

<b>Application Alert</b>
Disconnecting the field wiring will cause a not OK condition.

If the sensor is installed directly into conduit in an appropriate flameproof installation, there will likely be conduit seals around the sensor leads at some point along the conduit, either at a flameproof terminal housing in the hazardous area and/or at the boundary to the safe area. Obviously, this can complicate sensor replacement. The correct method for replacement in this instance would be to:

- 1) Cut out existing conduit seals,
- 2) Remove the sensor,
- 3) Replace the conduit, housings and seal fittings,
- 4) Replace the sensor and pull long lengths of sensor wire back to safe areas or approved housings for termination, and
- 5) Repot the conduit seals.

If the housings are located in areas where the temperature will change dramatically from the time of calibration to the time of normal operation, **do not place excess long lead lengths in the housing**. Trim the lead lengths. Long lead lengths coiled in housings that are located in areas that change temperature after initial calibration may change resistance due to heating and cause a change in reading that does not reflect the actual gas levels.

**Splicing sensor leads to field wiring is not an acceptable method of flameproof installation for a hazardous area and should not be used.**

If the sensor was installed in the Bently Nevada flameproof housing, replacement of the sensor is much easier. Inside the housing is a terminal strip to which the sensor leads and field wiring leads safely terminate. Recall that the sensor itself is a seal. The old sensor that served as a seal at one entrance to the housing can simply be removed and the new sensor installed. The field wiring with the conduit seal at the second entry to the housing need not be replaced. With the Bently Nevada flameproof housing method of initial installation there is no need to cut and remove conduit seals when replacing sensors because the sensor leads were not imbedded in conduit seals, only the field wiring from the second housing exit were.

Never screw the Bently Nevada sensor into another vendor's flameproof housing. The Bently Nevada sensor is approved only for use with the Bently Nevada flameproof housing. Similarly, never install another vendor's hazardous area sensor into the Bently Nevada flameproof housing. Either of these configurations would result in an installation that does not comply with hazardous area certifications.

The Bently Nevada 350800 sensor is approved only for use with the Bently Nevada 3500/63 monitor. **Do not interface the Bently Nevada sensor to another vendor's monitor. Do not interface another vendor's sensor to the BN monitor.**

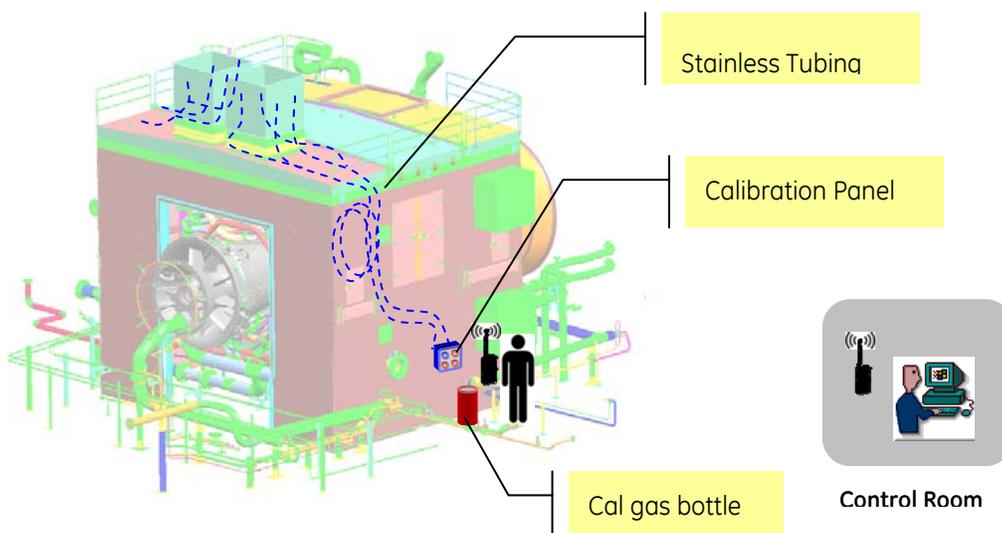
Whenever you replace a sensor or swap sensors on a channel you **must** perform a new calibration for that channel as described in Section 9.

## 5. Remote Calibrator Considerations

### 5.1 Installation

The 350810 Remote Haz Gas Calibrator is attached to the 350800 Hazardous Gas Sensor via a pinch clamp that is built into the calibrator. When attaching the calibrator to the sensor the clamp must be loose enough to allow the calibrator to slide over the sensor and bottom on the shoulder inside the remote calibrator's clamp. Torque the remote calibrator's two socket head cap screws to 25 in-lbs.

Use a 1/8" OD stainless steel supply line for connecting the calibrator to a panel where calibration gas will be applied. Ground the hardline at one end, preferably at the panel. Often this panel will be located outside an enclosed or inaccessible compartment as is shown in Figure 5-1. The supply line can be up to 100 feet in length.

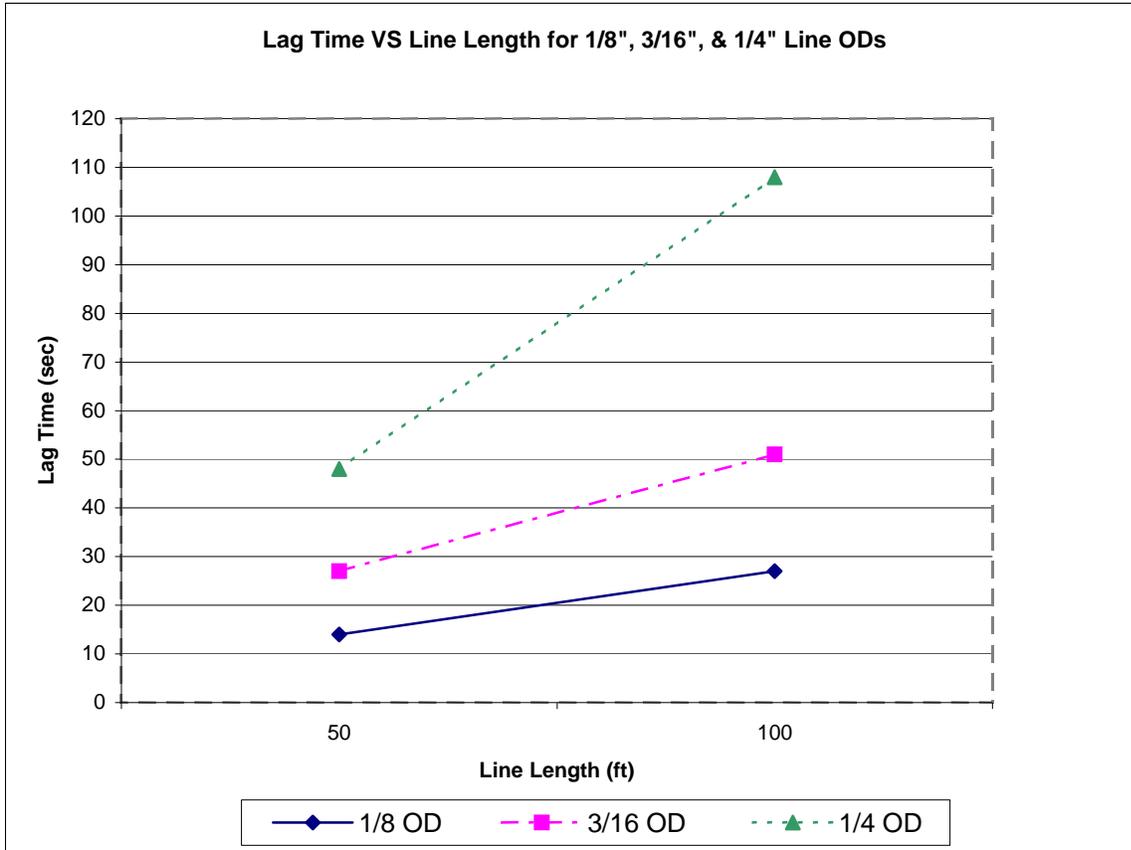


**Figure 5-1 Example of remote calibrator installation**

Larger supply line diameters will increase the response time and cause unnecessary consumption of the calibration gas. To assure the ability to calibrate in the time allotted by the firmware routine and to minimize the use of the calibration gas, 1/8" OD tubing should be used.

For informational purposes only, a table of response time versus length for different line diameters is included in Figure 5-2. "Lag Time" represents the time required for the calibration gas to reach the sensor. For any line size the haz gas

sensor requires an additional 30-40 seconds to stabilize during the calibration process. BN only recommends use of 1/8" line.



**Figure 5-2: Lag Time vs. Tubing Line Length--Informational only**

At the supply line exit from the compartment a 1/8" barbed line fitting with dust cap (both customer-supplied) is recommended. The dust cap is removed during the calibration process. When not calibrating, the dust cap will prevent contaminants from entering the line and potentially clogging the calibrator.

Figure 5-3 shows an example of an interface panel. Only the 100 ft length of 1/8" tubing and 1/4 NPT to 1/8" tube fittings are available through Bently Nevada (see Section 13.3.2). The other suggested parts are customer supplied.

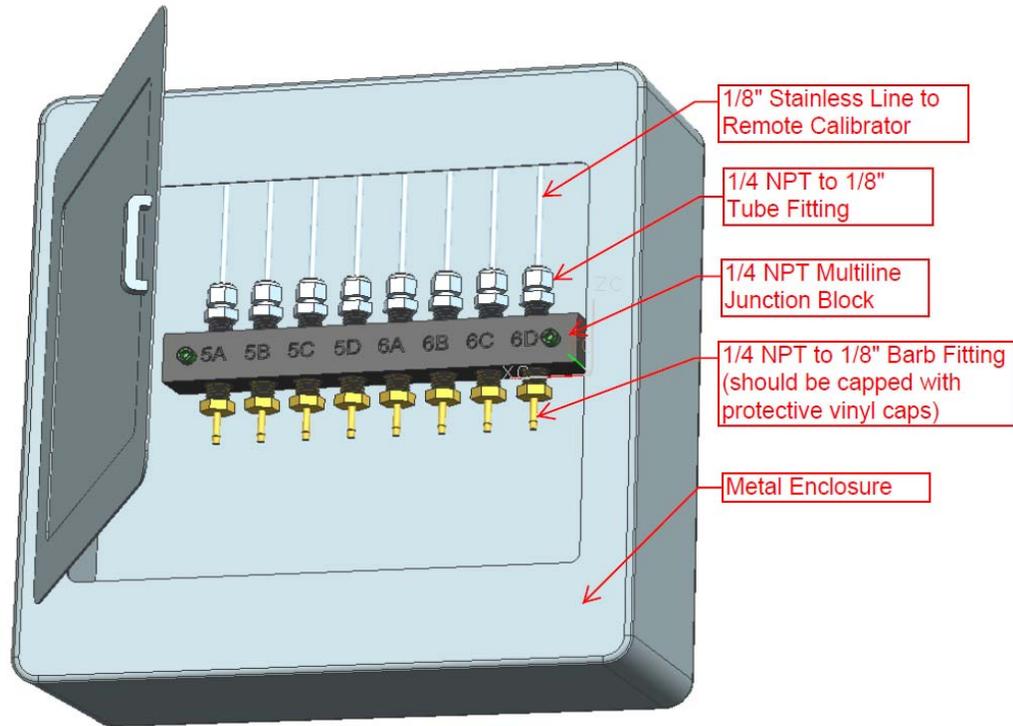


Figure 5-3: Example Interface Panel for Remote Calibrators

## 5.2 Orientation

If the 350800 Sensor is mounted in a location with an air velocity of 2 m/s or more, the Sensor must be mounted facing into the air flow as shown in Figure 5-4. In this orientation, then, the Remote Calibrator's air intake orientation is not critical.

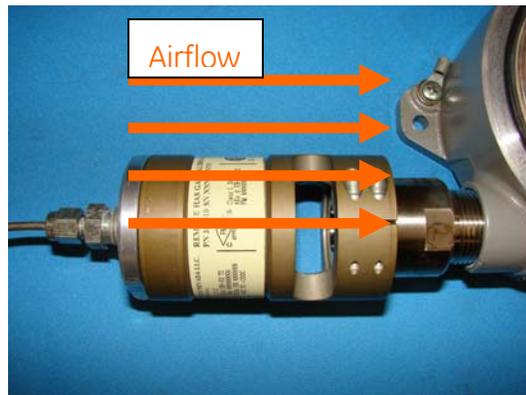
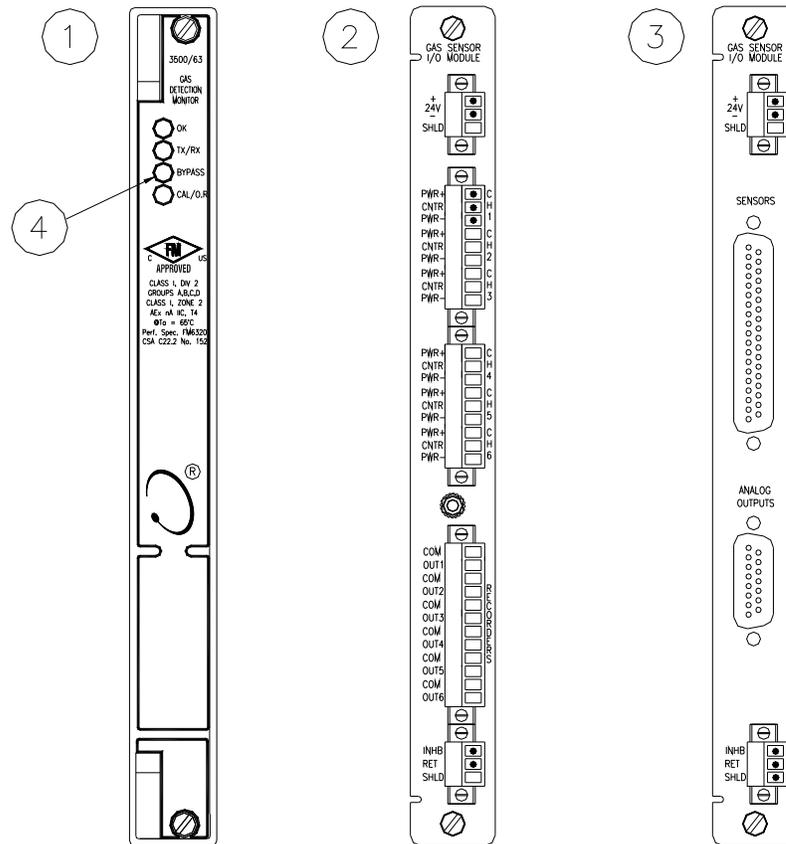


Figure 5-4: Sensor must face into high airflow (orientation of air intake opening of Remote Calibrator is not critical)



## 6. Hazardous Gas Detection Monitor

The 3500/63 Hazardous Gas Detection Module completes the necessary bridge circuitry, delivers a constant current from an external power supply to the sensor side of the bridge, and provides the signal conditioning necessary to report the gas concentration in % LEL for the Hazardous Gas Detection System. The six-channel 3500/63 Hazardous Gas Detection Module is actually made up of a Main Module and a choice of Interface Modules (I/Os), depending on termination and wiring requirements. Refer to Figure 6-1.



1. Main Module, front view.
2. Internal Termination I/O Module, rear view.
3. External Termination I/O Module, rear view.
4. Status LEDs.

**Figure 6-1: Hazardous Gas Main Module and I/O Modules**

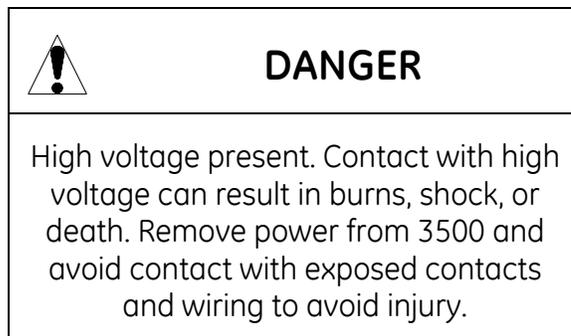
Each module accepts inputs from up to 6 catalytic bead sensors and uses these inputs to drive alarms. You can install the hazardous gas module in a 3500 rack in any slot (slots 2 to 15) to the right of the RIM (or TDI). You may install the modules in a 3500 rack that includes other 3500 monitoring functions. The internal power

supply in the first rack position powers the module itself. You can install dual supplies in this first position for added redundancy.

Each hazardous gas monitoring system uses an external +24 Vdc power supply (See Section 12.11 for ordering information), on page 138). The system requires the external supply to provide the increased power (i.e., 300 mA per sensor) needed to keep all the sensors at their operating temperature. The external power supply interfaces with the top connector of each I/O (refer to Figure 6-1 on page 27) of the 3500 Hazardous Gas Modules in the rack. The module regulates the power before sending it out to each sensor.

The 3500/63 arrives from the factory in an unconfigured state. You install it into a 3500 rack and configure it to perform the required monitoring functions.

When performed properly, you may install the 3500/63 Hazardous Gas Detection Monitor into or remove it from the rack while power is applied to the rack. Refer to the *Rack Installation and Maintenance Manual* (part number 129766-01) for the proper procedures.



## 6.1 Available Data

The Hazardous Gas Detection Module returns two proportional values per channel to the host software via the Rack Interface Module or TDI, to a Communications Gateway Module, a Display Interface Module, or to System 1\* software. These two proportional values are “% LEL” and “Cal Status”. The Hazardous Gas Detection Module also returns both module and channel statuses.

### 6.1.1 Proportional Values

The Hazardous Gas Detection Module has two available Proportional Values. These values are the measurement of gas concentration (Direct) and the calibration status of a channel (Cal Status). These values are used to monitor the machine or area in question.

The Direct measurement full-scale range is 0% to 100% LEL of the gas for which the channel was calibrated. For example, if the channel calibration procedure used methane, the measured range of 0% to 100% LEL corresponds to methane gas concentrations of 0% to 5% by volume of air. The available setpoint range for

the direct value is from 1% to 60% LEL as prescribed by performance standards. You can set two different levels of alarm: Alert/Alarm1 and Danger/Alarm2.

The Cal Status values indicate whether or not a specified calibration interval has expired. You can adjust the specified calibration intervals by configuring the Alert/Alarm 1 setpoint. The setpoint range is from 1 to 365 days. You cannot select the Danger/Alarm 2 setpoint, which is restricted to the recommended 90-day calibration interval for the specific sensor type in a given application.

### **6.1.2 Statuses**

This section describes the available statuses and where you can find them.

#### **Module Status**

##### **Module OK State**

This indicates if the module is functioning correctly. A monitor returns a Not OK status under any of the following conditions:

- Module hardware failure
- Node voltage failure
- Configuration failure
- Sensor failure
- Slot ID failure
- Channel Not OK

If the Module OK status goes Not OK, then the system OK Relay on the Rack Interface I/O Module will be driven Not OK.

##### **Module Bypass**

Enabled: Indicates that at least one channel's alarms have been kept from alarming (bypassed).

Disable: No channels' alarms have been bypassed.

##### **Alert/Alarm 1 State**

This indicates whether any channel within the module has entered Alert/Alarm 1. A module will enter the Alert/Alarm 1 state when a value provided by the module exceeds its configured Alert/Alarm 1 setpoint.

### **Danger/Alarm 2 State**

This indicates when any channel within the module has entered Danger/Alarm 2. A module will enter the Danger/Alarm 2 state when a value provided by the module exceeds its configured Danger/Alarm 2 setpoint.

### **Configuration Fault**

This indicates whether or not the monitor's configuration is valid.

### **Channel Status**

#### **Channel OK State**

This indicates whether or not the monitor has detected a fault on an individual channel. The monitor returns a Not OK status under any of the following conditions:

- Sensor wiring open or shorted
- Sensor signal outside its acceptable range in the negative direction
- Channel-specific hardware failure

#### **Channel Bypass**

This indicates that the channel has bypassed alarming for its monitored values. A channel bypass status may result from the following conditions:

- Module has never been configured
- Module is in configuration mode
- Channel has an invalid configuration
- Module is in power up self-test
- Fatal error found during self-test
- Alarming is bypassed via a software switch
- Channel has never been calibrated
- Channel is Not OK

#### **Alert/Alarm 1 State**

This indicates whether the channel has entered Alert/Alarm 1. A channel will enter the Alert/Alarm 1 state when that channel's value provided by the module exceeds its configured Alert/Alarm 1 setpoint.

### Danger/Alarm 2 State

This indicates whether the channel has entered Danger/Alarm 2. A channel will enter the Danger/Alarm 2 state when the channel's value provided by the module exceeds its configured Danger/Alarm 2 setpoint.

#### Channel Off

Enabled: This indicates that the channel has not been configured to be active so that the channel is off. The monitor channels may be turned off (inactivated) using the Rack Configuration Software and is available on the Options Screen.

Disabled: This indicates that the channel is on because it has been configured to be active.

Table 6:1 shows where the statuses can be found.

Statuses	Communication Gateway Module	Rack Configuration Software	Operator Display Software
Module OK	X	X	
Module Bypass		X	
Module Alert/Alarm 1 State	X	X	
Module Danger/Alarm 2 State	X	X	
Module Configuration Fault		X	
Channel OK	X	X	X
Channel Bypass	X	X	X
Channel Alert/Alarm 1 State	X	X	X
Channel Danger/Alarm 2 State	X	X	X
Channel Off	X	X	

**Table 6:1: Location of Module and Channel Statuses**

## Special Status

### Over Range

Over Range is a special status that is unique to the 3500/63 Hazardous Gas Detection System (as compared to other 3500 modules). Over Range indicates that the monitor has detected a gas concentration that exceeds the monitor's measurement range. The software will report the monitored value as greater than 100% LEL in numerical displays such as bar graphs. The monitor will flash the Cal LED on the module's front panel and post an "Entered Over Range" message to the System Event List. The analog recorder output will also be driven to a minimum of 20.5 mA. Any time the channel responds to an Over Range condition, the monitor will latch the Over Range state. This state cannot be cleared until

- 1) The channel reads a value less than 100% LEL, AND
- 2) Some event resets the system (such as the user pushing the reset button).

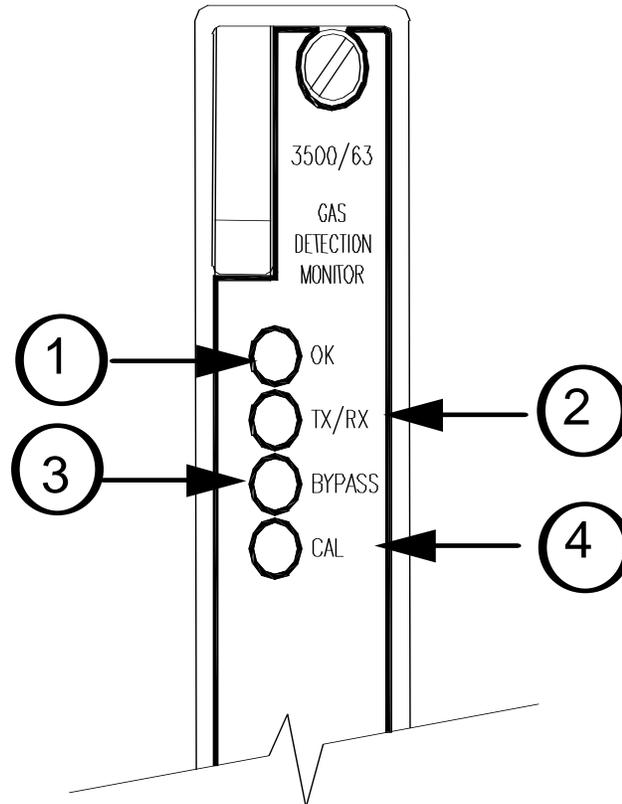


## DANGER

A monitor Over Range condition can indicate a concentration of hazardous gas above the lower explosion limit. Hazardous gas concentrations above the lower explosion limit may result in injury or death. All personnel in the affected area should immediately take precautionary measures per their facility's practices and procedures should the monitor indicate an Over Range condition.

## 6.2 LED Descriptions

The LEDs on the front panel of the 3500/63 Hazardous Gas Detection Module as shown in Figure 6-2 indicates the operating status of the module as shown in the following figure. Refer to Section 11.7 for all of the available LED conditions.



1. **OK:** Green color indicates that the Hazardous Gas Detection Module and the Gas Sensor I/O Module are operating correctly.
2. **TX/RX:** Flashes at the rate that messages are received and transmitted.
3. **BYPASS:** Red color indicates that some or all of the module functions are temporarily suppressed.
4. **CAL:** Indicates that the Hazardous Gas Module is in either the calibration mode or the calibration check mode. If flashing the module is in a latched Over Range condition.

**Figure 6-2: Monitor LEDs**

## 6.3 Triple Modular Redundant TMR Configuration

You can configure the 3500 Hazardous Gas Detection Module in a Triple Modular Redundant (TMR) module set for 2 out of 3 voting. A TMR configuration requires 3 6-channel Hazardous Gas Detection Modules with separate sensor inputs for each channel of the TMR channel group. TMR configurations must also meet the following requirements:

- Each channel of the TMR channel group must reside on a separate 3500/63 Module.
- The modules within the TMR group must be in physically adjacent slots within the 3500 Rack.
- TMR configurations must use the 3500/34 TMR Relay Module.

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## 7. Configuration Information

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### Application Advisory

The 3500/63 Hazardous Gas Detection System is a component that may be used in a safety shutdown system. The overall performance of the shutdown system depends upon other components in the system. A System Integrator who is familiar with safety shutdown systems must incorporate all of these components into a working system. The System Integrator and the End User are ultimately responsible for the proper functioning of the safety shutdown system.

The 3500/63 Hazardous Gas Detection Module requires a valid configuration to operate properly. This section lists the monitor options (Section 7.2), available setpoints (Section 7.3), and software switches (Section 7.4) for the Hazardous Gas Detection Module.

To configure the Hazardous Gas Detection Module, use this section to first gather the configuration information and then use the Rack Configuration Software to set options and download the configuration to the module. The *3500 Monitoring System Rack Configuration and Utilities Guide* (part number 129777-01) shows how to install and operate the Rack Configuration Software.

### 7.1 Hardware Considerations

The slots in the rack, from left to right, are numbered from 0 to 15. The power supplies for the 3500 rack occupy slot 0 and the 3500/22 Transient Data Interface (TDI) or 3500/20 Rack Interface Module (RIM) occupies slot 1. Slots 2 through 15 are called “monitoring positions”. You can install the 3500/63 modules into any of the monitoring positions.

The 3500/63 requires an external power supply to provide enough power to the sensors. See power supply ordering information in Section 13.2.

GE gas turbine applications use the TMR TDI (with standard hasz gas monitors) and dual power supplies.

### 7.2 Monitor Options

This section describes the options available on the 3500/63 Hazardous Gas Detection Monitor configuration screens and discusses configuration considerations.

## 7.2.1 Configuration Considerations

Consider the following items before configuring a Hazardous Gas Detection System:

- You cannot modify the full-scale range. The full-scale range is always 0% to 100% LEL.
- You should always connect hazardous gas detection systems to at least one latching alarm, which is required for North American Certified Systems. We recommend that you implement the latching alarms through one of the 3500 relay modules or an interface to an external control system that has been certified for use in a hazardous gas system.
- Agency performance standards for hazardous gas systems require that alarm setpoints must be less than or equal to 60% LEL. The Setpoints in the 3500/63 cannot be set above 60% LEL.
- You cannot download configuration when the Hazardous Gas Module is in an alarm state, calibration/verify mode, or user test mode.
- Catalytic bead sensors do not support intrinsically safe barriers. The 350800 Hazardous Gas Sensor is Zone 1 approved. The method of protection is flameproof.
- Calibration gas concentration must be 50% LEL.

## 7.2.2 Basic Configuration Options

This section describes the options available on the 3500/63 Hazardous Gas Detection Monitor configuration screen. Figure 7-1 shows the first options screen.

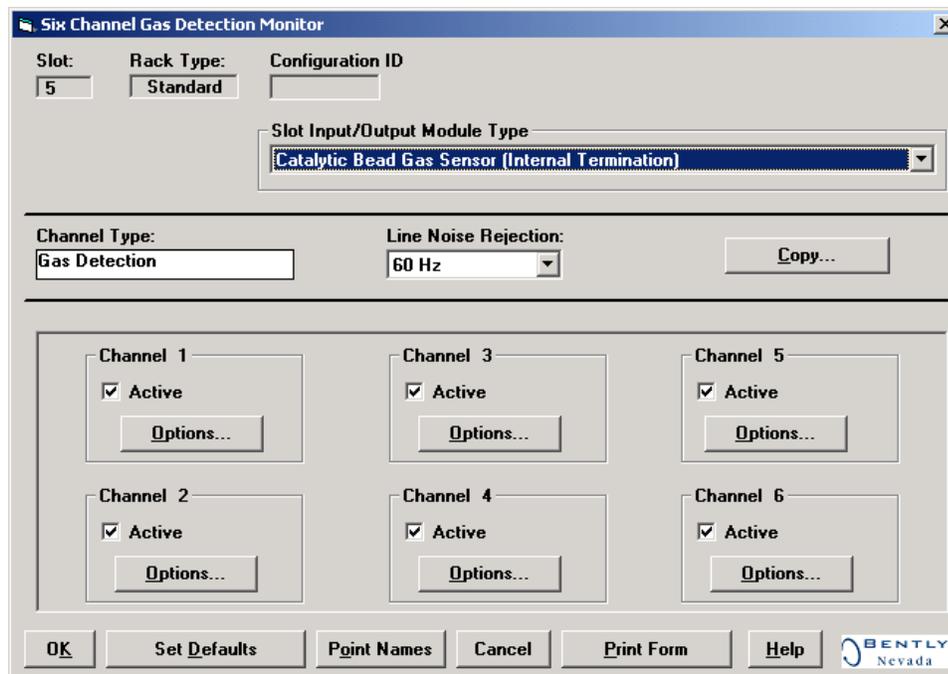


Figure 7-1: Monitor Options Screen

### Reference Information

These fields contain information that indicates which module you are configuring.

#### Slot

The slot indicates the location of the 3500/63 module in the 3500 rack (2 through 15).

#### Rack Type

The rack type specifies the type of Rack Interface Module installed in the rack (Standard or TMR) combined with the position of the TMR Rack switch.

#### Configuration ID

The configuration ID is a unique six-character identifier that the user enters when downloading a configuration to the 3500 rack.

#### Input/Output (I/O) Module

This option allows you to select the type of Input/Output (I/O) module connected to the 3500 module. When you download a configuration to a 3500 monitor, the monitor compares this field against the type of I/O module that is physically

installed in the rack behind the specified monitor. If this field does not match the installed I/O module, the monitor will reject the configuration.

The I/O module is located in the slot directly behind the monitor module in a panel mount rack, or directly above the monitor in a bulkhead mount rack. The I/O module routes signals from the sensors to the monitor and provides a 4 to 20 mA analog output for each sensor input. The I/O module does not power the sensors. You must connect an external power supply to the I/O module to provide power for the sensors. The I/O module does regulate the power to the sensors.

The possible I/O module types for the 3500/63 monitor are the Internal Termination Catalytic Bead Sensor and External Termination Catalytic Bead Sensor. Internal Termination I/O modules require you to wire each sensor directly to the I/O module. External Termination I/O modules require you to wire each sensor directly to external termination block modules. Note that you should connect these I/O modules only to an approved sensor, such as the 350800 Hazardous Gas Sensor.

### **Channel Type**

The channel type is Gas Detection.

### **Line Noise Rejection**

This setting will identify the line noise frequency to filter on sensor signals. The choices are 50 Hz and 60 Hz. Select the value corresponding to the line frequency of the power grid connected to your monitoring system. If the 3500 Monitoring System uses a DC power supply, select 60 Hz for the setting.

### **Copy Button**

This allows you to copy the configuration from a specific channel to one or more of the other channels in the Gas Detection monitor.

<b>NOTE</b>
The copy operation does not include alarming setpoints or associations of point name(s). If you wish to copy the setpoints from one channel to another, you must use the Copy button in the Setpoint Configuration screen

### **Channel Activity**

Channel Activity allows you to control whether or not the monitor channel is used. (If the box is checked, the channel is used.)

Note that designating a channel Inactive does not disable the electrical power to the channel, monitor, or sensor. Thus, the risk of electrical shock remains in place until the rack power source as well as the sensor power source is removed.

**Options Button**

This button allows you to move to the channel options screen. (See below.)

**OK Button**

This button will save all settings on the current configuration screen and return you to the previous screen.

**Set Defaults Button**

The Set Defaults button will return all settings on the current configuration screen as well as the settings on lower level screens to the default settings.

<b>NOTE</b>
Clicking on Set Defaults returns the settings on all lower level screens to their default settings even if the changes at lower levels were confirmed by clicking on the OK button on the lower level screen.

**Point Names Button**

Point names are custom names that you can assign to a channel of data so that an operator can more easily identify the examined machine points. In the 3500 System, default names are displayed as RxxSxxCxx that indicates to which rack, slot, and channel the data pertains. The point names feature allows you to assign more meaningful names.

**Cancel Button**

This button will return all settings on the current configuration screen and any lower level screens to their previous settings and return you to the previous screen.

<b>NOTE</b>
Clicking on Cancel returns the settings on all lower level screens to their previous settings even if the changes at lower levels were confirmed by clicking on the OK button on the lower level screen.

### Print Form Button

This button sends a copy of the current configuration screen to the printer.

The Options Button for each channel takes you to the Channel Options configuration screen shown in Figure 7-2.

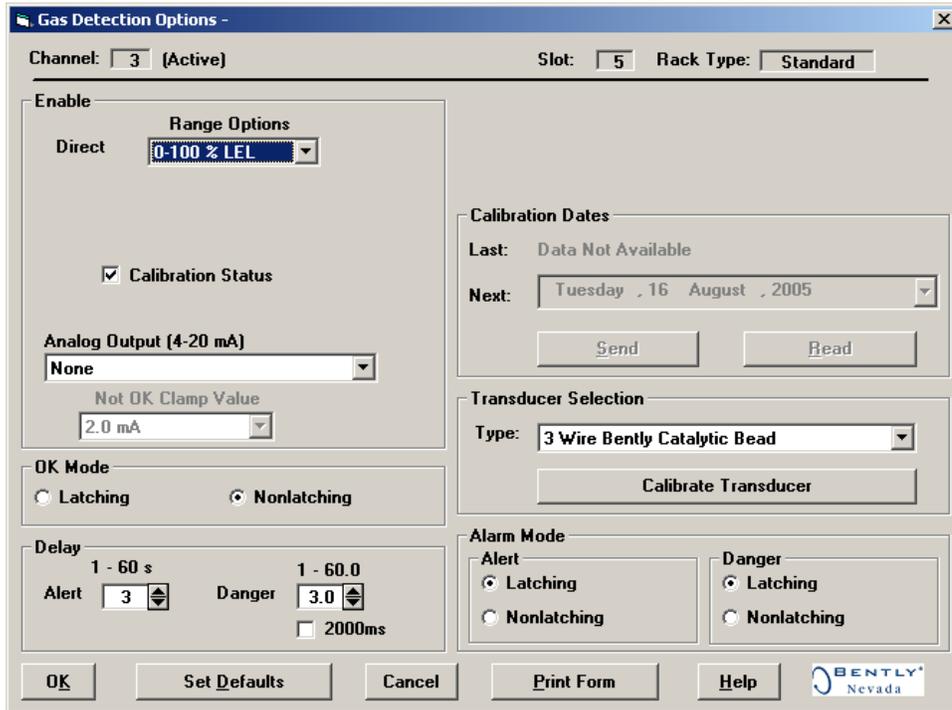


Figure 7-2: Channel Options Screen

### Enable

The 3500/63 Hazardous Gas Detection Module has two available measurements: Direct and Cal Status. Either of these two can drive Alarm state changes and subsequently drive relay outputs.

### Direct

Direct is the measurement of gas concentration in units of % LEL. By default this proportional (PPL) value is always enabled. The Direct proportional value has user-configurable setpoints for both Alert/Alarm 1 and Danger/Alarm 2. You can set both of these setpoints as Enabled or Disabled.

### Cal Status

This indicates the number of days that have elapsed since the last successful calibration. You can set this proportional value as Enabled or Disabled. The Cal Status proportional value offers a user-configured setpoint only for Alert/Alarm 1. The recommended calibration interval (90 days) will always determine the

---

Danger/Alarm 2 setpoint. You can configure both of these setpoints to be Enabled or Disabled.

Please note that if the System time in the RIM or TDI is older than the Next Calibration Date the monitor will invalidate the Cal Status proportional value.

### **Range Options**

The Direct proportional value is always 0% - 100% LEL. There is no range option for the Cal Status Value; it always is 0 - 365 days.

### **Analog Output (4 to 20 mA)**

The Analog Outputs are physically located on the rear of the Hazardous Gas Detection Module I/O and are industry standard 4-20mA signals. There is one output per channel. The user can configure what measurement to send out the Analog Output for each channel. For the 3500/63 the only options are "None" or "Direct". If Direct is chosen, the 4-20mA signal output will be proportional to the measured value of the channel over the full-scale range of 0% to 100% LEL. When the Analog Output is set for Direct:

The output of 4 to 20 mA is proportionally scaled to 0 to 100 %LEL

If the channel is bypassed or driven to a Not OK status, the output will be clamped to the user-selected Not OK Clamp Value. (See below)

If the channel is in Over Range the 4-20 mA output will be a minimum of 20.5 mA, but may be as high as 22.4 mA.

If the channel is in Calibration Mode the corresponding output will default to 1.5 mA.

### **Not OK Clamp Value**

The Not OK clamp value is the level of the Analog Output to which a proportional value defaults when that channel or proportional value is bypassed or is defeated (e.g., when a problem occurs with the sensor). This user-selected value can range from 2 mA to 3.5 mA in increments of 0.5mA on the Analog Output lines. The module will clamp only the values available from the Analog Outputs, the Communication Gateway Module, and the Display Interface Module to the specified value when the proportional value is invalid.

### **OK Mode**

When a channel's sensor input is outside its allowable range the channel will go NotOK. The OK LED on the monitor will go out. The 4-20mA output will go to the user configured NotOK state (2.0, 2.5, 3.0, or 3.5mA which equate to -12.5, -9.375, -6.25, -3.125 %LEL, respectively as seen in an HMI). After the channel's sensor input returns to an allowable range it will take 30 seconds before the channel goes to live monitoring. While the hazardous gas channel is NotOK the alert and danger alarms are defeated.

Options for Latching or Non-latching in the OK Mode group determine how the channel OK status is affected when the channel goes Not OK and then returns to an OK state. This status also affects the state of the OK relay that is part of the Rack Interface Module (RIM) or Transient Data Interface Module (TDI), whichever is in the rack.

### Latching

If a channel is configured for Latching OK and if the channel has gone Not OK, the status will stay Not OK until a reset is issued **even if the channel has returned to an OK state**. This mode allows you to know that the channel has at some time in the past entered the NotOK state. Upon entering the NotOK state alert and danger alarms and the Rack OK relay are defeated and the channel remains in this state until it is reset. To reset a latched Not OK, use one of the following methods after the Not OK condition has been corrected:

- Set the Channel Reset software switch in the 3500 Rack Configuration Software
- Issue a channel reset command through the Communication Gateway Module or Display Interface Module.
- Depress the Reset button on the front of the rack.

When you configure a channel for Latching OK, you must reset the monitor after powering up to clear the latched condition.

### Non-latching

When you configure a channel for Non-latching OK, the channel OK status of the Hazardous Gas Detection Module will return to an OK state once the Not OK condition is removed.

### Delay (Alarm Time)

You can configure the additional amount of time that the monitor will delay issuing an alarm from the point it is first identified as an alarm. Under fully loaded conditions the system takes a minimum of 2 seconds to identify that a channel is in alarm. Each alarm also has its own setting to add additional alarm delay. The Alert time delay and the Danger time delay can each be set from 1 to 60 seconds. These delays are added to the minimum delay of 2000 ms, or 2 seconds.

The Danger alarm also allows you to specify the minimum amount of delay by selecting the 2000 ms check box. Note that the actual minimum delay may actually be less than 2000 ms, based upon such factors as how many channels are active within the monitor. If you check the 2000 ms box, the total time for the monitor to annunciate a Danger Alarm will not exceed 2 seconds even with all channels in alarm.

---

## Calibration Dates

The software provides the dates of the “Last” and “Next” calibration as references to operating personnel. The software will automatically populate the “Last” date when you perform a successful calibration. The software will also display the “Last” date to the nearest minute. This allows personnel to discriminate between calibration cycles conducted on the same day.

If the time between the “Last” calibration date and the current date exceeds the recommended 90-day calibration interval without you re-calibrating the channel in question, the monitor will add a message to the System Event List stating that the recommended calibration interval has expired. This message will be informational in nature and will not cause a Not OK condition.

You can set the “Next” date to note when the next scheduled calibration should take place. This field will be reported to the nearest day. If the system reaches the “Next” calibration date without this date being reset, the monitor will add a message to the System Event List to this effect. This message will be informational in nature and will not cause a Not OK condition.

### Send Button

This button stores the “Next” date that you set to note when the next scheduled calibration should take place.

### Read Button

The Read button retrieves the “Last” and “Next” calibration dates that are stored in the I/O module.

### Transducer (Sensor) Selection

You may connect the following transducer (sensor) types to the hazardous gas detection module:

- Bently Nevada 350800 Catalytic Bead
- Catalytic Bead

You should use only an approved sensor with the 3500 Hazardous Gas Detection System.

### Calibrate Transducer (Sensor) Button

This button moves the user to the Gas Detection Calibration Screen.

### Alarm Mode

### Latching

Once a latching alarm is active, it will remain active even after the proportional value drops below the configured setpoint level. The channel will remain in alarm until one of the following methods resets it:

- Setting the Channel Reset (Aux 2) software switch in the 3500 Rack Configuration Software.
- Issuing a channel reset command through the Communication Gateway Module or Display Interface Module.
- Depressing the Reset button on the front of the rack.

### Non-latching

When a non-latching alarm is active, it will go inactive as soon as the proportional value drops below the configured setpoint level and its associated hysteresis value (see below for hysteresis).

Note that Alert/Alarm 1 should be the first level alarm that occurs when the sensor signal level exceeds the selected value. Danger/Alarm 2 should be the second level alarm that occurs when the sensor signal level exceeds the selected value. However, you can deactivate either or both of the Alarms. You set the Alert and Danger values on the Setpoint screen.

#### Application Advisory

FM certification for a Hazardous Gas Detection System requires that you configure the Danger/Alarm 2 for latching, unless the system is connected to an auxiliary system that accomplishes the same purpose as latching and FM has approved all components as a system.

## 7.3 Available Setpoints

This section specifies the available setpoints for the Hazardous Gas Detection Module. A setpoint is the level within the full-scale range that determines when an alarm occurs. The 3500/63 Hazardous Gas Detection Module allows you to set both the Alert/Alarm 1 setpoints and the Danger/Alarm 2 setpoints for the Direct proportional value of % LEL. You can also set the Alert/Alarm 1 setpoint for the Cal Status proportional value, but cannot adjust the Cal Status Danger/Alarm 2 setpoint. This setpoint value is determined by, and set to, the recommended calibration interval of 90 days. The channel will drive an indication if either proportional value exceeds its setpoint(s).

### Application Advisory

Alert/Alarm 1 and Danger/Alarm 2 setpoints for the Direct proportional value must be set less than or equal to 60% LEL. The configuration software will not permit setpoints greater than 60% LEL.

Use the screen in the Rack Configuration Software shown in Figure 7-3 to adjust Alert/Alarm 1 and Danger/Alarm 2 setpoints. You can enable or disable each alarm setpoint by selecting or clearing the appropriate "Enabled" checkbox below each setpoint.

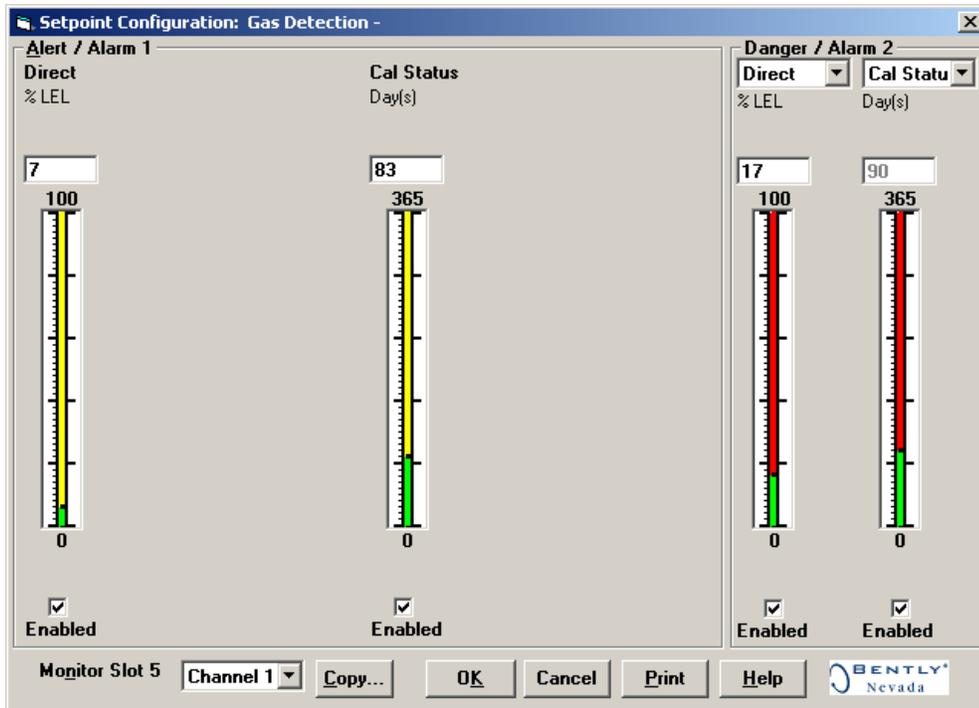


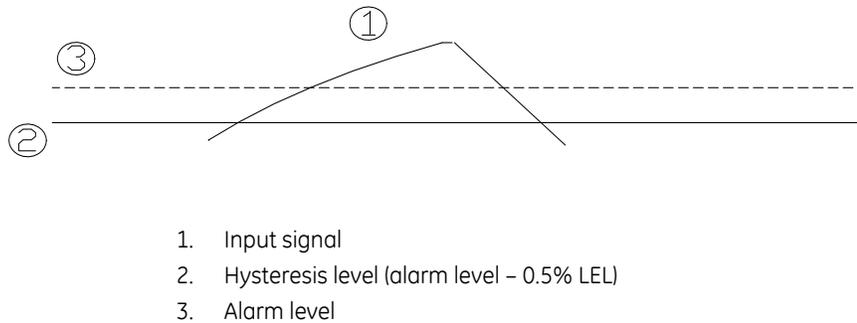
Figure 7-3: Setpoint Configuration Screen

Table 7:1 lists the Alert/Alarm 1 and Danger/Alarm 2 setpoints for the 3500 Hazardous Gas Detection System. The Communication Gateway Module and Display Interface Module use the setpoint number. All the Alert/Alarm 1 setpoints are provided first, followed by the configured Danger/Alarm 2 setpoints.

Setpoint Number	Setpoint
1	Alert Direct
3	Alert Cal Status
5	Danger Direct
7	Danger Cal Status

**Table 7:1: Available Setpoints****Alarm Hysteresis**

Alarm Hysteresis is not selectable. Alarm Hysteresis is the difference between the level that a signal must pass to enter an alarm and the level that it must pass to exit an alarm, as shown in Figure 7-4. Both Direct setpoints have an Alarm Hysteresis of 0.5% LEL. For the Hazardous Gas Monitor the Alarm Hysteresis band for a setpoint is below the setpoint. For example, if a setpoint is set at 17% LEL, the hysteresis level is at 16.5% LEL. The module would enter alarm at 17% LEL, but would not go out of alarm until the gas concentration fell to 16.5% LEL.

**Figure 7-4 Alarm Hysteresis**

## 7.4 Software Switches

The hazardous gas detection monitor supports two module software switches and four channel software switches. (See Figure 7-5.) These switches let you temporarily bypass, inhibit, or invoke monitor and channel functions. Use the **Software Switches** screen under the **Utilities** Option on the main screen of the Rack Configuration Software to set these switches. No changes will take effect until you click on the **Set** button.

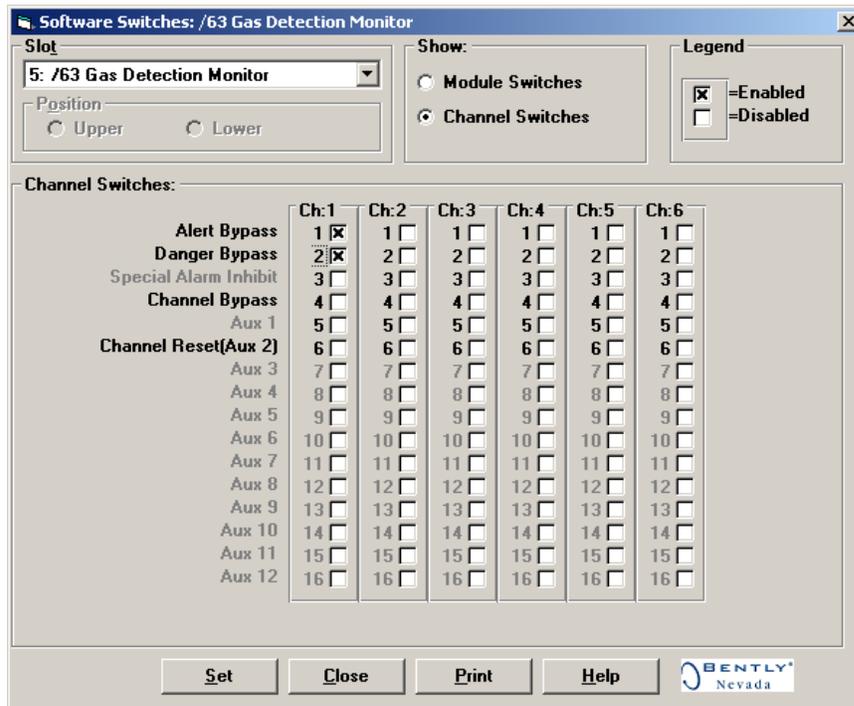


Figure 7-5 Software Switches Screen

**Show**

**Module Switches** radial button:

**Configuration Mode**

This switch allows you to configure the monitor. To configure the monitor, select this box and set the key switch on the front of the Rack Interface Module or TDI in the PROGRAM position. When the Rack Configuration Software downloads a configuration it will automatically enable and disable this control. If the connection to the rack is lost during the configuration process, uncheck this box to remove the module from Configuration Mode.

**Monitor Alarm Bypass**

When you select the box for this switch, the monitor does not perform alarming functions. The monitor still provides all monitored values.

The Gateway Communication Module and Display Interface Module use the monitor switch number.

**Table 7:2: Monitor Switches**

Monitor Switch Number	Switch Name
1	Configuration Mode
3	Monitor Alarm Bypass

**Channel Switches** radial button:

**Alert Bypass**

When you select the box for this switch, the channel does not perform Alert alarming functions.

**Danger Bypass**

When you select the box for this switch, the channel does not perform Danger alarming functions.

**Channel Bypass**

When you select the box for this switch, the channel provides no alarming functions and supplies no monitored values.

**Channel Reset (Aux 2)**

This switch resets latched alarms and latched Not OKs.

The Communication Gateway Module and the Display Interface Module use the channel switch number.

**Table 7:3: Channel Switches**

Channel Switch Number	Switch Name
1	Alert Bypass
2	Danger Bypass
4	Channel Bypass
6	Channel Reset

## 8. I/O Module Descriptions

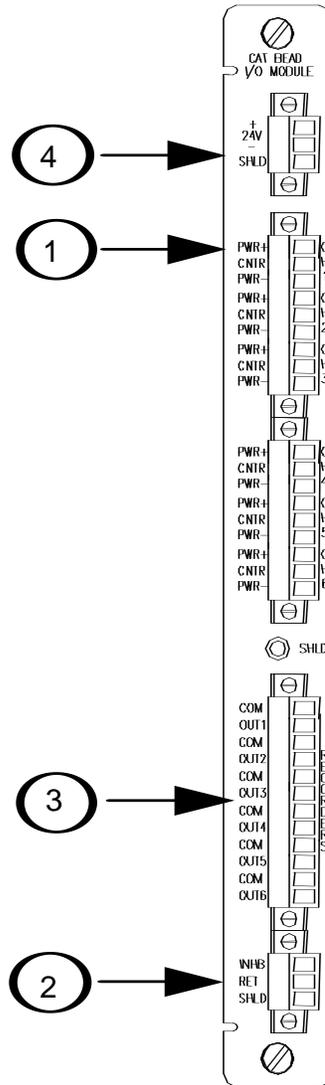
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The Hazardous Gas Detection I/O Module receives the signal from the sensor and routes it to the Hazardous Gas Detection Module. The I/O module also routes externally supplied power to the sensor and provides a 4 to 20mA Analog Output for each sensor input channel. Install one I/O module for each monitor. Install the I/O module directly behind the monitor in a rack mount or panel mount rack or directly above the monitor in a bulkhead rack.

This section describes how to use the connectors on the I/O modules. The 3500/63 Field Wiring Diagram (refer to Section 15) shows how to connect the sensors, system contacts, and analog outputs to the I/O module.

### 8.1 Internal Termination Gas Sensor I/O Module

The Internal Termination Gas Sensor I/O Module requires you to wire the sensors and the analog outputs directly to the I/O module. This section shows what this I/O module looks like and shows where and how to connect the wires to the Euro Style connector. Refer to Figure 8-1 and to Figure 8-2.

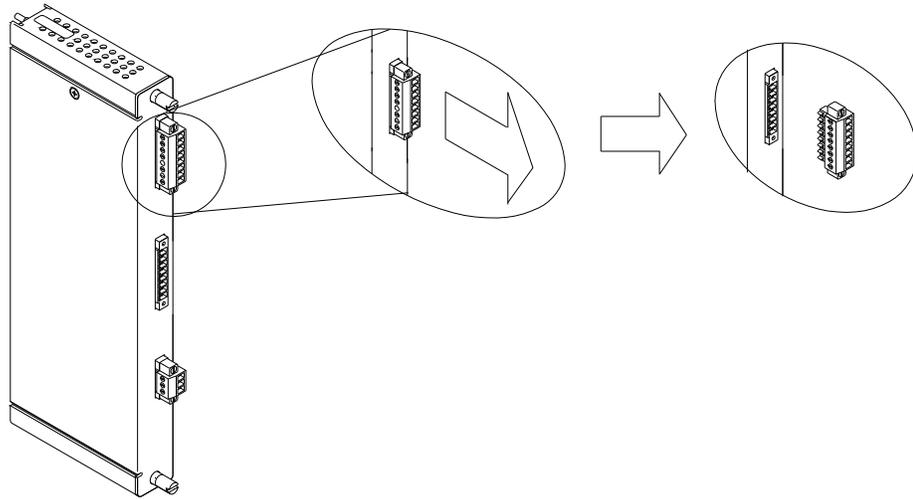


1. Connect the wire from the sensors to the I/O Module.
2. INHB/COM: Connect to an external switch. Used to inhibit all alarms on the module.
3. OUT/COM: Connect the 4 to 20 mA analog outputs to a chart recorder or other appropriate device.
4. SENSOR PWR: Connect to an external +24 Vdc supply for sensor power.

**Figure 8-1: Connections to I/O with Euro Connectors**

### 8.1.1 Wiring Euro Style Connectors

To remove a Euro style connector from its base, loosen the screws attaching the connector to the base, grip the connector firmly, and pull.

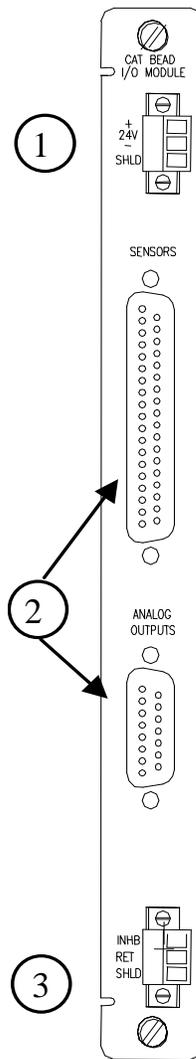


**Figure 8-2: Typical I/O Module Showing Euro Style Connectors**

Refer to the 3500/63 Field Wiring Diagram Section 15 for the recommended wiring. During wiring, do not remove more than 6 mm (0.25 in) of insulation from the wires before connecting the wire to the terminal connector. Never pull the connector out by its wires because this could loosen or damage the wires or connector.

## 8.2 External Termination Gas Sensor I/O Module

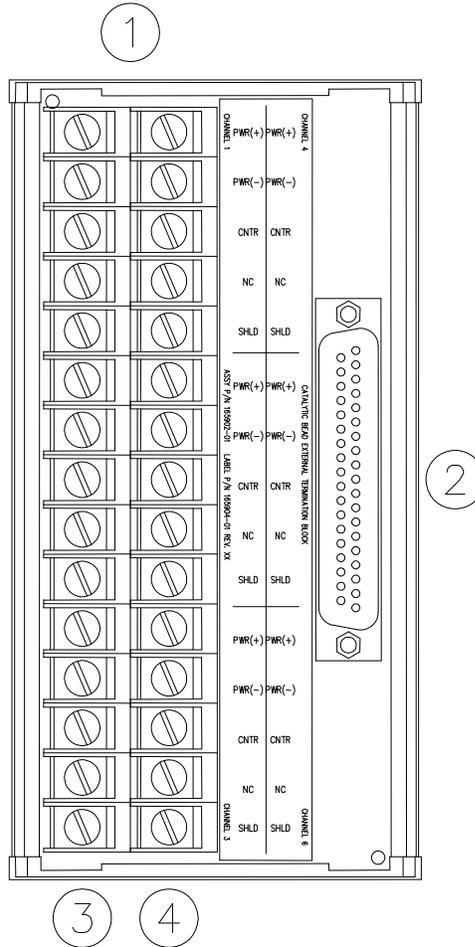
The External Termination Gas Sensor I/O Module requires you to wire the sensors and the analog outputs to an external termination block. This external termination block then connects to the I/O module via parallel communications cables. This section shows what this I/O module looks like and shows where and how to connect the wires to both the I/O module and the external termination block.



1. Connect external sensor power to the I/O Module.
2. Cable Connections: Connect to an external termination block.
3. INHB/COM: Connect to an external switch. Used to inhibit all alarms on the module.

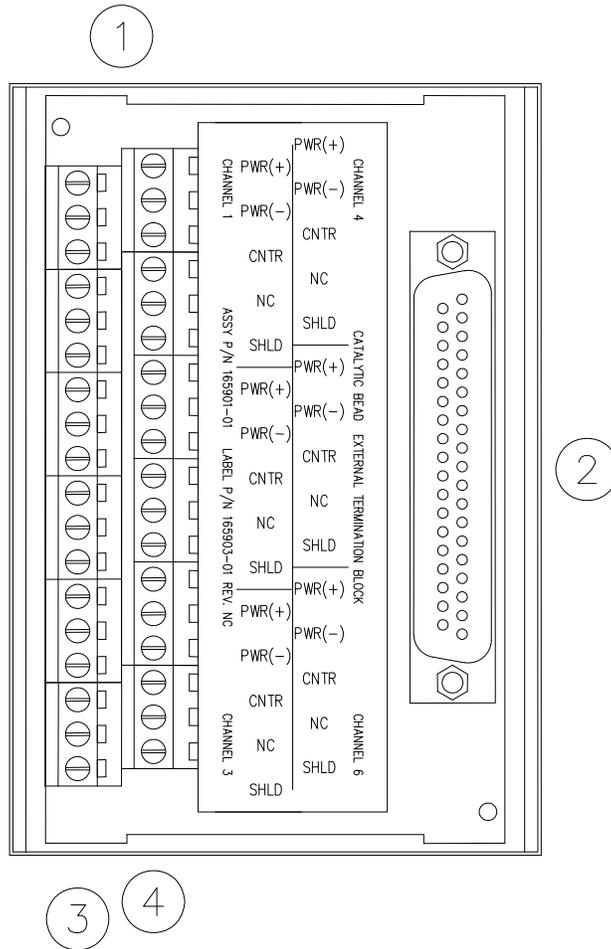
**Figure 8-3: External Termination I/O Module**

### 8.3 External Termination Blocks



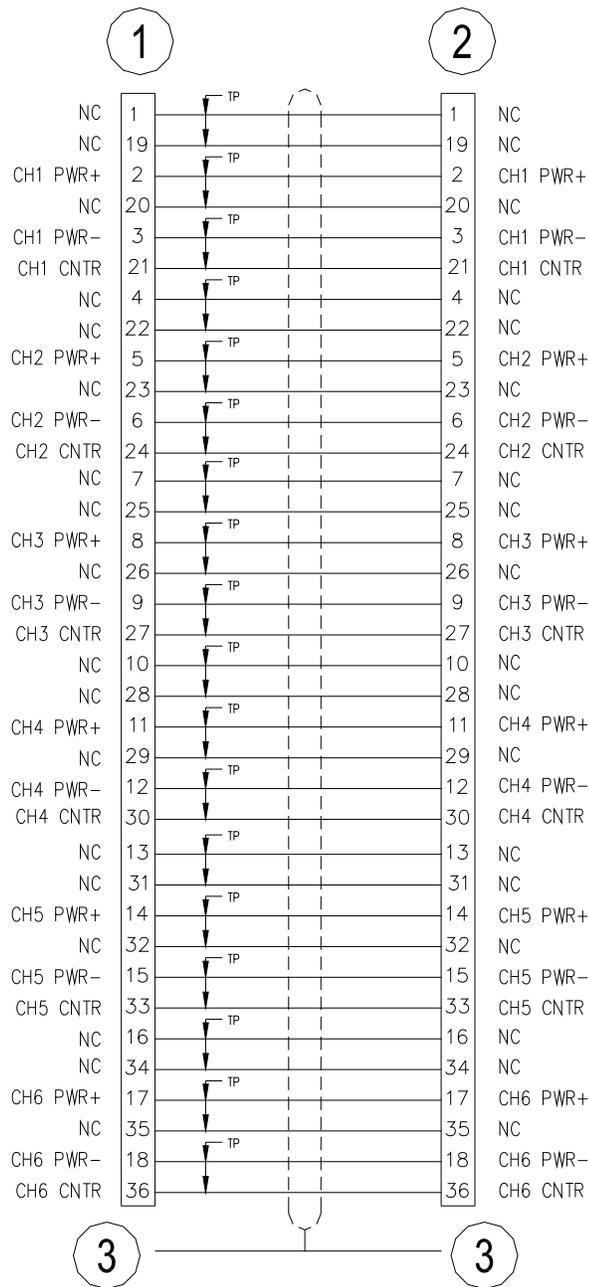
1. Connect the wire from the gas sensors associated with channels 1-6 to the External Termination Block.
2. Connect the Gas Sensor I/O module to the External Termination Block. Use Cable 134544-XXXX-XX.
3. Channels 1, 2, 3
4. Channels 4, 5, 6

**Figure 8-4: Monitor/Sensor External Termination Block (Terminal Strip Connectors)**



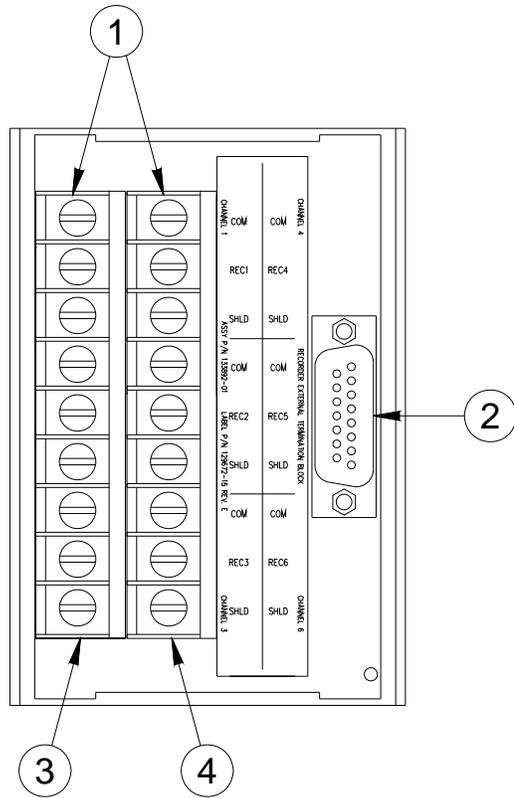
1. Connect the wire from the gas sensors associated with channels 1-6 to the External Termination Block.
2. Connect the Gas Sensor I/O module to the External Termination Block. Use Cable 134544-XXXX-XX.
3. Channels 1, 2, 3
4. Channels 4, 5, 6

**Figure 8-5: Monitor/Sensor External Termination Block (Euro Connectors)**



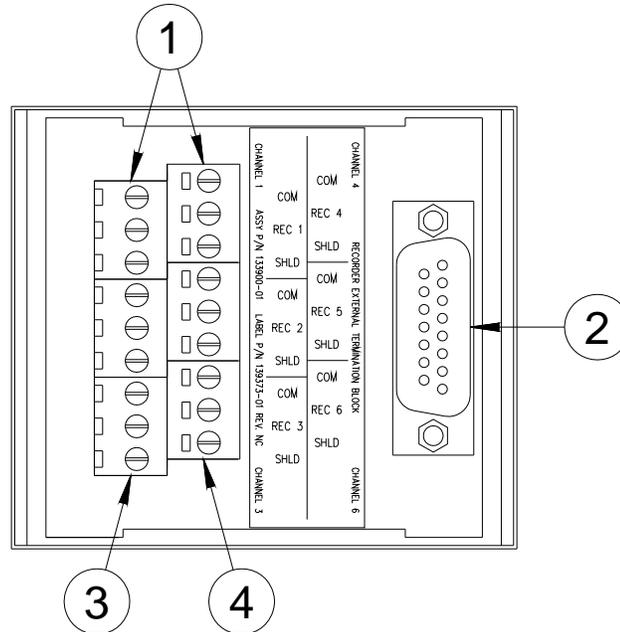
1. Male 3500 I/O connector, non-isolated,
2. Male 3500 external termination block, non-isolated
3. Shield to connector shell

**Figure 8-6: Sensor External Termination Blocks Wiring Diagram**



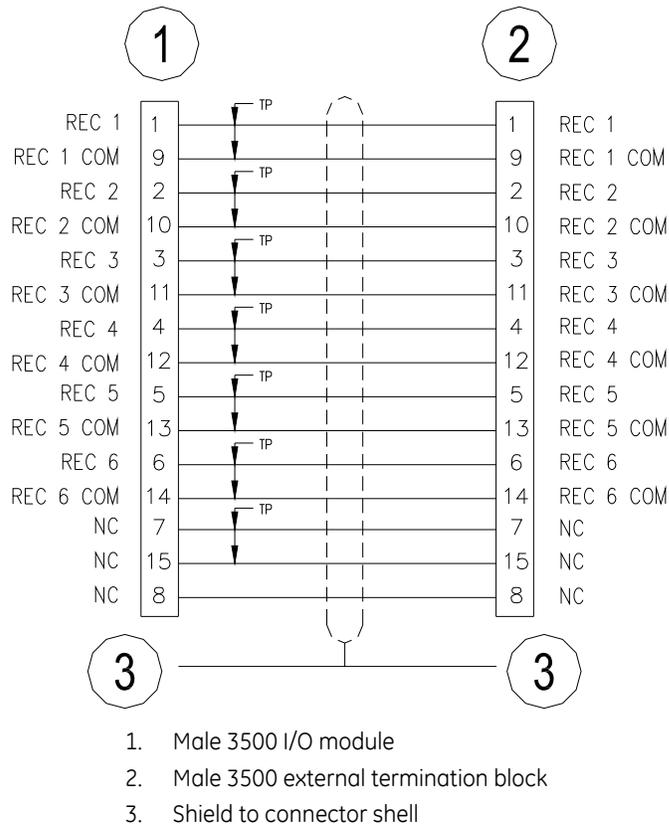
1. Connect the recorders associated with Channel 1, 2, 3, 4, 5, and 6 to the Recorder External Termination Block.
2. Connect the Gas Sensor I/O module Recorder Channels to the External Termination Block using cable 134543-XXXX-XX.
3. Recorder Channel 1, Channel 2, Channel 3
4. Recorder Channel 4, Channel 5, Channel 6

**Figure 8-7: Recorder External Termination Block (Terminal Strip Connectors)**



1. Connect the recorders associated with Channel 1, 2, 3, 4, 5, and 6 to the Recorder External Termination Block.
2. Connect the Gas Sensor I/O module Recorder Channels to the External Termination Block using cable 134543-XXXX-XX.
3. Recorder Channel 1, Channel 2, Channel 3
4. Recorder Channel 4, Channel 5, Channel 6

**Figure 8-8: Recorder External Termination Block (Euro Connectors)**



**Figure 8-9: Recorder Terminal Block Wiring Diagram**

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## 9. Monitor Channel Calibration

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The Hazardous Gas Detection System requires you to calibrate each channel of each monitor while a unique, permanently mounted sensor is connected. Calibration is performed using the 3500 Rack Configuration Software and a quantity of the target gas in a 50% LEL concentration. Calibration can be accomplished by using a hand-held calibration kit (non-remote calibration) at the sensor location, or by interfacing from a remote location to the 350800 Haz Gas Sensor that is fitted with a remote calibrator and stainless steel tubing.

Calibration is an interactive process that generally requires two individuals and a pair of walkie-talkies. One individual follows the prompts in the 3500 Rack Configuration Software and instructs the other individual to expose the sensor to the calibration gas at the proper time. The monitor takes an initial reading of clean air and a second reading when exposed to the calibration gas. It then internally adjusts hardware settings to correspond to the two levels of the gas and extrapolates from these settings to cover the full-scale range. Note that only one channel may be in calibration mode at a time.

### Application Advisory

Swapping sensors from one channel to another, or installing a new sensor on a channel without recalibrating could result in a channel being miscalibrated and even a false or missed trip. Any time a sensor is moved to another channel or a new sensor is installed it must be recalibrated after 30minutes under power while connected to the channel on which it will be used. The sensor must be in its exact location and orientation under which it will be expected to detect gas. Refer to Section 4 for information regarding all the hazardous gas sensor installation issues and requirements.

## 9.1 Calibration Procedure

	<b>DANGER</b>
<p>The normal calibration procedure involves the handling of combustible gas that is below the lower explosive limits. Exposure to or ignition of combustible gas can result in injury or death. Review and comply with all local and national safety regulations related to the handling of combustible gases and confined spaces where applicable.</p>	

Although the concentration of calibration gas is below the lower explosive limit, be sure to observe all safety precautions that relate to handling combustible gas. In particular, we strongly recommend the following:

1. Refer to the Material Safety Data Sheet (MSDS) that accompanies the gas canister for any required personal protective equipment (PPE) requirements.
2. Remove all ignition sources from the vicinity of the sensor prior to performing the calibration procedure.

Based upon the location and requirements of your installation, personnel who handle combustible gases and enter confined spaces may require additional training.

### 9.1.1 Required Test Equipment

The calibration procedure in this section requires the following:

#### 9.1.1.1 Cal Gas

A canister of 50% LEL calibration gas. This gas should be representative of the target gas to be detected. For example, if the sensor is to detect methane, then use methane as the calibration gas. Refer to Section 13.3.3 for ordering information.

#### 9.1.1.2 Clean Air Gas

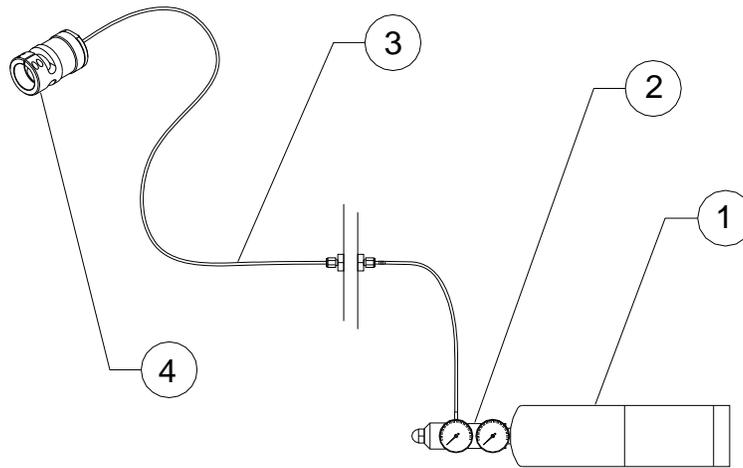
If using the remote calibrator a canister of clean air is also required to ensure a valid zero gas atmosphere during the calibration process. Refer to Section 13.3.3 for ordering information.

## 9.1.1.3 Means for calibration

### Application Advisory

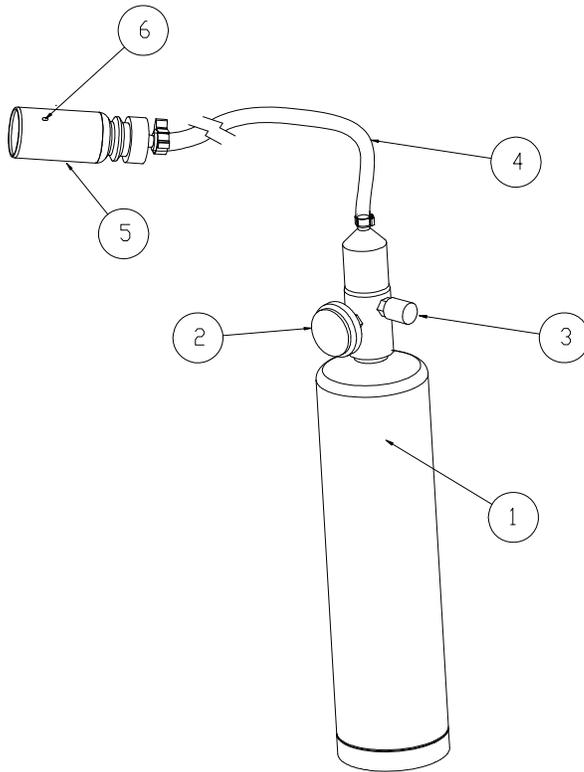
Flow rate to the sensor head is critical for correct calibration. It is highly recommended that you use the BN specified regulators for calibration. Note that the regulators are **different** depending on whether the Remote Calibrator is used for remote calibration or the calibration kit is used for manual (non-remote) calibration. The Remote Calibrator requires a regulator that delivers gas or clean air at 10 +/- 1 psi and a flow rate greater than 2 L/min. The calibration kit regulator delivers gas at 0.5 L/min.

A Remote Calibrator with Peripheral Equipment (Figure 9-1) OR Calibration Kit (Figure 9-2) is required.



1. Calibration Bottle
2. Regulator with length of Tygon® tubing (flow  $\geq$  2 L / min)
3. Stainless steel line
4. Remote Calibrator, part number 350800

**Figure 9-1 Remote Calibrator with Peripheral Equipment for Remote Calibration**



1. Calibration Gas Bottle (not part of kit; must be ordered separately)
2. Regulator (flow is 0.5 L / min)
3. On/Off
4. Tygon® Hose
5. Calibration Boot
6. Calibration Boot Vent Hole

**Figure 9-2: Calibration Kit, 168868-01, for Manual (Non-remote) Cal**

<b>Application Advisory</b>
Prior to calibration the user should visually inspect the Tygon® calibration hose for any obvious punctures that would prevent the correct concentration of gas from reaching the sensor head.

#### 9.1.1.4 Manuals / instruction sheets

Manuals in addition to this manual are:

- 129777-01 for information on using Rack Configuration software.
- 168724-01 or the appropriate sensor manual for additional information concerning the sensor and calibration.

- 169027-01 Calibration Kit Instructions sheet.
- 284746-01 Remote Calibrator pamphlet.

### 9.1.1.5 3500 Rack Configuration Software

Computer running 3500 Configuration Software while connected to the rack.

### 9.1.1.6 3500 Configuration Key

The physical 3500 System configuration key to put the rack in configuration mode.

### 9.1.1.7 Passwords

The password for connecting to the 3500 Rack and/or for configuring the monitor if the system has been password protected.

## 9.1.2 Calibration Steps

Channels of an unconfigured monitor or I/O cannot be calibrated. Before calibration an initial configuration must be downloaded to the monitor. Refer to Section 7.

Use the following steps to calibrate a channel:

1. Power the sensor for at least 30 minutes prior to attempting the calibration. This will permit the catalytic beads to warm up and stabilize prior to calibration.
2. The channel must be in an OK state prior to calibration. If a channel is in a NotOK state determine the cause and correct the issue. Refer to Section 11 for troubleshooting help. In some cases the NotOK condition may not be removable by following troubleshooting measures. For example, if you connected a sensor to a channel that had already been calibrated with another older sensor the new sensor may be out of range in the negative direction causing it to go NotOK because the channel is still using the old sensor calibration data. In a case like this you may need to put the channel into bypass prior to beginning calibration by using the software switches (Refer to Section 7.4).

### Application Advisory

Note that if you use the software switch to put the channel into bypass the analog output will go to the NotOK configured clamp value. Then, when in calibration mode the analog output goes to 1.5mA.

3. If the channel is in an Alarm state or an Over Range state you must remove that condition before calibration. If necessary:
  - a) Remove the alarm condition.

- b) Acknowledge any removed alarm, if it was latching.
- 4. Identify the catalytic bead gas sensor to be calibrated.
- 5. If you will be using your system with a removable sintered/dust guard (not applicable to the BN sensor), ensure that the sintered/dust guard of the sensor is clean, dry, and installed during all steps of calibration. Refer to the sensor manual for additional information.

**Application Advisory**

For all applications you must calibrate the system using the same conditions under which you will use it. For example, if your system will use a removable sintered/dust guard on the sensor (not applicable to the BN sensor) you must calibrate the channel with the sintered/dust guard installed on the sensor. Note that you cannot remove the sintered guard from the 350800 sensors. Another example would be that the cabinet in which the haz gas monitors reside should be closed during calibration to ensure that the monitors themselves are under their operating temperature during the calibration process.

- 6. Prepare the clean air gas and the calibration gas so that it will be ready for you to apply to the sensor head when the software prompts you in Steps 16 and 20. Refer to the sensor manual (168724-01), the calibration kit manual (169027-01), or the remote calibrator manual (284746-01).
- 7. Verify that the 3500 System configuration key switch on the front of the 3500 rack in which the Hazardous Gas monitor resides is in Program mode position.
- 8. Open the Rack Configuration Software and connect to the rack that has monitors you will calibrate.
- 9. If this is a recalibration of an existing sensor it is advisable to verify the channel/sensor Scale Factor prior to recalibration. Tracking the Scale Factor of a channel/sensor from calibration to calibration can give an indication of the remaining life of the sensor and is required as part of record keeping to maintain SIL suitability. See Figure 10-1 and corresponding Section 10.1.2.4.
- 10. Right-click on the monitor to be calibrated and choose *Options...* This will initiate the calibration process. See Figure 9-3.

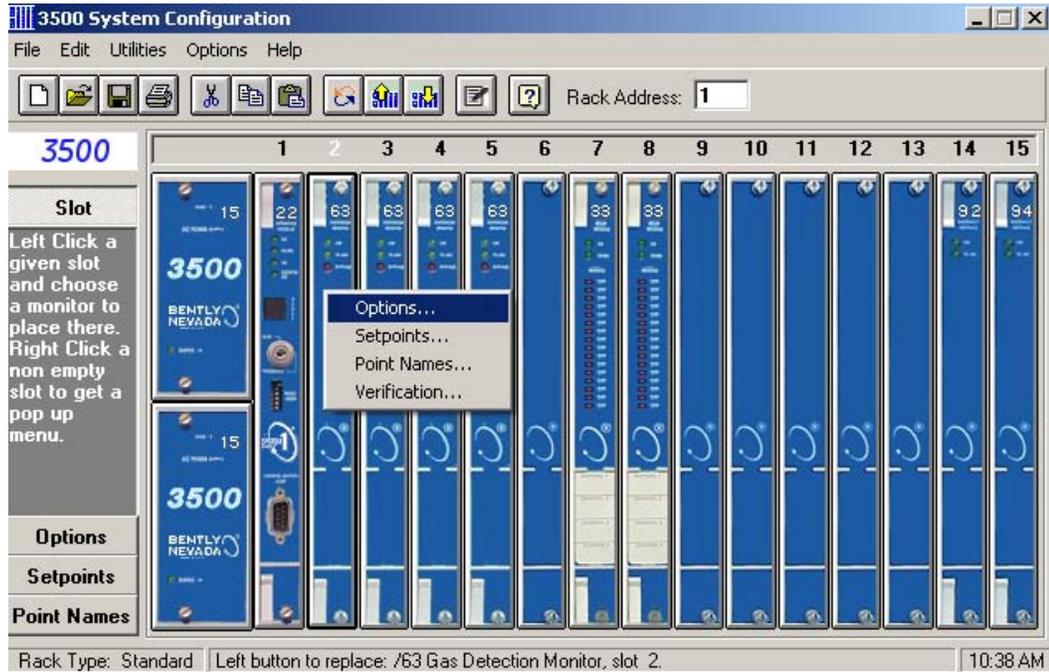


Figure 9-3: Slot to be Calibrated

11. Select the channel you wish to calibrate on the Monitor Options screen by clicking on that channel's *Options...* button. See Figure 9-4.

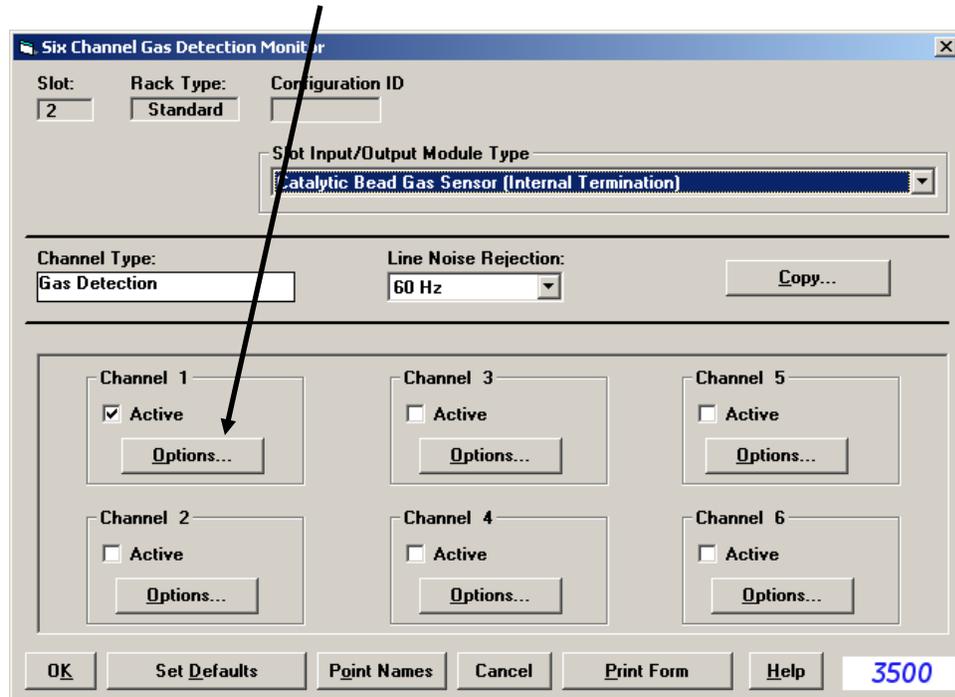


Figure 9-4: Gas Detection Monitor Options

12. Click the *Calibrate Transducer* button on the Gas Detection Options screen. See Figure 9-5.

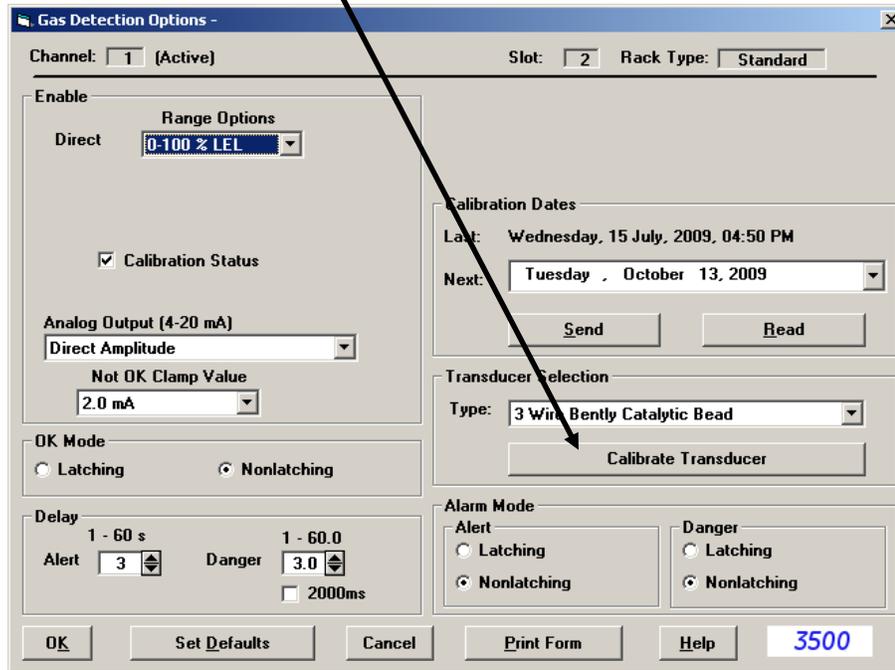


Figure 9-5: Gas Detection Calibrate Transducer

13. A message box as shown in Figure 9-6 will give a warning that a channel that is put into calibration mode may cause a relay to change states.

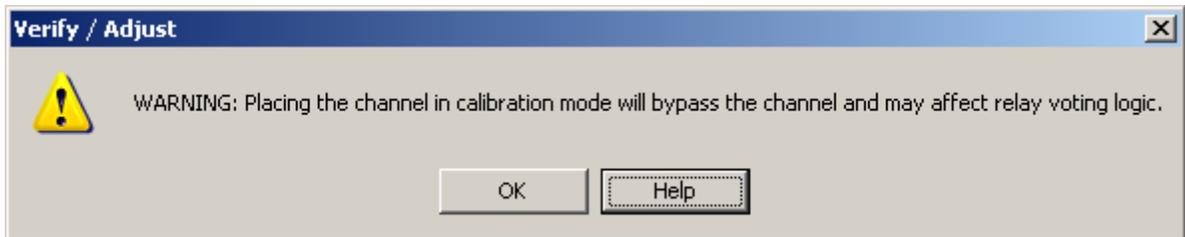


Figure 9-6: Possible relay trip warning

Caution must be taken when calibrating a channel. TIL1566 for retrofit haz gas protection uses 2oo3 and/or 2oo4 voting logic to trip or shutdown the unit. Before calibrating a channel, the other channels of that voting group should be in an OK and non-Alarm state. If they are not, correct the issues with the other channel first before proceeding with the calibration otherwise there is a risk of false trip.

Select OK to proceed. Note that after you select OK you will have the option of not proceeding with the calibration by choosing Cancel on the next screen.

Gas Detection Calibration -

Channel: 1 (Active) Slot: 2 Rack Type: Standard

Gas Calibration Options

Time-out: 4 Minutes (1 - 15 Minutes)

Gas Concentration: 50 % LEL

Start Channel Calibration Abort!

Ready to Start or Verify a Channel Calibration.

Elapsed Time: 0%

OK Cancel Print Form Help 3500

**Figure 9-7: Gas Detection Calibration Screen**

14. Enter the *Time-out* period for the calibration process on the Gas Detection Calibration screen (See Figure 9-7). This period is the amount of time the monitor will idle and wait for the sensor to detect a stable gas concentration during the calibration process. Select a timeout interval that will provide ample time for you to apply the target gas once you receive the prompt. The default value is 4 minutes. Click the Start Channel Calibration button.
15. Enter the configuration password when the software prompts you (see Figure 9-8). If the configuration is not password protected leave the password box blank.



**Figure 9-8: Configuration Password Request Screen**

16. Click OK to put the channel into bypass to begin the calibration. See Figure 9-9. Clicking the OK button will inhibit the alarms on the channel in question. During this process the Cal LED and the Bypass LED on the front panel of the monitor will be illuminated and the 4-20 mA output will go to the calibration mode value of 1.5 mA.



**Figure 9-9: Initiate Bypass for Calibration**

17. When the channel is being put into bypass a screen similar to that shown in Figure 9-10 will be displayed.

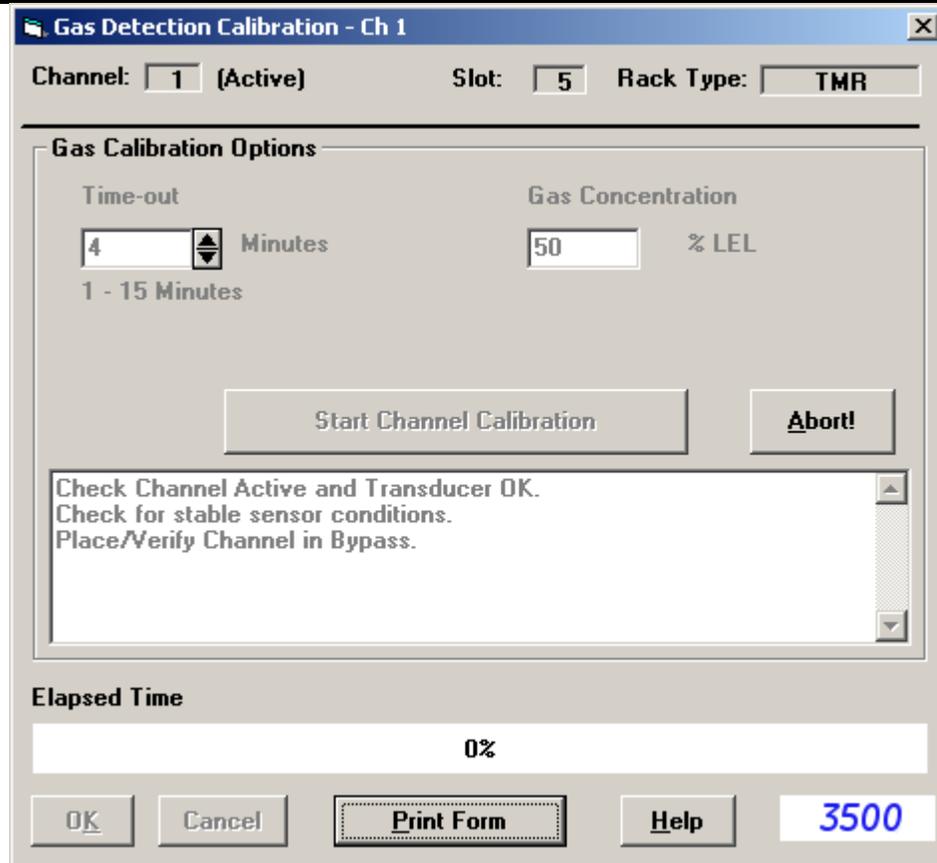


Figure 9-10: Channel being placed into bypass

18. After the channel is in bypass the warning of Figure 9-11 is shown.

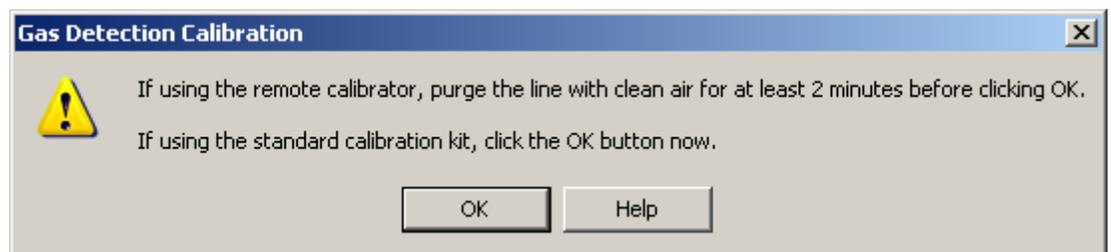


Figure 9-11: Purge Line Warning

If using the remote calibrator purge the line first by applying clean air for at least 2 minutes **before** clicking the OK button. Use Method 1 below to apply the clean air to the remote calibrator. There could be a column of calibration gas remaining in the line since the last time the user calibrated the channel with the remote calibrator. After clearing the line for 2 minutes click OK.

If using the manual calibration kit click OK and following Method 2 below.

Once the OK button is clicked the channel will attempt to take a zero gas reading.

**Method 1: remote calibrator:** Connect the remote calibrator regulator to the clean air supply bottle. At the panel connect the flexible line from the regulator to the hardline that interfaces to the remote calibrator and open the valve.

<b>Application Advisory</b>
<p>Be sure to use the correct regulator for the method of calibration used. The Remote Calibrator requires a regulator that delivers gas or clean air at 10 +/- 1 psi and a flow rate greater than 2L/min. The calibration kit regulator delivers gas at 0.5L/min.</p>

**Method 2: cal kit calibration:** Allow the channel to take a reading of clean ambient air.

- A short period will pass while the monitor reads a “Zero Concentration” value. (See Figure 9-12.) The monitor will use this reading to help establish the scale factor of the gas sensor.

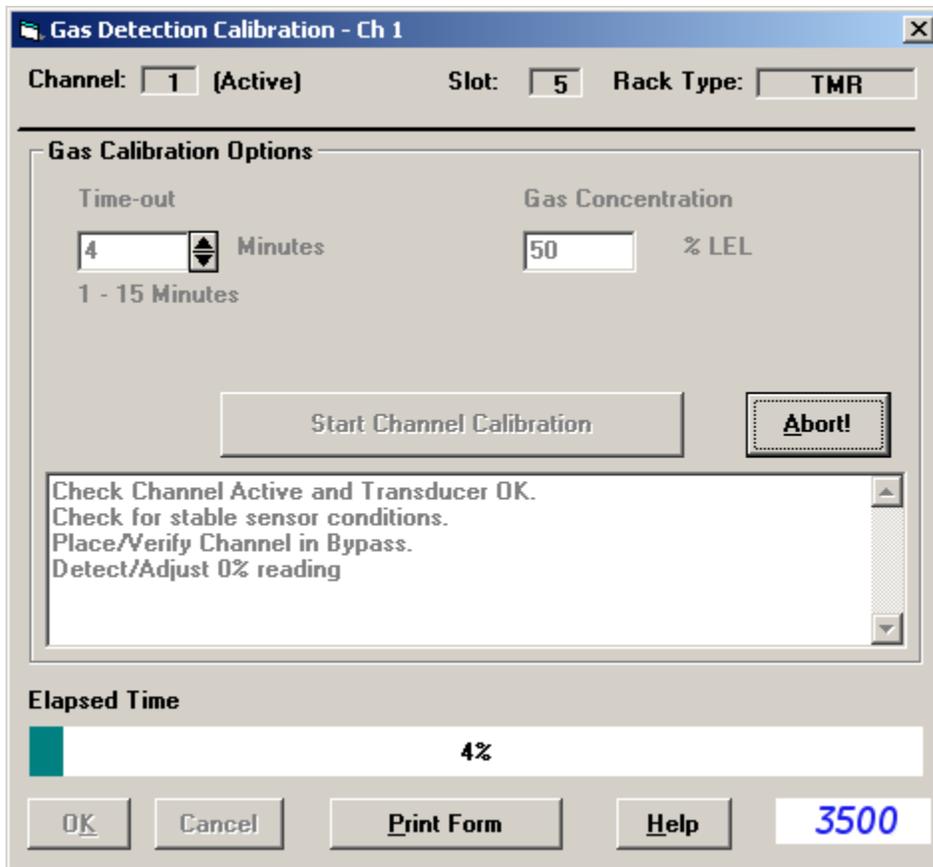


Figure 9-12: Gas Detection Calibration Screen 0 %LEL reading

## Application Advisory

Aborting during the calibration process will cause the bypass to be removed and the channel will return to the state it was in prior to starting calibration.

20. Upon obtaining a successful 0% reading, the software will display a dialog screen (see Figure 9-13) instructing you to click OK and *then* to apply the calibration gas to the sensor. It is critical that you click OK prior to applying the gas.



**Figure 9-13 Gas Detection Calibration--Apply Gas Screen**

**First** select "OK" and then apply calibration gas per one of the following methods:

**Method 1: remote calibrator:** Close the valve and remove the clean air bottle from the regulator. Connect the remote calibrator regulator to the cal gas supply bottle and open the valve.

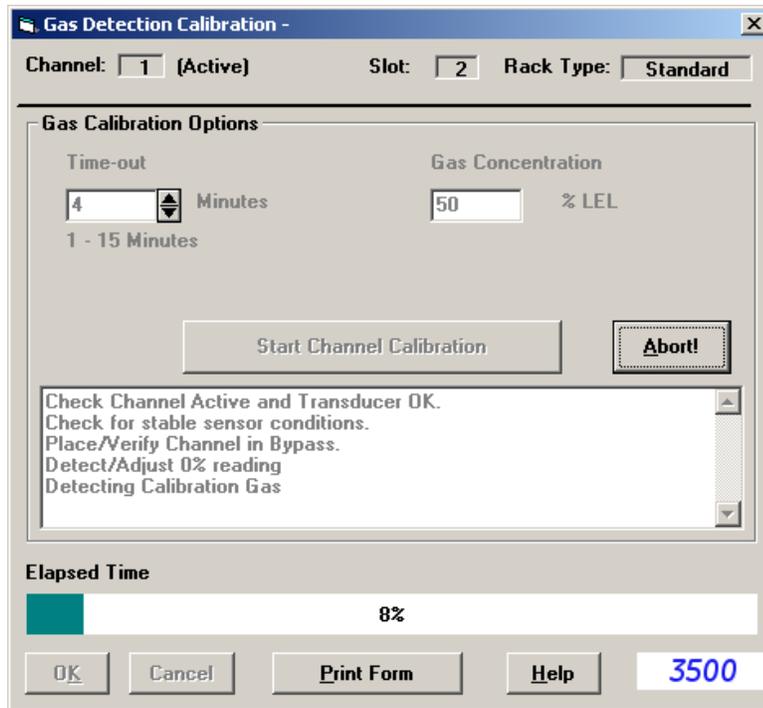
**Method 2: cal kit calibration:** Connect the cal kit regulator to the cal gas supply bottle. Apply the calibration gas to the sensor head by placing the sensor boot over the sensor head and opening the gas cylinder valve. It is important that you allow the calibration gas to flow past the sensor head, so do not put the sensor boot so far over the sensor head that the small vent hole in the side of the boot is covered or blocked.

If gas does not reach the sensor face within twice the time out set in step 14 above the calibration routine will be exited and will revert to the last-used parameters for that channel.

## Application Advisory

If you Apply gas prior to clicking the OK button shown in Figure 9-13 the calibration will not be successful.

21. While the channel is detecting the calibration gas the screen shown in Figure 9-14 will be displayed.



**Figure 9-14: Gas Detection Calibration—Detecting Calibration Gas Screen**

22. Once the system has successfully recognized the gas concentration, the monitor will select the proper channel hardware settings to account for the associated sensor’s scale factor. This will take a few seconds to complete. Once completed, the message shown in Figure 9-15 will appear.



**Figure 9-15: 40-Second Timer Message**

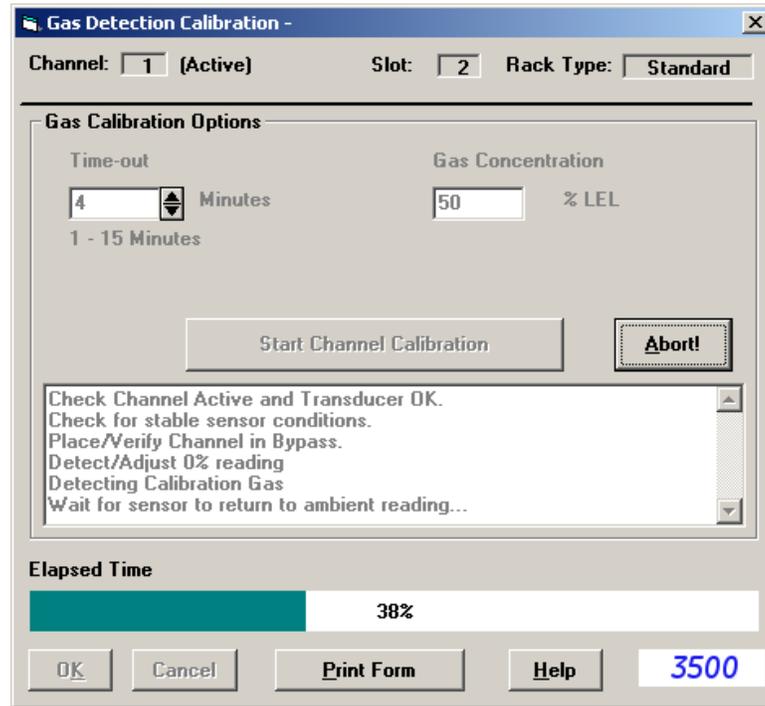
23. Select OK and **immediately** close the valve **AND**:

**Method 1 remote calibrator:** remove the flexible vinyl line from the interface panel's barbed fitting.

NOTE: Not removing the flexible line when clicking OK at the prompt could result in a failed cal. Pressure in the line must bleed off within a specific time period. This time period is used to determine if the remote calibrator's slide has opened after a calibration.

**Method 2 cal kit calibration:** remove the sensor calibration boot from the sensor head.

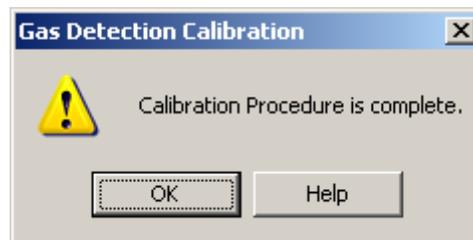
The message box will be updated with the “Wait for sensor to return to ambient reading” message as shown in Figure 9-16.



**Figure 9-16 Gas Detection Calibration – Bleed off timer**

The monitor is now detecting the sensor’s reading which must fall to an acceptable level within the specified time period indicating an opened calibrator slide and clean air.

24. If the final reading is acceptable, the new calibration hardware settings will be saved, the channel will come out of bypass, and begin using the new calibration parameters for normal monitoring. The message of Figure 9-17 will appear.



**Figure 9-17: Gas Detection Calibration Complete Screen**

25. Select *OK* to exit out of the Gas Detection Calibration Complete screen above. The software returns to the initial calibration screen (see Figure 9-18).

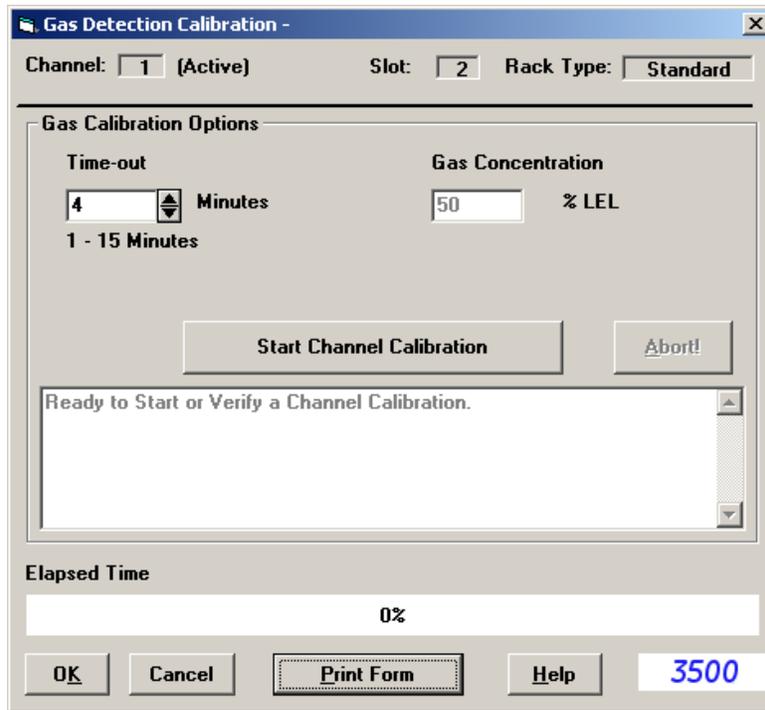


Figure 9-18: Initial Calibration Screen

26. Select *OK* to return to the Options screen shown in Figure 9-19.

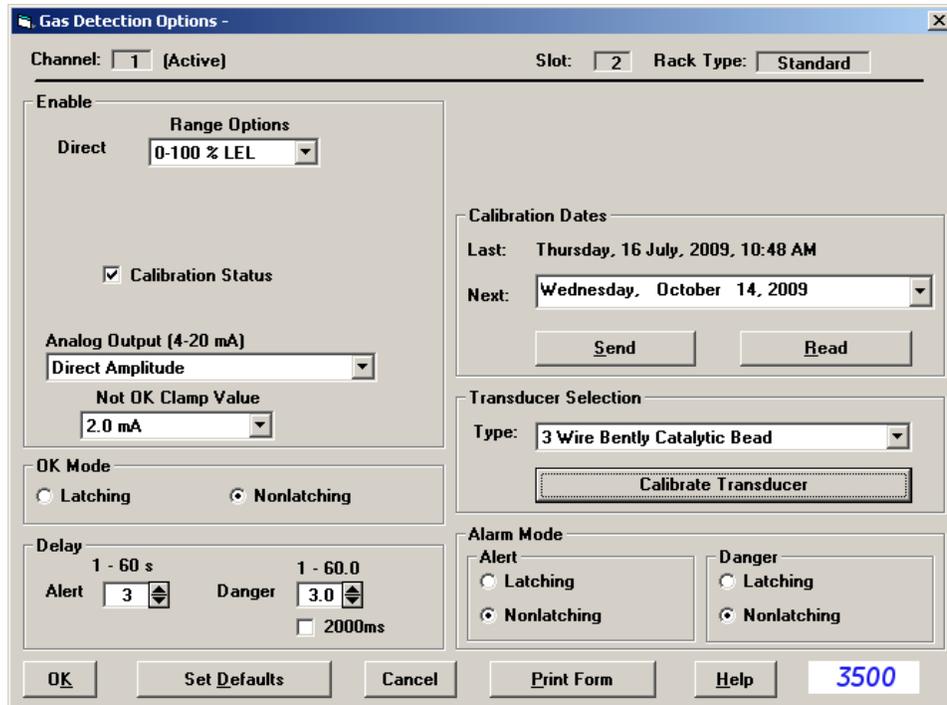


Figure 9-19: Gas Detection Channel Options Screen—Calibration Dates Updated

Note that the software has updated the *Calibration Date* field labeled *Last*: to the current (today's) date. You cannot change this date unless you

recalibrate the channel. The monitor will use the last calibration date plus 90 days to identify when the Danger/Alarm2 Cal Status 90-day setpoint has been exceeded, if you enable that alarm.

The software has updated the *Next:* calibration date field to today's date plus 90 days as the default. You can change this field. When monitor reaches the date in the *Next:* field the software will post "Recommend Recalibration" in the System Events Log to remind you to recalibrate the sensor/channel. Thus, this can be a mechanism for you to receive a reminder in the System Events Log that you should recalibrate the channel before reaching the 90-day Cal Status alarm deadline if you enable that associated setpoint.

27. Select *OK* until you completely exit out of the configuration dialog screens.
28. Verify the channel calibration. See Section 10.1.3.
29. For your records it is advisable to log the Scale Factor as seen in the Verification Screen (refer to Section 10.1.3). Tracking the Scale Factor of a channel/sensor from calibration to calibration can give an indication of the remaining life of the sensor and is required as part of record keeping to maintain SIL suitability. See Figure 10-1 and corresponding Section 10.1.2.4.
30. Remember to put the key lock on the front of the rack back into the Run Mode position to protect the configuration after calibration.

### 9.1.3 Calibration Troubleshooting

Refer also to:

- Section 11 for sensor, wiring and monitor troubleshooting information.
- Section 7.4 for how to use software switches.

#### 9.1.3.1 Aborting a Calibration

If at any time you have aborted a calibration using the Abort button you must restart the calibration procedure and perform a valid successful calibration or the channel will remain in a bypassed condition, no longer monitor for hazardous gas. A bypassed channel will cause 2oo4 voting to be reduced to 1oo3 voting. A bypassed channel will cause 2oo3 voting to be reduced to 1oo2 voting in the 3500/33 relay card that votes on NotOK conditions.

#### 9.1.3.2 Rack Error Message

The Rack Error Message shown in Figure 9-20 indicates that you may be trying to download a configuration or change setpoints when the channel is already in an Over Range state or in an Alarm state.



**Figure 9-20 Rack Error Message**

In order to calibrate a channel that is in one of these states you must:

1. Purge the sensor (allowing fresh air to reach the sensor) to remove an Alarm or Over Range condition, or,
2. Remove the Over Range and Alarm conditions to unlatch a latched alarm, and then
  - a. Press the Reset switch on the front of the rack, or
  - b. Use the software switch, Channel Reset (Aux 2) (refer to Section 7.4) to reset the channel, or
3. Use the software switch utility in the 3500 Rack Configuration software (refer to Section 7.4) to put the Over Range or Alarming channel into bypass.

### 9.1.3.3 Cal Not Successful Error

The “Cal not successful error” message shown in Figure 9-21 indicates that the system encountered a problem during the calibration procedure.



**Figure 9-21 Cal not successful error message**

One possible cause is trying to enter calibration mode when the channel:

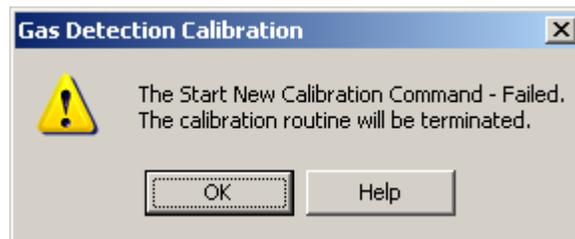
- Is not Active,
- Is in a Not OK condition,
- Is in an alarm state,
- Has a latched alarm,

- Bleed off timer failed

When you click the OK button to acknowledge this message, the software may display additional troubleshooting error messages to help you identify the problem. Refer to the additional information below.

#### 9.1.3.4 Start New Calibration Command - Failed

The Start New Calibration Command—Failed error message of Figure 9-22 indicates that you may be trying to calibrate a channel when the channel is already in an Over Range state, in an Alarm state, or in a NotOK state and cannot be put into a bypass condition automatically by the calibration routine.



**Figure 9-22 Start New Calibration Command – Failed**

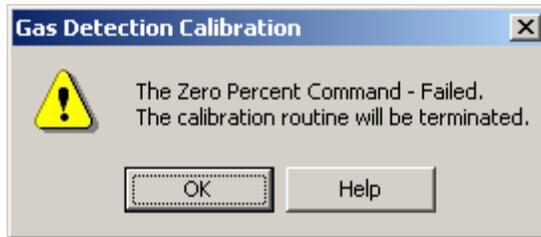
In order to calibrate a channel that is in one of these states you must first:

1. Have activated the channel and downloaded to that monitor
2. If the channel is in a Not OK state, use the software switch utility in the 3500 Rack Configuration software (refer to Section 7.4) to put the channel into bypass. The software channel bypass will be released at the end of a successful calibration. If the channel still cannot be calibrated verify the sensor wiring.
3. If the channel is in an active alarm state, assume gas is present. Wait until the gas is cleared. Unlatch the alarm and perform a valid calibration.
4. If the channel has a latched alarm, but gas is not present remove the Over Range and Alarm conditions by releasing the latch
  - a. Press the Reset switch on the front of the rack, or
  - b. Reset the channel using the software switch, Channel Reset (Aux 2) (refer to Section 7.4).
5. For cases where a channel has never been configured with the associated sensor, the channel may be in alarm when gas is not present. For example, newly received systems from the factory may indicate an alarm when first interfaced to real sensors in the field for which they have never been calibrated. Or, if you swap sensors around during troubleshooting the channel will use the first sensor's calibration information. This is because the calibration information is stored on the

I/O and not in the sensor. For these cases for which a valid calibration has never been performed with a given sensor and the channel is in Alarm and no gas is present, use the software switches to bypass the channel before starting the calibration. The bypass will be removed once a valid calibration has been performed. If the calibration is not successful the channel will be held in bypass and NotOK until a valid calibration is performed.

### 9.1.3.5 Zero Percent Command - Failed

If the monitor cannot determine a zero reading you will get the dialog box shown in Figure 9-23. Click the OK button to acknowledge this message and follow additional instructions.



**Figure 9-23 Fail Zero Percent Command**

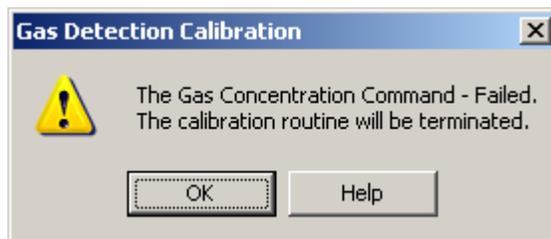
Possible causes for this message are:

- Field wiring error
- Sensor damaged--opened beads
- A sensor that has reached the end of its life
- Gas is present in the ambient environment

### 9.1.3.6 Gas Concentration Command Failed

The dialog box shown in Figure 9-24 will be shown if:

- The channel fails to detect an acceptable gas reading.



**Figure 9-24 Fail Gas Concentration Command**

The reason for this message may be due to:

For the case of failure to detect an acceptable gas reading:

- Gas bottle was empty
- Gas was applied to the wrong sensor
- The sensor is poisoned (refer to Section 11.3)
- The sensor is at the end of its useful life (refer to Section 11.3)
- Gas was not applied at that appropriate time
- The slide on the remote Calibrator failed to close over the sensor face and is stuck in the open position (refer to Section 10.4 )
- The remote calibrator orifice is clogged (refer to Section 10.4)
- The remote calibrator tubing is blocked or open
- The user clicked the OK button on the previous message **after** gas was being applied instead of **before** gas was applied. Refer to Figure 9-25.



Figure 9-25 Apply Cal Gas instruction

#### 9.1.3.7 Confirm Calibration Command Failed

The dialogue box shown in Figure 9-26 will be shown if the bleed off timer step at the end of calibration fails because the gas did not disperse within the 40 seconds allowed.

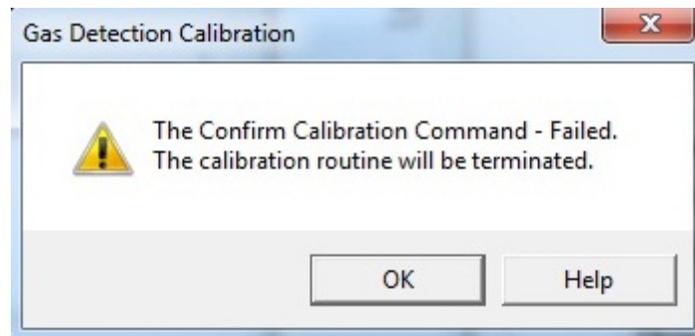


Figure 9-26 Confirm Calibration Command

The reason for this message may be due to:

- The gas was not removed from the sensor face at the appropriate time in the calibration routine
- A shutoff valve was used at the interface panel, and was not left open when prompted to remove the vinyl calibration gas tubing. Closing the interface shutoff valve at this prompt will leave pressure in the line that may cause the bleed off timer to fail
- The slide is stuck closed on the remote calibrator (refer to Section 10.4)
- There is gas present in the ambient environment

### 9.1.3.8 Other Error Messages

If the channel fails the gas application step and/or times out you may get error messages such as those in Figure 9-27, or Figure 9-28. These error messages mean that the gas concentration at the sensor head did not stabilize in time for the firmware to calculate the channel sensitivity before timing out, or that the sensor is faulty and has reached the end of its useful life.



Figure 9-27 Firmware Timed Out Error message

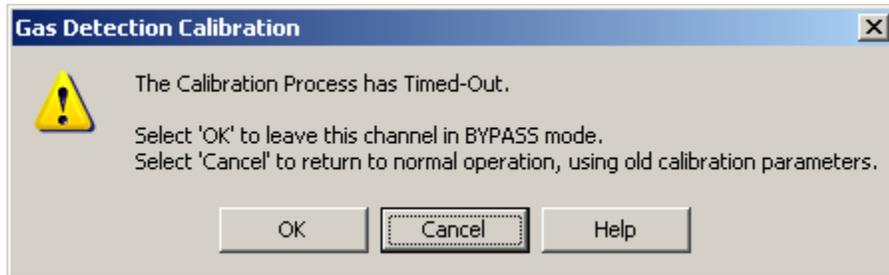


Figure 9-28 Cal Process Time Out Error Message

Possible causes for these errors include the following:

- The Time Out setting is too low.
- The sensor has reached the end of its useful life.
- The gas was applied to the wrong sensor.
- The calibration equipment is faulty.

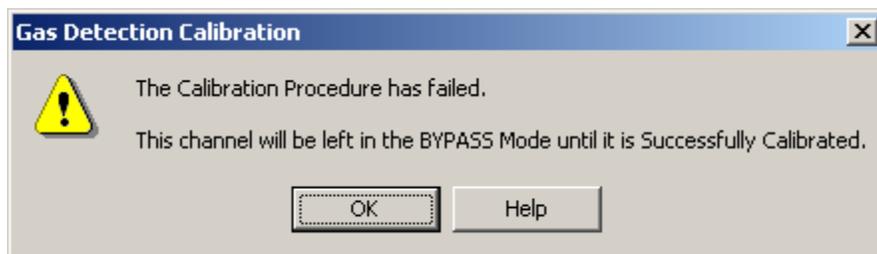
- The test gas canister is out of calibration gas.
- There is a hole in the tubing.
- The valve or regulator is faulty.
- The calibration equipment is being used incorrectly.
  - Valve not opened correctly.
  - Small hole on the sides of the calibration boot of the cal kit is being covered up or sealed off and air is not allowed to flow to the sensor head.
- The diameter of the hardline tubing to the remote calibrator is greater than 1/8" or the length is longer than 100 ft.

Possible corrective actions include the following:

- Verify that you followed the calibration procedure correctly and applied gas to the right sensor.
- Verify that the calibration equipment is not faulty
- Recalibrate with the Time Out time increased.
- Replace the old sensor with a new one and recalibrate the channel.  
NOTE: It is suggested that you first try to calibrate a sensor at least twice before declaring the sensor faulty.
- Contact Bently Nevada, Inc. technical support and/or service.

### 9.1.3.9 Calibration Failure Bypass Mode

For various failures, the channel will be placed in the Bypass mode until it can be calibrated with a viable sensor per the message of Figure 9-29.



**Figure 9-29 Cal Procedure Failed Error message**

While in channel bypass, Alert and Danger alarms will be defeated, the channel will be NotOK and the 4-20mA output will be at the configured clamp value.

## 9.2 Verify Calibration

After calibrating the sensor at least every 90 days, you should verify the channel and monitor operation. See Section 10.1.3 on page 86.

## 10. Maintenance

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### 10.1 Verifying a 3500 Rack – Hazardous Gas Detection System

When using catalytic bead sensors, it is important to calibrate your system at regular intervals. We strongly recommend that you calibrate the catalytic bead sensors once every 90 days. You should shorten the 90-day interval if:

- The sensors have detected a gas leak above 100%LEL,
- The sensors have detected any gas leak for more than 5 to 10 minutes, or
- Poisoning of the sensor is suspected.

Once you have recalibrated the sensors, you may also wish to verify other monitor operating features for all active channels in the monitor. For the sensor/monitor channel combination you may verify:

- The accuracy of channel proportional values for each active channel,
- The alarms, and
- The Not OK indications of channels.

#### 10.1.1 Required Test Equipment

The verification procedures in this section require the same test equipment as described in Section 9.1.1 Required Test Equipment, on page 60.

#### 10.1.2 Using the Rack Configuration Software

Use the Rack Configuration Software to display output from the rack during verification. To perform the test procedures in this section you must be familiar with the following features of the Rack Configuration Software:

- Enable and disable channels and alarms
- Bypass channels and alarms
- Display the Verification Screen

The Rack Configuration and Test Utilities Guide (part number 129777-01) explains how to perform these operations.

Figure 10-1 shows how the Verification screen displays the output from a 3500 rack:

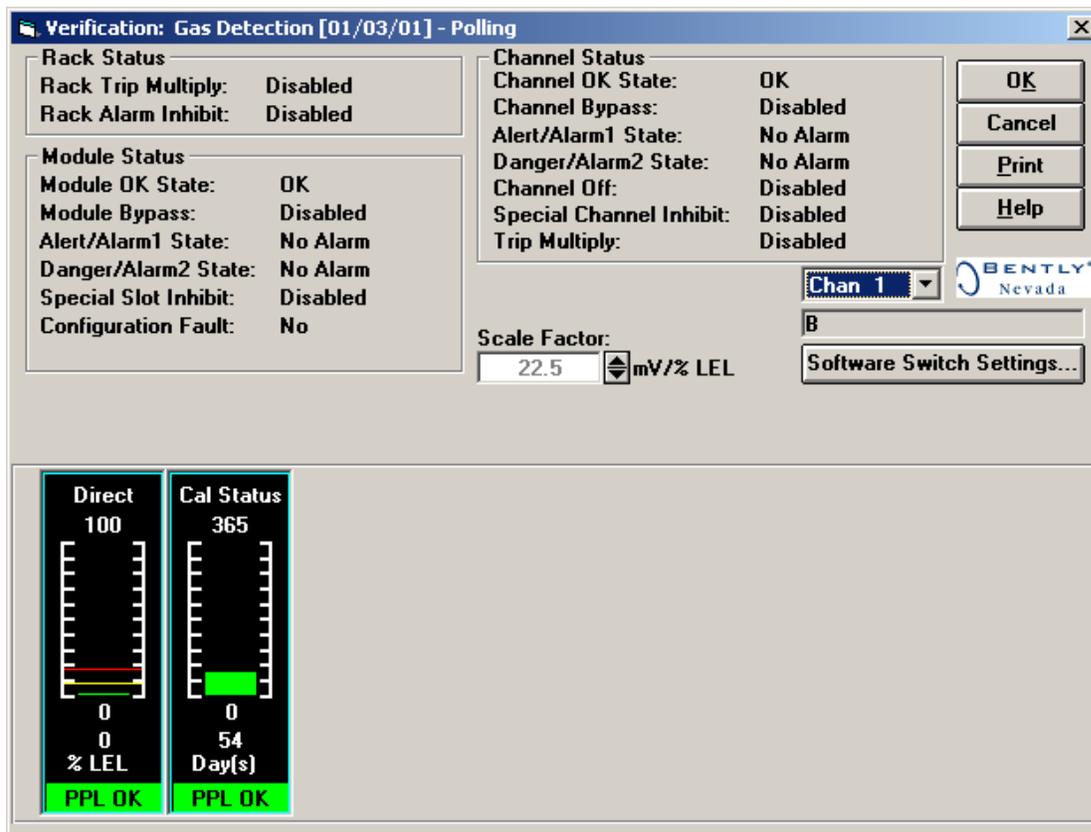


Figure 10-1 3500 Configuration Software Verification Screen

### 10.1.2.1 Rack Statuses

**Rack Trip Multiply:** This status on the Verification or Adjust screens indicates if any channel in the rack has trip multiply enabled.

**Rack Alarm Inhibit:** This shows the status of Rack Alarm Inhibit. When Rack Alarm Inhibit is enabled all alarms within the 3500 rack will be disabled. This is useful during servicing and verification of the rack. The user can invoke Rack Alarm Inhibit in 2 ways:

- Using the hardware contact on the Rack Interface I/O Module.
- Through Alarm Inhibit under the Utilities menu of the Rack Configuration Software.

When Rack Alarm Inhibit is enabled, all 3500 rack functions, except for alarms, continue to operate.

### 10.1.2.2 Module Statuses

**Module OK:** This status on the Verification or Adjust screens indicates that all channels in the module are OK.

**Module Bypass:** This status on the Verification or Adjust screens indicates if any channel in the module is bypassed.

**Alert/Alarm1 State:** This field displays output for verifying Alert/Alarm 1. Alert/Alarm 1 is displayed in yellow.

**Danger/Alarm2 State:** This field displays output for verifying Danger/Alarm2. Danger/Alarm 2 alarms are displayed in red.

### 10.1.2.3 Channel Statuses

**Channel OK State:** This state indicates that the channel is operating correctly.

**Channel Bypass:** This state indicates that the functions of the channel are temporarily suppressed.

**Alert/Alarm1 State:** This is the first level alarm that occurs when the sensor signal level exceeds the Alert/Alarm 1 setpoint.

**Danger/Alarm2 State:** This is the second level alarm that occurs when the sensor signal level exceeds the Danger/Alarm 2 setpoint.

**Channel Off:** This indicates that the channel has not been configured to be active (the channel is off). The monitor channels may be turned off (inactivated) using the Rack Configuration Software and are available on the Options Screen. "Disabled" indicates that the channel is on because it has been configured to be active.

**Special Alarm Inhibit:** This feature does not apply to the 3500/63 monitor and will always be shown as disabled.

**Trip Multiply:** This feature does not apply to the 3500/63 monitor and will always be shown as disabled.

### 10.1.2.4 Scale Factor

This indicates the change in output per change in input (sensitivity) of a sensor. This value is expressed as millivolts per % LEL. The change in this value from calibration to calibration indicates the change in the sensor sensitivity over time and over exposure to gasses and/or poisons.

#### Application Advisory

It is best practice to keep a log of the date and the resultant scale factor after each calibration for each channel for your records.

### 10.1.2.5 Software Switch Settings Button

This button displays a read-only version of the Software Switch screen. You cannot use this screen to enable or disable switch settings. Refer to Section 7.4, Software Switches, on page 46.

### 10.1.2.6 Bar graphs

Bar graphs display the current proportional values. The operator uses these graphics and associated digital readouts to verify channel output.

Alarm Setpoints are indicated on the bar graph as follows:

Danger/Alarm 2 - Solid Red Line

Alert/Alarm 1 - Solid Yellow Line

You can determine the Alarm Setpoint Value by selecting the line for the setpoint with the mouse cursor. Any channel bar graph value or channel that enters Alert/Alarm 1 or Danger/Alarm 2 will cause the alarm lines in the Channel Status box to indicate an alarm.

### 10.1.3 Verify Channel Accuracy

Use the following general test procedure to verify channel accuracy when the calibration or test gas is applied.

1. Immediately after calibrating a channel (see Section 0 on page 63) you may verify the channel.
2. Be sure to put the channel's alarms into bypass before applying any gas so as not to drive any relay state changes in the 3500 rack. Refer to Section 7.4 for information on setting software switches to place a channel's Alert and Danger alarms into bypass. Note that the analog outputs and any other system interfaces (such as Modbus outputs) will indicate the high levels of gas readings during this test. Therefore, be sure to bypass any other system alarms to which the channel may be interfaced, such as a control system.
3. Apply the calibration or test gas.
4. Use the Verification Screen within the 3500 Configuration Software to verify that the reading is within  $\pm 2\%$  LEL of the concentration of the test gas applied.
5. If the reading is not within 2% LEL of the test gas concentration, recalibrate the sensor and repeat the test. If the test still is not successful, go to Section 10.1.7, If a Channel Fails a Verification Test, on page 94.
6. Remove the calibration gas and verify that the signal returns to 0% LEL  $\pm 1\%$  LEL.

### Application Advisory

If using the remote calibrator while viewing the calibration screen ensure the signal drops below 5 %LEL within 40 seconds. If it does not, the remote calibrator slide may be stuck in the closed position preventing the sensor from being interfaced to the ambient air following the completion of the verification. If it does not drop below 5%LEL within 40 seconds, visually verify that the calibrator slide is not stuck in the closed position or repeat the test. If the signal still does not fall within the 40 seconds, replace the remote calibrator (and/or sensor); repeat the calibration, and this verification test.

7. Following the successful verification be sure to remove the software switch that set the soft bypass for the channel's alarms in step 2 above.
8. Repeat Steps 1 through 7 for all channels that are enabled.

## 10.1.4 Test Alarms

### 10.1.4.1 Test Description

The general test procedure for verifying accuracy and alarm operation consists of providing a sensor input signal that is sufficient to drive channels above the alarm setpoint levels. Generally, you can use calibration gas as the test gas. If necessary, purchase a test gas with a concentration that is greater than the configured alarm setpoints. Use the software display screens on the host screens to verify that the monitor output is correct when you apply the test gas. You need test only those alarm parameters that are configured and in use. The desired objectives of this test will be

1. To verify channel accuracy,
2. To exceed Alert/Alarm 1 and Danger/Alarm 2 Setpoints and induce alarms,
3. To produce a non-alarm condition once an alarm has been induced, and
4. To verify that "Latching" or "Non-Latching" alarms operate as configured.

When varying the signal from an alarm condition to a non-alarm condition, you must consider alarm hysteresis. To ensure that alarm hysteresis does not

interfere with the reading of alarm states, purge gas sensors with fresh air between gas applications and allow the sensor to stabilize to the 0% LEL point.

<b>Application Advisories</b>
<ol style="list-style-type: none"><li>1. Performance certification for a Hazardous Gas Detection System requires that the Danger/Alarm2 be configured for latching operation, unless the system connects to an auxiliary system that accomplishes the same purpose as latching.</li><li>2. Tests will exceed Alarm Setpoint levels and activate alarms. This could cause a relay contact to change state.</li></ol>

#### 10.1.4.2 Test Procedure

1. Purge the sensor with clean air at the end of verification, and verify that the channel reading is  $0\% \pm 2\%$  LEL. If it is not, repeat the calibration process and this step.
2. Apply the test gas.
3. Verify that the test gas activates any configured Alert/Alarm 1 and Danger/Alarm 2 that is below the value of the applied gas.
4. Turn off the gas cylinder valve and remove the calibration boot from the gas sensor or the flexible line from the interface panel. The reported gas concentration will drift to 0% LEL. This will lower the detected levels and remove the alarm conditions. The indicators for "Latching" alarms should persist and those for "Non-latching" alarms should clear. The digital readout does not latch and will display the currently detected level of gas for "Latching" as well as "Non-latching" alarms. Reset any "Latching" alarms.

<b>Application Advisory</b>
If using the remote calibrator while viewing the calibration screen ensure the signal drops below 5%LEL within 40 seconds. If it does not, the remote calibrator slide may be stuck in the closed position preventing the sensor from being interfaced to the ambient air following the completion of the verification. If it does not drop below 5%LEL within 40 seconds, visually verify that the calibrator slide is not stuck in the closed position or repeat the test. If the signal still does not fall within the 40 seconds, replace the remote calibrator (and/or sensor); repeat the calibration, and this verification test.

5. Repeat Steps 1 through 4 for all channels you wish to test.

## 10.1.5 Verify OK Status

### 10.1.5.1 Test Description

The general procedure for testing the channel OK status is to cause a Not OK condition and verify that the Verification Screen on the test computer, the monitor front panel LEDs, the Alarm Events List, and the System Events List report correct results. The channels should be active and in an OK condition before beginning this test.

### Application Advisory

Depending on the alarm logic employed putting a channel into a NotOK condition may cause a relay to change state.

### 10.1.5.2 Test Procedure

1. Disconnect the white wire from a gas sensor at the 3500/63 I/O module (or ET block). The OK LED on the front panel of the main module should go off. The Bypass LED should come on.
2. Observe the Verification screen within the 3500 Configuration Software. Verify that
  - the *Channel OK State* line and the *Monitor OK State* line read *Not OK*,
  - the *Channel Bypass* line and the *Monitor Bypass* line read *Enabled*, and
  - the Direct bar graph is grayed out and labeled *Invalid*.
3. Observe the Alarm Events List within the 3500 Configuration software. Verify that the software posted an *Entered Not OK* event for the given channel to the list.
4. Observe the System Events List within the 3500 Configuration software. Verify that the software posted *Fail HG Xdcr Check/Recal* and *Probable Open Transducer* events for the given channel the events to the list.
5. If you do not obtain the above results, go to Section 10.1.7, If a Channel Fails a Verification Test. Otherwise proceed to Step 6.
6. Reconnect the white wire from the gas sensor to the appropriate terminal on the back of the I/O module (or ET block, if using an ET I/O module). Verify that the OK LED on the front panel of the main module comes on and that the bypass LED goes off.
7. Observe the Verification Screen within the 3500 Configuration Software. Verify that:

- the *Channel OK State* line and the *Monitor OK State* line read *OK*,
  - the *Channel Bypass* line and the *Monitor Bypass* line read *Disabled*, and
  - the Direct bar graph is displaying a value and is labeled *PPL OK*.
8. Observe the Alarm Events List within the 3500 Configuration software. Verify that the software posted a *Left Not OK* event for the given channel to the list. The software may have also posted Entering and Exiting Alert and Danger messages to the list, depending on the transient input the monitor received when the white wire was reconnected and the configured alarm time delays. The message list should end with Exit Alarm messages, unless the alarms have been configured as latching. In that case you can clear the latched Alarm(s) by pushing the Reset button on the front of the rack and then verifying that the software has posted the Exit Alarm message(s) to the list.
  9. Observe the System Events List within the 3500 Configuration software. Verify that software posted *Pass HG Xdcr Check/Recal*, *Xdcr OK*, and *Recommend Recalibration* events to the list for the given channel . You need not recalibrate the sensor at this point because you are just reconnecting the originally calibrated sensor for this channel. The monitor will continue to use the calibration scale factor previously calculated and stored on the I/O for this sensor.
  10. If you do not obtain the above results, go to Section 10.1.7, If a Channel Fails a Verification Test, on page 94.
  11. Repeating the same procedure with the red wire will give the same results, except that you will not see a *Fail HG Xdcr Check/Recal* event in the System Events List, nor will software post Enter and Exit Alarm messages in the Alarm Events List after you reconnect the red wire.
  12. Disconnecting the white wire will cause the CAL LED to flash and Bypass LED to light and the OK LED to go off.
  13. Observe the Verification Screen. Verify that
    - The *Channel OK State* line and the *Monitor OK State* line read *Not OK*,
    - The *Channel Bypass* line and the *Monitor Bypass* line read *Enabled*, and
    - The Direct bar graph is grayed out and labeled *Invalid*.
  14. Observe the System Events List in the 3500 Rack Configuration Software. Verify that software posted *Fail HG Xdcr Check/Recal* and *Enter Over-Range Region* events in the list.
  15. Observe the Alarm Events. Verify that software posted an *Enter Not OK event* in the list.

16. Reconnect the white wire and push Reset.
17. Observe the Verification Screen. Verify that
  - The *Channel OK State* line and the *Monitor OK State* line read *OK*,
  - The *Channel Bypass* line and the *Monitor Bypass* line read *Disabled*, and
  - The Direct bar graph is reading a value as it was before you disconnected the wire.
18. Observe the System Events List in the 3500 Rack Configuration Software. Verify that software posted *Pass HG Xdcr Check/Recal* and *Exit Over-Range Region* events in the list.
19. Observe the Alarm Events. Verify that software posted an *Exit Not OK* event in the list.
20. Repeat Steps 1 through 19 for all channels that you wish to test.
21. Verify that all field wiring is connected.
22. Recalibrate any sensors/channels that you have repeatedly exposed to gas for more than 5 minutes cumulative time.

## 10.1.6 Verify Analog Outputs

### 10.1.6.1 Test Description

The general procedure for testing the analog outputs is to provide a sensor input signal using a known concentration of gas and verify that the Analog Output value is correct. The channels should be active, be in an OK condition, and must have a configured analog output before beginning this test.

<b>Application Advisory</b>
Depending on the alarm logic employed putting a channel into a NotOK condition or a high gas reading condition may cause a relay to change state.

### 10.1.6.2 Test Procedure

1. Make sure the sensor/channel combination has been recently calibrated as described in Section 9.1.2 on page 63.
2. Disconnect the COM and REC field wiring from the contact terminals on the Catalytic Bead I/O Module.
3. Connect an ammeter capable of measuring 4 mA to 20 mA to the COM and REC outputs of the I/O Module.
4. Apply the test gas to the sensor.

5. Verify that the value of the analog output in mA is proportional to the target gas concentration, based on the configured full-scale range for the channel and that is shown as the upper limit of the bar graph in the Verification screen. The tolerance on this value is  $\pm 3\%$  of full-scale gas concentration. The conversion from the displayed %LEL value is:

$$I_m = \frac{\%LEL \times 16}{FS_{conf}} + 4,$$

where  $I_m$  is the mA analog recorder output,

$FS_{conf}$  is the configured full-scale range, and

%LEL is the direct output shown in the 3500 Rack Configuration Software Verification Screen below the bar graph, in the 3500 Operator Display Software, or on a 3500 display.

The conversion from the mA record output back to %LEL is:

$$\%LEL = \left[ \frac{I_m - 4}{16} \right] \times FS_{conf}$$

For example, for a configured full-scale range of 100% LEL and a target gas of 50% LEL the analog output should read 12mA  $\pm 3\%$  of full scale gas concentration (mid-scale for a full scale of 100% LEL).

The following table illustrates the relationship between mA output and %LEL as may be interpreted by equipment which accepts the recorder outputs from the BN monitor:

	mA	%LEL
<b>cal mode</b>	1.5	-15.625
<b>user configured Not OK clamp value</b>	2	-12.5
	2.5	-9.375
	3	-6.25
	3.5	-3.125
	4	0
	5	6.25
	6	12.5
	7	18.75
	8	25
	9	31.25
	10	37.5
	11	43.75
	12	50
	13	56.25
	14	62.5
	15	68.75
	16	75
	17	81.25
	18	87.5
19	93.75	
20	100	

Recall that a channel that is NotOK will output from the recorder the configured NotOK clamp value. Also, to meet the performance standards for gas detection systems the BN system will indicate a fault by the time the signal falls to below -9% LEL. For example, if a channel is NotOK and configured for the 3.5 mA NotOK clamp, a control system receiving the recorder output information could be configured to interpret this as -3.125 %LEL when actually the BN calculated value is below -9 %LEL. For this example, then the control system should be considering -3.125% as a faulted channel.

- Remove the target gas from the sensor by first closing the gas cylinder valve, and then removing the gas coupling tube and boot from the sensor head or removing the flexible line from the interface panel.

### Application Advisory

If using the remote calibrator while viewing the calibration screen ensure the signal drops below 5%LEL within 40 seconds. If it does not, the remote calibrator slide may be stuck in the closed position preventing the sensor from being interfaced to the ambient air following the completion of the verification. If it does not drop below 5%LEL within 40

seconds, visually verify that the calibrator slide is not stuck in the closed position or repeat the test. If the signal still does not fall within the 40 seconds, replace the remote calibrator (and/or sensor); repeat the calibration, and this verification test.

7. Verify that the analog output goes to the 0% LEL value of  $4 \text{ mA} \pm 0.16 \text{ mA}$ . If you cannot verify that the analog output is correct, check the analog out configuration and connections. If you still cannot verify the output, go to Section 10.1.7, If a Channel Fails a Verification Test.
8. Disconnect the ammeter and reconnect the COM and REC field wiring to the contact terminals on the I/O Module.
9. Repeat Steps 1 through 9 for all channels that you wish to test.

### 10.1.7 If a Channel Fails a Verification Test

If a channel fails a verification test you should attempt to recalibrate the sensor and redo the test. If the channel still fails the verification test, and there is a remote calibrator, inspect it for proper operation (refer to Sections 10.4 and 10.4.1). If the remote calibrator is functioning properly, replace the sensor, calibrate the newly replaced sensor, and then redo the test. If the channel still fails the verification test you should replace the 3500/63 monitor. Refer to Section 1.2 for Handling and Storing Considerations.

You cannot repair the boards and components inside the 3500 modules in the field. You should replace modules that are not operating correctly with a spare.

	<b>DANGER</b>
High voltage present. Contact with high voltage can result in burns, shock, or death. Remove power from 3500 and avoid contact with exposed contacts and wiring to avoid injury.	

When performed properly, you may install the monitor modules into or remove them from the rack while power is applied to the rack. Refer to the *Rack Installation and Maintenance Manual* (part number 129766-01) for the proper procedure to do so.

1. Save the configuration for the module using the Rack Configuration Software.

2. Replace the module with a spare. Refer to the installation section in the *3500 Monitoring System Rack Installation and Maintenance Manual* (part number 129766-01).
3. Return the faulty module to Bently Nevada, Inc. for repair.
4. Download the configuration for the spare module using the Rack Configuration Software.
5. Recalibrate all the channels of the new monitor after connecting them to the sensors per Section 9.1.2 on page 60. You **MUST** perform this recalibration to ensure that the sensor and monitor will function correctly.
6. Verify the operation of the spare module per Section 10.1 on page 83.

## 10.2 Performing Firmware Upgrades

Occasionally, Bently Nevada, Inc. may require you to upgrade the original firmware in your 3500/63 Gas Detection Monitor. You must use the 3500 Rack Configuration Software to reconfigure the monitor after upgrading it's the monitor's firmware. The following firmware upgrade instructions are valid for firmware revisions 3.00 or higher. If the firmware revision is lower than 3.00 contact Bently Nevada, Inc. for the proper procedure to upgrade your firmware.

### Application Alert

When upgrading firmware in the 3500/63 monitor you must not interrupt power to the rack or remove the monitor that from the rack. Removing power or the monitor from the 3500 rack while upgrading firmware may make the monitor inoperable.

To upgrade the firmware in your 3500/63 monitor:

1. Start 3500 Rack Configuration Software version 3.90 or higher and connect to the rack.
2. Upload and save the current configuration of the monitor. The upgrade process will erase any configuration in the monitor.
3. Select **Upgrade Firmware** under the **Utilities** menu as shown in Figure 10-2.



Figure 10-2 Firmware Update Utility

4. Select the monitor you wish to update as shown in Figure 10-3.

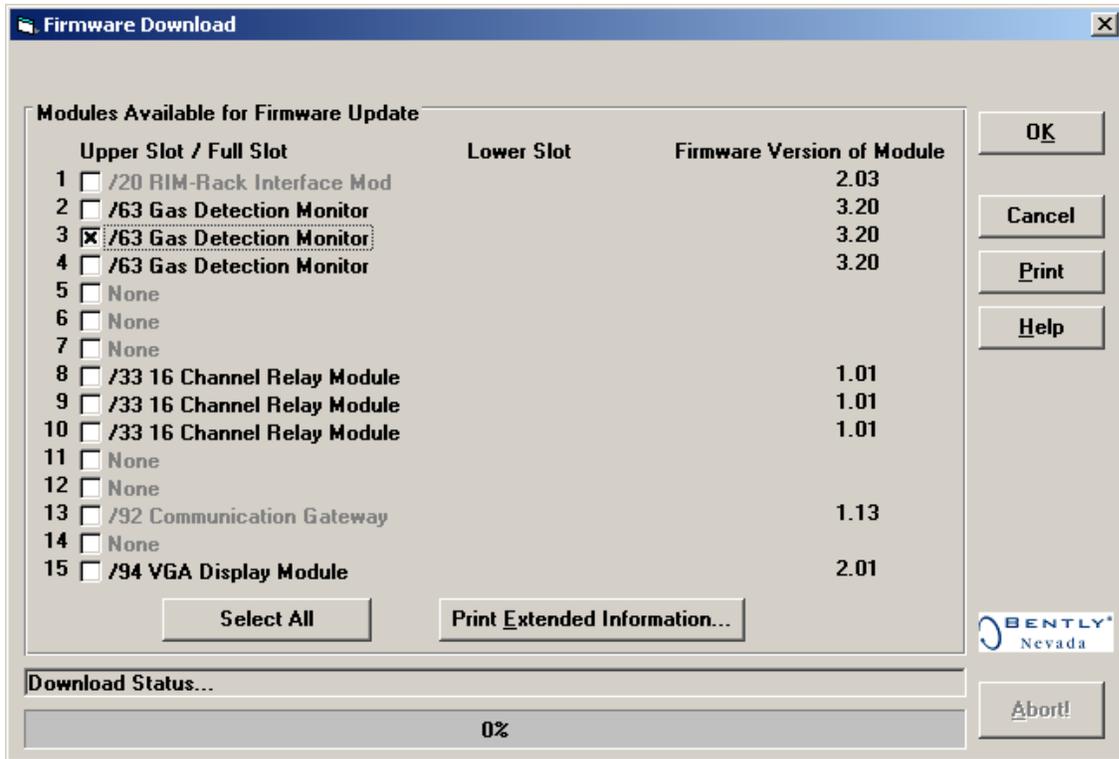


Figure 10-3 Firmware Download Screen

5. Click on the **OK** button. Note that you can select a 3500/63 Gas Detection Monitor only if its existing firmware revision is 3.00 or higher. If the monitor that you wish to upgrade has a firmware revision less than 3.00, contact Bently Nevada, Inc. for the proper procedure to do so.
6. Select the file to be downloaded when the software requests it and click on the **Open** button. The software will now download the file.
7. Download the configuration to the monitor after the firmware update is complete. If the process fails, depending on the failure mode, the monitor may revert to its old firmware. See Section 11.7 for an explanation of the LED fault conditions and associated failure modes. Under no circumstances should you remove the monitor until the upgrade process is complete.

## 10.3 Cleaning the Sensor

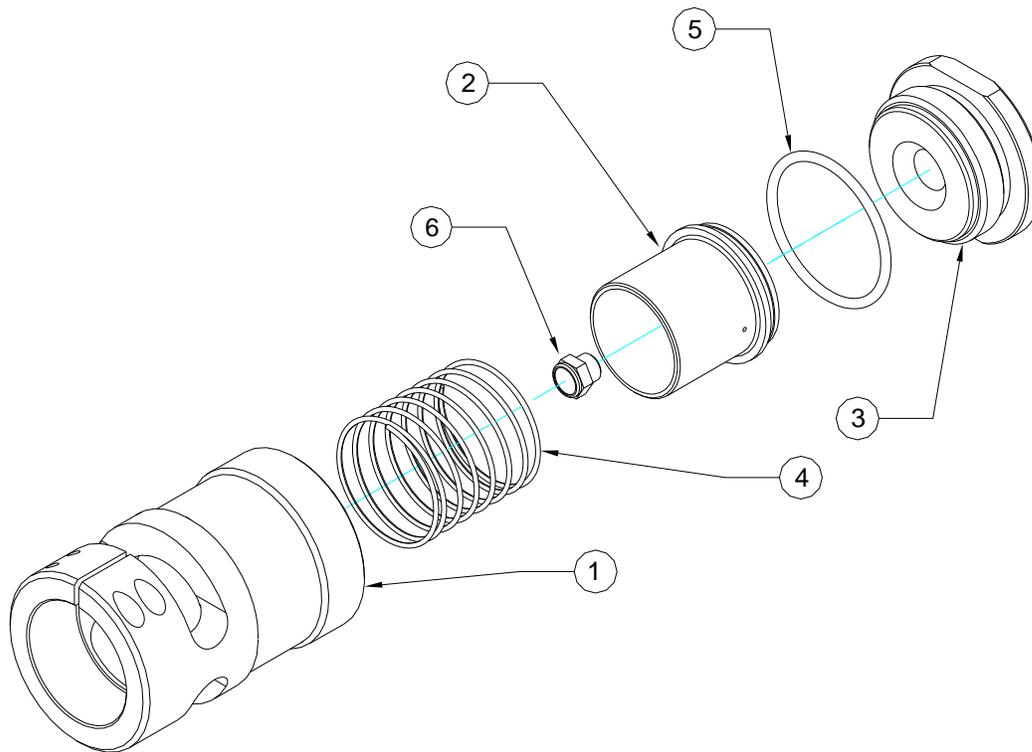
If the sensor shows signs of dust, dirt, or particulate deposits, the face of the sensor can be wiped with clean water and a lint free cloth. Dry the sensor with a clean cloth or paper towel. Any remaining water will evaporate off as the sensor warms up. Be sure to bypass the channel before cleaning.

## 10.4 Remote Calibrator Maintenance

Under normal operating conditions, the Remote Calibrator slide should operate freely without obstruction. Possible interference with slide operation could be caused by heavy debris buildup within the calibrator sliding assembly. Maintenance intervals will vary based on the quantity of debris to which the Remote Calibrator has been exposed. For most installations, disassembly and cleaning is recommended at least every two years.

### 10.4.1 Disassembly, Inspection, and Cleaning

To clean the Remote Calibrator, first disconnect the supply line. Then, loosen the two socket cap screws that clamp the Remote Calibrator to the Sensor, and remove the Calibrator from the Sensor.



**Figure 10-4 Remote Calibrator Exploded View**

Referring to Figure 10-4, with the Calibrator in a clean location, unthread the cap (Item 3), and inspect the O-ring (Item 5). Discard and replace O-ring on cap if damaged.

Remove the slide (Item 2) and spring (Item 4) from the housing (Item 1).

Clean the housing (item 1) and inspect the housing's interior sealing surface for damage or excessive wear. If the housing sealing surface, slide, or slide-seal is damaged, the Calibrator will need to be replaced.

Inspect the seal located on the slide (Item 2). If visual damage or excessive wear is noticeable on the seal, the Remote Calibrator should be replaced.

Use a 3/8" socket to remove the diffuser (Item 6) from the slide and clean using a solvent appropriate for the type of debris present. If air does not flow freely through the diffuser after cleaning, diffuser replacement will be necessary.

Inspect the slide orifice located in the center of the slide (Item 2). A 0.006" wire must be able to pass through this orifice. If this orifice is blocked and cannot be cleared, the Remote Calibrator must be replaced.

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## 10.4.2 Reassembly

Referring to Figure 10-4, with all components clean, reinstall diffuser (Item 6) in slide (Item 2).

Place spring (Item 4) on slide (Item 2) and lower this assembly into the housing (Item 1) spring end first. Lubrication is not required on the slide's seal.

If cap O-ring is dry, lubricate with a petroleum-based grease (see NOTE 1) capable of withstanding the temperature to which the calibrator is being subjected under normal use. NOTE: Silicone lubricants should not be used on the Remote Calibrator. Close proximity to silicones will damage the Haz Gas Sensor.

Use cap to compress spring while threading into the housing. Tighten until the cap is seated against the housing.

Reattach the remote calibrator to the sensor and then reattach the supply line to it (refer to Section 5.1 on page 23).



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# 11. Troubleshooting

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This section describes how to troubleshoot a problem with the 3500/63 Hazardous Gas Detection Module, its associated I/O modules, and sensors by using the information provided in this section.

## 11.1 Troubleshooting Measurements

The sensor itself completes a Wheatstone bridge. When not interfaced to a monitor and unpowered (cold), the measurement across the sensor leads will be approximately:

White to black: 6.5 ohms

White to red: 3.3 ohms (across catalytic bead)

Red to black: 3.3 ohms (across reference bead)

If the cold sensor measures open across either bead the sensor is damaged beyond repair. This can happen from miswiring (especially shorting black to earth ground) or from allowing liquid such as water to enter the sinter face. You must replace the sensor if the beads measure open.

When a +24V supply is interfaced to the back of the I/O module and the sensor is not connected, the sensor terminals, PWR+ to PWR- on the I/O, should read +24 V. The power provided to the sensor is 300mA, constant current.

When interfaced to a monitor, powered, and with no gas present the voltage across the sensor leads (at the I/O or at the termination strip in the housing) will read approximately:

White to black: +4.8 to 5.6 V

White to red: +2.4 to 2.8 V

Red to black: +2.4 to 2.8 V

## 11.2 Wiring Fault Indications

It is very important that all terminations at junction boxes and the back of the rack are tightened down, make good contact and are not able to vibrate. Also, there can be no shorts to earth ground in the sensor wiring. This would prevent calibration and could permanently damage the sensor. Intermittent wiring errors can cause damage to beads and high gas readings.

If changing sensors while power is on, ensure no gas is present and be sure to **disconnect the black lead last** (the PWR- connection at the I/O) when removing a sensor and **reconnect the black lead first** when installing a sensor.

Possible wiring faults are shown in Table 11:1 along with some indications.

**Table 11:1: Wiring Fault Indications**

Fault Condition	Changes in LED Indications	Channel Status	System Event List Message	Alarm Event List Message
Red lead open	Not OK off; Bypass on	Not OK; Invalid bar graph	Probable Open Transducer	Enter Not OK
White lead open	Not OK off; Bypass on; Cal/O.R. blinking	Not OK; Invalid bar graph	Fail HG Xdcr Check/Recal; Enter Over-Range Region; Prob. Xdcr Wiring Fault	Enter Not OK
Black lead open	Not OK off; Bypass on	Not OK; Invalid bar graph	Fail HG Xdcr Check/Recal; Probable Open Transducer	Enter Not OK
White shorted to Red	Not OK off; Bypass on	Not OK; Invalid bar graph	Probable Open Transducer	Enter Not OK
Red shorted to Black	Cal/O.R. blinking	In Alarm and Danger	Enter Over-Range Region	Enter Alert/Alarm1; Enter Danger/Alarm2
White shorted to Black	Not OK off; Bypass on	Not OK; Invalid bar graph	None	Enter Not OK
Black shorted to earth ground	Not OK off; Bypass on	Not OK; Invalid bar graph	Probable Open Transducer; Fail HG Xdcr Check/Recal	Enter Not OK
Red and White swapped (prior to startup)	Not OK off; Bypass on	Not OK; Invalid bar graph	Probable Open Transducer	Enter Not OK
Red and White swapped (prior to startup) AND black shorted to earth ground**	Not OK off; Bypass on	Not OK; Invalid bar graph	Probable Open Transducer; Enter Over-Range Region*	Enter Not OK
Short all three wires	Not OK off; Bypass on	Not OK; Invalid bar graph	None	Enter Not OK

\*\*This configuration applies more current than 300mA to the sensor and eventually causes one bead of the Wheatstone bridge in the sensor to open, at which point the channel goes into over-range. This irreversibly damages the sensor and makes it unusable. Replace the sensor.

Removing the fault would result in the reverse indications of those shown in the table. For example, if there was an intermittent opening and then closing of the red lead the indications may be:

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Upon opening the red lead:

- Channel Status goes to Not OK, invalid;
- OK LED goes off;
- Bypass LED comes on;
- Messages are: Enter Not OK, Probable Open Transducer

Then, upon closing the red lead:

- Channel Status goes to OK
- OK LED comes on;
- Bypass LED goes off;
- Messages are: Left Not OK, Xdcr OK; Recommend Recalibration

### 11.3 Confirming Poisoned or End-of-Life Sensor

The catalyst of the sensor can be poisoned permanently such that the sensor will never function correctly (refer to Section 4.2). Additionally, if the sensor has been exposed to large amounts of hazardous gas over an extended period of time, the catalyst can be used up, or spent. Also, over many years of use the catalyst can be used up over time. These are reasons why the channels should be periodically calibrated, at least every 90 days.

If a sensor is poisoned or the catalyst is spent the sensor will fail the Apply Calibration Step of the calibration routine because the catalytic bead fails to change adequately in the presence of gas. As an additional confirmation you can measure across the catalytic bead (white to red) while the sensor is under power (and has been for at least 30 minutes). Take a reading with no gas present. Take a second reading with gas present. Compare the two readings.

A known good, new sensor will show a difference in reading of 180mV with gas present. A sensor should be able to be calibrated all the way down to a difference of approximately 50mV. A difference less than 50mV will cause the sensor to fail to calibrate. The sensor must be replaced and the channel recalibrated if the sensor fails the calibration routine during the Apply Gas Step and the difference in voltage across the catalytic bead is less than 50mV with and without gas present.

It is recommended that you record the scale factor after each calibration (refer to Section 10.1.2). A known good sensor with 180mV change across the catalytic bead will result in a scale factor of 20-25 mV/%LEL. Tracking the scale factor and time between calibrations can help identify how fast the sensor catalyst is being spent. The channel will continue to be able to be calibrated down to 6 mV/%LEL. Below that you must replace the sensor. You may want to replace the sensor prior to this much reduction in sensitivity, depending on how long until the next

calibration, the trended deterioration in scale factor, and the scheduled maintenance activities.

## 11.4 Replacing Monitor or I/O

If for any reason it is determined that the main monitor card or I/O should be replaced or you swap components around during troubleshooting be aware of the following:

- The unique calibration parameters are stored on the I/O.
- Spare I/Os or main monitor cards from the factory have never had a configuration downloaded to them. They will fail to calibrate unless you download to them first. An indication that this is the problem would be seeing a Scale Factor in the verification screen of -1 mV/%LEL. Download a configuration to the new hardware first. Then calibrate each channel.

## 11.5 Monitor Self-test

To perform the Hazardous Gas Detection Module self-test:

1. Connect a computer running the Rack Configuration Software to the 3500 rack.
2. Select **Utilities** from the main screen of the Rack Configuration Software.
3. Select **System Events** from the Utilities menu.
4. Press the **Module Self-test** button on the System Events screen.

Application Advisory
Machinery protection will be lost while the monitor performs its self-test.

5. Select the slot that contains the Hazardous Gas Detection Module and press the **OK** button. The monitor will perform a full self-test and the System Events screen will be displayed. The list will not contain the results of the self-test.
6. Wait 30 seconds for the module to run a full self-test.
7. Press the **Latest Events** button. The System Events screen will be updated to include the results of the self-test.

8. Review the System Events List for any failed tests that were not subsequently shown as passed. If the monitor failed the self-test, refer to Section 11.8, System Event List Messages.

## 11.6 Troubleshooting Monitor Statuses

Because you can potentially use the 3500/63 Hazardous Gas Detection Monitor as a safety system, the monitor design implements certain safeguards to communicate, or possibly prevent, incorrect use of the monitor.

Table 11:2 describes the relationships between certain monitor statuses, alarm conditions, and the calibration routine.

Monitor/Channel Status	Calibration Allowed	Tasks Allowed During Any Active Alarm
Monitor Alarm Bypass	Yes	No
Channel Bypass	Yes	Yes
Alert Bypass	Yes	No
Danger Bypass	Yes	No
Alarm Inhibit via Hardware	Yes	No
Direct PPL Alarm 1 Activated	No	X
Direct PPL Alarm 2 Activated	No	X
Cal Status PPL Alarm 1 Activated	Yes	X
Cal Status PPL Alarm 2 Activated	Yes	X
X = Unaffected		

**Table 11:2: Statuses Affecting Tasks**

<b>NOTE</b>
<p>If there is an Active Alarm on the Direct PPL, you must set the Channel Bypass Switch for the Channel being calibrated in order to calibrate the channel.</p>

If a calibration routine fails, the monitor will automatically place the channel in the Bypass mode. The channel will remain in the Bypass mode until it is correctly

calibrated. Once you successfully calibrate the channel, the monitor will return the channel to its last known operating state. We recommend that you attempt to calibrate the monitor at least twice before deciding that a sensor is faulty.

Note that a Timeout condition is not considered to be a failed calibration.

## 11.7 LED Fault Conditions

Table 11:3 shows how to use the LEDs to diagnose and correct problems.

**Table 11:3: LED Fault Conditions**

OK	TX/RX	BYPASS	CAL	Scenario	Action
1 Hz flash	1 Hz flash			Monitor is not configured, is in Configuration Mode, or in Calibration Mode.	Reconfigure the Monitor or exit Configuration or Calibration Mode.
5 Hz flash				Monitor error	Check the System Event List for severity; correct error
ON	Flashing			Monitor is operating correctly.	No action required.
OFF				Monitor is not operating correctly or the sensor has faulted and has stopped providing a valid signal.	Check the System Event List and the Alarm Event List; correct error; replace sensor; replace monitor
	Not Flashing			Monitor is not communicating correctly.	Monitor is not executing alarming functions. Replace immediately.
		OFF		Alarming Enabled.	No action required.
		ON		Some or all Alarming Disabled.	No action required.
			OFF	Calibration Mode not Invoked.	No action required.
			ON	Calibration Mode Invoked. Alarms of this channel are inhibited.	Respond to software prompts.

OK	TX/RX	BYPASS	CAL	Scenario	Action
			ON	Verify Calibration Mode Invoked. Alarms of this channel are inhibited.	Respond to software prompts.
			Flashing	Over Range condition	The sensor is or has been exposed to more than 100%LEL gas. User must assume that the area being monitored contains hazardous concentrations of gas above the lower explosion limit and take precautionary measures per their facility's practices and procedures.
			ON	Calibration Mode Invoked. Alarms of this channel are inhibited.	Respond to software prompts.

## 11.8 System Event List Messages

This section describes the event messages that the Hazardous Gas Detection Module enters into the System Event List.

Example of a System Event List Message:

Sequence Number	Event Information	Event Number	Class	Event Date DDMMYY	Event Time	Event Specific	Slot
000000123	Device Not Communicating	32	1	02/01/90	12:24:31:99		5L

Sequence Number: The number of the event in the System Event List (for example, 123).

Event Information: The name of the event (for example, Device Not Communicating).

Event Number: Identifies a specific event.

Class: The severity of the event. The following classes are applicable:

**Table 11:4: Event List Message Class Values**

Class Value	Classification
0	Severe/Fatal Event
1	Potential Problem Event
2	Typical Logged Event
3	Reserved

Event Date: The date the event occurred.

Event Time: The time the event occurred.

Event Specific: Provides additional information of the events that use this field.

Slot: Indicates the module with which the event is associated. If a half-height module is installed in the upper slot or a full-height module is installed, the field will be 0 to 15. If a half-height module is installed in the lower slot then the field will be 0L to 15L. For example, a module installed in the lower position of slot 5 would be 5L.

The Hazardous Gas Detection Monitor may place the following event messages, which are listed in numerical order, in the System Event List. If an event marked with a star (\*\*) occurs, the monitor will stop alarming. If you are unable to solve any problems, contact the nearest Bently Nevada, Inc. office for assistance.

**\*\* Flash Memory Test**

Event Number: 11  
 Event Classification: Sever/Fatal Event  
 Action:  
     Replace the Monitor Module.

**\*\* EEPROM Memory Failure**

Event Number: 13  
 Event Classification: Potential Problem or Severe/Fatal Event  
 Action:  
     Replace the Monitor Module as soon as possible.

---

### **Device Not Communicating**

Event Number: 32

Event Classification: Potential Problem

Action:

Check to see if one of the following components is faulty:

- the Monitor Module
- the rack backplane

### **Device Is Communicating**

Event Number: 33

Event Classification: Potential Problem

Action:

Check to see if one of the following components is faulty:

- the Monitor Module
- the rack backplane

### **\*\* Neuron Failure**

Event Number: 34

Event Classification: Severe / Fatal Event

Action:

Replace the Monitor Module immediately.  
Monitor Module will stop alarming.

### **\*\* I/O Module Mismatch**

Event Number: 62

Event Classification: Severe / Fatal Event

Action:

Verify that the type of I/O module installed matches what was selected in the software. If the correct I/O module is installed, there may be a fault with the Monitor Module or the Monitor I/O module. Monitor Module will stop alarming.

### **I/O Module Compatible**

Event Number: 63

Event Classification: Severe / Fatal Event

Action:

Verify that the type of I/O module installed matches what was selected in the software. If the correct I/O module is installed, there may be a fault with the Monitor Module or the Monitor I/O module.

**Fail Main Board +5 V-A** (Fail Main Board +5 V - upper Power Supply)

Event Number: 100

Event Classification: Potential Problem

Action:

Verify that noise from the power source is not causing the problem.  
If the problem is not caused by noise, check to see if one of the following components is faulty:

- the Monitor Module
- the Power Supply installed in the upper slot

**Pass Main Board +5 V-A** (Pass Main Board +5 V - upper Power Supply)

Event Number: 101

Event Classification: Potential Problem

Action:

Verify that noise from the power source is not causing the problem.  
If the problem is not caused by noise, check to see if one of the following components is faulty:

- the Monitor Module
- the Power Supply installed in the upper slot

**Fail Main Board +5 V-B** (Fail Main Board +5 V - lower Power Supply)

Event Number: 102

Event Classification: Potential Problem

Action:

Verify that noise from the power source is not causing the problem.  
If the problem is not caused by noise, check to see if one of the following components is faulty:

- the Monitor Module
- the Power Supply installed in the lower slot

**Pass Main Board +5 V-B**(Pass Main Board +5 V – lower Power Supply)

Event Number: 103

Event Classification: Potential Problem

Action:

Verify that noise from the power source is not causing the problem.  
If the problem is not caused by noise, check to see if one of the following components is faulty:

- the Monitor Module
- the Power Supply installed in the lower slot

**\*\* Fail Main Board +5V-AB** (Fail Main Board +5 V (upper and lower Power Supplies))

Event Number: 104

Event Classification: Severe/Fatal Event

Action:

Verify that noise from the power source is not causing the problem. If the problem is not caused by noise, check to see if one of the following components is faulty:

- the Monitor Module
  - the Power Supply installed in the upper slot
  - the Power Supply installed in the lower slot
- Monitor Module will stop alarming.

**Pass Main Board +5V-AB** (Pass Main Board +5 V - upper and lower Power Supplies)

Event Number: 105

Event Classification: Severe/Fatal Event

Action:

Verify that noise from the power source is not causing the problem. If the problem is not caused by noise, check to see if one of the following components is faulty:

- the Monitor Module
- the Power Supply installed in the upper slot
- the Power Supply installed in the lower slot

**\*\* Fail +5VA** (Fail Main Board +5VA – upper and lower Power Supplies)

Event Number: 120

Event Classification: Potential Problem or Severe/Fatal Event

Action:

Check if there is a +/\_VA – AB event. If so follow the action for that event. Otherwise, replace the monitor Module. Monitor Module will stop alarming.

**Pass +5VA** (Pass Main Board +5VA – upper and lower Power Supplies)

Event Number: 121

Event Classification: Potential Problem or Severe/Fatal Event

Action:

The supply failed in the past and has now recovered. Check if there is a +/\_VA – AB event. If so follow the action for that event. Otherwise, replace the monitor Module. Monitor Module will stop alarming.

**\*\*Fail -5VA** (Fail Main Board -5VA – upper and lower Power Supplies)

Event Number: 128

Event Classification: Potential Problem or Severe/Fatal Event

Action:

Check if there is a +/-VA – AB event. If so follow the action for that event. Otherwise, replace the monitor Module. Monitor Module will stop alarming.

**Pass -5VA** (Pass Main Board +5VA – upper and lower Power Supplies)

Event Number: 129

Event Classification: Potential Problem or Severe/Fatal Event

Action:

The supply failed in the past and has now recovered. Check if there is a +/-VA – AB event. If so follow the action for that event. Otherwise, replace the monitor Module. Monitor Module will stop alarming.

**Fail Main Board +VA-A** (Fail Main Board +VA - upper Power Supply)

Event Number: 130

Event Classification: Potential Problem

Action: Verify that noise from the power source is not causing the problem.

If the problem is not caused by noise, check to see if one of the following components is faulty:

- the Monitor Module
- the Power Supply installed in the upper slot

**Pass Main Board +VA-A** (Pass Main Board +VA - upper Power Supply)

Event Number: 131

Event Classification: Potential Problem

Action: Verify that noise from the power source is not causing the problem.

If the problem is not caused by noise, check to see if one of the following components is faulty:

- the Monitor Module
- the Power Supply installed in the upper slot

**Fail Main Board +VA-B** (Fail Main Board +VA - lower Power Supply)

Event Number: 132

Event Classification: Potential Problem

Action:

Verify that noise from the power source is not causing the problem. If the problem is not caused by noise, check to see if one of the following components is faulty:

- the Monitor Module
- the Power Supply installed in the lower slot

**Pass Main Board +VA-B** (Pass Main Board +VA - lower Power Supply)

Event Number: 133

Event Classification: Potential Problem

Action:

Verify that noise from the power source is not causing the problem. If the problem is not caused by noise, check to see if one of the following components is faulty:

- the Monitor Module
- the Power Supply installed in the lower slot

**\*\* Fail Main Board +VA-AB** (Fail Main Board +VA - upper and lower Power Supplies)

Event Number: 134

Event Classification: Severe/Fatal Event

Action:

Verify that noise from the power source is not causing the problem. If the problem is not caused by noise, check to see if one of the following components is faulty:

- the Monitor Module
  - the Power Supply installed in the upper slot
  - the Power Supply installed in the lower slot
- Monitor Module will stop alarming.

**Pass Main Board +VA-AB** (Pass Main Board +VA - upper and lower Power Supplies)

Event Number: 135

Event Classification: Severe/Fatal Event

Action:

Verify that noise from the power source is not causing the problem. If the problem is not caused by noise, check to see if one of the following components is faulty:

- the Monitor Module
- the Power Supply installed in the upper slot
- the Power Supply installed in the lower slot

**Fail Main Board -VA-A** (Fail Main Board -VA - upper Power Supply)

Event Number: 136

Event Classification: Severe/Fatal Event

Action:

Verify that noise from the power source is not causing the problem.  
If the problem is not caused by noise, check to see if one of the following components is faulty:

- the Monitor Module
- the Power Supply installed in the upper slot
- the Power Supply installed in the lower slot

**Pass Main Board -VA-A** (Fail Main Board -VA - upper Power Supply)

Event Number: 137

Event Classification: Severe/Fatal Event

Action:

Verify that noise from the power source is not causing the problem.  
If the problem is not caused by noise, check to see if one of the following components is faulty:

- the Monitor Module
- the Power Supply installed in the upper slot
- the Power Supply installed in the lower slot

**Fail Main Board -VA-B** (Fail Main Board -VA - lower Power Supply)

Event Number: 138

Event Classification: Severe/Fatal Event

Action:

Verify that noise from the power source is not causing the problem.  
If the problem is not caused by noise, check to see if one of the following components is faulty:

- the Monitor Module
- the Power Supply installed in the upper slot
- the Power Supply installed in the lower slot

**Pass Main Board -VA-B** (Fail Main Board -VA - lower Power Supply)

Event Number: 139

Event Classification: Severe/Fatal Event

Action:

Verify that noise from the power source is not causing the problem. If the problem is not caused by noise, check to see if one of the following components is faulty:

- the Monitor Module
- the Power Supply installed in the upper slot
- the Power Supply installed in the lower slot

**\*\* Fail Main Board -VA-AB** (Fail Main Board -VA - upper and lower Power Supplies)

Event Number: 140

Event Classification: Severe/Fatal Event

Action:

Verify that noise from the power source is not causing the problem. If the problem is not caused by noise, check to see if one of the following components is faulty:

- the Monitor Module
- the Power Supply installed in the upper slot
- the Power Supply installed in the lower slot

Monitor Module will stop alarming.

**Pass Main Board -VA-AB** (Pass Main Board -VA - upper and lower Power Supplies)

Event Number: 141

Event Classification: Severe/Fatal Event

Action:

Verify that noise from the power source is not causing the problem. If the problem is not caused by noise, check to see if one of the following components is faulty:

- the Monitor Module
- the Power Supply installed in the upper slot
- the Power Supply installed in the lower slot

**Device Configured**

Event Number: 300

Event Classification: Typical Logged Event

Action:

No action required.

**\*\* Configuration Failure**

Event Number: 301

Event Classification: Potential Problem or Severe/Fatal Event

Action:

Download a new configuration to the Monitor Module. If the problem still exists, replace the Monitor Module immediately. Monitor Module will stop alarming.

**\*\* Module Entered Cfg Mode (Module Entered Configuration Mode)**

Event Number: 302

Event Classification: Typical Logged Event

Action:

No action required.  
Monitor Module will stop alarming.

**Software Switches Reset**

Event Number: 305

Event Classification: Potential Problem

Action:

Download the software switches to the Monitor Module. If the software switches are not correct, replace the Monitor Module as soon as possible.

**Monitor TMR PPL Failed (Monitor TMR Proportional Value Failed)**

Event Number: 310

Event Classification: Potential Problem

Action:

Verify that the sensor is properly installed. If the sensor is properly installed, check to see if one of the following components is faulty:

- the sensor
- the I/O Module
- the 3500/63 Main Module

**Monitor TMR PPL Passed (Monitor TMR Proportional Value Passed)**

Event Number: 311

Event Classification: Potential Problem

Action:

Verify that the sensor is properly installed. If the sensor is properly installed, check to see if one of the following components is faulty:

- the Sensor
- the I/O Module
- the 3500/63 Main Module

**Module Reboot**

Event Number: 320  
Event Classification: Typical Logged Event  
Action:

No action required.

**\*\* Module Removed from Rack**

Event Number: 325  
Event Classification: Typical Logged Event  
Action:

No action required.  
Monitor Module will stop alarming.

**Module Inserted in Rack**

Event Number: 326  
Event Classification: Typical Logged Event  
Action:

No action required.

**Device Events Lost**

Event Number: 355  
Event Classification: Typical Logged Event  
Action:

No action required.  
This may be due to the removal of the Rack Interface Module for an extended period.

**Module Alarms Lost**

Event Number: 356  
Event Classification: Typical Logged Event  
Action:

No action required.  
This may be due to the removal of the Rack Interface Module for an extended period.

**Pass Module Self-test**

Event Number: 410  
Event Classification: Typical Logged Event  
Action:

No action required.

**\* Enabled Ch Bypass** (Enabled Channel Bypass)

Event Number: 416  
Event Classification: Typical logged event  
Event Specific: Ch x  
Action:  
No action required.  
Alarming has been inhibited by this action.

**Disabled Ch Bypass** (Disabled Channel Bypass)

Event Number: 417  
Event Classification: Typical logged event  
Event Specific: Ch x  
Action:  
No action required.

**\*\* Enabled Alert Bypass**

Event Number: 420  
Event Classification: Typical logged event  
Event Specific: Ch x  
Action:  
No action required.  
Alarming has been inhibited by this action.

**Disabled Alert Bypass**

Event Number: 421  
Event Classification: Typical logged event  
Event Specific: Ch x  
Action:  
No action required.

**\*\* Enabled Danger Bypass**

Event Number: 422  
Event Classification: Typical logged event  
Event Specific: Ch x  
Action:  
No action required.  
Alarming has been inhibited by this action.

**Disabled Danger Bypass**

Event Number: 423  
Event Classification: Typical logged event  
Event Specific: Ch x  
Action:  
No action required.



**Enabled Special Inh** (Enabled Special Inhibit)

Event Number: 424

Event Classification: Typical logged event

Event Specific: Ch x

Description: The hardware switch on the IO was enabled.

**Disabled Special Inh** (Disabled Special Inhibit)

Event Number: 425

Event Classification: Typical logged event

Event Specific: Ch x

Description: The hardware switch on the IO was disabled.

**\*\* Enabled Mon Alarm Byp** (Enabled Monitor Alarm Bypass)

Event Number: 426

Event Classification: Typical logged event

Action:

No action required.

Monitor Module will stop alarming.

**Disabled Mon Alarm Byp** (Disabled Monitor Alarm Bypass)

Event Number: 427

Event Classification: Typical logged event

Action:

No action required.

**Enabled SW Channel Reset** (Enabled Software Channel Reset)

Event Number: 432

Event Classification: Typical logged event

Event Specific: Ch x

Action:

No action required.

**Disable SW Channel Reset** (Disabled Software Channel Reset)

Event Number: 433

Event Classification: Typical logged event

Event Specific: Ch x

Action:

No action required.

**\*\* Fail Slot Id Test**

Event Number: 461

Event Classification: Severe/Fatal Event

Action:

Verify that the Monitor Module is fully inserted in the rack. If the Monitor Module is installed correctly, check to see if one of the following components is faulty:

- the Monitor Module
- the rack backplane

Monitor Module will stop alarming.

**Pass Slot Id Test**

Event Number: 462

Event Classification: Severe/Fatal Event

Action:

Verify that the Monitor Module is fully inserted in the rack. If the Monitor Module is installed correctly, check to see if one of the following components is faulty:

- the Monitor Module
- the rack backplane

**\*\* Fail Comm. ID Mismatch**

Event Number: 463

Event Classification: Potential Problem

Action:

Verify that the Monitor Module is fully inserted in the rack. If the Monitor Module is installed correctly, check to see if one of the following components is faulty:

- the Monitor Module
- the rack backplane

Monitor Module will stop alarming.

**Pass Comm. ID Mismatch**

Event Number: 464

Event Classification: Potential Problem

Action:

Verify that the Monitor Module is fully inserted in the rack. If the Monitor Module is installed correctly, check to see if one of the following components is faulty:

- the Monitor Module
- the rack backplane

**\*\* Enable Test Signal**

Event Number: 481  
Event Classification: Typical Logged Event  
Action:  
    No action required.  
    Monitor Module will stop alarming.

**Disable Test Signal**

Event Number: 482  
Event Classification: Typical Logged Event  
Action:  
    No action required.

**Setpoint Updated**

Event Number: 511  
Event Classification: Typical logged event  
Action:  
    No action required.

**Enable/Disable Group Reset**

Event Number: 521  
Event Classification: Typical logged event.  
Action:  
    No action required.

**\*\*I/O Module Removed**

Event Number: 550  
Event Classification: Typical logged event  
Action:  
    No action required.  
    Monitor Module will stop alarming.

**\*\* Possible Open XDCCR**

Event Number: 551  
Event Specific: Ch x  
Event Classification: Severe/Fatal Event  
Action:  
    Possible open in the signal path between the sensor and where the signal is conditioned, or possible leads swapped. The possible location for the problem may be:

- field wiring
- I/O module
- Monitor module

    Monitor may stop alarming.

**\*\* Possible Wiring Fault**

Event Number: 552

Event Specific: Ch x

Event Classification: Severe/Fatal Event

Action:

Possible open in the signal path between the sensor and where the signal is conditioned. The possible location for the open may be:

- field wiring
- I/O module
- Monitor module

Monitor may stop alarming.

**Xdcr OK**

Event Number: 553

Event Classification: Potential Problem

Action:

The sensor may have failed in the past and has now recovered. Check if there is other associated event messages. If so follow the action for those events, such as troubleshoot wiring, sensor, channel.

**\*\* I/O Calibration Failure**

Event Number: 560

Event Classification: Severe/Fatal Error

Action:

Replace the monitor module as soon as possible.

Monitor will stop alarming.

**\*\* ADC Failure**

Event Number: 562

Event Classification: Severe/Fatal Error

Action:

If this message is posted due to failure to calibrate, attempt to recalibrate the channel using a known viable sensor. Ensure wiring is correct. If this message is still reported, replace the monitor module immediately. Monitor module will stop alarming. Be sure to finally calibrate the channel with the sensor with which it is intended to be used.

**\*\* Enable Haz Gas Calibration**

Event Number: 620

Event Classification:

Description: Typical logged event, during calibration.

Action:

No action required.  
Monitor will stop alarming while calibration is enabled. Be sure to complete a successful calibration such that Disable Haz Gas Calibration follows Enable Haz Gas Calibration

**\*\* Disable Haz Gas Calibration**

Event Number: 621  
Event Classification:  
Description: Typical logged event, during calibration.  
Action:  
No action required.  
Monitor may resume alarming when calibration is disabled. Be sure to complete a successful calibration such that Disable Haz Gas Calibration follows Enable Haz Gas Calibration.

**\*\* Fail Haz Gas Pot Adjustment** (Problem during calibration routine)

Event Number: 622  
Event Classification: Potential Problem  
Action:  
Attempt to re-calibrate. Ensure wiring is correct. This error can occur due to the black lead being open. Ohm out sensor to ensure it does not have an opened bead.

**\*\* Invalid Cal Command** (Problem during calibration routine)

Event Number: 623  
Event Classification: Potential Problem  
Action:  
Caused by an invalid calibration command during:

- Initialization of cal routine
- 0% calculation
- Gas concentration calculation

Re-try calibration. Contact Bently Nevada, Inc. for assistance.  
Monitor will stop alarming while in calibration.

**\*\* Calibration Timeout** (Won't calibrate)

Event Number: 624  
Event Classification: Potential Problem  
Action:  
Verify test setup and procedure; re-try calibration; replace sensor (may be at end of life)  
Monitor will stop alarming while in calibration.

**\*\* Gas Change Not Detected**

Event Number: 625

Event Classification: Potential Problem

Action:

Verify test setup and procedure; gas canister may be empty; re-try calibration; replace sensor (may be at end of life)  
Monitor will stop alarming while in calibration.

**\*\* Gas Did Not Stabilize**

Event Number: 626

Event Classification: Potential Problem

Action:

Verify test setup and procedure; gas canister may be empty; verify calibration boot adequately interfaced to sensor head; re-try calibration; replace sensor (may be at end of life)  
Monitor will stop alarming while in calibration.

**\*\* Invalid HG Command**

Event Number: 627

Event Classification: Potential Problem

Action:

Unexpected internal failure; invalid channel indicated; contact Bently Nevada, Inc. for assistance.  
Monitor will stop alarming while in calibration.

**Calibration Aborted**

Event Number: 628

Event Classification: Potential Problem

Action:

Unless user purposely aborted calibration contact Bently Nevada, Inc. for assistance.

**Recommend Recalibration** (Recalibration recommended every 90 days)

Event Number: 629

Event Classification: Potential Problem

Description:

Event message logged because:

- Recalibration date has been passed. Recalibrate sensor.
- A channel returned to an OK state after the channel had experienced a NOT OK event.
- The module was just powered up.
- Calibration failed to initialize under the following conditions (NOT in soft bypass AND channel not in alarm AND (IO not calibrated OR (channel NOT OK AND not firm bypassed))).
- Calibration failed due to an out of range 0% voltage or 50% voltage.
- One of the following I/O module calibration parameter validation checks failed:
  - Gain pot setting,
  - Offset pot setting,
  - last calibration date,
  - next calibration date,
  - recommended date,
  - serial number.

Action:

Recalibrate the sensor/channel. If a successful calibration cannot be obtained, replace the sensor and calibrate the sensor/channel.

**Fail I/O Recorder Check (recorder outputs not functioning correctly)**

Event Number: 630

Event Classification: Potential Problem or Severe/Fatal if signal is used in other protection system

Action:

Check recorder output field wiring; replace I/O and/or main module

**Pass I/O Recorder Check**

Event Number: 631

Event Classification: Potential Problem or Severe/Fatal if signal is used in other protection system

Action:

The I/O recorder check may have failed in the past and has now recovered. Look for associated messages and follow those instructions.

**\*\* Fail HG XDCR/Recal Check**

Event Number: 632  
Event Classification: Severe/Fatal  
Event Specific: Ch x  
Action:

Open in the signal path between the sensor and where the signal is conditioned. The possible location for the open may be:

- Field wiring
- Sensor beads
- I/O module
- Monitor module

Monitor may stop alarming.

**Pass HG XDCR/Recal Check**

Event Number: 633  
Event Classification: Severe/Fatal  
Event Specific: Ch x  
Action:

The HG XDCR/Recal Check may have failed in the past and has now recovered. Look for associated messages and follow those instructions.

**\*\* Fail +24V Check/Recal**

Event Number: 634  
Event Classification: Potential Problem  
Action:

A possible problem in the signal path between the external 24Vdc power supply and where the power is used on the I/O to power the sensor. The possible location for the wiring fault may be:

- Field wiring between external supply and I/O
- Field wiring between I/O and sensor
- Or, the power supply itself or I/O module may be faulty.  
Correct faulty wiring and/or replace external power supply and/or I/O module.

Monitor may stop alarming.

**Pass +24V Check/Recal**

Event Number: 635  
Event Classification: Potential Problem  
Action:

The Fail +24V Check/Recal Check may have failed in the past and has now recovered. Look for associated messages and follow those instructions.

**Enter Over-Range Region**

Event Number: 636

Event Classification: Severe/Fatal

Action:

Monitor has determined that it is in the over-range region; i.e., reading greater than 100%LEL. This condition is latching. The condition cannot be cleared until the area is cleared of the hazardous gas and the system is reset.

Several wiring faults may also cause this fault:

- White lead open
- Red lead shorted to black lead
- Red and White lead swapped and black shorted to earth

**Exit Over-Range Region**

Event Number: 637

Event Classification: Severe/Fatal

Action:

Displayed when the over range condition is corrected and the system has been reset.

## 11.9 Alarm Event List Messages

The Hazardous Gas Monitor returns the following Alarm Event List Messages.

**Table 11:5: Hazardous Gas Monitor Alarm Event List Messages**

Alarm Event List Message	When the message will occur
Entered Alert / Alarm 1	A proportional value in the channel has entered Alert / Alarm 1 and changed the channel Alert / Alarm 1 status
Left Alert / Alarm 1	A proportional value in the channel has left Alert / Alarm 1 and changed the channel Alert / Alarm 1 status
Entered Danger / Alarm 2	A proportional value in the channel has entered Danger / Alarm 2 and changed the channel Danger / Alarm 2 status
Left Danger / Alarm 2	A proportional value in the channel has left Danger / Alarm 2 and changed the channel Danger / Alarm 2 status
Entered Not OK	Module went Not OK
Left Not OK	Module returned to the OK state

## 12. Safety Manual

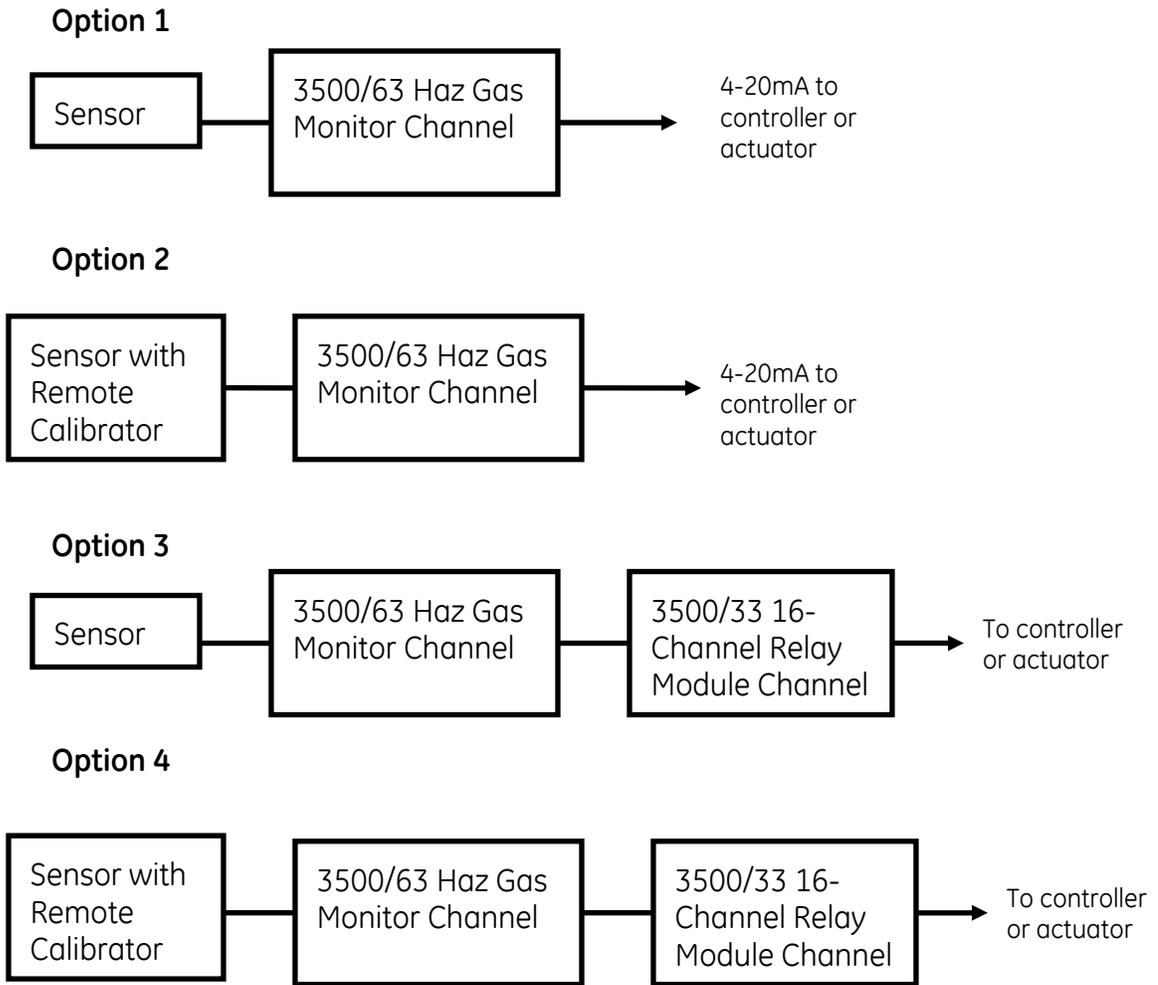
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This section of the manual contains important information on how the 3500/63 monitor, the 350800 gas sensor, and the 3500/33 Relay module may be used as **part of** a safety instrumented system (SIS). The safety function of the BN Hazardous Gas Protection System is:

- to provide measurement of gas levels in a 4 to 20 mA format to a controller (logic solver) that controls a final element, or
- to provide protection by continuously comparing current measurements of gas levels against configured alarm setpoints to drive alarm relays.

### 12.1 Certification

Exida has certified the 3500 Hazardous Gas Detection/Protection hardware and firmware as suitable for use in applications with a required Safety Integrity Level of 2 (SIL2) conforming to IEC 61508. The SIL2 suitability certification applies to all simplex architecture options illustrated in Figure 12-1. As shown, the system can be used to provide 4 to 20mA outputs to a controller or it can be used with a relay module to provide relay outputs to a controller or actuator. The system can be used with or without a remote calibrator. All options provide the hardware fault tolerance and safe failure fraction to meet SIL2 architectural requirements in a low demand mode as specified in IEC61508.



**Figure 12-1: SIL Capable Configurations**

## 12.2 Applicable Hardware/Software

The following hardware and software components (shown in Table 12:1 and in Table 12:2) of a 3500 Hazardous Gas Protection System are covered by the SIL capability rating and can be used to create the simplex options shown in Figure 12-1.

**Table 12:1: Safety Rated Hardware**

Part number	Description	Function
350800	Hazardous Gas Sensor with or without housing	Flameproof, continuous diffusion, catalytic bead detection head.
350810	Remote Calibrator	Permanently mounted device used to remotely calibrate the sensor when it is located in an area that is hazardous, high temperature, a confined space or otherwise not readily accessible.
3500/63	Hazardous Gas Detection/Protection Monitor	Six-channel monitor detects and alarms on combustible gas concentrations as a percentage of lower explosive limits (LEL). Two alarm setpoints (alert and danger) are user-configured. 4-20 mA outputs are proportional to 0 to 100%LEL. Provides 4 to 20 mA outputs to controller.
3500/33	16-Channel Relay Module (optional)	Each relay output is fully programmable using AND and OR voting logic. The Alarm drive logic can use alerts, dangers, Not-OK and individual channel parameters. When this optional module is included in the Haz Gas system, relays are programmed to change state, enabling initiation of audible or visible alarms and/or shutdown of machines or processes. May be used to provide output to controller in lieu of 4-20mA outputs provided by 3500/63.

**Table 12:2: Safety Relevant Hardware**

Part number	Description	Function
3500/05	Rack	The 3500 System rack design holds all 3500 monitor modules and rack power supplies. It allows the various 3500 modules to communicate with one another and the power supplies to distribute power to each module as required.
3500/15	Dual Power Supplies	Each accepts 20 to 140 Vdc input power, and provides conditioned power through the rack backplane for all installed 3500 modules. Two (redundant) supplies are required for the SIL capability rating.

Part number	Description	Function
3500/20	Rack Interface Module (RIM)	The Rack Interface Module (RIM) is the primary interface into the 3500 rack. It supports a Bently Nevada proprietary protocol used to configure the rack and to retrieve machinery information. The RIM must be located in slot 1 of the rack (next to the power supplies). The RIM provides the connections needed to support peripheral Bently Nevada Communications Processors and Dynamic Data Interfaces. Although the RIM does provide certain functions common to the entire rack, the RIM is not part of the critical monitoring path. The RIM's operation (or non-operation) has no effect on the proper, normal operation of the overall monitoring system.
3500/22	Transient Data Interface (TDI)	This TDI provides all the RIM functions of the 3500/20, and also incorporates the Transient Data (TDI) communications processor, providing full transient, steady state, or static-only data acquisition and direct connectivity to our System 1 software. It is used in place of the 3500/20 and is recommended whenever immediate, or future, online condition monitoring is desired.
164374	External Transducer Power Supply	Third-party supply used to power the gas sensors.
164376	External Supply Chassis	Third-party supply 3-position chassis.
168868-01	Calibration Kit	Used to calibrate the sensor channels.
169038	CH <sub>4</sub> (methane) 2.5% by volume (50% LEL)	Pressurized canister of gas used with calibration kit to calibrate channels to methane. May be customer supplied.
175974	H <sub>2</sub> (hydrogen) 2.0% by volume (50% LEL)	Pressurized canister of gas used with calibration kit to calibrate channels to hydrogen. May be customer supplied.
3500/01	Rack Configuration Software	3500 Monitor Racks must be configured from a host computer using the Rack configuration software. Utility software products are provided to verify connections to the rack and to test the operation of modules within the rack. Additionally, is used when calibrating each channel.

## 12.3 Low Demand Mode of Operation

SIL capability certification is based on the mode of operation of the system. The mode of operation is based on the relationship between the dangerous condition (the demand) and the diagnostic testing. The BN Hazardous Gas Protection System is certified based on a low demand mode of operation. In a low demand mode of operation, a dangerous condition is expected very infrequently. IEC 61508 states that the frequency of demand for low demand operation is no greater than one per year and no greater than twice during the proof-test interval. The proof test interval for the BN Hazardous Gas System is 90 days. See Section 12.9.

## 12.4 Hardware Fault Tolerance

The 1-channel BN system has a Hardware Fault Tolerance (HFT) of zero (0). That means for the simplex architecture no faults (0) can be tolerated for the system to still provide the required safety coverage.

Per table 3 in IEC 61508-02 (and replicated here in Table 12:3), a Safe Failure Fraction (SFF) of 90 to 99% is required for SIL 2.

**Table 12:3: Hardware Safety Integrity**

(Architectural constraints of type B\*\* safety-related subsystems)

Safe Failure Fraction	Hardware Fault Tolerance		
	0	1	2
< 60%	Not allowed	SIL1	SIL2
60% to < 90%	SIL1	SIL2	SIL3
90% to < 99%	SIL2	SIL3	SIL3
≥ 99%	SIL3	SIL4	SIL4

\*Note: The BN system is considered a type B subsystem because it involves a microprocessor.

Thus, the safety structure, tests, and diagnostics of the BN system are designed such that at least 90% of all failure modes are detected and/or result in a safe state.

## 12.5 Average Probability of Failure on Demand

SIL verification for low demand mode uses the average probability of failure on demand ( $PFD_{avg}$ ) for the entire safety instrumented function—from the sensor to the actuator of which the BN sensor (with or without remote calibrator) and monitor are a subsystem. See Table 12:4.

**Table 12:4: Safety Integrity Levels: Target failure measures for a safety function operating in low demand mode of operation**

Safety Integrity Level	Average probability of failure to perform its design function on demand
4	$\geq 10^{-5}$ to $< 10^{-4}$
3	$\geq 10^{-4}$ to $< 10^{-3}$
2	$\geq 10^{-3}$ to $< 10^{-2}$
1	$\geq 10^{-2}$ to $< 10^{-1}$

These values are applicable to the entire safety loop, including the BN 3500 Hazardous Gas Protection System as well as all other controllers and actuators that are supplied by the user and that are part of the safety instrumented function (SIF).

As shown in Table 12:4, in order for your application to satisfy a SIL2 requirement, the probability of dangerous failure for the entire safety instrumented function must be in the SIL2 range, that is, between  $10^{-2}$  and  $10^{-3}$ .

## 12.6 Failure Rates

Table 12:5 shows the failure rates for the BN components that can be used to make up a subsystem. These failure rates were calculated by a hardware assessment in the form of a Failure Modes, Effects, and Diagnostic Analysis (FMEDA) of the Bently Nevada system. A user of the 3500 BN Hazardous Gas Protection System can utilize these failure rates in a probabilistic model of a safety instrumented function (SIF) to determine suitability in part for safety instrumented system (SIS) usage in a particular safety integrity level (SIL).

**Table 12:5: Failure rates of BN components according to IEC 61508**

Device	$\lambda_{SD}$ (FITs)	$\lambda_{SU^2}$ (FITs)	$\lambda_{DD}$ (FITs)	$\lambda_{DU}$ (FITs)	SFF <sup>3</sup> (%)
350800 gas sensor	0	38	2778	188	
3500/63 – per gas sensor input	0	52	190	25	
3500/63 – common to all gas sensor inputs	0	128	732	50	
3500/63 – per mA output	0	3	104	10	
3500/63 – common to all mA outputs	0	2	45	0	
3500/63 – per relay output	0	90	0	26	
3500/63 – common to all relay outputs	0	225	788	105	
3500/63 – single gas sensor input, mA output	0	223	3849	273	93.7
3500/63 – single gas sensor input, mA output, w/350810 remote calibrator	0	263	3849	283	93.6
3500/63 – single gas sensor input, relay output	0	533	4488	394	92.7
3500/63 – single gas sensor input, relay output, w/350810 remote calibrator	0	573	4488	404	92.6

The worst case diagnostic test interval of the Bently Nevada Hazardous Gas System is 1 hour.

The step change response time (sudden exposure to 100%LEL) meets:

$$T_{50} \leq 10s$$

$$T_{60} \leq 12s$$

$$T_{90} \leq 30s$$

Time from exceeding configured setpoint to output indication (assuming no additional time delays added in module configurations):

4-20 recorder outputs: less than 2 seconds

relay output: less than 2 seconds

Common Cause for redundant configurations: A method for estimating the Beta Factor is provided in IEC 61508-6. Based on this approach, a Beta Factor of 10% may be used based on factors under control of the manufacturer. If the owner-operator of the plant institutes training and maintenance procedures specifically oriented toward common cause defense, a Beta Factor of 5% may be used.

## 12.7 Useful Lifetime

For hardware assessment according to IEC 61508 only random equipment failures are of interest. It is assumed that the equipment has been properly selected for the application and is adequately commissioned such that early life failures (infant mortality) may be excluded from the analysis. The assumption is also made that the equipment is maintained per the requirements of IEC 61511 and therefore a preventative maintenance program is in place to replace equipment before the end of its “useful life”.

The failure rates in Table 12:5 are valid for the useful lifetime of the product. The components that contribute to the dangerous undetected failure rate and therefore to the PFDavg calculation are electrolytic capacitors and the hazardous gas sensors themselves. The capacitors have an estimated useful lifetime of approximately 10 years. Therefore, the 3500/63 monitor and the 3500/33 relay cards shall be replaced every 10 years.

The life of the sensor depends on its years in service and whether it has been exposed to gases or poisons. Once a sensor has been put into service, it should be replaced when it cannot be recalibrated or at least every 5 years.

The life of the remote calibrator is dependent on the type and quantity of debris introduced as well as the care taken during maintenance. A remote calibrator should be replaced if, after maintenance, a valid calibration cannot be performed.

## 12.8 Restrictions

1. Outputs through a 3500/92 Communication Gateway or 3500/91 EGD module are not covered in this SIL certification. The SIL suitability rating covers only outputs in the form of the analog outputs per channel on the 3500/63 Hazardous Gas Detection Module and/or the outputs of the 3500/33 Relay module channels.

## 12.9 Proof Test Interval

The BN Hazardous Gas Protection System affords safety benefits from automatic diagnostic testing as well as prescribed periodic proof testing. The BN 350800 sensor requires periodic calibration and proof testing. The proof test interval required for the sensor/channel to maintain SIL2 suitability is 90 days based on sensor technology. The user may wish to use the Cal Status value (see Section 7.2.1) provided by each channel to ensure that he prepares for and meets the 90-day recalibration requirement. To perform the 90-day proof test for the sensor/channel recalibrate and verify the channel per Section 9.

Additionally, the user should determine the proof test interval required for the 4-20mA outputs if those are used as part of the safety system. Refer to Section 10.1.6 for instructions on verifying the 4-20mA outputs from the BN system.

The user should determine the proof test interval required for the relay outputs if the 3500/33 Relay Module is used as part of the safety system. Refer to Section 10.1.4 for testing alarms and to Section 10.1.5 for testing OK statuses if alarm limits and OK statuses are part of the relay voting logic. Refer also to the 3500/33 Relay Module Operations and Maintenance Manual, part number 162291-01.

## 12.10 Setup and Installation

For SIL capable systems, no special installation is required in addition to the standard installation practices outlined in this manual and those manuals that are pertinent to the 3500 components referred to in Section 12.2 except:

1. Dual Power Supplies in the rack are required.
2. External third party power supplies that provide the additional power for the sensors should be redundant and in an N + 1 configuration. Refer to Section 13 for ordering information.
3. When the 3500/33 relay card is used as part of the safety loop, the relays must be hardware configured as Normally Energized and the ARM and NO output terminals used so that a loss of power will result in the relays changing state. Refer to the 3500/33 Relay Operation and Maintenance Manual, 162291-01.
4. When using the system with the relay output as shown in architecture Options 3 and 4 the user must use relay logic to cause a change of relay state on a Not OK condition to appropriately handle internal detected failures.
5. The hazardous gas sensor/channel combination must be recalibrated at least every 90 days. The user may wish to use the Cal Status value (see Section 7.2.1) provided by each channel to ensure that he prepares for and meets this requirement.

6. The user must protect the configuration from unintended changes. Possible methods for accomplishing this are:
  - i. Restrict or control access to the physical key that is necessary to put the 3500 rack into the program switch mode.
  - ii. Set connection and configuration passwords. Refer to 3500/20 Rack Interface Module Operation and Maintenance Manual, p/n 129768-01, or 3500/22 Transient Data Interface Module Operation Manual, p/n 161580-01, for how to set these passwords.

These system requirements must be verified during the installation and commissioning to ensure that the designed safety integrity level is met.

## **12.11 Fault/ Failure Procedures**

Refer to Section 10 for maintenance.

Follow the procedures in Section 11 for Troubleshooting.

If a channel or module still cannot be verified, see section 10.1.7, for information on how to replace and/or return components.

## 13. Ordering Information

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### 13.1 Sensor

350800-01-BXXX-CXX

B: Lead Length

006 6 Inch Lead

096 96 Inch Lead

144 144 Inch Lead

180 180 Inch Lead

240 240 Inch Lead

C. Housing

00 None

01 Flameproof Housing

### 13.2 Hazardous Gas Detection Module

3500/63-AXX-BXX

A: Input/Output Module:

0 1 Internal Termination Catalytic Bead Input/Output Module

0 2 External Termination Catalytic Bead Input/Output Module

B: Agency Approvals:

0 1 FM(C/US), IEC

#### External Sensor Power Supply

(See specifications, Section 14, for requirements. Several possible external power supply options that may be purchased through Bently Nevada, Inc. are shown here.)

164374

Pepperl+Fuchs PS, 115 VDC input, +24Vdc output, 15A max, plugs into a 3-position chassis, can be up to 3 times redundant when more than 1 are ordered. At least dual redundancy is strongly recommend for a safety system.

164376

Chassis for 164374 power supply, can accommodate up to 3 redundant power supplies

284688

Phoenix Contact PS, 100-240 V AC input, +24 V DC output, 20A, DIN rail mount

175631

Diode Module used for creating redundant Phoenix Contact 24V power supplies.

**SPARES:**

163179-04

3500/63 Main Board

164578-01

Gas Sensor Internal Termination Input/Output Module

164895-01

Gas Sensor External Termination Input/Output Module

166848-01

*Haz Gas Detection System Operations and Maintenance Manual*

168724-01

Sensor instruction pamphlet

350801-02

Flameproof housing assembly, for use with Bently Nevada sensor only

**MISCELLANEOUS**

04425545

Grounding Wrist Strap (Single use only)

04400037

IC Removal Tool

**EXTERNAL TERMINATION BLOCKS**

165902-01

3500/63 External Termination Block for sensor (Terminal Strip Connectors)

165901-01

3500/63 External Termination Block for sensor (Euro Style Connectors)

133892-01

3500/63 External Termination Block for recorders (Terminal Strip Connectors)

133900-01

3500/63 External Termination Block for recorders (Euro Style Connectors)

00580440

Connector Header, Internal Termination, 3-position, Green

00580445

Connector Header, Internal Termination, 9-position, Green

00580446

Connector Header, Internal Termination, 12-position, Green

**CABLES**

**3500/63 Sensor (XDCR) Signal to External Termination (ET) Block Cable**

**134544-AXXXX-BXX**

**A:** Cable Length

**0 0 0 5**      5 feet (1.5 metres)

**0 0 0 7**      7 feet (2.1 metres)

**0 0 1 0**      10 feet (3 metres)

**0 0 2 5**      25 feet (7.5 metres)

**0 0 5 0**      50 feet (15 metres)

**0 1 0 0**      100 feet (30.5 metres)

**B:** Assembly Instructions

**0 1** Not Assembled

**0 2** Assembled

### **3500/63 Recorder Signal to External Termination (ET) Block Cable**

#### **134543-AXXX-BXX**

**A:** Cable Length

**0 0 0 5** 5 feet (1.5 metres)

**0 0 0 7** 7 feet (2.1 metres)

**0 0 1 0** 10 feet (3 metres)

**0 0 2 5** 25 feet (7.5 metres)

**0 0 5 0** 50 feet (15 metres)

**0 1 0 0** 100 feet (30.5 metres)

**B:** Assembly Instructions

**0 1** Not Assembled

**0 2** Assembled

## **13.3 Calibration**

### **13.3.1 Calibration Kit for Manual (non-remote) Calibration**

#### **168868-01**

Kit includes cal boot and tube assembly, regulator, and instruction sheet in a carrying case that can hold two gas cylinders (gas cylinders sold and shipped separately).

Spare parts for calibration kit:

169040

Carrying case

169039

Cal Kit Regulator (0.5 L/min)

168957-01

Cal boot & tube assembly

169027-01

Instruction sheet

166730-01

Calibration Procedure Instructional CD

### **13.3.2 Remote Calibrator and Peripherals for Remote Calibration**

**350810**

Remote Calibrator

Mount one remote calibrator on each sensor to enable ability for remote calibration.

**284357-01**

Remote Calibrator Regulator

10 psi 2-stage regulator with CGA600 connection and two feet of clear Tygon® tubing. For proper operation, the Remote Haz Gas Calibrator requires a gas supply of at least 2 liters/min and a regulator set pressure of  $10 \pm 1$  psi. This regulator is preset to these specifications.

**286642**

Supply Line Kit

100 ft of 1/8" OD coiled stainless tubing and two 1/4 NPT to 1/8" tube fittings.

Spare parts for Remote Calibrator:

284025

Spare O-ring for end Cap

286097

Spare Diffuser

286091

Pamphlet, Remote Calibrator

Spare part for supply line kit:

284833

1/4 NPT to 1/8" tube fitting

### **13.3.3 Calibration Gas**

Canisters of pressurized gas for use with the Calibration Kit and/or the Remote Haz Gas Calibrator are ordered and shipped separately. The following 34-liter canisters are pressurized to 500 psi and have a CGA600 connection that can be used with the 169039 or 284357-01 Regulator:

**169038**

CH<sub>4</sub> (methane) 2.5 % by volume (50 %LEL); balance air

**175974**

H<sub>2</sub> (hydrogen) 2.0 % by volume (50 %LEL); balance air

**284219**

Zero (clean) air. Required for remote calibrations.

## 13.4 Haz Gas Simulator Kit

For use in verifying wiring and voting logic. Not to take the place of calibration with actual sensors

Refer to data sheet 285166-01

<b>NOTE</b>
<p>If the 3500/63 Hazardous Gas Detection System is added to an existing 3500 Monitoring System, the following (or later) firmware and software versions are required:</p> <p>3500/22 TDI Firmware (when used in TMR config) – Revision 1.50 or later, 3500 Rack Configuration Software - Version 3.87 or later, 3500 Data Acquisition Software - Version 2.51 or later, 3500 Operator Display Software - Version 1.51 or later, 3500/92 Display Firmware - Revision 1.08 or later, 3500/94 Display Firmware – Revision 2.04 or later, System 1 Version 5.0 or later 3500/63 Haz Gas Monitor Firmware – Version 3.10 or later for approvals certification</p>



## 14. Specifications

### 14.1 350800 Sensor

Specified at +25 °C (+77 °F) unless otherwise noted, and when interfaced to the 3500/63 Hazardous Gas Detection Monitor. The sensor may be used alone, screwed directly into conduit, or with the flameproof housing for ease of sensor replacement.

Sensor Type

Flameproof, continuous diffusion, catalytic bead; CH<sub>4</sub> & H<sub>2</sub> sensor

Sensor Life

2 years minimum; 5 years, normal service

Calibration Flow Rate Required

0.5 L / min (for manual calibrations)

2.0 L/min (for remote calibrations)

Initial Sensitivity  
(as seen in the  
3500 Verification  
screen)

> 15 mV / % LEL; spent or poisoned sensors will not calibrate if sensitivity is reduced to below 6 mV/%LEL

Sensor Long-Term  
Zero Drift (20°C,  
50%RH, 101kPa)

< ±2.5% LEL, per month

Sensor Long-Term  
Sensitivity Drift  
(20°C, 50%RH,  
101kPa)

< 2.5% Signal, per month

Shift Due to  
Temperature (zero  
gas)

## 3500/63 Hazardous Gas Detection System

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	$\leq \pm 5\%$ LEL, $-40\text{ }^{\circ}\text{C}$ to $+200\text{ }^{\circ}\text{C}$ ( $-40\text{ }^{\circ}\text{F}$ to $+392\text{ }^{\circ}\text{F}$ )
Response to Step Change	<p><math>&lt; 10\text{ s}</math> to reach 50% LEL (<math>T_{50}</math> time) reading when 100% LEL gas applied</p> <p><math>&lt; 12\text{ s}</math> to reach 60% LEL (<math>T_{60}</math> time) reading when 100% LEL gas applied</p> <p><math>&lt; 30\text{ s}</math> to reach 90% LEL (<math>T_{90}</math> time) reading when 100% LEL gas applied</p>
Sensor Poison Resistance	T50 to 20 ppm HMDS (hexamethyldisiloxane) in 2.5% $\text{CH}_4$ $> 75$ minutes
Shock	250 g
Vibration	5 g from 10 Hz to 3200 Hz
Calibration Interval	90 days, recommended (3500/63 monitor auto reminder)
Operating Temperature	$-40\text{ }^{\circ}\text{C}$ to $200\text{ }^{\circ}\text{C}$ ( $-40\text{ }^{\circ}\text{F}$ to $392\text{ }^{\circ}\text{F}$ )
Storage Temperature	$0\text{ }^{\circ}\text{C}$ to $40\text{ }^{\circ}\text{C}$ ( $32\text{ }^{\circ}\text{F}$ to $104\text{ }^{\circ}\text{F}$ )
Effect of Humidity from 10% to 90% RH	$< \pm 5\%$ LEL from baseline (baseline-room temperature, 50% RH)
Materials	Stainless Steel body with integral sintered flame arrestor

## Sensor Housing

Flameproof and IP66

**14.2 350810 Remote Calibrator**

Specified at +25 °C (+77 °F) unless otherwise noted.

Calibrator Type: Continuous diffusion; pneumatic slide  
 Actuation Flow/Pressure: Minimum flow of 2 liters/min @ 10 ±1 psi

Operating Temperature: -40 °C to +200 °C (-40 °F to +392 °F)  
 Storage Temperature: -40 °C to +200 °C (-40°F to +392 °F)

Physical:

*Diameter* 50.3 mm (1.98 in)  
*Length* 85.1 mm (3.35 in)  
*Weight* 285 gm (0.63 lbm)

Inlet threads ¼ NPT

Materials:

<i>Housing, Cap, and Slide</i>	Hard Anodized Aluminum
<i>Spring</i>	Zinc plated Spring Steel
<i>Cap O-Ring</i>	Fluorocarbon
<i>Slide Seal</i>	PTFE (spring energized)

Software

3500 Rack Config, ver 3.94, or later  
 3500/63 Firmware, rev 3.50, or later

**14.3 3500/63 Monitor**

Specified at +25 °C (+77 °F) unless otherwise noted

Proportional  
Output Values

% LEL: Hazardous Gas Concentration

Calibration Status: Days since last calibration

Accuracy

*Monitor only*

± 0.34% LEL typical, ± 1% LEL maximum

*Monitor with an approved sensor (calibrated with 50%LEL)*

± 3% of full-scale gas concentration for 0-50%LEL and ± 5% LEL of full-scale gas concentration above 50% LEL

Full Scale Range

0 to 100 % LEL units

Monitor Resolution

0.0015%

Constant Current Supplied by Monitor to Sensor

290 to 312 mA @ 23 °C (73 °F)

289 to 313 mA @ -30 °C to +65°C (-22 °F to +149 °F)

OK Range

Monitor detects sensor and field wiring faults

Sensor Cable Resistance

20 Ω per bridge leg, maximum

Monitor Input Impedance

200 KΩ

Monitor Power Consumption

7.0 watts, typical

External Sensor Power Supply Requirements

+22 to +30 Vdc (+24Vdc nominal) @ 1.8 A nominal per monitor (300 mA per channel). Must be able to provide:

4.9 Ln (x) + 6.5 A in-rush current, where x is the number of monitors.

At least dual redundancy for safety system recommended.

Monitor Alarm Inhibit

Contact closure on I/O inhibits monitor alarms

Voltage

+5 Vdc, typical

Current

0.4 mA, typical; 4 mA, peak

Monitor Front  
Panel LEDs

*OK LED*

Indicates when the Hazardous Gas Monitor is operating properly

*TX/RX LED*

Indicates when the Hazardous Gas Monitor is communicating with other modules in the 3500 Rack

*Bypass LED*

Indicates that the Hazardous Gas Monitor is in either Over Range or in Calibration mode

*Cal LED*

Indicates that the monitor is in either Over Range or in Calibration Mode

Recorder (Analog)  
Outputs

Applicable to each channel

*Current Output*

+4 to +20 mA representing 0 to 100% of monitor channel full scale, i.e., 0 to 100 %LEL

*Not OK / Bypass  
Current*

User selectable as 3.5, 3.0, 2.5, or 2.0 mA

*Calibration Current*

1.5 mA during calibration process

*Over Range  
Current*

20.5 mA, minimum, always latching

*Compliance  
Voltage*

0 to +12 Vdc range across load

*Load Impedance*

600  $\Omega$ , maximum

*Resolution*

0.3662  $\mu$ A per bit

$\pm 0.25\%$  error @ 23  $^{\circ}$ C (73  $^{\circ}$ F)

$\pm 0.70\%$  error @ -30  $^{\circ}$ C to +65 $^{\circ}$ C (-22  $^{\circ}$ F to +149  $^{\circ}$ F)

update rate approximately 100 ms

Alarms

*Alarm Setpoints*

Alert/Alarm1 and Danger/Alarm2 setpoints can be set for the direct proportional value of %LEL. The Alert/Alarm 1 setpoint can be set for the Cal Status proportional value but cannot be set for the Cal Status Danger/Alarm 2 setpoint. This setpoint value is determined by, and set to, the recommended calibration interval of 90 days. Alarms are adjustable and can be set from 0 to 60% of full-scale for each measured value. This Monitor only has over alarm setpoints. Alarm setpoints are only valid when enabled.

*Alarm Accuracy*

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Within 0.13% of the desired value

*Alarm Hysteresis*

Fixed @ 0.5% LEL

Alarm Time Delays

Will not exceed 2 seconds with all channels in alarm and the minimum time delay configured. Alarm delays can be programmed using software, and can be set as follows:

*Alert*

From 1 to 60 seconds in 1 second intervals

*Danger*

From 1 to 60 seconds in 0.5 second intervals or to the minimum alarm time delay

Operating  
Temperature

-20 °C to +65 °C (-22 °F to +149 °F)

Storage  
Temperature

-40 °C to +85 °C (-40 °F to +185 °F)

Humidity

95%, non-condensing

Dimensions (Height  
x Width x Depth)

*Monitor Module*

241.3 mm x 24.4 mm x 241.8 mm (9.50 in x 0.96 in x 9.52 in)

*I/O Module*

241.3 mm x 24.4 mm x 99.1 mm (9.50 in x 0.96 in x 3.90 in)

Weight

*Monitor Module*

0.82 kg (1.8 lb)

*I/O Module*

0.20 kg (0.44 lb.)

Rack Space

*Monitor Module*

1 full-height front slot

*I/O Module*

1 full-height rear slot

**CE Mark Directives**

EMC Directives

IEC 60533  
<Maritime>

Radiated Emissions

Conducted Emissions

DNV Std for Cert 2.4 (3.14 & 3.15)

ClassNK, Part 7, Chapter 1 (1.3)

IEC/EN 61000-6-2  
Emissions

*Electrostatic  
Discharge*

EN 61000-4-2

*CISPR II/22*

EN 55022

*Conducted  
Emissions*

EN 55011

*Radiated  
Susceptibility*

EN 61000-4-3

IEC/EN 61000-6-4  
Immunity

*Electrical Fast  
Transient*

EN 61000-4-4

*Conducted  
Susceptibility*

EN 61000-4-6

Low Voltage  
Directives

EN 61010-1

IEC 61010-1

#### **HAZARDOUS AREA APPROVALS**

Monitor

AEx nA IIC

Class I, Zone 2

Class I, Div 2, Groups A, B, C, D

T4 @  $-20\text{ }^{\circ}\text{C} \leq T_a \leq +65\text{ }^{\circ}\text{C}$  ( $-4\text{ }^{\circ}\text{F}$  to  $+150\text{ }^{\circ}\text{F}$ )

Sensor

*ATEX*



II 2 G Ex d IIB+H2 T2

SIRA 06ATEX1173X

$-40\text{ }^{\circ}\text{C} \leq T_a \leq +200\text{ }^{\circ}\text{C}$  ( $-40\text{ }^{\circ}\text{F} \leq T_a \leq +392\text{ }^{\circ}\text{F}$ )

*IEC*

II 2 G Ex d IIB+H2 T2

IECEX SIR 06.0053X

$-40\text{ }^{\circ}\text{C} \leq T_a \leq +200\text{ }^{\circ}\text{C}$  ( $-40\text{ }^{\circ}\text{F} \leq T_a \leq +392\text{ }^{\circ}\text{F}$ )

*North America*

CLASS 1, ZONE 1

AEx d IIB+H2 T2

FM 3021960

$-40\text{ }^{\circ}\text{C} \leq T_a \leq +200\text{ }^{\circ}\text{C}$  ( $-40\text{ }^{\circ}\text{F} \leq T_a \leq +392\text{ }^{\circ}\text{F}$ )

Remote Calibrator

*ATEX*



II 2 G c IIB+H2 T2

SIRA 06ATEX6234

$-40\text{ }^{\circ}\text{C} \leq T_a \leq +200\text{ }^{\circ}\text{C}$  ( $-40\text{ }^{\circ}\text{F} \leq T_a \leq +392\text{ }^{\circ}\text{F}$ )

*IEC*

II 2 G Ex d IIB+H2 T2

IECEX SIR 06.0053X

$-40\text{ }^{\circ}\text{C} \leq T_a \leq +200\text{ }^{\circ}\text{C}$  ( $-40\text{ }^{\circ}\text{F} \leq T_a \leq +392\text{ }^{\circ}\text{F}$ )

*North America*

Not Required

**SYSTEM PERFORMANCE APPROVALS**

Certified to

FM 6320

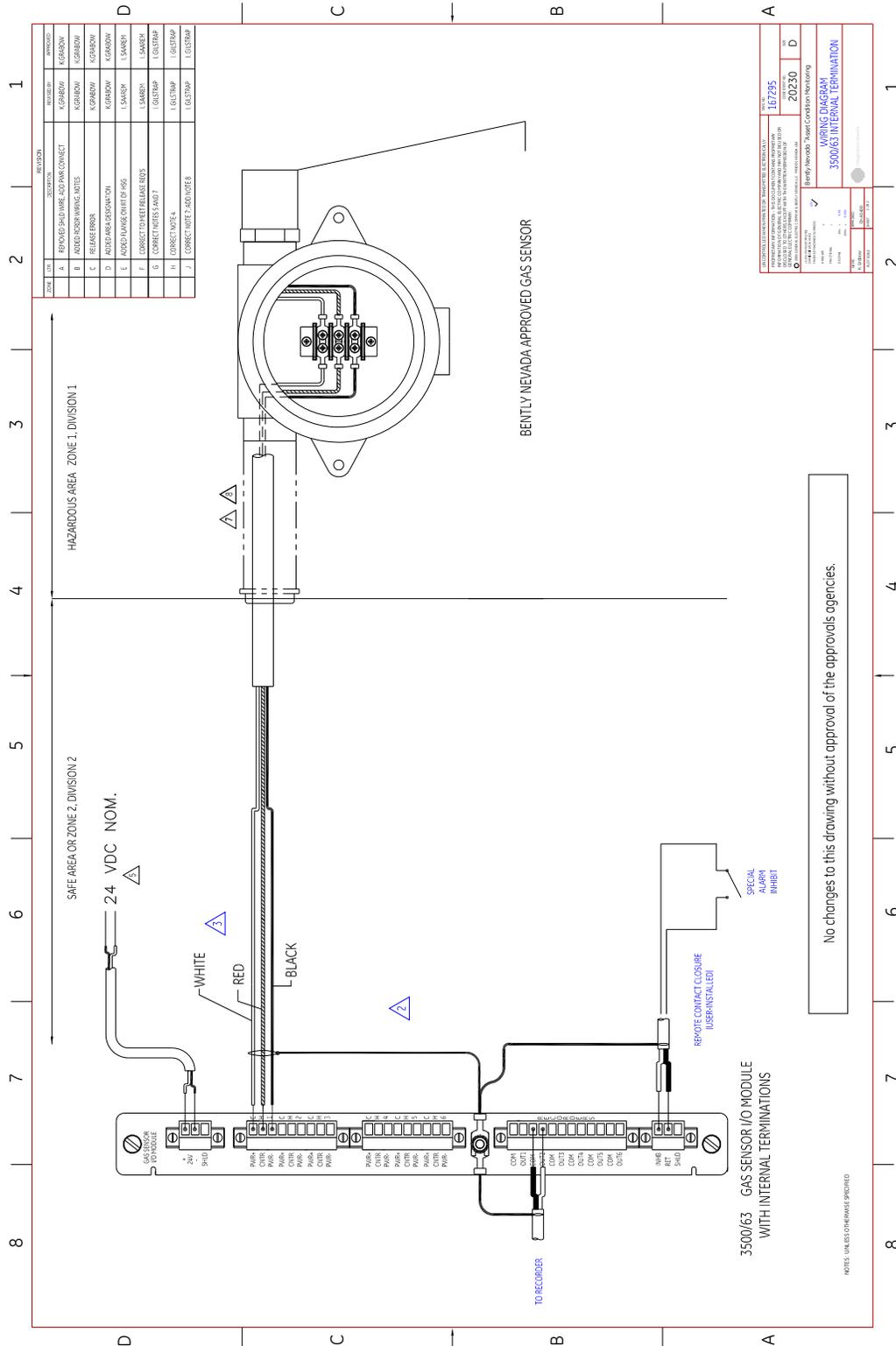
CSA C22.2 No. 152

ANSI / ISA—12.13.01

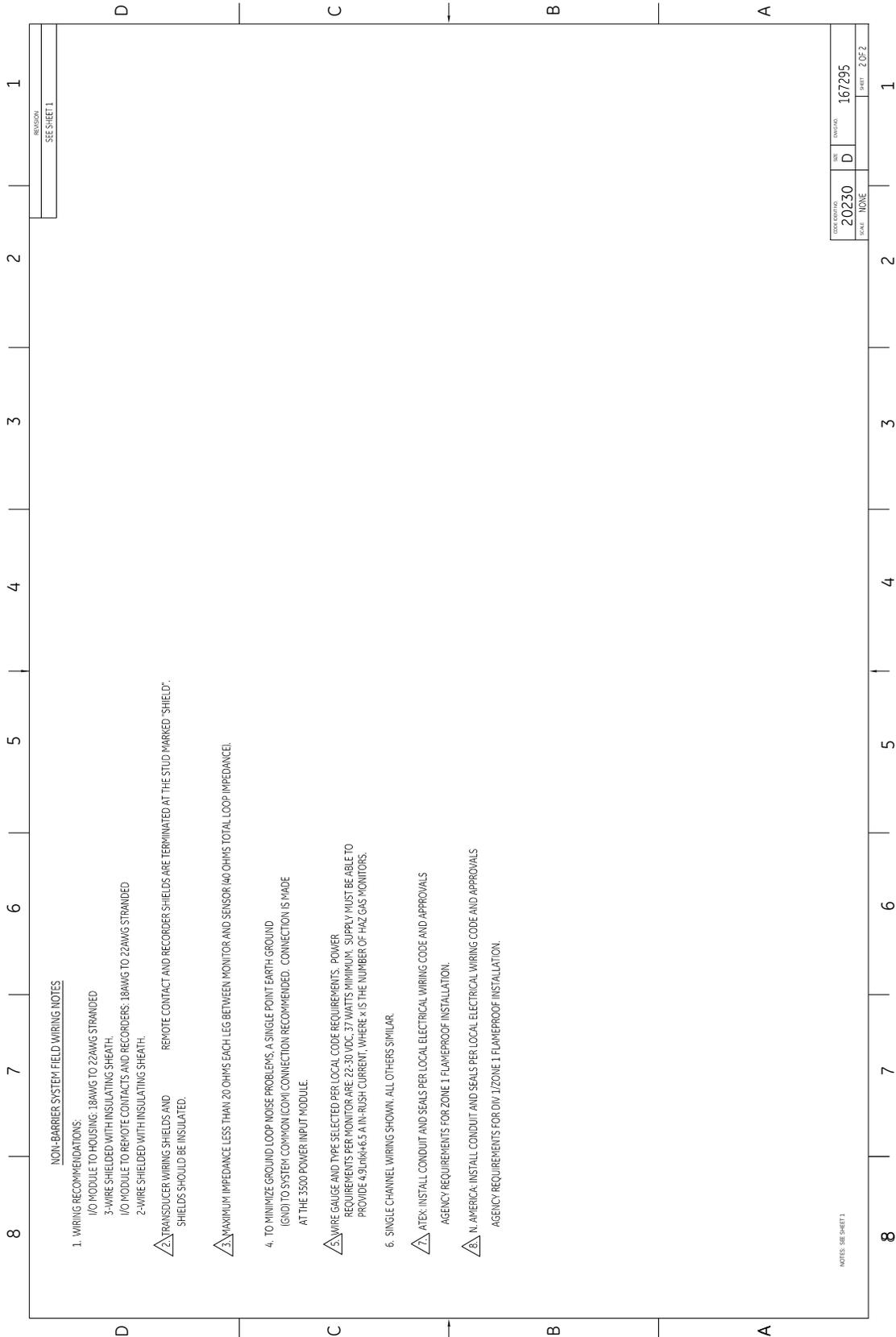
IEC 61779-1, -4

IEC 60079-29-1

# 15. Field Wiring Diagrams



# 3500/63 Hazardous Gas Detection System





# 3500/63 Hazardous Gas Detection System

