# Model TS4000

## Intelligent Sensor for Toxic Gas Detection



**Instruction Manual** **0307**



**MANTS4000**

**Part No.** **MANTS4000**
**Revision** **H/03-07**

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# About This Manual

This manual provides instructions for installing, operating, and maintaining the General Monitors (GM) TS4000 Toxic Gas Detector. The intended audience includes installation personnel, field service technicians, MODBUS programmers, and other technical staff involved in installing and using a TS4000.

## Format Conventions

Several format conventions are used throughout this manual for Notes, Cautions, Warnings, User Menus, and MODBUS notations. These conventions are described below.

### Notes, Cautions, and Warnings

**NOTE:** Notes provide supplementary detail such as exception conditions, alternate methods for a task, time saving tips, and references to related information.

**CAUTION:** These notices describe precautions to prevent hazardous conditions that may damage the equipment.

**WARNING:** These notices describe precautions to prevent hazardous conditions that may cause injury to people working with the equipment.

### Menu Formats

TS4000 User Menu keywords and LED digital display messages are shown in **bold** (example: **rSt**).

### MODBUS Register Formats

Hexadecimal numbers are used in MODBUS registers and are indicated by the addition of either “0x” in front of a number or “h” after the number (example: 0x000E or 000Eh, respectively).

## Other Sources of Help

General Monitors provides extensive documentation, white papers, and product literature for the company’s complete line of safety products, many of which can be used in combination with the TS4000. Many of these documents are available online at the General Monitors website at http://www.generalmonitors.com.

### Contacting Customer Support

For additional product information not contained in this manual, please contact General Monitors Customer Support. Refer to Section 8.0 for contact information.

# 1.0 Before Installation

## 1.1 System Integrity Verification

General Monitors' mission is to benefit society by providing safety solutions through industry leading products, services, and systems that save lives and protect capital resources from the dangers of hazardous flames, gases, and vapors.
General Monitors' safety products should be handled carefully and installed, calibrated, and maintained in accordance with the individual product instruction manuals.

To ensure operation at optimum performance, General Monitors recommends that prescribed maintenance procedures be followed.

## 1.2 Commissioning Safety Systems

Before power up, verify wiring, terminal connections, and stability of the mountings for all essential safety equipment including, but not limited to:

- Power supplies
- Control modules
- Field detection devices
- Signaling / output devices
- Accessories connected to field and signaling devices

After the initial power up and any factory specified warm-up period of the safety system, verify that all signal outputs, to and from the devices and modules, are within the manufacturers' specifications. Initial calibration / calibration checking / testing should be performed according to the manufacturers' recommendations and instructions.
Proper system operation should be verified by performing a full, functional test of all component devices of the safety system, ensuring that the proper alarm levels occur.

Fault / Malfunction circuit operations should be verified.

## 1.3 Notes and Warnings

**WARNING:** The TS4000 detects many extremely toxic gases. Exposure to such gases may result in sickness or death.

**WARNING:** The TS4000 contains components that can be damaged by static electricity. In order to avoid static electricity, special care must be taken when wiring the system to ensure that only the connection points are touched.

**WARNING:** The TS4000 is rated Explosion Proof (XP) and Intrinsically Safe (IS) for use in hazardous locations.

**WARNING:** Conduit seals must be used to preserve the explosion proof safety of the TS4000 and help prevent ingress of water from the conduit systems.

**WARNING:** Silicone Room Temperature Vulcanization (RTV) is not an approved moisture barrier. If used, damage to internal components will arise.

**WARNING:** Substitution of electrical components within the TS4000 may impair intrinsic safety.

**WARNING:** Damage to the TS4000 housing where any internal components or protective seals are broken, compromises the safety and usability of the device. A TS4000 with a damaged or open housing should not be used in a hazardous environment. Such damage includes fractures in the housing, cracks in any internal components, or cracks in the protective seals. Destruction of the electrochemical cell (ECC) will not affect the basic safety of the TS4000; however, the overall functionality of the TS4000 may be severely compromised.

**WARNING:** Do not use a TS4000 with a damaged housing in a hazardous environment.

**IMPORTANT:** Each TS4000 is shipped with an un-installed electrochemical sensor, to ensure that a fresh sensor is used during initial start-up. **DO NOT** install the electrochemical cell into the TS4000 until you are ready to apply power to the system. Since the TS4000 is not factory calibrated to a specific cell, an initial field calibration must be completed when installing this unit.

## 1.4 Glossary of Terms

**Table 1: Glossary of Terms**

| Term / Abbreviation | Definition |
|---|---|
| **A** | Amps |
| **AC** | Alternating Current |
| **AWG** | American Wire Gauge |
| **Baud Rate** | The number of signal level changes per second in a line, regardless of the information content of those signals |
| **bps** | Bits per second |
| **BU** | Base Unit |
| **Cable Armor** | Cable having interlocked or corrugated armor where it is essential to provide positive grounding of cable armor |
| **Cable Screen** | Mesh surrounding a cable |
| **COM** | DC Ground |
| **CR** | Control Room |
| **CRC** | Cycle Redundancy Check |
| **DC** | Direct Current |
| **DCS** | Distributed Control System |
| **De-Energized** | To disconnect from a power source |
| **ECC** | Electrochemical Cell |
| **EEPROM** | Electrically Erasable Programmable Read-Only Memory |
| **EMI** | Electromagnetic Interference |

| Term / Abbreviation | Definition |
|---|---|
| **ENERGIZED** | To apply voltage or energy |
| **FS** | Full Scale |
| **GM** | General Monitors |
| **Hex** | Hexadecimal Number |
| **I / O** | Input / Output |
| **IM** | Interface Module |
| **Instrument Earth** | Grounded using a grounding strap |
| **Intrinsically Safe** | Intrinsic safety is a protection concept employed in potentially explosive atmospheres |
| **IS** | Intrinsically Safe |
| **Latching** | Refers to relays remaining in the “on” state even after the “on” condition has been removed |
| **LED** | Light Emitting Diode |
| **mA** | Milli-Amps refers to 1/1000 of an Amp |
| **Master** | Controls one or more devices or processes |
| **MODBUS** | Master-slave messaging structure |
| **N/A** | Not Applicable |
| **NC** | Normally Closed |
| **NO** | Normally Open |
| **Non-Latching** | Refers to relays being reset to the initial state after “on” condition has been removed |
| **NPT** | National Pipe Thread |
| **OV Return** | Over voltage return |
| **OVDC** | Power Supply Common Ground |
| **Oxidation** | Combining with Oxygen |
| **PCB** | Printed Circuit Board |
| **PLC** | Programmable Logic Controller |
| **ppm** | Parts per million |
| **Reduction** | A chemical reaction in which one or more electrons are transferred from one atom or molecule to another |
| **RFI** | Radio Frequency Interference |
| **RMS** | Root-Mean-Square |
| **ROM** | Read Only Memory |
| **RTV** | Room Temperature Vulcanization |
| **Safety Earth** | Grounded to the earth |
| **Slave** | One or more devices or processes controlled by a master controller |
| **SMT** | Surface Mount Technology |
| **SPAN Value** | The programmed range of measurable parts per million |
| **TB** | Terminal Block |
| **V** | Volts |
| **VAC** | Volts Alternating Current |
| **VDC** | Volts Direct Current |
| **XP** | Explosion Proof |
| **Zero or Zeroing** | A process that eliminates background gas fluctuations during Calibration or Gas Check Modes |

# 2.0 Product Overview

## 2.1 General Description

The TS4000 is a +24VDC-powered toxic gas detector comprised of a Base Unit, Interface Module, and Electrochemical Cell (sensor) – refer to Sections 2.4, 2.5, and 2.6, respectively, for more information. The TS4000 supports a wide range of General Monitors' approved electrochemical cells, and operates as a universal toxic gas detector by simply replacing and calibrating sensors. The microprocessor-based electronics of the Interface Module process information at the sensor site and communicate detected gas values to the Base Unit for data control and display.

The TS4000 is certified as explosion proof with intrinsically safe outputs for use in hazardous locations. It can also be used for general-purpose, non-hazardous applications.

## 2.2 Features and Benefits

**Microprocessor-Based Electronics**: monitors fault conditions, processes input signals from the electrochemical cell, and provides outputs in the form of display codes and analog / digital signals.

**One Person Adjustment-Free Calibration**: using a magnet to initiate the calibration sequence, apply the gas, and wait for the display to indicate that the unit has completed the calibration. No user adjustments are required.

**Three Digit, Seven Segment LED**: indicates gas presence, operational modes, fault codes and calibration cues.

**Two Discrete LED Indicators**: indicates alarm and warning conditions.

**4-20 mA Analog Output**: transmits fault, calibration, and gas concentration levels to a remote display, computer, or other device such as an alarm, dispensing device, or master controller.

**Dual Redundant MODBUS RS-485 User Interface**: provides the ability to operate the TS4000 remotely, using 2 redundant channels. This interface allows the user to remotely change the alarm and warning relay settings, clear selected faults, issue calibration requests, enable gas check, issue end / abort commands, clear error counters, change baud rates, and change formats for serial communication lines.

## 2.3 Applications

The TS4000 Intelligent Sensor provides toxic gas detection for a wide range of applications, including, but not limited to the following:

**Table 2: Sample Industry Applications**

| Industries | Sample Applications |
|---|---|
| **Petroleum / Petro-Chemicals** | Refining, processing, storage, and liquefaction |
| **Chemicals / Pharmaceuticals** | Agricultural fertilizer production, ammonia plants, Dyes, inks, film processing, pigments, gas storage, refrigerants, propellants, and a wide range of toxic gases used in the manufacture of pharmaceuticals |
| **Automotive** | Plating processes and engine test cells |
| **Primary Metals** | Steel plants, aluminum plants, smelting, pickling, machining, and finishing |
| **Pulp and Paper** | Bleaching |
| **Utilities** | Coal gasification, incineration, and flue gas |
| **Water and Waste** | Chlorinating, sewage sludge and manhole entry |

## 2.4 Base Unit

The TS4000 Base Unit provides the display / control device for the entire TS4000. The Base Unit is built on the proven Intelligent Sensor platform and incorporates the following key features:

- Bright LED Digital Display (outdoor readable)
- MODBUS Communications
- High Rating Relays
- One Activation Point for Settings and Calibration
- Simplified Wiring and Field Connections
- Standard S4000 Platform Calibration Prompts
- Remote Sensor Placement Capability
- Remaining Sensor Life Indicator
- Low Total Cost of Ownership

**Figure 1: Base Unit**

## 2.5 Interface Module

The TS4000 Interface Module is encapsulated in an anodized aluminum housing enabling sensor information to be processed at the point of detection. The TS4000 provides a 4-20mA output signal proportional to 0 to 100% FS gas concentration at the Base Unit.

The Interface Module includes the following features:

- Galvanically isolated Intrinsic Safety Barrier to the internal electronics of the Interface Module
- Electrical conditioning circuitry for the electrochemical cell
- Mechanical and electrical interface for the electrochemical cell
- Explosion proof conduit seal from the Base Unit to the Interface Module
- Explosion proof housing for the Intrinsic Safety Barrier
- One I/O pair for digital serial communication to and from the Base Unit and Interface Module
- One +24VDC / COM GND pair for power into the Interface Module

**Monitored Faults:** data memory failure, failed to zero (during calibration), and failed to calibrate.

For engineering specifications covering the electrochemical cell and control electronics refer to Section 9.5.

**Figure 2: Interface Module**

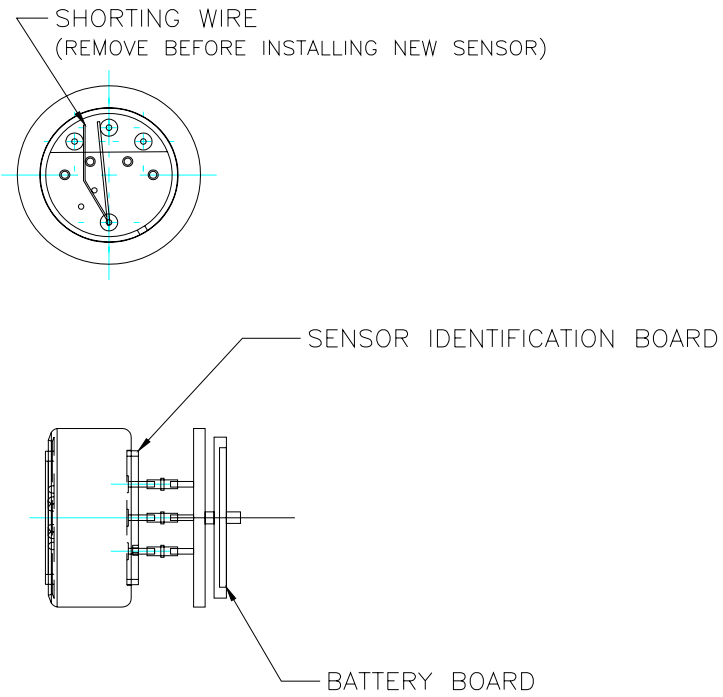
## 2.6 Electrochemical Cell

The TS4000 uses three electrode electrochemical cells joined to a sensor identification board (Figure 3) to provide the most stable and accurate gas detector possible.

**NOTE:** The Oxygen deficiency assembly contains only two electrodes.

Gas diffusing into the electrochemical cell reacts at the sensing electrode by reduction or oxidation depending on the type of sensor being used. The counter electrode acts to balance the reaction at the sensing electrode. If oxidation occurs at the sensing electrode, oxygen is reduced to form water at the counter electrode. If the sensing electrode reaction is a reduction, the counter electrode reaction is reversed and water is oxidized.

**Figure 3: Electrochemical Cell Assembly**




**NOTE:** The Oxygen sensor does not have an identification board. However, the TS4000 will automatically configure a fully functional Oxygen cell.

**NOTE:** For electrochemical cell shelf life information, consult the manufacturer's documentation.

# 3.0 Installation

**CAUTION:** The TS4000 contains components that can be damaged by static electricity. Always wear grounding apparel when handling or installing the unit.

**CAUTION:** Only skilled and trained personnel must perform installation and maintenance.

The basic steps in a typical installation are listed in the table below. The installation process may vary depending on the exact site configuration.

**Table 3: Installation Overview**

| Installation Step | | Detailed Description Section Number |
|---|---|---|
| **1** | Preparing for the installation | 3.1 and 3.2 |
| **2** | Installing the device | 3.3 |
| **3** | Mounting the TS4000<br>Steps 4 and 5 can be switched if attaching the cabling before mounting the Base Unit is easier | 3.4 |
| **4** | Installing cabling between the TS4000 and control room devices (including power, 4-20 mA, and MODBUS) | 3.5 |
| **5** | Powering on the TS4000 | 3.6 |

## 3.1 Unpacking the Equipment

All equipment shipped by General Monitors is packaged in shock absorbing containers that protect against physical damage. The contents should be carefully removed and checked against the enclosed packing list.

If any damage has occurred or there is any discrepancy in the order, please contact General Monitors. Refer to Section 8.0 for contact information.

**NOTE:** Each TS4000 is completely tested at the factory; however, each electrochemical sensor must be installed and calibrated, and a system check completed prior to start-up, to guarantee system integrity.

## 3.2 Preparing for the Installation

The TS4000 has unique installation procedures for either local or remote hardware configurations. Before installation, evaluate the gas leak locations and other conditions at the test site and configure the unit for that particular need.

### 3.2.1 Required Tools

The following tools are required to install the TS4000:

**Table 4: Required Tools**

| Tool | Use |
|---|---|
| **5 mm Allen head wrench** | To remove the TS4000 Base Unit enclosure lid (included) |
| **Flat-head screwdriver 3/16 inch (5 mm) maximum** | To connect wires into the Terminal Block (included) |
| **Adjustable wrench** | To make conduit and cable gland connections (not included) |

### 3.2.2 Detection Location Guidelines

There are no standard rules for detector placement since the optimum sensor location is unique for each application. Before installing the TS4000, check the conditions at the installation site to make this determination. The following guidelines can assist in determining the best possible placement of the TS4000:

**To Find a Suitable Installation Location**

1. Locate the TS4000 near potential gas leak sources and away from excessive heat, light, wind, dust, water, vibration, shock, and radio frequency interference (RFI). For Environmental Specifications, refer to Section 9.5.
2. Ensure the installation location has sufficient space to accommodate the Base Unit, Interface Module, electrochemical cell, and all necessary cabling.
3. Mount the TS4000 with the electrochemical cell pointing down and in an easily accessible location for reading of the LED display and calibration checks.

**WARNING:** Operation above or below temperature limits may cause unstable readings, resulting in false alarms or alarm failures. For Environmental Specifications, refer to Section 9.5.

Electrochemical cells may be affected by exposure to certain gases. While General Monitors uses extremely selective cells, some cross-sensitivity may occur. The more important combinations to keep in mind are listed in the table below:

**Table 5: Gas Combination Table**

| Cell Type | Gas Combinations | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Carbon Monoxide** | **Carbon Monoxide** | | **Ethylene** | | **Hydrogen** | | **Nitric Oxide** | |
| | Applied | Indicates | Applied | Indicates | Applied | Indicates | Applied | Indicates |
| | 100 ppm | 100 ppm | 100 ppm | 75 ppm | 100 ppm | 60 ppm | 100 ppm | 20 ppm |
| **Chlorine** | **Chlorine** | | **Nitrogen Dioxide** | | | | | |
| | Applied | Indicates | Applied | Indicates | | | | |
| | 100 ppm | 100 ppm | 100 ppm | 120 ppm | | | | |
| **Chlorine Dioxide** | **Chlorine Dioxide** | | **Nitrogen Dioxide** | | | | | |
| | Applied | Indicates | Applied | Indicates | | | | |
| | 100 ppm | 100 ppm | 100 ppm | 120 ppm | | | | |
| **Hydrogen Chloride** | **Hydrogen Chloride** | | **Sulfur Dioxide** | | | | | |
| | Applied | Indicates | Applied | Indicates | | | | |
| | 100 ppm | 100 ppm | 100 ppm | 35 ppm | | | | |
| **Hydrogen Sulfide** | **Hydrogen Sulfide** | | **Sulfur Dioxide** | | | | | |
| | Applied | Indicates | Applied | Indicates | | | | |
| | 100 ppm | 100 ppm | 100 ppm | 20 ppm | | | | |
| **Nitric Oxide** | **Nitric Oxide** | | **Hydrogen Sulfide** | | **Nitrogen Dioxide** | | | |
| | Applied | Indicates | Applied | Indicates | Applied | Indicates | | |
| | 100 ppm | 100 ppm | 100 ppm | 35 ppm | 100 ppm | 25 ppm | | |
| **Nitrogen Dioxide** | **Nitrogen Dioxide** | | **Chlorine** | | | | | |
| | Applied | Indicates | Applied | Indicates | | | | |
| | 100 ppm | 100 ppm | 100 ppm | 90 ppm | | | | |
| NOTE: All values are approximations based on experimental data. | | | | | | | | |

**WARNING:** When operating the TS4000 under the above conditions, all personnel operating and maintaining the units should be notified of the cross-sensitivity issues that are present at the site.

**CAUTION:** Do not paint the TS4000 assemblies.

If the Base Unit is painted, the LED display cannot be read.

If the Interface Module is painted, the gas is not able to diffuse into the sensor.

Ammonia, Chlorine, Chlorine Dioxide, and Hydrogen Chloride cell types may be sensitive to humidity variation (See Table 42 for Environmental Specifics).

## 3.3 Installation Overview

The TS4000 is shipped without the electrochemical cell installed. The electrochemical cell must be installed into the Interface Module and calibrated for proper operation. For wiring connections, refer to Section 3.5. For calibration instructions, refer to Section 4.9.

Once correctly installed, the TS4000 requires little or no maintenance other than periodic calibration checks to ensure system integrity. For optimum performance, General Monitors recommends establishing a calibration check schedule and that the complete system, including all alarm circuitry, is tested annually.

The mounting and overall dimensions for the TS4000 should be used when making installation determinations. For Mechanical Specifications, refer to Section 9.5.

### 3.3.1 Intrinsic Safety Barrier

The TS4000 has an Intrinsic Safety Barrier within the Interface Module. The Intrinsic Safety Barrier allows the user to change (hot swap) the electrochemical cell without powering down the TS4000 and without de-classifying the area. The TS4000 can be used in a hazardous area without additional hardware.

### 3.3.2 Electrochemical Cell Maintenance

The removal of particulate matter from the electrochemical cell must be done using clean water only. Solvents must never be used. The electrochemical cell must be thoroughly dried before refitting it to the Interface Module. Compressed air may be used to blow off the electrochemical cell, however, never blow compressed air directly into or near the face of an electrochemical cell.

**WARNING:** To avoid injury, use extreme caution when using compressed air.

Some typical items to check during maintenance examinations are:

- Electrochemical cell mounting, to see that it is secure
- Electrochemical cell cleanliness, to see that it is clear of oil, water, dust, or paint
- Cable connections for tightness and possible damage
- All detector placements are up-to-date with the layout of the facility
- If the facility has been altered, placement may need to be adjusted

## 3.4 Mounting Instructions

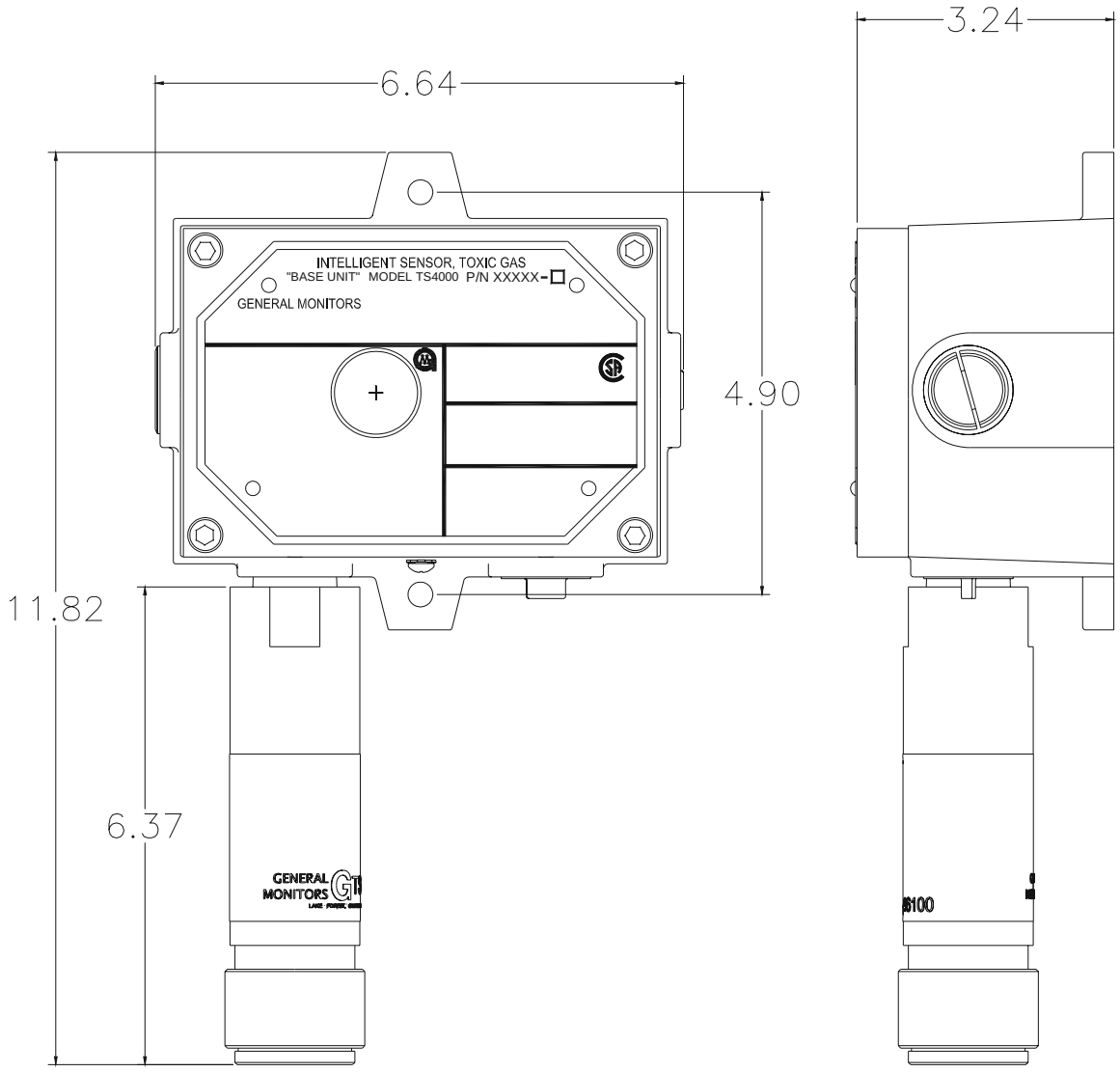
Mount the TS4000 using the boltholes on the Base Unit. For easy access and readability, the Base Unit may be mounted away from the Interface Module (remote configuration).

**NOTE:** For remote configurations, an additional explosion proof junction box must be used. Refer to Section 3.4.3 for remote mounting information and Section 9.5.1 for junction box information.

### 3.4.1 Mounting Dimensions

The following figure shows the mounting dimensions for the TS4000.

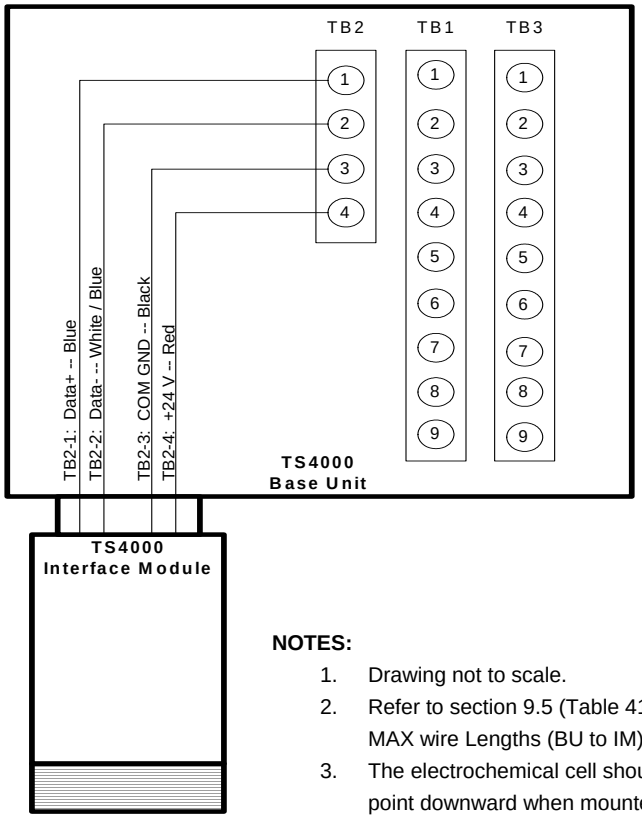
**Figure 4: Mounting Dimensions**



### 3.4.2 Mounting – Local Configuration

Local configuration refers to the configuration where the Base Unit and Interface Module are placed in the same location. This is commonly referred to as a stand-alone configuration.

**Figure 5: Local Configuration Diagram**




**NOTES:**

1. Drawing not to scale.
2. Refer to section 9.5 (Table 41) for MAX wire Lengths (BU to IM).
3. The electrochemical cell should always point downward when mounted).

Before mounting, review the following:

- Detection Location Guidelines listed in Section 3.2.2.
- Environmental Specifications listed in Section 9.5.

**To Mount the TS4000 – Local Configuration**

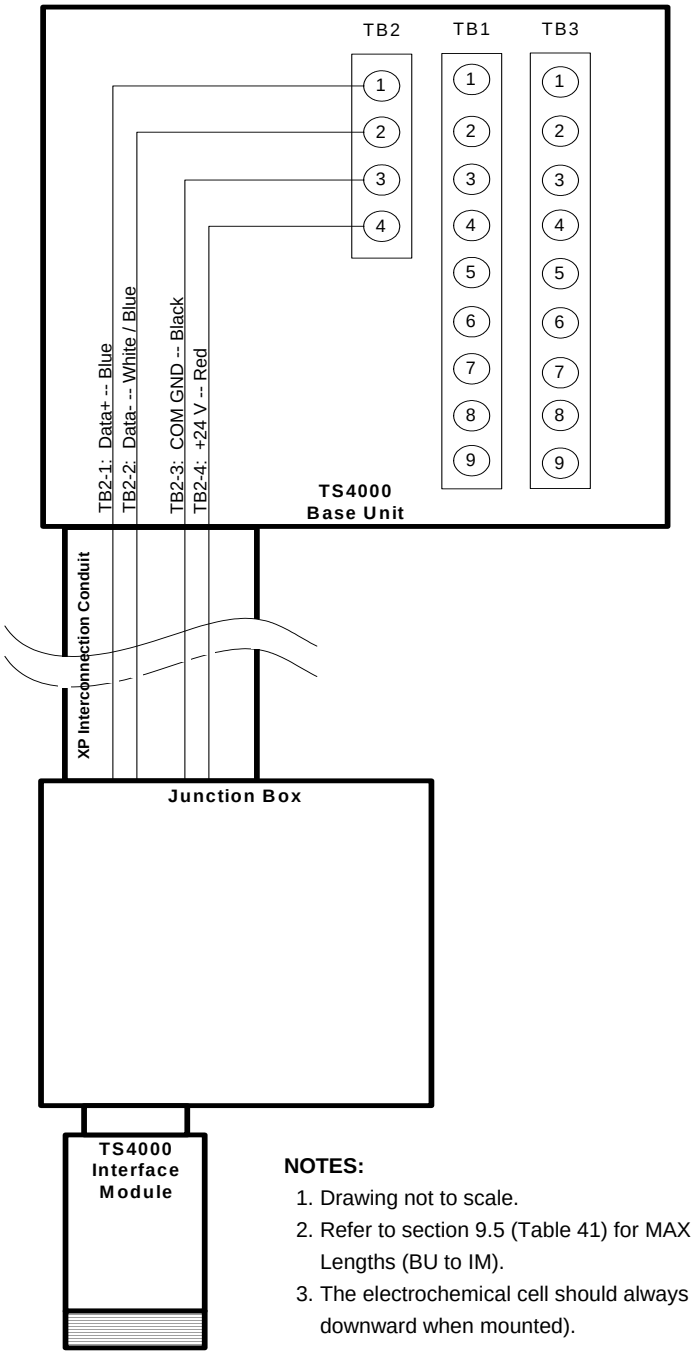
1. Mount the TS4000 Base Unit vertically to reduce the possibility of dirt and dust building up on the window.
2. Ensure the open slots of the gas passage are straight up and down to enable the gas to rise up and through the electrochemical cell.
3. Using the two boltholes, mount the TS4000 Base Unit to a stable surface or wall.

**NOTE:** Duct Mounting Kits are available from General Monitors. For more information, contact General Monitors Customer Support. For contact information, refer to Section 8.0.

### 3.4.3 Mounting – Remote Configuration with External Junction Box

In addition to the standard local configuration – Base Unit and Interface Module mounted in the same location – the TS4000 also supports remote placement of the Interface Module using a CSA certified external junction box. Refer to Section 9.5.1 for compatible junction boxes.

**Figure 6: Remote Configuration Diagram**




**NOTES:**

1. Drawing not to scale.
2. Refer to section 9.5 (Table 41) for MAX wire Lengths (BU to IM).
3. The electrochemical cell should always point downward when mounted).

Before mounting, review the following:

- Detection Location Guidelines listed in Section 3.2.2.
- Environmental Specifications listed in Section 9.5.

**To Mount the TS4000 – Remote Configuration**

1. Mount the TS4000 Base Unit vertically to reduce the possibility of dirt and dust building up on the display window.
    - Using the two boltholes, mount the TS4000 Base Unit to an appropriate surface or wall.
    - Using the available boltholes, mount the remote junction box to a stable surface or wall.
2. Connect the explosion proof conduit to the Base Unit and remote junction box.
    - Connect the Interface Module to the remote junction box.
    - Ensure the Interface Module is pointing down for maximum exposure.

**WARNING:** To maintain the explosion proof integrity of the TS4000, an explosion proof conduit must be used for remote configurations.

## 3.5 Wiring Connections

The red and black wires at the base of the Interface Module provide power for operation. The red wire is the positive lead and the black wire is the negative lead. The blue and white / blue wires are for serial data communication.

**NOTE:** General Monitors recommends that a four-wire shielded cable be used for making power and / or serial communication connections on the TS4000.

**To Make the Wiring Connections**

1. Ensure the Base Unit chassis is connected to chassis ground or connected to the cable shield, which is connected to chassis ground at the controller.

    Connect the black wire to the Ground Terminal TB2-3.

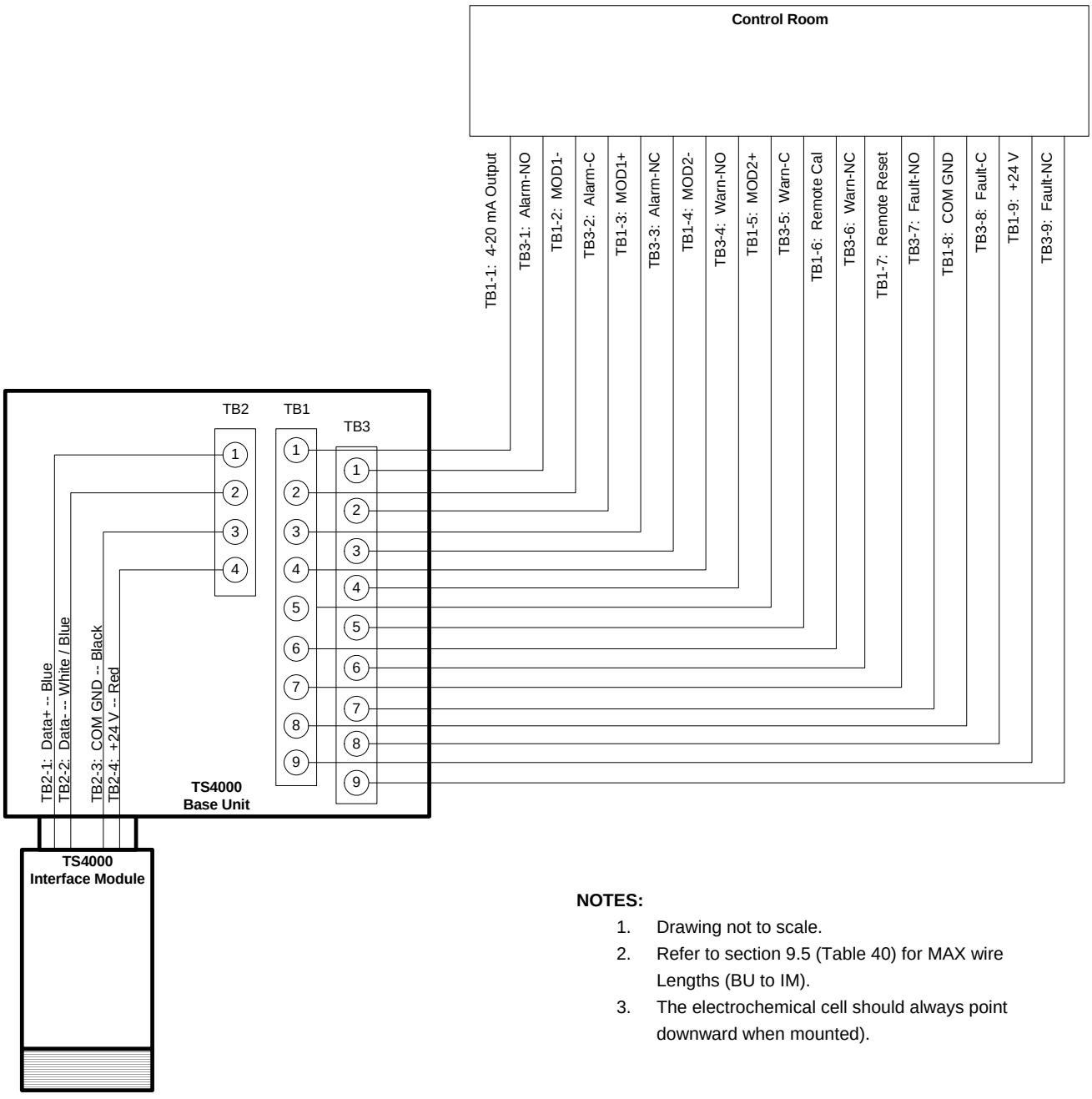
    Connect the blue wire to the Data Terminal TB2-1 and connect the white / blue wire to the Data Terminal TB2-2.

    Connect the red wire to the +24VDC Terminal TB2-4.

In order to prevent accidental shut down and ensure continual operation of the TS4000 a power switch is not included.

**NOTE:** Power **must** remain disconnected until all wiring connections are made. In all cases, the cable run should be as short as possible. Refer to Section 9.5 for the recommended distance between the TS4000 and the power supply

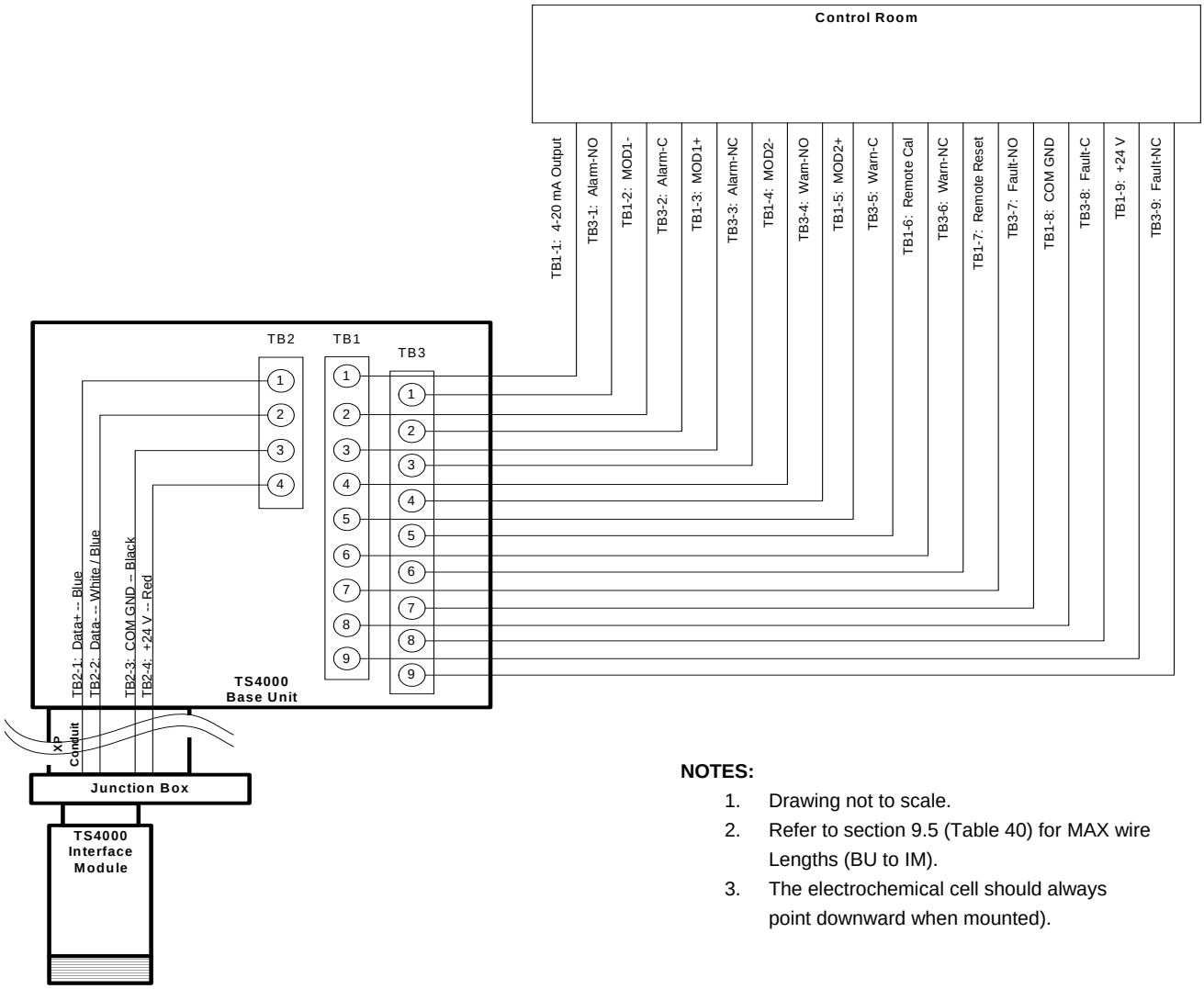
**Figure 7: Wiring Diagram – Local Configuration**




**NOTES:**

1. Drawing not to scale.
2. Refer to section 9.5 (Table 40) for MAX wire Lengths (BU to IM).
3. The electrochemical cell should always point downward when mounted).

**Figure 8: Wiring Diagram – Remote Configuration**




**NOTES:**

1. Drawing not to scale.
2. Refer to section 9.5 (Table 40) for MAX wire Lengths (BU to IM).
3. The electrochemical cell should always point downward when mounted).

### 3.5.1 Wiring Safety Notices

**WARNING:** Under **NO** circumstances should equipment be connected or disconnected when under power. This is against hazardous area regulations and may lead to serious damage to the equipment. Equipment damaged in this manner is not covered under warranty.

**WARNING:** Connect the TS4000 TB1-8 connector to the power supply DC Ground (COM) first, before connecting other devices. The DC Ground (COM) should also be disconnected last. The power supply must remain OFF until all cabling is completed. For detailed instructions, refer to power supply manual.

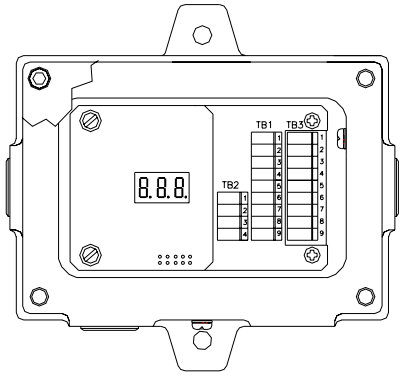
**CAUTION:** Avoid close proximity to cables associated with radio transmitters, welders, switch mode power supplies, inverters, battery chargers, ignition systems, generators, switch gear, arc lights, and other high frequency or high power switching process equipment.

### 3.5.2 Base Unit Wiring

Figure 9 shows the TS4000 terminal block connectors TB1, TB2, and TB3 that hold the wiring that connects the TS4000 to local alarms and control room equipment. You must remove the cover from the TS4000 Base Unit to access these connectors. The inside cover includes a label listing the function of each connector location.

To ensure safety, install cabling from the TS4000 to DC Ground on the power supply first, then the MODBUS and Analog device wiring connections. The +24VDC signal on the power supply must be connected last. Power to the TS4000 must remain **OFF** until all wiring is completed and the start-up readiness checklist has been verified; refer to Section 3.6.1.

**Figure 9: Terminal Block Connector Pinouts**




| TB2 | Signal | TB1 | Signal | TB3 | De-Energized | Energized |
|---|---|---|---|---|---|---|
| 1 | Data+ | 1 | 4-20 mA Output | 1 | Alarm-NC | Alarm-NO |
| 2 | Data- | 2 | MOD1- | 2 | Alarm-C | Alarm-C |
| 3 | COM GND | 3 | MOD1+ | 3 | Alarm-NO | Alarm-NC |
| 4 | +24VDC | 4 | MOD2- | 4 | Warn-NC | Warn-NO |
| | | 5 | MOD2+ | 5 | Warn-C | Warn-C |
| | | 6 | Remote Cal | 6 | Warn-NO | Warn-NC |
| | | 7 | Remote Reset | 7 | N/A | Fault-NO |
| | | 8 | COM GND | 8 | N/A | Fault-C |
| | | 9 | +24VDC | 9 | N/A | Fault-NC |

**CAUTION:** Contact with PCB components should be avoided to prevent damage by static electricity. All wire connections are made to the terminal blocks.

The following procedure is for attaching wiring to connectors in the TS4000 terminal blocks TB1, TB2, and TB3.

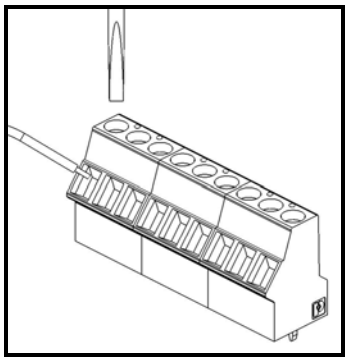
To Attach Wiring to a TS4000 Terminal Block using Spring Type Terminals:

1. Remove the Base Unit enclosure cover by loosening the four captive screws and lifting the cover straight up.
2. In the terminal block connector, insert a screwdriver into the orange tab and press down, opening the terminal.
3. Insert the 0.43-inch stripped wire into the terminal and release the orange tab to clamp the wire in the terminal. GENTLY tug on the wire to make sure it is locked securely in place.

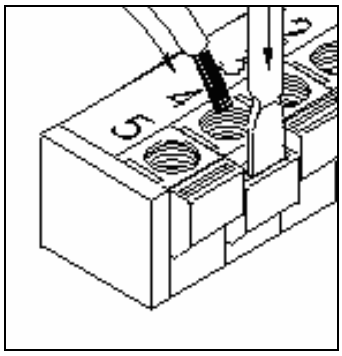
To Attach Wiring to a TS4000 Terminal Block using Screw Type Terminals:

1. Remove the Base Unit enclosure cover by loosening the four captive screws and lifting the cover straight up.
2. In the terminal block connector, use a screwdriver to loosen the top screw counter clockwise.
3. Insert the 0.43-inch stripped wire into the terminal and tighten the top screw clockwise. GENTLY tug on the wire to make sure it is locked securely in place.

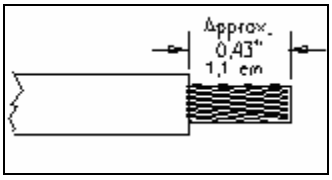
**Figure 10: Terminal Block Connector Detail**



**Screw Type terminal**



**Spring Type terminal**




## 3.5.3 Connecting to the Power Supply DC Ground

The TS4000 operates on nominal power of +24 VDC. A primary DC power source must be connected.

**NOTE:** In all cases, the cable run should be as short as possible. Refer to Section 9.5 for the recommended cable distances between the TS4000 and the power supply.

**To Connect the TS4000 to DC Ground**

1. Connect the Base Unit terminal block TB1-8 to the power supply Common (OVDC).
2. If the TS4000 is being used with a +24V power supply and an industrial analog to digital (A/D) converter, you must connect the negative supply (COM) of all three devices.

3. To make ground connections to GM devices, refer to the following table:

**Table 6: TS4000 to GM Display Device DC Ground Connections**

| From | To | |
|---|---|---|
| **TS4000** | **TA102A** | **TA502A** |
| TB1-8<br>COM (OVDC) | Rear Pin<br>30d or 30z | Rear Pin<br>30d or 30z |

## 3.5.4 Connecting Control Room Devices to the TB1 Block

The TB1 terminal block supports the connection from the TS4000 Base Unit to a power supply. It also has several types of output signal connections that can be forwarded to readout modules, display devices, and other control room equipment.

**Table 7: TS4000 Terminal Block TB1 Pinouts**

| TB1 Position | Function |
|---|---|
| 1 | 4-20mA Output |
| 2 | MOD1- |
| 3 | MOD1+ |
| 4 | MOD2- |
| 5 | MOD2+ |
| 6 | Remote CAL |
| 7 | Remote Reset |
| 8 | COM GND |
| 9 | +24VDC Power |

For information on the maximum recommended cable runs between the Base Unit and the Interface Module, refer to Section 9.5.

**To Connect an Analog Device to the TB1 Block**

1. Fasten the analog device wire to connector TB1, position 1.
2. To make analog connections to GM display devices, refer to the following table.

**Table 8: Connection to GM Display Device 4-20mA Connections**

| From | To | |
|---|---|---|
| **TS4000 Base Unit** | **TA102A** | **TA502A** |
| TB1-1 4-20mA Output | Rear Pin 26d or 26z | Rear Pin 26d or 26z |

**NOTE:** To make output signal connections to display devices, refer to the specific manual for that device. If the 4-20mA signal is not used, the signal wire must be connected to Ground (Terminal TB1-8).

**To Connect a MODBUS Device to the TB1 Block**

The TS4000 TB1 terminal block supports signals for two MODBUS channels. You can attach cabling to connect these signals to MODBUS-compatible devices in a control room using the TS4000 signal pinouts shown in the following table:

**Table 9: Connection to Control Room MODBUS Devices**

| From | To | From | To |
|---|---|---|---|
| **TS4000** | **First Device** | **TS4000** | **Second Device** |
| TB1-2 MOD1- | Refer to the documentation | TB1-4 MOD2- | Refer to the documentation |
| TB1-3 MOD1+ | Refer to the documentation | TB1-5 MOD2+ | Refer to the documentation |

**To Connect a Device for Remote Calibration or Relay Reset to the TB1 Block**

Connectors TB1-6 and TB1-7 can be cabled to a separate device to provide the ability to remotely calibrate the TS4000 and reset the TS4000 relays. To view the TS4000 LED display and use the remote calibration switch effectively, the device must be mounted within view of the display.

**Table 10: Connections to Remote Calibration and Relay Reset Devices**

| From | To |
|---|---|
| **TS4000** | **MODBUS Device** |
| TB1-6 Remote CAL | Refer to the device documentation |
| TB1-7 Remote Reset | Refer to the device documentation |

## 3.5.5 Connecting to the +24VDC Power Supply

The TS4000 operates on +24 VDC power. You must connect the TS4000 to a primary DC power source.

For Information on the maximum distance between the TS4000 and the control room equipment, refer to Section 9.5. Each cable run should be as short as possible.

**WARNING:** To protect the system from shorting, and to ensure the safety of installation personnel, the TS4000 +24VDC wire must be the **last** wire connected and the **first** wire disconnected. In addition, the power supply **must** remain **OFF** until all other cabling has been completed; refer to the power supply manual for instructions.

**NOTE:** The TS4000 is designed to continuously monitor the presence of hazardous gas leaks. A power switch is not included for the TS4000 to prevent accidental system shut down. Powering the system on and off is done from the power supply. An internal diode protects the TS4000 in the event of inadvertent power supply reversal.

**To Connect the TS4000 to the Power Supply +24VDC**

1. Connect the TS4000 TB1-9 connector to the power supply +24VDC terminal. The power supply manual for the location of this terminal.
2. For power connections to GM device power supplies, review the following table.

**Table 11: TS4000 to GM Display Device +24VDC Connections**

| From | To | |
|---|---|---|
| **TS4000** | **TA102A** | **TA502A** |
| TB1-9 +24 VDC | Rear Pin 28d or 28z | Rear Pin 28d or 28z |

## 3.5.6 Connecting Alarm Relay Devices to the TB3 Block

Terminal block TB3 contains the connections for the relay contacts for alarm equipment such as sirens; it is included on an optional circuit board module. The functioning of the Alarm and Warning relay connections varies depending on whether the relays are configured as Energized or De-Energized. For more information, refer to Sections 4.6.2 and 4.6.3.

**NOTE:** The default TS4000 configuration menu setting for the Warning and Alarm relays is De-Energized. The Fault relay is normally Energized. It will change state after power-up.

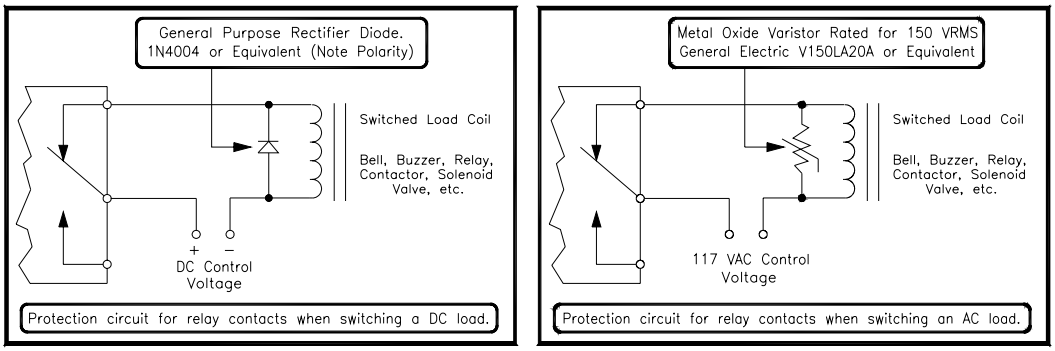
Use the following table as a guide for determining the Normally Open (NO) and the Normally Closed (NC) contacts for the Energized versus De-Energized setting.

**Table 12: TB3 Relay Contacts Energized / De-Energized Settings**

| Relay Type | TB3 Position | De-Energized | Energized |
|---|---|---|---|
| **Alarm** | 1 | Normally Closed | Normally Open |
| | 2 | Common | Common |
| | 3 | Normally Open | Normally Closed |
| **Warning** | 4 | Normally Closed | Normally Open |
| | 5 | Common | Common |
| | 6 | Normally Open | Normally Closed |
| **Fault** | 7 | | Normally Open |
| | 8 | | Common |
| | 9 | | Normally Closed |

**WARNING:** Relay contacts must be protected against transient and over-voltage conditions.

**Figure 11: Relay Protection for DC and AC Loads**




North American Approved Applications: The ALARM relay contact ratings are 8A @ 250 VAC and 8A @ 30VDC resistive max.

## 3.6 Applying Power and Starting Operation

Once the mounting, cabling, and alarm relay installation is complete, the TS4000 is ready to begin the power-on sequence. Please read this section carefully before applying power to the TS4000.

### 3.6.1 Start-up Readiness Checklist

Before applying power to the system for the first time, check the following items:

**Table 13: Start-up Readiness Checklist**

| Step | Description |
|---|---|
| 1 | Verify that the TS4000 is properly mounted. Make sure that the conduit / cable gland entries are pointed downward |
| 2 | Verify that all the signal wiring is installed correctly (Note: Power is not connected until after verifying Steps 1 – 7) |
| 3 | Verify connections between the TS4000 Base Unit and Interface Module |
| 4 | Verify connections between the TS4000 Base Unit and any control room devices |
| 5 | Make sure that the TS4000 cover is securely installed |
| 6 | Make sure to turn off any external devices, such as Trip Amplifiers, PLC devices or DCS systems until after the start-up sequence has completed |
| 7 | Once you are ready to begin start-up, verify that the power supply is connected properly. The TS4000 is powered by +24VDC (20 to 36 VDC voltage range). The TS4000 display outputs a low voltage fault at 18.5VDC or below |

**NOTE:** To protect the system from shorting, the +24VDC wire(s) to the power supply(s) should be connected after the readiness checklist is verified. The TS4000 is designed to continuously monitor the presence of hazardous gas leaks; a power switch is not included for the TS4000 to prevent accidental system shut down.

### 3.6.2 Start-up Process

**NOTE:** Powering on and off of the TS4000 is controlled from the external power supply; refer to the power supply manual for instructions. If there is a problem with the start-up or testing of the TS4000, contact General Monitors Customer Support. For contact information, refer to Section 8.0.

Upon first power-up, the TS4000 should be allowed to stabilize while the Interface Module attains the proper operating temperature. The TS4000 goes through the following process during this time period:

- During the Start-Up Mode, the LED display reads "**SU**"
- The display will briefly read "**F5**" upon initial start-up or when the electrochemical cell is replaced. The user needs to perform a sensor calibration to clear "**F5**".
- The unit then enters Operational Mode. It displays the current reading for the electrochemical cell in the following format*:*
    - **##.#** for FS concentrations ( < ) less than 50
    - ### for FS concentrations ( ≥ ) greater than or equal to 50

**NOTE:** If the reading is over the range of the electrochemical cell, the TS4000 registers "**OR**".

## 3.7 Maintaining Explosion Proof Integrity

The TS4000 Base Unit and Interface Module are rated explosion proof for use in the following hazardous locations:

- CSA: Class I, Division 1, Groups B, C, D and Class I, Zone 1, Ex d IIB+$H_2$, T6
- ATEX: EEx d mb ib IIC (-40ºC [ Ta [ + 75ºC)

Some of the factors that influence the explosion proof integrity of the TS4000 housing are:

- Strength of the enclosure material
- Thickness of the enclosure walls
- Flame path between the housing and cover
- Flame path of threaded joints

Anytime the TS4000 Base Unit cover bolts or the Interface Module are loosened while power is on, it is necessary to declassify the area. When replacing the cover, the gap between the lid and the housing should be less than .0015 inch or .038 mm. Make sure that the flame-path is free of dirt and debris before replacing the cover. Verify this by tightening the cover bolts to a torque setting of 50 inch-pounds and using a feeler gauge to ensure the gap between the cover and the housing is less than .0015 inch or .038 mm.

There are three unused entry holes in each TS4000 Base Unit housing: one on the left, one on the right, and one on the bottom. These entry holes are used as follows:

- To attach the TS4000 integral magnetic switch and wiring conduits to other devices, or
- To directly attach the Interface Module and to attach wiring conduits to alarm relays and control room equipment

The factory installs plugs in the unused entry holes, except one. A red plastic cap is placed into the remaining hole and must be removed before conduit can be attached to the housing. Each hole is tapped for ¾ inch NPT threads. If a particular entry hole is not used, it must be plugged during operation in the field.

**NOTE:** Always follow appropriate local or national wiring and installation requirements and use approved conduit plugs at the time of installation.

When a TS4000 Interface Module is attached to the Base Unit or a remote junction box for remote configuration, it must be screwed into the Base Unit / remote junction box housing using five to seven turns to ensure that the explosion proof integrity of the housing is maintained.

# 4.0 Operation

This section offers detailed instructions for completing several start-up operation and configuration tasks using the TS4000 menu system. Information regarding use of the TS4000 MODBUS commands as an alternate method for operating and configuring the unit is provided in Section 5.0, MODBUS Interface.

**CAUTION:** To avoid the possibility of false alarms, always remove or turn-off power prior to servicing, removing, or replacing an $O_2$ sensor.

## 4.1 Start-up Checklist

The following steps must be completed prior to system start-up. Refer to the following table:

**Table 14: Start-up Checklist**

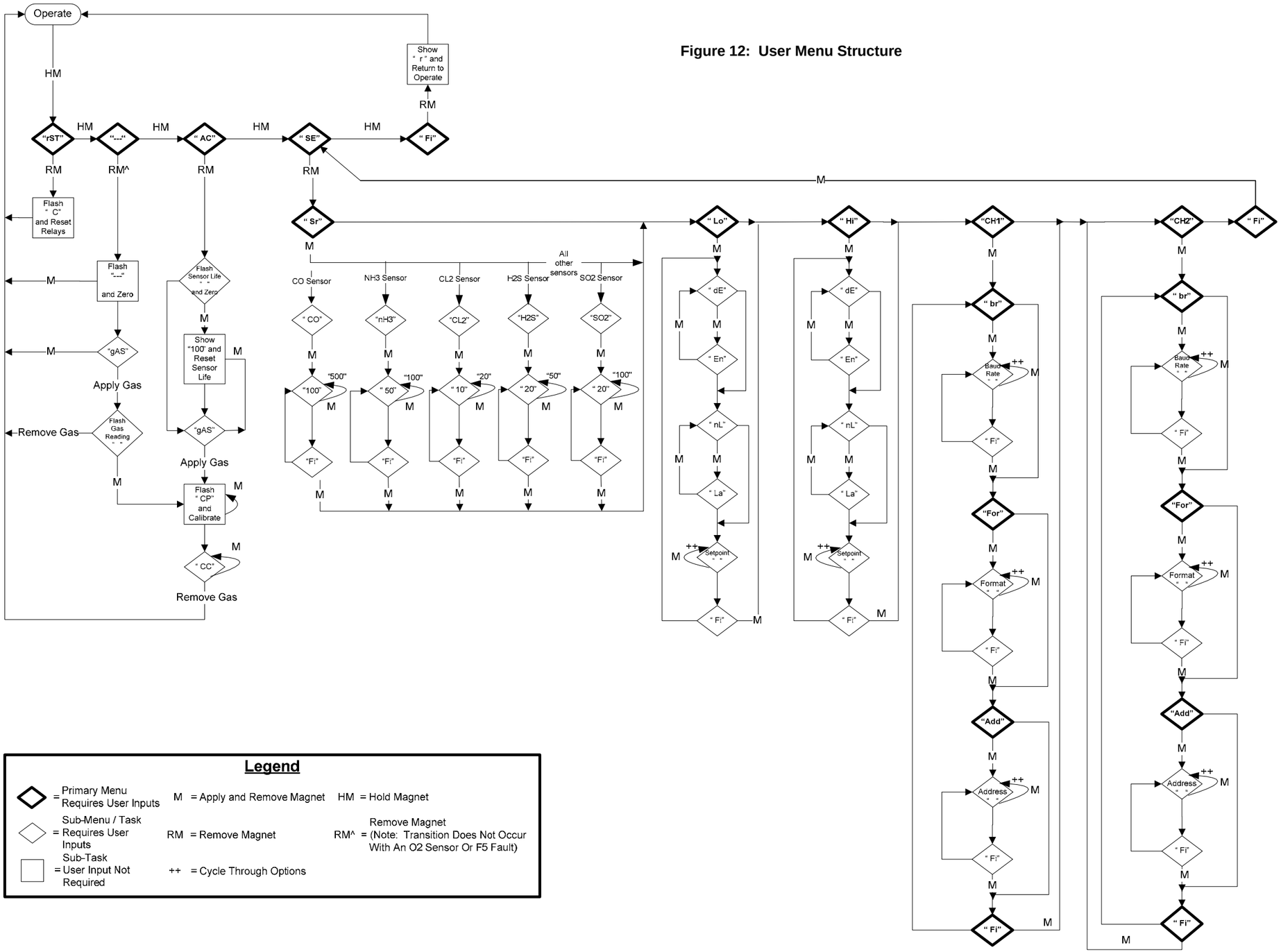
| Step | Description |
|---|---|
| 1 | Shut down any external devices, such as Trip Amplifiers, PLC's, or DCS systems. |
| 2 | Verify that the optional settings are set for the right configuration. |
| 3 | Verify that the unit is properly mounted. Ensure the conduit / cable gland entries are pointed downward. |
| 4 | Verify that the signal wiring is correct. |
| 5 | Verify that the power supply is connected properly. The TS4000 is powered by +24VDC (20 to 36 VDC voltage range). The detector outputs a low voltage fault (F6) at 18.5 VDC or below. |
| 6 | Make sure the lid is securely fastened or the area has been de-classified. |

## 4.2 User Menu Structure

The TS4000 includes many selectable options that provide the most flexible gas detector possible. These options include Selectable Sensor Range, Warn and Alarm Relay Set points and Configuration, and MODBUS Communications Settings. These options allow the unit to operate as a standalone device or in conjunction with a wide variety of controllers, computers, PLC, and DCS based systems. The following sections explain the available options and how they can be customized.

The following diagram provides a detailed view of the TS4000 menu structure:

**Figure 12: User Menu Structure**




## Legend

◇ = Primary Menu Requires User Inputs

◇ = Sub-Menu / Task Requires User Inputs

□ = Sub-Task User Input Not Required

M = Apply and Remove Magnet

RM = Remove Magnet

++ = Cycle Through Options

HM = Hold Magnet

RM^ = Remove Magnet (Note: Transition Does Not Occur With An O2 Sensor Or F5 Fault)

**NOTE:** If the TS4000 is ordered without relays or MODBUS communications, changing the relay or MODBUS settings will have no effect on the operation of the unit.

## 4.3 User Menu Display

The following table explains the User Menu abbreviations displayed on the 3-digit 7-segment LED display:

**Table 15: User Menu Display**

| User Menu Display | Definition |
|---|---|
| **Top Menu** | |
| **rSt** | Reset Relays |
| **---** | Gas Check |
| **AC** | Calibration |
| **SE** | Setup |
| **Fi** | Finish, exiting at any level of the menu to the upper level |
| **r** | Return from top menu to normal operation |
| **Reset Sub Menu** | |
| **C** | Clearing relays, appears for 2 seconds |
| **Gas Check Sub Menu** | |
| **---** | Flashing, unit is zeroing in Gas Check |
| **gAS** | Flashing, unit is finished zeroing and ready for gas to be applied |
| **###** | Flashing gas reading, unit is reading gas in Gas Check |
| **Calibration Sub Menu** | |
| **###** | Flashing remaining sensor life – Unit is zeroing in Calibration |
| **100** | Remaining sensor life was reset to 100, unit is still zeroing |
| **gAS** | Flashing – Unit is done zeroing and is ready for gas to be applied |
| **CP** | Flashing – Unit is seeing gas, calibration is in progress |
| **CC** | Steady – Unit has finished calibration and telling user to remove the gas |
| **Setup Menu** | |
| **Sr** | Sensor scale / type setting |
| **O2** | Oxygen deficiency sensor |
| **CO** | Carbon Monoxide sensor (range settings: 100 ppm and 500 ppm) |
| **100** | 100 ppm scale |
| **500** | 500 ppm scale |
| **NH3** | Ammonia sensor (range settings: 50 ppm and 100 ppm) |
| **50** | 50 ppm scale |
| **100** | 100 ppm scale |
| **Cl2** | Chlorine sensor (range settings: 10 ppm and 20 ppm) |
| **10** | 10 ppm scale |
| **20** | 20 ppm scale |
| **H2S** | Hydrogen Sulfide (range setting: 20 ppm and 50 ppm) |
| **20** | 20 ppm scale |
| **50** | 50 ppm scale |
| **LO** | Warning relay setting (Alarm setting for $O_2$) |
| **dE** | De-energize relay |
| **En** | Energize relay |
| **nL** | Non-latching relay |

| User Menu Display | Definition |
|---|---|
| **SO2** | Sulfur Dioxide (range setting: 20 ppm and 100 ppm) |
| **20** | 20 ppm scale |
| **100** | 100 ppm scale |
| **LA** | Latching relay |
| **##** | Relay set point |
| **Hi** | Alarm relay setting (Warning relay for $O_2$) |
| **##** | Relay set point |
| **Ch1** | User MODBUS channel 1 settings |
| **Ch2** | User MODBUS channel 2 settings |
| **Br** | Baud rate settings |
| **24** | 2,400 baud rate |
| **48** | 4,800 baud rate |
| **96** | 9,600 baud rate |
| **192** | 19,200 baud rate |
| **For** | Format Settings |
| **8n1** | 8 bits, no parity, 1 stop bit |
| **8n2** | 8 bits, no parity, 2 stop bits |
| **8o1** | 8 bits, odd parity, 1 stop bit |
| **8E1** | 8 bits, even parity, 1 stop bit |
| **Add** | Address Settings |
| **###** | Number in range 1 – 247 incrementing by magnet |
| **or** | Over range |

## 4.4 Start-up

Upon power-up, the software revision letters "**rN**'' (N – revision letter) are briefly displayed. The TS4000 then enters Start-up Mode ''**SU**", allowing the electrochemical cell to stabilize. Upon sensor stabilization, the TS4000 enters Operation Mode and displays the current gas concentration at the electrochemical cell. For detailed information on the Gas Check and Calibration Modes, refer to Sections 4.8 and 4.9, respectively.

**NOTE:** During power-up, the Base Unit may briefly display "**F1**" after displaying the software revision letter.

**NOTE:** A new sensor may take up to sixty minutes to stabilize once installed in the TS4000.

## 4.5 Using the Selection Magnet

To navigate the User Menu, you must use the supplied General Monitors magnet. It allows the user to access the built-in magnetic switch without compromising the explosion proof integrity of the Base Unit.

**Figure 13: Selection Magnet**

**To Use the Magnet**

1. Apply and hold the magnet over the GM logo on the Base Unit cover next to the display window. The User Menu is activated when the following menu sequence displays:

**Figure 14: Start-up Menu Sequence**


2. Remove the magnet to select the displayed menu option.

For more information about the User Menu, refer to Section 4.2.

**NOTE:** The User Menu remains active for six minutes. Inactivity for a period longer than this results in the TS4000 returning to normal operation.

## 4.6 Selectable Options

The TS4000 contains a number of user configurable options that can be selected using the supplied magnet.

**Figure 15: Selectable Options**


### 4.6.1 Sensor Range

The Sensor Range is configured automatically by the TS4000 when a new electrochemical cell is plugged into the Interface Module. The exceptions to this rule are specified below.

**NOTE:** The sensor scale / type option is disabled when the Sensor Range is automatically determined by the TS4000.

The Sensor Range for the following four sensor types is not uniquely determined by the TS4000 and must be configured manually:

- Carbon Monoxide (CO)
- Ammonia ($NH_3$)
- Chlorine ($Cl_2$)
- Hydrogen Sulfide ($H_2S$)
- Sulfur Dioxide (SO2)

For these four types, the sensor range must be set from the base unit, after the sensor is plugged into the interface module. When a Carbon Monoxide (CO) sensor cell is installed, the selectable ranges are either 100 ppm or 500 ppm Full Scale (FS). When an Ammonia ($NH_3$) sensor cell is installed, the user may select either 50 ppm or 100 ppm FS. When a Chlorine ($Cl_2$) sensor cell is installed, the user may select either 10 ppm or 20 ppm FS. When a Hydrogen Sulfide ($H_2S$) sensor cell is installed, the user may select either 20 ppm or 50 ppm FS. The 100 ppm Hydrogen Sulfide ($H_2S$) uses a different sensor cell. When a Sulfur Dioxide (SO2) sensor cell is installed, the user may select either 20 ppm or 100 ppm FS.

**To Change the Sensor Range for CO, $NH_3$, $Cl_2$, $H_2S$, and SO2**

1. Apply and hold the magnet on the GM logo on the Base Unit cover. Wait until "**SE**" displays and then remove the magnet. This action places the unit into Setup Mode, causing "**Sr**" to be displayed immediately.
2. Apply and remove the magnet. Wait until "**CO**", "**nH3**", "**CL2**", "**$H_2S$**" or **"SO2"** displays. Apply the magnet once again to select and configure the TS4000 for the installed sensor type. The user will then have the following sensor ranges to choose from (depending on the installed sensor):
    - "**CO**" – **100** and **500**

- "**nH3**" – **50** and **100**
- "**CL2**" – **10** and **20**
- "**$H_2S$**" **– 20 and 50**
- "**S02**" **– 20 and 100**

3. Apply and remove the magnet to select the correct range.
4. Once the correct sensor range is selected, the unit returns to the Setup Menu and depicts "**Lo**" on the display.
5. When "**Fi**" displays again, apply and remove the magnet to exit the Setup Menu.

**NOTE:** When the Sensor Range is changed, the Warning and Alarm set points are automatically scaled to the new range. The unit must now be calibrated to the new range. Refer to Section 4.9.

**CAUTION:** If the user does not complete the menu cycle a fault occurs. For more information about faults and fault codes, refer to Section 7.1.

### 4.6.2 Warning Relay Settings

The user can adjust the Warning Relay Settings for all sensors. The factory default settings and adjustment range for all gases other than $O_2$ are as follows:

- Non-latching (default)
- De-energized (default)
- 30% FS set point (default)
- 5% of FS (minimum)
- Alarm relay set point (maximum)

The default settings and adjustment range for $O_2$ are:

- 19.5% by volume (default)
- Alarm Relay set point (minimum)

**NOTE:** In general, most configuration procedures apply to all sensors. However, there are instances when a unique procedure is required for a given sensor or sensors. Wherever applicable, both generic and unique procedures are detailed in this manual.

**To Adjust the Warning Relay Settings for All Sensors except $O_2$**

1. Apply and hold the magnet on the GM logo on the Base Unit cover. Wait until "**SE**" displays and then remove the magnet. This action places the unit into Setup Mode.
2. After a few seconds "**Lo**" displays. Apply and remove the magnet to change the Warning Relay settings.
3. First, the Energized / De-Energized state of the relay displays by either "**En**" or "**dE**" being displayed, respectively. Apply and remove the magnet until the desired state is displayed.
4. After a few seconds the Latching / Non-Latching state of the relay displays by either "**LA**" or "**nL**". Apply and remove the magnet until the desired state is displayed.
5. After a few seconds, the current Warning Relay set point displays. Apply and remove the magnet to increment the set point by 1%. Apply and hold the magnet to increment faster.
6. Remove the magnet for three seconds to select the currently displayed set point. To save the setting, apply and remove the magnet when "**Fi**" displays.
7. To exit the Setup Menu, apply and remove the magnet when "**Fi**" displays again.
8. Finally, to exit the User Menu and return to normal operation, apply and remove the magnet when "**Fi**" is once again displayed.

**NOTE:** The Warning Relay set point cannot be set higher than the Alarm Relay set point.

**To Adjust the Warning Relay Settings for $O_2$**

1. Apply and hold the magnet on the GM logo on the Base Unit cover. Wait until "**SE**" displays and then remove the magnet. This action places the unit into Setup Mode.
2. After a few seconds "**Hi**" displays. Apply and remove the magnet to change the alarm settings.
3. First, the Energized / De-Energized state of the relay displays by either "**En**" or "**dE**" being displayed, respectively. Apply and remove the magnet until the desired state is displayed.
4. After a few seconds the Latching / Non-Latching state of the relay displays by either "**LA**" or "**nL**" being displayed, respectively. Apply and remove the magnet until the desired state is displayed.
5. After a few seconds, the current Warning Relay set point displays. Apply and remove the magnet to increment the set point by 1%. Apply and hold the magnet to increment faster.
6. Remove the magnet for three seconds to select the currently displayed set point. To save the setting, apply and remove the magnet when "**Fi**" displays.
7. To exit the Setup Menu, apply and remove the magnet when "**Fi**" displays again.
8. Finally, to exit the User Menu and return to normal operation, apply and remove the magnet when "**Fi**" is once again displayed.

### 4.6.3 Alarm Relay Settings

The user can adjust the Alarm Relay Settings for all sensors. The default Alarm Relay settings for all gases other than $O_2$ are the following:

- Latching (default)
- De-energized (default)
- 60% FS set point (default)
- 95% of FS (maximum)
- Warn relay set point (minimum)

The default Alarm Relay settings for $O_2$ are:

- 17.0% by volume (default)
- Warn relay set point (default)
- 60% FS (minimum)

**To Adjust the Alarm Relay Settings for All Sensors Except $O_2$**

1. Apply and hold the magnet on the GM logo on the Base Unit cover. Wait until "**SE**" displays and then remove the magnet. This action places the unit into Setup Mode.
2. After a few seconds "**Hi**" displays. Apply and remove the magnet to change the Alarm Relay settings.
3. First, the Energized / De-Energized state of the relay displays by either "**En**" or "**dE**" being displayed, respectively. Apply and remove the magnet until the desired state is displayed.
4. After a few seconds the Latching / Non-Latching state of the relay displays by either "**LA**" or "**nL**" being displayed, respectively. Apply and remove the magnet until the desired state is displayed.
5. After a few seconds, the current Alarm Relay set point displays. Apply and remove the magnet to increment the set point by 1%. Apply and hold the magnet to increment faster.
6. Remove the magnet for three seconds to select the currently displayed set point. To save the setting, apply and remove the magnet when "**Fi**" displays.
7. To exit the Setup Menu, apply and remove the magnet when "**Fi**" displays again.
8. Finally, to exit the User Menu and return to normal operation, apply and remove the magnet when "**Fi**" is once again displayed.

**NOTE:** The Alarm Relay set point cannot be set lower than the Warning Relay set point.

**To Adjust the Alarm Relay Settings for $O_2$**

1. Apply and hold the magnet on the GM logo on the Base Unit cover. Wait until "**SE**" displays and then remove the magnet. This action places the unit into Setup Mode.
2. After a few seconds "**LO**" displays. Apply and remove the magnet to change the alarm settings.
3. First, the Energized / De-Energized state of the relay displays by either "**En**" or "**dE**" being displayed respectively. Apply and remove the magnet until the desired state is displayed.
4. After a few seconds the Latching / Non-Latching state of the relay displays by either "**LA**" or "**nL**" being displayed, respectively. Apply and remove the magnet until the desired state is displayed.
5. After a few seconds, the current Alarm Relay set point displays. Apply and remove the magnet to increment the set point by 1%. Apply and hold the magnet to increment faster.
6. Remove the magnet for three seconds to select the currently displayed set point. To save the setting, apply and remove the magnet when "**Fi**" displays.
7. To exit the Setup Menu, apply and remove the magnet when "**Fi**" displays again.
8. Finally, to exit the User Menu and return to normal operation, apply and remove the magnet when "**Fi**" is once again displayed.

### 4.6.4 MODBUS Channel 1 Settings

**NOTE:** The available channel settings are 1-247 for both Channel 1 and Channel 2. If the desired setting is passed, the user must cycle through1 all remaining channels in order to once again return to the correct channel.

The default settings for Channel 1 are:

- Address 1
- 9,600 baud
- 8-N-1

**To Adjust the MODBUS Channel 1 Settings**

1. Apply and hold the magnet on the GM logo on the Base Unit cover. Wait until "**SE**" displays and then remove the magnet. This action places the unit into Setup Mode.
2. After a few seconds "**CH1**" displays. Apply and remove the magnet to select Channel 1. The Channel 1 menu level headings are then displayed.
3. To select the Channel 1 baud rate, apply and remove the magnet when "**Br**" displays. The current baud rate is then displayed. If another baud rate is required apply and remove the magnet until the required baud rate displays. The choices are:

- 19,200 baud "**192**"
- 9,600 baud "**96**"
- 4,800 baud "**48**"
- 2,400 baud "**24**"

4. To select the Channel 1 data format, apply and remove the magnet when "**For**" displays. The current format is then displayed. If another data format is required, apply and remove the magnet until the required data format displays. The choices are:
    - 8-N-1 "**8n1**"
    - 8-N-2 "**8n2**"
    - 8-E-1 "**8E1**"
    - 8-O-1 "**8o1**"
5. To select the Channel 1 address, apply and remove the magnet when "**Add**" displays. The current address is then displayed. Apply and remove the magnet to increment the address by 1, and hold the magnet down to increment faster.
6. Remove the magnet for three seconds to select the currently displayed address. To save the setting, apply and remove the magnet when "**Fi**" displays.
7. To exit the Setup Menu, apply and remove the magnet when "**Fi**" displays again.
8. Finally, to exit the User Menu and return to normal operation, apply and remove the magnet when "**Fi**" is once again displayed.

**NOTE:** The addresses for Channel 1 and Channel 2 can be the same when connected to different master devices.

### 4.6.5 MODBUS Channel 2 Settings

**NOTE:** The available channel settings are 1-247 for both Channel 1 and Channel 2. If the desired setting is passed, the user must cycle through all remaining channels in order to once again return to the correct channel.

The default settings for Channel 2 are:

- Address 2
- 9,600 baud
- 8-N-1

**To Adjust the MODBUS Channel 2 Settings**

1. Apply and hold the magnet on the GM logo on the Base Unit cover. Wait until "**SE**" displays and then remove the magnet. This action places the unit into Setup Mode.
2. After a few seconds "**CH2**" displays. Apply and remove the magnet to select Channel 2. The Channel 2 menu level headings are then displayed.

3. To select the Channel 2 baud rate, apply and remove the magnet when "**Br**" displays. The current baud rate is then displayed. If another baud rate is to be selected, apply and remove the magnet until the required baud rate displays. The choices are:
    - 19,200 baud "**192**"
    - 9,600 baud "**96**"
    - 4,800 baud "**48**"
    - 2,400 baud "**24**"
4. To select the Channel 2 data format, apply and remove the magnet when "**For**" displays. The current format is then displayed. If another data format is required, apply and remove the magnet until the required data format displays. The choices are:
    - 8-N-1 "**8n1**"
    - 8-N-2 "**8n2**"
    - 8-E-1 "**8E1**"
    - 8-O-1 "**8o1**"
5. To select the Channel 2 address, apply and remove the magnet when "**Add**" displays. The current address is then displayed. Apply and remove the magnet to increment the address by 1, and hold the magnet down to increment faster.
6. Remove the magnet for three seconds to select the currently displayed address. To save the setting, apply and remove the magnet when "**Fi**" displays.
7. To exit the Setup Menu, apply and remove the magnet when "**Fi**" displays again.
8. Finally, to exit the User Menu and return to normal operation, apply and remove the magnet when "**Fi**" is once again displayed.

## 4.7 Relay Reset

**Figure 16: Relay Reset**


If the Warning and/or Alarm Relays are configured as latching, it is possible to manually reset the relays, once the detected gas level has dropped below the configured set point. This can be accomplished in three ways:

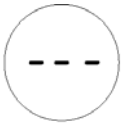
1. The relays can be reset using the MODBUS Interface. Refer to Section 5.0.
2. The relays can be reset using the magnetic switch in the Base Unit. Place the magnet over the GM logo on the cover of the Base Unit. After three seconds the display shows "**rSt**". Remove the magnet and the relays are reset.
3. The relays can be reset using the Remote Reset input terminals on TB2. Connect a normally open switch between terminal TB2-7 and TB2-8. Closing the switch momentarily resets the relays. General Monitors explosion proof switch, P/N 30051-1

can be used for this purpose and installed in one of the unused ¾" conduit entries on the TS4000.

**NOTE:** Red LEDs above and below the digital display indicate that the Alarm and Warning Relays are active. Latching relays can only be reset if the gas concentration has fallen below their respective relay set points.

## 4.8 Gas Check Mode

**Figure 17: Gas Check**




The sensor's response can be checked without activating external alarms by placing the TS4000 in Gas Check Mode. In this mode, the alarm relays are inhibited and the analog output is fixed at 1.5mA.

**NOTE:** Gas Check Mode is not accessible when either an $O_2$ sensor or no sensor is installed in the TS4000.

### 4.8.1 Gas Check Procedure

**To Run Gas Check Mode for All Sensors Except $O_2$**

1. Apply and hold the magnet over the GM logo on the Base Unit cover. Remove the magnet when three dashes "**---**" appear in the display window. This action places the unit into Gas Check Mode.
2. The "**---**" flash while the settings are being set to zero.
3. Once the unit has been set to zero, "**gAS**" appears in the display window.
4. Apply the test gas to the sensor, the value of the gas concentration is then indicated by the flashing display (with readings typically stabilizing within one to two minutes).
5. When the reading has stabilized and the test is complete, remove the gas. When the gas concentration drops below 5% FS the unit returns to normal operation.

**NOTE:** The test gas concentration must be at least 10% FS before the unit can complete the Gas Check sequence. If the TS4000 is placed in the Gas Check Mode and no gas is applied within ten minutes, the unit returns to normal operation. If the TS4000 is in Gas Check Mode and gas is applied longer than ten minutes, the unit will also revert to a Fault condition. Removing the applied gas will return the TS4000 to normal operation.

#### 4.8.1.1 Ending Gas Check Mode

Gas Check Mode can be ended after the zeroing stage and while the unit is waiting for gas to be applied. Applying the magnet over the GM logo, after the unit has been zeroed and prior to gas being applied, will terminate the Gas Check Mode and save the zero settings.

#### 4.8.1.2 Aborting Gas Check Mode

Gas Check Mode can be aborted during the zeroing stage (prior to "**gAS**" being displayed) if gas has not yet been applied to the sensor. Simply reapply the magnet to the GM logo on the Base Unit cover and the unit returns to normal operation.

**NOTE:** It is not possible to abort or end the Gas Check Mode once gas is applied.

#### 4.8.1.3 Transferring from Gas Check Mode to Calibration

The TS4000 can be transitioned directly from Gas Check Mode to Calibration Mode by reapplying the magnet to the GM logo, after applying gas and allowing for the sensor reading to stabilize. For more information on Calibration Mode, refer to Section 4.9

## 4.9 Calibration Mode

**Figure 18: Calibration Mode**


General Monitors recommends that the TS4000 be calibrated one hour after start-up and also 24 hours later. Calibrations should be checked at least every 90 days, to ensure system integrity. The user should not expect problems with sensor life or stability. Frequent calibrations will ensure optimum product performance. More frequent calibration checks are recommended for environments where mud and/or other unintended contaminants may collect on the sensor or there is a presence of other extreme conditions.

General Monitors recommends that a calibration schedule be established and followed; refer to Section 9.6 for a sample calibration schedule. A log should also be kept showing calibration dates and sensor replacement dates.

**NOTE:** Calibration Mode is only accessible when a sensor is installed in the TS4000.

**NOTE:** The sensor should be powered for a minimum of one hour prior to calibration.

**NOTE:** A timeout will occur if the calibration procedure is not completed in at most 10 minutes.

### 4.9.1 Calibration Procedure

Entering Calibration Mode automatically disables the alarm circuits by sending a 1.5mA output signal and disabling the Warn and Alarm relays, if present. This also prevents activation of the remote relay contacts when using a General Monitors Readout / Relay Display Module with the TS4000.

**To Run Calibration Mode for All Sensors Except $O_2$**

1. Apply and hold the magnet over the GM logo on the cover of the Base Unit. Wait until "**AC**" appears in the display window. Remove the magnet to select "**AC**". The unit is now in Calibration Mode.

2. The display flashes the Remaining Sensor Life. The user can choose to reset or not to reset the sensor life at this point. Ensure that the sensor is exposed to clean air during this time. For more information about Remaining Sensor Life, refer to Section 4.10.
3. The Remaining Sensor Life flashes while the unit is being set to zero. Once the unit has been set to zero "**gAS**" appears in the display window.
4. Apply the calibration gas concentration to the sensor (50% FS of the required range of detected gas). The display changes from "**gAS**" (apply gas) to "**CP**" (Calibration in Progress) indicating that the sensor is responding to the calibration gas. While the unit is reading the gas concentration, the menu is disabled.
5. After three to five minutes, the display changes from "**CP**" to "**CC**" indicating that the calibration is complete.
6. Remove the gas and wait for the unit to return to normal operation. The display may indicate a few percent of FS and will eventually drop to "**0**". If a unit time out occurs the user receives a calibration fault.

The TS4000 is now calibrated and the sensor calibration constants are stored in the non-volatile memory (EEPROM).

**To Run Calibration Mode for $O_2$**

1. Apply and hold the magnet over the GM logo on the cover of the Base Unit. Wait until "**AC**" appears in the display window. Remove the magnet to select "**AC**". The unit is now in Calibration Mode.
2. The display flashes the Remaining Sensor Life. The user can choose to reset or not to reset the sensor life at this point. Ensure that the sensor is exposed to clean air during this time. For more information about Remaining Sensor Life, refer to Section 4.10.
3. After three to five minutes, the unit will complete calibration, return to normal operation, and display the Oxygen gas reading.

#### 4.9.1.1 Ending Calibration

Calibration Mode can be ended after the zeroing stage and while the unit is waiting for gas to be applied. Applying the magnet over the GM logo, after the unit has been zeroed and prior to gas being applied will terminate the Calibration Mode and save the zero settings.

#### 4.9.1.2 Aborting Calibration

Calibration can be aborted only during the zeroing stage before "**gAS**" is displayed.

**To Abort Calibration**

1. Apply and remove the magnet once to reset remaining sensor life. Apply and remove the magnet once more to abort calibration.

If calibration is not complete within ten minutes, the unit reverts to a Fault condition. This condition can be only be cleared by recalibrating or restarting the unit.

**NOTE:** It is not possible to abort calibration once gas is applied.

## 4.10 Remaining Sensor Life

The TS4000 provides an estimate of remaining sensor life, in percent remaining, to provide the user with an early warning of the need for sensor replacement. The remaining sensor life is updated each time the unit is calibrated. The current remaining sensor life estimate displays during the zeroing portion of a calibration sequence. It can also be read using the MODBUS interface. Refer to Section 5.0 for more information.

**NOTE:** The remaining sensor life is only an estimate of the amount of life remaining for the sensor. This estimate can be influenced by many factors, including environmental conditions, poisons, etc. It should be used only as an estimate for preventive maintenance and logistics purposes.

### 4.10.1 Initializing the Remaining Sensor Life

The remaining sensor life estimate must be initialized each time a new electrochemical cell is installed. The initialization should be done during the first calibration of a newly installed sensor. After the sensor has been powered for a minimum of one hour, enter Calibration Mode (refer to Section 4.9). While the display is flashing the remaining sensor life estimate, apply the magnet until the flashing number changes to "**100**." This indicates that the sensor life will be reset upon completing calibration.

## 4.11 Calibration Equipment – Portable Purge Calibrator

A Portable Purge Calibrator is used for field calibration of the TS4000. The operational / storage temperature range for the Portable Purge Calibrator is 0°F to +130°F (-18°C to +54°C).

**NOTE:** Do not store the cylinder with the regulator fully engaged in the cylinder valve.

**To use a Portable Purge Calibrator**

1. Make sure the Portable Purge Calibrator contains a gas concentration equivalent to 50% FS for the unit that is going to be calibrated.
2. Ensure that the sensor is exposed to clean air. If it is suspected that background or interfering gas is present, purge the sensor with clean air.
3. Place the gas cup over the sensor.

4. Apply and remove the magnet and then navigate to "**AC**", then apply and remove the magnet to enter calibration.
5. Apply the calibration gas when "**gAS**" is displayed.
6. "**CP**" is displayed when the sensor detects gas (indicating "Calibration in Progress").
7. "**CC**" is displayed to indicate "Calibration Complete."
8. Remove the gas by closing the valve on the cylinder and remove the cup allowing the sensor to read clean air. The display changes from "**CC**" to indicate a few ppm and then drops to "**0**".

The unit is now calibrated and the new calibration constants are stored in the EEPROM. For calibration accessories from General Monitors, refer to Sections 9.5.4 and 9.7.

Use Table 16 to determine 50% of full scale for the different gases that are monitored.

**Table 16: Sensor Flow Rates**

| Sensor Type | 50% of Full-Scale | Recommended Flow Rates (mL/Minute) |
|---|---|---|
| Ammonia | 25 ppm, 50 ppm | 500 |
| Carbon Monoxide | 50 ppm, 250 ppm | 500 |
| Chlorine | 5 ppm | 1000 |
| Chlorine Dioxide | 1.5 ppm | 1000 |
| Hydrogen Chloride | 10 ppm | 1000 |
| Nitric Oxide | 50 ppm | 500 |
| Nitrogen Dioxide | 10 ppm | 1000 |
| Ozone | 0.5 ppm | 1000 |
| Sulfur Dioxide | 10 ppm, 50ppm | 500 |
| Hydrogen Sulfide | 10 ppm, 25 ppm, 50 ppm | 500 |

# 5.0 MODBUS Interface

## 5.1 Introduction

The TS4000 provides the ability of communicating via the industry standard MODBUS protocol, while acting as the slave device in a typical master / slave configuration. Upon receiving an appropriate query from the master, the TS4000 will respond with a formatted message as defined below.

## 5.2 Baud Rate

The TS4000 baud rate is selectable using either the MODBUS Communications Interface or Base Unit User Menus. The selectable baud rates are 19,200, 9,600, 4,800, or 2,400 bits per second (bps). The factory set baud rate is 9,600 bps.

## 5.3 Data Format

The data format is selectable using either the MODBUS Communications Interface or Base Unit User Menus. The factory set data format is 8-N-1. The selectable data formats are as follows:

**Table 17: Selectable Data Formats**

| Data Bits | Parity | Stop | Format |
|---|---|---|---|
| 8 | None | 1 | 8-N-1 |
| 8 | Even | 1 | 8-E-1 |
| 8 | Odd | 1 | 8-O-1 |
| 8 | None | 2 | 8-N-2 |

## 5.4 Function Codes Supported

The TS4000 supports the following function codes:

- Function Code 03 (Read Holding Registers) is used to read status from the slave unit.
- Function Code 06 (Preset Single Register) is used to write a command to the slave unit.

## 5.5 MODBUS Read Status Protocol (Query / Response)

A master device reads registers from the TS4000 by sending an 8-byte message as described in Table 18.

**Table 18: MODBUS Read Register(s) Request**

| Byte | MODBUS | Range | Referenced to TS4000 |
|---|---|---|---|
| 1st | Slave Address | 1-247* (Decimal) | TS4000 ID (Address) |
| 2nd | Function Code | 03 | Read Holding Registers |
| 3rd | Starting Address Hi | 00 | Not Used by the TS4000 |
| 4th | Starting Address Lo | 00-44 (Hex) | TS4000 Commands |
| 5th | Number of Registers Hi | 00 | Not Used by the TS4000 |
| 6th | Number of Registers Lo** | 01 – 45 (Hex) | Number of 16 Bit Registers |
| 7th | CRC Lo | 00-FF (Hex) | CRC Lo Byte |
| 8th | CRC Hi | 00-FF (Hex) | CRC Hi Byte |

* Address 0 is reserved for Broadcast Mode and is not supported at this time.
** A maximum of 69 registers can be requested during a single block of time.

Upon receiving a valid read register request from the master device, the TS4000 will respond with a message as described in Table 19. If the query generates an error, an exception message is returned to the master device (refer to Section 5.7).

**Table 19: MODBUS Read Register(s) Response**

| Byte | MODBUS | Range | Referenced to TS4000 |
|---|---|---|---|
| 1st | Slave Address | 1-247* (Decimal) | TS4000 ID (Address) |
| 2nd | Function Code | 03 | Read Holding Registers |
| 3rd | Byte Count ** | 02 – 8A (Hex) | Number of Data Bytes (N+) |
| 4th | Data Hi ** | 00-FF (Hex) | TS4000 Hi Byte Status Data |
| 5th | Data Lo ** | 00-FF (Hex) | TS4000 Lo Byte Status Data |
| : | : | : | : |
| : | : | : | : |
| N+4 | CRC Hi | 00-FF (Hex) | CRC Hi Byte |
| N+5 | CRC Lo | 00-FF (Hex) | CRC Lo Byte |

* Address 0 is reserved for Broadcast Mode and is not supported at this time.
** Byte count and the number of returned data bytes depends on the number of requested registers.
+ N denotes the number of returned data bytes.

## 5.6 MODBUS Write Command Protocol (Query / Response)

A master device writes to a TS4000 register by sending a properly formatted 8-byte message as described in Table 20.

**Table 20: MODBUS Write Register Request**

| Byte | MODBUS | Range | Referenced to TS4000 |
|---|---|---|---|
| 1st | Slave Address | 1-247* (Decimal) | TS4000 ID (Address) |
| 2nd | Function Code | 06 | Preset Single Registers |
| 3rd | Register Address Hi | 00 | Not Used by TS4000 |
| 4th | Register Address Lo | 00-FF (Hex) | TS4000 Register Address Lo Byte |
| 5th | Preset Data Hi | 00-03 (Hex) | TS4000 Hi Byte Command Data |
| 6th | Preset Data Lo | 00-FF (Hex) | TS4000 Lo Byte Command Data |
| 7th | CRC Hi | 00-FF (Hex) | CRC Hi Byte |
| 8th | CRC Lo | 00-FF (Hex) | CRC Lo Byte |
| * Address 0 is reserved for Broadcast Mode and is not supported at this time. | | | |

Upon receiving a valid register write request from the master device, the TS4000 will respond with a message as described in Table 21. If the write request generates an error, an exception message is returned to the master device (refer to Section 5.7).

**Table 21: MODBUS Write Register Response**

| Byte | MODBUS | Range | Referenced to TS4000 |
|---|---|---|---|
| 1st | Slave Address | 1-247* (Decimal) | TS4000 ID (Address) |
| 2nd | Function Code | 06 | Preset Single Registers |
| 3rd | Register Address Hi | 00 | Not Used by TS4000 |
| 4th | Register Address Lo | 00-FF (Hex) | TS4000 Register Address Lo Byte |
| 5th | Preset Data Hi | 00-FF (Hex) | TS4000 Hi Byte Command Data |
| 6th | Preset Data Lo | 00-FF (Hex) | TS4000 Lo Byte Command Data |
| 7th | CRC Hi | 00-FF (Hex) | CRC Hi Byte |
| 8th | CRC Lo | 00-FF (Hex) | CRC Lo Byte |
| * Address 0 is reserved for Broadcast Mode and is not supported at this time. | | | |

## 5.7 Exception Responses and Exception Codes

### 5.7.1 Exception Response

In a normal communications query and response, the master device sends a query to the TS4000. Upon receiving the query, the TS4000 processes the request and returns a response to the master device. An abnormal communication between the two devices produces one of four possible events:

1. If the TS4000 does not receive the query due to a communications error, then no response is returned from the TS4000 and the master device will eventually process a timeout condition for the query.
2. If the TS4000 receives the query, but detects a communication error (CRC, etc.), then no response is returned from the TS4000 and the master device will eventually process a timeout condition for the query.
3. If the TS4000 receives the query without a communications error, but cannot process the response within the master's timeout setting, then no response is returned from the TS4000. The master device eventually processes a timeout condition for the query in order to prevent this condition from occurring; the maximum response time for the TS4000 is 200 milliseconds. Therefore, the master's timeout setting should be set to 200 milliseconds or greater.
4. If the TS4000 receives the query without a communications error, but cannot process it due to reading or writing to a non-existent TS4000 command register, then the TS4000 returns an exception response message informing the master of the error.

   The exception response message has two fields that differentiate it from a normal response. The first is the function code – byte 2. This code will be 0x83 for a read exception and 0x86 for a write exception. The second differentiating field is the exception code – byte 3 – that is described in Section 5.7.2.

   In addition, the total exception response length is 5-bytes rather than the normal message length.

**Table 22: Exception Response**

| Byte | MODBUS | Range | Referenced to TS4000 |
|---|---|---|---|
| 1st | Slave Address | 1-247* (Decimal) | TS4000 ID (Address) |
| 2nd | Function Code | 83 or 86 (Hex) | Preset Single Registers |
| 3rd | Exception Code | 01 – 06 (Hex) | Appropriate Exception Code (See Below) |
| 4th | CRC Hi | 00-FF (Hex) | CRC Hi Byte |
| 5th | CRC Lo | 00-FF (Hex) | CRC Lo Byte |
| * Address 0 is reserved for Broadcast Mode and is not supported at this time. | | | |

### 5.7.2 Exception Code

**Exception Code Field:** In a normal response, the TS4000 returns data and status in the response data field. In an exception response, the TS4000 returns an exception code (describing the TS4000 condition) in the data field. Below is a list of exception codes that are supported by the TS4000:

**Table 23: Exception Codes**

| Code | Name | Description |
|---|---|---|
| **1** | Illegal Function | The function code received in the query is not an allowable action for the TS4000. |
| **2** | Illegal Data Address | The data address received in the query is not an allowable address for the TS4000. |
| **3** | Illegal Data Value | A value contained in the query data field is not an allowable value for the TS4000. |
| **4** | Slave Device Failure | An unrecoverable error occurred while the TS4000 was attempting to perform the requested action. |
| **5** | Acknowledge | The TS4000 has accepted the request and is processing it, but a long duration of time will be required to do so. This response is returned to prevent a timeout error from occurring in the master. |
| **6** | Device Busy | The TS4000 is engaged in processing a long-duration program command. The master should retransmit the message later when the slave is free. |

## 5.8 Command Register Locations

**Table 24: Command Register Locations**

| Parameter | Function | Value | Access | Register Address | Master I/O Address |
|---|---|---|---|---|---|
| **Analog** | 0-20mA current output | 16-Bit | R | 0x0000 | 40001 |
| **Mode** | Indicates and controls mode | 16-Bit | R / W | 0x0001 | 40002 |
| **Status / Error** | Indicates errors | 16-Bit | R | 0x0002 | 40003 |
| **Sensor Raw Data** | Raw sensor voltage output | 16-Bit | R | 0x0003 | 40004 |
| **Model** | Identifies the TS4000 model number in decimal (403) | 16-Bit | R | 0x0004 | 40005 |
| **Software Revision** | Indicates the software revision | 2 ASCII | R | 0x0005 | 40006 |
| **Temperature Value** | Sensor temperature output (°C + 100) | 16-bit | R | 0x0006 | 40007 |
| **Middle and Last LED Display Digits** | Indicates the value currently displayed on the 2nd and 3rd digits of the 7-segment LED | 2-ASCII | R | 0x0007 | 40008 |
| **First LED Display Digit and LED Light** | Indicates the value currently displayed on the 1st digit of the 7-segment LED and the value for LED alarm / warning light | 2-ASCII | R | 0x0008 | 40009 |
| **Not Used** | N/A | N/A | N/A | 0x0009 – 000C | 40010 – 40013 |
| **Alarm Relay Settings** | Read or change settings for the Alarm Relay | 16-Bit | R / W | 0x000D | 40014 |
| **Warn Relay Settings** | Read or change settings for the Warning Relay | 16-Bit | R / W | 0x000E | 40015 |
| **Com1 Address** | Read or change settings for the Com1 Address | 8-Bit | R / W | 0x000F | 40016 |
| **Com1 Baud** | Read or change settings for the Com1 Baud Rate | 8-Bit | R / W | 0x0010 | 40017 |
| **Com1 Data Format** | Read or change settings for the Com1 Data Format | 8-Bit | R / W | 0x0011 | 40018 |
| **Com2 Address.** | Read or change settings for the Com2 Address | 8-Bit | R / W | 0x0012 | 40019 |
| **Com2 Baud** | Read or change settings for the Com2 Baud Rate | 8-Bit | R / W | 0x0013 | 40020 |
| **Com2 Data Format** | Read or change settings for the Com2 Data Format | 8-Bit | R / W | 0x0014 | 40021 |
| **Not Used** | N/A | N/A | N/A | 0x0015 | 40022 |
| **Reset Relays** | Reset any latched relays | (0) | W | 0x0016 | 40023 |
| **Sensor Life** | Read the remaining sensor life | 8-Bit | R | 0x0017 | 40024 |
| **Sensor Scale** | Read the sensor full scale | 8-Bit | R | 0x0018 | 40025 |
| **Sensor Type** | Read and change sensor type (write $O_2$, CO, $NH_3$ only) | 8-Bit | R / W | 0x0019 | 40026 |
| **Not Used** | N/A | N/A | N/A | 0x001A – 001F | 40027 - 40032 |

| Parameter | Function | Value | Access | Register Address | Master I/O Address |
|---|---|---|---|---|---|
| **Total Receive Errors** | Total number of receive errors on user MODBUS channel | 8-Bit | R | 0x0020 | 40033 |
| **Data Errors** | Total number of illegal data errors | 8-Bit | R | 0x0021 | 40034 |
| **Function Code Errors** | Total number of function code errors | 8-Bit | R | 0x0022 | 40035 |
| **Starting Address Errors** | Total number of starting address errors | 8-Bit | R | 0x0023 | 40036 |
| **Note Used** | N/A | N/A | N/A | 0x0024 | 40037 |
| **CRC Hi Errors** | Total number of CRC Hi errors | 8-Bit | R | 0x0025 | 40038 |
| **CRC Low Errors** | Total number of CRC Low errors | 8-Bit | R | 0x0026 | 40039 |
| **Not Used** | N/A | N/A | N/A | 0x0027 - 002C | 40040 – 40045 |
| **Clear User Com Errors** | Clear all user MODBUS communication error counters | (0) | W | 0x002D | 40046 |
| **IM Com Errors** | Number of IM-to-BU communication errors | 8-Bit | R / W | 0x002E | 40047 |

## 5.9 Command Register Details

The following sections provide a detailed description of each user MODBUS command register.

### 5.9.1 Analog (0x0000)

A read returns a value, which is proportional to the 0-20mA output current. The current is based on a 16-bit value. The scaling is 0-65535 decimal, which corresponds to 0-21.7mA.

### 5.9.2 Mode (0x0001)

A read returns the present mode of the TS4000. A write command changes the mode to the requested mode.

**EXCEPTION:** Returns an Exception Code 03 (Illegal Data Value) if an illegal write is requested.

**Table 25: Base Unit Mode Bitmap**

| Bit | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
|---|---|---|---|---|---|---|---|---|
| **Mode** | Calibrate | Initial | Gas Being Read | Remove Gas | Apply Gas | Alarm Level | Warn Level | Run |
| **Hex Value** | 0x0080 | 0x0040 | 0x0020 | 0x0010 | 0x0008 | 0x0004 | 0x0002 | 0x0001 |
| **Dec Value** | 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 |
| **Access** | R / W | R | R | R | R | R | R | R |
| **Bit** | **16** | **15** | **14** | **13** | **12** | **11** | **10** | **9** |
| **Mode** | Not Used | Not Used | Not Used | Base Setup | Sensor Life Reset | Bad Error | OK Error | Gas Check |
| **Hex Value** | 0x8000 | 0x4000 | 0x2000 | 0x1000 | 0x0800 | 0x0400 | 0x0200 | 0x0100 |
| **Dec Value** | 32768 | 16384 | 8192 | 4096 | 2048 | 1024 | 512 | 256 |
| **Access** | R | R | R | R | R / W | R | R | R / W |

The following table describes the Base Unit operating modes.

**Table 26: Mode Descriptions**

| Mode | Description |
|---|---|
| **RUN** | Normal mode of operation for the TS4000 BU, IM, and electrochemical cell. The latter takes readings and outputs them to the IM. The BU then polls the IM every ten seconds. |
| **WARN LEVEL** | IM reports toxic gas reading exceeding warning level. |
| **ALARM LEVEL** | IM reports toxic reading exceeding alarm level. |
| **APPLY GAS** | When the Calibration or Gas Check Modes has been invoked, the apply gas bit informs the user when to apply gas to the TS4000. |
| **REMOVE GAS** | This bit informs the user to remove the gas after the TS4000 has finished Calibration or Gas Check. |
| **GAS BEING READ** | This bit informs the user that the gas is being read in either Calibration or Gas Check Mode. |
| **INITIAL** | This informs the user that the TS4000 is in Start-up Mode. |
| **CALIBRATE** | Writing a one (1) to this bit informs the IM to zero and then calibrate the sensor. The no gas, apply gas, and remove gas informs the user when to apply or remove gas. |
| **GAS CHECK** | This mode will place the TS4000 in Gas Check Mode. The user applies gas and the sensor current is disabled. |
| **OK ERROR** | Cautionary errors (such as low line) that do not force the TS4000 to go offline but indicate an unsafe operating situation. |
| **BAD ERROR** | Major errors that prohibit the TS4000 from operating in a safe manner and result in the unit going offline. The TS4000 will not inform the user of any gas being present. |
| **SENSOR LIFE RESET** | This bit informs the user that the Remaining Sensor Life Reset command has been given by the BU and acknowledged by the IM. |
| **BASE SETUP** | This bit informs the user that a magnet is accessing the setup "**SE**" menu option on the BU. |

### 5.9.3 Status / Error (0x0002)

A Read command returns the bit map for any Error that is presently occurring, with duration of at least ten seconds. The duration requirement screens out transient and intermittent errors. The following table shows the errors that are represented by each bit in the register.

**Table 27: Base Unit Status Error Bitmap**

| Bit | 4 | 3 | 2 | 1 |
|---|---|---|---|---|
| **Error** | **F3:** Base Unit Rom Error | **F2:** Calibrate Timeout | **F1:** No Sensor Plugged | **F0:** IM Offline Error |
| **Hex Value** | 0x0008 | 0x0004 | 0x0002 | 0x0001 |
| **Dec Value** | 8 | 4 | 2 | 1 |
| **Bit** | **8** | **7** | **6** | **5** |
| **Error** | **F7:** Base Unit EEPROM Error | **F6:** Voltage Low | **F5:** Sensor Failure | **F4:** Sensor Rate of Change Error |

| | | | | |
|---|---|---|---|---|
| **Hex Value** | 0x0080 | 0x0040 | 0x0020 | 0x0010 |
| **Dec Value** | 128 | 64 | 32 | 16 |
| **Bit** | **12** | **11** | **10** | **9** |
| **Error** | **FF:** Base Unit RAM Error | **F10:** Switch Error | **F9:** Gas check Timeout | **F8:** Base Setup Timeout |
| **Hex Value** | 0x0800 | 0x0400 | 0x0200 | 0x0100 |
| **Dec Value** | 2048 | 1024 | 512 | 256 |
| **Bit** | **16** | **15** | **14** | **13** |
| **Error** | Not Used | Not Used | No Used | Not Used |
| **Hex Value** | 0x8000 | 0x4000 | 0x2000 | 0x1000 |
| **Dec Value** | 32768 | 16384 | 8192 | 4096 |

### 5.9.4 Sensor Raw Data (0x0003)

A read returns the sensor raw voltage data in 16-bit read-only register.

### 5.9.5 Unit Type (0x0004)

The MODBUS identification number for the TS4000 is 4003.

### 5.9.6 Software Revision (0x0005)

A read returns the software revision of the TS4000 utilizing two ASCII characters.

### 5.9.7 Sensor Temperature Output (0x0006)

A read returns the sensor temperature output in °C + 100, a 16-bit value.

### 5.9.8 Alarm Relay Settings (0x000D)

A read returns the present Alarm settings of the TS4000. A write command changes the settings to the requested values. The set points are programmable in 1% FS steps.

A 1 in the 9$^{th}$ bit position means the output is latching, a 0 means it is Non-Latching. A 1 in the 8$^{th}$ bit position means the output is normally energized, a 0 means it is normally De-Energized. The Alarm set point cannot be set below the Warning set point.

**Factory Default Settings are as Follows:**

- For all gases, except $O_2$, factory default is 60% FS, non-latching, de-energized.
- For $O_2$, factory default is 17.0% by volume, non-latching, de-energized**.**

**EXCEPTION:** Returns an Exception Code 03 (Illegal Data Value) if an illegal write is requested.

**Table 28: Alarm Relay Settings**

| Byte | Function | Bit Position | Access |
|---|---|---|---|
| **High** | Not Used | **15 MSB** | Read |
| | Not Used | **14** | Read |
| | Not Used | **13** | Read |
| | Not Used | **12** | Read |
| | Not Used | **11** | Read |
| | Not Used | **10** | Read |
| | Latching / Non-Latching | **9** | Read / Write |
| | Energized / De-Energized | **8** | Read / Write |
| **Low** | Set point | **7-0** | Read / Write |

### 5.9.9 Warn Relay Settings (0x000E)

A read returns the present Warn settings of the TS4000. A write command changes the settings to the requested values. The set points are programmable in 1% FS steps.

A 1 in the 9th bit position means the output is latching, a 0 means it is Non-Latching. A 1 in the 8th bit position means the output is normally energized a 0 means it is normally De-Energized. The Warn set point cannot be set above the Alarm set point.

**Factory Default Settings are as Follows:**

- For all gases, except $O_2$, factory default is 30% FS, non-latching, de-energized.
- For $O_2$, factory default is 19.5% by volume, non-latching, de-energized.

**EXCEPTION:** Returns an Exception Code 03 (Illegal Data Value) if an illegal write is requested.

**Table 29: Warning Relay Settings**

| Byte | Function | Bit Position | Access |
|---|---|---|---|
| **High** | Not Used | **15 MSB** | Read |
| | Not Used | **14** | Read |
| | Not Used | **13** | Read |
| | Not Used | **12** | Read |
| | Not Used | **11** | Read |
| | Not Used | **10** | Read |
| | Latching / Non-Latching | **9** | Read / Write |
| | Energized / De-Energized | **8** | Read / Write |
| **Low** | Set point | **7-0** | Read / Write |

### 5.9.10 Com1 Address (0x000F)

A read command returns the current address for Com1. A write command changes the address to the requested value. Valid addresses are 1-247 decimal. **Factory default is 1**.

**EXCEPTION:** If the address is not in range an Illegal Data Value (03) is returned.

### 5.9.11 Com1 Baud Rate (0x0010)

A read command returns the current baud rate for Com1. A write command changes the baud rate to the requested values. Valid settings are shown in Table 30. **Factory default is 19,200 baud.**

**Table 30: Com1 Baud Rate**

| Baud Rate | Value | Access |
|---|---|---|
| 2400 | 0 | Read / Write |
| 4800 | 1 | Read / Write |
| 9600 | 2 | Read / Write |
| 19,200 | 3 | Read / Write |

**EXCEPTION:** If the baud rate is not in range, an Illegal Data Value (03) is returned.

### 5.9.12 Com1 Data Format (0x0011)

A read command returns the current data format for Com1. Write command changes the data format to the requested values. Valid settings are shown in Table 31. **Default format is 8-N-1**.

**Table 31: Selectable Data Formats**

| Data Bits | Parity | Stop | Format | Value | Access |
|---|---|---|---|---|---|
| 8 | None | 1 | 8-N-1 | 0 | Read / Write |
| 8 | Even | 1 | 8-E-1 | 1 | Read / Write |
| 8 | Odd | 1 | 8-O-1 | 2 | Read / Write |
| 8 | None | 2 | 8-N-2 | 3 | Read / Write |

**EXCEPTION:** If the data format is not in range, an Illegal Data Value (03) is returned.

### 5.9.13 Com2 Address (0x0012)

A read command returns the current address for Com2. A write command changes the address to the requested values. Valid addresses are 1-247 decimal. **Factory default is 2**.

**EXCEPTION:** If the address is not in range, an Illegal Data Value (03) is returned.

### 5.9.14 Com2 Baud Rate (0x0013)

A read command returns the current baud rate for Com2. A write command changes the baud rate to the requested values. Valid settings are shown in Table 32. **Factory default is 19,200 baud**.

**Table 32: Com2 Baud Rate**

| Baud Rate | Value | Access |
|---|---|---|
| 2400 | 0 | Read / Write |
| 4800 | 1 | Read / Write |
| 9600 | 2 | Read / Write |
| 19,200 | 3 | Read / Write |

**EXCEPTION:** If the baud rate is not in range, an Illegal Data Value (03) is returned.

### 5.9.15 Com2 Data Format (0x0014)

A read command returns the current data format for Com2. Write command changes the data format to the requested values. Valid settings are shown in Table 31. **Default format is 8-N-1**.

**EXCEPTION:** If the data format is not in range, an Illegal Data Value (03) is returned.

### 5.9.16 Reset Relays (0x0016)

A write to this register with a data value of 1 will reset any latched alarms provided the current gas level is below the alarm set point (or above it for $O_2$).

### 5.9.17 Sensor Life (0x0017)

A read returns the current estimate of remaining sensor life in percentage.

### 5.9.18 Sensor Scale (0x0018)

A read returns the current sensor scale. Sensor scale value is determined automatically by sensor type, and cannot be written over MODBUS. For a list of available sensor scales and associated sensor types, refer to Table 33.

### 5.9.19 Sensor Type (0x0019)

A read returns the current sensor type. A write is allowed only if the current sensor is set to:

- "0" (no sensor)
- "2" or "3" (any CO sensor)
- "4" or "19" (any $Cl_2$ sensor)
- "9" or "10" (any $NH_3$ sensor)

If the sensor type is set to:

- "0", only sensor type value of "1" can be written, defining $O_2$ sensor
- "2" or "3", only sensor type values of "2" and "3" can be written, defining CO – 100 ppm and CO – 500 ppm scale sensors, respectively
- "9" or "10", only sensor type values of "9" and "10" can be written, defining $NH_3$ – 50 ppm or $NH_3$ – 100 ppm scale sensors, respectively

In all other cases, the sensor type is determined automatically when the sensor is plugged in. Write attempts in such cases will return a data Exception Code 03 (Illegal Data Value).

**Table 33: Sensor Types and Scales**

| Sensor Type | Sensor ID | Full Scale Value |
|---|---|---|
| 0 | No Sensor Detected | None |
| 1 | $O_2$ | 25% Volume |
| 2 | CO – 100 | 100 ppm |
| 3 | CO – 500 | 500 ppm |
| 4 | $Cl_2$ – 10 | 10 ppm |
| 5 | $ClO_2$ | 3 ppm |
| 6 | HCl | 20 ppm |
| 7 | NO | 100 ppm |

| Sensor Type | Sensor ID | Full Scale Value |
|---|---|---|
| 8 | $NO_2$ | 20 ppm |
| 9 | $NH_3$ – 50 | 50 ppm |
| 10 | $NH_3$ – 100 | 100 ppm |
| 11 | $O_3$ | 1 ppm |
| 12 | $SO_2$ -20 | 20 ppm |
| 13 | $SO_2$ -100 | 100 ppm |
| 14 | $H_2S$ – 20 | 20 ppm |
| 15 | $H_2S$-100 | 100 ppm |
| 16-18 | Reserved | N/A |
| 19 | $Cl_2$ – 20 | 20 ppm |
| 20 | $H_2S$ – 50 | 50 ppm |

### 5.9.20 Total Receive Errors (0x0020)

A read indicates the total MODBUS Communication Receive Errors that occurred in the slave device. The maximum count is 255. Beyond 255 the count resets to zero and begins counting again.

### 5.9.21 Total Data Errors (0x0021)

A read indicates the total number of illegal data write attempts that occurred in the slave device. The maximum count is 255. Beyond 255 the count resets to zero and begins counting again.

### 5.9.22 Function Code Errors (0x0022)

A read indicates the number of Function Code Errors that occurred in the slave device. The maximum count is 255. Beyond 255 the count resets to zero and begins counting again.

### 5.9.23 Starting Address Errors (0x0023)

The counter is incremented for each address that does not equal the device address.

A read indicates the number of Starting Address Errors that occurred in the slave device. The maximum count is 255. Beyond 255 the count resets to zero and begins counting again.

### 5.9.24 CRC High Byte Errors (0x0025)

A read indicates the number of RXD CRC Hi Byte Errors that occurred in the slave device. The maximum count is 255. Beyond 255 the count resets to zero and begins counting again.

### 5.9.25 CRC Low Byte Errors (0x0026)

A read indicates the number of RXD CRC Hi Byte Errors that occurred in the slave device. The maximum count is 255. Beyond 255 the count resets to zero and begins counting again.

### 5.9.26 Clear Communication Errors (0x002D)

A read indicates the total number of MODBUS Communication Errors. The maximum count is 255. Beyond 255 the count resets to zero and begins counting again. A write resets this value to 0. Only a write of value “0” is allowed for this register.

### 5.9.27 Clear Interface Module Communication Errors (0x002E)

A read indicates the total number of Interface Module to Base Unit Communication Errors. The maximum count is 255. Beyond 255 the count resets to zero and begins counting again. A write resets this value to 0. Only a write of value “0” is allowed for this register.

# 6.0 Maintenance

## 6.1 General Maintenance

**WARNING:** Disconnect or inhibit external devices such as Trip Amplifiers, PLC's, or DCS systems before performing any maintenance on the TS4000.

## 6.2 Storage

The TS4000 should be stored in a clean, dry area and within the temperature and humidity ranges specified in Section 9.5.

For long-term storage, remove the electrochemical cell and re-install the shorting wire. Place the electrochemical cell in the original container and close the lid.

**NOTE:** Insert red dust caps into any vacant cable entry holes prior to storage.

# 7.0 Troubleshooting

**CAUTION:** Component repair must be undertaken either by General Monitors' personnel, or by authorized service engineers. SMT PCB repair shall only be performed at a General Monitors facility. Failure to comply with these requirements voids the product warranty.

**NOTE:** Shutdown or disconnect all TS4000 external alarm wiring prior to conducting checks that may cause the unit to enter an alarm condition.

## 7.1 Fault Codes and Remedies

The TS4000 has self-diagnostics incorporated into the microprocessor's program. If a fault is detected, the output signal drops to 0mA, the Fault relay de-energizes, and a Fault Code is displayed.

Table 34 lists the ten fault conditions monitored by the TS4000, along with suggestions for resolving these faults. If repeated attempts to resolve the faults are unsuccessful, return the TS4000 to the factory or authorized service center for repair.

**Table 34: Fault Codes**

| Fault Code | Fault Type | Description | Action |
|---|---|---|---|
| **F0**** | IM Communication | (1) IM does not communicate<br>(2) IM microprocessor has Flash Data, Flash Code, or RAM error | • Verify that the BU and IM are properly wired |
| **F1**** | No Sensor | (1) No sensor is plugged into the IM<br>(2) Non-functional Oxygen sensor plugged into IM | • Ensure sure that there is a sensor plugged into the IM<br>• Verify Oxygen sensor functionality and replace if necessary |
| **F2**** | Calibration Timeout | IM fails to complete calibration within ten minutes | • Remove gas, if present, and recalibrate<br>• If successive calibration attempts fail, verify calibration gas<br>• If calibration gas verified, replace sensor and recalibrate |
| **F3**** | Base Unit ROM | BU microprocessor controller has a ROM error | • Return the BU to the factory or authorized service center for repair |
| **F4**** | Sensor Rate of Change | Sensor reading has a high rate of change (is not stable) | • Wait until the sensor reading stabilizes<br>• Replace electrochemical cell if fault persists |

| Fault Code | Fault Type | Description | Action |
|---|---|---|---|
| **F5**** | Sensor Failure | (1) Sensor failure<br>(2) New un-calibrated sensor plugged into the IM<br>(3) Sensor range error | • Recalibrate the sensor.<br>• Replace sensor if fault persists |
| **F6** | Low Supply Voltage* | Supply voltage at the TS4000 dropped below +18.5VDC | • Ensure that the supply voltage is at least +20VDC at the BU |
| **F7**** | BU EEPROM | Failed attempt to update the EEPROM | • Return the BU to the factory or authorized service center for repair |
| **F8** | Base Setup Timeout | BU was left in Setup Mode for over six minutes without the magnet being applied | • Enter the BU User Menu Structure to clear the fault |
| **F9**** | Gas Check Timeout | Gas was applied for more than six minutes | • Remove the applied gas (the unit will automatically clear the fault) |
| **F10** | Switch Error | Fault occurs if either the Remote Reset, Remote Calibrate, or magnetic switch is closed for more than two minutes | • Check the wiring on the Remote Reset and Remote Calibrate switches<br>• If the magnetic switch is shorted (stuck), the BU must be returned to the factory or authorized service center for repair |
| **FF**** | RAM Error | BU has a RAM error | • Return the BU to the factory or authorized service center for repair |

*NOTE: The recommended power cable resistance for the TS4000 is 20 Ω per conductor (40 Ω loop), at +24VDC.

**NOTE: These faults are not overridden by an alarm or warning condition, and always have higher priority over all other faults. For all other faults, an alarm or warning condition (gas reading) will override a fault being displayed.

If the two or more faults occur simultaneously, the Base Unit will display the higher priority fault. The table below describes the fault code priorities:

**Table 35: Fault Code Priorities**

| Priority | Fault | Priority | Fault |
|---|---|---|---|
| **1** | F3 | **7** | F4 |
| **2** | F7 | **8** | F8 |
| **3** | FF | **9** | F2 |
| **4** | F0 | **10** | F9 |
| **5** | F1 | **11** | F6 |
| **6** | F5 | **12** | F10 |

# 8.0 Customer Support

## 8.1 General Monitors' Offices

**Table 36: GM Locations**

| Area | Phone/Fax/Email |
|---|---|
| **UNITED STATES** | |
| | Toll Free: +1-800-446-4872 |
| Corporate Office: | Phone: +1-949-581-4464 |
| 26776 Simpatica Circle | Fax: +1-949-581-1151 |
| Lake Forest, CA 92630 | Email: info@generalmonitors.com |
| | |
| 9776 Whithorn Drive | Phone: +1-281-855-6000 |
| Houston, TX 77095 | Fax: +1-281-855-3290 |
| | Email: gmhou@generalmonitors.com |
| | |
| **UNITED KINGDOM** | |
| Heather Close | Phone: +44-1625-619-583 |
| Lyme Green Business Park | Fax: +44-1625-619-098 |
| Macclesfield, Cheshire, | Email: info@generalmonitors.co.uk |
| United Kingdom, SK11 0LR | |
| | |
| **IRELAND** | |
| Ballybrit Business Park | Phone: +353-91-751175 |
| Galway, Republic of Ireland | Fax: +353-91-751317 |
| | Email: info@gmil.ie |
| | |
| **SINGAPORE** | |
| No. 2 Kallang Pudding Rd. | Phone: +65-6-748-3488 |
| #09-16 Mactech Building | Fax: +65-6-748-1911 |
| Singapore 349307 | Email: genmon@gmpacifica.com.sg |
| | |
| **MIDDLE EAST** | |
| LOB12, #G20 | Phone: +971-4-8815751 |
| P.O. Box 61209 | Fax: +971-4-8817927 |
| Jebel Ali, Dubai | Email: gmme@emirates.net.ae |
| United Arab Emirates | |

# 9.0 Appendix

## 9.1 Warranty

General Monitors warrants the TS4000 to be free from defects in workmanship or material under normal use and service within two (2) years (one (1) year for electrochemical cells) from the date of shipment. General Monitors will repair or replace without charge any equipment found to be defective during the warranty period. Full determination of the nature of, and responsibility for, defective or damaged equipment will be made by General Monitors' personnel.

Defective or damaged equipment must be shipped prepaid to General Monitors or the representative from which shipment was made. In all cases this warranty is limited to the cost of the equipment supplied by General Monitors. The customer will assume all liability for the misuse of this equipment by its employees or other personnel.

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

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

## 9.2 Conversion Matrix – Percent of Scale to Scaled Value

**Table 37: Conversion Matrix – Percent of Scale to Scaled Value**

| % of Scale | Full Scale Value | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1.00 | 3.00 | 10.0 | 20.0 | 25.0 | 50 | 100 | 500 |
| 0 | 0.00 | 0.00 | 0.0 | 0.0 | 0.0 | 0 | 0 | 0 |
| 1 | 0.01 | 0.03 | 0.1 | 0.2 | 0.3 | 1 | 1 | 5 |
| 2 | 0.02 | 0.06 | 0.2 | 0.4 | 0.5 | 1 | 2 | 10 |
| 3 | 0.03 | 0.09 | 0.3 | 0.6 | 0.8 | 2 | 3 | 15 |
| 4 | 0.04 | 0.12 | 0.4 | 0.8 | 1.0 | 2 | 4 | 20 |
| 5 | 0.05 | 0.15 | 0.5 | 1.0 | 1.3 | 3 | 5 | 25 |
| 6 | 0.06 | 0.18 | 0.6 | 1.2 | 1.5 | 3 | 6 | 30 |
| 7 | 0.07 | 0.21 | 0.7 | 1.4 | 1.8 | 4 | 7 | 35 |
| 8 | 0.08 | 0.24 | 0.8 | 1.6 | 2.0 | 4 | 8 | 40 |
| 9 | 0.09 | 0.27 | 0.9 | 1.8 | 2.3 | 5 | 9 | 45 |
| 10 | 0.10 | 0.30 | 1.0 | 2.0 | 2.5 | 5 | 10 | 50 |
| 11 | 0.11 | 0.33 | 1.1 | 2.2 | 2.8 | 6 | 11 | 55 |
| 12 | 0.12 | 0.36 | 1.2 | 2.4 | 3.0 | 6 | 12 | 60 |
| 13 | 0.13 | 0.39 | 1.3 | 2.6 | 3.3 | 7 | 13 | 65 |
| 14 | 0.14 | 0.42 | 1.4 | 2.8 | 3.5 | 7 | 14 | 70 |
| 15 | 0.15 | 0.45 | 1.5 | 3.0 | 3.8 | 8 | 15 | 75 |
| 16 | 0.16 | 0.48 | 1.6 | 3.2 | 4.0 | 8 | 16 | 80 |
| 17 | 0.17 | 0.51 | 1.7 | 3.4 | 4.3 | 9 | 17 | 85 |
| 18 | 0.18 | 0.54 | 1.8 | 3.6 | 4.5 | 9 | 18 | 90 |
| 19 | 0.19 | 0.57 | 1.9 | 3.8 | 4.8 | 10 | 19 | 95 |
| 20 | 0.20 | 0.60 | 2.0 | 4.0 | 5.0 | 10 | 20 | 100 |
| 21 | 0.21 | 0.63 | 2.1 | 4.2 | 5.3 | 11 | 21 | 105 |
| 22 | 0.22 | 0.66 | 2.2 | 4.4 | 5.5 | 11 | 22 | 110 |
| 23 | 0.23 | 0.69 | 2.3 | 4.6 | 5.8 | 12 | 23 | 115 |
| 24 | 0.24 | 0.72 | 2.4 | 4.8 | 6.0 | 12 | 24 | 120 |
| 25 | 0.25 | 0.75 | 2.5 | 5.0 | 6.3 | 13 | 25 | 125 |
| 26 | 0.26 | 0.78 | 2.6 | 5.2 | 6.5 | 13 | 26 | 130 |
| 27 | 0.27 | 0.81 | 2.7 | 5.4 | 6.8 | 14 | 27 | 135 |
| 28 | 0.28 | 0.84 | 2.8 | 5.6 | 7.0 | 14 | 28 | 140 |
| 29 | 0.29 | 0.87 | 2.9 | 5.8 | 7.3 | 15 | 29 | 145 |
| 30 | 0.30 | 0.90 | 3.0 | 6.0 | 7.5 | 15 | 30 | 150 |
| 31 | 0.31 | 0.93 | 3.1 | 6.2 | 7.8 | 16 | 31 | 155 |
| 32 | 0.32 | 0.96 | 3.2 | 6.4 | 8.0 | 16 | 32 | 160 |
| 33 | 0.33 | 0.99 | 3.3 | 6.6 | 8.3 | 17 | 33 | 165 |
| 34 | 0.34 | 1.02 | 3.4 | 6.8 | 8.5 | 17 | 34 | 170 |
| 35 | 0.35 | 1.05 | 3.5 | 7.0 | 8.8 | 18 | 35 | 175 |
| 36 | 0.36 | 1.08 | 3.6 | 7.2 | 9.0 | 18 | 36 | 180 |
| 37 | 0.37 | 1.11 | 3.7 | 7.4 | 9.3 | 19 | 37 | 185 |
| 38 | 0.38 | 1.14 | 3.8 | 7.6 | 9.5 | 19 | 38 | 190 |
| 39 | 0.39 | 1.17 | 3.9 | 7.8 | 9.8 | 20 | 39 | 195 |

| % of Scale | Full Scale Value | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1.00 | 3.00 | 10.0 | 20.0 | 25.0 | 50 | 100 | 500 |
| 40 | 0.40 | 1.20 | 4.0 | 8.0 | 10.0 | 20 | 40 | 200 |
| 41 | 0.41 | 1.23 | 4.1 | 8.2 | 10.3 | 21 | 41 | 205 |
| 42 | 0.42 | 1.26 | 4.2 | 8.4 | 10.5 | 21 | 42 | 210 |
| 43 | 0.43 | 1.29 | 4.3 | 8.6 | 10.8 | 22 | 43 | 215 |
| 44 | 0.44 | 1.32 | 4.4 | 8.8 | 11.0 | 22 | 44 | 220 |
| 45 | 0.45 | 1.35 | 4.5 | 9.0 | 11.3 | 23 | 45 | 225 |
| 46 | 0.46 | 1.38 | 4.6 | 9.2 | 11.5 | 23 | 46 | 230 |
| 47 | 0.47 | 1.41 | 4.7 | 9.4 | 11.8 | 24 | 47 | 235 |
| 48 | 0.48 | 1.44 | 4.8 | 9.6 | 12.0 | 24 | 48 | 240 |
| 49 | 0.49 | 1.47 | 4.9 | 9.8 | 12.3 | 25 | 49 | 245 |
| 50 | 0.50 | 1.50 | 5.0 | 10.0 | 12.5 | 25 | 50 | 250 |
| 51 | 0.51 | 1.53 | 5.1 | 10.2 | 12.8 | 26 | 51 | 255 |
| 52 | 0.52 | 1.56 | 5.2 | 10.4 | 13.0 | 26 | 52 | 260 |
| 53 | 0.53 | 1.59 | 5.3 | 10.6 | 13.3 | 27 | 53 | 265 |
| 54 | 0.54 | 1.62 | 5.4 | 10.8 | 13.5 | 27 | 54 | 270 |
| 55 | 0.55 | 1.65 | 5.5 | 11.0 | 13.8 | 28 | 55 | 275 |
| 56 | 0.56 | 1.68 | 5.6 | 11.2 | 14.0 | 28 | 56 | 280 |
| 57 | 0.57 | 1.71 | 5.7 | 11.4 | 14.3 | 29 | 57 | 285 |
| 58 | 0.58 | 1.74 | 5.8 | 11.6 | 14.5 | 29 | 58 | 290 |
| 59 | 0.59 | 1.77 | 5.9 | 11.8 | 14.8 | 30 | 59 | 295 |
| 60 | 0.60 | 1.80 | 6.0 | 12.0 | 15.0 | 30 | 60 | 300 |
| 61 | 0.61 | 1.83 | 6.1 | 12.2 | 15.3 | 31 | 61 | 305 |
| 62 | 0.62 | 1.86 | 6.2 | 12.4 | 15.5 | 31 | 62 | 310 |
| 63 | 0.63 | 1.89 | 6.3 | 12.6 | 15.8 | 32 | 63 | 315 |
| 64 | 0.64 | 1.92 | 6.4 | 12.8 | 16.0 | 32 | 64 | 320 |
| 65 | 0.65 | 1.95 | 6.5 | 13.0 | 16.3 | 33 | 65 | 325 |
| 66 | 0.66 | 1.98 | 6.6 | 13.2 | 16.5 | 33 | 66 | 330 |
| 67 | 0.67 | 2.01 | 6.7 | 13.4 | 16.8 | 34 | 67 | 335 |
| 68 | 0.68 | 2.04 | 6.8 | 13.6 | 17.0 | 34 | 68 | 340 |
| 69 | 0.69 | 2.07 | 6.9 | 13.8 | 17.3 | 35 | 69 | 345 |
| 70 | 0.70 | 2.10 | 7.0 | 14.0 | 17.5 | 35 | 70 | 350 |
| 71 | 0.71 | 2.13 | 7.1 | 14.2 | 17.8 | 36 | 71 | 355 |
| 72 | 0.72 | 2.16 | 7.2 | 14.4 | 18.0 | 36 | 72 | 360 |
| 73 | 0.73 | 2.19 | 7.3 | 14.6 | 18.3 | 37 | 73 | 365 |
| 74 | 0.74 | 2.22 | 7.4 | 14.8 | 18.5 | 37 | 74 | 370 |
| 75 | 0.75 | 2.25 | 7.5 | 15.0 | 18.8 | 38 | 75 | 375 |
| 76 | 0.76 | 2.28 | 7.6 | 15.2 | 19.0 | 38 | 76 | 380 |
| 77 | 0.77 | 2.31 | 7.7 | 15.4 | 19.3 | 39 | 77 | 385 |
| 78 | 0.78 | 2.34 | 7.8 | 15.6 | 19.5 | 39 | 78 | 390 |
| 79 | 0.79 | 2.37 | 7.9 | 15.8 | 19.8 | 40 | 79 | 395 |
| 80 | 0.80 | 2.40 | 8.0 | 16.0 | 20.0 | 40 | 80 | 400 |
| 81 | 0.81 | 2.43 | 8.1 | 16.2 | 20.3 | 41 | 81 | 405 |
| 82 | 0.82 | 2.46 | 8.2 | 16.4 | 20.5 | 41 | 82 | 410 |
| 83 | 0.83 | 2.49 | 8.3 | 16.6 | 20.8 | 42 | 83 | 415 |
| 84 | 0.84 | 2.52 | 8.4 | 16.8 | 21.0 | 42 | 84 | 420 |

| % of Scale | Full Scale Value | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1.00 | 3.00 | 10.0 | 20.0 | 25.0 | 50 | 100 | 500 |
| 85 | 0.85 | 2.55 | 8.5 | 17.0 | 21.3 | 43 | 85 | 425 |
| 86 | 0.86 | 2.58 | 8.6 | 17.2 | 21.5 | 43 | 86 | 430 |
| 87 | 0.87 | 2.61 | 8.7 | 17.4 | 21.8 | 44 | 87 | 435 |
| 88 | 0.88 | 2.64 | 8.8 | 17.6 | 22.0 | 44 | 88 | 440 |
| 89 | 0.89 | 2.67 | 8.9 | 17.8 | 22.3 | 45 | 89 | 445 |
| 90 | 0.90 | 2.70 | 9.0 | 18.0 | 22.5 | 45 | 90 | 450 |
| 91 | 0.91 | 2.73 | 9.1 | 18.2 | 22.8 | 46 | 91 | 455 |
| 92 | 0.92 | 2.76 | 9.2 | 18.4 | 23.0 | 46 | 92 | 460 |
| 93 | 0.93 | 2.79 | 9.3 | 18.6 | 23.3 | 47 | 93 | 465 |
| 94 | 0.94 | 2.82 | 9.4 | 18.8 | 23.5 | 47 | 94 | 470 |
| 95 | 0.95 | 2.85 | 9.5 | 19.0 | 23.8 | 48 | 95 | 475 |
| 96 | 0.96 | 2.88 | 9.6 | 19.2 | 24.0 | 48 | 96 | 480 |
| 97 | 0.97 | 2.91 | 9.7 | 19.4 | 24.3 | 49 | 97 | 485 |
| 98 | 0.98 | 2.94 | 9.8 | 19.6 | 24.5 | 49 | 98 | 490 |
| 99 | 0.99 | 2.97 | 9.9 | 19.8 | 24.8 | 50 | 99 | 495 |
| 100 | 1.00 | 3.00 | 10.0 | 20.0 | 25.0 | 50 | 100 | 500 |

## 9.3 Periodic Testing / Calibration of Field Devices

Periodic testing and calibrating of the TS4000 should be performed according to the schedules and procedures outlined in the TS4000 Instruction Manual. Testing and calibration procedures should include, but are not limited to the following:

- Verifying zero reading
- Verifying application of a known concentration of gas

When testing produces results outside of General Monitors' specifications, re-calibration or repair / replacement of the suspect device(s) should be performed. Calibration intervals should be independently established through a documented procedure, including a calibration log maintained by plant personnel or third party testing service.

## 9.4 Periodic System Verification

The following system verifications should be performed at least annually:

- Verify wiring, terminal connections, and stability of mounting for all integral safety equipment including, but not limited to the following:
  - Power supplies
  - Control modules
  - Field detection devices
  - Signaling and indicating devices
  - Accessories connected to field and signaling devices
- Verify proper safety system operation by performing a full, functional test of all component devices – ensuring appropriate levels for all Alarm and Warning conditions
- Verify fault / malfunction circuit operation

## 9.5 Specifications

**Table 38: System Specifications**

| Specification | Description |
|---|---|
| **Sensor Type** | Electrochemical cell |
| **Typical Life (Electrochemical Cell)** | 2 to 3 years under normal conditions |
| **Warranty** | - Two years for the Base Unit and Interface Module<br>- One year for the electrochemical cell |
| **Malfunctions Monitored** | - Calibration Errors<br>- Data Memory Errors |
| **Measuring Ranges** | - Ammonia ($NH_3$): 0-50 ppm, 0-100 ppm<br>- Carbon Monoxide (CO): 0-100 ppm, 0-500 ppm<br>- Chlorine ($Cl_2$): 0-10 ppm, 0-20 ppm<br>- Chlorine Dioxide ($ClO_2$): 0-3 ppm<br>- Hydrogen Chloride (HCl): 0-20 ppm<br>- Hydrogen Sulfide ($H_2S$): 0-100 ppm, 0-50 ppm, 0-20 ppm<br>- Nitric Oxide (NO): 0-100 ppm<br>- Nitrogen Dioxide ($NO_2$): 0-20 ppm<br>- Oxygen ($O_2$): 0-25% by volume<br>- Ozone ($O_3$): 0-1 ppm<br>- Sulfur Dioxide ($SO_2$): 0-20 ppm, 0-100 ppm |
| **Response Time**<br>(100% FS Gas Applied) | - $Cl_2$ and $ClO_2$: T90 < 60 sec<br>- CO, $H_2S$ and $NO_2$: T90 < 30 sec<br>- HCl: T90 < 100 sec<br>- $NH_3$ and $O_3$: T90 < 90 sec<br>- NO and $SO_2$: T90 < 10 sec<br>- $O_2$: T90 < 15 sec |
| **Repeatability** | ± 2% of full scale except ± 0.1 ppm for $O_3$, ± 0.2 ppm for $ClO_2$ and ± 1% of full scale for $O_2$ |
| **Zero Drift** | < 5% per year |
| **Approvals** | CSA, ATEX, CE Marking, GOST |

**Table 39: Mechanical Specifications – Base Unit**

| Specification | Description |
|---|---|
| **Length** | 6.6 inches (168mm) |
| **Height** | 3.3 inches (84mm) |
| **Width** | 4.4 inches (112mm) |
| **Weight** | 5.5 pounds (2.5kg) |
| **Mounting Holes** | 4.9 inches (124mm) center to center |

**Table 40: Mechanical Specifications - Interface Module**

| Specification | Description |
|---|---|
| **Length** | 6.6 inches (168mm) |
| **Diameter** | 1.75 inches (44mm) |
| **Weight** | 1.0 pounds (0.45kg) |
| **Mounting** | ¾ inch NPT |
| **Housing** | Anodized Aluminum |

**Table 41: Cable Requirements**

**Cable Requirements: 3-wire shield cable. Maximum distance between TS4000 and power source @ 24VDC nominal.**

| AWG | FEET | METERS |
|---|---|---|
| 14 | 3430 | 1040 |
| 16 | 1900 | 580 |
| 18 | 1500 | 460 |
| 20 | 1000 | 300 |

**Maximum distance for analog output (600 ohms max).**

| AWG | FEET | METERS |
|---|---|---|
| 14 | 9000 | 2740 |
| 16 | 5200 | 1585 |
| 18 | 3800 | 1160 |
| 20 | 2400 | 730 |

**Max distance between the transmitter and IM module:**

| AWG | FEET | METERS |
|---|---|---|
| 14 | 2000 | 610 |
| 16 | 1550 | 410 |
| 18 | 1050 | 320 |
| 20 | 650 | 200 |

**Table 42: Electrical Specifications**

| Specification | Description |
|---|---|
| **General Purpose Installations** | Maximum distance between the TS4000 and the power source @ 24VDC nominal (600 Ω load resistor maximum) is 3,000 feet (910 meters) |
| **Input Power** | 20 to 36VDC range; +24VDC nominal 0.120amps |
| **Relay Ratings (Optional)** | 8A @ 250 VAC/8A @ 30 VDC resistive maximum<br>(3x) SPDT – Warning, Alarm and Fault |
| **Power Consumption** | Start-up 125mA, Normal Operation 120mA |
| **Output Current** | 600 Ω maximum @ 24VDC<br>Signal Range: 4-22mA Detection Range: 4-20mA<br>Start-up: 1.5mA Calibration: 1.5mA<br>Fault: < 1.0mA Over-range: 22mA |
| **Electrical Classification** | Class I, Division 1 & 2, Groups B, C and D;<br>Class II, Division 1 & 2, Groups E, F & G; Class III;<br>Ex d ib IIB + $H_2$ T5, Type 4X with Remote Interface Module;<br>EEx d mb IIC (-40ºC [ Ta [ + 75ºC) |
| **Status Indicator** | LED Display with Normal, Gas Present, Fault and Calibration Cues |

**Table 43: Environmental Specifications**

| Specification | Description |
|---|---|
| **Operating Temperature Range*** (For All Gases Other Than $NH_3$, $H_2S$) | -4°F to +122°F (-20°C to +50°C) |
| **Operating Temperature Range*** (For $H_2S$) | -40°F to +122°F (-40°C to +50°C) |
| **Operating Temperature Range*** (For $NH_3$) | -40°F to +104°F (-40°C to +40°C) |
| **Storage Temperature Range** (Base Unit and Interface Module) | -40°F to +185°F (-40°C to +85°C) |
| **Storage Temperature Range*** (Electrochemical Cells) | 32°F to +68°F (0°C to +20°C) |
| **Humidity Range*** | 15% to 90% relative humidity, non-condensing |
| **Pressure Range** | Atmospheric ± 10% |
| * Requirements are driven by electrochemical cell specifications. | |

**Table 44: TS4000 Toxic Gas Sensor Accuracy Specifications**

| Accuracy | ChemCell Type and Range |
|---|---|
| ±2 ppm or ±10% of Reading, Whichever Is Greater | - Carbon Monoxide (CO): 0-100 ppm, 0-500 ppm<br>- Chlorine ($Cl_2$): 0-10 ppm, 0-20 ppm<br>- Hydrogen Chloride (HCl): 0-20 ppm<br>- Hydrogen Sulfide ($H_2S$): 0-100 ppm, 0-50 ppm, 0-20 ppm<br>- Nitric Oxide (NO): 0-100 ppm<br>- Nitrogen Dioxide ($NO_2$): 0-20 ppm<br>- Sulfur Dioxide ($SO_2$): 0-20 ppm, 0-100 ppm |
| ±20% of Reading | - Ammonia ($NH_3$): 0-50 ppm, 0-100 ppm<br>- Ozone ($O_3$): 0-1 ppm<br>- Chlorine Dioxide ($ClO_2$): 0-3 ppm |
| ±1% of Oxygen | - Oxygen ($O_2$): 0-25% by volume |

**NOTE:** Ammonia, Chlorine, Chlorine Dioxide, and Hydrogen Chloride electrochemical cells are sensitive to changes in humidity, especially at temperatures above 77°F (25°C). To avoid false alarms caused by humidity variations, it is recommended that alarm set points be set above 20% of the full-scale range.

### 9.5.1 Junction Boxes

The following General Monitors junction boxes are compatible with the TS4000 remote configuration:

**Figure 19: 10252 Round Anodized Aluminum Junction Box**

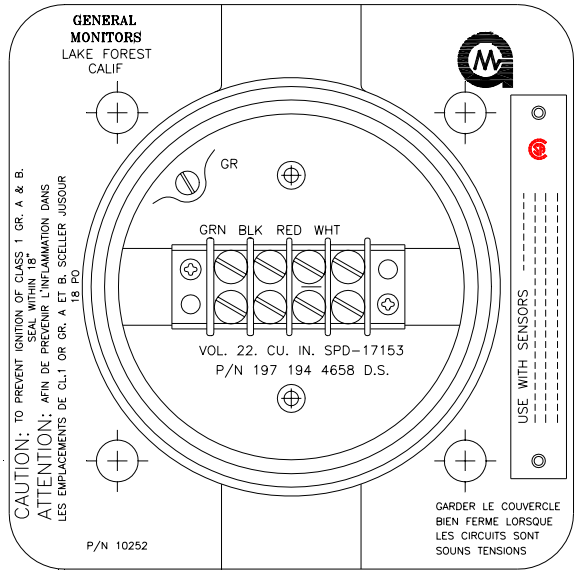
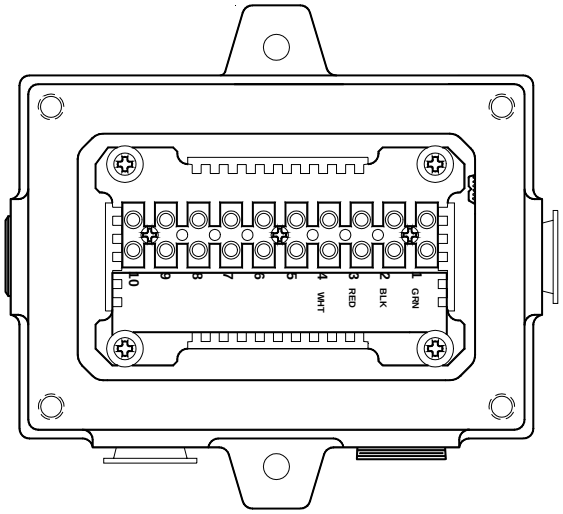



**Figure 20: 31305-2 Anodized Aluminum Junction Box**



### 9.5.2 Splash – Guards

The following General Monitors splash - guards are compatible with the TS4000:

**Figure 21: 45167-1 Splash – Guard Used for $Cl_2$, $ClO_2$, and $O_3$ Gases**

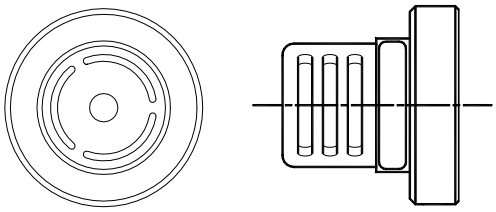
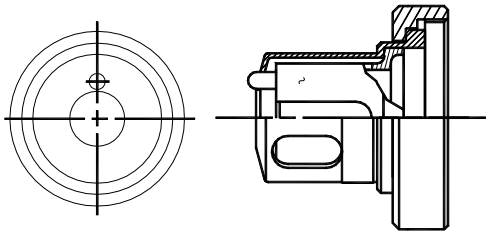


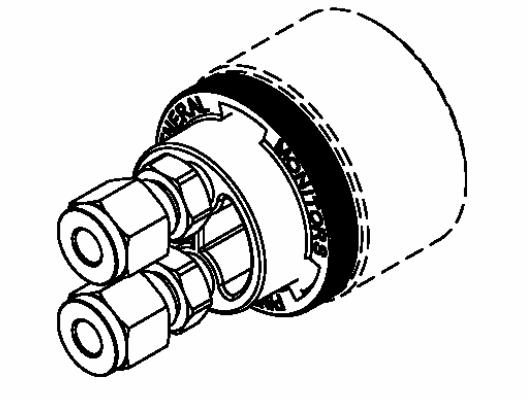
**Figure 22: 70631-2 Splash – Guard**



### 9.5.3 Accessories

The following General Monitors accessories are compatible with the TS4000:

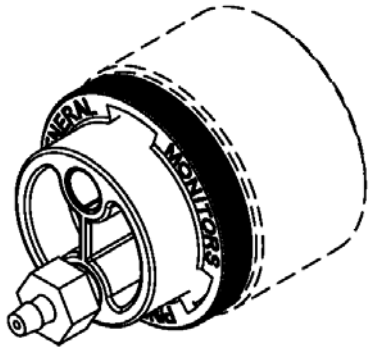
**Figure 23: 45170-1 Flow Block**



### 9.5.4 Calibration Accessories

The following General Monitors calibration accessories are compatible with the TS4000:

**Figure 24: 45172-1 Calibration Plug**



## 9.6 Calibration Schedule

Establishing a periodic calibration schedule is critical to maintaining optimal product performance. Below is a sample schedule for the TS4000:

Detector Serial Number: _____ Location: _____

1) Installation and preliminary calibration. Record date after preliminary calibration is performed:
Date: _____

2) 24-hour calibration. Record date after 24-hour calibration is performed:
Date: _____

3) 7 day calibration check (Record date and reading of calibration check. Repeat after 7 days if reading deviates more than ±20%. Otherwise go to step 4).

| Date | Reading | Date | Reading | Date | Reading |
|---|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ | _____ | _____ |

4) 14 day calibration check (Record date and reading of calibration check. Repeat after 14 days if reading deviates more than ±20%. Otherwise go to step 5).

| Date | Reading | Date | Reading | Date | Reading |
|---|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ | _____ | _____ |

5) 30-day calibration check (Record date and reading of calibration check. Repeat after 30 days if reading deviates more than ±20%. Otherwise go to step 6).

| Date | Reading | Date | Reading | Date | Reading |
|---|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ | _____ | _____ |

6) 60-day calibration check (Record date and reading of calibration check. Repeat after 60 days if reading deviates more than ±20%. Otherwise go to step 7).

| Date | Reading | Date | Reading | Date | Reading |
|---|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ | _____ | _____ |

7) 90-day calibration check:

| Date | Reading | Date | Reading | Date | Reading |
|---|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ | _____ | _____ |
| _____ | _____ | _____ | _____ | _____ | _____ |

## 9.7 Parts and Accessories

Replacement boards for the TS4000 Base Unit are available directly from General Monitors. The Interface Module, however, is a fully encapsulated device and consequently has no replaceable parts. The part number for various TS4000 parts and accessories is listed below:

**Table 45: TS4000 Part Numbers**

| TS4000 | Part Number |
|---|---|
| **Base Unit** | 46066 |
| **Interface Module** | 46100 |
| **Sensor Cap** | 45103-1 |
| **Replacement O-Ring for Sensor Assembly** | 925-5030 |
| **Selection Magnet** | 30060-1 |
| **Screwdriver** | 10450-1 |
| **5mm Allen Wrench** | 954-014 |
| **NOTE:** The TS4000 ships with a Base Unit, Interface Module, and specified electrochemical cell. Detection of the various gases detailed in Table 38 is achieved by hot swapping the chosen electrochemical cell into the TS4000. | |

**Table 46: Replacement Sensors**

| Gas Type | Range | Part Number |
|---|---|---|
| **Ammonia ($NH_3$)** | **0 - 50 ppm** | 45123-6 |
| **Ammonia ($NH_3$)** | **0 - 100 ppm** | 45123-6 |
| **Carbon Monoxide (CO)** | **0 - 100 ppm** | 45123-3 |
| **Carbon Monoxide (CO)** | **0 - 500 ppm** | 45123-3 |
| **Chlorine ($Cl_2$)** | **0 - 10 ppm** | 45123-2 |
| **Chlorine ($Cl_2$)** | **0 - 20 ppm** | 45123-2 |
| **Chlorine Dioxide ($ClO_2$)** | **0 - 3 ppm** | 45123-1 |
| **Hydrogen Chloride (HCl)** | **0 - 20 ppm** | 45123-4 |
| **Hydrogen Sulfide ($H_2S$)** | **0 - 20 ppm, 0 - 50 ppm** | 45186-10 |
| **Hydrogen Sulfide ($H_2S$)** | **0 - 100 ppm** | 45186-11 |
| **Nitric Oxide (NO)** | **0 - 100 ppm** | 45123-7 |
| **Nitrogen Dioxide ($NO_2$)** | **0 - 20 ppm** | 45123-8 |
| **Oxygen ($O_2$)** | **0 – 25% by Vol** | 45213-1 |
| **Ozone ($O_3$)** | **0 - 1 ppm** | 45123-14 |
| **Sulfur Dioxide ($SO_2$)** | **0 - 20 ppm, 0-100ppm** | 45123-9 |
| **NOTE:** Consult the manufacturer's documentation for information on various electrochemical cells. | | |

**Table 47: Mounting Accessories**

| Accessory | Part Number |
|---|---|
| Splash-Guard ($Cl_2$, $ClO_2$, $O_3$) | 45167-1 |
| Splash-Guard (Standard) | 70631-2 |
| Flow Block (Including Retainer / Calibration Plug) | 45170-1 |
| Flow Block Retainer | 45147-1 |
| Aluminum Junction Box (Small) | 10252 |
| Aluminum Junction Box (Large) | 31305-2 |
| Plastic Junction Box (3/4" NPT) | 45160-1 |
| Plastic Junction Box (M20) | 45160-2 |
| ¾" NPT, Adapter, Plastic | 961-009 |
| 20 mm x ¾" NPT Adapter, Brass | 961-006 |

**Table 48: TS4000 Calibration Accessories**

| Accessory | Part Number |
|---|---|
| Case | 914-135 |
| Tubing | 931-085 |
| Regulator (1000 ml/min) For $Cl_2$, $NO_2$, $ClO_2$, HCl, $O_3$ | 922-022 |
| Regulator (500 ml/min) For $SO_2$, NO, CO, $H_2S$,$NH_3$ | 922-023 |
| Calibration Plug | 914-152 |
| Calibration Cup | 1400152-1 |

**Table 49: Calibration Kits (Cylinder, Regulator, and Tubing)**

| Calibration Kit | Range | Cylinder Concentration | Part Number |
|---|---|---|---|
| Ammonia ($NH_3$) | 0 – 50ppm | 25 ppm | 1400263-1 |
| Ammonia ($NH_3$) | 0 – 100ppm | 50 ppm | 1400263-2 |
| Carbon Monoxide (CO) | 0 – 100ppm | 50 ppm | 1400263-9 |
| Carbon Monoxide (CO) | 0 – 500ppm | 250 ppm | 1400263-10 |
| Chlorine ($Cl_2$) | 0 – 10ppm | 5 ppm | 1400263-3 |
| Chlorine ($Cl_2$) | 0 – 20ppm | 10 ppm | 1400263-22 |
| Chlorine Dioxide ($ClO_2$) | 0 - 3 ppm | * | 1400263-4 |
| Hydrogen Chloride (HCl) | 0 – 20ppm | 10 ppm | 1400263-5 |
| Hydrogen Sulfide ($H_2S$) | 0 – 100ppm | 50 ppm | 1400263-33 |
| Hydrogen Sulfide ($H_2S$) | 0 – 50ppm | 25 ppm | 1400263-34 |
| Hydrogen Sulfide ($H_2S$) | 0 – 20ppm | 10 ppm | 1400263-35 |
| Nitric Oxide (NO) | 0 – 100ppm | 50 ppm | 1400263-6 |
| Nitrogen Dioxide ($NO_2$) | 0 – 20ppm | 10 ppm | 1400263-7 |
| Oxygen ($O_2$) – 20.9% | 0 – 25% by Vol | 20.9% | 1400263-11 |
| Ozone ($O_3$) | 0 – 1ppm | * | 1400263-15 |
| Sulfur Dioxide ($SO_2$) | 0 – 20ppm | 10 ppm | 1400263-8 |
| Sulfur Dioxide ($SO_2$) | 0 – 100ppm | 50 ppm | 1400263-21 |

***** Consult Manufacturer

**Table 50: Spare Cylinders**

| Cylinder Type | Range | Cylinder Concentration | Part Number |
|---|---|---|---|
| **Ammonia ($NH_3$)** | **0 – 50ppm** | **25 ppm** | 1400262-1 |
| **Ammonia ($NH_3$)** | **0 – 100ppm** | **50 ppm** | 1400262-2 |
| **Carbon Monoxide (CO)** | **0 – 100ppm** | **50 ppm** | 1400262-9 |
| **Carbon Monoxide (CO)** | **0 – 500ppm** | **250 ppm** | 1400262-10 |
| **Chlorine ($Cl_2$)** | **0 – 10ppm** | **5 ppm** | 1400262-3 |
| **Chlorine ($Cl_2$)** | **0 – 20ppm** | **10 ppm** | 1400262-22 |
| **Chlorine Dioxide ($ClO_2$)** | **0 – 3ppm** | ***** | 1400262-4 |
| **Hydrogen Chloride (HCl) –** | **0 – 20ppm** | **10 ppm** | 1400262-5 |
| **Hydrogen Sulfide ($H_2S$) –** | **0 – 100ppm** | **50 ppm** | 1400255-5 |
| **Hydrogen Sulfide ($H_2S$)** | **0 – 20ppm** | **10 ppm** | 1400255-1 |
| **Hydrogen Sulfide ($H_2S$)** | **0 – 50ppm** | **25 ppm** | 1400255-3 |
| **Nitric Oxide (NO)** | **0 – 100ppm** | **50 ppm** | 1400262-6 |
| **Nitrogen Dioxide ($NO_2$)** | **0 – 20ppm** | **10 ppm** | 1400262-7 |
| **Oxygen ($O_2$) – 20.9%** | **0 – 25% by Vol** | **20.9%** | 1400262-11 |
| **Ozone ($O_3$)** | **0 – 1ppm** | ***** | 1400262-15 |
| **Sulfur Dioxide ($SO_2$)** | **0 – 20ppm** | **10 ppm** | 1400262-8 |
| **Sulfur Dioxide ($SO_2$)** | **0 – 100ppm** | **50 ppm** | 1400262-21 |

***** Consult Manufacturer

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## ADDENDUM
## Product Disposal Considerations

This product may contain hazardous and/or toxic substances.

EU Member states shall dispose according to WEEE regulations. For further General Monitors' product WEEE disposal information please visit:
www.generalmonitors.com/customer_support/faq_general.html

All other countries or states: please dispose of in accordance with existing federal, state and local environmental control regulations.