Model TS4000H

Intelligent Sensor for Toxic Gas Detection

Instruction Manual **09-15**

Part No. **MANTS4000H**
Revision **M/09-15**

This page intentionally left blank.

Table of Contents

Table of Figures

Table of Tables

About This Manual

This manual provides instructions for installing, operating, and maintaining the General Monitors (GM) TS4000H Toxic Gas Detector. The intended audience includes installation personnel, field service technicians, Modbus programmers, and other technical staff involved in installing and using a TS4000H.

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

TS4000H 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 TS4000H. 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 manufacturer's specifications. Initial calibration, calibration checking, and 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 TS4000H detects many extremely toxic gases. Exposure to such gases may result in sickness or death.

WARNING: The TS4000H 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 TS4000H Base Unit is rated Explosion Proof (XP) and the Interface Module Intrinsically Safe (IS) for use in hazardous locations.

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 TS4000H may impair intrinsic safety.

WARNING: Damage to the TS4000H housing where any internal components or protective seals are broken, compromises the safety and usability of the device. A TS4000H 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 TS4000H; however, the overall functionality of the TS4000H may be severely compromised.

WARNING: Do not use a TS4000H with a damaged housing in a hazardous environment.

DO NOT OPEN WHEN AN EXPLOSIVE ATMOSHPERE IS PRESENT. READ AND UNDERSTAND INSTRUCTION MANUAL BEFORE OPERATING OR SERVICING. OPEN CIRCUIT BEFORE REMOVING COVER. POTENTIAL ELECTROSTATIC CHARGING HAZARD – USE ONLY DAMP CLOTH FOR CLEANING.

NE PAS OUVRIR UN PRÉSENCE D'ATMOSPHÉRE EXPLOSIVE. LIRE ET COMPRENDRE MANUEL D'INSTRUCTIONS AVANT D'UTILISER OU SERVICE. OUVRIR LE CIRCUIT AVANT D'ENLEVER LE COUVERCLE. DANGER POTENTIEL ÉLECTROSTATIQUE DE CHARGE – UTILISATION UNIQUEMENT UN CHIFFON HUMIDE POUR LE NETTOYAGE.

IMPORTANT: Each TS4000H 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 TS4000H until you are ready to apply power to the system. Since the TS4000H is not factory calibrated to a specific cell, an initial field calibration must be completed when installing this unit.

SPECIAL CONDITIONS OF SAFE USE PERTAINING TO ATEX/IECEx INSTALLATIONS:

The TS4000H shall not be used as a Safety Related Device as defined by ATEX Directive 94/9/EC,

The Intelligent Sensor Toxic Gas Interface Module Type TS4000(H) shall be installed on a suitably certified Flameproof or Increased Safety enclosure.

The Interface Module Type TS4000(H) shall not be used in an atmosphere that contains more than 21% oxygen.

The Interface Module Type TS4000(H) input power to the equipment shall be limited to 1W.

The Interface Module Type TS4000(H) has a temperature rise of 10K/W and is suitable for use with equipment having a temperature class of T5 in an ambient temperature of up to 75°C.

The Interface Module Type TS4000(H) must be protected by a fuse with a breaking capacity of 1500A fitted in the external circuits.

1.4 Glossary of Terms

Table 1: Glossary of Terms

Term / Abbreviation	Definition
A	Amperes
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
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
HART	Highway Addressable Remote Transducer. A master-slave field communications protocol
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

Term / Abbreviation	Definition
	been removed
NPT	National Pipe Thread
OV Return	Over voltage return
0VDC	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
MOD1	Modbus Channel 1
MOD2	Modbus Channel 2
Lo	If there is Modbus register that contains 32 bit value, it will be divided into 2 16-bit registers named Lo for lower 16 bit value and Hi for upper 16 bit value
Hi	Upper 16 bit value Modbus register

2.0 Product Overview

2.1 General Description

The TS4000H is a +24 VDC-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 TS4000H 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 TS4000H Base Unit is certified as explosion proof and the Interface Module as intrinsically safe 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 TS4000H 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.

HART User Interface: Provides the ability to operate the TS4000H remotely, using two-way communication protocol. This interface allows the user to remotely change the alarm and warning relay settings, read/clear logged events, issue calibration and gas check requests, issue end / abort commands, and many more. For more details on HART commands, refer to the TS4000H HART Communication Manual.

2.3 Applications

The TS4000H Intelligent Sensor provides toxic gas detection for a wide range of applications, including, but not limited to the following:

Industries	Sample Applications
Automotive	Plating processes, engine test cells, foundries, parking garages
Chemicals / Pharmaceuticals	Agricultural fertilizer production, dyes, inks, film processing, pigments, gas storage, refrigerants, propellants, and a wide range of toxic gases used in the manufacture of pharmaceuticals
Food and Beverage	Baking facilities, bottling plants, breweries, distilleries, fish and meat packing plants, grain storage
Petroleum / Petro-Chemicals	Refining, processing, storage, and liquefaction
Primary Metals	Steel plants, aluminum plants, smelting, pickling, machining, and finishing
Pulp and Paper	Bleaching, chemical pulp processing, chemical recovery, water treatment
Utilities	Coal gasification, incineration, flue gas, power plants
Water and Waste	Chlorinating, sewage sludge and manhole entry

Table 2: Sample Industry Applications

2.4 Base Unit

The TS4000H Base Unit provides the display / control device for the entire TS4000H. The Base Unit is built on the proven Intelligent Sensor platform and incorporates the following key features:

- Bright LED Digital Display (outdoor readable)
- Modbus and HART Communications
- 8A Relays
- One Activation Point for Settings and Calibration
- Simplified Wiring and Field Connections
- Intuitive Calibration Prompts
- Remote Sensor Placement Capability
- Remaining Sensor Life Indicator
- Low Total Cost of Ownership

Figure 1: Base Unit

2.5 Interface Module

The TS4000H Interface Module is encapsulated in an anodized aluminum housing enabling sensor information to be processed at the point of detection. The TS4000H provides a 4-20 mA 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 seal from the Interface Module to the Base Unit
- One I/O pair for digital serial communication to and from the Base Unit and Interface Module
- One +24 VDC / 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 TS4000H uses electrochemical cells with three electrodes and a sensor identification board (Figure 3). This design provides 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.

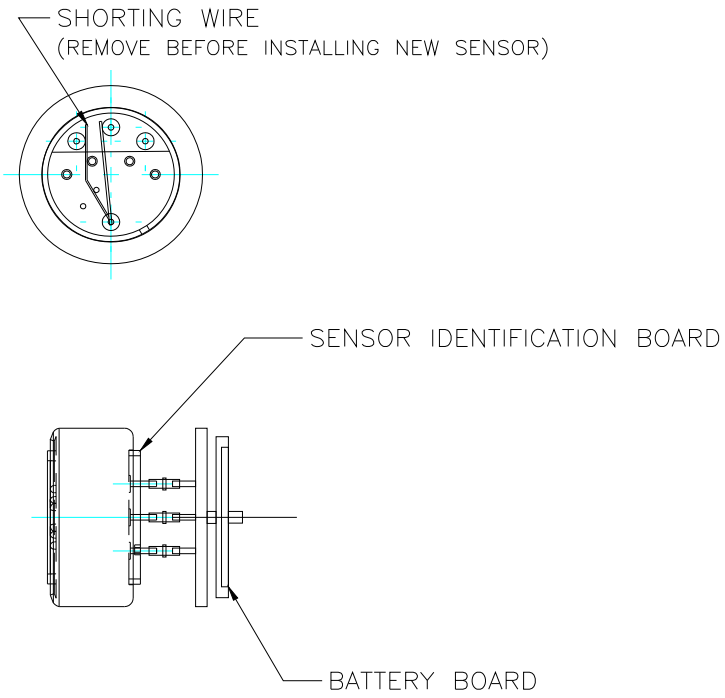


Figure 3: Electrochemical Cell Assembly

NOTE: The oxygen sensor does not have an identification board. Nonetheless, the TS4000H 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 TS4000H 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.

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 TS4000H 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 TS4000H and control room devices (including power, 4-20 mA, and Modbus)	3.5
5	Powering up the TS4000H	3.6

Table 3: Installation Overview

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 TS4000H 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 TS4000H 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 TS4000H:

Tool	Use
5 mm Allen head wrench	To remove the TS4000H 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)

Table 4: Required Tools

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 TS4000H, check the conditions at the installation site to make this determination. The following guidelines can assist in determining the best possible placement of the TS4000H:

To Find a Suitable Installation Location

1. Locate the TS4000H 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 TS4000H with the electrochemical cell pointing down and in an easily accessible location for reading of the LED display and performing routine maintenance.

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 following table.

Cell Type	Gas Combinations					
Ammonia	**Carbon Monoxide**		**Hydrogen Sulfide**		**Sulfur Dioxide**	
	Applied	Indicates	Applied	Indicates	Applied	Indicates
	50 ppm	0 ppm	25 ppm	7 ppm	10 ppm	0 ppm
Carbon Monoxide	**Ethylene**		**Hydrogen**		**Nitric Oxide**	
	Applied	Indicates	Applied	Indicates	Applied	Indicates
	100 ppm	75 ppm	100 ppm	60 ppm	100 ppm	20 ppm
Chlorine	**Nitrogen Dioxide**					
	Applied	Indicates				
	100 ppm	120 ppm				
Chlorine Dioxide	**Nitrogen Dioxide**					
	Applied	Indicates				
	100 ppm	120 ppm				
Hydrogen	**Carbon Monoxide**		**Ethylene**		**Nitric Oxide**	
	Applied	Indicates	Applied	Indicates	Applied	Indicates
	100 ppm	200 ppm	100 ppm	75 ppm	10 ppm	≤2 ppm
Hydrogen Chloride	**Sulfur Dioxide**					
	Applied	Indicates				
	100 ppm	35 ppm				
Hydrogen Sulfide	**Sulfur Dioxide**		**Ammonia**		**Carbon Monoxide**	
	Applied	Indicates	Applied	Indicates	Applied	Indicates
	100 ppm	100 ppm	100 ppm	0 ppm	100 ppm	0 ppm
Nitric Oxide	**Hydrogen Sulfide**		**Nitrogen Dioxide**			
	Applied	Indicates	Applied	Indicates		
	100 ppm	35 ppm	100 ppm	25 ppm		
Nitrogen Dioxide	**Chlorine**					
	Applied	Indicates				
	100 ppm	90 ppm				
NOTE: All values are approximations based on experimental data.						

Table 5: Gas Combination Table

WARNING: When operating the TS4000H 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 TS4000H 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. Chlorine, Chlorine Dioxide, and Hydrogen Chloride cell types may be sensitive to humidity variation (See Table 44 for Environmental Specifications).

3.3 Installation Overview

The TS4000H 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 TS4000H requires little maintenance. 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 TS4000H should be used when making installation determinations. For Mechanical Specifications, refer to Section 9.5.

3.3.1 Intrinsic Safety Barrier

The TS4000H 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 TS4000H and without declassifying the area. The TS4000H can be used in a hazardous area without additional hardware.

3.3.2 Electrochemical Cell Maintenance

The removal of particulates from the electrochemical cell must be done using compressed, instrument grade air. The air nozzle must be kept at a distance to prevent damaging the cell by the force of the air current. Solvents must never be used.

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 TS4000H using the bolt holes 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 TS4000H.

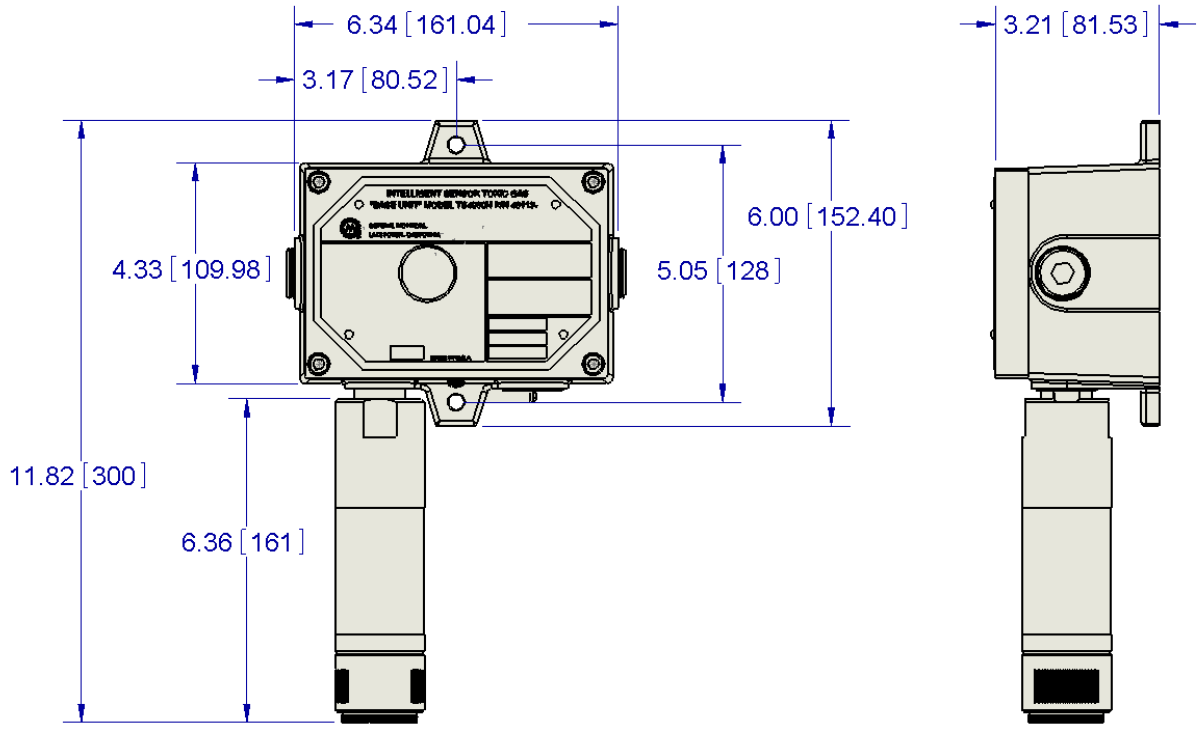


Figure 4: Mounting Dimensions

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.

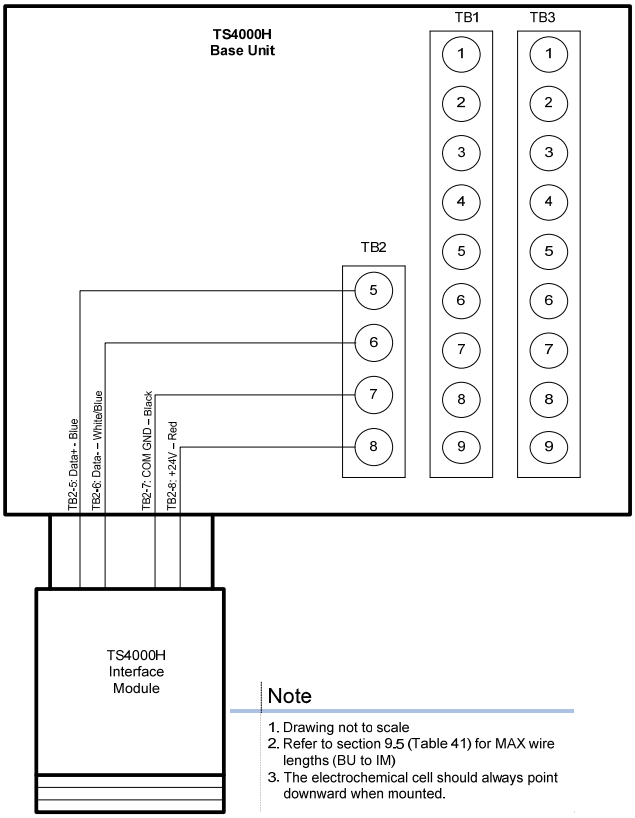


Figure 5: Local Configuration Diagram

Before mounting, review the following:

Detection Location Guidelines listed in Section 3.2.2.

Environmental Specifications listed in Section 9.5.

To Mount the TS4000H – Local Configuration

1. Mount the TS4000H 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 bolt holes, mount the TS4000H 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 TS4000H also supports remote placement of the Interface Module using an external junction box. Refer to Section 9.5.1 for compatible junction boxes.

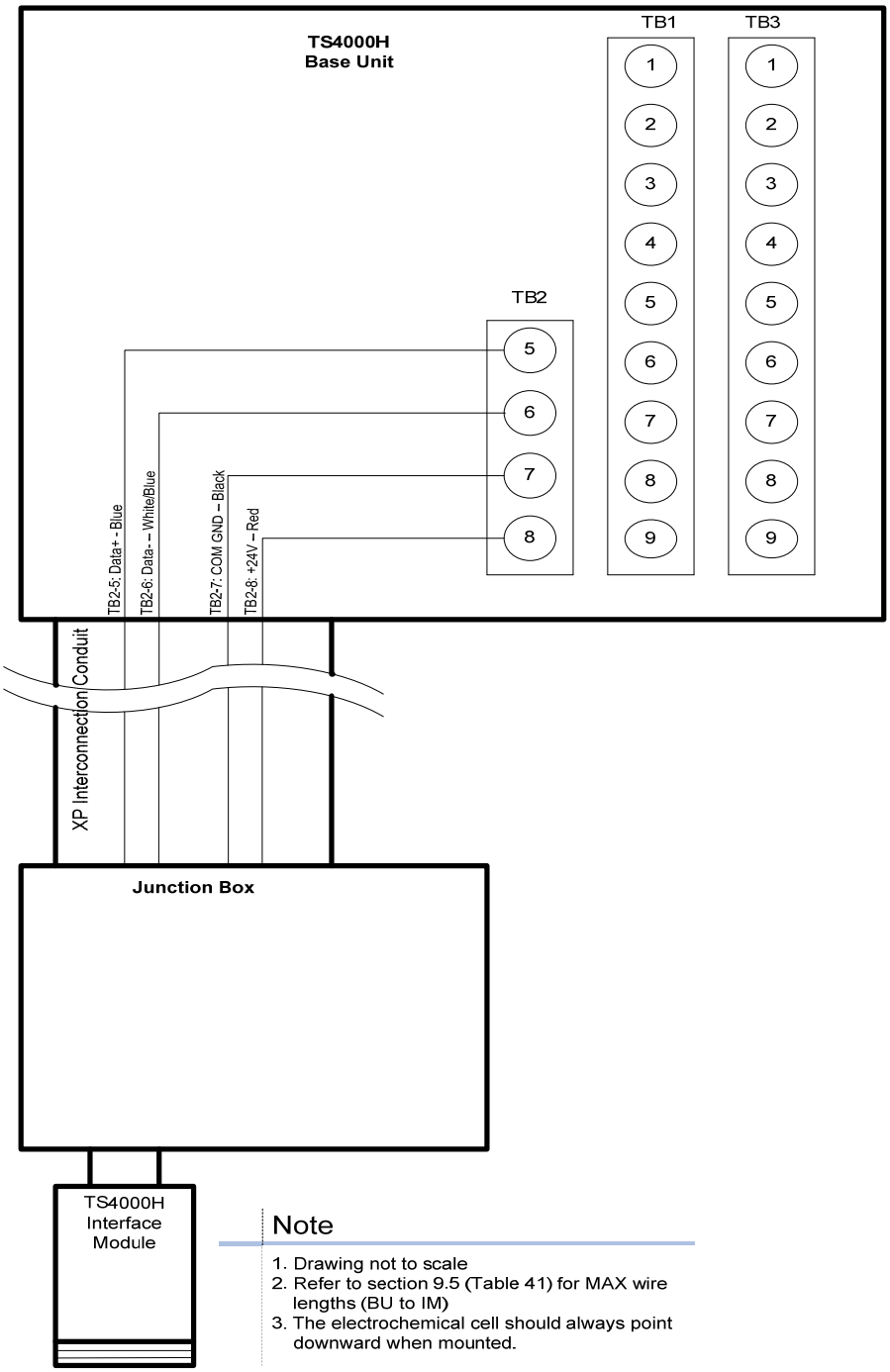


Figure 6: Remote Configuration Diagram

Before mounting, review the following:

Detection Location Guidelines listed in Section 3.2.2.

Environmental Specifications listed in Section 9.5.

To Mount the TS4000H – Remote Configuration

1. Mount the TS4000H Base Unit vertically to reduce the possibility of dirt and dust building up on the display window.
   - Using the two bolt holes, mount the TS4000H Base Unit to an appropriate surface or wall.
   - Using the available bolt holes, mount the remote junction box to a stable surface or wall.
2. Connect the conduit/cable between 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.

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 TS4000H.

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.
2. Connect the black wire to the Ground Terminal TB2-7.
3. Connect the blue wire to the Data Terminal TB2-5 and connect the white / blue wire to the Data Terminal TB2-6.
4. Connect the red wire to the +24 VDC Terminal TB2-8.

In order to prevent accidental shut down and ensure continual operation of the TS4000H 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 TS4000H and the power supply.

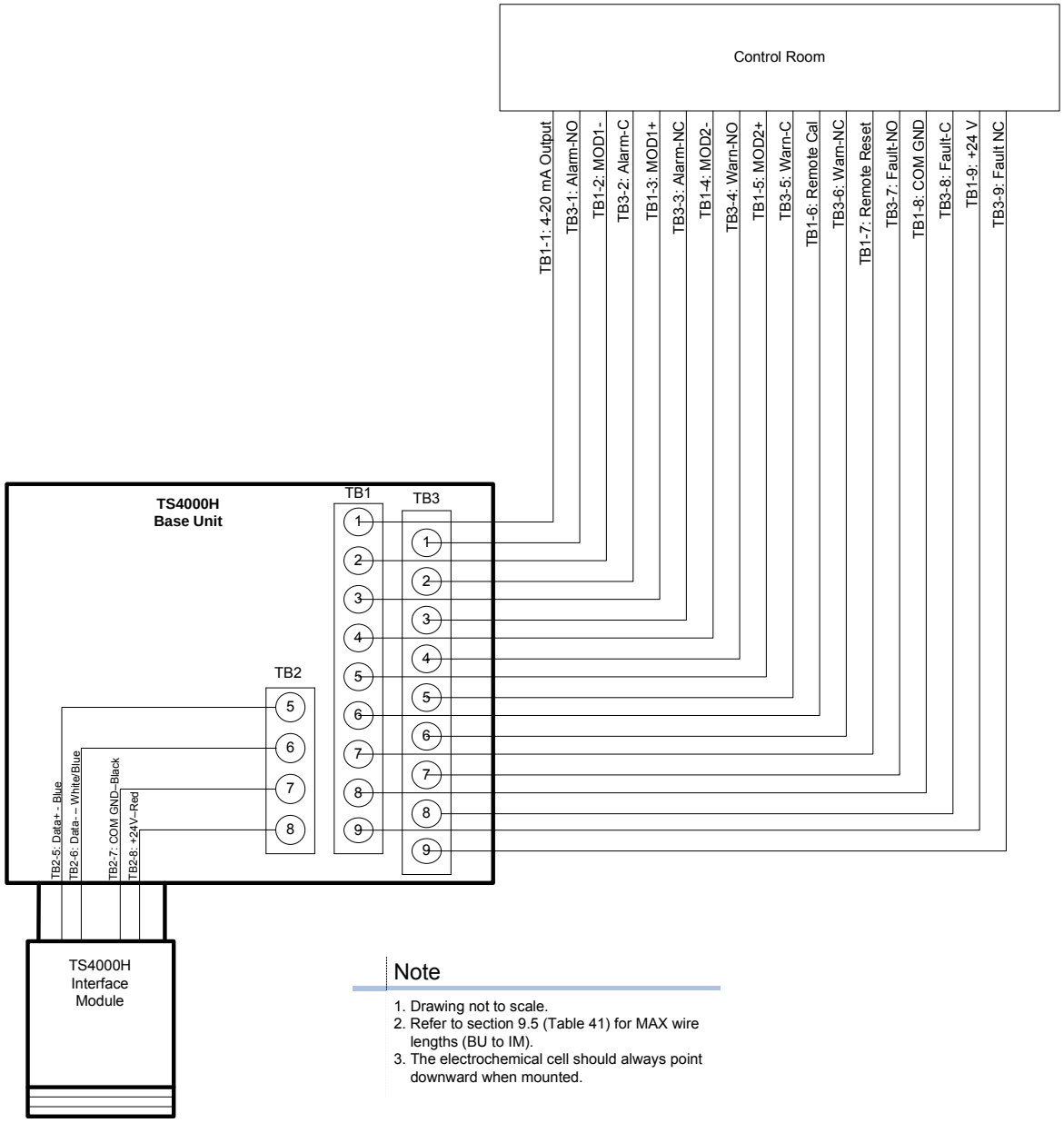


Figure 7: Wiring Diagram – Local Configuration

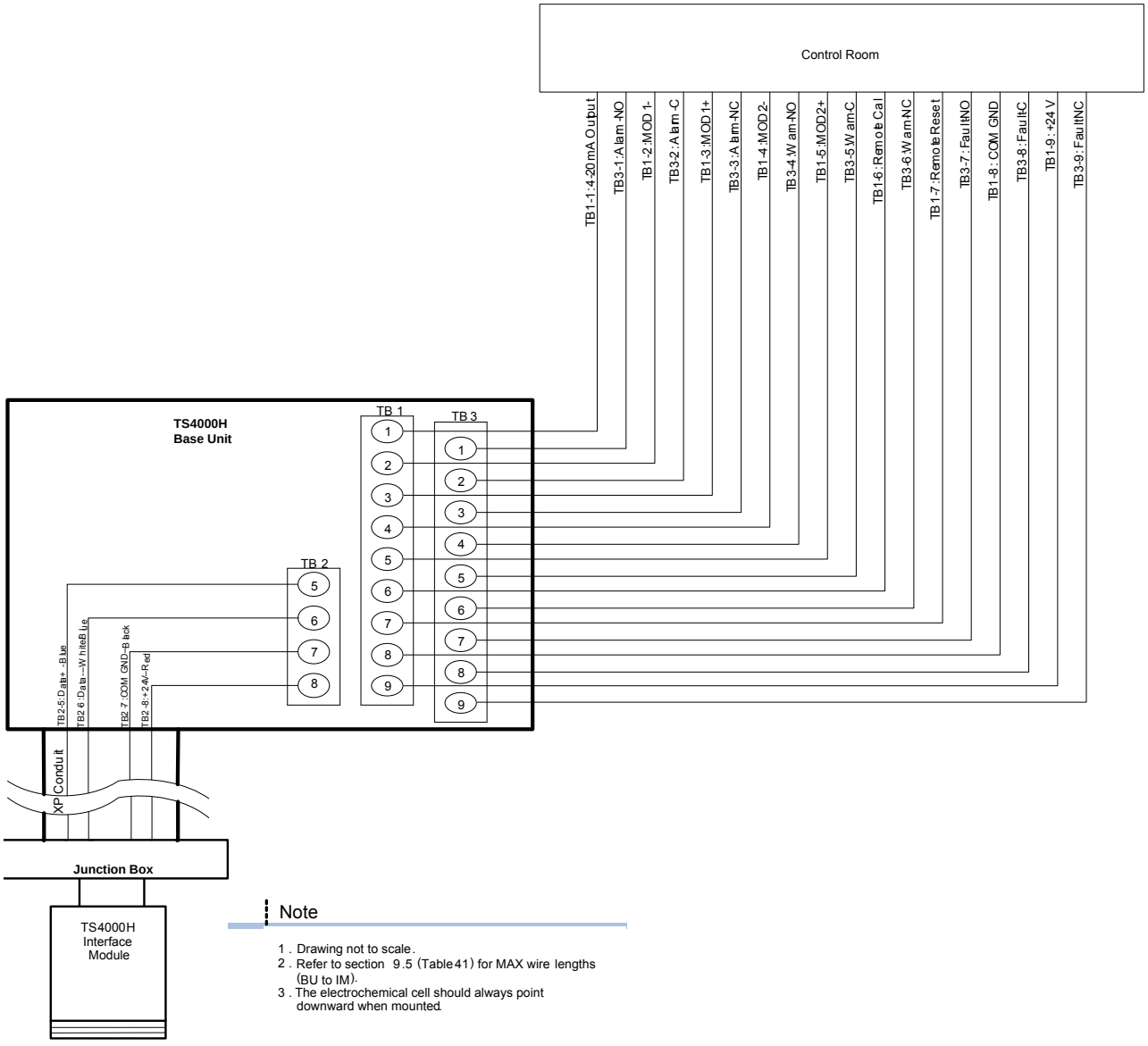


Figure 8: Wiring Diagram – Remote Configuration

3.5.1 Wiring Safety Notices

WARNING: Under **NO** circumstances should equipment (other than an electrochemical cell) 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.

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 TS4000H terminal block connectors TB1, TB2, and TB3 that hold the wiring that connects the TS4000H to local alarms and control room equipment. You must remove the cover from the TS4000H 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 TS4000H to DC Ground on the power supply first, then the Modbus and Analog device wiring connections. The +24 VDC signal on the power supply must be connected last. Power to the TS4000H must remain **OFF** until all wiring is completed and the start-up readiness checklist has been verified; refer to Section 3.6.1.

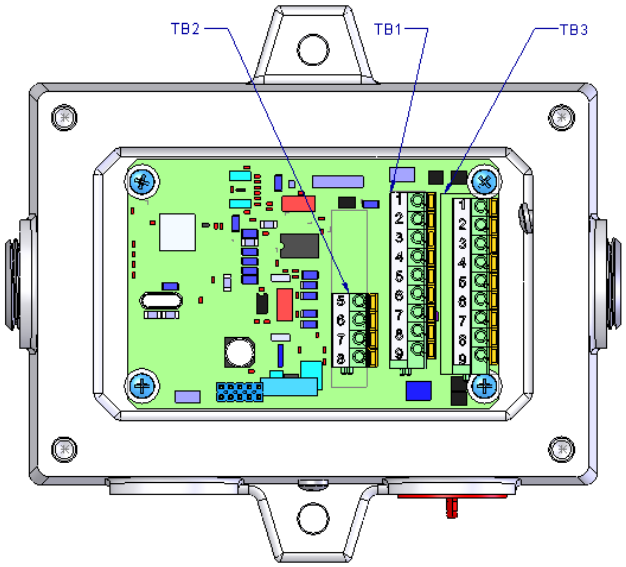


Figure 9: Terminal Block Connector Pin outs

TB2	Signal
5	Data+
6	Data-
7	COM GND
8	+24 VDC

TB1	Signal
1	4-20 mA Output
2	MOD1-
3	MOD1+
4	MOD2-
5	MOD2+
6	Remote Cal
7	Remote Reset
8	COM GND
9	+24 VDC

TB3	De-Energized	Energized
1	Alarm-NC	Alarm-NO
2	Alarm-C	Alarm-C
3	Alarm-NO	Alarm-NC
4	Warn-NC	Warn-NO
5	Warn-C	Warn-C
6	Warn-NO	Warn-NC
7	N/A	Fault-NO
8	N/A	Fault-C
9	N/A	Fault-NC

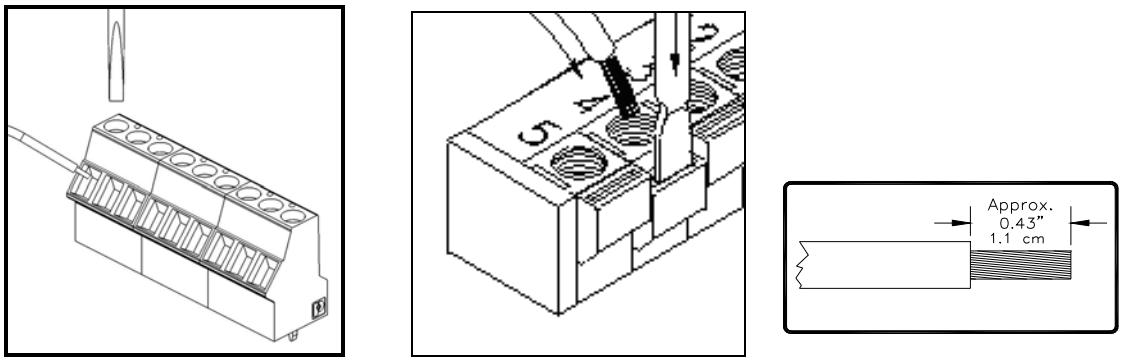
CAUTION: Contact with PCB components should be avoided to prevent damage by static electricity. All wire connections are made to the terminal blocks. The following procedure is for attaching wiring to connectors in the TS4000H terminal blocks TB1, TB2, and TB3.

To Attach Wiring to a TS4000H Terminal Block using Spring Type Terminals (see Fig. 10):

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 TS4000H Terminal Block using Screw Type Terminals (see Fig. 10):

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.



Screw Type terminal **Spring Type terminal**

Figure 10: Terminal Block Connector Detail

3.5.3 Connecting to the Power Supply DC Ground

The TS4000H 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 TS4000H and the power supply.

To Connect the TS4000H to DC Ground

1. Connect the Base Unit terminal block TB1-8 to the power supply Common (0 VDC).
2. If the TS4000H is being used with a +24V power supply and an industrial analog to digital (A/D) converter, the negative supply (COM) of all three devices must be connected.

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

From	To
TS4000H	**TA502A**
TB1-8 COM (0 VDC)	Rear Pin 30d or 30z

Table 6: TS4000H to GM Display Device DC Ground Connections

3.5.4 Connecting Control Room Devices to the TB1 Block

The TB1 terminal block supports the connection from the TS4000H 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.

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

Table 7: TS4000H Terminal Block TB1 Pinouts

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.

From	To
TS4000H Base Unit	**TA502A**
TB1-1 4-20 mA Output	Rear Pin 26d or 26z

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

NOTE: To make output signal connections to display devices, refer to the specific manual for that device. If the 4-20 mA 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 TS4000H 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 TS4000H signal pin outs shown in the following table:

From	To	From	To
TS4000H	**First Device**	**TS4000H**	**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

Table 9: Connection to Control Room Modbus Devices

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 TS4000H and reset the TS4000H relays. To view the TS4000H LED display and use the remote calibration switch effectively, the device must be mounted within view of the display.

From	To
TS4000H	**Modbus Device**
TB1-6 Remote CAL	Refer to the device documentation
TB1-7 Remote Reset	Refer to the device documentation

Table 10: Connections to Remote Calibration and Relay Reset Devices

3.5.5 Connecting to the +24 VDC Power Supply

The TS4000H operates on +24 VDC power. You must connect the TS4000H to a primary DC power source.

For Information on the maximum distance between the TS4000H 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 TS4000H +24 VDC 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 TS4000H is designed to continuously monitor the presence of hazardous gas leaks. A power switch is not included for the TS4000H to prevent accidental system shut down. Powering the system on and off is done from the power supply. An internal diode protects the TS4000H in the event of inadvertent power supply reversal.

To Connect the TS4000H to the Power Supply +24 VDC

1. Connect the TS4000H TB1-9 connector to the power supply +24 VDC terminal. The power supply manual for the location of this terminal.
2. For power connections to GM device power supplies, review the following table.

From	To
TS4000H	**TA502A**
TB1-9 +24 VDC	Rear Pin 28d or 28z

Table 11: TS4000H to GM Display Device +24 VDC Connections

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 TS4000H 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.

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

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

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

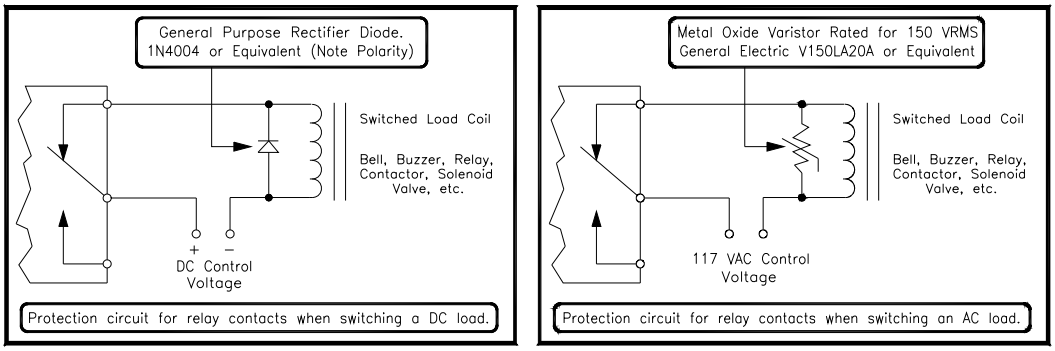


Figure 11: Relay Protection for DC and AC Loads

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

***European Union (EU) Approved Applications**:* The ALARM relay contact ratings are 8 A, 30 V RMS/42.4 V peak or 8 A @ 30 VDC resistive max.

3.6 Applying Power and Starting Operation

Once the mounting, cabling, and alarm relay installation is complete, the TS4000H is ready to begin the power-on sequence. Please read this section carefully before applying power to the TS4000H.

3.6.1 Start-up Readiness Checklist

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

Step	Description
1	Verify that the TS4000H 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 TS4000H Base Unit and Interface Module
4	Verify connections between the TS4000H Base Unit and any control room devices
5	Make sure that the TS4000H 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 TS4000H is powered by +24 VDC (20 to 36 VDC voltage range). The TS4000H display outputs a low voltage fault at 18.5 VDC or below

Table 13: Start-up Readiness Checklist

NOTE: To protect the system from shorting, the +24 VDC wire(s) to the power supply(s) should be connected after the readiness checklist is verified. The TS4000H is designed to continuously monitor the presence of hazardous gas leaks; a power switch is not included for the TS4000H to prevent accidental system shut down.

3.6.2 Start-up Process

NOTE: Powering on and off of the TS4000H 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 TS4000H, contact General Monitors Customer Support. For contact information, refer to Section 8.0.

Upon first power-up, the TS4000H should be allowed to stabilize while the Interface Module attains the proper operating temperature. The TS4000H 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 or equal 50
- ### for FS concentrations (>) greater than 50

NOTE: If the reading is over the range of the electrochemical cell, the TS4000H registers "**or**."

3.7 Maintaining Explosion Proof Integrity

The TS4000H Base Unit and Interface Module are rated for use in the following hazardous locations:

CSA: Class I, Divisions 1 & 2, Groups B, C, D, Class II, Division 1 & 2, Groups E, F & G Class III;

ATEX/IECEx: Interface module: Class I, Zone 1, Group IIC

Display Unit: Class I, Zone 1, Group IIB+ H_2 and Zone 21, Group IIIC

Some of the factors that influence the explosion proof integrity of the TS4000H 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 TS4000H Base Unit cover bolts or the Interface Module are loosened while power is on, it is necessary to de-classify 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 TS4000H 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 TS4000H 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 TS4000H 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 TS4000H menu system. Information regarding use of the TS4000H 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:

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 TS4000H is powered by +24 VDC (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.

Table 14: Start-up Checklist

4.2 User Menu Structure

The TS4000H 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, Modbus Communications Settings, and HART Communication Settings if HART is present on the device. 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 TS4000H menu structure:

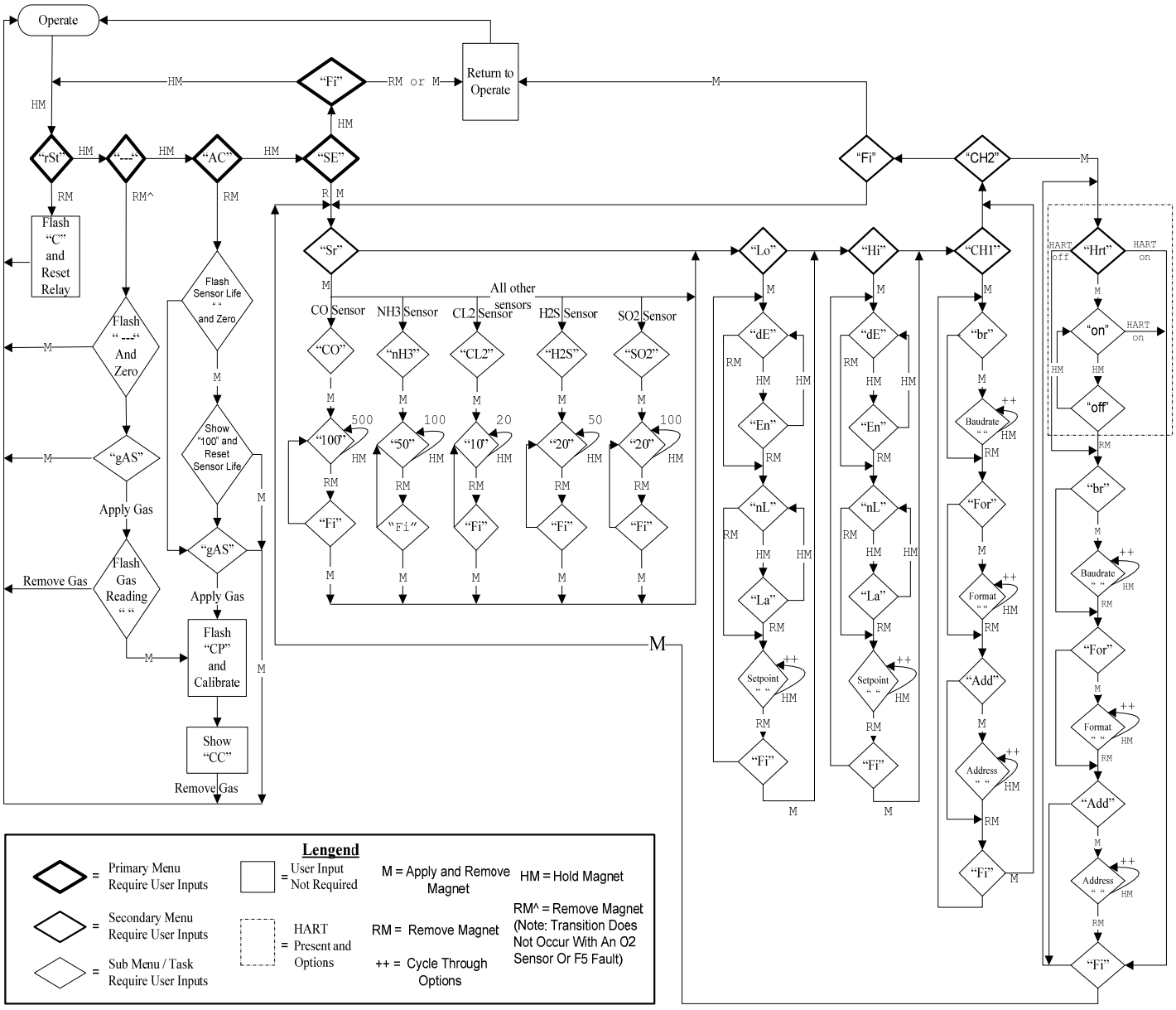


Figure 12: User Menu Structure

NOTE: If the TS4000H 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:

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
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

Table 15: User Menu Display

En	Energize relay
nL	Non-latching relay
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
Hrt	HART settings, HART chip present on the device
on	HART option, enable HART communication
off	HART option, disable HART communication

Table 15: User Menu Display

4.4 Start-up

Upon power-up, the **TS4000H** will display "**8.8.8.**" on three 7-segment LCDs, two Alarm and Warning LEDs. The software revision letters "**rN**'' (N – revision letter) are briefly displayed. The TS4000H then enters Start-up Mode ''**SU**", allowing the electrochemical cell to stabilize. Upon sensor stabilization, the TS4000H 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 TS4000H.

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 two minutes. Inactivity for a period longer than this results in the TS4000H reverting to F10 fault.

4.6 Selectable Options

The TS4000H 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 TS4000H 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 TS4000H.

The Sensor Range for the following five sensor types is not uniquely determined by the TS4000H and must be configured manually:

- Ammonia (NH_3)
- Carbon monoxide (CO)
- Chlorine (Cl_2)
- Hydrogen sulfide (H_2S)
- Sulfur dioxide (SO_2)

For these five 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 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 (SO_2) sensor cell is installed, the user may select either 20 ppm or 100 ppm FS.

To Change the Sensor Range for CO, Cl_2, H_2S, NH_3, and SO_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, causing "**Sr**" menu to be displayed immediately.
2. Apply and remove the magnet and wait until "**CO**", "**CL2**", "**H2S**", "NH3", or **"SO2"** appears on the display. The user will then have the following sensor ranges to choose from (depending on the installed sensor):
    - "**CO**" – **100** and **500**
    - "**CL2**" – **10** and **20**
    - "**H_2S**" **– 20** and **50**
    - **"NH_3" – 50 and 100**
    - "**S02**" **– 20** and **100**

3. Apply and remove the magnet to see the sensor range appears on the display. Apply the magnet to cycle through the ranges, and remove the magnet to select the correct range on the display. When "**Fi**" of the sensor range menu displays, apply and remove the magnet to exit this menu.
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 and return to normal operation.

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: A fault occurs if the user does not complete the menu cycle. 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 the magnet until the desired state is displayed, and remove to select the desired state.
4. After a few seconds the Latching / Non-Latching state of the relay displays by either "**LA**" or "**nL**." Apply the magnet until the desired state is displayed, and remove to select the desired state.
5. After a few seconds, the current Warning Relay set point displays. Apply and hold the magnet to increment the set point by 1%.
6. Remove the magnet 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 and return to normal operation.

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 the magnet until the desired state is displayed, and remove to select the desired state.
4. After a few seconds the Latching / Non-Latching state of the relay displays by either "**LA**" or "**nL**" being displayed, respectively. Apply the magnet until the desired state is displayed, and remove to select the desired state.
5. After a few seconds, the current Warning Relay set point displays. Apply and hold the magnet to decrement the set point by 1%.
6. Remove the magnet 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 and return to normal operation.

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 (maximum)
- 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 the magnet until the desired state is displayed, and remove to select the desired state.
4. After a few seconds the Latching / Non-Latching state of the relay displays by either "**LA**" or "**nL**" being displayed, respectively. Apply the magnet until the desired state is displayed, and remove to select the desired state.
5. After a few seconds, the current Alarm Relay set point displays. Apply and hold the magnet to increment the set point by 1%.
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 and return to normal operation.

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 hold the magnet to decrease the set point by 1%.
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 and return to normal operation.

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 through 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 hold the magnet until the required baud rate displays, and remove to select the required baud rate. 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 hold the magnet until the required data format displays, and remove to select the required data format. 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 hold the magnet to increment the address by 1.
6. Remove the magnet 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 and return to normal operation.

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

To restore Modbus Channel 1 and 2 defaults:

Hold the reset input low and turn on the power (F10 error may be displayed):
• Channel 1 address factory default is 1
• Channel 1 baud rate factory default is 9600.
• Channel 1 format factory default is 8-N-1.
If Channel 2 is available (HART is disabled):
• Channel 2 address factory default is 2
• Channel 2 baud rate factory default is 9600.
• Channel 2 format factory default is 8-N-1.

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. If HART is enabled, user can not use Modbus Channel 2.

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 hold the magnet until the required baud rate displays, and remove to select the required baud rate. 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 hold the magnet until the required data format displays, and remove to select the required data format. 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 hold the magnet to increment the address by 1.
6. Remove the magnet 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 and return to normal operation.

4.6.6 HART/Modbus SELECT

This option is not shown if HART was not purchased for the TS4000H. When HART is selected via setup, the Modbus Channel 2 setup is not displayed or available. When Channel 2 is changed from HART to Modbus, the previous Modbus Channel 2 settings are used. Refer to Section 4.2 for User Menu Structure.

To Enable/Disable HART Communication

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 enable HART, apply and remove the magnet when "**Hrt**" displays. The current HART status is then displayed. If "**off**" is displayed, apply the magnet until "**on**" option displays. To disable HART, if "**on**"is displayed, apply the magnet until "**off**" option displays.
4. Remove the magnet to select the currently displayed HART option. To save the setting, apply and remove the magnet when "**Fi**" displays.
5. To exit the Setup Menu, apply and remove the magnet when "**Fi**" displays again and return to normal operation.

4.7 Relay Reset

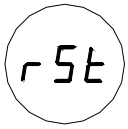


Figure 16: Relay Reset

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 about 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 TB1. Connect a normally open switch between terminal TB1-7 and TB1-8. 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 TS4000H.

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

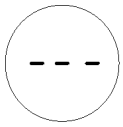


Figure 17: Gas Check

The sensor's response can be checked without activating external alarms by placing the TS4000H in Gas Check Mode. In this mode, the alarm relays are inhibited and the analog output is fixed at 1.5 mA.

NOTE: Gas Check Mode is not accessible when either an O_2 sensor or no sensor is installed in the TS4000H.

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 "**---**" flashes 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 TS4000H is placed in the Gas Check Mode and no gas is applied within ten minutes, the unit returns to normal operation. If the TS4000H 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 TS4000H 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 and removing 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 and remove 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 TS4000H can be transitioned directly from Gas Check Mode to Calibration Mode by reapplying and removing 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 TS4000H 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 TS4000H.

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 10 minutes.

4.9.1 Calibration Procedure

Entering Calibration Mode automatically disables the alarm circuits by sending a 1.5 mA 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 TS4000H.

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 TS4000H 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.

NOTE: The sensor life figure displayed is that calculated on completion of the last calibration. To determine the current sensor life, calibrate unit and then repeat steps 1 and 2.

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 and remove, 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 again 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 TS4000H 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: Remaining sensor life is an estimate of sensor degradation derived from sensor sensitivity. Because sensor sensitivity is affected by factors other than the natural sensor degradation, users must establish their own reference by resetting sensor life whenever these factors are at play. Some examples of these factors are new sensor installations, sensor replacement, change of the target gas, and changes in the access of gas to the sensor (e.g. splash guard). If sensor life is not reset, the remaining sensor life indicator will no longer reflect the true state of the sensor.

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 and remove the magnet, the flashing number changes to "**100**" after about 3 seconds. 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 TS4000H. 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.

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

Table 16: Sensor Flow Rates

5.0 Modbus Interface

5.1 Introduction

The TS4000H 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 TS4000H will respond with a formatted message as defined below.

5.2 Baud Rate

The TS4000H 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:

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

Table 17: Selectable Data Formats

5.4 Function Codes Supported

The TS4000H 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 TS4000H by sending an 8-byte message as described in Table 18.

Byte	Modbus	Range	Referenced to TS4000H
1st	Slave Address	1-247* (Decimal)	TS4000H ID (Address)
2nd	Function Code	03	Read Holding Registers
3rd	Starting Address Hi	00	Not Used by the TS4000H
4th	Starting Address Lo	00-44 (Hex)	TS4000H Commands
5th	Number of Registers Hi	00	Not Used by the TS4000H
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.

Table 18: Modbus Read Register(s) Request

Upon receiving a valid read register request from the master device, the TS4000H 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).

Byte	Modbus	Range	Referenced to TS4000H
1st	Slave Address	1-247* (Decimal)	TS4000H 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)	TS4000H Hi Byte Status Data
5th	Data Lo **	00-FF (Hex)	TS4000H 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.

Table 19: Modbus Read Register(s) Response

5.6 Modbus Write Command Protocol (Query / Response)

A master device writes to a TS4000H register by sending a properly formatted 8-byte message as described in Table 20.

Byte	Modbus	Range	Referenced to TS4000H
1st	Slave Address	1-247* (Decimal)	TS4000H ID (Address)
2nd	Function Code	06	Preset Single Registers
3rd	Register Address Hi	00	Not Used by TS4000H
4th	Register Address Lo	00-FF (Hex)	TS4000H Register Address Lo Byte
5th	Preset Data Hi	00-03 (Hex)	TS4000H Hi Byte Command Data
6th	Preset Data Lo	00-FF (Hex)	TS4000H 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.			

Table 20: Modbus Write Register Request

Upon receiving a valid register write request from the master device, the TS4000H 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).

Byte	Modbus	Range	Referenced to TS4000H
1st	Slave Address	1-247* (Decimal)	TS4000H ID (Address)
2nd	Function Code	06	Preset Single Registers
3rd	Register Address Hi	00	Not Used by TS4000H
4th	Register Address Lo	00-FF (Hex)	TS4000H Register Address Lo Byte
5th	Preset Data Hi	00-FF (Hex)	TS4000H Hi Byte Command Data
6th	Preset Data Lo	00-FF (Hex)	TS4000H 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.			

Table 21: Modbus Write Register Response

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 TS4000H. Upon receiving the query, the TS4000H 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 TS4000H does not receive the query due to a communications error, then no response is returned from the TS4000H and the master device will eventually process a timeout condition for the query.
2. If the TS4000H receives the query, but detects a communication error (CRC, etc.), then no response is returned from the TS4000H and the master device will eventually process a timeout condition for the query.
3. If the TS4000H 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 TS4000H. 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 TS4000H is 200 milliseconds. Therefore, the master's timeout setting should be set to 200 milliseconds or greater.
4. If the TS4000H receives the query without a communications error, but cannot process it due to reading or writing to a non-existent TS4000H command register, then the TS4000H 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.

Byte	Modbus	Range	Referenced to TS4000H
1st	Slave Address	1-247* (Decimal)	TS4000H 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.			

Table 22: Exception Response

5.7.2 Exception Code

Exception Code Field: In a normal response, the TS4000H returns data and status in the response data field. In an exception response, the TS4000H returns an exception code (describing the TS4000H condition) in the data field. Below is a list of exception codes that are supported by the TS4000H:

Code	Name	Description
1	Illegal Function	The function code received in the query is not an allowable action for the TS4000H.
2	Illegal Data Address	The data address received in the query is not an allowable address for the TS4000H.
3	Illegal Data Value	A value contained in the query data field is not an allowable value for the TS4000H.
4	Slave Device Failure	An unrecoverable error occurred while the TS4000H was attempting to perform the requested action.
5	Acknowledge	The TS4000H 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 TS4000H is engaged in processing a long-duration program command. The master should retransmit the message later when the slave is free.

Table 23: Exception Codes

5.8 Command Register Locations

Table 24: Selectable Data Formats

Parameter	Function	Value	Access	Register Address	Master I/O Address
Analog	0-20 mA 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 TS4000H model number in decimal (4007)	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 – 000B	40010 – 40012
HART Configuration	Hi byte: AO range; Lo byte: Enable/Disable HART Communication	16 bit	R/W	0x000C	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
MOD1 Address	Read or change settings for the MOD1 Address	8-Bit	R / W	0x000F	40016
MOD1 Baud	Read or change settings for the MOD1 Baud Rate	8-Bit	R / W	0x0010	40017
MOD1 Data Format	Read or change settings for the MOD1 Data Format	8-Bit	R / W	0x0011	40018
MOD2 Address	Read or change settings for the MOD2 Address	8-Bit	R / W	0x0012	40019
MOD2 Baud	Read or change settings for the MOD2 Baud Rate	8-Bit	R / W	0x0013	40020
MOD2 Data Format	Read or change settings for the MOD2 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

Parameter	Function	Value	Access	Register Address	Master I/O Address
Sensor Scale	Read the sensor full scale	8-Bit	R	0x0018	40025
Sensor Type	Read and change sensor type (write CO, CL_2, H_2S, NH_3, SO_2 only)	8-Bit	R / W	0x0019	40026
Not Used	N/A	N/A	N/A	0x001A – 001F	40027 - 40032
Total Receive Errors (MOD1)	Total number of receive errors on user Modbus channel	16-Bit	R	0x0020	40033
Data Errors (MOD1)	Total number of illegal data errors	16-Bit	R	0x0021	40034
Function Code Errors (MOD1)	Total number of function code errors	16-Bit	R	0x0022	40035
Starting Address Errors (MOD1)	Total number of starting address errors	16-Bit	R	0x0023	40036
Not Used	N/A	N/A	N/A	0x0024	40037
CRC Hi Errors (MOD1)	Total number of CRC Hi errors	16-Bit	R	0x0025	40038
CRC Low Errors (MOD1)	Total number of CRC Low errors	16-Bit	R	0x0026	40039
MOD1 Overrun Errors	Total number of overrun (MOD1 hardware) errors	16-Bit	R	0x0027	40040
MOD1 Framing Errors	Total number of framing (MOD1 hardware) errors	16-Bit	R	0x0028	40041
MOD1 Parity Errors	Total number of parity (MOD1 hardware) errors	16-Bit	R	0x0029	40042
MOD1 (hardware) Total Receive Errors	Total number total of receive (MOD1 hardware) errors	16-Bit	R	0x002A	40043
Not Used	N/A	N/A	N/A	0x002B	40044
Clear MOD1(hardware) Errors	Clear all MOD1(hardware) errors	(0)	W	0x002C	40045
Clear User Com Errors (MOD1)	Clear all user Modbus communication error counters of MOD1	(0)	W	0x002D	40046

Parameter	Function	Value	Access	Register Address	Master I/O Address
IM Com Errors	Read to return number of IM-to-BU communication errors. Write 0 to clear errors	16-Bit	R/W	0x002E	40047
Not Used	N/A	N/A	N/A	0x002F – 0x0042	40048 - 40067
Total Receive Errors (MOD2)	Total number of receive errors on user Modbus channel	16-Bit	R	0x0043	40068
Data Errors (MOD2)	Total number of illegal data errors	16-Bit	R	0x0044	40069
Function Code Errors (MOD2)	Total number of function code errors	16-Bit	R	0x0045	40070
Starting Address Errors (MOD2)	Total number of starting address errors	16-Bit	R	0x0046	40071
Not Used	N/A	N/A	N/A	0x0047	40072
CRC Hi Errors (MOD2)	Total number of CRC Hi errors	16-Bit	R	0x0048	40073
CRC Low Errors (MOD2)	Total number of CRC Low errors	16-Bit	R	0x0049	40074
MOD2 Overrun Errors	Total number of overrun (MOD2 hardware) errors	16-Bit	R	0x004A	40075
MOD2 Framing Errors	Total number of framing (MOD2 hardware) errors	16-Bit	R	0x004B	40076
MOD2 Parity Errors	Total number of parity (MOD2 hardware) errors	16-Bit	R	0x004C	40077
MOD2 (hardware) Total Receive Errors	Total number total of receive (MOD1 hardware) errors	16-Bit	R	0x004D	40078
Clear MOD2 (hardware) Errors	Clear all MOD2 (hardware) errors	(0)	W	0x004E	40079
Clear User Com Errors (MOD2)	Clear all user Modbus communication error counters	(0)	W	0x004F	40080
Clear Logged Events	Clear all logged events and reset event happened flag	(0,1)	W	0x0050	40081

Parameter	Function	Value	Access	Register Address	Master I/O Address
Runtime Meter	Running time meter (number of seconds) Hi word	16-Bit	R/W	0x0051	40082
Runtime Meter	Running time meter (number of seconds) Lo word	16-Bit	R/W	0x0052	40083
Real Time Clock Year and Month	Read/Set year and month of RTC	16-Bit: Upper Byte:0-99 year, Lower Byte: 1 – 12 month	R/W	0x0053	40084
Real Time Clock Day and Hour	Read/Set day and hour of RTC	16-Bit: Upper Bytes: 1 – 31 day, Lower Byte: 0 – 23 hour	R/W	0x0054	40085
Real Time Clock Minute and Second	Read/Set minutes and seconds of RTC	16-Bit: Upper Byte:0 – 59 minute, Lower Byte:0 – 59 second	R/W	0x0055	40086
Power Cycle Flag	Read Power Cycle Flag	(0,1)	R	0x0056	40087
Event Index	Event index of Logged Event	0 to 9	R/W	0x0057	40088
Warning Seconds Time Hi	Number of seconds stored in Hi word for a warning event log entry	16-Bit	R	0x0058	40089
Warn Seconds Time Low	Number of seconds stored in Lo word for a warning event log entry	16-Bit	R	0x0059	40090
Warning Real Time Clock Year, Month	Hi byte – year, low byte – month for an warning event log entry	16-Bit: Upper Byte:0-99 year, Lower Byte: 1 – 12 month	R	0x005A	40091
Warning Real Time Clock Day, Hour	Hi byte – day, low byte – hour for an warning event log entry	16-Bit: Upper Bytes: 1 – 31 day, Lower Byte: 0 – 23 hour	R	0x005B	40092
Warning Real Time Clock Minute, Second	Hi byte – min, low byte – sec for an warning event log entry	16-Bit: Upper Byte:0 – 59 minute, Lower Byte:0 – 59 second	R	0x005C	40093
Warning Reserved	N/A	N/A	R	0x005D-0x005E	40094-40095
Warning Event Count	Warning event counts	16-Bit	R	0x005F	40096

Parameter	Function	Value	Access	Register Address	Master I/O Address
Alarm Seconds Time Hi	Number of seconds stored in Hi word for an alarm event log entry	16-Bit	R	0x0060	40097
Alarm Seconds Time Low	Number of seconds stored in Lo word for an alarm event log entry	16-Bit	R	0x0061	40098
Alarm Real Time Clock Year, Month	Hi byte – year, low byte – month for an alarm event log entry	16-Bit: Upper Byte:0-99 year, Lower Byte: 1 – 12 month	R	0x0062	40099
Alarm Real Time Clock Day, Hour	Hi byte – day, low byte – hour an alarm event log entry	16-Bit: Upper Bytes: 1 – 31 day, Lower Byte: 0 – 23 hour	R	0x0063	40100
Alarm Real Time Clock Minute, Second	Hi byte – min, low byte – sec for an alarm event log entry	16-Bit: Upper Byte:0 – 59 minute, Lower Byte:0 – 59 second	R	0x0064	40101
Alarm Reserved	N/A	N/A	R	0x0065-0x0066	40102-40103
Alarm Event Count	Alarm event counts	16-Bit	R	0x0067	40104
Fault Seconds Time Hi	Number of seconds stored in Hi word for a fault event log entry	16-Bit	R	0x0068	40105
Fault Seconds Time Low	Number of seconds stored in Lo word for a fault event log entry	16-Bit	R	0x0069	40106
Fault Real Time Clock Year, Month	Hi byte – year, low byte – month for a fault event log entry	16-Bit: Upper Byte:0-99 year, Lower Byte: 1 – 12 month	R	0x006A	40107
Fault Real Time Clock Day, Hour	Hi byte – day, low byte – hour for a fault event log entry	16-Bit: Upper Bytes: 1 – 31 day, Lower Byte: 0 – 23 hour	R	0x006B	40108
Fault Real Time Clock Minute, Second	Hi byte – min, low byte – sec for a fault event log entry	16-Bit: Upper Byte:0 – 59 minute, Lower Byte:0 – 59 second	R	0x006C	40109
Fault Code	Fault code. Same code as register 0x0002 (40003)	16-Bit	R	0x006D	40110

Parameter	Function	Value	Access	Register Address	Master I/O Address
Fault Reserved	N/A	N/A	R	0x006E	40111
Fault Event Count	Fault event counts	16-Bit	R	0x006F	40112
Maintenance Seconds Time Hi	Number of seconds stored in Hi word for a maintenance event log entry	16-Bit	R	0x0070	40113
Maintenance Seconds Time Low	Number of seconds stored in Hi word for a maintenance event log entry	16-Bit	R	0x0071	40114
Maintenance Real Time Clock Year, Month	Hi byte – year, low byte – month for a maintenance event log entry	16-Bit: Upper Byte:0-99 year, Lower Byte: 1 – 12 month	R	0x0072	40115
Maintenance Real Time Clock Day, Hour	Hi byte – day, low byte – hour for a maintenance event log entry	16-Bit: Upper Bytes: 1 – 31 day, Lower Byte: 0 – 23 hour	R	0x0073	40116
Maintenance Real Time Clock Minute, Second	Hi byte – min, low byte – sec for a maintenance event log entry	16-Bit: Upper Byte:0 – 59 minute, Lower Byte:0 – 59 second	R	0x0074	40117
Maintenance reserved	N/A	N/A	R	0x0075-0x0076	40118-40119
Maintenance Event Count	Maintenance event counts	16-Bit	R	0x0077	40120
Calibration Seconds Time Hi	Number of seconds stored in Lo word for a calibration event log entry	16-Bit	R	0x0078	40121
Calibration Seconds Time Low	Number of seconds stored in Lo word for a calibration event log entry	16-Bit	R	0x0079	40122
Calibration Real Time Clock Year, Month	Hi byte – year, low byte – month for a calibration event log entry	16-Bit: Upper Byte:0-99 year, Lower Byte: 1 – 12 month	R	0x007A	40123
Calibration Real Time Clock Day, Hour	Hi byte – day, low byte – hour a calibration event log entry	16-Bit: Upper Bytes: 1 – 31 day, Lower Byte: 0 – 23 hour	R	0x007B	40124

Parameter	Function	Value	Access	Register Address	Master I/O Address
Calibration Real Time Clock Minute, Second	Hi byte – min, low byte – sec for a calibration event log entry	16-Bit: Upper Byte:0 – 59 minute, Lower Byte:0 – 59 second	R	0x007C	40117
Calibration Code	Calibration code: 2	16-Bit	R	0x007D	40118
Calibration Reserved	N/A	N/A	R	0x007E	40119
Calibration Event Count	Calibration event counts	16-Bit	R	0x007F	40120
Event Happened	Read event happened flag	16-Bit	R	0x0080	40121

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

5.9.2 Mode (0x0001)

A read returns the present mode of the TS4000H. 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.

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

Table 25: Base Unit Mode Bitmap

The following table describes the Base Unit operating modes.

Mode	Description
Run	Normal mode of operation for the TS4000H 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 TS4000H.
Remove Gas	This bit informs the user to remove the gas after the TS4000H 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 TS4000H 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 TS4000H 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 TS4000H to go offline but indicate an unsafe operating situation.
Bad Error	Major errors that prohibit the TS4000H from operating in a safe manner and result in the unit going offline. The TS4000H 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.

Table 26: Mode Descriptions

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 TS4000H is 4007.

5.9.6 Software Revision (0x0005)

A read returns the software revision of the TS4000H 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 Display Registers (0x0007 & 0x0008)

The LED display is also present on the Modbus. It is at registers 0x0007 and 0x0008.

The first register (0x0007) contains the ASCII values of the LED Least Significant Digit (LSD) and Middle Digit (MID). The lower byte represents the LSD, and the upper the MID. If the decimal point located in either LED LSD or MID illuminates, the most significant bit of either lower or upper byte will get logic 1.

The second register (0x0008) contains the ASCII value of the LED Most Significant Digit (MSD) and the values of Warning or Alarm LED. The lower byte is the Warning LED 0x01 or Alarm LED 0x02 or both Warning and Alarm 0x03. The upper is the ASCII value of the LED MSD. If the decimal point in this position illuminates, the most significant bit will get logic 1.

5.9.9 HART Configuration (0x000C)

A read returns the 16 bit value, with upper byte = 0x01 (current range 3.5 – 20 mA) or 0x00 (current range 1.25 – 20 mA), lower byte = 0x01 (HART enabled) or 0x00 (HART disabled).

A write changes to upper byte with 1 (current range 3.5 – 20 mA) or 0 (current range 1.25 – 20 mA), to lower byte with 1 (enable HART) or 0 (disable HART).

5.9.10 Alarm Relay Settings (0x000D)

A read returns the present Alarm settings of the TS4000H. 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 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, latching, de-energized.
- For O_2, factory default is 17.0% by volume, latching, de-energized**.**

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

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

Table 28: Alarm Relay Settings

5.9.11 Warn Relay Settings (0x000E)

A read returns the present Warn settings of the TS4000H. 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.

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

Table 29: Warning Relay Settings

5.9.12 MOD1 Address (0x000F)

A read command returns the current address for MOD1. 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.

5.9.13 MOD1 Baud Rate (0x0010)

A read command returns the current baud rate for MOD1. A write command changes the baud rate to the requested values. Valid settings are shown in Table 30. **Factory default is 9600 baud.**

Baud Rate	Value	Access
2400	0	Read / Write
4800	1	Read / Write
9600	2	Read / Write
19200	3	Read / Write

Table 30: MOD1 Baud Rate

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

5.9.14 MOD1 Data Format (0x0011)

A read command returns the current data format for MOD1. Write command changes the data format to the requested values. Valid settings are shown in Table 31. **Default format is 8-N-1**.

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

Table 31: Selectable Data Formats

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

5.9.15 MOD2 Address (0x0012)

A read command returns the current address for MOD2. 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.

5.9.16 MOD2 Baud Rate (0x0013)

A read command returns the current baud rate for MOD2. A write command changes the baud rate to the requested values. Valid settings are shown in Table 32. **Factory default is 9600 baud**.

Baud Rate	Value	Access
2400	0	Read / Write
4800	1	Read / Write
9600	2	Read / Write
19200	3	Read / Write

Table 32: MOD2 Baud Rate

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

5.9.17 MOD2 Data Format (0x0014)

A read command returns the current data format for MOD2. Write command changes the data format to the requested values. Valid settings are shown in Table 33. **Default format is 8-N-1**.

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

Table 33: MOD2 Baud Rate

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

5.9.18 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).

5.9.19 Sensor Life (0x0017)

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

5.9.20 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 34

Sensor Type	Sensor ID	Full Scale Value
0	No Sensor Detected	None
1	O_2	25% v/v
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
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	H_2 - 500	500 ppm
17-18	Reserved	N/A
19	Cl_2 – 20	20 ppm
20	H_2S – 50	50 ppm

Table 34: Sensor Scale

5.9.21 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 SOOO2
- "12" or "13" (any NH_3 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

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).

5.9.22 MOD1 Total Receive Errors (0x0020)

A read indicates the total Modbus Communication Receive Errors that occurred in the slave device. The maximum count is 65535. Beyond 65535 the count resets to zero and begins counting again.

5.9.23 MOD1 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 65535. Beyond 65535 the count resets to zero and begins counting again.

5.9.24 MOD1 Function Code Errors (0x0022)

A read indicates the number of Function Code Errors that occurred in the slave device. The maximum count is 65535. Beyond 65535 the count resets to zero and begins counting again.

5.9.25 MOD1 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 65535. Beyond 65535 the count resets to zero and begins counting again.

5.9.26 MOD1 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 65535. Beyond 65535 the count resets to zero and begins counting again.

5.9.27 MOD1 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 65535. Beyond 65535 the count resets to zero and begins counting again.

5.9.28 MOD1 Hardware Overrun Errors (0x0027)

A read indicates the number of hardware UART Overrun Errors that occurred in the slave device. The maximum count is 65535 and then the counter will rollover to zero and begin counting again.

5.9.29 MOD1 Hardware Framing Errors (0x0028)

A read indicates the number of Hardware UART Framing Errors that occurred in the slave device. The maximum count is 65535 and then the counter will rollover to zero and begin counting again.

5.9.30 MOD1 Hardware Parity Errors (0x0029)

A read indicates the number of Hardware UART Parity Errors that occurred in the slave device. The maximum count is 65535 and then the counter will rollover to zero and begin counting again.

5.9.31 MOD1 Hardware Total Receive Errors (0x002A)

A read indicates the total Hardware UART errors that occurred in the slave device. The maximum count is 65535 and then the counter will rollover to zero and begin counting again. The total errors are an accumulation of the individual communication errors of registers 0x0027 – 0x0029.

5.9.32 MOD1 Hardware Clear Errors (0x002C)

A write 0 resets all MOD1 Hardware UART communication errors of registers 0x0027 – 0x002A to 0. Only a write of value “0” is allowed for this register.

5.9.33 MOD1 Clear Communication Errors (0x002D)

A write 0 resets all MOD1 Total Data Errors, Function Code Errors, Starting Address Errors, CRC High Byte Errors, and CRC Low Byte Errors to 0. Only a write of value “0” is allowed for this register.

5.9.34 Clear Interface Module Communication Errors (0x002E)

A read indicates the total number of Interface Module to Base Unit Communication Errors. The maximum count is 65535. Beyond 65535 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.

5.9.35 MOD2 Total Receive Errors (0x0043)

A read indicates the total Modbus Communication Receive Errors that occurred in the slave device. The maximum count is 65535. Beyond 65535 the count resets to zero and begins counting again.

5.9.36 MOD2 Total Data Errors (0x0044)

A read indicates the total number of illegal data write attempts that occurred in the slave device. The maximum count is 65535. Beyond 65535 the count resets to zero and begins counting again.

5.9.37 MOD2 Function Code Errors (0x0045)

A read indicates the number of Function Code Errors that occurred in the slave device. The maximum count is 65535. Beyond 65535 the count resets to zero and begins counting again.

5.9.38 MOD2 Starting Address Errors (0x0046)

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 65535. Beyond 65535 the count resets to zero and begins counting again.

5.9.39 MOD2 CRC High Byte Errors (0x0048)

A read indicates the number of RXD CRC Hi Byte Errors that occurred in the slave device. The maximum count is 65535. Beyond 65535 the count resets to zero and begins counting again.

5.9.40 MOD2 CRC Low Byte Errors (0x0049)

A read indicates the number of RXD CRC Hi Byte Errors that occurred in the slave device. The maximum count is 65535. Beyond 65535 the count resets to zero and begins counting again.

5.9.41 MOD2 Hardware Overrun Errors (0x004A)

A read indicates the number of hardware UART Overrun Errors that occurred in the slave device. The maximum count is 65535 and then the counter will rollover to zero and begin counting again.

5.9.42 MOD2 Hardware Framing Errors (0x004B)

A read indicates the number of Hardware UART Framing Errors that occurred in the slave device. The maximum count is 65535 and then the counter will rollover to zero and begin counting again.

5.9.43 MOD2 Hardware Parity Errors (0x004C)

A read indicates the number of Hardware UART Parity Errors that occurred in the slave device. The maximum count is 65535 and then the counter will rollover to zero and begin counting again.

5.9.44 MOD2 Hardware Total Receive Errors (0x004D)

A read indicates the total Hardware UART errors that occurred in the slave device. The maximum count is 65535 and then the counter will rollover to zero and begin counting again. The total errors are an accumulation of the individual communication errors of registers 0x0027 – 0x0029.

5.9.45 MOD2 Hardware Clear Error (0x004E)

A write 0 resets all MOD2 Hardware UART communication errors of registers 0x0027 – 0x002A to 0. Only a write of value “0” is allowed for this register.

5.9.46 MOD2 Clear Communication Errors (0x004F)

A write 0 resets all MOD2 Total Data Errors, Function Code Errors, Starting Address Errors, CRC High Byte Errors, and CRC Low Byte Errors to 0. Only a write of value “0” is allowed for this register.

5.10 TS4000H Run Time Meter and Real Time Clock (Time/Date)

There is a run time meter and real time clock (Time/Date) in the TS4000H detector.

The run time meter indicates that the TS4000H is operating in the time of seconds. The meter starts at zero second when it is first powered up, updates every second and saves in the non-volatile memory every 24 hours of the device operating. The meter stops running if the device power is off, and when the device power is on, it will reload the seconds in the non-volatile memory.

Second Hi register 0x0051 and Second Lo register 0x0052 are used to read/write the seconds (32-bit value) from/to the run time meter. The Second Hi contains the upper value of the seconds and the Lo the lower value, both have ranges from 0 to 65535 or 0xFFFF. The user must at least write new second value to Lo register in order to get the change affected. Since the user has written the new value, the meter will run on the new seconds and saves in the non-volatile memory. Reading two Hi and Lo will return current run time seconds of the meter.

Note that if changing the run time meter, the new seconds will also be converted to year, month, day, hour, minute and second of the Time/Date clock.

Real Time Clock (RTC) year and month register 0x0053, RTC day and hour 0x0054 and RTC minute and second 0x0055 are used to read/write the Time/Date clock. Write 0 – 99 to register 0x0053 to change year and month, 1-12 to 0x0054 to change day and hour, and 0-59 to 0x0055 to change minute and second. The user must at least write new minute and second to RTC minute and second register 0x0055 in order to get the change affected. After changing the new time and date, the TS4000H unit will be clocked on the new time.

Note that if changing the time and date, this new time will also be automatically converted to the run time meter seconds since January 1, 2000, the seconds are saved in non-volatile memory, and the meter will run on the new converted seconds.

5.11 Conversion between Run Time Meter and Time/Date Clock

The internal clock may be set in one of two different ways. It may be set to a time/date format and unit will automatically convert to the number of seconds since January 1, 2000 for the unit run time meter. Or, it may be set to the number of seconds since January 1, 2000 and the unit will do the time/date conversion automatically for the Time/Date clock.

If the Power Cycle Flag is set (1), the time/date structure will be read 00/00/00 until it is reset by the user. When the clock or run time meter is reset, the Power Cycle Flag will be reset to zero, and the Power Cycle Flag value is saved in the register 0x0056.

The clock must be reset each time the unit is powered up in order to remain correct. The Power Cycle Flag will be set to 1 during each power up, and then reset when the time is updated by the first setting of the clock.

Note that clock value in Date/Time format is meaningless, unless the clock is set to actual time. This value should be set to zeroes on each power up.

5.12 Event Logging

There are two user scenarios. In one case the TS4000H detector is used as a stand alone device and all events will be time-stamped with the seconds of the run time meter that represents the time the unit has been powered-up in service. In this case a time-stamp might the number of the seconds of service. The other scenario is where the detector is connected to a host computer system in which case the host can set the detector clock every time it is powered-up and the time-stamp will be of the form of real time clock Time and Date (e.g.

5/20/2005 10:15am). Throughout this document the first scenario is called run-time and the second is called real-time. These two scenarios cannot be used interchangeably; if the user wants real time stamps, they must always set the clock after power-up; otherwise they must never set the clock.

The following will show users how to log out Fault, Warning, Alarm, Calibration, and Maintenance events.

5.12.1 Fault Event

- Whenever a fault occurs, the fault and the time of the fault will be recorded. If the same fault occurs, it is logged for every 30 seconds.
- The quantity of faults will be saved in a counter and the counter increments when there is a new fault, the count is saved after the event. When the fault is removed, it is not saved and the counter is not incremented. The maximum count is 65535 and then the counter will rollover to zero and begin counting again.
- There are a total of 10 event time stamps stored. If there is a new fault after that, the oldest event time stamp is no longer to be logged.

5.12.1.1 Event Index (0x0057)

Before the user wants to read a logged time of a fault, warning, alarm, calibration, or maintenance event, the user has to write a number to this event index register.

An event index range should be determined before to read all event logged times. The user should read Fault Event Count (0x006F), or other (Warning, Alarm, Calibration, Maintenance) Event Count registers, in order to determine the range of the index event. The range is valid if it equals fault event count minus 1 provided that fault counter is less or equal 10. If the counter is greater than 10, the range is 0 to 9, and because the maximum events logged are 10, the maximum range is also 0 to 9.

An index event number is reverse to the number of the event. For example, if there are 5 fault logged events, writing 0 will affect the event logged time #5, or 4 the event logged time #1.

A read will return the value that is just written.

NOTE: This Event Index register is used for all Fault, Warning, Alarm, Calibration and Maintenance Logged Events.

5.12.1.2 Fault Seconds Time Hi (0x0068)

A read will return the upper seconds stored in Hi word for a Fault event log entry. The maximum value is 65535 or 0xFFFF in hex.

5.12.1.3 Fault Seconds Time Hi (0x0069)

A read will return the lower seconds stored in Lo word for a Fault event log entry. The maximum value is 65535 or 0xFFFF in hex.

5.12.1.4 Fault Real Time Year and Month (0x006A)

A read will return the year and the month of a fault event. The year range is [0 – 99], the month is [1 - 12].

5.12.1.5 Fault Real Time Day and Hour (0x006B)

A read will return the day and the hour of a fault event. The day range is [1 – 31], the hour is [0 – 23].

5.12.1.6 Fault Real Time Minute and Second (0x006C)

A read will return the minute and the second of a fault event. The minute range is [0 – 59], the second is [0 – 59].

5.12.1.7 Fault Code (0x006D)

A read will return the code of a fault type, and as same as the register 0x0002's.

5.12.1.8 Fault Event Count (0x006F)

A read will return the number of the logged fault events. The maximum count is 65535 and then the counter will rollover to zero and begin counting again.

5.12.2 Warning Event

The time the gas level reaches the Warning level is recorded. Each time this happens a counter is incremented, the count is also saved. The end of the event is when the gas goes below Warning level. There are a total of 10 event time stamps stored. The Warning event time is logged for every 30 seconds.

5.12.2.1 Warning Seconds Time Hi (0x0058)

A read will return the upper seconds stored in Hi word for a Warning event log entry. The maximum value is 65535 or 0xFFFF in hex.

5.12.2.2 Warning Seconds Time Lo (0x0059)

A read will return the upper seconds stored in Lo word for a Warning event log entry. The maximum value is 65535 or 0xFFFF in hex.

5.12.2.3 Warning Real Time Year and Month (0x005A)

A read will return the year and the month of a Warning event. The year range is [0 – 99], the month is [1 - 12].

5.12.2.4 Warning Real Time Day and Hour (0x005B)

A read will return the day and the hour of a Warning event. The day range is [1 – 31], the hour is [0 – 23].

5.12.2.5 Warning Real Time Minute and Second (0x005C)

A read will return the minute and the second of a Warning event. The minute range is [0 – 59], the second is [0 – 59].

5.12.2.6 Warning Event Count (0x005F)

A read will return the number of the logged warning events. The maximum count is 65535 and then the counter will rollover to zero and begin counting again.

5.12.3 Alarm Event

The time the gas level reaches the Alarm level is recorded. Each time this happens a counter is incremented, the count is also saved. The end of the event is when the gas goes below alarm level. There are a total of 10 event time stamps stored. The Alarm event time is logged for every 30 seconds.

5.12.3.1 Alarm Seconds Time Hi (0x0060)

A read will return the upper seconds stored in Hi word for an Alarm event log entry. The maximum value is 65535 or 0xFFFF in hex.

5.12.3.2 Alarm Seconds Time Lo (0x0061)

A read will return the upper seconds stored in Lo word for an Alarm event log entry. The maximum value is 65535 or 0xFFFF in hex.

5.12.3.3 Alarm Real Time Year and Month (0x0062)

A read will return the year and the month of an Alarm event. The year range is [0 – 99], the month is [1 - 12].

5.12.3.4 Alarm Real Time Day and Hour (0x0063)

A read will return the day and the hour of an Alarm event. The day range is [1 – 31], the hour is [0 – 23].

5.12.3.5 Alarm Real Time Minute and Second (0x0064)

A read will return the minute and the second of an Alarm event. The minute range is [0 – 59], the second is [0 – 59].

5.12.3.6 Alarm Event Count (0x0067)

A read will return the number of the logged alarm events. The maximum count is 65535 and then the counter will rollover to zero and begin counting again.

5.12.4 Maintenance Event

The time that a Gas Check occurs is saved in the maintenance event log. Each successful Gas Check increments the maintenance count. There are a total of 10 event time stamps stored.

5.12.4.1 Maintenance Seconds Time Hi (0x0070)

A read will return the upper seconds stored in Hi word for a Maintenance event log entry. The maximum value is 65535 or 0xFFFF in hex.

5.12.4.2 Maintenance Seconds Time Lo (0x0071)

A read will return the upper seconds stored in Lo word for a Maintenance event log entry. The maximum value is 65535 or 0xFFFF in hex.

5.12.4.3 Maintenance Real Time Year and Month (0x0072)

A read will return the year and the month of a Maintenance event. The year range is [0 – 99], the month is [1 - 12].

5.12.4.4 Maintenance Real Time Day and Hour (0x0073)

A read will return the day and the hour of a Maintenance event. The day range is [1 – 31], the hour is [0 – 23].

5.12.4.5 Maintenance Real Time Minute and Second (0x0074)

A read will return the minute and the second of a Maintenance event. The minute range is [0 – 59], the second is [0 – 59].

5.12.4.6 Maintenance Event Count (0x0077)

A read will return the number of the logged Maintenance events. The maximum count is 65535 and then the counter will rollover to zero and begin counting again.

5.12.5 Calibration Event

The time that a successful calibration occurs is saved in the event log. A counter is incremented for each successful calibration. If the unit fails calibration, the event is not recorded. If the calibration is aborted, the event is also not recorded. There are a total of 10 event time stamps stored.

5.12.5.1 Calibration Seconds Time Hi (0x0078)

A read will return the upper seconds stored in Hi word for a Calibration event log entry. The maximum value is 65535 or 0xFFFF in hex.

5.12.5.2 Calibration Seconds Time Lo (0x0079)

A read will return the upper seconds stored in Lo word for a Calibration event log entry. The maximum value is 65535 or 0xFFFF in hex.

5.12.5.3 Calibration Real Time Year and Month (0x007A)

A read will return the year and the month of a Calibration event. The year range is [0 – 99], the month is [1 - 12]

5.12.5.4 Calibration Real Time Day and Hour (0x007B)

A read will return the day and the hour of a Calibration event. The day range is [1 – 31], the hour is [0 – 23]

5.12.5.5 Calibration Real Time Minute and Second (0x007C)

A read will return the minute and the second of a Calibration event. The minute range is [0 – 59], the second is [0 – 59]

5.12.5.6 Calibration Event Count (0x007F)

A read will return the number of the logged Calibration events. The maximum count is 65535 and then the counter will rollover to zero and begin counting again.

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 TS4000H.

6.2 Storage

The TS4000H 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 TS4000H external alarm wiring prior to conducting checks that may cause the unit to enter an alarm condition.

7.1 Fault Codes and Remedies

The TS4000H has self-diagnostics incorporated into the microprocessor's program. If a fault is detected, the output signal drops to 0 mA, the Fault relay de-energizes, and a Fault Code is displayed. Table 35 lists the ten fault conditions monitored by the TS4000H, along with suggestions for resolving these faults. If repeated attempts to resolve the faults are unsuccessful, return the TS4000H to the factory or authorized service center for repair.

Table 35: Fault Codes

Fault Code	Fault Type	Description	Action
F0**	IM Communication	(1) IM does not communicate (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 (2) Non-functional Oxygen sensor plugged into IM	• Ensure that there is a sensor plugged into the IM • 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 • If successive calibration attempts fail, verify calibration gas • 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 • Replace electrochemical cell if fault persists
F5**	Sensor Failure	(1) Sensor failure (2) New un-calibrated sensor plugged into the IM (3) Sensor range error	• Recalibrate the sensor. • Replace sensor if fault persists

Fault Code	Fault Type	Description	Action
F6	Low Supply Voltage*	Supply voltage at the TS4000H 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 • 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 TS4000H is 20 Ω per conductor (40 Ω loop), at +24 VDC.

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

Table 36: Fault Code Priorities

8.0 Customer Support

8.1 General Monitors' Offices

Area	Phone/Fax/Email
UNITED STATES	
	Toll Free: +1-800-446-4872
Corporate Office: 26776 Simpatica Circle Lake Forest, CA 92630	Phone: +1-949-581-4464 Fax: +1-949-581-1151 Email: info@generalmonitors.com
	Phone: +1-281-855-6000
9776 Whithorn Drive Houston, TX 77095	Fax: +1-281-855-3290 Email: gmhou@generalmonitors.com
UNITED KINGDOM	
Heather Close Lyme Green Business Park Macclesfield, Cheshire, United Kingdom, SK11 0LR	Phone: +44-1625-619-583 Fax: +44-1625-619-098 Email: info@generalmonitors.co.uk
IRELAND	
Ballybrit Business Park Galway Republic of Ireland	Phone: +353-91-751175 Fax: +353-91-751317 Email: info@gmil.ie
SINGAPORE	
Block 5, Amk Tech II, #05-20/22/23 Ang Mo Kio Industrial Park 2A Singapore 567760	Phone: +65-6-748-3488 Fax: +65-6-748-1911 Email: genmon@gmpacifica.com.sg
UAE	
B 19-Warehouse/LIU-Row B2 Dubai Airport Free Zone Dubai 54910, United Arab Emirates	Phone: +971-4-294-3640 Email: gmme@generalmonitors.com

Table 37: GM Locations

9.0 Appendix

9.1 Warranty

General Monitors warrants the TS4000H 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

% 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
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

% of Scale	Full Scale Value							
	1.00	3.00	10.0	20.0	25.0	50	100	500
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
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

% of Scale	Full Scale Value							
	1.00	3.00	10.0	20.0	25.0	50	100	500
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

Table 38: Conversion Matrix – Percent of Scale to Scaled Value

9.3 Periodic Testing / Calibration of Field Devices

Periodic testing and calibrating of the TS4000H should be performed according to the schedules and procedures outlined in the TS4000H 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

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 - One year for the electrochemical cell
Malfunctions Monitored	- Calibration Errors - Data Memory Errors
Measuring Ranges	- Ammonia (NH3): 0-50 ppm, 0-100 ppm - Carbon Monoxide (CO): 0-100 ppm, 0-500 ppm - Chlorine (Cl_2): 0-10 ppm, 0-20 ppm - Chlorine Dioxide (ClO_2): 0-3 ppm - Hydrogen (H_2): 0-500 ppm - Hydrogen Chloride (HCl): 0-20 ppm - Hydrogen Sulfide (H_2S): 0-20 ppm, 0-50 ppm, 0-100 ppm - Nitric Oxide (NO): 0-100 ppm - Nitrogen Dioxide (NO_2): 0-20 ppm - Oxygen (O_2): 0-25% v/v - Ozone (O_3): 0-1 ppm - Sulfur Dioxide (SO_2): 0-20 ppm, 0-100 ppm
Response Time (100% FS Gas Applied)	- Cl_2,ClO_2, NH_3: T90 < 60 s - CO, H_2, H_2S and NO_2: T90 < 30 s - HCl: T90 < 100 s - O_3: T90 < 90 s - NO and SO_2: T90 < 10 s - O_2: T90 < 15 s
Repeatability	± 2% of full scale except ± 0.1 ppm for O_3, ± 0.2 ppm for ClO_2 and ± 1% v/v for O_2
Zero Drift	< 5% per year
Approvals	CSA, ATEX, IECEx, CE Marking, GOST, HART: • Approved by the HART Communication Foundation • Compatible with Emerson 375 Field Communicator • Listed in Emerson Process Management's AMSaware device list SIL 2 suitable per FM IEC 61508 approval

Table 39: System Specifications

Specification	Description
Length	6.3 inches (161 mm)
Height	3.2 inches (81 mm)
Width	4.3 inches (110 mm)
Weight	5.5 pounds (2.5 kg) – AL, 14.0 lbs (6.4 kg) – SS
Housing	Aluminum alloy (6061-T6 cover, A356-T6 base) or 316 stainless steel
Mounting Holes	5.0 inches (127 mm) center to center

Table 40: Mechanical Specifications – Base Unit

Specification	Description
Length	6.37 inches (162 mm)
Diameter	1.75 inches (44 mm)
Weight	1.0 pounds (0.45 kg)
Mounting	¾ inch NPT
Housing	Anodized Aluminum A356-T6

Table 41: Mechanical Specifications – Interface Module

Cable Requirements: 3-wire shield cable. Maximum distance between TS4000H and power source @ 24 VDC nominal:

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

Maximum distance for analog output (500 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: Cable Requirements

Specification	Description
General Purpose Installations	Maximum distance between the TS4000H and the power source @ 24 VDC nominal is 3,430 feet (1040 meters)
Input Power	20 to 36 VDC range; +24 VDC nominal 0.120 A
Relay Ratings (Optional)	8A @ 250 VAC/ 8A @ 30 VDC resistive maximum (3x) SPDT – Warning, Alarm and Fault
Power Consumption	Start-up 125 mA, Normal Operation 120 mA
Output Current	500 Ω maximum @ 24 VDC **Non-HART or HART not Enabled:** - Signal Range: 0-22 mA - Detection Range: 4-20 mA - Start-up: 1.5 mA - Calibration: 1.5 mA - Gas check: 1.5 mA - Setup mode: 1.5 mA - Fault: < 1.0 mA - Over-range: 21.7 mA **HART:** - Signal Range:3.5-22 mA - Detection Range: 4-20 mA - Start-up: 3.5 mA - Calibration: 3.5 mA - Gas check: 3.5 mA - Setup mode: 3.5 mA - Fault: 3.5 mA - Over-range: 21.7 mA **HART modified AO:** - Signal Range:1.25-22 mA - Detection Range: 4-20 mA - Start-up: 1.5 mA - Calibration: 1.5 mA - Gas check: 1.5 mA - Setup mode: 1.5 mA - Fault: 1.25 mA - Over-range: 21.7 mA
Approvals Classification	Base Unit: CSA: Class I, Division 1 & 2, Groups B, C and D; Class II, Division 1 & 2, Groups E, F & G; Class III; Type 4X ATEX/IECEx: II 2 G D Ex db IIB + H_2 T5 Gb, Ex tb IIIC T100°C Db (-40°C ≤ Ta ≤ +70°C) Interface Module: CSA: Ex d ia IIB + H_2 T5 ATEX/IECEx: II 2 G Ex d mb ib IIC Gb (-40°C ≤ Ta ≤ +75°C)
EMC Protection	EN 50081-2, EN 50270
Status Indicator	LED Display with Normal, Gas Present, Fault and Calibration Cues

Table 43: Electrical Specifications

Specification	Description
Operating Temperature Range* (For All Gases Other Than H_2S, NH_3)	-4°F to +122°F (-20°C to +50°C)
Operating Temperature Range* (For H_2S and NH_3)	-40°F to +122°F (-40°C to +50°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) NH_3, H_2, CO and O_2 Cells: 60°F to 80°F (+16°C to +27°C)
Humidity Range*	15% to 90% relative humidity, non-condensing
Pressure Range	Atmospheric ± 10%
* Requirements are driven by electrochemical cell specifications.	

Table 44: Environmental Specifications

Accuracy	ChemCell Type and Range
±2 ppm or ±10% of reading, whichever is greater	- Carbon monoxide (CO): 0-100 ppm - Chlorine (Cl_2): 0-10 ppm, 0-20 ppm - Hydrogen chloride (HCl): 0-20 ppm - Hydrogen sulfide (H_2S): 0-20 ppm, 0-50 ppm, 0-100 ppm - Nitric oxide (NO): 0-100 ppm - Nitrogen dioxide (NO_2): 0-20 ppm - Sulfur dioxide (SO_2): 0-20 ppm, 0-100 ppm
±3% of full scale	- Carbon monoxide (CO): 0-500 ppm - Hydrogen (H_2): 0-500 ppm
±5 ppm or ±10% of reading, whichever is greater	- Ammonia (NH_3): 0-50 ppm, 0-100 ppm
±20% of reading	- Ozone (O_3): 0-1 ppm - Chlorine dioxide (ClO_2): 0-3 ppm
± 1% v/v of oxygen	- Oxygen (O_2): 0-25% v/v

Table 45: TS4000H Toxic Gas Sensor Accuracy Specifications

NOTE: 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 TS4000H remote configuration:

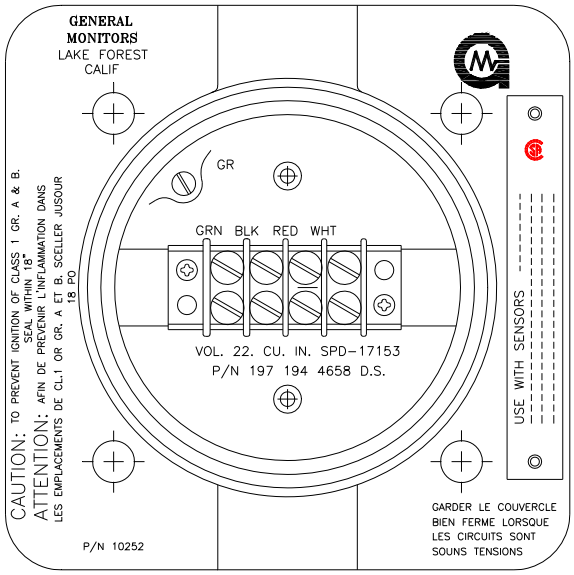


Figure 19: 10252-1 Round Anodized Aluminum Junction Box

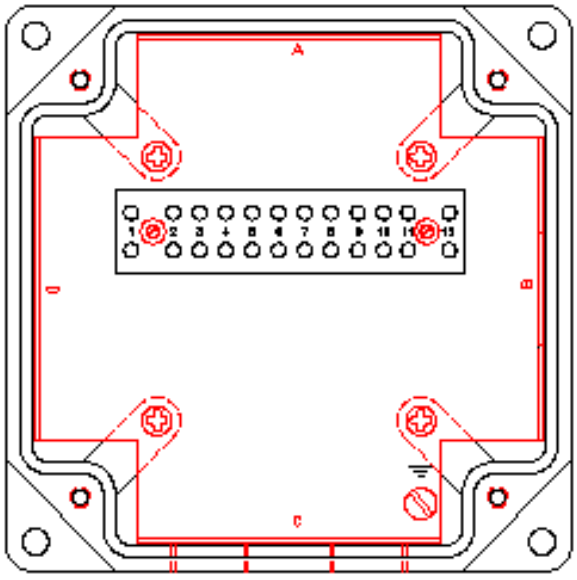


Figure 20: B13-020-1 European Aluminum Junction Box

9.5.2 Splash Guards

The following General Monitors splash guards are compatible with the TS4000H:

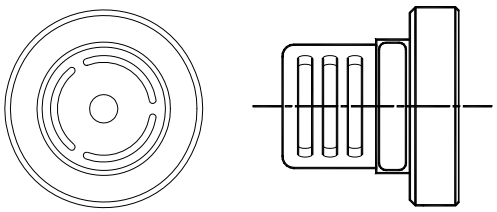


Figure 21: 45167-1 Splash Guard Used for Cl_2, ClO_2, and O_3 Gases

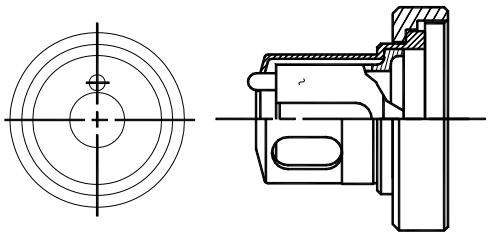


Figure 22: 70631-2 Splash Guard

9.5.3 Accessories

The following General Monitors accessories are compatible with the TS4000H:

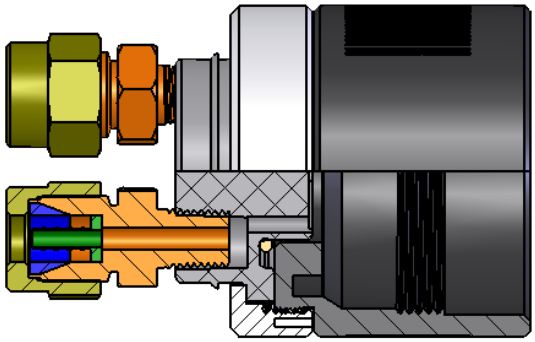


Figure 23: 45170-1 Flow Block Assy

9.5.4 Calibration Accessories

The following General Monitors calibration accessories are compatible with the TS4000H:

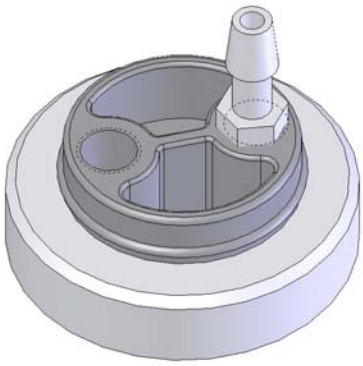


Figure 24: 45172-1 Calibration Plug Assy

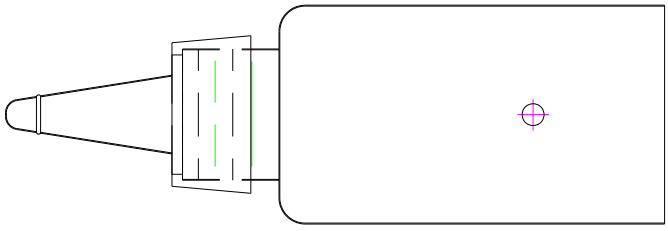


Figure 25: 1400152-1 Calibration Cup for calibrating with splash guard

9.6 Calibration Schedule

Establishing a periodic calibration schedule is critical to maintaining optimal product performance. Below is a sample schedule for the TS4000H:

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 TS4000H 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 TS4000H parts and accessories is listed below:

NOTE: The TS4000H ships with a Base Unit, Interface Module, and specified electrochemical cell. Detection of the various gases detailed in Table 39 is achieved by hot swapping the chosen electrochemical cell into the TS4000H.

TS4000H	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
5 mm Allen Wrench	954-014

Table 46: TS4000H Part Numbers

Gas Type	Range	Part Number
Ammonia (NH_3)	**0 - 50 ppm**	45186-6
Ammonia (NH_3)	**0 - 100 ppm**	45186-6
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 (H_2)	**0 - 500 ppm**	45186-12
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% v/v**	45249-1
Ozone (O_3)	**0 - 1 ppm**	45123-14
Sulfur Dioxide (SO_2)	**0 - 20 ppm, 0-100 ppm**	45123-9
NOTE: Consult the manufacturer's documentation for information on the shelf life of the various electrochemical cells.		

Table 47: Replacement Sensors

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 (CSA)	10252-1
Polyester Housing (ATEX)	B13-020-1
Plastic Junction Box (¾ inch NPT)	45160-1
Plastic Junction Box (M20)	45160-2
¾ inch NPT, Adapter, Plastic	961-009
20 mm x ¾ inch NPT Adapter, Brass	961-006

Table 48: Mounting Accessories

Accessory	Part Number
Case	914-172
Tubing	931-085
Regulator (1000 ml/min) For Cl_2, ClO_2, HCl, NH_3, NO_2, O_3	922-022
Regulator (500 ml/min) For CO, H_2, H_2S, NO, SO_2	922-023
Calibration Plug	45172-1
Calibration Cup (for use with splash guard)	1400152-1

Table 49: TS4000H Calibration Accessories

Calibration Kit	Range	Cylinder Concentration	Part Number
Ammonia (NH_3)	**0 – 50 ppm**	**25 ppm**	1400263-1
Ammonia (NH_3)	**0 – 100 ppm**	**50 ppm**	1400263-2
Carbon Monoxide (CO)	**0 – 100 ppm**	**50 ppm**	1400263-9
Carbon Monoxide (CO)	**0 – 500 ppm**	**250 ppm**	1400263-10
Chlorine (Cl_2)	**0 – 10 ppm**	**5 ppm**	1400263-3
Chlorine (Cl_2)	**0 – 20 ppm**	**10 ppm**	1400263-22
Chlorine Dioxide (ClO_2)	**0 - 3 ppm**	*	1400263-4
Hydrogen (H_2)	**0 – 500 ppm**	**250 ppm**	1400263-38
Hydrogen Chloride (HCl)	**0 – 20 ppm**	**10 ppm**	1400263-5
Hydrogen Sulfide (H_2S)	**0 – 100 ppm**	**50 ppm**	1400263-33
Hydrogen Sulfide (H_2S)	**0 – 50 ppm**	**25 ppm**	1400263-34
Hydrogen Sulfide (H_2S)	**0 – 20 ppm**	**10 ppm**	1400263-35
Nitric Oxide (NO)	**0 – 100 ppm**	**50 ppm**	1400263-6
Nitrogen Dioxide (NO_2)	**0 – 20 ppm**	**10 ppm**	1400263-7
Oxygen (O_2) – 20.9%	**0 – 25% v/v**	**20.9% v/v**	1400263-11
Ozone (O_3)	**0 – 1 ppm**	*	1400263-15
Sulfur Dioxide (SO_2)	**0 – 20 ppm**	**10 ppm**	1400263-8
Sulfur Dioxide (SO_2)	**0 – 100 ppm**	**50 ppm**	1400263-21

***** Consult Manufacturer

Table 50: Calibration Kits (Cylinder, Regulator, and Tubing)

Cylinder Type	Range	Cylinder Concentration	Part Number
Ammonia (NH_3)	**0 – 50 ppm**	**25 ppm**	1400262-1
Ammonia (NH_3)	**0 – 100 ppm**	**50 ppm**	1400262-2
Carbon Monoxide (CO)	**0 – 100 ppm**	**50 ppm**	1400262-9
Carbon Monoxide (CO)	**0 – 500 ppm**	**250 ppm**	1400262-10
Chlorine (Cl_2)	**0 – 10 ppm**	**5 ppm**	1400262-3
Chlorine (Cl_2)	**0 – 20 ppm**	**10 ppm**	1400262-22
Chlorine Dioxide (ClO_2)	**0 – 3 ppm**	*****	1400262-4
Hydrogen (H_2)	**0 – 500 ppm**	**250 ppm**	1400262-38
Hydrogen Chloride (HCl)	**0 – 20 ppm**	**10 ppm**	1400262-5
Hydrogen Sulfide (H_2S)	**0 – 100 ppm**	**50 ppm**	1400255-5
Hydrogen Sulfide (H_2S)	**0 – 20 ppm**	**10 ppm**	1400255-1
Hydrogen Sulfide (H_2S)	**0 – 50 ppm**	**25 ppm**	1400255-3
Nitric Oxide (NO)	**0 – 100 ppm**	**50 ppm**	1400262-6
Nitrogen Dioxide (NO_2)	**0 – 20 ppm**	**10 ppm**	1400262-7
Oxygen (O_2) – 20.9%	**0 – 25% by Vol**	**20.9%**	1400262-11
Ozone (O_3)	**0 – 1 ppm**	*****	1400262-15
Sulfur Dioxide (SO_2)	**0 – 20 ppm**	**10 ppm**	1400262-8
Sulfur Dioxide (SO_2)	**0 – 100 ppm**	**50 ppm**	1400262-21

***** Consult Manufacturer

Table 51: Spare Cylinders

Index

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/faqs

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