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# GSI - MTG™

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## Multi-function Tank Gauge

The MTG™ "Multi-function Gauge" provides **more data and the lowest cost of ownership of any tank gauge on the market.** MTG™ customers experience both economic and operational benefits from its use, typically seeing payback on the MTG™ within the first year of operation.



The GSI "Multi-function Tank Gauge" (MTG™) provides the most **accurate inventory measurement and real time profiling** of product within a liquid storage tank.

The MTG™ can determine the **product quality** (Specific gravity and water content in product) as the transfer is being made into a receiving tank.

With crude oil or products with lower specific gravities, water pockets can form as the product is settling. The pockets can be missed by a gauge sample if located in other areas of the tank, i.e., not vertically aligned with the sample hatch. MTG™ has the ability to **determine water content in product**, thus providing better accuracy than manual sampling of water content in product.

The MTG™ has the ability to **monitor the settling of water from the crude oil** and emulsion layers, allowing you to determine when to use de-emulsifiers or automate water bleed off, thus providing a **quicker turn-around of tank assets and a reduction of tanks** needed for processing the same product volume.

With the MTG™ you have absolute knowledge of the quality of product, i.e., percentage water in product and specific gravity. **Improved quality of product, no more paying royalties on the production of water and emulsion, in shipping product it means no transportation cost for water and emulsion.**

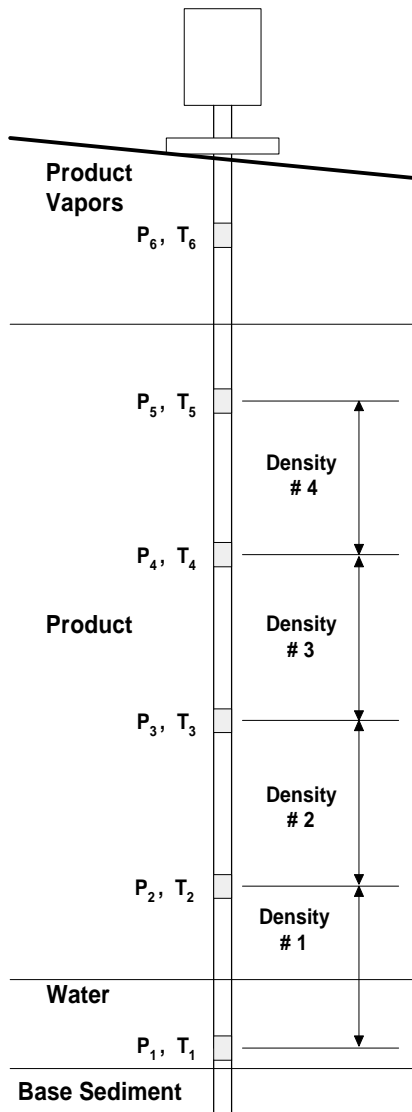
The MTG™ benefits are not limited to only Crude Oil tanks. The MTG™ provides even further benefits to refined products with a host of solutions to operational needs.

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The MTG™ provides **continuous knowledge of where the product interface is in a tank**. Therefore, it can be used to monitor any liquid application involving control of a liquid and secondary liquid with a difference in specific gravity of .05 or greater.

On product tanks, the MTG's real time profiling can show any type of **density or temperature stratification** within a tank. On lubricant product tanks, overheating of the product can cause discoloration. The MTG™ has high and low alarms for all multi-spot temperature points and density strata. MTG™ shows operations **when it's necessary to mix or heat the product, and when it's a waste of electricity**.

MTG™ can be used for **in-tank blending of product**. By monitoring the specific gravity or density of multiple strata you can determine when a product is uniformly mixed in a tank, to determine **when product meets product specification and when it is off specification**.

The MTG™ provides for High and Low alarms for both Vapor Pressure and Vapor Temperature. The MTG™ tank gauge can **notify operations of a stuck tank vent** before any structural damage can be done.

The MTG™ can **monitor the efficiency of gas blanketing** on a tank (Vapor Pressure), thus optimizing the control to reduce electrical costs.

The historical data gathered from the Vapor Pressure and Vapor Temperature can also be used in the **reporting of hydrocarbon emission** from your storage tanks.

With the ability to monitor data on hydrocarbon emissions (Vapor pressure and Vapor temperature) you can **determine the real net effect of product temperature and seals in inventory loss**.

The MTG™ has the ability to provide **high and low alarms for the following: Mass, Level, Multiple Spot Temperature Points, Multiple Density Strata, Free Water Level, Water Content, Vapor Pressure, Vapor Temperature, and Mass Sensitivity for Leak Detection** (Unauthorized Movement).

Figure 1 to the left shows a Multi-function Tank Gauge in a tank. Pages 4 - 7 will describe the MTG's physical attributes and how the MTG™ works. This Figure will be referred to for clarification on terms and capabilities.

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Since the MTG™ contains more than one sensor, the **MTG™ has built-in redundancy for many alarm points (Level, Mass, etc.) built into the design.**

Physically, **MTG™ has NO MOVING PARTS, installs in service, uses only one top tank entry, and doesn't require a stilling well or standpipe (with or without calibration pins). MTG™ is self-calibrating and self-diagnostic.**

### **Calculating Net Volume / Inventory**

**MTG™ provides "Custody Transfer" accuracy** on mass inventory measurement. **Mass measurement is not affected directly by temperature error as with level inventory measurement.** You can have the most accurate level device in the world, but with as little as a 0.1° F error in temperature measurement, it would be a wasted investment. It should also be noted that to achieve a claimed accuracy in any measurement, you need a reference that is 3 to 5 times the claimed accuracy of the device being measured. Therefore, suggestions of 0.5 mm or 1 mm accuracy of any level tank gauge is questionable.

Level inventory measurement can also be affected by the physical mounting of the device on the tank. If a level device is mounted directly to the tank roof, it will be subject to roof movement from the normal expansion and contraction of the tank during emptying and filling. **The MTG™ is bottom referenced.** This means that while the gauge installs from the top, the gauge stands on the bottom with a flexible double O-ring slip flange on the tank top. This allows the MTG™ to rest on the bottom (tank floor) as the tank roof and shell expand and contract during product movements.

There is no other tank gauging technology on the market that provides both **accurate quantitative and qualitative measurement** from one instrument. MTG™ is an evolution in Tank Gauging, i.e., **a tank gauge that provides more than just Level, Average temperature, and Water bottoms.** A tank gauge that provides the most economic incentives and the most accurate inventory available.

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### **MTG™ "Multi-function Tank Gauge" provides:**

- Mass
- Level
- Multiple Spot Temperatures or Average Temperature
- Multiple Density Strata or Average Density
- Free Water level
- 2nd Interface level
- Water content in Product
- Water content in Emulsion
- Vapor Pressure (Alarms)
- Vapor Temperature
- Mass sensitivity for Leak Detection
- Volume by Mass and/or Level
- Q<sup>2</sup> (Quantitative & Qualitative Measurement) and more..

## Physical description of the MTG™ Multi-function Tank Gauge Solution

MTG™ is a probe (see Figure 1, Page 2) that is inserted into a tank in sections from the top. It is composed of the following:

The MTG™ Assembly includes multiple pipe sections with 3 to 6 Sensor Modules. These sections consist of 2.8" outside diameter Stainless Steel Pipe threaded at both ends and fitted either with a special threaded sleeve or with a Sensor Module. The Probe Assembly is delivered to the job site in sections of varying length (usually 5' to 8' long) depending on tank height and number of sections included. Each Sensor Module is factory pre-assembled with a section of stainless steel pipe along with sensor cables. All pipe section lengths and Sensor Module dimensions are precision manufactured on NC machines and are re-measured at the factory. The above design provides smooth pipe surface all over the Probe Assembly and makes it easily applicable in tanks with cone and floating roofs (seals). The wires are all terminated in an Explosion Proof, NEMA 7 Aluminum housing on top of the probe.

Each Sensor Module consists of a 4-wire RTD and proprietary Pressure Sensor. The Pressure Sensors are typically accurate to between .01% Upper Range Limit (URL) and .02% URL. In no case will the error be greater than .04% URL.

The MTG™ assembly also includes a dual microprocessor based transmitter located at the top of the probe. The MTG™ transmitter polls all sensors, performs accurate analog to digital conversion and data processing including correction algorithms and strapping tables. The MTG™ Transmitter provides capabilities for the complete processing of data - mass, level, temperature, volume, water or interface, etc. The MTG™ transmitter communicates with any MODBUS RTU Host via IEEE/EIA RS-485 communications bus. MTG™ options include: Communications via Bluetooth™, Spread spectrum radio, Cellular, and Satellite using MODBUS RTU protocol and solar powering of the MTG™.

The TGI (Tank Gauge Interface) and newer E/TGI™ (Enhanced Tank Gauge Interface), configurations include a Local Display and set of IS Zener Barriers. Supports from one to four MTG™ probes. This may vary depending on MTG™ structure, number of sensor modules per MTG™ and length or gauge of the field wiring.

In addition, the E/TGI™ has computing power, which may be necessary in special or non-standard applications including protocol conversion. The E/TGI™ is supplied with a programmable display, IS Barriers, RS 485 bus repeater, surge protection, a NEMA 7 Explosion



MTG Assembly  
& Transmitter



MTG Sensor Module



TGI Tank Gauge Interface

Proof or NEMA 4x Weather Proof rated enclosure, etc. Communication options include: RS-485, 10BASE-T, 10BASE-FL (Fiber Link), Spread spectrum radio, Cellular, and Satellite using MODBUS RTU or MODBUS encapsulated TCP/IP protocol. Bluetooth™ communications can be added to the E/TGI for short distance (100m) radio communications with Bluetooth™ enabled MTG's.

The ISB (Intrinsic Safety Box) can be used instead of the TGI. Where the TGI has a local display, the ISB does not. The ISB comes in either a NEMA 7 for mounting in explosion proof areas or NEMA 4X enclosure for field mounting in non hazardous locations. It comes with zener barriers, RS 485 line booster, and surge protection. Note: The ISB is not an intelligent device like the TGI, it passes through any communications directly to the MTG transmitter via RS-485 and MODBUS RTU protocol.

#### Cabling / Communications Topologies

Hard wire - Each TGI or E/TGI™ is a Modbus RTU master for a number of MTG's connected via hard wire (RS-485 multi-drop) and a Modbus RTU slave (external multi-drop RS 485 loop) for the host system. Host systems could include **Win TG Pro Software—Windows Tank Gauge Software (Distributed Application Design - Windows 2000, XP, and .NET platform)**, Terminal automation systems, PLC, RTU, or DCS, etc.

Ethernet - The E/TGI™ has been designed with optional single or redundant 10BASE-FL Ethernet connections. This option allows communications at greater speeds, but most importantly provides electrical isolation between tanks.

WEB Enabled Device - The E/TGI™ Enhanced Gauge Interface can be provided as a WEB enabled device, allowing anyone with WEB access and password to view MTG™ information associated with the enabled E/TGI™. The E/TGI™ can access data on up to four MTG's, which means locations with four tanks or less could be monitored remotely via the WEB.

GSI Bluefield™ Topology (Patent Pending) - Is a tank farm communications topology that combines Host connection via standard Ethernet Hub (10BASE-FL Fiber Link) , Intelligent Switches regionally located, E/TGI™ - Enhanced Tank Gauge Interface communicating via Ethernet back to the host and communicating with the MTG™ via Bluetooth™ (GSI Blueboard™ Interface) at both the MTG™ and E/TGI™. **Bluefield™ can reduce typical field cabling costs by 30% - 60%.**



MTG Installation Kit



MTG in background, installed on a cut & cover (buried) tank and a TGI™ - Tank Gauge Interface

## MTG™ Theory of Operation

The MTG™ Multi-function Tank Gauge is based upon mass and temperature measurement. The MTG™ design eliminates problems with earlier mass technologies such as Bubblers, HTG (Hydrostatic Tank Gauge), and some other techniques utilizing nitrogen bubbles measured at multiple locations and multiplexed through one pressure transducer. These earlier technologies suffered problems due to the improper design of the product, not because they used mass based measurement.

MTG™ (Multi-function Tank Gauge) overcomes the problems with both reference point movement and temperature change that affects level devices. Some level devices claim to be non-obtrusive, however, to do net volume a temperature device is required. The MTG™ has no moving parts and uses only one tank entry for all measurements. In addition to mass, the MTG™ provides accurate level and temperature measurement.

The MTG™ Multi-function Tank Gauge is constructed of sensor, joint, and pipe sections assembled into a vertical probe assembly. The standard configuration includes up to six sensor units, consisting of both an accurate pressure and temperature sensor module located in each of the sensor units.

The probe is assembled and lowered into the tank from the top. A double O-ring seal in the slip flange allows the probe to sit on the tank floor. As the tank expands or contracts from normal emptying and filling the MTG™ remains bottom referenced.

Usually the sensor sections are spread evenly over the tank height. The first one is always located near the bottom and the last one is always in the vapor space of the tank. In some custom configurations the sensor location inside the liquid space may vary based upon the product or service application.

The MTG™ probe is a rigid stainless steel construction with each sensor position precisely located.

The differential value  $P_1 - P_6$  (see figure 1 on page 2) can be presented as:

$$P_1 - P_6 = D * H * g \quad (1)$$

Where: **D** is the liquid density;  
**H** is the height of the liquid column above the first sensor;  
**g** is the local gravity constant.

Therefore the mass of the liquid above the first pressure sensor can be calculated as follows:

$$M = (P_1 - P_6) * S / g = D * H * S = D * V \quad (2)$$

Where **S** is the average cross-section area of the tank given by the tank strapping table;  
**g** is the gravity constant;  
**V** is the resulting volume of the liquid above the first pressure sensor:

The pressure difference  $DP_{12} = P_1 - P_2$  gives the average density value  $D_{12}$  in the area between first and second sensors provided that the distance  $H_{12}$  between the corresponding pressure sensing points is precisely known:

$$D_{12} = (P_1 - P_2) / g / H_{12} \quad (3)$$

The density layers between the rest of the sensors are calculated in the same way:

$$D_{23} = (P_2 - P_3) / g / H_{23} \quad (4)$$

$$D_{34} = (P_3 - P_4) / g / H_{34} \quad (5)$$

$$D_{45} = (P_4 - P_5) / g / H_{45} \quad (6)$$

The density values measured as per formulas 3 to 6 and temperature measurements taken in the same points along the tank height allow building a density distribution curve.

The level of liquid  $L$  in the tank is calculated as follows:

$$L = H_i + P_i / g / D_i \quad (5)$$

Where  $H_i$  is the location of the last sensor unit covered with liquid;  
 $P_i$  is the pressure measurement taken from the last sensor unit covered with liquid;  
 $D_i$  is the current density value.

**Note:** All above formulas are simplified. More accurate expressions for some of the values may be found in the International Standard ISO 11223-1 and API Chapter 16, Section 2.

Pressure sensors located in second to fifth units may not be covered by liquid from time to time due to liquid movement of the tank during normal tank operation. The MTG System automatically identifies uncovered sensors. When stable conditions are detected, it re-calibrates the uncovered sensors automatically. A proprietary algorithm provides for bottom sensor re-calibration by using simultaneous measurement results from three to six pressure sensors.



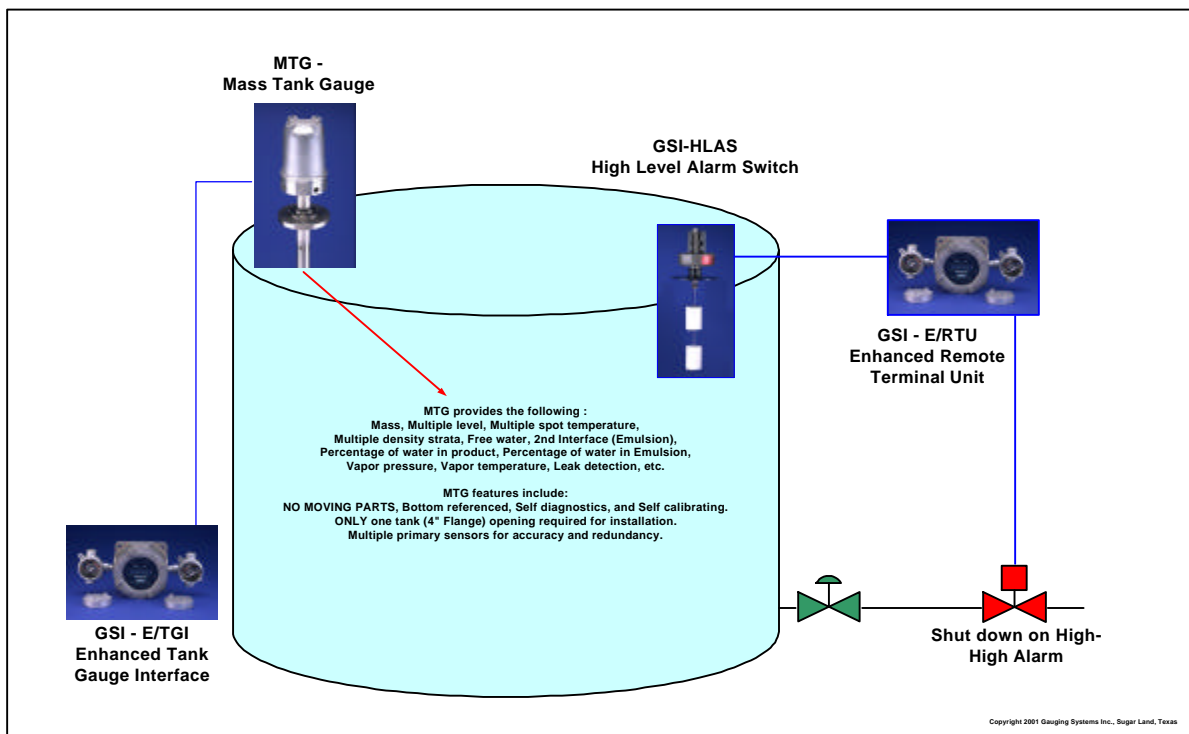
## MTG System Configuration & Components

Gauging Systems Inc. - "Specialists in liquid Level / Mass Tank Gauging", also has vast experience in systems integration. GSI has integrated most technologies, electrical standards, and protocols used commercially in tank gauging around the world for the last 19+ years. Regardless of manufacturer, GSI can integrate the MTG™ Multi-function Tank Gauge with most existing systems or provide alternative solutions.

On new system installations GSI can provide full two-way communications capabilities from the Win TG PRO™ Software to the MTG™. This allows for full MTG™ data displays featuring real-time profiling, multiple density strata, water content in product, second interface, vapor pressure, vapor temperature, etc., i.e., data that is not normally found in other tank gauging manufacturers, process control, or DCS software. In addition, the MTG can be configured or monitored for maintenance purposes from the control room via 10BASE-FL bus, Ethernet cabling in the field.

The E/TGI™ Enhanced Tank Gauge Interface is a local display and protocol convertor. When integrating the MTG™ with other electrical standards and protocols, the E/TGI™ is used as the translational device. The MODBUS RTU communications or Bluetooth™ remains normal to and from the MTG™, the E/TGI™ takes the register data and converts this data to the host protocol through the use of a personality module (first introduced in the industry on the GSI 2000/MACB Transmitter). This allows communications to the host in the appropriate electrical standard and protocol.

MTG™ system configurations might change slightly based upon cabling topology, if local displays are needed, etc. GSI has field experience with just about any topology imaginable including: Hardwire, Fiber, Cellular, Radio, Satellite, WEB enabled, Intranet, PLC, RTU, DCS, etc.





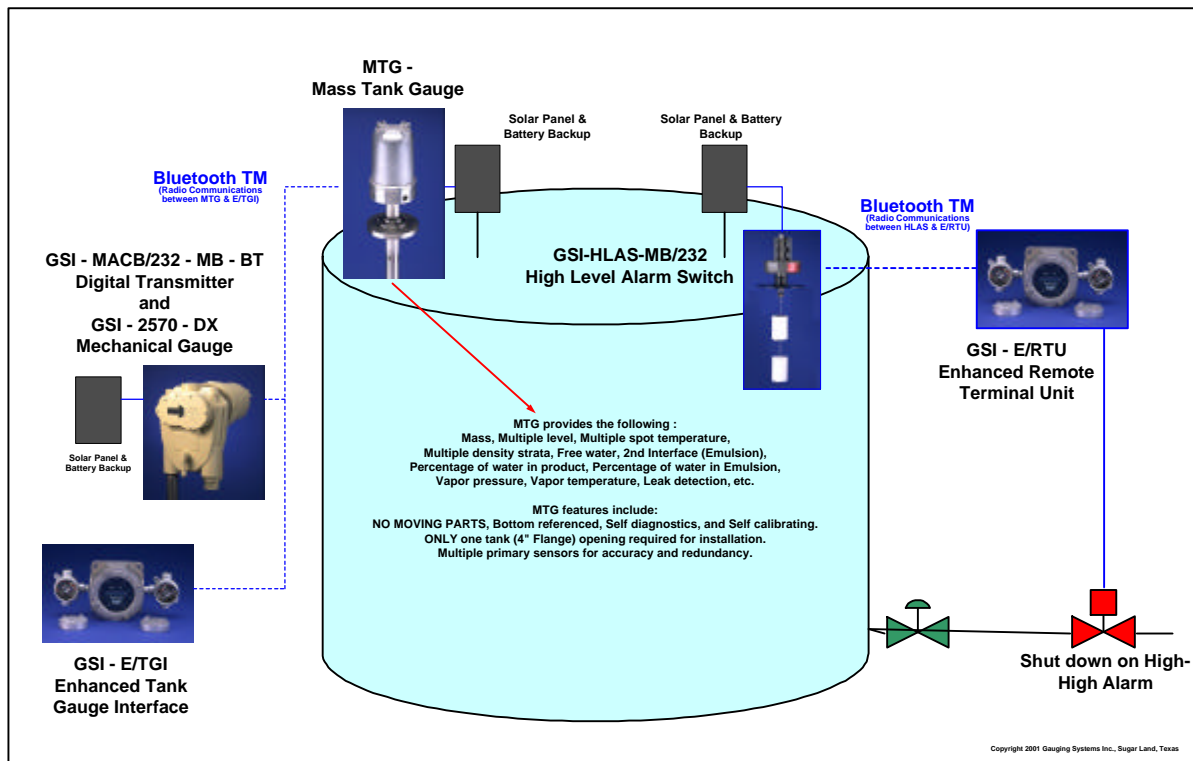
# Bluefield™

(Patent Pending)

The major cost in any tank gauging or tank farm automation project is the field wiring. Normally two-thirds (2/3) of the cost is on wire, conduit, electrical fitting, etc. The upgrade of older technology in the field is often delayed because of the capital money needed to replace the communications infrastructure. This means the benefits are also delayed and cost you money..

**Bluefield™ is a Communications Topology** designed to 1) Reduce the cost cabling vs. conventional hardware, 2) Increase the data throughput speed and reliability using commercial standards, 3) Provide electrical isolation to all field hardware (against power surges and lightning), and 4) Provide two-way communications from Intranet based servers or application users (Tank Gauge Software) all the way to the **MTG™ Multi-function Tank Gauge** (or other field devices).

The standards adapted for the **Bluefield™ Topology** are known by most computer people and consist of the following: Win TG PRO™ Software based upon Microsoft™ Windows 2000 or XP Operating System and designed for .NET ready platform, Ethernet 10BASE-FL (Fiber Link) hubs and smart switches acting as the field interfaces, Commercial grade Fiber Optic cable run into the tank farm to the GSI E/TGI™ Enhanced Tank Gauge Interface (local display) or GSI E/RTU™ Enhanced Remote Terminal Unit (with Single or redundant TCP/IP addresses and 10BASE-FL connections). Communications to the **MTG™ Multi-function Tank Gauge** over **Bluetooth™**, i.e., Short distance (328 ft.), 2.4GHz radio communications (or hardwired). See GSI Product Bulletin 5150 on the **Bluefield™ Topology**.



Tank Instrumentation for **Bluefield™ Tank Farm Communications Topology**

## MTG Multi-function Tank Gauge Specification

### General:

Measurement Parameters:	Mass, Level, Volume, Multiple Density Strata, Multiple Spot Temperature Points, Free Water Level, 2nd Interface (Emulsion) Level, Percentage of water in product, Vapor Pressure, Vapor Temperature, and Mass Leak Detection Sensitivity.
Pressure Range:	50 PSI liquid head & vapor pressure (for higher ranges consult GSI)
Safety Approvals:	UL, CSA, and CENELEC (I.S. Certification)

### Performance:

Mass:	±0.05% of Full Scale
Density:	±0.0015 grams/cubic centimeter
Level:	±0.15% of Full Scale between Sensor Modules
Temperature:	0.1°C

### Power Specifications:

MTG Transmitter Input Voltage:	7..16 VDC (after Zener Barriers)
Maximum Current Consumption:	18 mA

### Environmental:

MTG Transmitter Enclosure:	Aluminum casting
Wetted Parts Materials:	Standard: 303 SS & 304 SS Options: 316 SS, 316L SS, PTFE Coated, Titanium, Hastelloy C
Non-wetted Parts Material:	Standard: 303 SS & 304 SS Options: 316 SS, 316L SS, Titanium, Hastelloy C
TGI Enclosure:	Standard: NEMA 7 Explosion Proof Enclosure. Optional: NEMA 4X plastic box or NEMA 4X 316 SS box.
Operating Temperature:	Standard: -4°F to 158°F (-20°C to 70°C) Options: -13°F to 176°F (-25°C to 80°C), -40°F to 212°F (-40°C to 100°C)

### Field Installation Requirements:

Mounting:	4" ANSI, 6" ANSI, or 8" ANSI flange. Others available upon request
Field Wiring:	IEEE RS 485 (Two signal wires, Power, Ground)
Protocol:	Modbus RTU

**NOTE:** The MTG uses IS (Zener) Barriers either housed within the E/TGI, TGI, or ISB products. These products use NEMA 7 Explosion Proof Housing within the tank dike or NEMA 4X Weather Proof Enclosures outside the Hazardous Area. Disconnect or shut off power to the MTG before opening the MTG, E/TGI, TGI, or ISB.

## MTG™ Ordering Information

### MTG™ Multi-function Tank Gauge

**Model No. Specification: MTG 3000 / A - B - C - D - E**

**A = Tank Height in Inches or Meters** (from datum plate to mounting flange)  
Please indicate Meters in the following manner: 15.65M with "M" designator

**B = Number of Sensor Modules**

- |                                    |                                 |
|------------------------------------|---------------------------------|
| (A) Two Pressure and Two RTD's     | (E) Six Pressure and Six RTD's  |
| (B) Three Pressure and Three RTD's | (F) Additional RTD's            |
| (C) Four Pressure and Four RTD's   | (G) Additional Pressure Sensors |
| (D) Five Pressure and Five RTD's   | (J) Redundant P1 (Bottom)       |

**C = Mounting Flange** (Installation)

- |                            |                  |
|----------------------------|------------------|
| (4) = 4" Flange (Standard) | (8) = 8" Flange  |
| (6) = 6" Flange            | (9) = 10" Flange |

**D = Material, Wetted parts**

- |   |                   |
|---|-------------------|
| (S) = 303 SS Sensor Module / 304 SS Probe | (T) = Titanium    |
| (N) = 316 SS                              | (H) = Hastelloy C |
| (L) = 316L SS                             |                   |

**E = Sensor Housing(s)**

- |                               |  |
|-------------------------------|--|
| (5) = Standard Sensor Housing | (7) = "Z Cut" Sensor Housing<br>for viscous products |
|-------------------------------|--|

