Magnetrol®

THERMATEL® MASS FLOW MEASUREMENT

SPECIAL APPLICATION SERIES

Introducing Thermatel

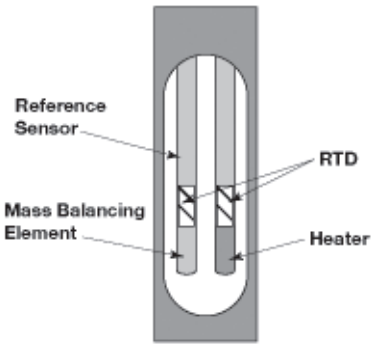
Magnetrol TA2 thermal mass flow transmitters measure mass flow by detecting heat dissipation from a heated surface.

Mass Flow Measurement

Thermal flow meters measure flow rate in units of mass flow (SCFM or NM^3/hr) rather than flow at operating conditions. Because temperature and pressure variations will influence the gas density, mass flow measurement provides optimum measurement accuracy despite temperature and pressure variations.

In addition to greater measurement accuracy, mass flow is also measured to accommodate an industry's measurement standards. Chemicals react on the basis of mass relationships of ingredients. Combustion is based upon the mass flow rate of the air and fuel. In addition, a facility's gas consumption is based upon mass flow.

Thermatel Technology



Operating on the basis of heat transfer, Thermatel TA2 transmitters measure mass flow by detecting heat dissipation from a heated surface. Their sensor probes contain two mass balanced elements with precision matched RTDs. The reference RTD measures the process temperature (up to +400 °F, +200 °C) while the second RTD measures the temperature of the heated sensor.

A brief discussion of the TA2 technology follows on page 4. For a thorough discussion of thermal dispersion technology, download our 32-page Thermatel Measurement Handbook at ***www.magnetrol.com***.

Thermatel Benefits

Thermatel flow meters offer distinct advantages over many traditional gas flow measuring methods*:

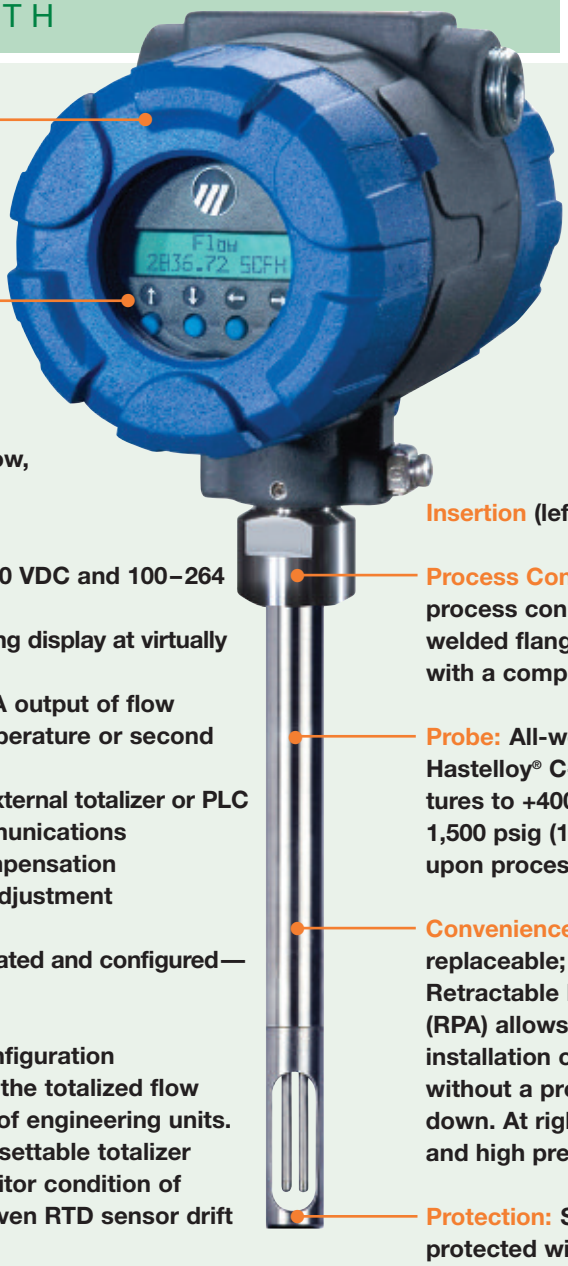
- Direct mass flow measurement does not require pressure or temperature input for density correction as do many gas flow technologies, such as differential pressure.
- Offers excellent low flow sensitivity: mass velocities of 10 ft/min (0.05 m/s) to 50,000 ft/min (250 m/s) (gas dependent).
- Measures low velocities as well as high flow rates for a turndown rate of 100:1 or more.
- Thermatel probes create negligible pipe blockage resulting in very low pressure drops.
- Thermatel measurement functions are accomplished without moving parts—resulting in little or no maintenance and fewer on-line problems.
- Thermatel transmitters have been engineered for easy installation and fast set-up while providing rugged, accurate and reliable service.
- Calibrated for your application, each instrument is ready for immediate field installation and operation.
- Installed cost of Thermatel is very competitive with other gas mass flow measurement technologies.
- FM, FMc, ATEX approvals for combustible gases.
- Available as insertion or Inline styles.
- Flow body designs for pipe sizes as small as ½ inch

*These conditions will compromise Thermatel performance: (1) a continuous presence of condensed moisture; (2) an excessive probe buildup; (3) an attempt to measure media for which the instrument was not calibrated.

TA2 SPECIFICATIONS

Supply Voltage:	100-264 VAC, 50-60 Hz 11.6-30 VDC
Flow Range:	10-50,000 SFPM (0.05-250 Nm/s) (gas dependent)
Flow Accuracy:	±1% of reading plus 0.5% of calibration range
Temperature Accuracy:	±2° F (1° C)
Repeatability:	±0.5% of reading
Sensor Range:	-50° to +400° F (-45° to +200° C) Rated to 1,500 psig (103 bar)
Turn Down:	100:1 (application dependent)

TA2 IN DEPTH



Integral or Remote: All electronics are housed in a compact, explosion-proof enclosure mounted on the probe or at a remote location.

Display: Optional two-line, 16 digits/line, alphanumeric backlit display module with four-button keypad for easy configuration. Displays flow rate, temperature, totalized flow, and diagnostic messages.

TA2's Electronics Features:

- Unit accepts both 11.5 to 30 VDC and 100–264 VAC input power
- Rotatable housing for viewing display at virtually any angle
- Active and passive 4-20 mA output of flow
- Second mA output for temperature or second flow range
- Pulse output available for external totalizer or PLC
- HART and PACTware communications
- Real time temperature compensation
- Automatic pipe blockage adjustment
- Very low heat input
- Unit delivered factory calibrated and configured—simplifies startup
- Flow profile compensation
- Easy. Intuitive software configuration
- Software totalizer displays the totalized flow usage in the user's choice of engineering units.
- Both resettable and non-resettable totalizer
- Complete diagnostics monitor condition of probe, circuit, wiring and even RTD sensor drift

Insertion (left) **or In-Line style** (above)

Process Connections: Selection of process connections includes threads, welded flange construction, and use with a compression fitting.

Probe: All-welded 316 stainless steel; Hastelloy® C-276 optional. Process temperatures to +400° F (+200° C); Pressure rating to 1,500 psig (103 bar); ratings are dependent upon process connections.

Convenience: Probe is field-replaceable; Optional hot tap Retractable Probe Assembly (RPA) allows for probe installation or removal without a process shut-down. At right, standard and high pressure RPAs.

Protection: Sensor is protected within a durable enclosure to prevent damage if the probe is inserted too far into a pipe.

HART COMMUNICATION PROTOCOL

AMS aware™

PACTware™

Principle of Operation

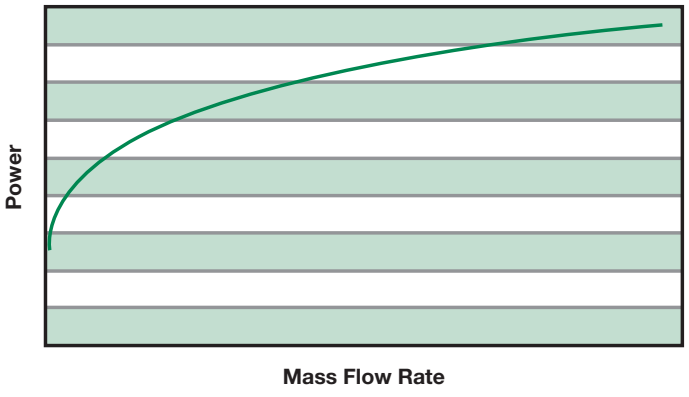
TA2 thermal mass flow transmitter technology for measuring mass flow.

The TA2 uses the proven Constant Temperature Difference Technology for mass flow measurement. There are two elements in the sensor as shown on page 2. The RTD in the reference pin measures the process temperature of the gas where the sensor is located; a variable amount of power is applied to the heater in the second pin to maintain a specified temperature difference. The amount of the temperature difference is set during the calibration to optimize the performance for the particular application.

At low mass flow rates there is little heat transfer and the amount of power required to maintain the desired temperature difference is low. However, as the mass flow rate increases, the power requirements increase. Changes in heat transfer are greatest at low velocities which provide excellent low flow sensitivity. As the mass flow increases the power increases in a non-linear manner as shown in the chart below. The curve continues permitting flow measurements at high velocities; this provides very high turndown capabilities.

The units are factory calibrated to establish this relationship between heat transfer and mass flow. Calibration is performed by placing the TA2 in a flow bench and flowing a known amount of gas past the sensor. The signal is measured at each flow rate. A minimum of 10 data points are taken over the operating range of the instrument. Once calibrated this is a permanent calibration unless something happens to the sensor. The TA2 provides a simple method which permits the user to verify calibration in the field.

Flow Calibration Curve



The TA2 is designed with advance digital electronics which produce very low amounts of heat input to the sensor. Testing by FM has demonstrated a maximum of a 4 °C (7.2 °F) temperature rise of the heated element which is much lower than other designs. This permits the TA2 to measure much higher velocities than other designs without running out of power.

One of the advantages of the Constant Temperature Difference Technology is the response time. There is some thermal mass which needs to heat up or cool down with changes in flow. The TA2 incorporates an advance PID control circuit which immediately detects changes in temperature difference to provide very rapid response in the flow measurement. Once at constant flowing conditions, the signal remains extremely stable.

Mass Flow of Air

Applications: The flow of air (78% nitrogen, 21% oxygen and traces of eight other gases) is monitored in nearly all industrial settings, including applications for processing; air/gas mixing; cooling; blowing & drying; combustion; aeration; ventilation; filtration; ingredient mixing; air sampling, and many others. Significant air-flow variables include pipe diameters, wide flow ranges, varying velocities and low flow sensitivity. Large-duct flow applications for Thermatel include combustion air flow used in determining fuel-to-air mixtures for industrial boilers, heaters, furnaces and kilns.

TA2 Air Flow Applications:

• Aeration Flows	Wastewater Treatment
• Combustion Air	Boilers, Kilns, Heaters
• Test Air Flow	Pump and Equipment Mfgrs.
• Air Flow Rate	Metals Processing and Recovery
• Spray Drying	Food, Bio-Pharm, Chemical
• Remediation	Agricultural, Environmental
• Heat Treating	Manufacturing, Metals
• Drying Air Flow	Pulp and Paper
• Reheat Air Flow	PowerGen
• Leak Detection	All Industries

The combustion efficiency of burners, furnaces and dryers is enhanced by obtaining repeatable flow measurement of the inlet combustion air. Ducts can vary from six-inches in diameter to many square feet. Too little air and combustion is incomplete; too much air and combustion efficiency is greatly reduced.

Application Insights

Measuring Mass Flow in Large Pipes and Ducts.

The larger the diameter of a pipe, stack or duct, the greater the likelihood of significant flow velocity profile distortions. In these highly skewed flow conditions, a single point flow meter won't do the job. So, what's the best measurement solution?

A frequent choice for greater measurement accuracy is the multi-point sensor array. Here, two or more flow sensors are placed along an extended-length insertion element. With more sensor points across the interior expanse of the duct, the more representative will be the flow measurement. And, if you install two of these arrays in crisscross fashion inside the duct (as diagramed at top right), you have a sensor array that will provide very good results. The price you pay for this set-up, however, is cost; for the multi-point array is engineering-intensive at the front end, and maintenance-intensive down the line.

Option #2 is to insert four TA2s (or more, as needed) from opposite sides of a duct (bottom right) and average their output signals. This approach uses standard Thermatel flow meters for accurate and reliable mass flow measurement at a lower installed cost, and with less maintenance headaches in the future. ■

ABOVE: Two, custom-engineered multi-point arrays. BELOW: Four standard TA2 flow meters.

Compressed Air Flow

Applications: Air that is compressed and contained at a pressure greater than atmosphere has become industry's universal power source. Seventy percent of all manufacturers operate compressed air **(CA)**. Process operations dependent upon CA include pneumatic tools; materials handling; painting; oxidation; fractionation; cryogenics; refrigeration; dehydration; filtration and aeration. Flow meters help ensure efficient operation at rated SCFM output and are also used to detect leaks. A Flow Meter with a Totalizer provides an accurate measurement of CA consumption.

TA2 Compressed Air Flow Applications:

• Automation & Process Systems	All Industries
• Pneumatic tools, Painting	All Industries
• Materials Handling Systems	All Industries
• Filling, Capping, Packaging	Bottling, Packaging
• PET, PE Bottle Blowing	Plastic Containers
• Labs, Pill Coating	Pharmaceuticals
• Soil Remediation	Environmental Industry
• Drilling, Pipelines	Oil and Natural Gas
• Pressurizing Gas Lines	Natural Gas
• Food & Drug Processing	Foods, Pharmaceuticals

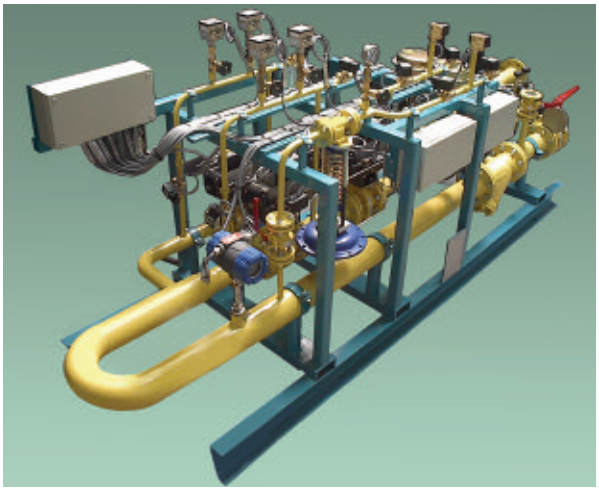
Nitrogen Gas Flow

Applications: Nitrogen gas **(N2)** is the most widely used commercial gas. Colorless, odorless, tasteless, and nonflammable, its inertness makes it an ideal blanketing gas to protect flammable or explosive solids and liquids from contact with air. Keeping chemicals, pharmaceuticals and foods within a nitrogen atmosphere keeps them protected from oxygen and moisture degradation. Oil, gas and petrochemical industries purge tanks and pipes with nitrogen to replace hazardous or undesirable atmospheres. In refinery maintenance, nitrogen quickly cools catalyst temperatures to vastly reduce shutdown time.

TA2 Nitrogen Gas Flow Applications:

• Tank Blanketing	Chemicals, Foods, Hydrocarbons Bio-Pharm, Semi-Conductor
• Gas Purging	Natural Gas, Refinery Industries
• Pressure Transfer	Storage Vessels, All Industries
• Cooling, Freezing	Refineries, Food Processing
• Forming Control	Metal Casting
• Heat Treatment	Shield Gas for Steel and Iron
• Pill & Tablet coating	Pharmaceutical, Nutritional
• Inerting of LNG	Tankers, Transport Vessels
• Drilling, Processing	Oil and Natural Gas Industries

Natural gas is one of the major energy sources for fueling large central power stations as well as smaller industrial furnaces and boilers. Flow rate measurement and totalization of flow usage are vital to efficient operations.



This Glycol Regeneration Skid serving a natural gas field in Holland features three TA2s—two measuring air flow to an incinerator and one measuring natural gas.

Nitrogen flow in a two-inch line at a chemical plant. Point-of-use consumption of compressed air and gases will permit the user to obtain improved usage rate information for more efficient operations. Some centralized facilities bill the individual plants for gas usage.

Natural Gas Flow

Applications: Natural gas is a mixture of hydrocarbon gases, primarily (70-90%) methane (CH_4). In its pure form it is colorless, odorless and combustible. The cleanest burning fossil fuel, natural gas trails electricity as the second most used energy source in industry. Industrial demand accounts for 40 percent of total natural gas demand, the highest of any sector. With a multitude of industrial uses, natural gas is consumed primarily in pulp and paper; metals manufacture; power generation; petroleum refining; stone, clay and glass manufacture; chemicals production; plastic resin production; and food processing.

TA2 Natural Gas Flow Applications:

• Extraction, Production	Natural Gas Industry
• Waste Treatment, Incineration	All Industry Sectors
• Co-Firing Technology	Power Generation
• Base Ingredients, Feedstocks	Plastics, Chemicals, Bio-Pharm
• Preheating, IR heating	Iron and Steel, Powder Coating
• Processing	Food, Chemicals, Refining, Paper
• Manufacturing	Stone, Clay and Glass
• Primary and Backup Fuels	Industrial Boilers, Furnaces
• Gas Desiccant Systems	Plastics, Bio-Pharm, Confections
• Gas Absorption Systems	Heating & Cooling of H_2O

Natural gas flow at a gas production plant is monitored to provide flow measurement from each individual well. The main custody transfer meter is positioned downstream from where the flow from individual lines is combined.

Application Insights

Thermatel: Precisely Calibrated To Your Gas Flow Requirements.

Every gas has distinct thermal properties that affect the convective heat transfer of the Thermatel sensor. It is for this reason that each flow meter is calibrated in the Magnetrol Calibration Lab to our customer's specific requirements. The instrument is performance tested under conditions of gas composition, flow rates, velocities, and temperatures. Once installed, the unit goes directly into service without any need for field set-up, calibration, or adjustment.

The Magnetrol NIST Traceable Calibration Facility

Our customer has total control over field configuration of the TA2. By using a simplified procedure, they can configure the instrument in order to change pipe or duct size, the range and span of the 4-20 mA signal, the units of measurement, or installation factors.

Some competitors' flow meters require their calibration to include a specified cable length, and any subsequent cable changes will affect the unit's accuracy. The TA2's cable length is independent of their calibration. This allows our customers to provide their own cable, or change its length in the field.

The TA2's probe and circuit boards are also field replaceable. New calibration factors can be entered into the instrument by using the TA2's keypad or with a HART® remote communicator. ■

TA2

Argon Gas Flow

Applications: Composing slightly less than 1% of the air, Argon **(Ar)** is a colorless, odorless, tasteless, non-corrosive, nonflammable, and nontoxic gas. It is the most abundant of the "rare" gases, those with an extremely weak tendency to chemically interact with other materials. Argon is commercially valued in multi-industry applications for its near total inertness and low cost. Argon is utilized to produce specialty products; protect and maintain product quality; and lower operating costs in steelmaking. It is essential in metal fabrication; light bulbs; the production of electronic equipment; and in thermal glass and plastics manufacture.

TA2 Argon Gas Flow Applications:

• Degasification	Aluminum, Titanium, Stainless Steel
• Heat Transfer	Electronics, Semiconductors
• Bulb Media	Fluorescent, Incandescent Lighting
• Thermal Media	Thermopane Window Manufacturing
• Argon Lasers	DNA Sequencing, Electronics, Printing
• Arc, Tig, Mig Welding	Manufacturing, Metal Fabrication
• Filler Gas	Silicone and Germanium Manufacturing
• Gas-plasma Treating	Plastics, Painting and Coating
• Spectrometry	Anodizing, Plating, Powder Coating
• Cryoablation	Medical technology

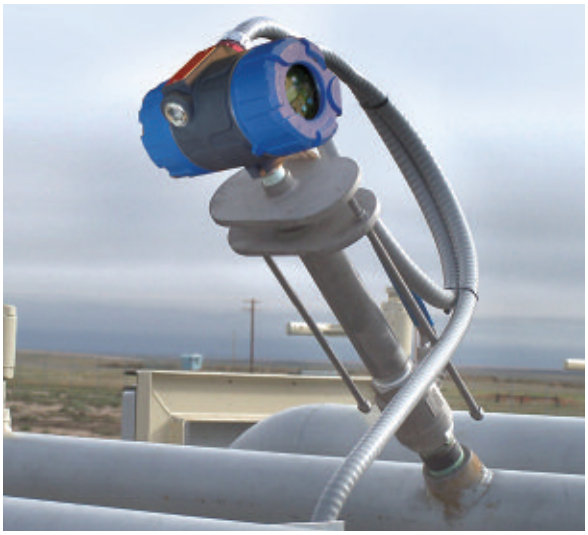
Hydrogen Gas Flow

Applications: Hydrogen **(H_2)**, the lightest of gases, is colorless, odorless, tasteless, flammable and nontoxic (at atmosphere). It has the highest combustion energy release per unit of weight of any commonly occurring material. Hydrogen's industrial applications include chemical processing; metal production; petroleum refining; electronics; power; pharmaceuticals and foods. With the development of a viable fuel cell technology, new application opportunities in the automotive sector will no doubt surface. Consideration must be given to Hydrogen's volatility and its greater cooling effect on the sensor compared to other gases.

TA2 Hydrogen Gas Flow Applications:

• Treating, Welding, Annealing	Steel, Stainless Steel, Copper
• Hydrodesulfurization	Oil Refineries
• Catalytic Cracking	Oil Refineries
• Vitamin Manufacturing	Pharmaceuticals, Supplements
• Oxidation Preventative	Glass Manufacturing
• Hydrogenation of Fatty Acids	Food and Dairy
• Carrier Gas	Integrated Circuits
• Generator Coolant	Power Generation
• Rocket Fuel, Fuel Cells	Aerospace, Automotive
• Making NH_3, CH_3OH, H_2O_2	Chemicals, Polymers, Solvents

The flow of large ducts and stacks, as in this power generation boiler, can be measured using multiple standard TA2s to obtain an averaging of the flow rate. This approach is more economical and easier to maintain than custom-designed, multiple-point array systems.



Retractable Probe Assemblies (RPAs) permit installation of the instrument in applications which must remain in continuous operation. RPA designs with pressure ratings up to 720 psi are available.

Hydrogen gas has many industrial applications. Using a catalyst and large quantities of hydrogen, hydrotreatment (above) removes 90% of the sulfur, oxygen, nitrogen and metals from gasoline refinery feedstocks.

Oxygen Gas Flow

Applications: Oxygen **(O_2)** is the second-largest volume industrial gas. Because it forms compounds with virtually all chemical elements it is most often bound with other elements in silicates, oxides, and water compounds. Oxygen is highly oxidizing and reacts vigorously with combustible materials generating heat in the reaction process. Ozone **(O_3)** is an allotropic form of oxygen that is more reactive. Oxygen finds numerous uses in steelmaking and metals refining; chemicals and pharmaceuticals; petroleum processing; glass and ceramic manufacture; pulp and paper manufacture; and in municipal and industrial effluent treatment.

TA2 Oxygen Gas Flow Applications:

• Furnace Combustion	Steel Making, Haz Mat Industry
• Metal Processing	Copper, Lead, Zinc Manufacturing
• Glass Smelters	Glass Manufacturing
• Raw Material for Oxidation	Chemical Industry
• Coal Gasification	Chemical Feedstock Production
• Catalyst Regeneration	Oil Refineries
• Oxy-fuel Furnaces	Glass Manufacturing, Pulp & Paper
• Pulp Bleaching Agent	Pulp & Paper
• Biological Treatment	Municipal Wastewater Treatment
• Water Oxygenators	Aqua Culture, Water Treatment

The largest industrial user of gaseous oxygen is the steel industry. Oxygen-enriched air increases combustion temperatures in open hearth and blast furnaces.

Application Insights

The Inline Advantages

Magnetrol offers an inline sensor for the TA2 Mass Flow Meters. The principle reasons for using an inline—or flow body—configuration for mass flow measurement are:

- The inline configuration measures lower flow rates within smaller pipe sizes. Flow rates of less than 1 SCFM (1.7 Nm^3/h) can be detected in pipe sizes as small as ½".
- As most flow meters are of the in-line type, they represent a more traditional approach to flow measurement. Also, the flow body can be used to replace other flow meters of the same dimensions.
- The inline style provides optional flow conditioning to obtain a predictable flow profile and remove swirl at the sensor. This is especially important when an insufficient straight run of pipe is placed before the flow meter. ■

TA2 with Flow Body

Carbon Dioxide Gas Flow

Applications: Carbon dioxide **(CO_2)** is an odorless, colorless, non-combustible and slightly toxic gas with a pungent acidic taste. It constitutes a fraction of our air, about 0.036%. Carbon dioxide is valued in industry for its reactivity, inertness and ability to create cold conditions. Large quantities of gaseous CO_2 are produced and consumed in making fertilizers, plastic resins, and rubber. Other important uses include beverage carbonation; food and pharmaceutical processing; enhancement of oil recovery from oil wells; a raw material for producing many chemicals; treatment of alkaline water; and manufacturing CO_2 fire extinguishing systems.

TA2 Carbon Dioxide Flow Applications:

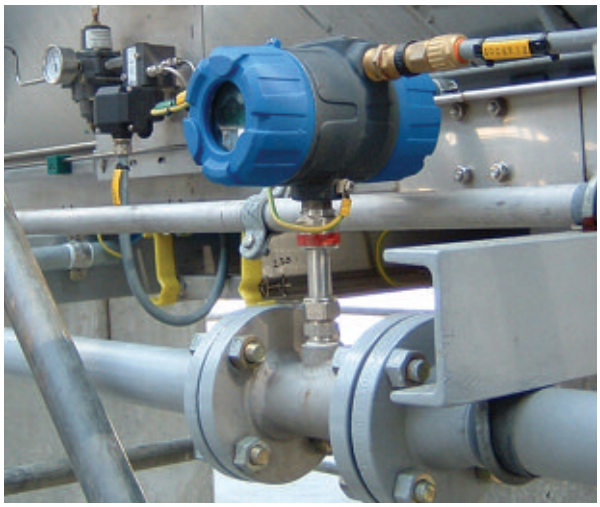
• MIG/MAG Welding Shield	Metal Industries
• Casting Mold Hardening	Metal Industries
• Dry-Ice Feed	Manufacturing, Construction
• Urea, Methanol Production	Chemical Industry
• Oil Extraction Well Priming	Petroleum Industry
• Flash Removal	Rubber and Plastics
• Dry Ice & CO_2 Coolant	Food and Beverages
• Beverage Carbonation	Soft Drinks, Beer, Sparkling Wine
• Blanketing Agent	Foods, Pharmaceuticals
• Fertilizer Processing	Agricultural Chemicals

Exhaust & Waste Gas

Applications: Exhaust gases in a wide variety of compositions range from the ecologically benign to toxic emissions. Off-gases are vapors emitted from extraction and treatment systems that are discharged directly to the atmosphere, captured or destroyed. Hydrocarbon gases from industrial operations are often “flared” in a high-temperature oxidation process which burns combustible components of waste. Natural gas, propane, ethylene, propylene, butadiene and butane constitute over 95 percent of the waste gases flared. Consideration must be given to changes in gas composition, abruptness of flow change, low pressures, and a wide range of velocities.

TA2 Exhaust & Waste Gas Applications:

• Vent Lines	All Industries
• Waste CO_2	Petrochemicals, Chemical Production
• SO_2 Off-Gas	Metals, Chemicals, Pharmaceuticals
• Flare Stacks, Headers	Oil Platforms, Refineries; Chemicals
• Flue Gas	Power Generation
• Waste-to-Energy Gas	Landfill, Waste Treatment Plant
• Waste Flow Mixing	Incinerators, All Industries
• Flare Gas Recovery	Electricity, Steam, Hot Water Generation
• NC Gas Disposal	Pulp and Paper



Measuring natural gas flow to a furnace. The use of an insertion probe permits the TA2 to be installed in lines of various sizes and with considerable installation flexibility while also ensuring economical mass flow measurement.

Today’s refineries and chemical plants frequently burn-off waste gases in a flare line. Because both flow rates and gas compositions vary, the TA2 can be used to obtain relative flow indication.

Due to environmental laws and restrictions, oil and gas platform operators must monitor and report the amount of flared gases. The consistent composition, low flow sensitivity, and high turndown capabilities make the TA2 an ideal flow meter for this service.

LFG, Digester & Bio-Gas

Applications: These gases are typically composed of 65% methane **(CH_4)** and 35% carbon dioxide **(CO_2)**. Landfill gas **(LFG)** is generated from the degradation of biodegradable wastes. Digester gas results from the anaerobic decomposition of organic matter in municipal wastewater treatment. Bio-gas is created from livestock production, agricultural and industrial effluents and sewage treatment. Flaring and venting as management strategies for these gases is giving way to energy harvesting technologies with the economic advantage of creating heat, electricity, fuel or feedstocks while also reducing carbon emissions that would ordinarily result from flaring operations.

TA2 LFG, Digester & Bio-Gas Applications:

- Anaerobic Digestion Gas — Municipal Wastewater Treatment
- Methane Gas for Heat, Power — Boilers, Power Co-Generation
- Digester Gas Recirculation — Wastewater Treatment
- Bio-Mass to Bio-Gas — Wood Scrub-to-Gas Conversion
- LFG Monitoring, Harvesting — Municipal Landfills
- Sewer Gas Processing — Municipal Treatment Systems
- Displacement Digester — Manure to Bio-gas Conversion
- Gas Venting and Flaring — Landfills and General Industry
- Bio-Engine and Motor Fuel — Generator, Engine Manufacturers

Bio-gas, a mixture of methane and carbon dioxide, results from the decomposition of organic materials and can be harvested as a fuel source. Due to its low flow sensitivity and low pressure drop, the TA2 is an excellent flow meter for measuring bio-gases.

Application Insights

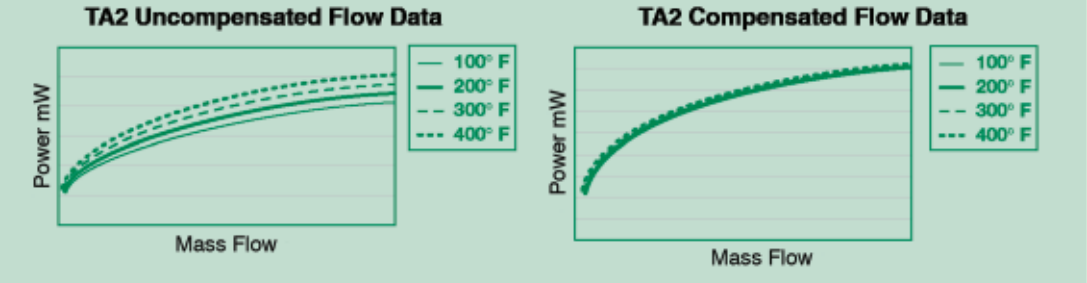
Temperature Compensation of the Mass Flow Measurement

Thermal Mass Flow Transmitters measure heat transfer and infer the mass flow based upon calibration information. The gas properties that effect convective heat transfer, however, are affected by changing temperatures.

After extensive testing and analysis on the effect of changes in flow at different temperatures, Magnetrol has developed a proprietary method of providing temperature compensation over the entire operating range of the instrument.

Thermatel Flow Meters measure the temperature and then apply a correction in the flow measurement based upon the operating temperature.

The charts below show data from the TA2 with and without temperature compensation. These graphs demonstrate the effectiveness of Magnetrol temperature compensation of the mass flow measurement based upon varying gas properties. ■



PLEASE NOTE: The instruments recommended in this guide are based on field experience with similar applications and are included as a general guide to flow control selection. However, because all applications differ, customers should determine suitability for their own purposes.

Magnetrol

Worldwide Level and Flow Solutions℠

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