AMETEK®
PROCESS INSTRUMENTS

ETHYLENE INDUSTRY SOLUTIONS

Real-time analysis of ethylene production processes to optimize yield while maximizing uptime and maintaining safety and environmental compliance

Analyzer solutions to reduce environmental emissions, ensure safe operation, and optimize ethylene conversion and product quality.

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PROCESS INSTRUMENTS

AMETEK PROCESS INSTRUMENTS

Ethylene is the most produced organic compound globally and is an important building block for the petrochemical and chemical industry with over 150 million tons of ethylene produced yearly. The main commercial production of ethylene is by thermo/steam cracking of different hydrocarbon feed stocks, which is typically divided into a few main steps: cracking, quenching, compression and drying, and separation.

Ethylene plants can use a wide range of hydrocarbon feed stocks. One of the most common types is naphtha, a mixture of hydrocarbons that has a boiling range of 30°C to 200°C (86°F to 392°F). In some regions, including the United States and the Middle East, ethane and propane are the most commonly used feed stocks in ethylene production. The rapidly growing production of shale gas has resulted in construction on many new and expanded ethylene plants globally. Most of the ethylene produced is used in the production of polyethylene and ethylene oxide which is a feed stock for many more complex hydrocarbons and polymers. Process analytics ensures process control via online monitoring of the various process streams in olefin production.

Process control through compositional analysis by online analyzers results in maximized yields and ensures product quality.

AMETEK, Inc.

AMETEK Process Instruments is a worldwide manufacturer of process analyzers and instrumentation. We focus our experience on designing new, innovative analyzers that help our customers achieve higher levels of productivity and quality. By seeking out ways to overcome the limitations of current methods of process monitoring, control and quality assurance, we have created some of the most capable, unique technologies in the world.

A business unit of the Process and Analytical Instruments division of AMETEK Inc., we are part of a global corporation with a growth plan founded on four key strategies: Operational Excellence, Strategic Acquisitions, Global & Market Expansion and New Products.

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Find the right solution for your ethylene plant

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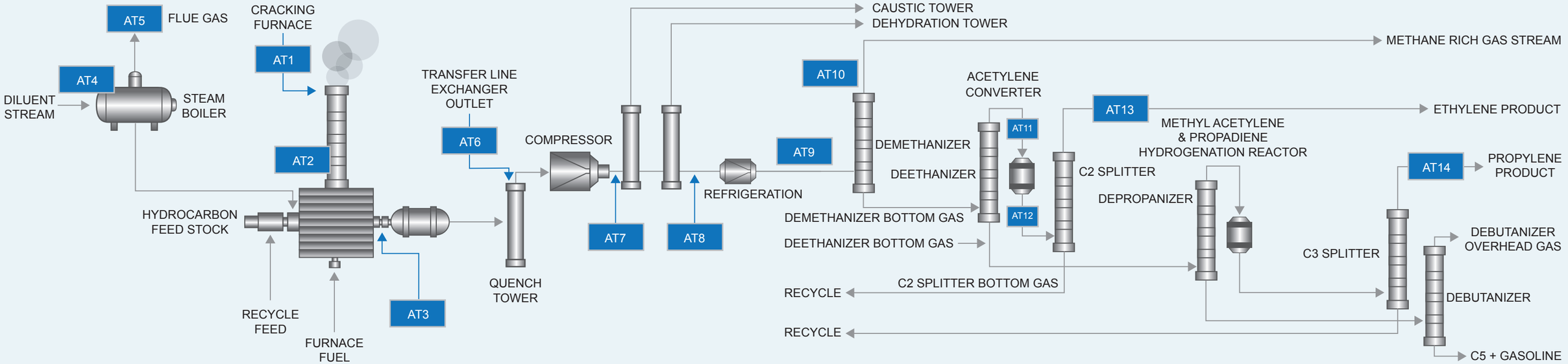

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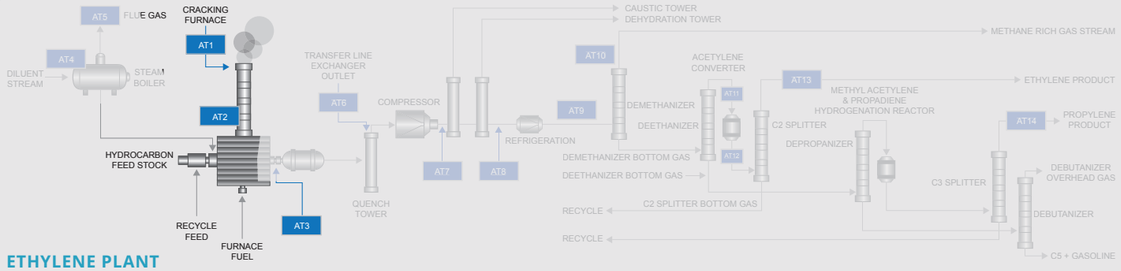
CRACKING FURNACE



ETHYLENE PLANT

The first section of the ethylene plant is the pyrolysis furnace that "cracks" the feedstock into ethylene and other light hydrocarbons. The hydrocarbon feed stock is preheated and cracked in the presence of steam in tubular pyrolysis furnaces. The residence time in the cracking furnace (~871°C/~1600°F) is generally only a few seconds. The furnace temperature and residence time determine the distribution of hydrocarbon products.

The next step is the fractionation to separate the desired products. The diagram opposite refers to the main process units in a typical ethylene production plant. The analyzers and analytes measured are referenced using "AT" numbers. The analyte concentrations range from high percent to low parts per million (ppm) levels.

AT1: CRACKER FURNACE COMBUSTION CONTROL

MEASURES: **O_2, Combustibles ($CO+H_2$), Methane/Hydrocarbons (CH_4+)**

PRODUCTS: **5100HD, WDG-V**

Within the cracker furnace, burners are used to generate the heat required for the cracking process. At the burner, fuel is combusted in the presence of air. Optimal combustion is typically at a setpoint of 1-2% excess oxygen (O_2). A flue gas analyzer is used to monitor the excess O_2 levels, and additional measurements can be made to detect incomplete combustion by measuring combustibles ($CO+H_2$) and to detect flame-out during start-up by measuring methane and hydrocarbons. The hydrocarbon measurement can also serve to detect potential process leaks from the tubes.

AT2: STACK GAS

MEASURES: **SO_2, NOx, CO, CO_2, O_2**

PRODUCTS: **9900, 914, 5100HD**

In the United States, Environmental Protection Agency (EPA) regulations require continuous emissions monitoring of stack gas for sulfur dioxide (SO_2) and oxides of nitrogen (NOx).

AT3: FURNACE DECOKING

MEASURES: **CO, CO_2**

PRODUCTS: **5100HD**

In ethylene production, a hydrocarbon feed stream mixed with steam enters a tubular reactor where, under controlled conditions, the feed stock is cracked at 800 to 850°C (1472 to 1562°F) into smaller molecules within 0.1 to 0.5 seconds. This process takes place in the radiant coils of the furnace. To maximize conversion rates, the furnace needs to be periodically decoked and using a TDLAS analyzer is the preferred method of monitoring the decoking process.

Refer to Application Note A-0523 Monitoring the Furnace Decoking Process in Ethylene Production for more in-depth information about this process.

PRODUCT SOLUTIONS

5100HD

Uses tunable diode laser absorption spectroscopy (TDLAS) technology, and can be configured with one or two absorption cells.

- Cracker Furnace Combustion Control
- Stack Gas
- Furnace Decoking

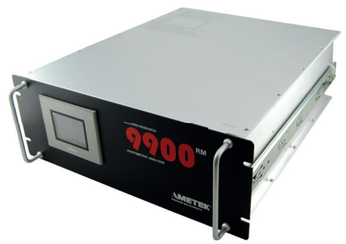
WDG-V

Designed for safety and serviceability, the WDG-V provides accurate measurements of oxygen (O_2), combustibles ($CO+H_2$) and methane (CH_4) for combustion applications.

- Cracker Furnace Combustion Control

9900

Single or multi-component gas analyzer that can be used alone or as an integrated part of a continuous emissions monitoring (CEM) system.



- Stack Gas

914

Custom-built continuous emissions monitoring (CEM) system using dry extractive sampling techniques to meet compliance monitoring regulations.

- Stack Gas

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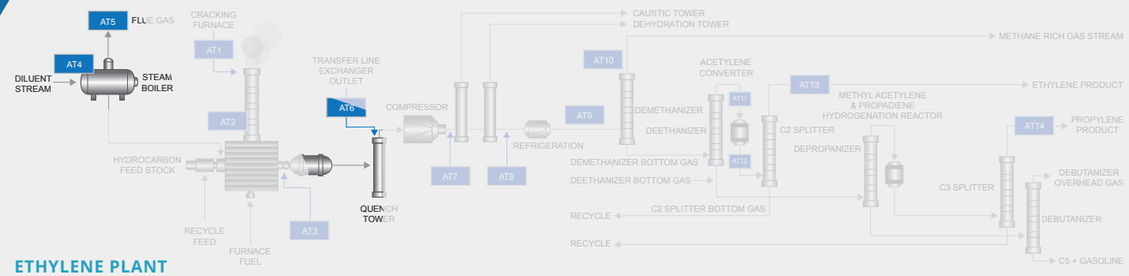
CRACKING FURNACE



ETHYLENE PLANT

AT4: STEAM BOILER COMBUSTION CONTROL

MEASURES: **O_2, Combustibles ($CO+H_2$), Methane/Hydrocarbons (CH_4+)**

PRODUCTS: **WDG-V**

A boiler is used to generate steam, which can be added to the feed to decrease coking and lower hydrocarbon pressure to increase olefin yield. A flue gas analyzer is used to measure oxygen (O_2) and control the burner of the boiler. The flue gas analyzer can also measure combustibles ($CO+H_2$) to optimize combustion, and it can measure methane/hydrocarbons to detect potential flame outs or fuel leaks during start-up.

AT5: BOILER FLUE GAS

MEASURES: **NOx, CO, O_2**

PRODUCTS: **9900, 914**

Continuous emissions monitoring of carbon monoxide (CO), NOx, and O_2 in the flue gas is performed to meet emission regulation requirements.

AT6: TRANSFER LINE EXCHANGER OUTLET

MEASURES: **CO, CO_2**

PRODUCTS: **5100HD**

Analysis of the furnace effluent gas provides valuable information on process control for the plant. The ratio of the types of products produced depends on the tubular furnace's temperature and pressure. The effluent coming off the reactor results in various products. A knowledge of CO and CO_2 concentrations assists in optimizing the cracking process.

PRODUCT SOLUTIONS

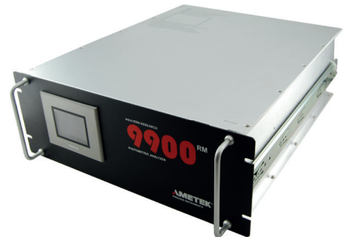
WDG-V

Designed for safety and serviceability, the WDG-V provides accurate measurements of oxygen (O_2), combustibles ($CO+H_2$) and methane (CH_4) for combustion applications.

• Steam Boiler Combustion Control

9900

Single or multi-component gas analyzer that can be used alone or as an integrated part of a continuous emissions monitoring (CEM) system.



• Boiler Flue Gas

914

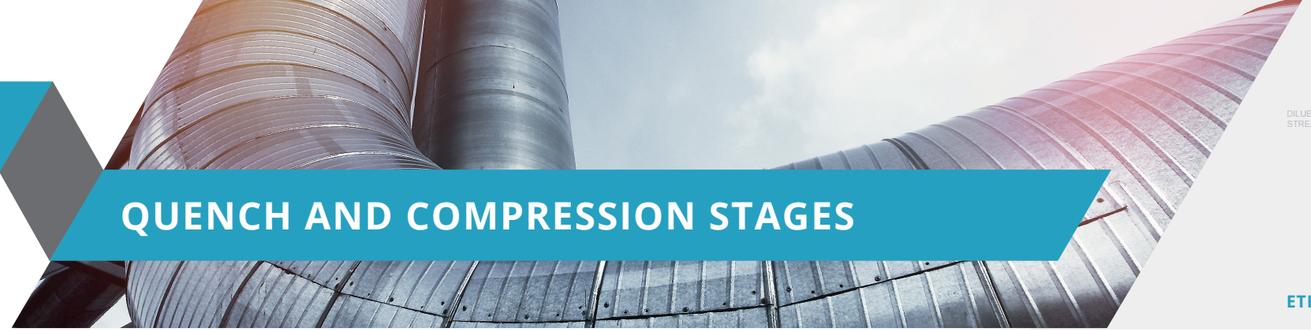
Custom-built continuous emissions monitoring (CEM) system using dry extractive sampling techniques to meet compliance monitoring regulations.

• Boiler Flue Gas

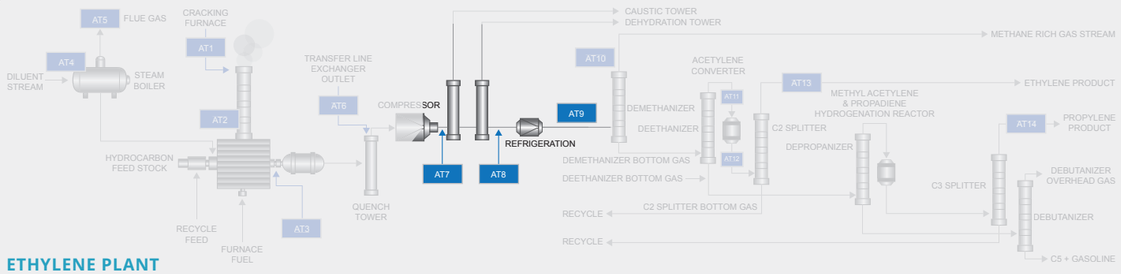
5100HD

Uses tunable diode laser absorption spectroscopy (TDLAS) technology, and can be configured with one or two absorption cells, providing dual stream analysis and/or the measurement of multiple analytes at the same time.

• Transfer Line Exchanger Outlet



QUENCH AND COMPRESSION STAGES



ETHYLENE PLANT

Following the cracking process, the gas is quenched and compressed to remove any remaining heavy hydrocarbons, hydrogen sulfide (H_2S) and carbon dioxide (CO_2). The required quench stages are determined by the feed stock.

After water quenching, the gas is compressed to separate the hydrocarbons from the quench water. Then, a caustic solution is used to remove the acid gases H_2S and CO_2. The cracked gas undergoes further cooling and drying before separation begins.

AT7: INLET OF CAUSTIC TOWER

MEASURES: **H_2S, CO_2**

PRODUCTS: **5100HD**

The cracked hydrocarbons are rapidly quenched in several stages. The quench stages are determined by the feed stock. After the water quench step, the gases pass through a series of compressors where the hydrocarbons are separated from the quench water. Next, the gases are scrubbed of hydrogen sulfide (H_2S) and carbon dioxide (CO_2) using a caustic solution. The acid gases are stripped from the caustic solution and incinerated or sent to a sulfur recovery unit if high sulfur is present in the feed stock. H_2S and CO_2 in the cracked gas after caustic scrubber are analyzed using a 5100 TDLAS analyzer for process control.

AT8: OUTLET OF DEHYDRATION TOWER

MEASURES: **H_2O**

PRODUCTS: **3050-DO, 5100HD**

Following the removal of the acid gases the cracked gas goes through a dehydration process using one or more absorption beds filled with molecular sieve to continuously remove water before the cracked gas reaches the refrigeration phase.

AT9: REFRIGERATION OUTLET

MEASURES: **CO**

PRODUCTS: **5100HD**

Prior to entering the demethanizer the treated feedstock is analyzed for the amount of CO as a process control factor.

PRODUCT SOLUTIONS

5100HD

Uses tunable diode laser absorption spectroscopy (TDLAS) technology, and can be configured with one or two absorption cells, providing dual stream analysis and/or the measurement of multiple analytes at the same time.

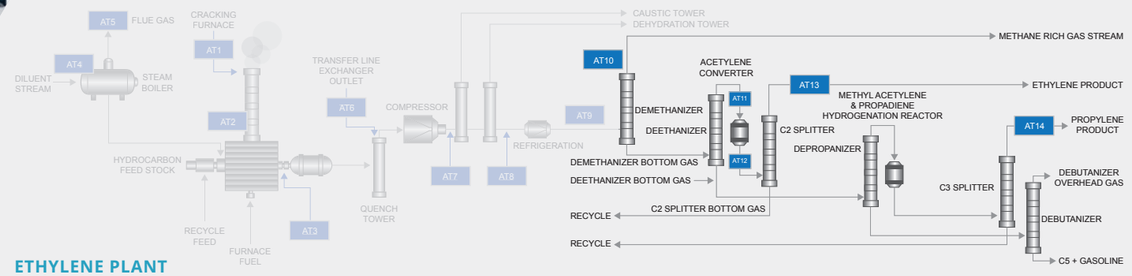
- **Inlet of Caustic Tower**
- **Outlet of Dehydration Tower**
- **Refrigeration Outlet**

3050-DO

Proven, accurate quartz crystal microbalance (QCM) technology with built-in verification provides operators with increased measurement confidence. Available with the optional AMEVision display unit interface.

- **Outlet of Dehydration Tower**

SEPARATION AND HYDROGENATION STAGES



ETHYLENE PLANT

The remainder of the processing plant operating units separate the olefins from the saturated hydrocarbons. If ethane is used as a feedstock, there will be little or no C3 or higher hydrocarbons and the depropanizer and debutanizer separation units will not be present.

AT10: DEMETHANIZER OFF GAS

MEASURES: **CH_4, C_2H_6, C_2H_4, CO, CO_2**

PRODUCTS: **5100HD**

After the removal of the hydrogen, the cracked gas passes into a demethanizer where the bulk of the methane is removed from the higher molecular weight compounds. The demethanizer overhead includes methane with some impurities such as hydrogen, CO, and trace amounts of ethylene. The methane rich stream is blended with natural gas and used to heat the cracking furnace.

AT11/12: ACETYLENE CONVERTER INLET AND OUTLET

MEASURES: **Acetylene**

PRODUCTS: **5100HD**

Depending on the hydrocarbon feedstock used, the cracking furnace design, and operating conditions, the amount of acetylene byproduct can vary from 0.2 to 0.9% by weight. The most common method for acetylene removal is through selective vapor phase hydrogenation.

$$C_2H_2 + H_2 \rightarrow C_2H_4$$

It should be noted that during hydrogenation process other chemical reactions can occur and as a result ethylene could be converted to ethane if the reaction goes too far.

$$C_2H_4 + H_2 \rightarrow C_2H_6$$

To best control the reaction, continuous – no cycle time delay – measurement of the inlet and outlet of the first bed and acetylene converter outlet is achieved with a TDLAS analyzer. Although some processors choose to only measure the inlet or the outlet acetylene levels, measuring both optimizes catalyst life and conversion rates to ethylene, and reduces the amount of ethane created.

AT13: ETHYLENE PRODUCT

MEASURES: **H_2O, NH_3, C_2H_2, C_2H_6**

PRODUCTS: **3050-DO, 5100HD**

The fractionated products from the C2 splitter overhead are the ethylene product, which is analyzed for process control purposes.

AT14: PROPYLENE PRODUCT

MEASURES: **H_2O**

PRODUCTS: **3050-DO**

The fractionated products from C3 splitter are sent into the propylene product, which is analyzed for process control purposes.

PRODUCT SOLUTIONS

5100HD

Uses tunable diode laser absorption spectroscopy (TDLAS) technology, and can be configured with one or two absorption cells, providing dual stream analysis and/or the measurement of multiple analytes at the same time.

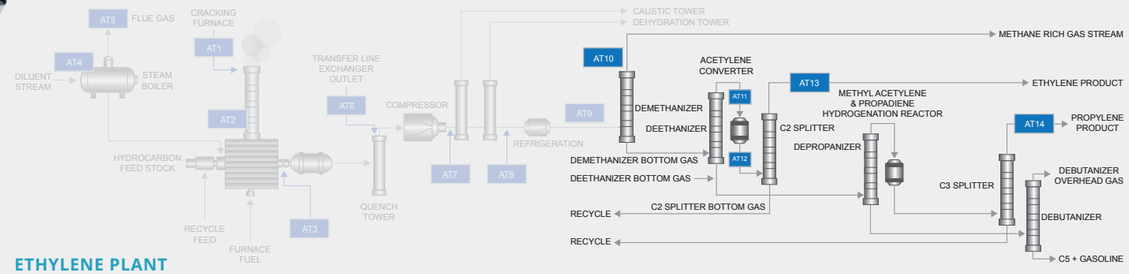
- Acetylene Converter Inlet and Outlet
- Ethylene Product
- Demethanizer Off Gas

3050-DO

Proven, accurate quartz crystal microbalance (QCM) technology with built-in verification provides operators with increased measurement confidence. Available with the optional AMEVision display unit interface.

- Ethylene Product
- Propylene Product

SEPARATION AND HYDROGENATION STAGES



ETHYLENE PLANT

PROCESSES NOT PICTURED IN DIAGRAM:

AT15: THERMAL OXIDIZER

MEASURES: **O_2, Combustibles ($CO+H_2$), Methane/Hydrocarbons (CH_4+)**

PRODUCTS: **WDG-V**

For air pollution control, a thermal oxidizer is used to treat the waste gases and unwanted byproducts of the process. Thermal oxidizers typically use direct flame incineration of the waste streams and burner management systems are used for combustion control. A flue gas analyzer is used to measure oxygen to ensure proper operating setpoints. The flue gas analyzer can also measure combustibles ($CO+H_2$) to optimize combustion, and it can measure methane/hydrocarbons to detect potential flame outs or fuel leaks during start-up.

AT16: TANK HEAD SPACE MONITORING

MEASURES: **O_2**

PRODUCTS: **5100HD**

There are many organic vapor streams where it is critical to monitor the oxygen concentration to minimize the risk of explosion. For example, the tank head space contains volatile compound levels exceeding the Upper Explosive Limits (UEL) and therefore nitrogen blanketing is carried out to generate a non-combustible atmosphere with acceptably low levels of oxygen.
To increase safety and minimize the use of nitrogen simultaneously, the nitrogen blanketing gas is controlled as a function of oxygen concentration in the headspace to ensure the oxygen concentration is below the lower explosive limit (LEL).

PRODUCT SOLUTIONS

WDG-V

Designed for safety and serviceability, the WDG-V provides accurate measurements of oxygen (O_2), combustibles ($CO+H_2$) and methane (CH_4) for combustion applications.

• Thermal Oxidizer

5100HD

Uses tunable diode laser absorption spectroscopy (TDLAS) technology, and can be configured with one or two absorption cells, providing dual stream analysis and/or the measurement of multiple analytes at the same time.

• Tank Head Space Monitoring

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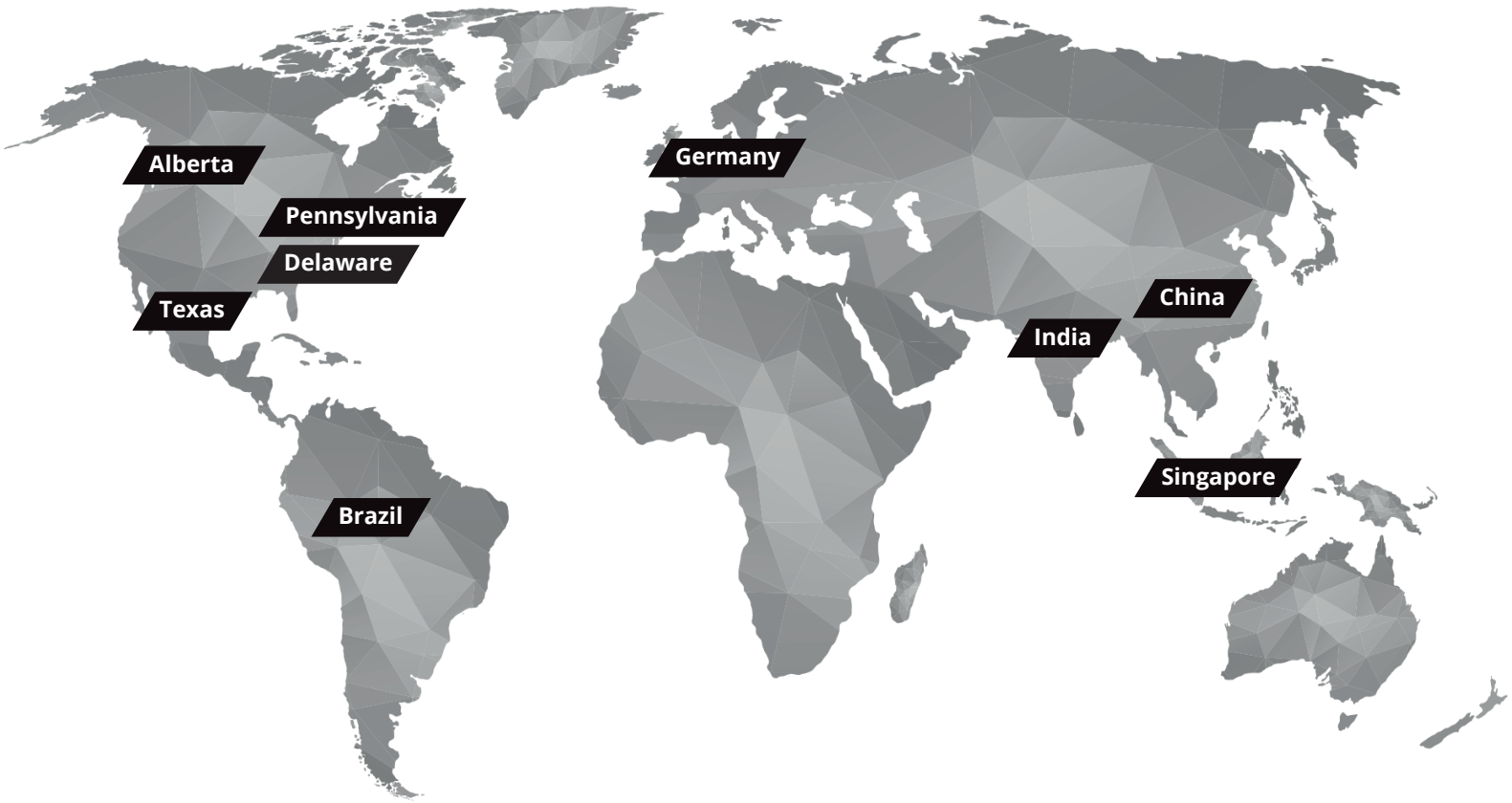
AMETEK Service Assistance Program plans offer coverage up to 24 hours a day, 365 days of the year.

As worldwide experts in the manufacture of process analyzers and instrumentation, we have supplied solutions to industry since 1962, providing the widest range of analysis technology available.

Through process application consulting, we create custom-designed solutions that meet the needs of your specific application or process.



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