AMETEK®
PROCESS INSTRUMENTS

POWER GENERATION SOLUTIONS

Real-Time Measurement for Process Optimization, Safety and Emissions Compliance

Analyzer solutions to reduce operational costs, increase safety, and minimize polluting gases.

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PROCESS INSTRUMENTS

AMETEK PROCESS INSTRUMENTS

As the backbone of the industrial world, the power industry is constantly faced with challenges that include increasing environmental regulations, a continuously aging infrastructure and pressures for new and evolving electric demands.

Often, power providers are leveraging time-tested combustion techniques to generate steam to drive a turbine and produce electric power. The key to safety, fuel efficiency and cost-effectiveness within these applications is to control the ratio of air-to-fuel by measuring residual oxygen (O_2) and combustibles ($CO+H_2$) after combustion.

AMETEK Process Instruments is a leader in combustion optimization. Our robust combustion analyzers use a proven zirconium oxide O_2 sensor for accurate combustion control, with optional catalytic detectors for combustibles and methane for an all-in-one measurement solution. We also offer fast-response tunable diode laser solutions for low-maintenance, non-contact control, and safety monitoring.

Building on more than 60 years of industry experience, we deliver a wide range of solutions for combustion optimization and control across the power generation industry, including:

- **Coal**
- **Natural gas**
- **Biofuel**

AMETEK Process Instruments is your partner for quality analyzers in the power generation industry.

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.

CONTENTS

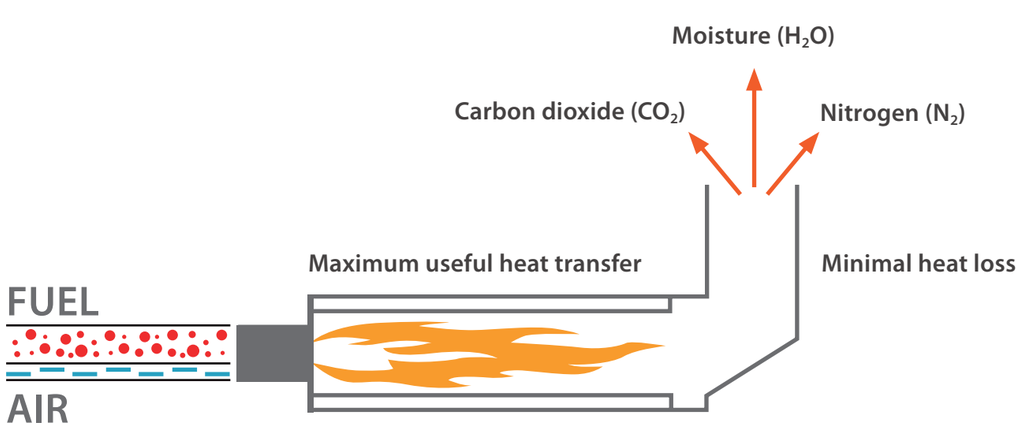
A REVIEW OF COMBUSTION THEORY

PERFECT STOICHIOMETRIC COMBUSTION

Combustion theory:

Perfect combustion

1) **Releases the maximum amount of heat which can be used to generate steam with minimal heat losses**
2) **Assumes that exactly enough air is present to completely react all of the fuel**
3) **Assumes that perfect mixing occurs at the burner and that no unwanted byproducts are generated, such as combustibles ($CO+H_2$) or nitrogen oxides (NOx)**



$$CH_4 + 2\ O_2 + N_2 \longrightarrow CO_2 + 2\ H_2O + N_2$$

~1,010 BTU/ft³ = maximum efficiency

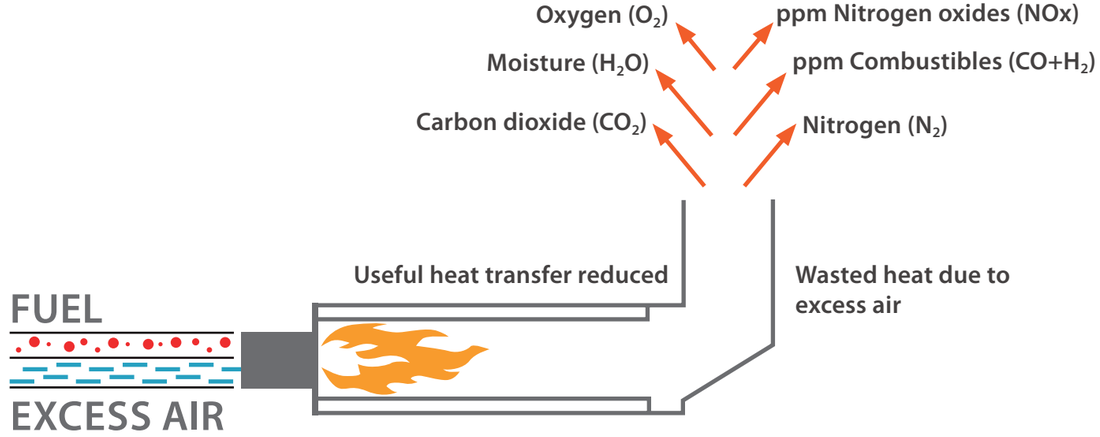
EXCESS AIR

Real world combustion:

- **ppm levels of carbon monoxide (CO), unburned fuel and NOx can occur as a result of poor mixing within the burner and combustion chamber**
- **Combustion processes often use excess air (or more air than stoichiometrically required, often 20% more) in order to reduce CO formation, reducing the useful heat transfer of the system**

Power plant combustion issues:

- **Poor air/fuel mixing**
- **Changing load conditions**
- **Malfunctioning burners**
- **Variable fuels**



$$CH_4 + 2.4\ O_2 + N_2 \longrightarrow CO_2 + 2\ H_2O + 0.4\ O_2 + N_2 + \text{ppm CO} + \text{ppm } H_2 + \text{ppm NOx}$$

~950 BTU/ft³ = 5.7% less efficient

COMBUSTION FUNDAMENTALS

A REVIEW OF COMBUSTION THEORY

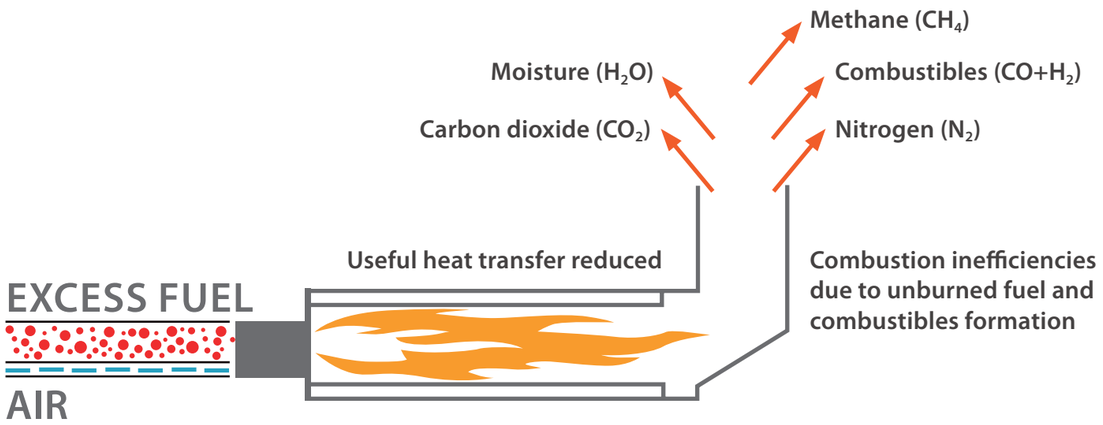
EXCESS FUEL (SUBSTOICHIOMETRIC COMBUSTION)

Real world combustion:

- **For any power application, operating with excess fuel is dangerous and may have deadly consequences**
- **Operating with excess fuel causes incomplete combustion of the fuel and forms high levels of combustibles – in the form of carbon monoxide (CO) and hydrogen (H_2)**
- **Operating with excess fuel significantly reduces the heat transfer of the system as less heat is generated from the partially burned fuel**

Power plant combustion issues:

- **Early detection of rises in combustibles ($CO+H_2$)**
- **Immediate detection of flame-out and methane leaks**
- **Data tracking of oxygen (O_2) measurements**



$$CH_4 + 1.6\ O_2 \longrightarrow 0.6\ CO_2 + 1.6\ H_2O + 0.4\ CO + 0.4\ H_2$$

~660 BTU/ft³ = 35% less efficient

OPTIMIZING COMBUSTION CONTROL

The key to fuel economy, lower operational costs, improved safety and reduced emissions is to find the optimal combustion setpoint. Measuring O_2 by itself can provide a control point for operation. Measuring combustibles ($CO+H_2$) as well can unlock the optimum control point for operation by minimizing the efficiency losses from excess air and excess combustibles - as illustrated on Figure 1. Combustibles in this context is defined as the carbon monoxide (CO) and hydrogen (H_2) created from incomplete combustion of the fuel.

Measuring combustibles in this way doesn't just provide an optimization control parameter, but also a safety measurement for preventing accumulation of CO, which represents a safety and explosion hazard. AMETEK products can also measure methane (CH_4) and hydrocarbons, which provides additional safety control to prevent an explosion hazard, and detect potential flame-out and gas leaks during start-up of boilers and process heaters.

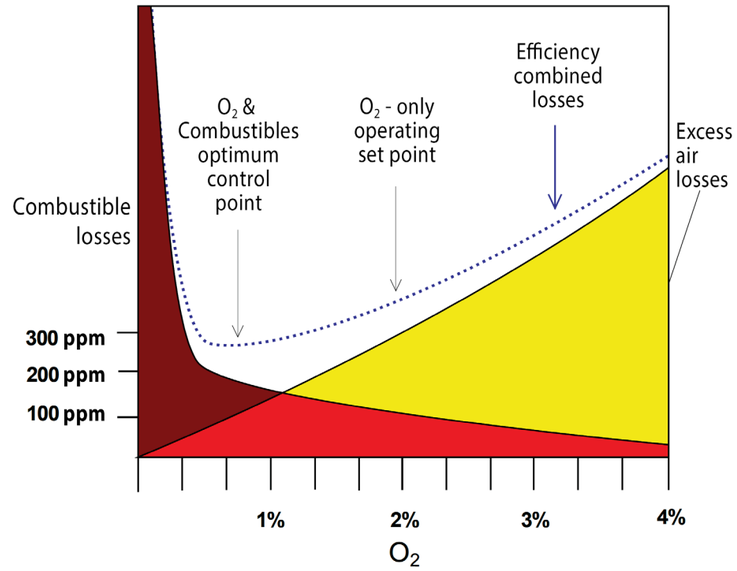
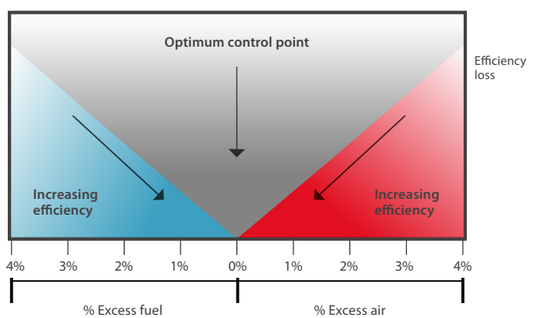


Figure 1. Overlaying combustibles vs. Excess oxygen with efficiency losses to find the optimal control point (this figure for illustration purposes only)



PERFORMANCE OBJECTIVES

- **Maximize steam or power production while minimizing fuel consumption**
- **Maintain thermal efficiency throughout load swings**
- **Minimize NOx emissions**
- **Maximize safety integrity levels**
- **Maximize uptime**
- **Maximize heat delivery with varying fuel quality**

POWER PLANT SAFETY

COAL FIRED POWER GENERATION

Plant Safety

In combustion processes, low-oxygen (O_2) and fuel-rich environments have the potential for a dangerous explosion. A fuel-rich environment is characterized by high levels of combustibles, particularly carbon monoxide (CO), so any safety monitoring or Emergency Shutdown Procedure (ESP) system must measure these continuously. It is also important to ensure O_2 levels remain optimal.

Combustion boiler conditions can change from safe to unsafe operation rapidly, so a fast measurement response is important to trigger shutdown protocols ahead of a serious problem. Measuring CO only will not detect an increase of unburned hydrocarbons during start up, so a methane (CH_4) measurement may also be required.

Key considerations:

- Continuous, low-maintenance operation
- Advanced digital communications for remote operation
- Rapid response to changing boiler conditions
- Measurement of unburned hydrocarbons or leaks to prevent explosion levels

AMETEK ADVANTAGE

- **Non-contact technology with low maintenance requirements**
- **Specific measurements available for each analyte**
- **Measurement of methane (CH_4) enables added safety monitoring beyond that of CO alone**

Process Control

Coal is pulverized and, because of mill configuration and burner arrangement, uneven distribution occurs. The result is uneven combustion with areas of high and low gas concentration in the furnace, which is referred to as stratification. Duct geometry and dimensions prevent thorough mixing. Therefore, multipoint oxygen (O_2) and combustibles ($CO+H_2$) analysis is used for combustion control. Achieving the required air-to-fuel ratio is challenging, as this is constantly affected by changes in loading conditions, fuel composition and, in the case of solid fuels, fuel particle size.

Key considerations:

- Need for multiple analyzers
- Optimized fuel consumption
- Reduction of harmful emissions
- Elimination of safety hazards
- Efficient heat transfer through an optimized air-to-fuel ratio

AMETEK ADVANTAGE

- **Reliable O_2 monitoring using proven zirconium oxide technology**
- **Hot/wet analysis from insitu probe measurements**
- **Variety of probe sizes**
- **Fast and easy field servicing of probes**
- **Measurement of combustibles enables optimized combustion control, even with variable fuels**

PRODUCT SOLUTIONS

MEASURES: **O_2, CO, CH_4, CO_2**

5100HD

Using tunable diode laser absorption spectroscopy (TDLAS), the 5100HD hosts a dual-laser platform, enabling two separate lasers to share a common optical path. For safety systems, this allows non-contact, dual stream analysis of O_2 and CO in the flue gas. Providing an extremely specific measurement for each analyte, TDLAS is highly sensitive with a fast response speed. With very low-maintenance requirements, the 5100HD uses sealed reference cells to line-lock the lasers and continuously verify the optical system performance, enhancing reliability for safety applications.

PRODUCT SOLUTIONS

MEASURES: **O_2, Combustibles, CH_4**

WDG-V with optional Blowback

Rated for SIL 2 O_2 measurement, the WDG-V combustion analyzer measures both O_2 and $CO+H_2$ to ensure safe, efficient operation of the burner management system. The close-coupled extractive system enables a fast response across a wide range of flue gas applications up to 1648°C (3000°F). Zirconium oxide sensor technology provides precise control of low O_2 setpoints with confidence, while catalytic detectors enable combustibles detection for control interlocks and safety shutdown. An optional methane (CH_4) sensor for start-up safety is available. Adding a blowback system also enables accurate, reliable operation in high-particulate combustion conditions.

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COAL FIRED POWER GENERATION

NATURAL GAS FIRED POWER GENERATION

PRODUCT SOLUTIONS

MEASURES: O_2

WDG 1200/1210

Offering a versatile range of probe lengths, the rugged WDG 1200/1210 flue gas analyzers utilize industry-proven zirconium oxide sensor technology for reliable net oxygen (O_2) measurements. The WDG 1200 has integral electronics while the 1210 offers remote electronics. The controller provides precision temperature control for optimum stability and over-temperature protection. The entire sensor assembly, including heater, can be removed without disturbing the outer protection tube, which remains in the process, making field service fast and easy, reducing expensive downtime.

WDG Insitu

The WDG Insitu is a direct-sensing O_2 probe suitable for applications where the flue gas temperature does not exceed 800°C (1472°F). Completely field serviceable, its unique inner/outer probe design enables the removal of cell, heater and thermocouple assembly through the probe head. The inner probe assembly exposes the reference side of the zirconium oxide cell to ambient air, removing the need for instrument air utilities at the probe mounting location. Combining easy component access with reduced utility requirements, the WDG Insitu provides a cost-effective, reduced maintenance solution for fired boiler operations, and offers a range of different probe lengths.

Process Control

The efficiency of the combustion process depends upon the reaction between fuel and air, as a source of oxygen (O_2), to deliver high temperatures.

A well-controlled process relies on the best possible air-to-fuel ratio in order to maximize the heat capture of the furnace.

Excess O_2 creates cooler burning conditions and can combine with nitrogen and sulfur to produce unwanted emissions. However, if there is insufficient O_2, combustion is incomplete, leaving unburned combustibles in the exhaust gas and creating a risk of dangerous explosions. Therefore, process control is critical for both efficient operation and safety.

Key considerations:

- Maximize heat production while minimizing fuel consumption
- Maximize thermal efficiency and heat delivery
- Minimize stack emissions

AMETEK ADVANTAGE

- **O_2 and combustibles measurements from a single analyzer for optimized combustion control**
- **Proven, reliable zirconium oxide and catalytic sensor technology**
- **Hot/wet analysis from insitu probe measurements**
- **Variety of probe sizes**
- **Fast and easy field servicing of probes**

PRODUCT SOLUTIONS

MEASURES: **O_2, Combustibles, CH_4**

WDG-V

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NATURAL GAS FIRED POWER GENERATION

PRODUCT SOLUTIONS

MEASURES: O_2

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WDG 1200/1210

Offering a versatile range of probe lengths, the rugged WDG-1200/1210 flue gas analyzers use industry-proven zirconium oxide sensor technology for reliable net O_2 measurements. The WDG-1200 has integral electronics while the WDG-1210 offers remote electronics. The controller provides precision temperature control for optimum stability and over-temperature protection. The entire sensor assembly, including heater, can be removed without disturbing the outer protection tube, which remains in the process, making field service fast and easy. Since there is no need to return the probe to the factory for repair, expensive downtime is avoided.

PRODUCT SOLUTIONS

MEASURES: O_2

WDG-VRM

A rack-mounted combustion analyzer, the WDG-VRM can be used alone or as an integrated part of a continuous emission monitoring system. Designed for optimized combustion control, it also provides extra safety protection, measuring excess O_2 to ensure safe, efficient operation of the burner management system. Low O_2 setpoints can be precisely controlled with confidence through zirconium oxide sensor technology.

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BIOFUEL POWER GENERATION

Process Control

Biofuels can be broadly defined as solid, liquid, or gas fuel derived from recently living biological material. These fuels can be derived from crops (either high in sugar or vegetable oil) or from other materials, such as wood or landfill gas. The increased costs of traditional fuels and the uncertainty of their supply has prompted greater use of biofuels for power generation. However, such fuels have varying energy content making it difficult to operate the combustion process efficiently and safely.

When controlling combustion, process efficiency depends upon achieving the best possible ratio of air-to-fuel. This allows the heat capture of the boiler to be maximized, and the optimum amount of fuel to be used. Achieving the required air-to-fuel ratio is challenging, as this is constantly affected by changes in loading conditions, fuel composition, fuel particle size, and caloric content. Careful monitoring of oxygen (O_2) and combustibles can ensure efficient combustion for biofuel power generation.

Key considerations:

- Optimizing fuel consumption
- Reduction of harmful emissions
- Elimination of safety hazards
- Ensuring efficient heat transfer by optimizing air-to-fuel ratio
- Presence of high-particulate-producing fuels
- Production of ash and soot

AMETEK ADVANTAGE

- **O_2 and combustibles measurements from a single analyzer for optimized combustion control**
- **Convective sampling design and blowback options for high-particulate applications**
- **Non-contact technology solution for low-maintenance requirements**
- **Solutions include proven, reliable zirconium oxide and catalytic sensor technology and advanced, fast-response tunable diode laser absorption spectroscopy (TDLAS)**

PRODUCT SOLUTIONS

MEASURES: **CO, O_2, CH_4**

5100HD

Using TDLAS, the 5100HD hosts a dual-laser platform, enabling two separate lasers to share a common optical path. For combustion control systems, this allows non-contact, dual-stream analysis of O_2 and carbon monoxide (CO) in the flue gas for optimum efficiency. This analyzer is also suitable for combustion applications with high sulfur dioxide (SO_2) concentrations. Providing an extremely specific measurement for each analyte, TDLAS is highly sensitive with a fast response speed. As a non-contact analyzer, the 5100HD offers very low maintenance requirements. The 5100HD uses sealed reference cells to line-lock the lasers and continuously verify the optical system performance, enhancing reliability.

WDG-HPII/C

The WDG-HPII/C flue gas analyzer uses a unique convective flow sampling technology that combines the advantages of insitu probe high-particulate sampling with the high temperature and corrosion resistance of extractive analyzers. Proven zirconium oxide sensor technology delivers accurate O_2 measurements in ranges from 0-1% to 0-100%. Completely field serviceable, the WDG-HPII/C is suitable for high-particulate environments and flue gas temperatures up to 1537°C (2800°F). This analyzer has an optional catalytic sensor to measure ppm-level amounts of combustibles.

MEASURES: **O_2, Combustibles**

WDG-V with optional Blowback

Rated for SIL 2 O_2 measurement, the WDG-V combustion analyzer measures both O_2 and combustibles to ensure safe, efficient operation of the burner management system. The close-coupled extractive system enables a fast response across a wide range of flue gas applications up to 1648°C (3000°F). Zirconium oxide sensor technology provides precise control of low O_2 setpoints with confidence, while catalytic detectors enable combustibles detection for control interlocks and safety shutdown An optional methane (CH_4) sensor for start-up safety is available. Adding a blowback system also enables accurate, reliable operation in high-particulate combustion conditions.

MEASURES: **O_2, Combustibles, CH_4**

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BIOFUEL POWER GENERATION

Bagasse Combustion

Bagasse is the dry, fibrous residue left following the extraction of juice from sugar cane or sorghum stalks. It is popular in cogeneration, producing both electricity and useful heat at the same time. When controlling combustion, process efficiency depends upon achieving the best possible ratio of air-to-fuel. This allows the heat capture of the furnace to be maximized, and the optimum amount of fuel to be used. Achieving the required air-to-fuel ratio is challenging, as this is constantly affected by changes in loading conditions, fuel composition, fuel particle size, and ash content.

Key considerations:

- Maximize heat production while minimizing fuel consumption
- Maximize thermal efficiency and heat delivery
- Minimize stack emissions

AMETEK ADVANTAGE

- **Oxygen (O_2)and combustibles ($CO+H_2$) measurements from a single analyzer for optimized combustion control**
- **Convective sampling design and blowback options for high-particulate applications**
- **Solutions include proven, reliable zirconium oxide and catalytic sensor technology**

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MEASURES: **O_2, Combustibles**

PRODUCT SOLUTIONS

MEASURES: **O_2, Combustibles, CH_4**

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MEASURES: **O_2**

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EMISSIONS MONITORING

Emission Control

The combustion processes used in power generation inevitably produce emissions of harmful gases and particulate matter. The levels of these pollutants can be regulated through efficient process control, but there is also a requirement to continuously monitor emissions to demonstrate compliance with local environmental directives.

Excess oxygen (O_2) in the combustion reaction will combine with nitrogen and sulfur to create harmful emissions.

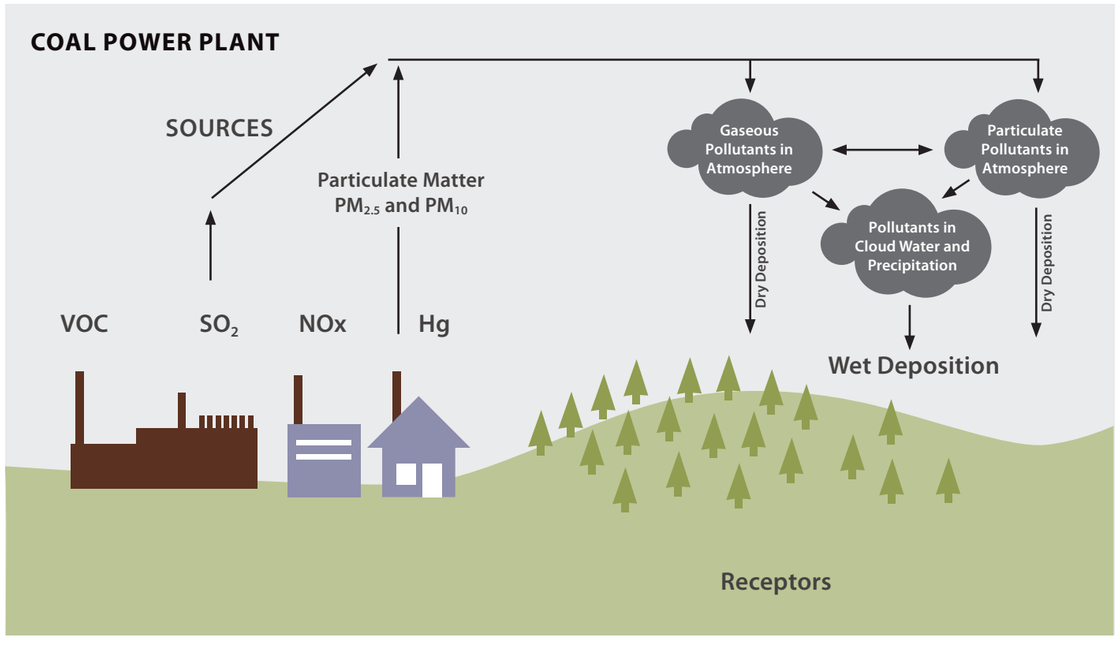
Accurate monitoring allows plant operators to demonstrate that their process remains within the permitted emissions limits, minimizing the risks to human health and the wider environment.

Key considerations:

- Need to monitor a variety of pollutant gases
- Continuous and accurate measurements are essential to maintain regulatory compliance

AMETEK ADVANTAGE

- **Emissions analyzers can be easily integrated into a continuous emission monitoring (CEM) system for a comprehensive solution**
- **Several flue gas components can be measured simultaneously, for economical analysis**
- **Wall-mounted (WM) and rack mounted (RM) options available**



PRODUCT SOLUTIONS

9900RM/WM

MEASURES: **SO_2, NOx, ClO_2**

A single or multi-component gas analyzer, the 9900 operates as a standalone device or can be integrated into a CEM system. Available in rack mount (RM) and wall mount (WM) versions, it can be configured to measure most gas species that absorb in the ultraviolet (UV) range. Up to five components can be measured simultaneously, making the 9900 highly economical for multi-component gas analysis applications. Free of interference from water and CO_2, the 9900 uses AMETEK's proprietary high-resolution UV technology in a dual-beam, multiple-wavelength configuration, supported by powerful data processing.

914 Continuous Emission Monitor (CEM) System

MEASURES: **SO_2, NOx**

Using cold, dry extractive sampling techniques, the 914 CEM system is built to order to meet compliance monitoring and reporting requirements. As standard, the 914 uses AMETEK's 9900RM analyzer for sulfur oxide and oxides of nitrogen (NOx) analysis, with appropriate analyzers added to the system for other required measurements. These instruments are mounted in a free-standing 19-inch rack, or can be optionally provided in an enclosed rack, free-standing enclosure, or walk-in shelter depending on environmental conditions. Optional data collection and control functions are also available.

WDG-VRM

MEASURES: **O_2**

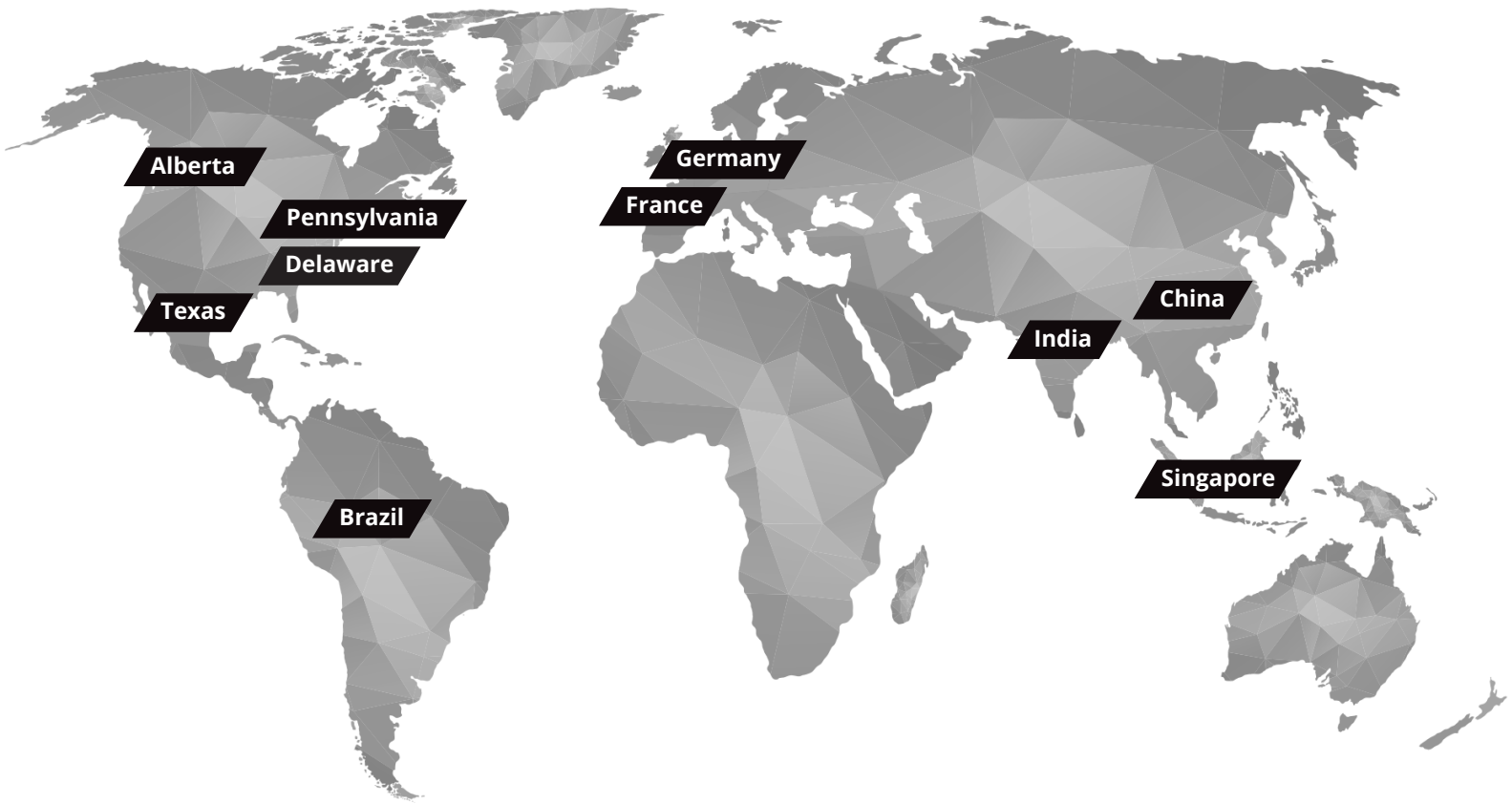
As a rack-mounted combustion analyzer, the WDG-VRM can be used alone or as an integrated part of a CEM system. Designed for optimized combustion control, it also provides extra safety protection, measuring excess O_2 to ensure safe, efficient operation of the burner management system. Low O_2 setpoints can be precisely controlled with confidence through zirconium sensor technology.

AMETEK Process Instruments delivers worldwide sales and service support through a network of direct and factory-trained global distribution channels.

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.



SALES, SERVICE & MANUFACTURING

USA - Pennsylvania
150 Freeport Road
Pittsburgh PA 15238
Tel: +1 412 828 9040
Fax: +1 412 826 0399

USA - Delaware
455 Corporate Blvd.
Newark DE 19702
Tel: +1 302 456 4400
Fax: +1 302 456 4444

Canada - Alberta
2876 Sunridge Way NE
Calgary AB T1Y 7H9
Tel: +1 403 235 8400
Fax: +1 403 248 3550

WORLDWIDE SALES AND SERVICE LOCATIONS

USA
Tel: +1 713 466 4900
Fax: +1 713 849 1924

Brazil
Tel: +55 19 2107 4100

France
Tel: +33 1 30 68 89 20
Fax: +33 1 30 68 89 99

Germany
Tel: +49 2159 9136 0
Fax: +49 2159 9136 39

India
Tel: +91 80 6782 3200
Fax: +91 80 6780 3232

Singapore
Tel: +65 6484 2388
Fax: +65 6481 6588

China
Beijing
Tel: +86 10 8526 2111
Fax: +86 10 8526 2141
Chengdu
Tel: +86 28 8675 8111
Fax: +86 28 8675 8141
Shanghai
Tel: +86 21 5868 5111
Fax: +86 21 5866 0969

AMETEK® PROCESS INSTRUMENTS

One of a family of innovative process analyzer solutions from AMETEK Process Instruments.
Specifications subject to change without notice.

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