Rethinking Gas Analytics

Gas Applications for GPro 500 Analyzers

ELSCOLAB

METTLER TOLEDO

Gas Applications eBooklet
Contents

The GPro 500 TDL analyzers are designed for ease of installation and low maintenance operation in a wide variety of process applications in the refining, petrochemical, and associated process industries. With a range of innovative process interface adaptions, they provide a truly flexible and cost-effective measurement solution.

This Applications eBooklet is intended as a convenient reference to a selection of the most common GPro 500 applications. The versatility of the analyzers means they are suited to an extensive assortment of processes, so what is presented here is not an exhaustive list. As new applications are realized, these will be added to the eBooklet.

Each page provides a brief overview of the application, a process diagram highlighting the installation location, and the rationale behind the measurement. Additional information, including typical gas stream parameters and tips on probe selection will assist in achieving the most suitable configuration to meet measurement requirements.

Find out more
www.mt.com/TDL

Direct Chlorination and Oxy-Chlorination
Process Control

Purpose

EDC (1,2-ethylene dichloride), alternatively known as 1,2-dichloroethane, is an important intermediate chemical in the manufacture of vinyl chloride monomer (VCM).
There are two important oxygen measurement locations in a typical EDC plant. These are the direct chlorination and the oxy-chlorination process paths. An accurate, reliable and fast responding measurement is required in each case.

Direct chlorination

- Measurement in the feed pipe to ensure that impurities in the chlorine do not contain too elevated levels of O_2 (small amounts of oxygen inhibit secondary formation of undesired by-products).

Oxy-chlorination

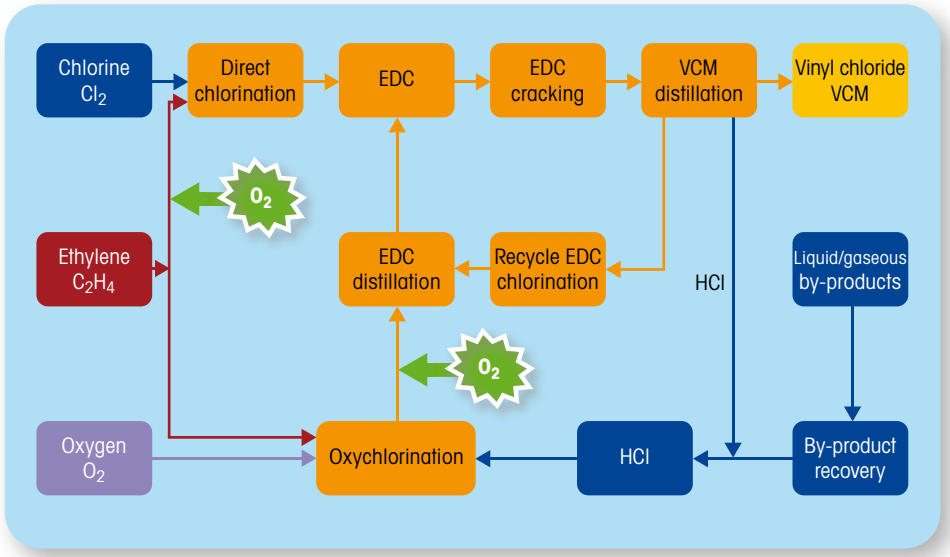
- For preventing the O_2 concentration rising above the Limiting Oxygen Concentration (LOC). The goal is to improve product yield within safety limits (If the LOC is reached, purge gas is introduced to reduce O_2 levels).

Description

- Primary path is the direct chlorination (highly exothermic!).
- The produced EDC is fed to the cracking unit, producing 50 % EDC, 50 % VCM (95 % pure) and HCl by-product.
- After cracking, the VCM distillation separates the VCM from the unreacted EDC, going to recycle unit for further use.
- The HCl as a by-product is fully re-used for oxy-chlorination (exothermic) with oxygen as the feedstock.
- Complete conversion of input chlorine is reached when both reactions are in balance.

Process conditions (direct chlorination)

Available insertion length	0.1 – 0.3 m
Temperature	–150 °C
Pressure	4 – 6 bar(a)
Measurement range	0 – 10 vol.%
Dust load	Low, aerosols
Required response time	< 2 s



Process benefits of GPro 500

- A paramagnetic system is not fast enough; but more importantly, the gas is extremely corrosive and just a small droplet in the sample is fatal to an extractive system.
- The GPro 500's probe design allow installation in the process itself, even closer to the process than other competing TDLs and without a slip stream installation.

Tips and hints

Typical nitrogen flow rate for process windows purging is 1 to 10 l/min.

Product recommendation

GPro 500 O_2; 290, 390, or 590 mm probe.

Click here for more information

VCM Waste Gas Recovery
Safety Monitoring

Purpose
To measure with high accuracy and reliability the O_2 concentration in the waste gas before the incinerator. A short response time is the most crucial feature required to rapidly detect if a critical O_2 concentration has been reached.

Typical thresholds
- 12 vol-% open N_2 bypass, 6 vol-% shutoff.

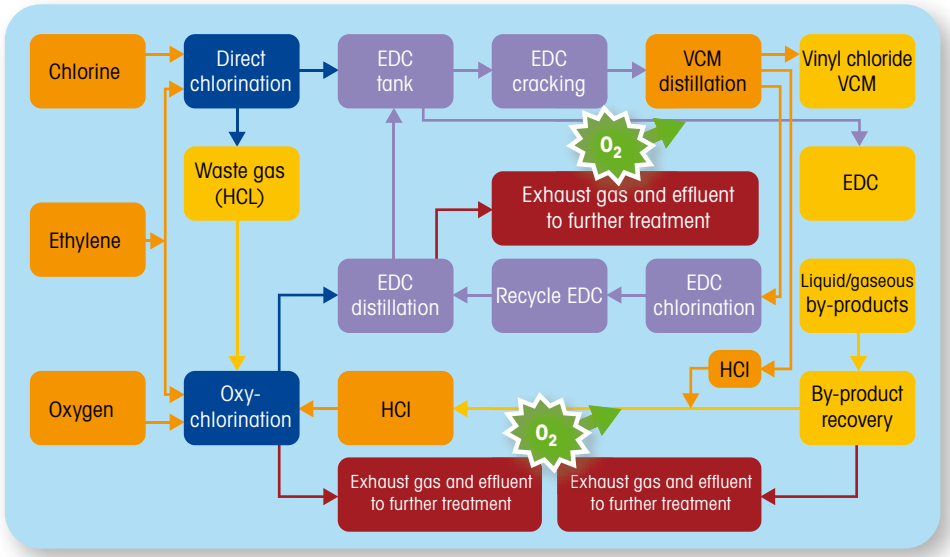
If an increased O_2 level is detected, the waste gas is re-directed through a bypass and mixed with N_2. When the O_2 concentration is low enough the gas is sent back to the incinerator.

Description
- Large volumes of waste gases containing VCM, O_2, and other components are generated during VCM production at different sections of the plant.
- For environmental reasons the gases must be further treated and recycled as much as possible.

Waste gas incineration
- O_2 is an important reactant in the production of VCM. O_2, when present in a certain concentration, creates an explosion risk. It is therefore crucial to monitor the O_2 concentration in the waste gas continuously before the incinerator.
- High O_2-containing waste gas must run through a bypass for inerting before incineration.

Process benefits of GPro 500
- Because of the harsh condition of the gas (highly corrosive) an extractive type analyzer is not suitable for this application.
- The response time is crucial: the faster the system can detect an increase in the O_2 concentration, the lower the safety margin that is required (high throughput).

Process conditions	
Available insertion length	> 1 m
Temperature	0… 30 °C
Pressure	1 – 5 bar(a)
Measurement range	0 – 21 vol.%
Dust load	Very low
Required response time	< 2 s



- Large amounts of N_2 can be saved since less waste gas runs through the bypass for inerting.
- N_2 purge gas cools the waste gas stream, so a fast control loop helps to save energy.

Tips and hints
The smallest pipe diameter where the GPro 500 can be installed is DN100 (4").

Product recommendation
GPro 500 O_2; 290, 390, or 590 mm probe.

Click here for more information

FCC Units
Combustion Optimization

Purpose
To provide a fast, reliable O_2 reading that can be used to optimize combustion control. Measurement system must provide high availability despite the harsh conditions at the measurement location. Due to the high dust load in the CO boiler, O_2 measurement takes place after the ESD filter.

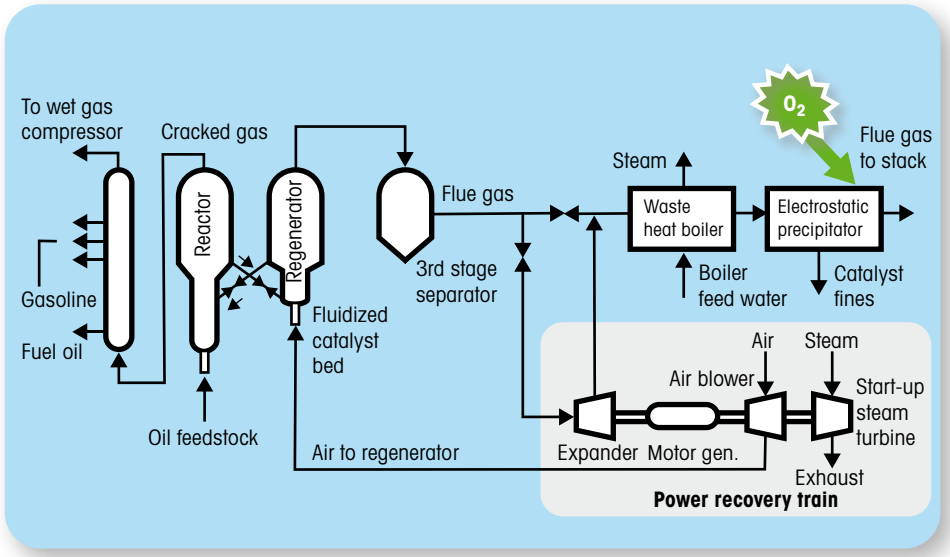
CO combustion needs to be optimized for
- maximum heat
- minimal emissions

To control the oxygen level, air is added.

Description
- Fluidized-bed catalytic cracking (FCC) is the most important and widely used refinery process for converting low value heavy oils into more valuable gasoline and lighter products.
- FCC yield is key to a refinery's profitability.
- The catalyst is covered with coke from the cracking reaction which lowers its activity. Therefore, the catalyst is fed to the regenerator to recover its activity by burning off the coke with air.
- The flue gas leaving the regenerator contains a large quantity of CO. This is burnt to CO_2 in a furnace referred to as the "CO boiler" to reduce CO to acceptable levels and recover the available energy.

Process benefits of GPro 500
Against extractive systems
- Fast response times make the combustion control process more efficient, leading to higher energy output.
- High dust loads in the CO boiler make it difficult for extractive systems to perform reliably here.

Process conditions	
Available insertion length	2 – 4 m
Temperature	230 – 350 °C
Pressure	Atmospheric
Measurement range	0 – 10 vol.%
Dust load	Low after filter
Required response time	< 10 s



Against zirconia oxide probes
- Longer lifetimes, less maintenance.

Tips and hints
Install the GPro 500 after the ESP filter for low dust conditions. Response time will be only slightly affected.

Product recommendation
GPro 500 O_2, 290, 390, or 590 mm probe, depending on process pipe diameter.

Click here for more information

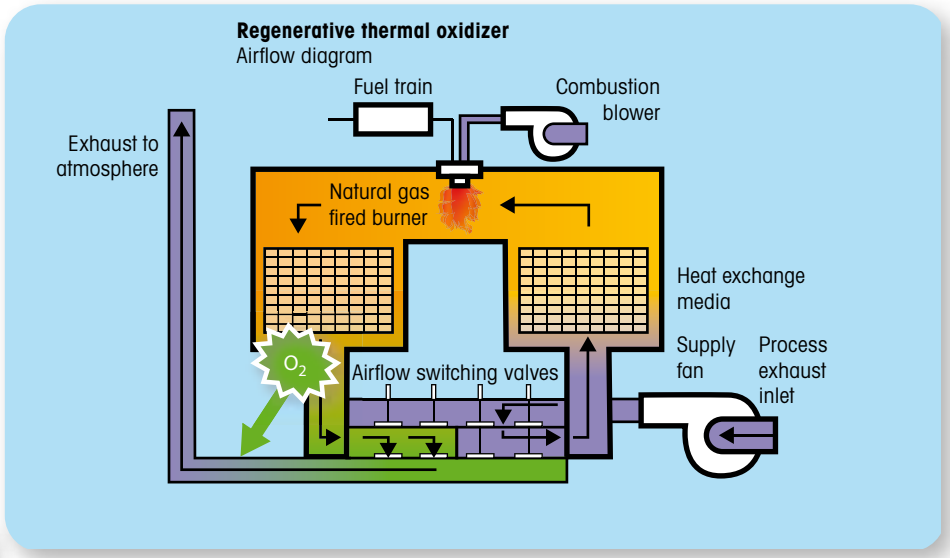
Thermal Oxidizer
Combustion Efficiency

Purpose
A thermal oxidizer should eliminate with maximum efficiency the Volatile Organic Compounds (VOCs) content of the incoming gas stream by burning the VOCs in a high oxygen content environment. It is important to control the combustion within the correct oxygen range using air. The measurement system must determine the O_2 concentration quickly and reliably on the output of the thermal oxidizer, despite the harsh conditions.

Description
- Thermal oxidation is often used to control emissions of VOCs from process industries.
- Oxidation breaks the molecular bonds of any HC to ultimately convert them to CO_2 and H_2O when the correct conditions are present.
- Thermal oxidation is capable of very high VOC destruction efficiency, but the fuel consumption and cost to heat the VOC-laden process can be severe.
- To ensure sufficient thermal oxidation with the lowest possible fuel consumption, it is crucial to measure the O_2 concentration accurately.

Process benefits of GPro 500
- Paramagnetic O_2 analyzer technology is considered much too slow. Also, the potential presence of various HCs can cause interference which is difficult if not impossible to compensate for.

Process conditions	
Available insertion length	0.2 – 1 m
Temperature	350 °C
Pressure	Balanced draft
Measurement range	12 – 12 vol.%
Dust load	1 – 20 mg/m³
Required response time	< 2 s



Tips and hints
For higher accuracy (up to fourfold), user longer probes to increase optical path length.

Product recommendation
GPro 500 O_2; 290, 390, or 590 mm probe, depending on process pipe diameter.

Click here for more information

Package Boilers
Combustion Efficiency

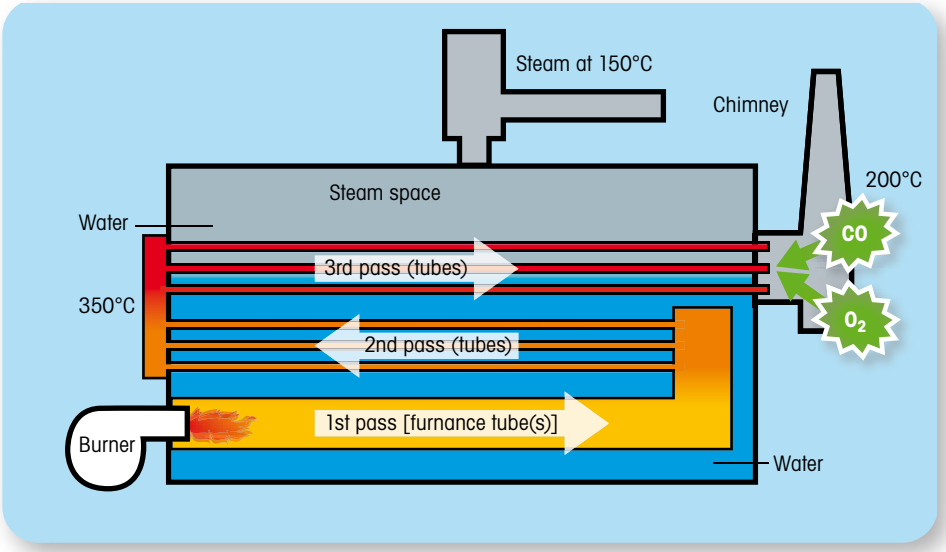
Purpose
Package boilers are "off the shelf" complete boiler systems usually of small to medium scale, used to generate steam for downstream plant use. Combustion measurement is normally used for monitoring only on these boilers.

Description
- The typical package boiler is a water tube boiler or flue and smoke tube boiler with a capacity of 5 to 20 t/h (average steam generation capacity). The most widely used fuels are heavy oil, light oil, and gas. They are used to generate steam for downstream utilization.
- Typical flue gas conditions encountered in the average package boiler are not extreme, with flue temperatures circa <300 °C.
- The typical installation point will be at the boiler or economiser outlet.

Process benefits of GPro 500
- The GPro 500's NP filter probe design allow installation in the process itself, without the need for process side purge as is common with competing TDL analyzers.
- This is an ideal application for an in situ probe type TDL measurement, where the compact size, single flange entry and probe configuration allows direct installation in place of traditional ZrO_2 or non-CO specific combustibles analyzers.

Process conditions

Temperature	150 – 300 °C
Pressure	± 0.5 KPa
Measurement range	0 – 21 % O_2 0 – 1 % CO
Dust load	< 1 g/Nm^3
Required response time	< 2 s



Tips and hints
Confirm potential dust loading so that the filter probe pore size can be better determined.
Confirm that the filter probe will not be exposed to condensation. The NP filter probe is designed for high, dry process conditions.

Product recommendation
GPro 500 CO, O_2; 290, 390, or 590 mm NP filter probe.

Click here for more information

Power Generation
Combustion Control

Purpose
O_2 and CO concentrations are measured to:
- minimize excess air
- maximize efficiency
- reduce emissions

Conditions to be avoided
- Fuel-rich burner conditions: CO levels increase as a precursor to hydrocarbon breakthrough.
- Burner flame-out: temperature and moisture drop, oxygen increases rapidly.
- Process tube leaks: moisture increases rapidly.

Description
Combustion control is a generic process to be found in many segments and applications:

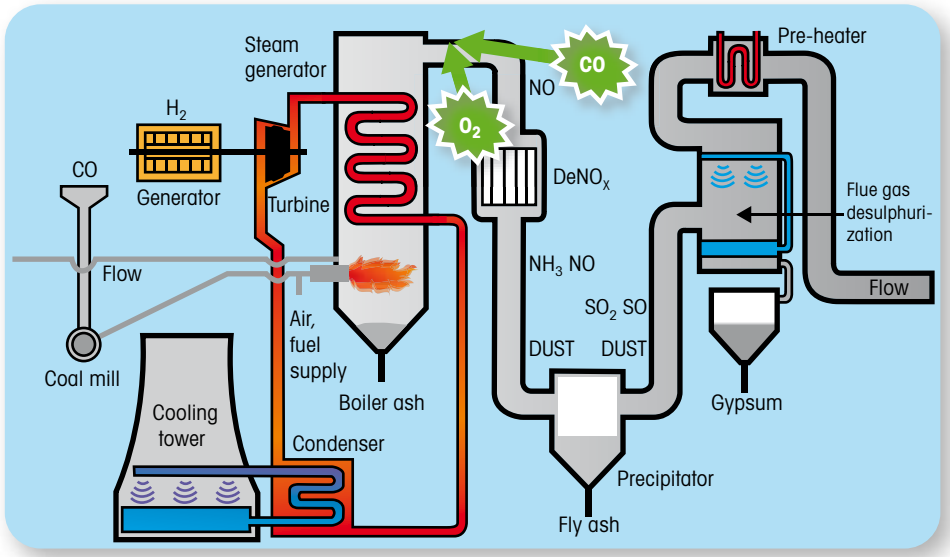
Power generation
- Fossil fuel-fired power plants
- Gas turbines
- Co-generation plants

Chemical and petrochemical
- Waste incinerators
- Steam boilers
- $DeNO_x$

Oil and gas, refining
- Waste incinerators
- Process heaters

Process benefits of GPro 500
- In situ measurement enables faster measurement compared to extractive paramagnetic O_2 technology and longer lifetime and reliability over zirconium oxide analyzers, providing lower maintenance, enhanced process control and higher efficiency.
- Ability to measure closer to the burner(s) zone (firebox) allows the identification of single faulty burners.

Process conditions	
Available insertion length	Wide ducts
Temperature	> 350 °C
Pressure	Balanced draft
Measurement range	0 – 10 vol. O_2 %
	0 – 20 vol. ppm %
Dust load	Very high



- Additional measurements available: temperature, moisture content (for wet/dry calculations).

Tips and hints
Use both CO and O_2 TDLs at the same location in order to allow in-sync measurements for trim control.

Measurement challenges
- Ash content
- Very high temperatures
- Presence of SO_2, NO_x

Product recommendation
- GPro 500 O_2; 290, 390, or 590 mm probe, depending on process pipe diameter.
- GPro 500 CO; standard or filter probe.

Click here for more information

Process Heaters
Combustion Control

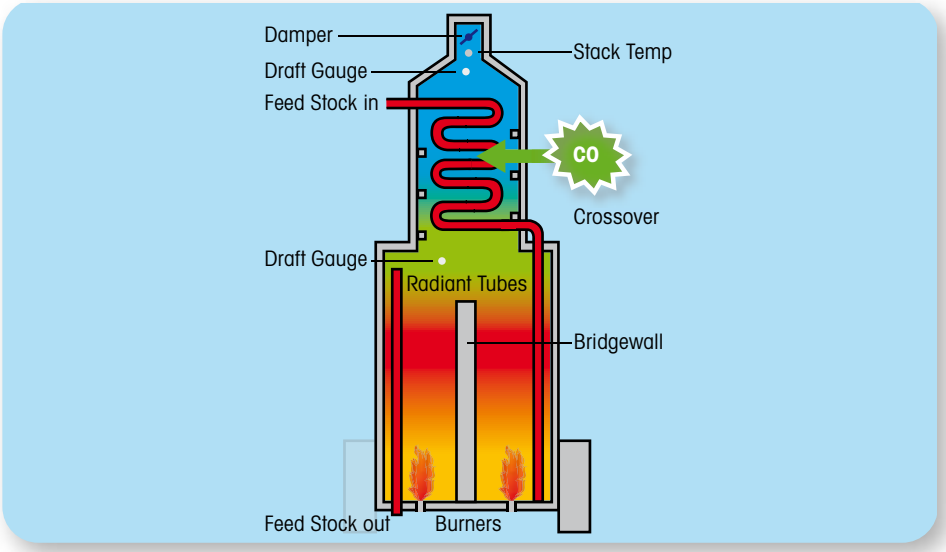
Purpose
Process heaters are numerous in the refinery, petrochemical and chemical industries. Thy are extremely large consumers of fuel and therefore a primary target for combustion efficiency monitoring and control, where large fuel savings can be quickly realized.

Description
- A process direct-fired heat exchanger used to raise the temperature of a feed flowing through coils of tubes aligned throughout the heater in the convection and radiant section. Typical temperatures are 400 °C – 550 °C (800 – 1000 °F).
- CO is typically measured in the convection zone and used as a control signal to monitor for combustible gases breakthrough which occurs if the process heater has insufficient excess air.

Process benefits of GPro 500
- The GPro 500's NP filter probe design **allows installation in the process itself,** without the need for process side purge as is common with competing TDL analyzers.
- This is an ideal application for an in situ probe type TDL measurement, where the compact size, single flange entry and probe configuration allows direct installation in place of traditional ZrO_2 or non-CO specific combustibles analyzers.

Process conditions

Temperature	350 – 600 °C
Pressure	0.1 – 0.8 KPa
Measurement range	0 – 21 % O_2 0 – 1 % CO
Dust load	< 1 g/Nm^3
Required response time	< 2 s



Tips and hints
Confirm potential dust loading so that the filter probe pore size can be better determined.
Confirm that the filter probe will not be exposed to condensation. The NP filter probe is designed for high, dry process conditions.

Look for potential opportunities for ESP filter protection downstream.

Product recommendation
GPro 500 CO; 290, 390, or 590 mm NP filter probe.

Click here for more information

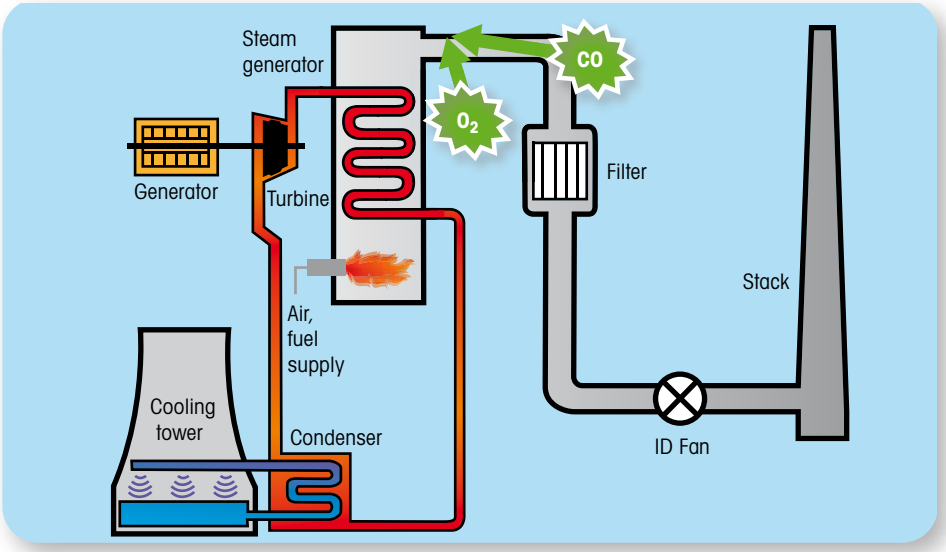
Heavy Oil or Gas-fired Power Generation
Combustion Control

Purpose
Power generation boilers are usually large scale installations which consume large quantities of fuel and as such often deploy combustion control rather than simple combustion monitoring to provide maximum combustion efficiency.

Description
- Heavy oil or gas is the usual fuel used and is used to generate stream in a continuous closed loop.
- This steam is in turned utilized to drive a steam turbine and generator set.
- O_2 and CO are typically measured after the economizer.
- Smaller cogeneration plants may use one measurement point, but larger electric power facilities will typically use multiple sample points.

Process benefits of GPro 500
- The GPro 500's NP filter probe design **allows installation in the process itself,** without the need for process side purge as is common with competing TDL analyzers.
- This is an ideal application for an in situ probe type TDL measurement, where the compact size, single flange entry and probe configuration allows direct installation in place of traditional ZrO_2 or non-CO specific combustibles analyzers.

Process conditions	
Temperature	250 – 350 °C
Pressure	0.1 – 0.8 KPa
Measurement range	0 – 21 % O_2 0 – 1 % CO
Dust load	< 1 g/Nm^3
Required response time	< 2 s



Tips and hints
Confirm potential dust loading so that the filter probe pore size can be better determined.
Confirm that the filter probe will not be exposed to condensation. The NP filter probe is designed for high, dry process conditions.

Look for potential opportunities for ESP filter protection downstream.

Product recommendation
GPro 500 CO, O_2; 290, 390, or 590 mm NP filter probe.

Click here for more information

Fired Heaters
Combustion Control

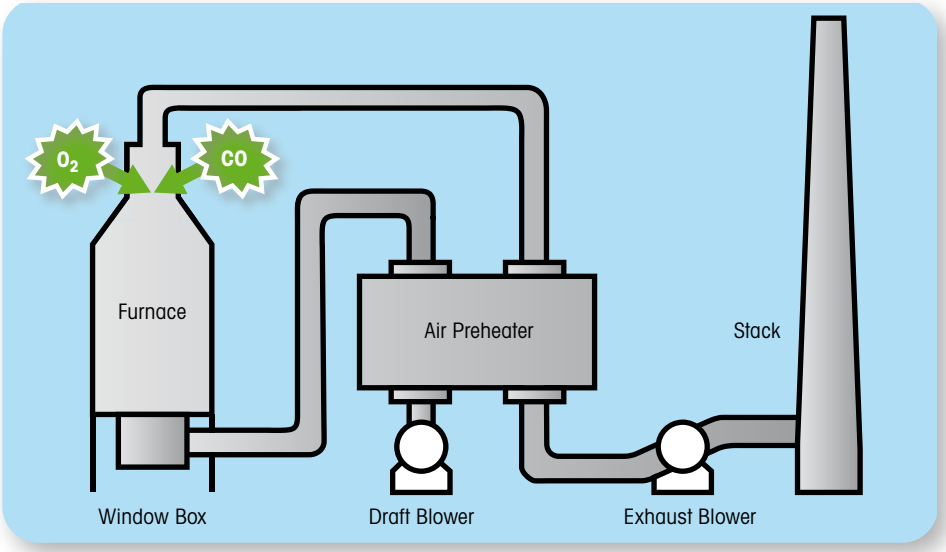
Purpose
Fired heaters are used extensively through the refinery and chemical industries and are large consumers of fuel. Combustion efficiency is crucial to minimize fuel use, maximize production and maintain emissions below statuary targets.

Description
- A fired heater is a heat exchanger used to raise the temperature of a feed flowing through coils of tubes aligned throughout the heater in the convection and radiant section. Typical temperatures are 400 °C – 550 °C (800 – 1000 °F).
- CO is typically measured in the convection zone and used as a control signal to monitor for combustible gases breakthrough which occurs is the process heater has insufficient excess air.

Process benefits of GPro 500
- The GPro 500's NP filter probe design **allows installation in the process itself,** without the need for process side purge as is common with competing TDL analyzers.
- This is an ideal application for an in situ probe type TDL measurement, where the compact size, single flange entry and probe configuration allows direct installation in place of traditional ZrO_2 or non-CO specific combustibles analyzers.

Process conditions

Temperature	350 – 600 °C
Pressure	0.1 – 0.8 KPa
Measurement range	0 – 21 % O_2 0 – 1 % CO
Dust load	< 1 g/Nm³
Required response time	< 2 s



Tips and hints
Confirm potential dust loading so that the probe filter pore size can be better determined.
Confirm that the filter probe will not be exposed to condensation. The NP filter probe is designed for high, dry process conditions

Look for potential opportunities for ESP filter protection downstream.

Product recommendation
GPro 500 CO, O_2; 290, 390, or 590 mm NP filter probe.

Click here for more information

Electrostatic Precipitators
Safety Monitoring

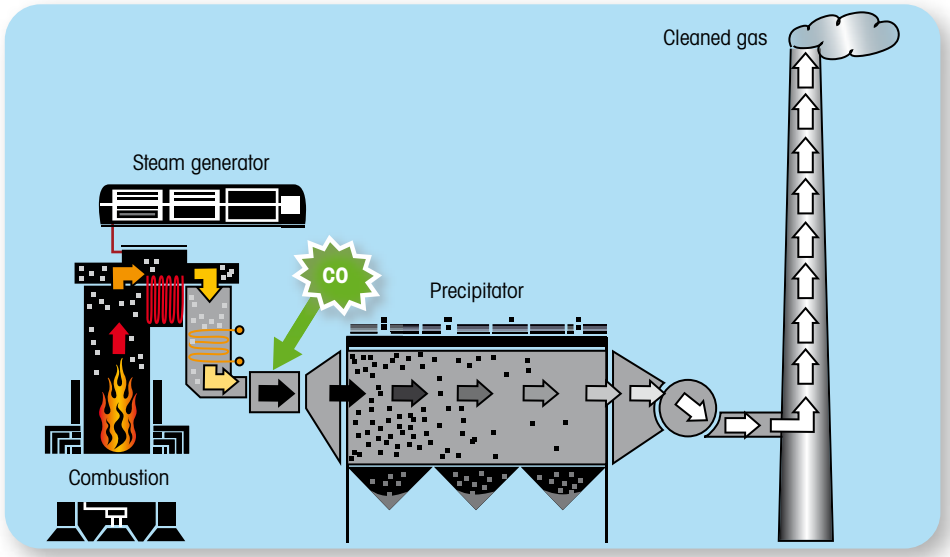
Purpose
To provide a very fast in-line measurement of CO to ensure explosive levels of combustible gas do not reach the electrically charged plates of the electrostatic precipitator (ESP), thus preventing the likelihood of an explosion within the ESP. Fast speed of response is required to ensure the ESP is shut down as soon as the CO level reaches 3 %, typically.

Description
Electrostatic precipitators operate by generating a high voltage static electric field between a series of metal pipes and plates. The entrained particles are first passed between negatively charged plates causing the particles to become negatively charged. They then pass through positive or grounded plates and are deposited onto the plates' surfaces. The plates are periodically vibrated by electrical or pneumatic rappers to remove the particles, which are collected and safely disposed of.

A well-managed ESP can remove up to 99.9 % of particulate material. Therefore, ESPs offer an efficient, high performance and low maintenance filtration system without the need to maintain or replace filtration media. This results in greater process reliability and reduced operating costs.

Process benefits of GPro 500
- Fast response time (< 2 sec).
- Elimination of risk of explosion in the ESP.
- Reduced incidence of unnecessary ESP shutdowns.
- ESP can operate safely for longer periods at higher CO levels.

Process conditions	
Available insertion length	0.1 – 1 m
Temperature	40 – 200 °C
Pressure	800 – 2000 mbara
Measurement range	0 – 3 vol.%
Dust load	High > 500 mg/m³
Required response time	< 2 s



- Reduced unfiltered emissions and reduced environmental impact.
- Maintain statutory environmental compliance.

Tips and hints
The GPro 500 can withstand a signal intensity loss of 90 %. With ISM® technology, cleaning of the optics due to fouling can be preemptively detected.

Product recommendation
GPro 500 CO; 290, 390, or 590 mm probe, depending on process pipe diameter.

Click here for more information

Flare Stacks
Header Inertization

Purpose
Flares are used to gather and eliminate waste gas which is otherwise not feasible to use or transport. They also act as a safety device to protect vessels or pipes from over-pressuring due to unplanned upsets. Flares must be continuously available, long-lasting, and able to perform in all emergency conditions.

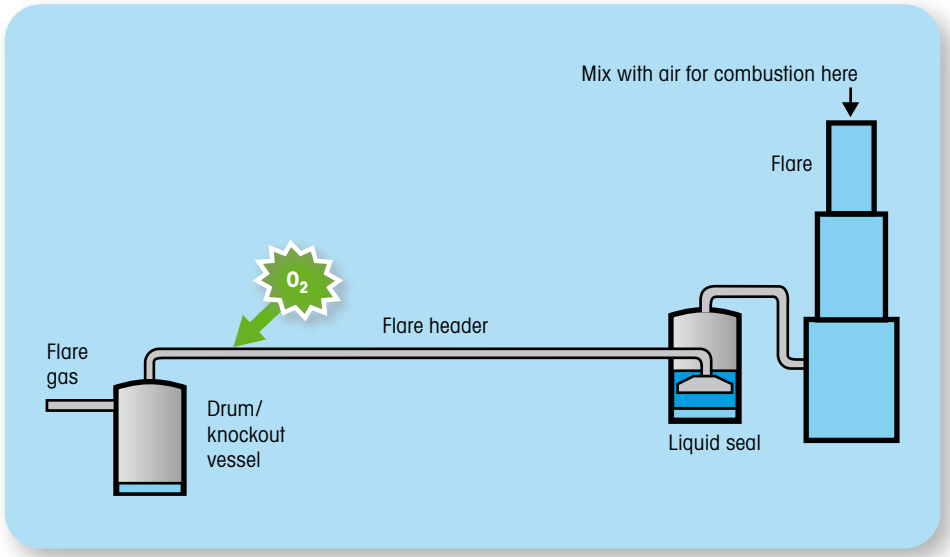
Global Gas Flaring Reduction Initiative
- Gas flaring is generally considered as detrimental.
- Waste of resources (5 % of natural gas output is flared).
- Contributes to greenhouse effect, acid rain, climate change.
- Negative visual impact.

Description
- For measuring the O_2 concentration in the gas stream going to the flare.
- Reliability is the most crucial feature required as the system must measure correctly despite a varying background of HCs.
- Air leakage into the system can cause an increase of the O_2 concentration and possibly lead to an explosion.
- The O_2 level is measured after the flare drum for safety.
- If O_2 value rises, the header is purged with nitrogen, CO_2, or even natural gas.

Process benefits of GPro 500
- In cases when no measurement is in place, O_2 measurement will improve flare safety.
- One problem with paramagnetic system is that the large amount of hydrocarbons interferes with the O_2. This interference is difficult if not impossible to compensate for due to the varying background of various hydrocarbons.

Process conditions

Available insertion length	> 1 m
Temperature	150 °C
Pressure	1 – 5 bar(a)
Measurement range	0 – 10 vol.%
Dust load	Very low
Required response time	< 2 s



- The GPro 500 probe design allows for fast installation in DN100 pipes and short shutdown times in continuous flares.

Tips and hints
For spot checks without process interruptions, use the calibration tube for verification in less than 5 minutes.

Product recommendation
GPro 500 O_2; 290, 390, or 590 mm probe, depending on process pipe diameter.

Click here for more information

Carbon Black Production
Fire Prevention

Purpose

If a fire begins inside the bag house, the CO levels will rise. To ensure such a dangerous fire is detected quickly, a fast response and reliable in-line detection of CO combustible gas at the bag house exit is required.

Description

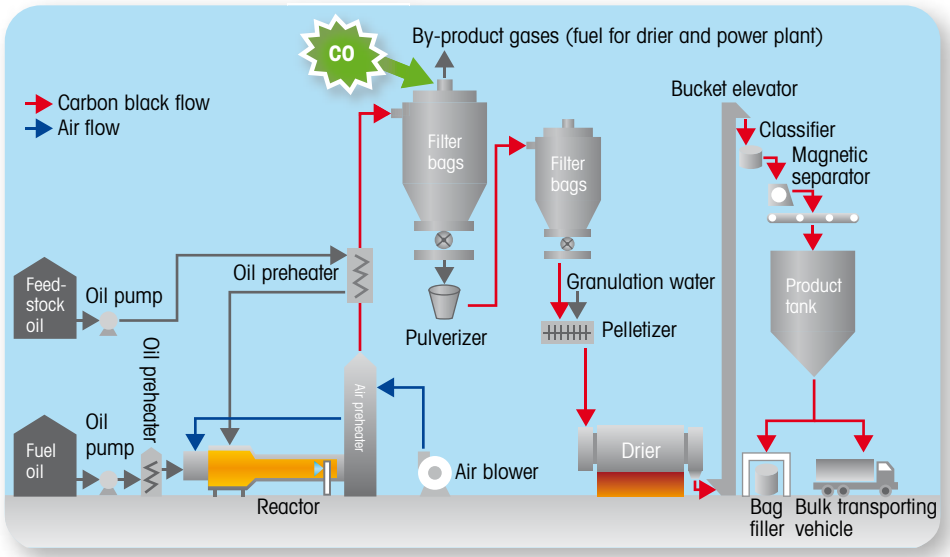
Petroleum oil or coal oil is partially combusted in air in a pyrolysis reactor at high temperature (700 to 900 °C). The reaction is stopped at a precisely controlled time, via water quenching, to obtain maximum yield. The hot off gas from the reactor, which contains some combustibles, is used first in the air preheater to heat the incoming air and then to heat the incoming feed stock to improve energy efficiency. The raw carbon black and effluent gas from the reactor pass to the main bag filter house where the carbon black is separated and collected, and the now cleaned combustible gas is used downstream.

Process benefits of GPro 500

- The GPro 500 analyzer ensures process safety due to its in situ installation, fast response, and dust tolerance, making it highly suited for this application.
- With the GPro 500 there is no need for alignment, purge gas demands are low, and maintenance is minimal.
- An extractive system is not suitable as the lag time between the tapping point and the analyzer can be several minutes, which is sufficient time for a fire to take hold.

Process conditions

Available insertion length	0.1 – 1 m
Temperature	100 – 200 °C
Pressure	1000 – 1100 mbara
Measurement range	250 – 2000 ppm (v) CO
Dust load	up to 50 g/m³
Required response time	< 2 s



Tips and hints

For particularly high dust loads, select a shorter probe in order to reduce transmission loss.

Product recommendation

GPro 500 CO; 290, 390, or 590 mm probe, depending on process pipe diameter.

Click here for more information

Tanker Loading / Unloading
Vapor Recovery

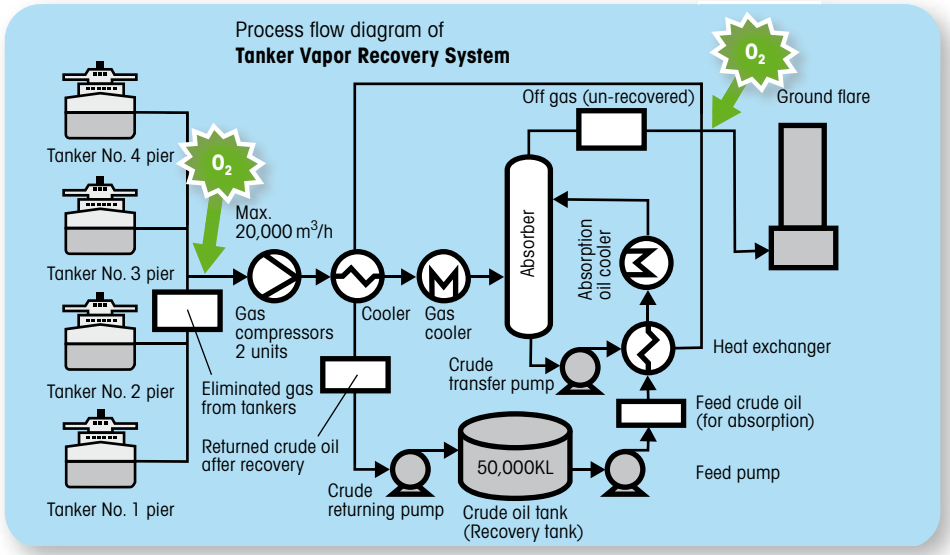
Purpose
To provide a short response time so that if a critical O_2 level is reached, nitrogen is purged in order to avoid explosive conditions developing. The system must be able to measure O_2 concentration correctly, even with a large variation in the background gas composition (different types and concentrations of hydrocarbons). The analyzer must provide high availability despite the harsh conditions at the measurement location.

Description
- The gas produced in the Tanker Vapor Recycle plant contains combustible components and O_2 in varying concentrations.
- The combination of combustibles and O_2 are, under certain conditions, highly explosive. Therefore, the O_2 concentration must be monitored continuously.
- Air can be sucked in through leaks and increase the oxygen content above the LOC.
- The O_2 value is used to immediately start preventive measures (i.e. inerting with purge gas) if a critical level is reached.

Process benefits of GPro 500
- Paramagnetic O_2 analyzers have historically been used for this application.
- The problem with this technology is that the large amount of hydrocarbons interferes with the O_2 measurement and the presence of high water levels can severely damage the expensive paramagnetic cell.
- The hydrocarbon interference is difficult if not impossible to compensate for due to the varying background of various hydrocarbons.

Process conditions

Available insertion length	approx. 1 m
Temperature	< 50 °C
Pressure	< 2 bar(a)
Measurement range	0 – 10 vol.%
Dust load	< 100 mg/m³
Required response time	< 2 s



Tips and hints
Install the GPro 500 horizontally in the process pipe in order to avoid humidity build-up on process windows.

Product recommendation
GPro 500 O_2; 290, 390, or 590 mm probe, depending on process pipe diameter.

Click here for more information

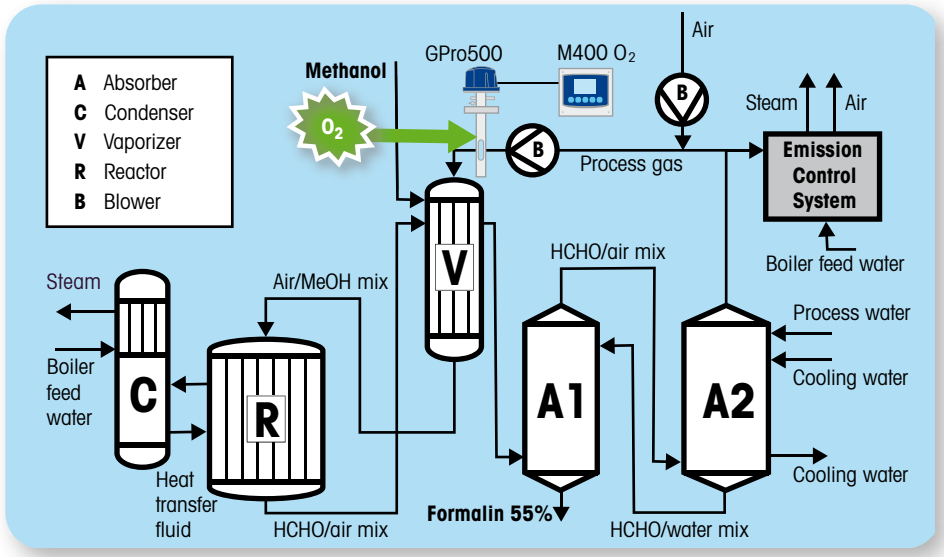
Formaldehyde Production
Process Control

Purpose
The O_2 concentration at the inlet of the methanol vaporizer is a critical control parameter for yield optimization and process safety. Process optimization is achieved by operating at the highest O_2 level possible without exceeding the Lower Explosive Limit (LEL) of the gas stream. The O_2 monitoring system's speed of response is a critical component for the ability to control the process.

Description
Based on the catalytic oxidation of methanol in the presence of excess air, the methanol-air mixture is kept below the lower explosion limit via dilution with a partial recycle of the nitrogen-rich exhaust gas. Methanol is pumped continuously from the storage tank and evaporated in a tubular heat exchanger, mixed with the oxidizing gas and preheated before being fed to the reactor. The reactor is filled with pellets of iron-molybdenum oxide catalyst. A highly efficient (>92 %) exothermal oxidation reaction takes place. The formaldehyde-containing gas produced is cooled first in a steam kettle, and then in the tubular heat exchanger. The cooled gas is washed in a multistage absorption column with water (producing aqueous formaldehyde solution) or with urea solution (producing stabilized urea-formaldehyde solution).

Process benefits of GPro 500
- Compared to the traditional paramagnetic technology used for this application, the GPro 500 offers fast response, sample system free, direct in-process measurement.
- The fast speed of response and reliability of the measurement allows the process to run safely with higher levels of O_2, increasing product yield significantly. So benefits include: (1) increased product yield due to tighter O_2 process control, (2) fast O_2 measurement for safer plant operation, (3) extended catalyst life through running leaner O_2/methanol feedstock blend into the reactor.

Process conditions	
Available insertion length	0.1 – 1 m
Temperature	45 – 100 °C
Pressure	1 – 2.5 bar
Measurement range	5 – 10 Vol.%
Dust load	Low
Required response time	< 2 s



Tips and hints
The unique SpectraID™ technology ensures better system reliability with line locking on three absorption lines.

Product recommendation
GPro 500 O_2; 290, 390, or 590 mm probe, depending on process pipe diameter.

Click here for more information

Moisture in H_2 Reformer Gas
Catalyst Protection

Purpose

Catalytic reforming is the process of converting low octane naphtha's to higher octane compounds, collectively called **"reformates".** These high octane reformates are added to refined gasoline to increase its octane value.

The measurement and control of moisture in the hydrogen recycle gas is essential to ensure efficiency of the plant and protection of the expensive catalyst.

Description

- Typical levels of moisture in the H_2 recycle gas are between 10 – 20 ppm, lower than this and the catalyst will deteriorate whereas too higher level will strip chlorine from the catalyst, reducing its catalytic activity, reducing the reforming efficiency and increasing costs.
- Measurement is made before the compressor where the process pressure is lower and suitable for TDL measurement.

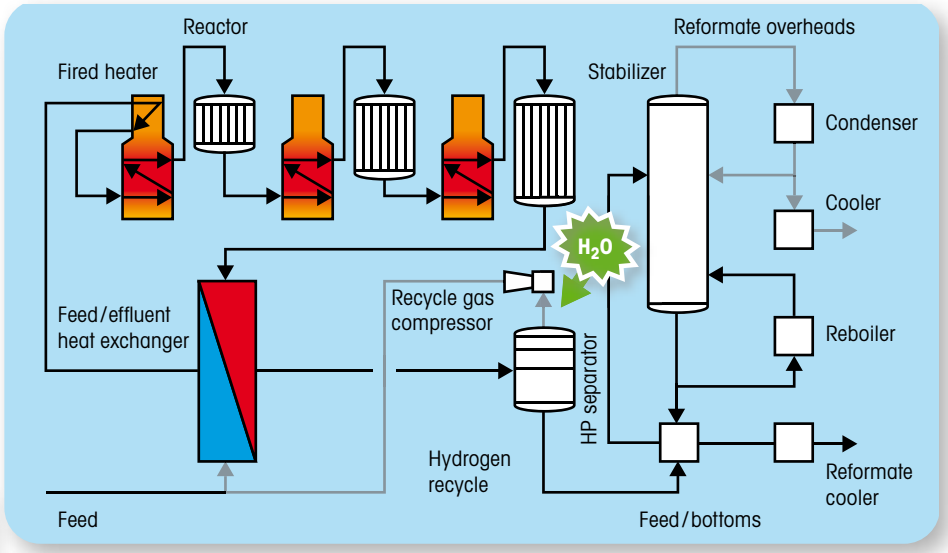
Process benefits of GPro 500

- Ceramic sensors are sensitive to the catalyst regeneration cycle due to presence of HCl, meaning they need protection during this phase of the cycle, increasing cost and maintenance and possible early failure.
- The GPro 500 TDL is not affected by the background gases present offering improved catalyst protection and reduced costs.

Process conditions

Temperature	30 – 50 °C
Pressure	*
Measurement range	0 – 100 vol. ppm
Dust load	Low, aerosols
Required response time	< 2 s
Background gases	H_2 (80 %), C1 (8 %), C2 (5 %), C3 (4 %), C4 (2 %), trace HCl

* Due to large pressure variations on this process, always confirm pressure range with user



Tips and hints

When reviewing the application always check and confirm the expected levels of aerosols present in the flowing gas stream.

Product recommendation

GPro 500 H_2O; 290, 390, or 590 mm standard probe.

Alternative: non-filter wafer cell or possibly extractive cell.

Click here for more information

H_2O in Cl_2 (Tower Dryer Exhaust)
Process Efficiency

Purpose
Wet chlorine is corrosive to many plant materials downstream and also produces hydrates and hydrous iron chloride. For this reason the chlorine must be dried to prevent this corrosion. Tower dryers perform this drying process. The chlorine drying process needs to be controlled by an on-line measurement of moisture in chlorine gas.

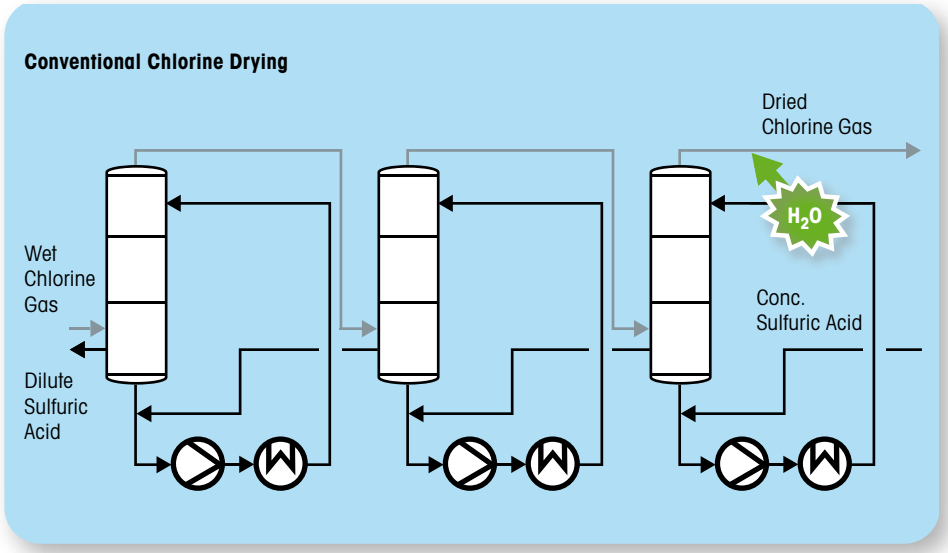
Description
The drying system uses high concentration sulphuric acid to extract moisture from the chlorine gas after the chlorine cooler. The system typically consists of two or more packed towers operating in series, primary and secondary with possibly also a tertiary tower. In these towers chlorine gas is contacted with sulphuric acid in counter current flow where moisture present in the gas stream is transferred to the sulphuric acid liquid stream.

Process benefits of GPro 500
- Corrosive wet chlorine can be a challenge for other moisture measurement technologies, such as AlO_3-chilled mirrors and electrochemical sensors, due to corrosive sample causing sensor or mirror damage.
- Fast response compared to other moisture measurement techniques. Reduces possibility of "off-spec" wet chlorine reaching the chlorinator.
- The GPro 500's design is unaffected by the process stream conditions.

Process conditions

Temperature	~ 50 °C
Pressure	*
Measurement range	0 – 100 vol. ppm
Dust load	Low, aerosols
Required response time	< 2 s

* Due to large pressure variations on this process, always confirm pressure range with user



Tips and hints
Consideration should be given to selection of suitable process adaption materials. During upset conditions, wet chlorine is very corrosive, so if such conditions might exist, consider Hastelloy C or other alloys. Confirm with customer their preferred materials and seek guidance from the METTLER TOLEDO applications team.

Product recommendation
GPro 500 H_2O; 290, 390, or 590 mm standard probe.
Alternative: non-filter wafer cell or possibly extractive cell.

Click here for more information

Ethylene Oxide (ETO) Production
Plant Safety and Product Yield

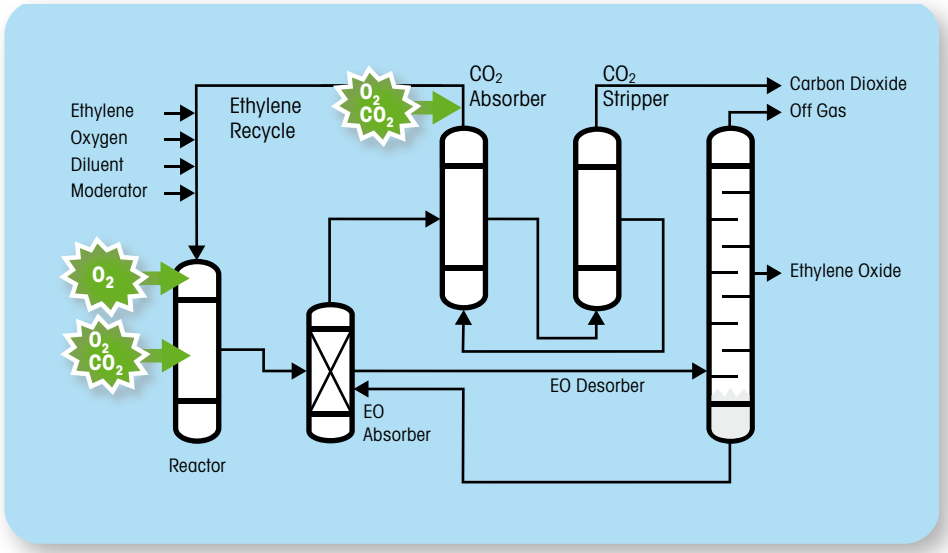
Purpose
The levels of O_2 are critical for high product yield and safe production of ethylene oxide. If too high then the oxidation reaction can run-away with dangerous safety consequences for the plant. If too low, the yield from the reactors will be reduced.
CO_2 is measured in the reactor off gas to optimize the reaction and in the ethylene recycle line (reactor inlet).

Description
- Direct oxidation of ethylene is accomplished by passing ethylene and oxygen over a silver catalyst at elevated pressures and temperature (17 barg, 250 °C). Under these conditions the ethylene oxide (ETO) is in gas phase.
- The process is a precisely controlled closed loop where the ethylene and oxygen are fed to the reactor at a controlled rate.
- Side reactions produce undesired CO and H_2O which are controlled via a catalytic moderator. The process is very exothermic.
- Typical O_2 levels are 7 % with reactor shutdown at 9 %.
- Ethylene oxide plants operate with a high integrity shutdown system to provide emergency shutdown if O_2 levels rise to critical levels.
- Normally a voting system is adopted using 3 analyzers per measurement point, were N_2 purge valves automatically open to purge the mixing nozzles.

Process benefits of GPro 500
- Speed of response, measurement reliability, stability and accuracy are critical requirements for oxygen measurement in ETO plants. The GPro 500 meets these analysis requirements and offers a comprehensive measurement solution.
- The GPro 500 offers the added benefits of dust tolerance, low purge gas demands and minimal maintenance.

Process conditions

Available insertion length	n.a. (extractive)
Temperature	250 °C
Pressure	17 bara
O_2 range	0–25 vol%
CO_2 range	0–5 vol%
Dust load	Very low
Required response time	< 2 s



- Ethylene and ETO are both extremely flammable. Normally ATEX Zone 1 (cat 2) or FM US Cl1, Div2 area classification.

Tips and hints
The GPro 500 has OPIS certification meaning it is certified safe for use with Zone 0 flammable sample streams, since the laser power is too low to present an ignition source. Often for this critical safety application, extractive systems are preferred, usually to allow for regular calibration/validation checking.

Product recommendation
GPro 500 O_2%, CO_2% with 20, 40, 80 or 100 cm OPL Extractive cell.

Alternative 290, 390 or 590 mm SP Probe for in situ installations.

Click here for more information

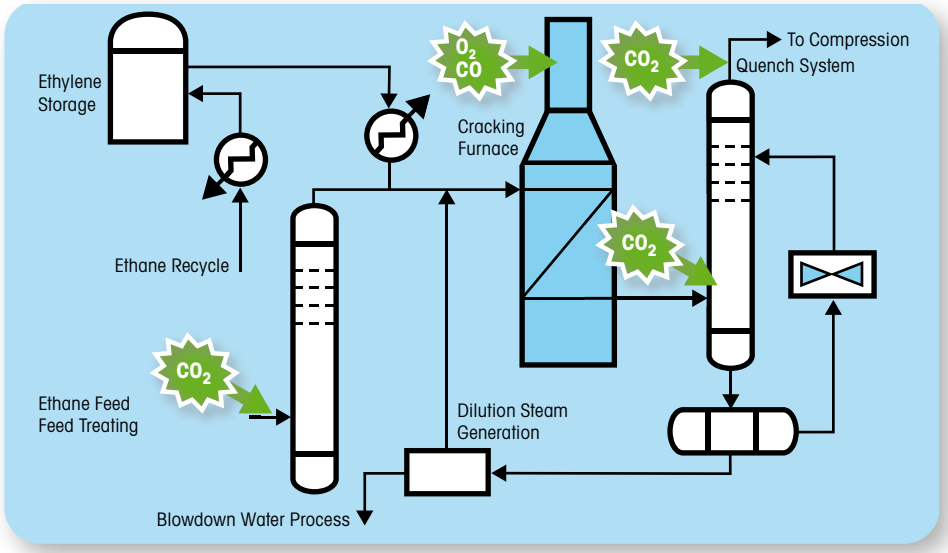
Ethylene (C_2H_4) Production
Feedstock and De-coke

Purpose
Ethylene is a key feedstock for many chemical processes.
Ethylene is a very versatile due to its chemically reactive double molecular bond and is used in many downstream chemical processes.

Description
CO_2 is measured in the raw feedstock to ensure freezing does not occur at the "cold end" of the process. CO_2 is also measured during the cracker de-coke cycle and in the transport line to product compression.

- Ethylene is produced by the process of thermal cracking.
- Ethylene plants are generally large and designed to handle a variety of feedstocks, principally ethane, but also other light HCs or gas oils.
- The feedstock is pre-treated to remove CO_2 and H_2S before cracking.
- The cracker rapidly heats the gas with steam without air breaking the molecules apart, where some rearrange to form ethylene.

Process benefits of GPro 500
- The GPro 500 offers fast speed of response required to ensure rapid feedback and control of feedstock quality.
- NDIR analyzers can suffer from cross-interference from the high levels of HCs.
- NIR analyzers utilize motor driven spinning optical filters and infrared sources that require scheduled maintenance. and regular replacement. The GPro 500 is fully solid-state with the benefit of very low maintenance.



Process conditions	
Available insertion length	0.2 – 1.5 m or Extractive
Temperature	Feedstock 250 °C De-coke > 150 °C
Pressure	1 – 5 bar(a)
CO_2 range	Feedstock 0 – 5 vol% De-coke 0 – 25%
O_2/CO combustion	0 – 10 vol%, 0 – 2000 ppm
Dust load	Low to moderate
Required response time	< 2 s

Tips and hints
For the feedstock and de-coke measurements. In situ may also be viable. Look for potential O_2 and CO measurements for furnace combustion efficiency.

The GPro 500 can withstand a signal intensity loss of 90 %. With ISM® technology, cleaning of the optics due to fouling can be preemptively detected.

Product recommendation
Due to high pressures and temperatures, the usual measurement philosophy is to use extractive systems. GPro 500 O_2%, CO_2%, CO with 20, 40, 80 or 100 cm OPL Extractive cell. Alternative 290, 390 or 590 mm SP Probe for in situ.
For combustion, NP filter probe with or without blowback is ideal.

Click here for more information

PTA Plant
Safety and Process Efficiency

Purpose

PTA or Polymer grade (or Pure) Terephthalic Acid is combined with ethylene to produce Polyethylene Teraphthalate or PET.
This is the most widely used polyester used in the manufacture of plastic bottles etc.
PTA is made by the oxidation of p-xylene two methyl groups to carboxylic acid at high pressure and temperature.

Description

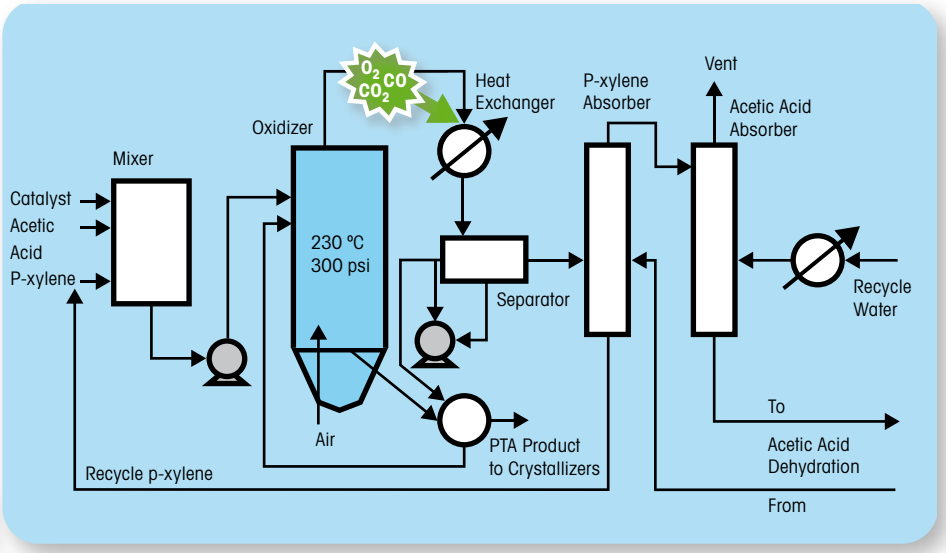
- Residual O_2 from the reactor off-gas is a critical safety measurement to prevent runaway oxidation and potential explosion.
- Additionally CO_2 is often measured in the off-gas to provide further information on progress of reaction and safety.
- Some plants will also measure CO from the reactor off-gas again for control/progress of application/safety.
- Residual O_2 and possibly CO_2 is also measured in off-gas from crystallizers.

Process benefits of GPro 500

- Fast speed of response and high accuracy is essential for the critical O_2 safety measurement of the reactor off-gas.
- Paramagnetic cells are delicate and expensive to replace. NDIR analyzers typically use motors and broadband IR sources which need periodic replacement.
- GPro 500 is fully solid state with long operational life.

Process conditions

Available insertion length	n.a. (extractive)
Temperature	50 °C
Pressure	15 – 30 barg
O_2 range	0 – 10 vol%
CO_2 range	0 – 5 vol%
CO range	0 – 5 vol%
Dust load	Low
	< 250 mg/m³
Required response time	< 2 s



Tips and hints

When reviewing the application always check and confirm the expected levels of aerosols present in the flowing gas stream.

Due to the very high process pressures, normally an extractive configuration is most appropriate. Due to the relatively high measurement range and low accuracy requirement, shorter path lengths are usually suitable.

Product recommendation

GPro 500 O_2%, CO_2%, CO with 20, 40, 80 or 100 cm OPL Extractive cell.

Click here for more information

Steam Reforming Hydrogen Production
Process Efficiency

Purpose

Hydrogen is used in many processes inc. ammonia production, petroleum processing and in the production of foods & fats.
The foremost method for hydrogen production utilizes a technique called steam-methane reforming.
A hydrocarbon feedstock is reacted with high temperature steam under high pressure over a catalyst.

Description

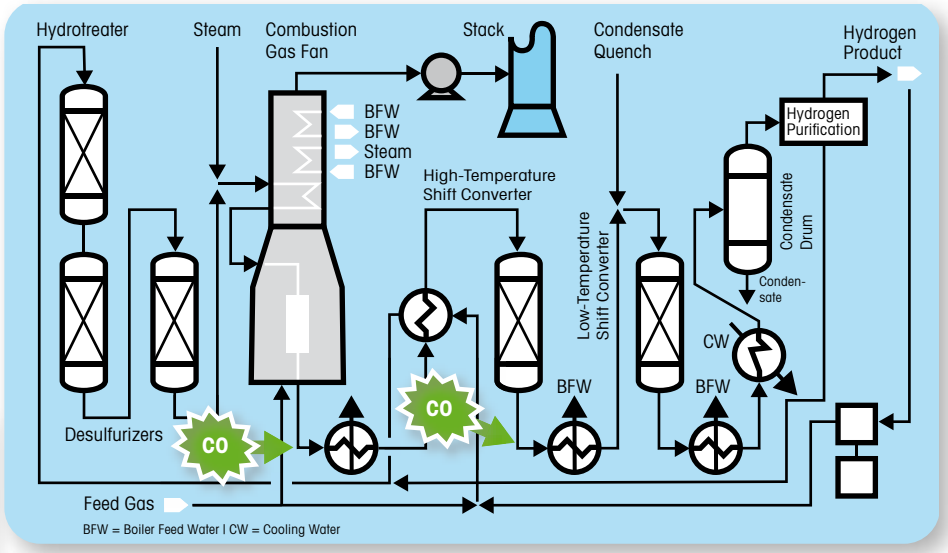
- At 700 – 1100 °C and in the presence of a nickel based catalyst (Ni), steam reacts with methane in a reformer to yield carbon monoxide and hydrogen. Measurement of CO provides control/efficiency of the reaction.
  Reaction: $CH_4 + H_2O = CO + 3\ H_2$
- Hydrogen is additionally recovered by a lower-temperature gas-shift reaction with the carbon monoxide produced in the first reaction. CO is measured to monitor efficiency.
  Reaction: $CO + H_2O \rightarrow CO_2 + H_2$

Process benefits of GPro 500

- With the GPro 500 in situ installations there is no need for alignment, purge gas demands are low, and maintenance is minimal.
- Fast speed of response for maximum process efficiency.
- Fully flexible extractive cell options
- GPro 500 is fully solid state with long operational life.

Process conditions

Available insertion length	DN 150 – 300 or Extractive
Temperature	500 – 600 °C
Pressure	3 – 25 ba(ra)
CO range	0 – 10 vol% 0 – 2000 ppm
Dust load	Low
Required response time	< 2 s



Tips and hints

For higher accuracy (up to fourfold), user longer probes to increase optical path length.

GPro 500's unique measurement algorithm ensures no measurement errors due to H_2 line narrowing.

Product recommendation

GPro 500 CO with 20, 40, 80 or 100 cm OPL Extractive cell. Or for in situ 290 or 390 mm SP Probe.

Click here for more information

Styrene Monomer Production
Process Efficiency

Purpose
Styrene monomer is an oily, colorless, sweet smelling liquid and is the important precursor chemical used for the manufacture of resins, plastics, copolymers and of course polystyrene.
Aluminum chloride or zeolite catalyst is used in the alkylation process.

Description
Two step method: 1) Alkylation of benzene with ethylene to produce ethylbenzene. 2) Dehydrogenation to produce styrene.

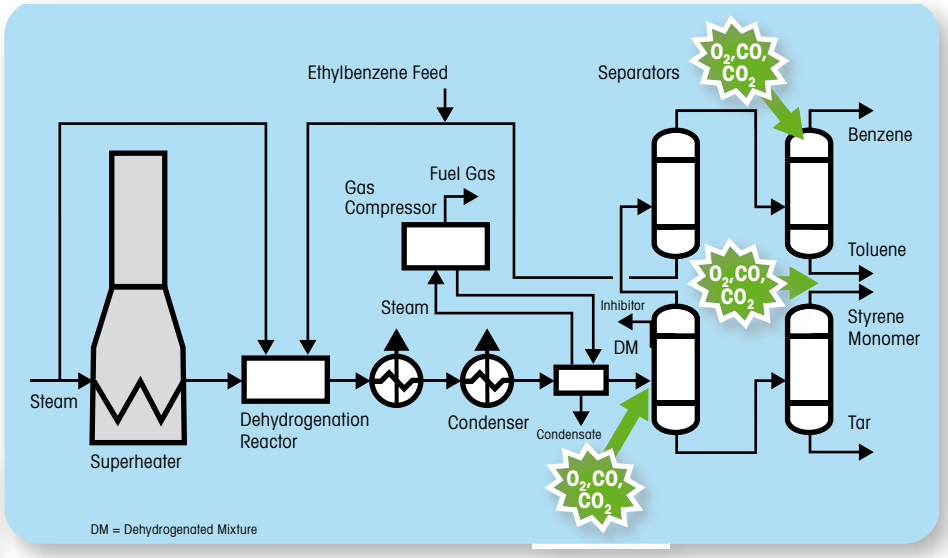
- O_2 is measured at various locations in the process to ensure oxygen is not entering the process lines. The presence of O_2 decreases efficiency and creates unwanted compounds.
  Also O_2 from product separators outlets is required.
- Additionally CO and CO_2 are often measured to optimize the process for maximum conversion.

Process benefits of GPro 500

- NDIR analyzers have been used, but can suffer from significant cross-interference
- NDIR analyzers have typically slow response times
- NDIR analyzers typically use motors and broadband IR sources, which need periodic replacement.
- GPro 500 is fully solid state with long operational life.

Process conditions

Available insertion length	0.2–1 m or Extractive
Temperature	< 250 °C
Pressure	1.5–2 bar(a)
O_2 range	0–10 vol%
CO_2 range	0–5 vol%
CO range	0–5 vol%
Dust load	0–500 mg/m³
Required response time	< 2 s



Tips and hints
The unique Spectra ID™ technology ensures better system reliability with line locking on three absorption lines.

With in situ installations for analyzer verification without process interruptions, use the calibration tube for verification in less than 5 minutes.

Product recommendation
For in situ installations:
GPro O_2%, CO_2%; 500, 290 or 390 mm SP probe.

For extractive:
20 or 40 cm OPL extractive cell.

Longer path lengths can be used for higher sensitivity.

Click here for more information

Synthesis Gas (Syngas) Production
Process Efficiency

Purpose

Syn(thesis) Gas is a mixture of CO and H_2. It is utilized in the production of oxo alcohols, methanol and synthetic fuels.

One of the main methods for its production is the partial oxidation of methane and steam.

Description

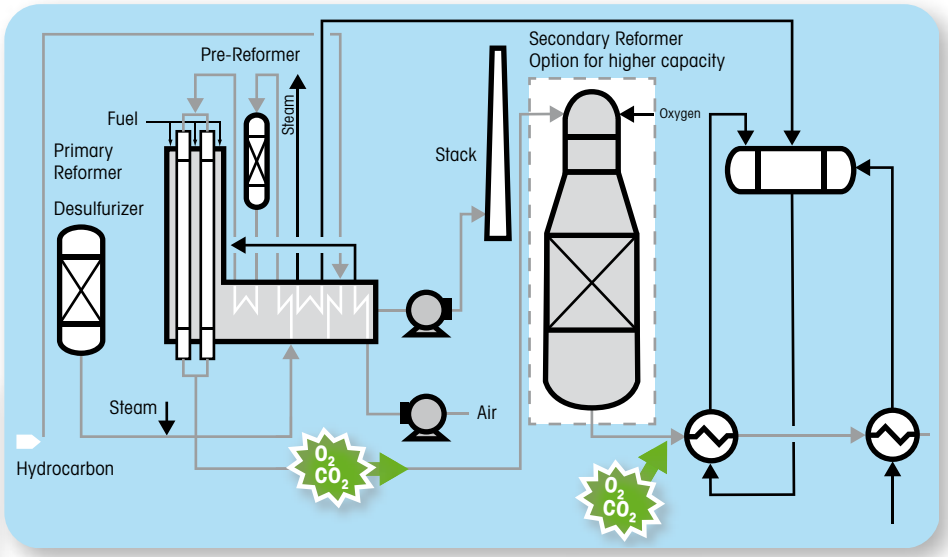
- Syngas is produced by the process of steam reforming and partial oxidation of hydrocarbons to produce CO and H_2.
  This is achieved via the following reaction: .
  $CH_4 + H_2O = CO + 3H_2$
- The ratio of CO to H_2 can be adjusted during the conversion process to yield the desired gas blend.
  Principally this process is identical to that used in hydrogen production where additional catalytic conversion of CO is undertaken.

Process benefits of GPro 500

- Fast speed of response for maximum process efficiency.
- High maintenance – NDIR analyzers typically use motors and broadband IR sources, which need periodic replacement.
- The GPro 500 is fully solid state with long operational life.

Process conditions

Available insertion length	DIN150–300 or Extractive
Temperature	500 °C
Pressure	1–10 bar(a)
CO_2 range	0–10 vol%
CO range	0–10 vol%
Dust load	0–500 mg/m³
Required response time	<2 s



Tips and hints

The unique Spectra ID™ technology ensures better system reliability with line locking on three absorption lines.

For in situ installations for analyzer verification without process interruptions, use the calibration tube for verification in less than 5 minutes.

Product recommendation

GPro 500 O_2%, CO_2% with 20, 40, 80 or 100 cm OPL Extractive cell.

CO/CO_2 % combined measurement.

Click here for more information

Ammonia (NH_3) Synthesis
Process Efficiency

Purpose

Ammonia is one of the most important inorganic chemicals having wide use as a fertilizer and as a feedstock for many processes including the production of plastics, explosives, man-made fibres and for the production of nitric acid. Steam reforming using the Haber-Bosch process combines hydrogen with HC feed to produce NH_3.

Description

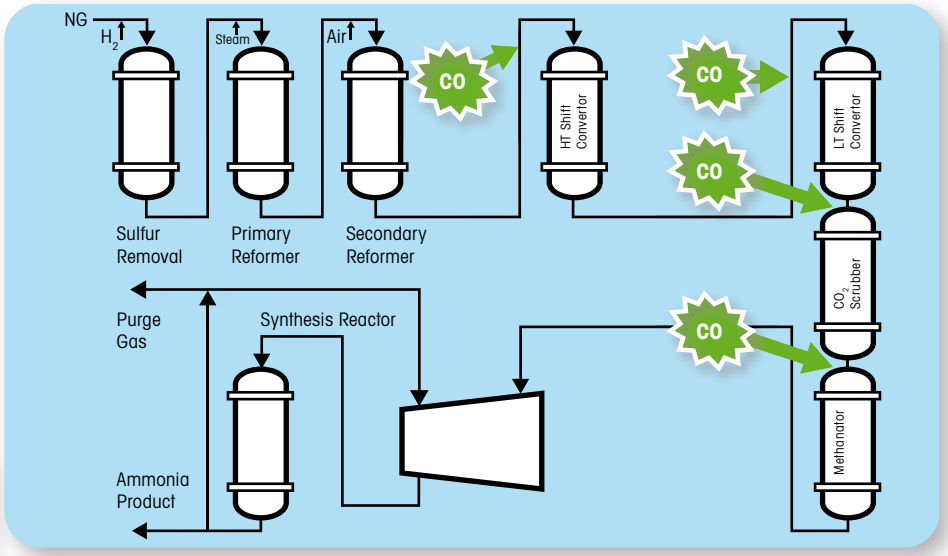
- Methane is first treated to remove sulfur compounds and then reacted with steam over a catalyst. The reaction is:
  $CH_4 + H_2O \rightarrow 3H_2 + CO$
- The synthesis reactor then converts the synthesis gas into
  NH_3 $3H_2 + N2 \rightarrow 2NH_3$
- CO is measured before and after the shift convertors to confirm efficiency
- Some plants also measure ppm level of CO and CO_2 from scrubber outlets

Process benefits of GPro 500

- NDIR analyzers have been used, but can suffer from significant cross-interference
- NDIR analyzers have typically slow response times
- NDIR analyzers typically use motors and broadband IR sources, which need periodic replacement.
- GPro 500 is fully solid state with long operational life

Process conditions

Available insertion length	0.2 – 1.5 m or Extractive
Temperature	50 °C – 250 °C
Pressure	1 – 5 bar(a)
CO range	0 – 1000 ppm
Dust load	low
Required response time	< 2 s



Tips and hints

For in situ installations the GPro 500 must be mounted horizontally in the process pipe in order to ensure consistent purge gas flow and protection of the process windows.

Product recommendation

GPro 500 CO with 20, 40, 80 or 100 cm OPL Extractive cell.

Alternatively for in situ a 290, 390 or 590 mm SP Probe dependent on pipe diameter.

Click here for more information

For more information go to

www.mt.com/TDL

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