

Comparison of Oxygen Measurement Technologies

Selection Criteria to Help You Choose the Right Tool

There is no single measurement technology that will work for every application. METTLER TOLEDO is dedicated to identifying and offering the best technologies for robust in process gas measurements. For making oxygen measurements, we have two technologies. The following is a general guideline for selecting the best technology. To make the final determination, please contact your local METTLER TOLEDO representative.

Oxygen measurement across the process industries

From preventing the build-up of explosive gas mixtures in chemical processes, to nitrogen blanketing for inhibiting product oxidation, to ensuring carbon dioxide purity in the Food and Beverage industry, measurement of oxygen is a vital element of many industrial processes.

Amperometric

This is an electro-chemical measurement technology housed in a compact package. It is a depleting technology, some maintenance and consumables is required. Chemical interferences are possible; knowledge of the gas composition is required for evaluation.

For more information on this technique, refer to the Measurement Theory section of this catalog.

Tunable Diode Laser (TDL)

METTLER TOLEDO's TDL technology is immune to most interferences and the sensor's materials of construction are quite robust. There is no regular maintenance and the sensor is designed for long term continuous operation while

being virtually drift free. TDL is suited for the most challenging and critical applications. The physical package is a bit larger than the amperometric and optical sensors. For more information on this technique, refer to the Measurement Theory section of this catalog.

	Amperometric	TDL Oxygen
Applications	Inerting & Blanketing	Process Control, Safety & Combustion
Flow required	No, great for tank inerting	Certain applications require flow
Range	5-50,000 ppm or 50 ppm to 60%	0.01 – 100%
Max temperature	70 °C (158 °F)	600 °C (1112 °F)
Low pressure	–0.81 bar (–11.8 psig)	–0.9 bar (–13.05 psig)
High pressure	+7.95 bar (115.3 psig)	+9 bar (130.53 psig)
N₂ purging required	No	Sometimes
Maintenance, consumables	Required	No
Capital	\$	\$\$\$
Probe size	Very small, for confined spaces	Larger, for pipes 2" dia. or larger
Hazardous area technique	Intrinsic safety	Explosion proof
Background gas interference	Susceptible to some	None
SIL	No	SIL2 compatible version available
ATEX/FM Approved	Yes	Yes

TDL Gas Analyzers

For Every Installation Location in Your Plant



Standard Purged

Wafer

Non-Purge

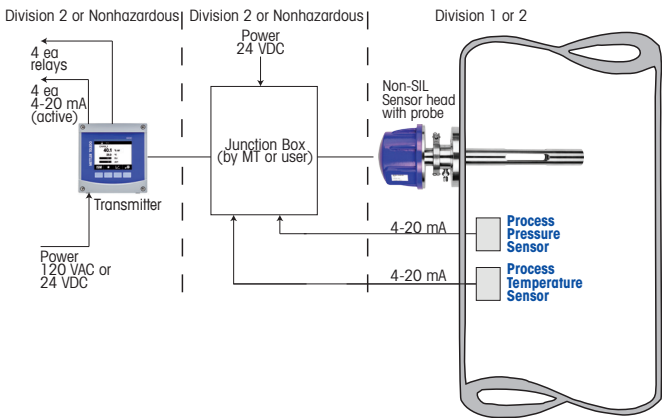
Non-Purged with filter and Blow-back

Extractive

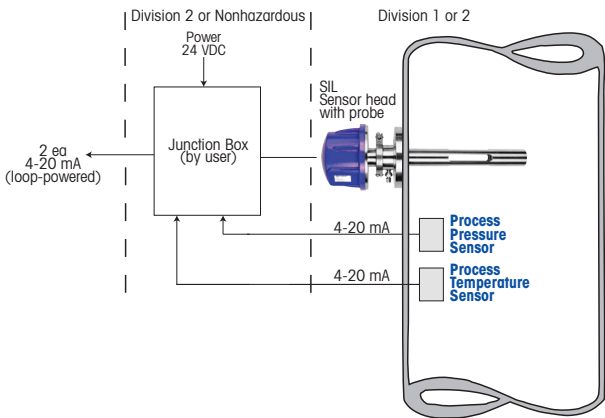
Cross-Pipe

Optical Path Interface	Insertion probe	Flow thru. Body is part of pipeline system	Insertion probe	Insertion probe	Extractive cell	Full diameter
Min Flow Requirement	Yes	Yes	No	Yes	No	Yes
Process Interface / Size	Mounts in pipe 4" diameter or larger	2", 150 lb ANSI or 3", 150 lb ANSI or 4", 150 lb ANSI	Mounts in pipe 4" diameter or larger	Mounts in pipe 4" diameter or larger	N/A	Pipes 1 – 3 m diameter
Typical Application	Near saturated gas stream e.g. combined gas vent line to destruct unit	Near saturated gas stream e.g. dryer, solvent, vapor recovery	Clean dry gases e.g. Storage tank safety blanket	Dry gases with particulate e.g. Flue gases	Clean dry gases from customer's extractive gas sampling system e.g. marine vapor recovery	Hot, flue gases, e.g. ammonia slip/ducts, and stacks

Transmitter version



Direct analog out version



GPro 500 TDL Building Your Measurement System

Selection of Components

For proper operation and optimal performance in your process, each element of your measurement system must be carefully chosen. A complete measurement system requires components including a sensor, junction box, cable and transmitter.

Sensor Selection

METTLER TOLEDO sensors are high performance and long lasting. However, proper selection must be made according to the application and process environment to which it will be exposed. Customers will need to fill out an application questionnaire to assist with sensor selection.

Basic selection considerations are:

- Gas to be measured
- Measurement range
- Operating temperature/pressure range
- Alarm level
- Accuracy required
- Background gases & concentrations
- Ambient temperature
- Contaminants (particulates, oils, condensate, aerosols)
- Piping/vessel sizes
- Gas stream velocity
- Dust and particle content

The sensor is made up of two significant pieces, as discussed below:

1a. Sensor-Spectrometer Portion (head)

Once it has been determined that we can successfully make the desired measurement, selection of correct head is relatively simple

Choices include:

- Gas to be measured (presently O₂, CO, CO₂, HCl, H₂S, CH₄ CO/CH₄, CH₄, NH₃ and H₂O vapor)
- Safety approval type (FM or ATEX)
- Requirement for SIL2

1b. Sensor – Process Adaption Portion

Upon detailed review of the process conditions and using our many years of experience, we select the best style adaption for the application and the appropriate size.

This is a brief summary of the process adaption styles (each available in various sizes):

- Purged probe
- Non-purged probe
- Non-purged probe with filter and optional blowback
- Wafer
- Extractive
- White cell

In addition to the sensor style and size, other decisions include:

- Seal material (Kalrez® types or graphite)
- Optic material (borosilicate glass, quartz or sapphire)
- Wall thickness (to accommodate wall insulation)
- Process connection size
- Material of construction: 316L stainless steel and C22 Hastelloy are standard; others are available on request.



2. Transmitter Selection

Transmitters are the component that communicates a sensor's readings into displayed measurements. The transmitter also transfers the data to the process control system.

Most users want the convenience of having a local display, multiple analog inputs/outputs and alarms. For these users we select the model M400, Type 3 transmitter. This 4 wire transmitter is ATEX/FM approved for Zone/Division 2 areas, is suitable for indoor or outdoor use and can be powered from AC or DC.

If your site requires a SIL version of the GPro 500, that version does not utilize the separate (M400) transmitter. The SIL version of the GPro 500 has a simple transmitter built into the sensor's head. It does not have the functionality of the M400, it simply has 2 analog (4–20mA) signal outputs (loop powered).

3. Junction Box

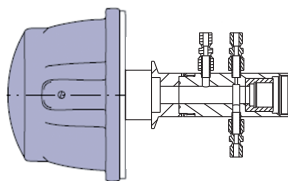
The multi-core cable that connects on one end to the GPro 500 head terminates the other end at a junction box that houses a 16 position terminal strip. METTLER TOLEDO offers a junction box or users can provide their own junction box. The junction box needs to be rated for the area where it will be installed.

4. Cable

A multi-core cable is used to connect the GPro 500 head to the junction box. Note: on the FM unit, the cable is shipped loose, the ATEX unit has the cable pre-terminated in the sensor's head.

5. Verification Cell

Although not part of the GPro 500, a verification cell is a useful tool to verify calibration and for troubleshooting.



To use the cell, remove the sensor head from the probe and connect the cell to the head using the Tri-Clamp and special gasket. One verification cell can be used for multiple units on the same site. Ambient air can be used as a check gas for the oxygen sensor. To introduce other gases, the cell has inlet and outlet fittings.

6. Diagnostic Software

The MT TDL Suite is PC software with a variety of functions to see into and capture information about the operation of your GPro 500. It is not mandatory to ever use this software but most users find it a powerful tool. The software suite will automatically detect the gas that your unit is designed to measure and will display it appropriately.



7. Thermal Barrier

If the process gas is expected to be at a temperature between 250 °C to 600 °C, a thermal barrier can be used to protect the sensor's electronics. The thermal barrier is effectively a spool piece mounted between the sensor and the sensor head.

GPro 500 Sensor

In Situ Sensor Convenience, with the Power of an Analyzer



Tunable Diode Laser (TDL) measurement technology is recognized for speed and accuracy of measurement, and immunity to background gases. To this, METTLER TOLEDO has added the simplicity of use and low maintenance of in-line sensor design, plus advanced predictive diagnostics. The result is the GPro 500 series, a highly durable line of oxygen sensors for process and safety applications in chemical plant and petrochemical operations.

Specifications

Measurement O₂

Effective path length	Probes: 200, 400, 800 mm (7.87", 15.75", 31.49")
	Wafer: 50, 80, 100 mm (1.96", 3.15", 3.94")
	Extractive cells: 200, 400, 800 mm, 1 m, (7.87", 15.75", 31.49", 39.37")
Lower detection limit (in 1 meter path length at ambient standard conditions, dry gas, no dust load, in N ₂ background)	
	100 ppm-v
Measurement range	0–100 %
Accuracy	2 % of reading or 100 ppm O ₂ , whichever is greater
Linearity	Better than 1 %
Resolution	< 0 ... 0.01 % vol O ₂ (100 ppm-v)
Sampling rate	1 second
Response time (T ₉₀)	O ₂ in N ₂ 21 % > 0 % in < 2 sec
Warm up time	Typically < 1 minute
Repeatability	± 0.25 % of reading or 0.05 % O ₂ (whichever is greater)
Process pressure range	0.1 bar–10 bar (abs)* / 1.45 psi–145.03 psi (abs)
Process temperature range	0–250 °C (32–482 °F)
	Optional (for probe installation) 0–600 °C (0–1112 °F) with additional thermal barrier

* firmware 6.23 or higher

Features Overview

- One-flange installation without alignment
- In situ measurement without sampling system
- Low cost-of-ownership with virtually no maintenance
- Low purge gas consumption for minimum operating costs
- Large choice of process interface options



Did You Know

Tunable Diode Laser spectrometers are insensitive to background interference from the process gas and moisture, and are largely resistant to heavy dust loads.

▶ www.mt.com/GPro500

Measurement (All measurement specifications with reference to standard conditions T & P with no dust or particulates) and 1 m optical path

Measurement:	O ₂	CO (ppm)	CO (%)	H ₂ O	H ₂ O ppm	CO ₂ (%)
Effective path length	Probes: 200, 400, 800 mm (7.87", 15.75", 15.75", 31.50"). Wafer Cell: 104 mm, 110 mm, 154 mm, 164 mm, 214 mm (4.09", 4.33", 6.06", 6.46", 8.43") Extractive cells: 200 mm, 400 mm, 800 mm, 1 m, 8 m (7.87", 15.75", 31.50", 39.37", 315")					
Measurement range and standard conditions ¹⁾	0–100%	0–2%	0–100%	0–20%	0–1%	0–100%
Lower Detection Limit ²⁾	100 ppm-v	1 ppm-v	1500 ppm-v	5 ppm-v	1 ppm-v	1000 ppm-v
Accuracy	1% of reading or 100 ppm O ₂ , whichever is greater	2% of reading or 1 ppm, whichever is greater	2% of reading or 1500 ppm, whichever is greater	2 % of reading or 10 ppm, whichever is greater	2% of reading or 1 ppm, whichever is greater	2% of reading or 1000 ppm, whichever is greater
Linearity	Better than 1%	Better than 1%	Better than 1%	Better than 1%	Better than 1%	Better than 1%
Sampling rate	1 second	1 second	1 second	1 second	1 second	1 second
Response time (T90)	O ₂ in N ₂ 21% >0% in <2 sec	CO in N ₂ 300 ppm-v to 0% in <4 sec	CO in N ₂ 1% to 0% in <4 sec	H ₂ O in N ₂ 1% to 0% in <4 sec	H ₂ O in N ₂ 1% to 0% in <4 sec	CO ₂ in N ₂ 1% to 0% in <4 sec
Warm-up time	Typically <1 hour	Typically <1 hour	Typically <1 hour	Typically <1 hour	Typically <1 hour	Typically <1 hour
Repeatability	±0.25% of reading or 0.05% O ₂ , whichever is greater	±0.25% of reading or 5 ppm-v CO, whichever is greater	±0.25% of reading or 0.75%-v CO, whichever is greater	±0.25% of reading or 50 ppm-v H ₂ O, whichever is greater	±0.25% of reading or 10 ppm-v H ₂ O, whichever is greater	±0.25% of reading or 5000 ppm-v CO ₂ , whichever is greater
Process pressure range	0.1 bar to 10 bar (abs)*/ 1.45 psi to 145.03 psi (abs)*	0.8 bar to 2 bar (abs)/ 11.6 psi to 29.psi (abs)	0.8 bar to 1.5 bar (abs)/ 11.6 psi to 21.7.psi (abs)	0.8 bar to 2 bar (abs)/ 11.6 psi to 29.psi (abs)	0.8 bar to 5 bar (abs)/ 11.6 psi to 72.5 psi (abs)	0.8 bar to 2 bar (abs)/ 11.6 psi to 29 psi (abs)
Process temperature range	0 to +250 °C (+32 to +482 °F) Standard. 0 to +600 °C (0 to +1112 °F) with built in thermal barrier. 0 to +150 °C (+32 to +302 °F) (PFA, PTFE filter)					
* firmware 6.23 or higher						

	CO ppm/CH ₄ %	CO ₂ %/CO %	HCl (ppm)	H ₂ S (%)	CH ₄ ppm	NH ₃ ppm
Effective path length	Probes: 200, 400, 800 mm (7.87", 15.75", 15.75", 31.50"). Wafer Cell: 104 mm, 110 mm, 154 mm, 164 mm, 214 mm (4.09", 4.33", 6.06", 6.46", 8.43") Extractive cells: 200 mm, 400 mm, 800 mm, 1 m, 8 m (7.87", 15.75", 31.50", 39.37", 315")					
Measurement range and standard conditions ¹⁾	0–2% (CO) 0–10% (CH ₄)	0–100% (CO ₂ and CO)	0–3%	0–50%	0–1 %	0–1 %
Lower Detection Limit ²⁾	0–200°C: 1 ppm-v (CO), 5 ppm-v (CH ₄) 200–600°C: 5 ppm-v (CO), 25 ppm-v (CH ₄)	1000 ppm-v (CO ₂) 1500 ppm-v (CO)	0.6 ppm-v	20 ppm-v	1 ppm-v	1 ppm-v
Accuracy	2% of reading or 1 ppm (CO)/25 ppm-v (CH ₄), whichever is greater	2% of reading or 1000 ppm, whichever is greater	2% of reading or 0.6 ppm, whichever is greater	2% of reading or 20 ppm, whichever is greater	2 % or 1 ppm	2 % or 1 ppm
Linearity	Better than 1%	Better than 1%	Better than 1%	Better than 1%	Better than 1%	Better than 1%
Sampling rate	1 second	1 second	1 second	1 second	1 second	1 second
Response time (T90)	CO/CH ₄ in N ₂ 2% to 0% in <4 sec	CO ₂ in N ₂ 1% to 0% in <4 sec	HCl in N ₂ 1% to 0% in <4 sec	H ₂ S in N ₂ 1% to 0% in <4 sec	CH ₄ in N ₂ 1% to 0% in <4 sec	NH ₃ in N ₂ 1% to 0% in <4 sec
Warm-up time	Typically <1 hour	Typically <1 hour	Typically <1 hour	Typically <1 hour	Typically <1 hour	Typically <1 hour
Repeatability	±0.25% of reading or 5 ppm-v CO/500 ppm-v CH ₄ , whichever is greater	±0.25% of reading or 5000 ppm-v CO ₂ or CO, whichever is greater	±0.25% of reading or 3 ppm-v HCl, whichever is greater	±0.25% of reading or 100 ppm-v H ₂ S, whichever is greater	±0.25% of reading or 5 ppm-v CH ₄ , whichever is greater	±0.25% of reading or 5 ppm-v NH ₃ , whichever is greater
Process pressure range	0.8 bar to 2 bar (abs)/ 11.6 psi to 29 psi (abs)	0.8 bar to 2 bar (abs)/ 11.6 psi to 29 psi (abs)	0.8 bar to 3 bar (abs)/ 11.6 psi to 43.5 psi (abs)	0.8 bar to 2 bar (abs)/ 11.6 psi to 29 psi (abs)	0.8 bar to 3 bar (abs)/ 11.6 psi to 43.5 psi (abs)	0.8 bar to 3 bar (abs)/ 11.6 psi to 43.5 psi (abs)
Process temperature range	0 to +250 °C (+32 to +482 °F) Standard. 0 to +600 °C (0 to +1112 °F) with built in thermal barrier. 0 to +150 °C (+32 to +302 °F) (PFA, PTFE filter)					

¹⁾ Measurement range and standard conditions (ambient temperature and pressure, 1 m path length).²⁾ Lower Detection Limit (in 1 meter path length at ambient standard conditions, dry gas, no dust load, in N₂ background).

Gas Analyzers

Measure Everywhere It Matters

Variant Configurator

Gas Analyzer		GPro 500	A	T	A	O	P	B	K	S	O	2	O	P	D	1	X	S	_	_	/	A	X
30 027 126*, 30 538 717**		GPro 500	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	/	Y	Y
Hazardous area approvals																							
ATEX/IECEX Ex d			A	T																			
FM Class 1 Div 1			U	S																			
Gases																							
Oxygen					A	O																	
CO					C	O																	
H ₂ O					H	O																	
H ₂ O ppm					H	1																	
CO ₂ %					C	2																	
CO %					C	1																	
CO % + CO ₂ %					C	C																	
CO ppm + CH ₄ %					C	M																	
H ₂ S					S	1																	
HCl ppm					L	O																	
CH ₄ ppm					M	O																	
NH ₃ ppm					N	O																	
Process interfaces																							
Standard Probe purged (SP)							P																
Standard Probe purged twin (SP)							T																
Non-purged Filter Probe (NP)							F																
Non-purged Filter Probe twin (NP)							R																
Non-purged Filter Probe with Blow-back (BP)							B																
Non-purged Filter Probe with Blow-back twin							U																
Wafer (W)							W																
Extractive Cell (E)							E																
Cross-pipe Folded Path (C)							C																
Process optics***																							
Borosilicate							B																
Quartz							Q																
Sapphire							S																
Dual Window Borosilicate							C																
Dual Window Quartz							R																
Dual Window Sapphire							T																
Process sealings**																							
Kalrez® 6375								K															
Graphite								G															
Kalrez® (FDA grade) 6230								F															
Kalrez® 6380								S															
Kalrez® 0090								R															
EPDM FDA								Q															
Wetted materials***																							
1.4404 (equivalent to 316L)										S	O												
Hastelloy C22										C	O												
Optical path probes and extractive cell***																							
200 mm (7.9")												2	O										
400 mm (15.7")												4	O										
800 mm (31.5")												8	O										
1 m (3.3 ft)												0	1										
2 m (6.6 ft)												0	2										
3 m (9.8 ft)												0	3										
4 m (13.1 ft)												0	4										

Variant Configurator (continued)

Gas Analyzer	GPro 500	A	T	A	O	P	B	K	S	O	2	O	P	D	1	X	S	_	_	/	A	X
30 027 126*, 30 538 717**	GPro 500	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	/	Y	Y
5 m (16.4 ft)											0	5										
6 m (19.7 ft)											0	6										
None											X	X										
Process connections***																						
DN 50/PN 25													P	D								
ANSI 2"/300 lbs													P	A								
DN 50/PN 16													L	D								
ANSI 2"/150 lbs													L	A								
DN 80/PN 16													G	D								
ANSI 3"/150 lbs													G	A								
DN 100/PN 25													N	D								
ANSI 4"/300 lbs													N	A								
ANSI 4"/150 lbs													M	A								
DN 50/PN 16 and 40													W	1								
DN 80/PN 16 and 40													W	2								
DN 100/PN 16													W	3								
ANSI 2"/150 lbs													W	4								
ANSI 3"/150 lbs													W	5								
ANSI 4"/150 lbs													W	6								
Swagelok 6 mm													E	M								
Swagelok 1/4"													E	I								
Wall thickness***																						
100 mm															1							
200 mm															2							
300 mm															3							
None															X							
Filters***																						
Filter A – 40 µm																	A					
Filter B – 100 µm																	B					
Filter C – 200 µm																	C					
Filter D – 3 µm																	D					
Filter PTFE Membrane																	E					
No Filter																	X					
Add-on modules***																						
None																	X	_	_	/		
With Thermal Barrier (up to 600 °C)																	H	_	_	/		
2-fold Multireflection Cell																	2	_	_	/		
3-fold Multireflection Cell																	3	_	_	/		
Cable																						
5 m (16.4 ft)																					A	
15 m (49.2 ft)																					B	
25 m (82.0 ft)																					C	
40 m (131.2 ft)																					D	
None																					X	
Communication interfaces																						
RS 485 (for M400)																						X
RS 485 and Direct Analog (SIL)																						A

* Normal delivery time. ** Short delivery time. *** Other configurations upon request.