INTEGRATOR BRIEFING

Tunable Diode Laser Process & CEMS Monitoring

Cross-duct laser measurement for process control and compliance CEMS — what it is, what it needs, and where it fits.

Cliff Gordon
President · M&C TechGroup North America

WHO WE ARE

M&C TechGroup Overview

Analyzer sample systems engineered for reliability and performance.

1985
Founded

2025
Joined MSA Safety

200+
Employees worldwide

- **German-engineered**, with U.S.-based manufacturing and system integration
- **Core competencies**: gas sampling, conditioning, process control, and analyzer integration
- **Certifications & patents** — refinery-proven sample-system designs
- **Technology-neutral** — supports GC, TDL, FTIR, UV, and NDIR platforms
- **Dedicated teams** for engineering, design, and project execution

M&C Global Headquarters – Germany

GLOBAL FOOTPRINT

Worldwide Network

700+

GasEye measurement points in service

6

continents with installed base

40+

years of field-proven engineering

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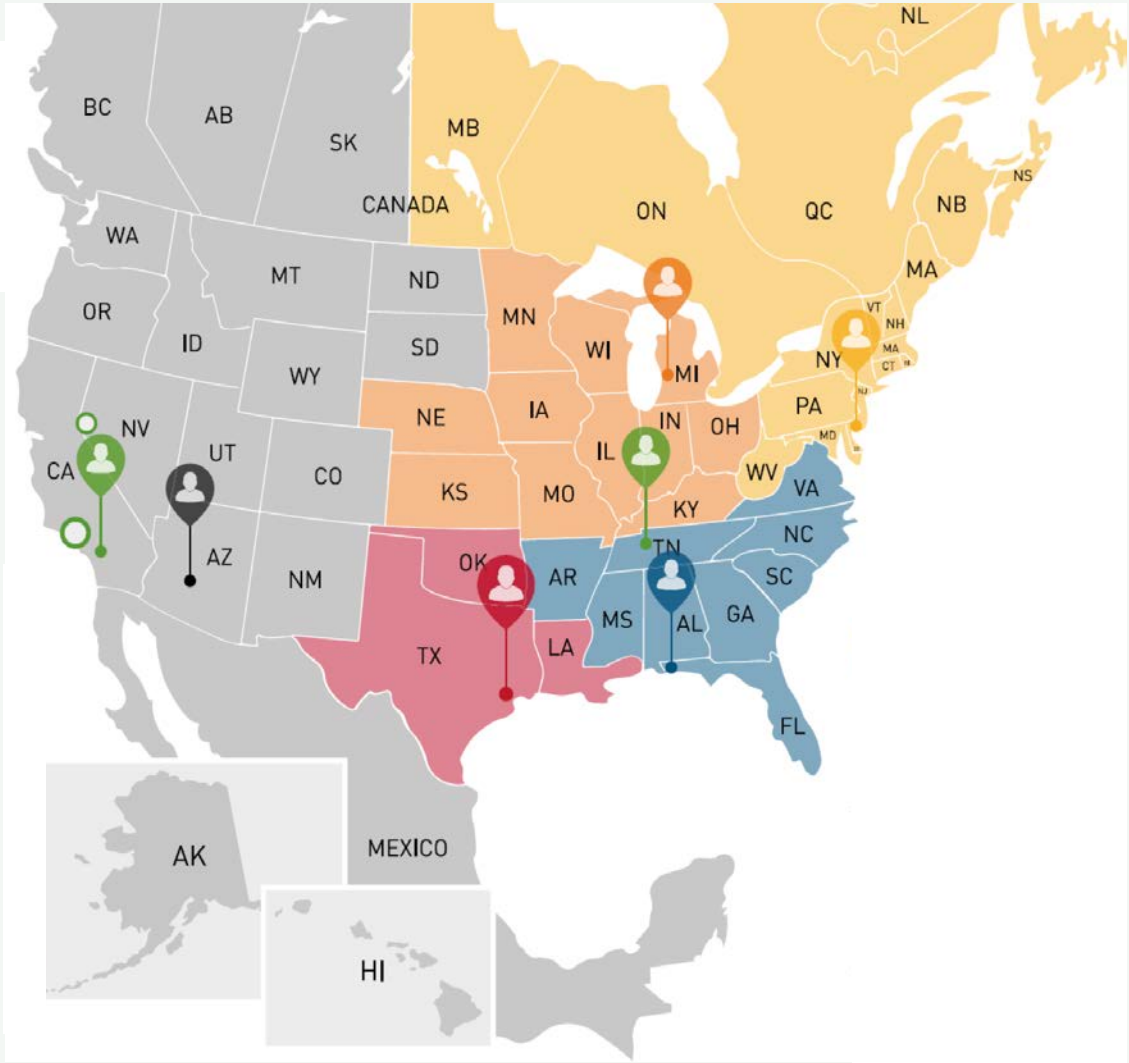


OUR TDL TRACK RECORD

A 12-Year Head Start in TDL

Who M&C is — and why we moved to laser measurement early.

Who We Are

M&C engineers the gas sampling and conditioning systems that extractive analyzers have relied on for decades — precision hardware for demanding process gas.

Many Years in TDL

More than decade ago, M&C entered the tunable diode laser market — early, as the technology matured for real industrial measurement.

We Saw the Shift

The industry began moving from traditional extractive methods to TDL — for the accuracy, speed, and low maintenance covered in the pages ahead.

MSA The Safety Company

M&C

AGENDA

What We'll Cover

MSA The Safety Company

SECTION 01

The TDL Portfolio

What M&C and Airoptic offer, and where each configuration fits.

01

THE PORTFOLIO

What You Can Sell

Cross-Duct GasEye

- Transmitter and receiver on opposed flanges; central unit on the duct
- NO/NO_2, CO/CO_2, NH_3/O_2, H_2O — two species per path
- Paths up to 25 m, IP66, −30 to +60 °C — no shelter, no fiber run
- The default for stacks, ducts, and SCR outlets

Beam-Split

- Analyzer in the CEMS shelter, fiber to compact heads on the stack
- One analyzer can cover more than one path or stack
- Internal flow-through calibration cell
- For hard-to-reach platforms or when the plant wants electronics indoors

Extractive, When It Fits

- M&C probes, heated lines, and sample conditioning
- GenTwo analyzers for O_2, CO, NOx and multi-component work
- For species, ranges, or sites where in-situ is not the right answer
- Same channel, same support — one supplier for the whole system

Two jobs, one platform: a process monitor feeding the DCS for tuning and control, or a certified Part 75 CEMS reporting through ECMPS. The hardware on the duct is the same — the scope decides the cell, the gases, and the paperwork.

THE PORTFOLIO

Path Configurations

Path 1 — NO / NO_2

- NO and NO_2 measured separately
- NOx calculated, no converter

Path 2 — CO / CO_2

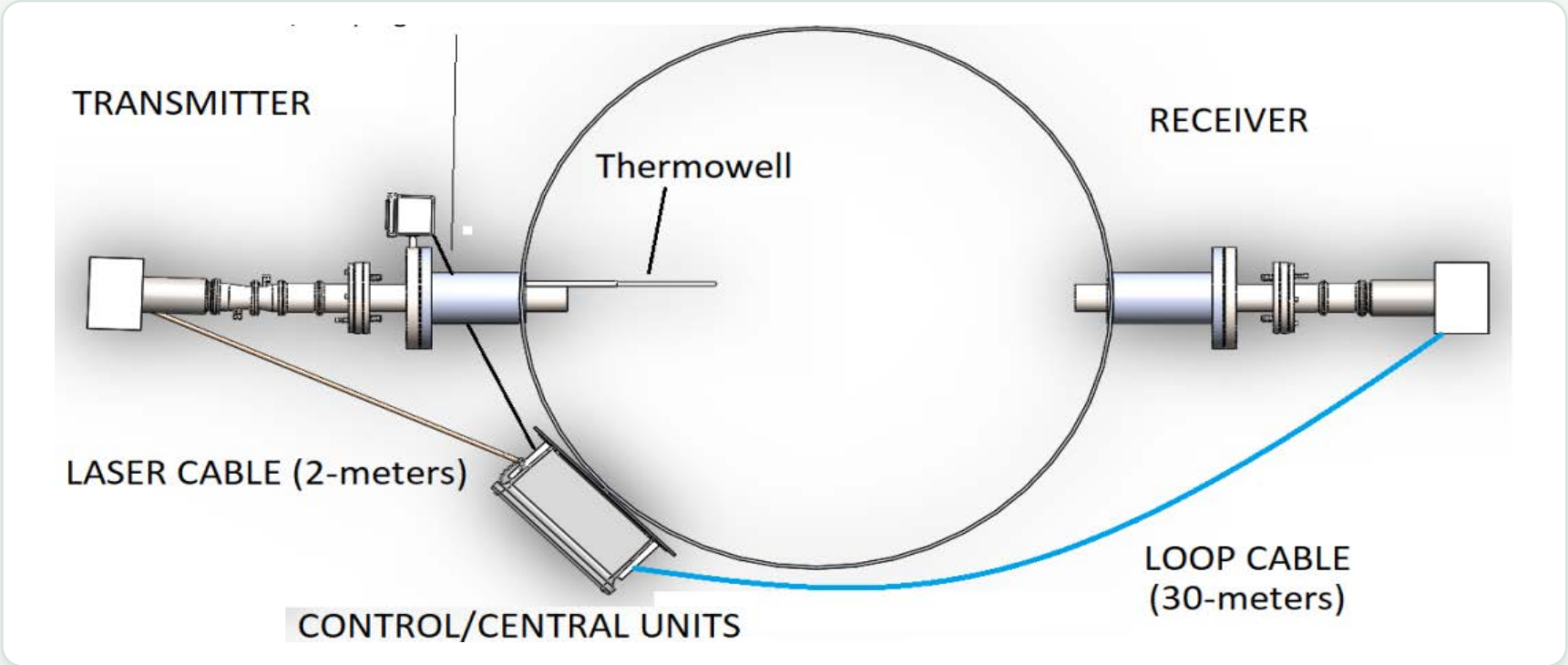
- CO and CO_2 on one path
- H_2O available on the same path

Path 3 — NH_3 / O_2

- Optional third path
- NH_3 slip with O_2 correction

Output

- 4–20 mA or Modbus TCP
- Direct to the DCS or the DAS



Transmitter and receiver mount on opposing flanges; the central unit sits between them. Everything is on the duct — no shelter run, no sample line.

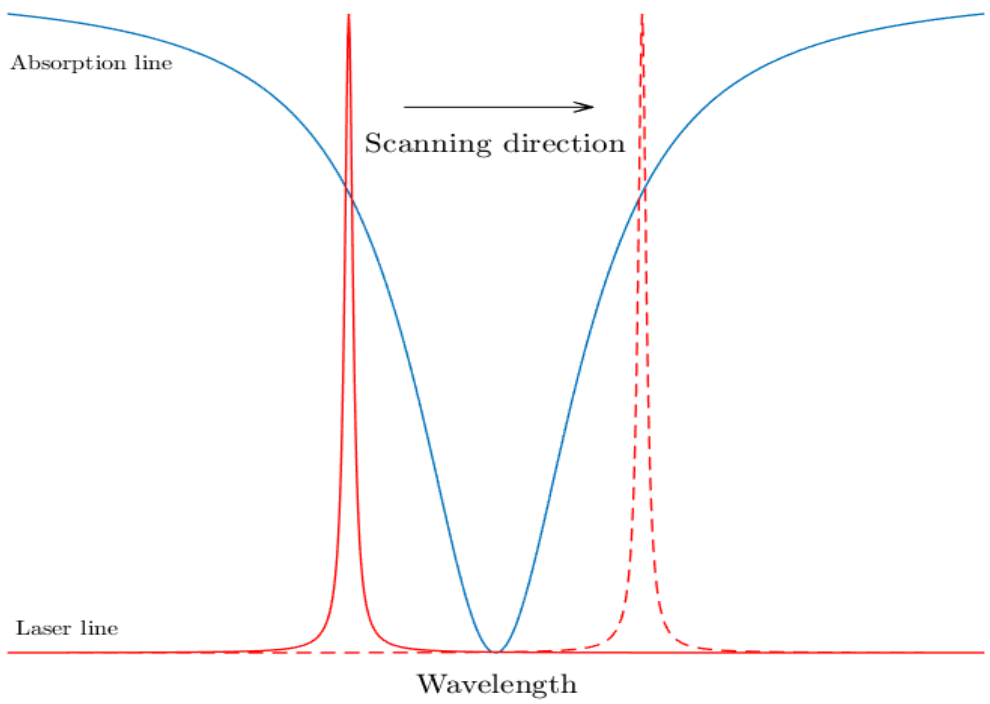
SECTION 02

How the Measurement Works

One laser, one absorption line, and the whole width of the duct.

HOW IT WORKS

Single-Line Absorption Spectroscopy

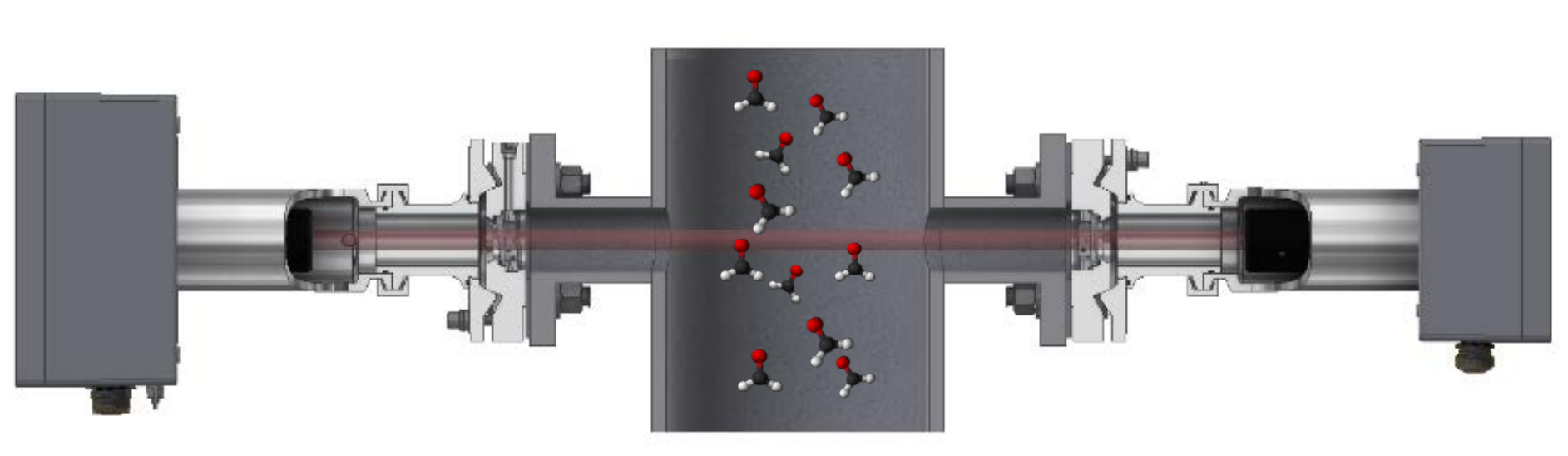


The laser sweeps across one absorption line. Depth of absorption is concentration.

- A semiconductor laser emits infrared light tuned to one specific absorption line of the target gas.
- The beam crosses the duct and lands on a detector on the far flange.
- The laser scans that single line continuously at very high spectral resolution.
- How much light the gas absorbs across the path gives the concentration directly — first principles, not a correlation.
- Because only one line is scanned, other process gases do not interfere. There is nothing to cross-correct for.
- Nothing is extracted, dried, or converted. The gas is measured where it is, at process conditions.

HOW IT WORKS

What Actually Mounts on the Duct



Transmitter

Houses the laser. IP66 coated aluminium, purged optics.

Receiver

Detector with a four-stage amplifier — auto gain, no potentiometer.

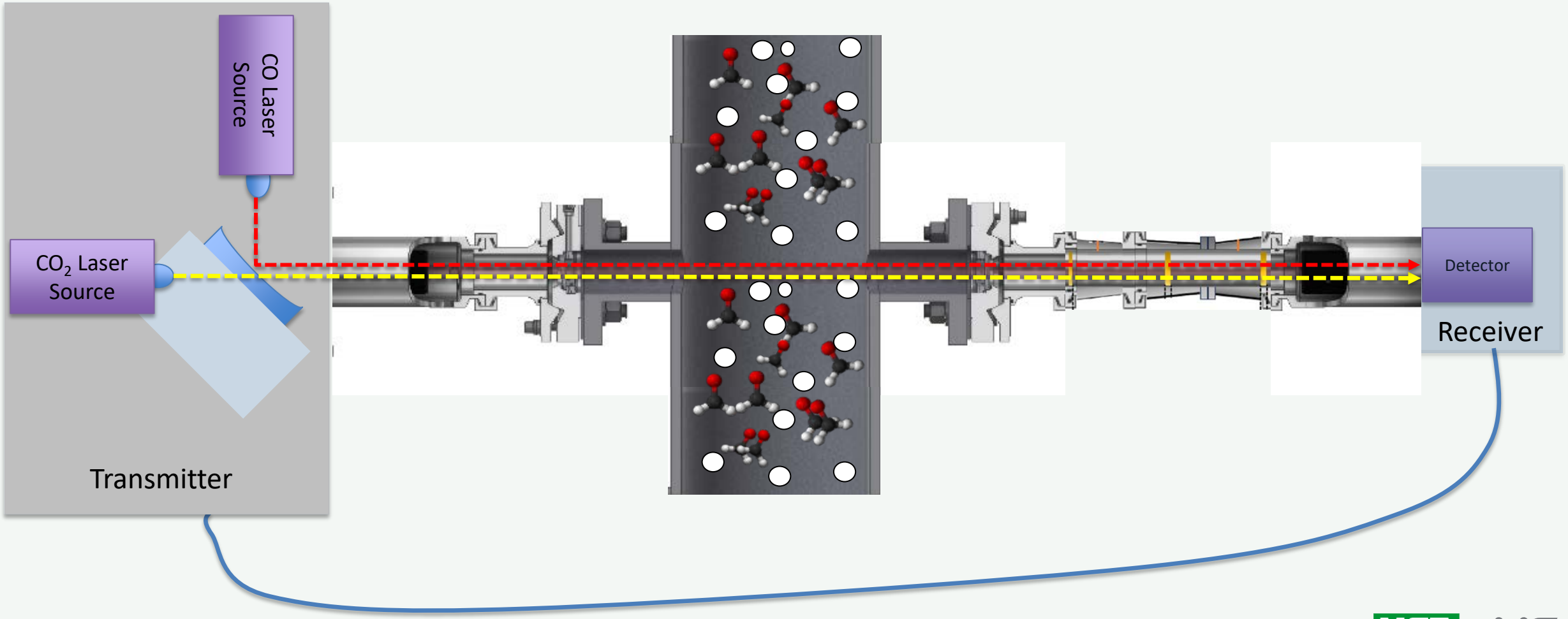
Central Unit

Electronics and I/O. Web server built in for remote access.

Loop Cable

One cable carries 24 VDC and communications. No optical fiber run.

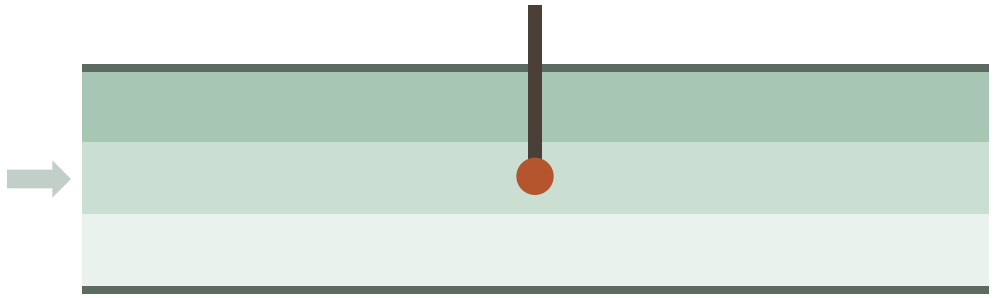
What Actually Mounts on the Duct



HOW IT WORKS

Full-Duct Path vs. a Single Point

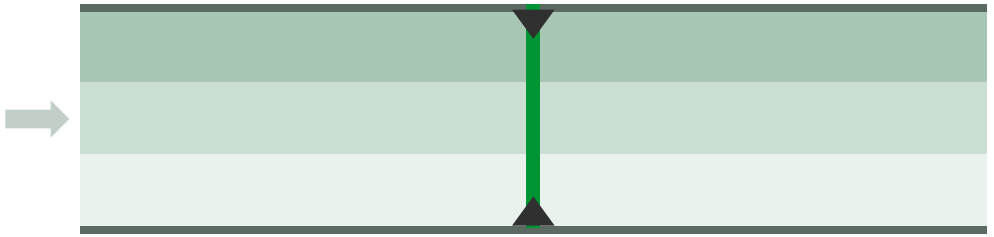
Point Measurement · Extractive



Samples one point in one layer

- Reads one location on one radius of the duct
- Stratification after an SCR or a burner shows up as bias, not as noise
- Requires siting studies to defend where the probe sits
- A plugged line or a leak is the entire measurement

Path Measurement · Cross-Duct



Integrates the full duct height

- Every molecule between the two flanges contributes to the reading
- The result is a true average across the duct, not a sample of it
- Stratification is averaged out instead of being sampled into the answer
- Nothing to plug, nothing to leak — the sample is never removed

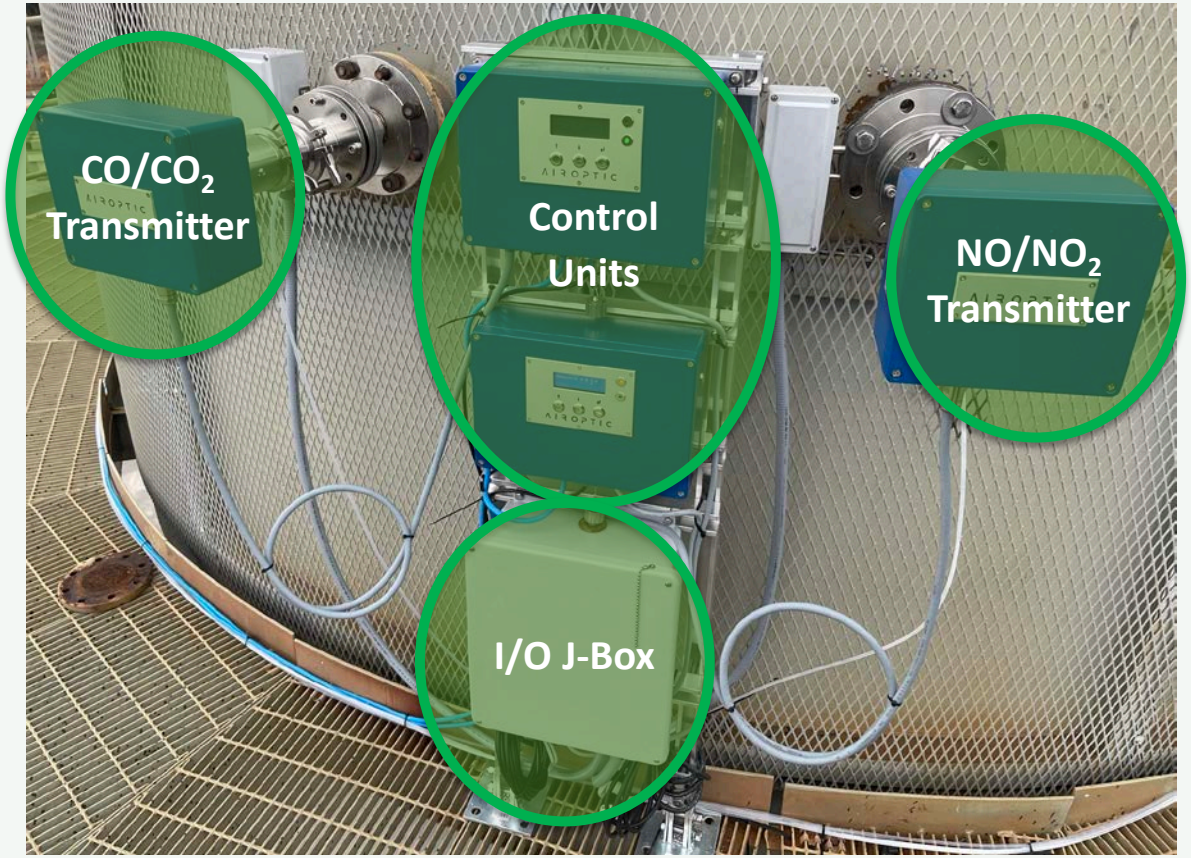
HOW IT WORKS

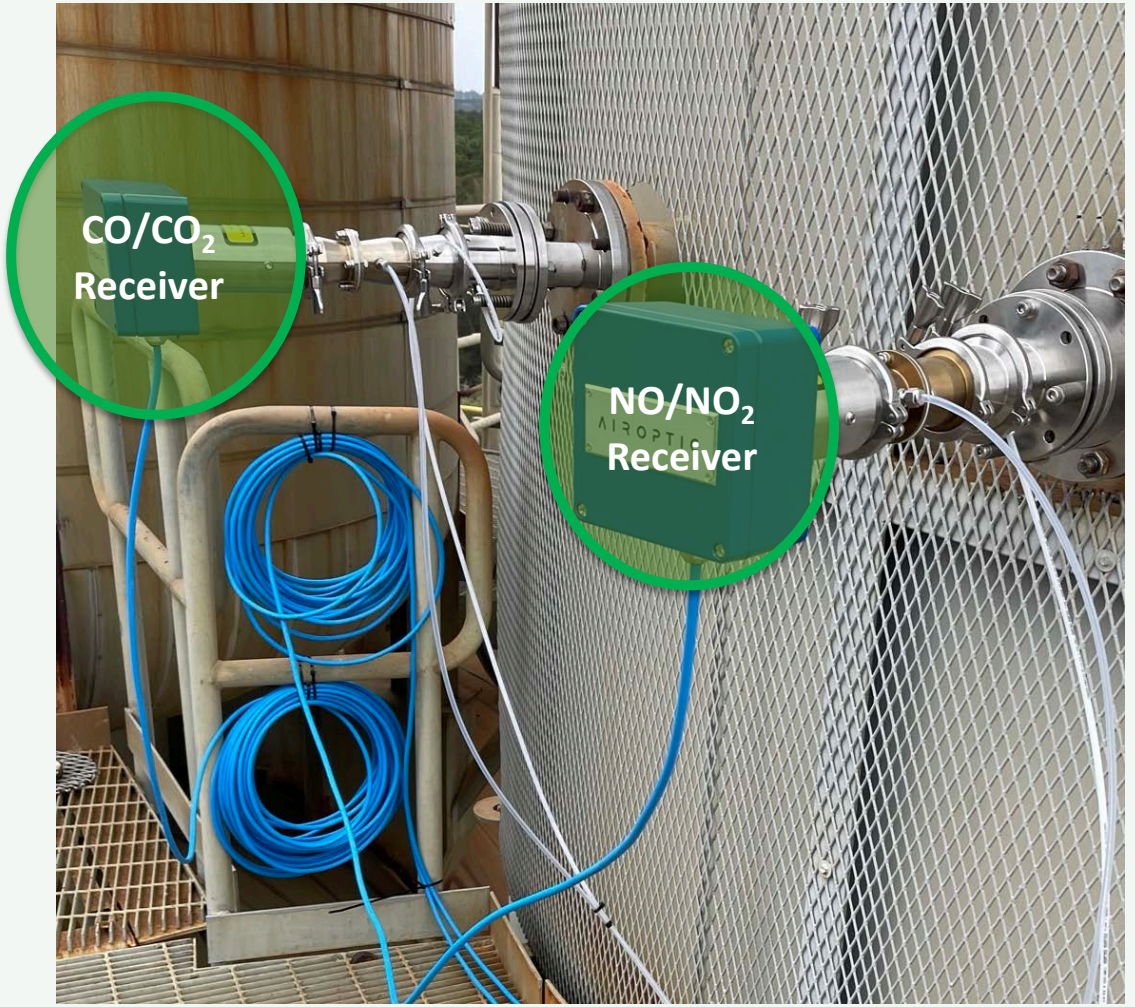
M&C – AirOptic TDL

HOW IT WORKS

Optical Monitor Configuration

Installation requirements





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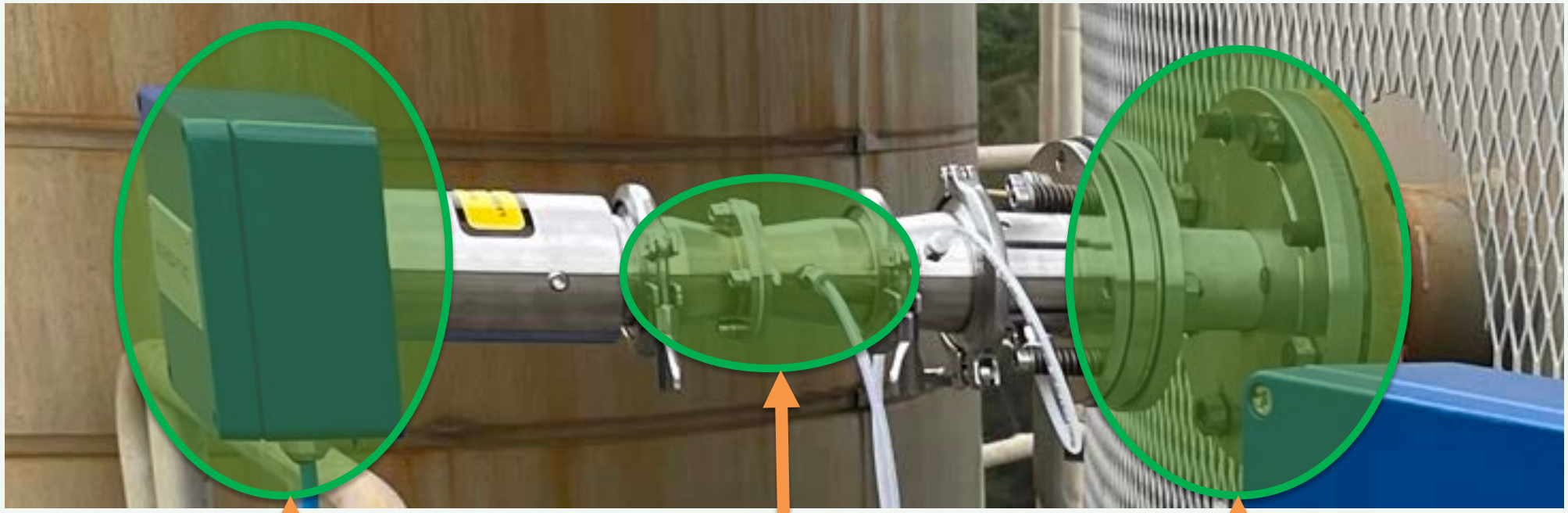
HOW IT WORKS

Installation Detail

Receiver, calibration cell, and adapter flange



SECTION 03

Accuracy, Specificity & Response

Where the number comes from, and how fast you get it.

03

ACCURACY

Published Analytical Performance

DETECTION LIMIT
(@ 5 m path)

CO	< 0.004	NO	< 0.02
CO_2	< 0.004	NO_2	< 0.2

ACCURACY

2%

OF READING

PRECISION

1%

OF READING

STABILITY

≈ 0

DRIFT

Why the Number Holds

- No sample conditioning — nothing is dried, diluted, or converted before the measurement
- No NO_2 converter, so no converter efficiency to verify or replace
- Single-line spectroscopy means no cross-interference from other process gases
- Concentration comes from physics — absorption, path, temperature, pressure

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RESPONSE

Fast Enough to Tune On

100 ms

Minimum T90 response, measured in the duct

5 min

Warm-up from cold to measuring

30–120 s

Typical extractive transport lag — site dependent

Why It Matters for Remote Tuning

- Extractive shows the duct as it was — delayed by probe, line, chiller, pump, and analyzer volume.
- In-situ shows the duct as it is — load, burner, and ammonia changes appear immediately.
- For tuning, transport lag is the limit — not analyzer accuracy.

FIELD EVIDENCE · PATH vs POINT

In firebox CO field tests, a path TDL caught excursions of 8,700 / 2,017 / 1,345 ppm that adjacent point sensors missed — registering only 1 of 6 spikes.

TDL field study · path vs point CO

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TRACK RECORD

This Is Not a Prototype

Installed Base

- 704 GasEye measurement points in service as of the 2021 reference list
- Analyzers supplied 2016–2024: 330 O_2 · 291 CO · 160 NO · 140 CO_2 · 58 NO_2
- Rated to 550 °C for NO/NO_2 and 1350 °C for CO, CO_2, and O_2

Utility Demonstrations

- 2023 — EPRI demonstration on a Southern Company combined-cycle turbine in the Southeast, side by side with the existing CEMS
- 2025 — LG&E Cane Run certified and reported optical CEMS data through ECMPS
- 2026 — M&C combined-cycle Installation and certification of CO/CO_2 and NO/NO_2 in progress

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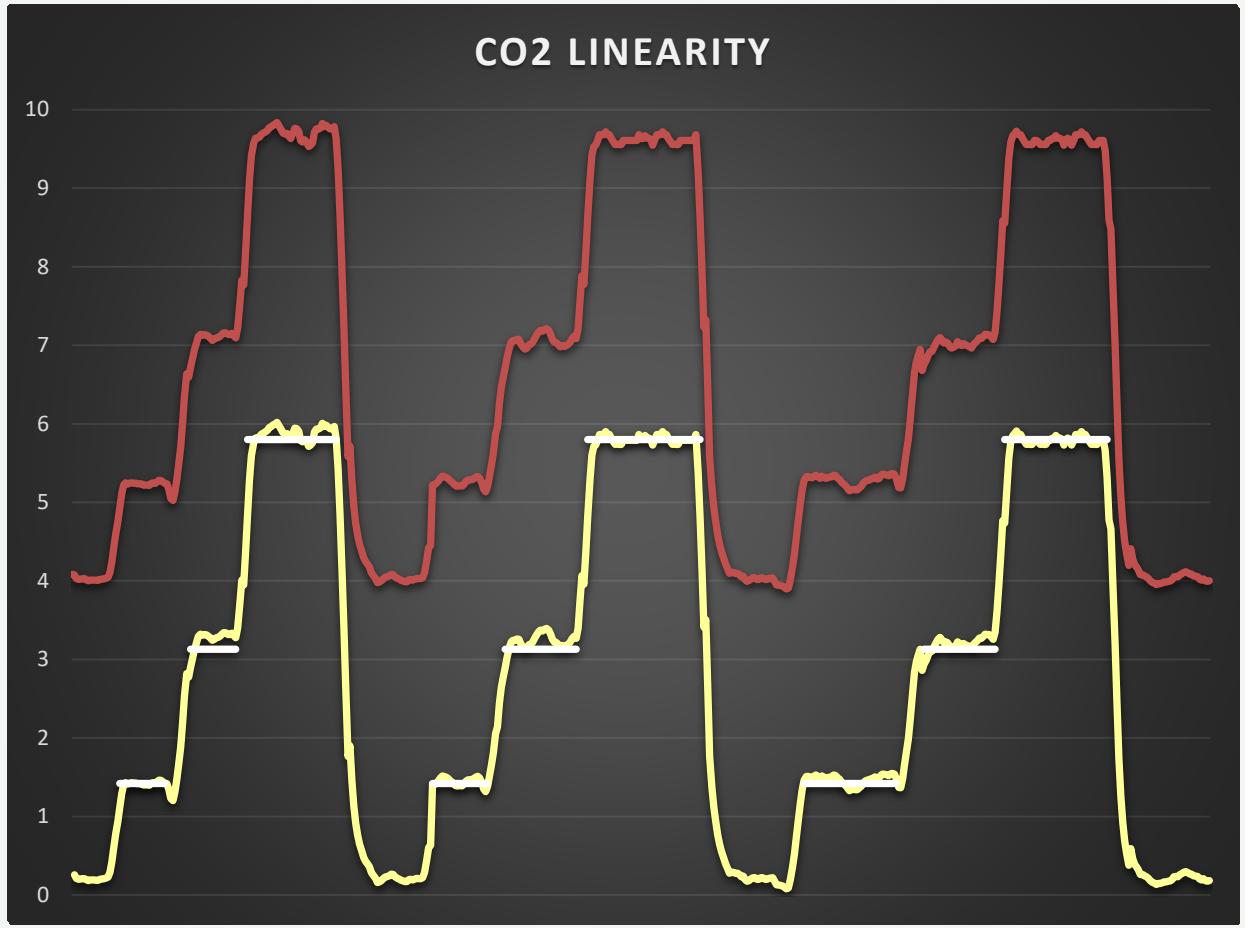
DEMONSTRATION & QA

TDL Demonstration & QA Results

Phase 1 — Linearity

CONC	BIAS	LOW	MID	HIGH
5.24	4.02	1.22		
7.12	4.02		3.10	
9.69	4.02			5.67
5.26	4.04	1.22		
7.08	4.04		3.04	
9.61	4.04			5.58
5.32	4.00	1.32		
7.06	4.00		3.06	
9.62	4.00			5.62
	Average:	1.25	3.07	5.62
	Certified Conc:	1.42	3.13	5.80
	Abs Diff (<0.5%):	0.17	0.06	0.18
	Lin Error (<5%):	11.7%	2.0%	3.1%
	TESTSTATUS	PASS*	PASS	PASS
PASS* indicates Alt PS was used to satisfy requirement				

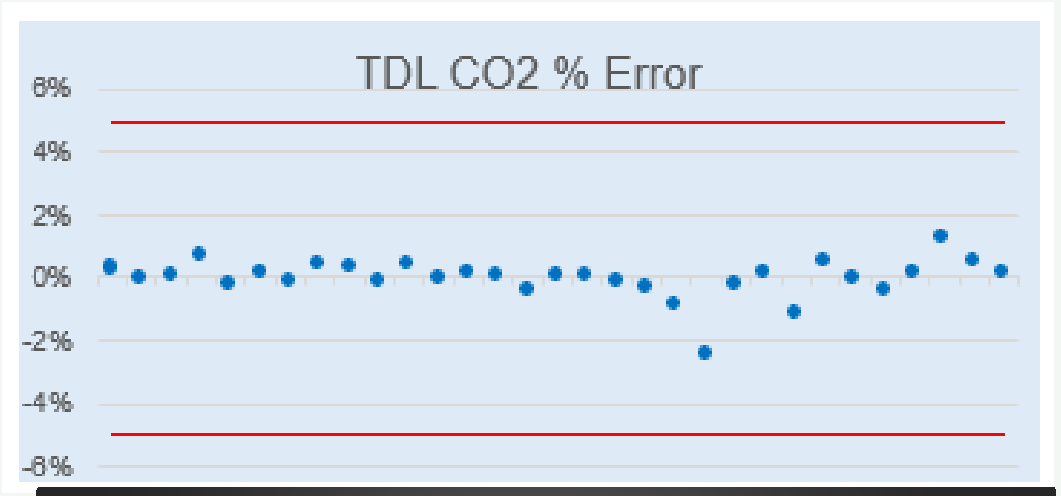


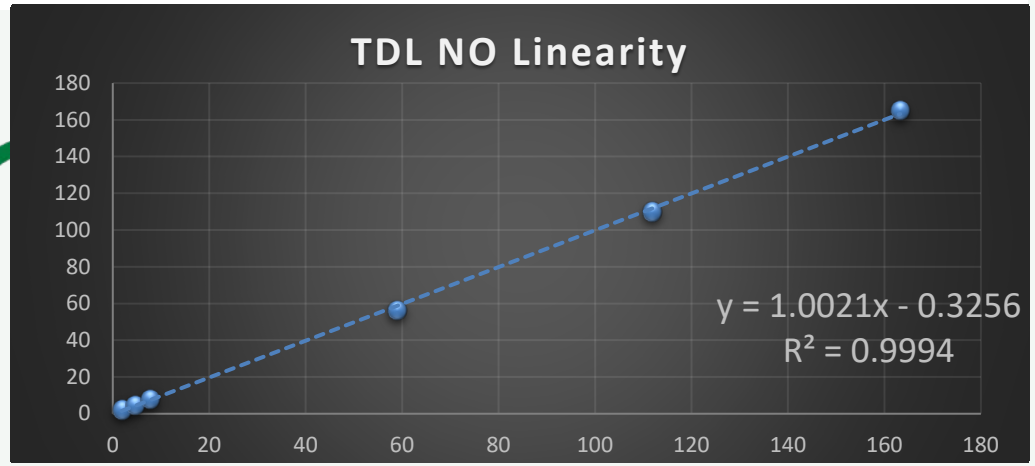
DEMONSTRATION & QA

TDL Demonstration & QA Results

Phase 1 — Summary

- All analyzers passed all Part 75 QA requirements for certification.
  - EPRI had RATA performed
- Calibrations can be passed without external reference or background-subtraction detectors.
- IP-CEMS are a feasible option for NO_x, CO, and (O_2) CO_2 compliance systems.





DEMONSTRATION & QA

RATA Results

Relative Accuracy Test Audit

RATA Summary

COMPONENT	RM	CEMS	ABS DIFF	RA	LIMIT
TDL CO_2 (%)	4.07%	4.16%	-0.09%	**2.48%**	10% RA / 1%
TDL CO (ppm) (pseudo)	0.8 ppm	0.5 ppm	0.28 ppm	**6.0%**	10% RA / 5 ppm
TDL NO_X (ppm)	2.7 ppm	2.6 ppm	0.13 ppm	**9.69%**	10% RA / 15 ppm
TDL NO_X (lbs/mmBTU)	0.008	0.008	0.008	**5.37%**	10% RA / 0.02 lbs/mmBTU

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SECTION 04

What Maintenance Looks Like

The honest comparison — including what you still have to do.

MAINTENANCE

Extractive vs. Cross-Duct

Traditional Extractive System

- Rebuild sample pump
- Replace peristaltic pump tubing
- Rebuild analyzer pumps — NOx, CO, CO_2
- Replace probe O-rings and gaskets
- Verify and change probe filters
- Replace the NO_2 converter
- Replace the IR source
- Abbreviated linearities after each of the above

Cross-Duct TDL

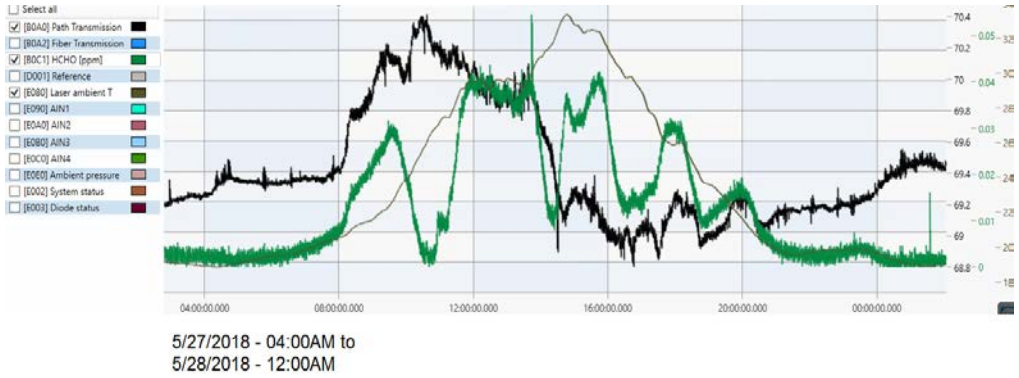
- Verify light transmission is above minimum
- Clean the optical windows when transmission says to
- Check alignment if transmission drops
- Nothing to rebuild, nothing to replace on a schedule
- No moving parts anywhere in the measurement
- No consumables — no tubing, filters, or converters
- Laser life expectancy is greater than ten years

Every item in the left column is a task that also puts the monitor out of service while you do it.

MAINTENANCE

What Upkeep Actually Looks Like

Light Transmission, Trended Continuously



Transmission is recorded alongside concentration. A slow decline means the windows need cleaning; a step change means alignment. The analyzer tells you what it needs before the data goes bad.

- The beam is deliberately defocused so the detector sees a large target — the system tolerates real-world duct movement.
- More than 99% of the light can be lost or off target and the concentration measurement is still valid.
- Mount to structural steel near supports or expansion joints and decouple the optics with flexible gaskets.
- Purge air keeps the windows clean — 20 LPM per path, or blowers.
- Everything on the duct is IP66 and rated −30 °C to +60 °C ambient. No conditioned cabinet on the platform.

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SECTION 05

Making It Work

Install requirements, verification, and the two scopes it can serve.

05

SCOPE

Two Scopes, One Set of Hardware

Process Monitor

- Signals to the DCS for tuning, trending, and control — availability is what matters
- No Part 75 or Part 60 certification, no RATA, no ECMPS, no EPA Protocol gas requirement
- Weekly zero and span through the calibration cell (Optional), with light transmission logged as the health record
- Records kept to the plant's own standard, not a submittal

Compliance CEMS

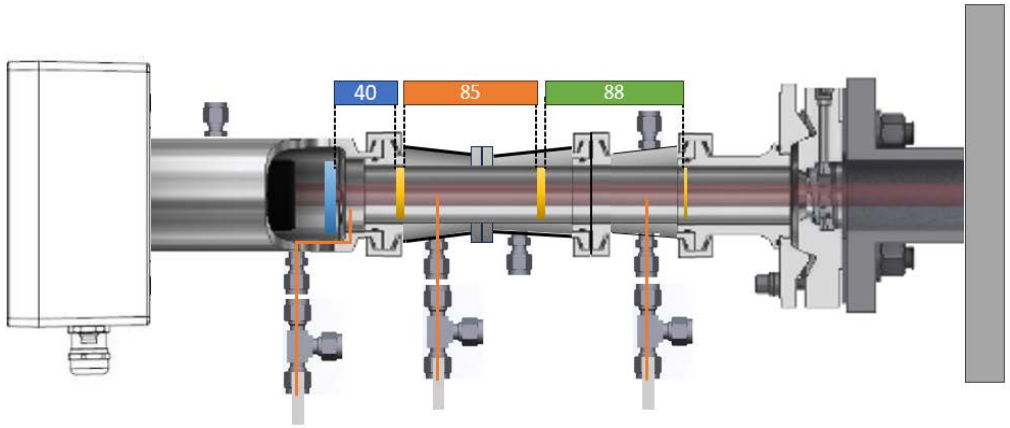
- Monitoring plan and reporting through ECMPS; path monitor per Part 75 Appendix A
- Certification: 7-day calibration error, linearity, cycle time, RATA — the same tests as any CEMS
- Ongoing QA: daily calibration error, quarterly linearity, annual RATA, all through the cell
- EPA Protocol gases at equivalent concentrations, sized to the cell and the duct

Same transmitter, receiver, and central unit either way. The scope decides the calibration cell, the gases, and the paperwork — Section 07 walks through the compliance side in detail.

VERIFICATION

Manual Verification

In-Line Calibration Cell



Cell sits in the optical path on the transmitter or receiver side. Cal gas in, vent out, purged around it.

The Routine

- Analyzer records the native process background before the check
- Zero air, then span gas, flows through the cell in the beam path
- Response is compared against the calculated expected value for that cell — path length, temperature, and pressure corrected
- Background is subtracted; the check passes or it does not
- Light transmission logged at the same time as a health record
- Can be run manually or sequenced automatically

INSTALL

What the Installation Needs

Mechanical

- Four 4" flanges — two per path, opposed
- Path length up to 25 m capability
- Mount near structural supports; decouple with flexible gaskets

Utilities

- One 120 VAC 20 A circuit per path
- 20 LPM instrument air purge per path, or blowers
- Analyzers run on 24 VDC from the central unit

Signals

- 4–20 mA or Modbus TCP to the DCS
- Built-in web server for diagnostics and spectra
- Alarm and status contacts available

What We Need to Size a System

- Duct inside dimension and flange locations
- Process temperature and pressure range across loads
- Available power, purge air, and DCS or DAS I/O

SECTION 06

Ammonia (NH_3) Measurement

The same laser platform — for SCR control, or for a permit limit.

AMMONIA

NH_3 on the Same Platform

Process — SCR Control

- Real-time ammonia slip at the SCR outlet — no transport lag, no adsorption loss in a heated line
- Extractive NH_3 is hard: it sticks to sample lines and forms ammonium salts in coolers. In-situ measures it where it is
- NH_3 and O_2 share one path, so the O_2 correction rides on the same measurement
- Pairs with the NO/NO_2 path for closed-loop reagent trim — outputs to the DCS like every other path

Compliance — Permit Slip Limit

- Low single-digit ppm permit limits sit comfortably above the detection limit at typical stack path lengths
- Zero and span through the same calibration-cell approach used on the NOx and CO paths
- QA built on the path-monitor framework already in front of the agency for the other species
- Light transmission logged alongside concentration — the same health record, the same diagnostics

Optional Path 3 measures NH_3 and O_2 together. Same four flanges per path, same central unit, same DCS interface — nothing new to learn or maintain.

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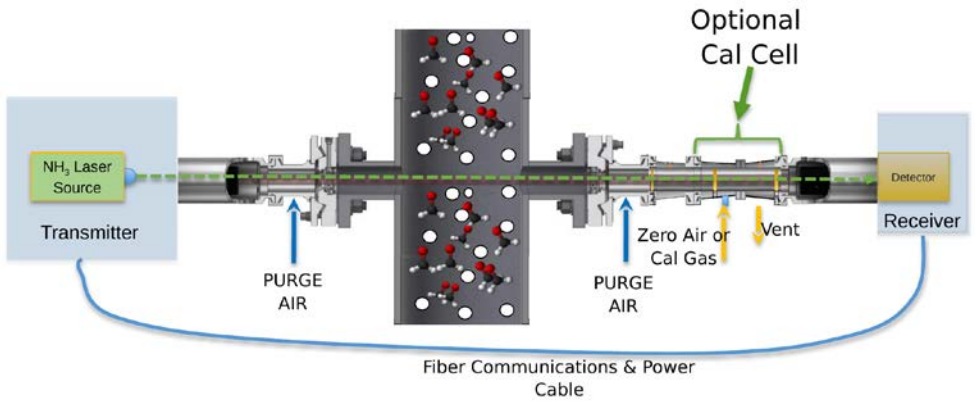
AMMONIA

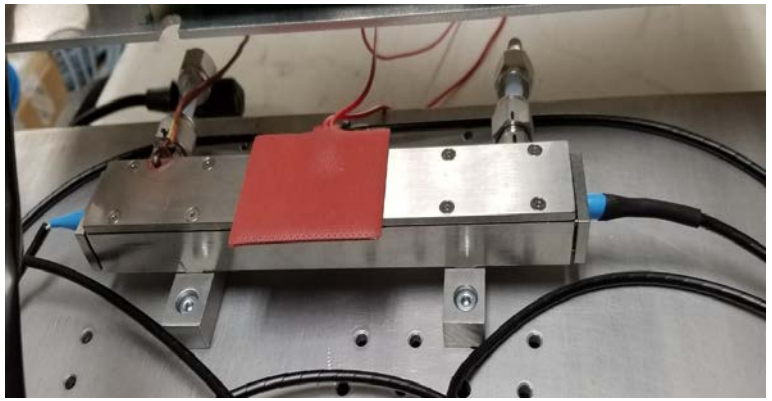
Two Ways to Mount the NH_3 Analyzer

Cross-Duct — Single Analyzer



- Transmitter and receiver on opposing flanges — identical to the NO/NO_2 and CO/CO_2 paths
- Optional calibration cell at the receiver flange for zero, span, and verification
- Everything lives on the duct: IP66 heads, one loop cable, no shelter run

Beam-Split — Analyzer in the Shelter



- Analyzer sits in the CEMS shelter; fiber runs to compact heads on the stack
- One analyzer can serve more than one stack or path
- Internal flow-through calibration cell (pictured) — checks run in the shelter, not on the platform

SECTION 07

When the Measurement Is Compliance

Same hardware, certified under Part 75 — what changes, and what it takes.

07

COMPLIANCE

What Part 75 Already Covers for Path Monitors

Siting & Definition

- Appendix A §1.1.2 defines and sites path monitors — the language closely mirrors PS-18
- A full-duct path answers the stratification question instead of raising it

Certification Tests

- §3.1 Calibration error (7-day drift) · §3.2 Linearity · §3.3 RATA · §3.5 Cycle time
- §5.1 Reference gas — EPA Protocol required, as for any CEMS
- Same tests, same acceptance criteria — nothing waived

Where PS-18 Fills In

- Part 75 does not say how a path monitor's calibration result is calculated; PS-18's formulas have been generally approved
- Parity — bottle tag equal to reported reference value — is not a Part 75 requirement; CAPD agrees, ECMPS accepts

Where It Stands

EPA has accepted a Part 75 monitoring plan built on integrated-path CEMS

2025 — LG&E Cane Run certified an optical CEMS and reported through ECMPS

2026 — M&C combined-cycle NO/NO_2 and CO/CO_2 certification in progress

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COMPLIANCE

Calibration Gas Is the One Real Difference

Equivalent Concentration (PS-18)

$$C_{i,eff} = C_i \times PL_{cell} / PL_{stack} \times T_{stack} / T_{ref} \times LSF$$

The cell is short and cool; the stack is long and hot. The cylinder has to make up the difference.

Path ratio	0.10 m cell on a 5.0 m stack → 0.02	**50×**
Temperature ratio	500 °C stack, 50 °C cell → 2.4	**~21×**
Line strength factor	Instrument- and gas-specific, set at the factory	**~5×**

Cylinders at a Combined Cycle — 100 °C Stack, 50 °C Cell

	SPAN	EFFECTIVE CONC.	CYLINDER
NO	200 ppm	> 160 ppm	**~ 2,400 ppm**
CO	1,000 ppm	> 500 ppm	**~ 7,200 ppm**
NO_2	25 ppm	> 22.5 ppm	**~ 400 ppm**
CO_2	6 % / 16 %	> 4.8 % / 12.4 %	**~ 63 % / 160 %**

85 mm cell. At a 500 °C simple-cycle stack the same spans need roughly 280 / 2,100 / 90 ppm.

NO, NO_2, and CO are available as EPA Protocol gas at these levels. CO_2 is not — which is why the cell design matters: a longer effective cell and a controlled cell temperature bring every number back into reach.

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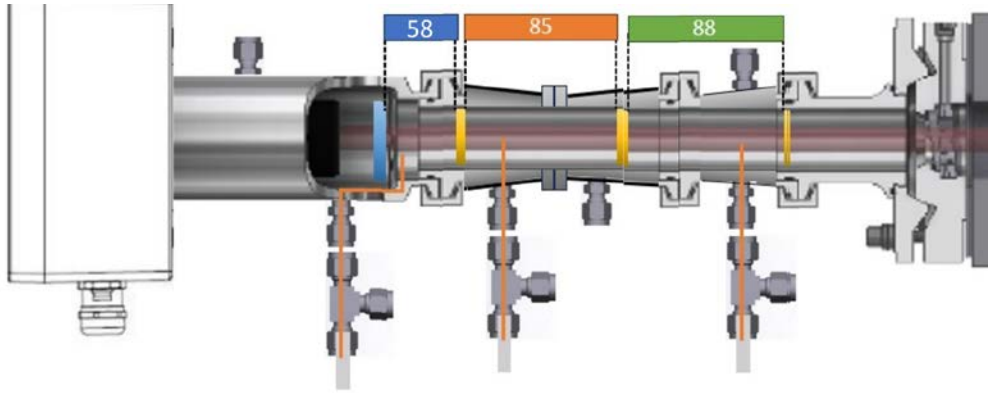
COMPLIANCE

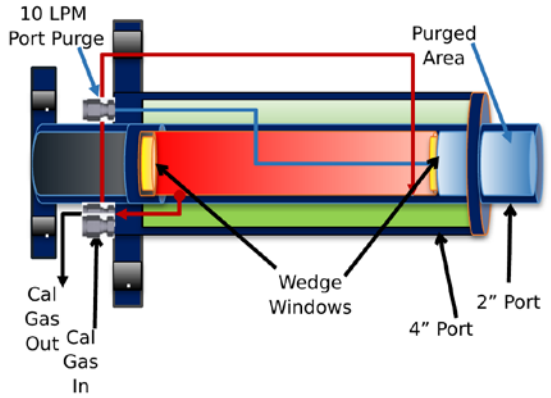
Calibration Cell Options

Three-Section Cell



- Three sections (58, 85, 88 mm) used alone or combined give low, mid, and high linearity points from one workable cylinder set
- Cell temperature is controlled, which sets the line strength factor
- The configuration used at the Southern Company demonstration — every Part 75 linearity ran through it

In-Line / In-Situ Cell



- Cell sits inside the port on a 4"–6" adapter — wedge windows, 10 LPM port purge, cal gas in and out at the flange
- Checks run without disturbing the optical heads or the alignment
- Requires a 6" port; the spool adapter adds length when needed

The cell is sized at design to the actual duct path length and stack temperature range — which is why we ask for both before quoting.

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COMPLIANCE

From Process Monitor to Compliance CEMS

01

Monitoring Plan

- Path monitor per Appendix A §1.1.2
- PS-18 calculation method for calibration results
- Submitted through ECMPS like any other plan

02

Cell & Gas Design

- Cell sized to the actual duct path and temperature range
- Equivalent concentrations calculated per span
- EPA Protocol NO, NO_2, CO specified

03

Certification

- 7-day calibration error, linearity, cycle time, RATA
- Same tests and acceptance criteria as any Part 75 CEMS
- Run through the cell — no sample system in the loop

04

Ongoing QA

- Daily calibration error, quarterly linearity, annual RATA
- Light transmission logged as the health record
- No pumps, filters, or converters on the maintenance schedule

Nothing on the duct changes between a process installation and a compliance one. What changes is the calibration cell, the gases, and the paperwork — and the hardware is ready for either on day one.

MSA The Safety Company

WHY M&C TDL

One Platform, Both Jobs

Better data for process control, a certified path for compliance, and far less to maintain.

Better Measurement

- Full cross-duct path — a true average, not one point
- NO, NO_2, CO, CO_2 measured directly, no cross-interference
- ~2% accuracy, 1% precision, near-zero drift
- Detection limits with headroom across the load range

Less to Own & Maintain

- No sample conditioning to dry, dilute, or convert
- No NO_2 converter to verify or replace
- In-situ, self-calibrating — no sample lines, no field cal
- Proven in continuous duty — SIL2-rated reliability

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