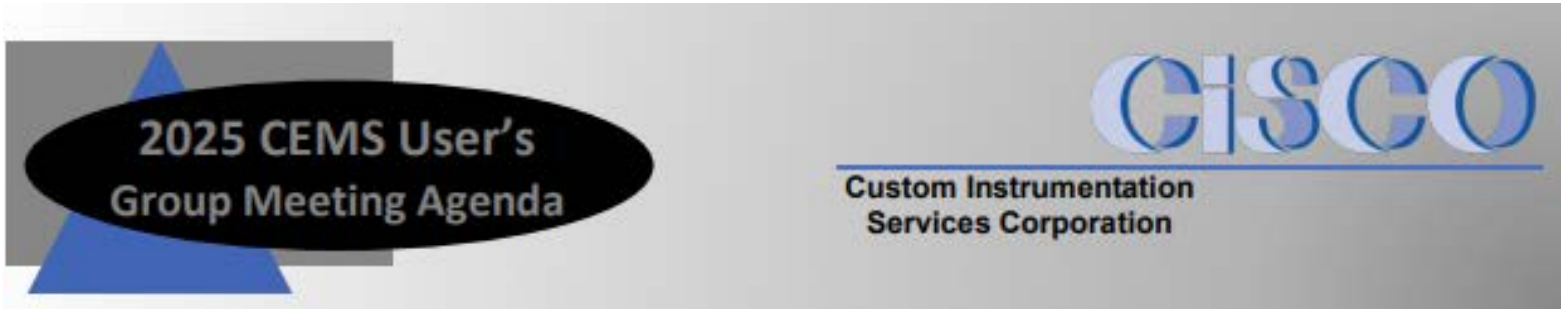
Continuous Emissions Monitoring Systems
-CEMS-
…Heated Sample Line Consideration …

September 2025

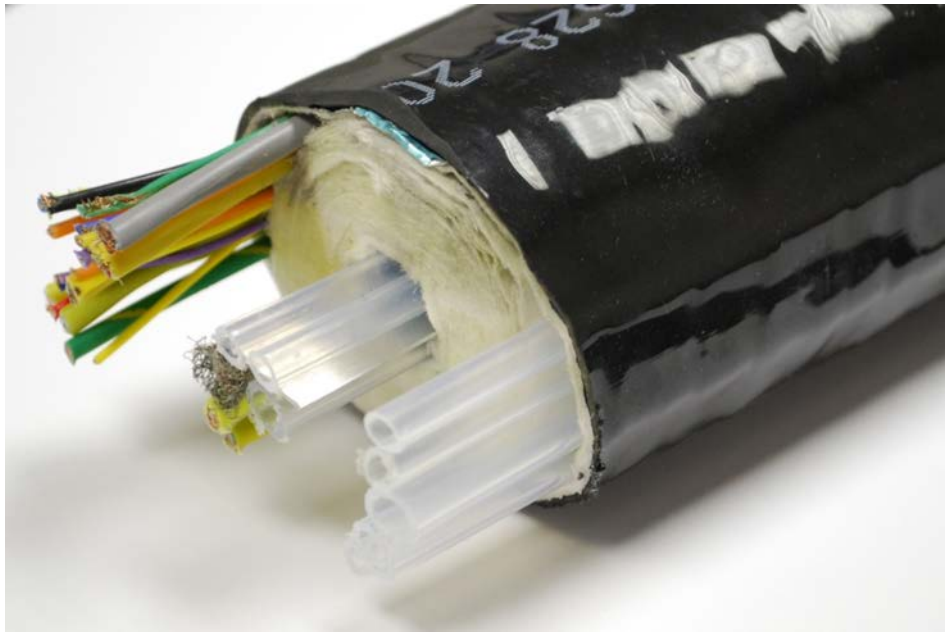


Bob Bertik...

...IT'S ME AGAIN...

- This segment is regarding CEMS heated sample lines
- I will kick it off with a brief discussion on design considerations
- Then hand it over to an industry colleague, Mr. Mike Leuz of CEM Service Group to discuss experiences and best practices for installation

Heated Sample Lines



- CEMS Bundles are an Engineered Product…
- Not an off of the shelf product…
- Very Rarely are any of them the same…

Major Components of a CEMS

A	B	C	D
"Front-End" Sample Conditioning Components	**Analyzers**	**Calibration Gas**	**Data Acquisition Handling and Reporting System**
-Gas Sample Probes ***-Heated Sample Line*** -Gas Coolers / Chillers -Sample Pump -Peristaltic Pump -Ammonia Scrubber Flowmeters, Regulators, Pressure, Vacuum Gauges, Alarms…	-NOx -CO -O2 -SOx -CO2 -HCl -Hg -THC . H2S . CH4	-Span Gases -Zero Gas	-Compliance Software -Data Collection -Housekeeping functions such as calibrations, blow back, alarms, etc.

LOTS TO THINK ABOUT AND CONSIDER

…Too much to read but you get the idea…

Water %, Dew Point, Sample Line Maintain temperature, Process Temperature, Analyzer flow rates, Stack Pressure; Vortex induced vibrations, wall effects, upstream equipment, proximate pipeline bends, positioning in gas flow, center 1/3 sampling, aerosol formation at tip of probe tube, flow eddies at tip of probe tube, particulate accumulation at tip of probe tube, Dust Load, minimizing diameter of sample path, maintaining constant sample pathway diameter, surface finish, selection of surface treatment, appropriate material selection for media, beware use of dissimilar material, minimize length of sample path, minimize number of components in sample pathway, minimize wetted surface areas, minimize internal volumes, dead legs in sample pathway, dead legs in valves and fittings, threaded connections, flanged connections, seals, avoid contamination accumulation, ability to clean entire sample pathway, ability to remove & replace filtered contamination, ability to validate sample system, minimize flow rate, stratification!!

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ONE SIZE DOES
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Application Questionnaire

Like other engineered products, when starting fresh, this or a written spec should always be the guiding document(s)

O'BRIEN

STACKPAK™ Design Request

When completing this form, please indicate units of measurement whenever they are applicable.

°F or °C | ft or m | in or mm | Psig or Barg

Use the TAB key to move to the next input field.

Name: _____
Email: _____
Date Required: _____
Company: _____
Bundle Needed on Site by: _____

Site Conditions

◯Outdoor ◯Indoor
Low Ambient _____
High Ambient _____

Quantity

Quantity Required _____
Continuous Lengths _____
_____

Heating Conditions

Desired Maintenance Temperature _____
Maximum Tube Exposure Temperature _____

Available Voltage(s) _____VAC
Required Approvals _____

Temperature Sensor?
Type (if requested) _____ Sensor Location(s) _____

Heated Process Tube(s)

Tube 1	Tube 2	Tube 3	Tube 4
Material _____	Material _____	Material _____	Material _____
Outside Diameter _____	Outside Diameter _____	Outside Diameter _____	Outside Diameter _____
Wall Thickness _____	Wall Thickness _____	Wall Thickness _____	Wall Thickness _____

Unheated Process Tube(s) (Maximum of (2) metal tubes)

Tube 1	Tube 2	Tube 3	Tube 4
Material _____	Material _____	Material _____	Material _____
Outside Diameter _____	Outside Diameter _____	Outside Diameter _____	Outside Diameter _____
Wall Thickness _____	Wall Thickness _____	Wall Thickness _____	Wall Thickness _____

Messenger Wire(s) Please note High Temperature requirements when applicable

Wire 1	Wire 2	Wire 3	Wire 4
Number _____	Number _____	Number _____	Number _____
Size _____ AWG	Size _____ AWG	Size _____ AWG	Size _____ AWG
Notes: _____	Notes: _____	Notes: _____	Notes: _____
_____	_____	_____	_____

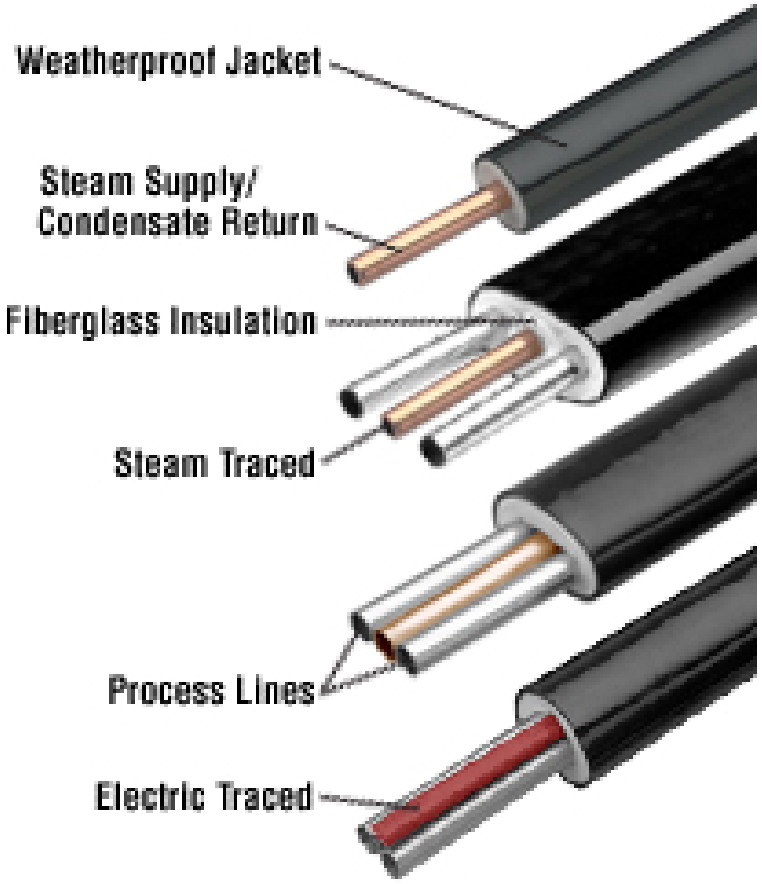
Accessories

☐Power Connection Kit	☐Heat Shrink Boot	☐Thermostat/Controller	☐Jacket Patch Kit
☐End Termination Kit	☐Entry Seal	☐Tracer Splice Kit	☐Silicone End Sealant

SUBMIT RESET

AMETEK® THERMAL PROCESS MANAGEMENT

What is a tubing bundle?



A tubing bundle is a small diameter tube or group of tubes packaged in an insulated, weatherproofed jacket. It's either steam or electric traced to provide freeze protection or temperature maintenance of process fluid or gasses.

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What does a tubing bundle do?

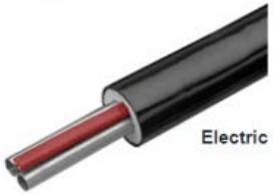
Two Heating Methods

Electric

Steam

Why Do We Heat? – Two Reasons

Prevent Freezing



Keep sample above a dew-point

Heated Sample Line Design

Design starts with input from the Customer:

- Ambient temperatures (high/low – Coldest Day of the year)
- Maintain temperature (Dew-Point consideration)
- Maximum inlet temperature
- Operating voltage and circuit breaker sizing
- Heated tubes (qty, size, wall thickness, material, spares)
- Unheated tubes (qty, size, wall thickness, material, spares)
- Imbedded Sensor and Pass-Thru Wires
- Area approval requirements (Hazloc Div I, Div 2, GP, etc.)
- Temperature control/monitoring (i.e., sensor type and location)
- Length (it can be cut and trimmed to fit in the field…go long!)
- End preparation (e.g., flush cut, finished, extensions)
- Jacket material (UV protection, lowest ambient protection)
- Special printing on outer jacket

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Heated Sample Line Design Continued

- Part of the design of every sample line bundle requires a thermal dynamic calculation
- Computer modeling of predicted temperature distribution within the bundle
- Using the content specifications (tubing, wires, what's heated, what's not) the model accurately predicts the temperature performance under the given process conditions
- Formulas are based on worst case conditions and identify proper type and sizing of the heat trace, heat transfer aids such as mylar foil and the amount of insulation
- *Key Considerations*
  - Ambient conditions
  - Maintain temperature
  - Constant temperature control
  - Dew point management
  - Material compatibility
  - Contents

Consequence of Condensation

- Loss of Analyte, What you are trying to measure
- Water mixing w/ particulate, blocking the flow path
- Corrosion if the liquid is acidic
- Delayed response times

Tubing Selection

Common Materials

- **TEFLON**
  - Inert but with temperature limitations (typically < 400ºF) + Permeation
- **STAINLESS STEEL**
  - welded, seamless but cleanliness and adsorption problems with some applications
- **ELECTRO-POLISHED**
  - Improved surface finish for improved adsorption resistance and improved response times
- **ELECTRO-POLISHED / SILCONERT COATED**
  - For a product that is chemically inert but strong as steel
  - Prevents adsorption of sticky molecules vs untreated metal surfaces
  - Recommended when measuring low levels of sticky or reactive compounds (e.g. SO2, H2S)
  - Can be used for PFAS material replacement

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Imbedded Sensor(s) & Pass-Thru Wires / Electrical Conductors

Common Materials

- Sensors for Control or Remote Monitoring or Pass thru
  - Thermocouple (type K or J), RTD (2-wire; 3-wire)
  - Location within sample line – sensor wants to be placed so that when installed it is reading ambient temperature not inside a shelter
  - Pass thru sensors can also be considered for other heated devices (e.g. heated probe tube, Ammonia Converter)

- Pass thru Power Wires (e.g., heated filter, heated probe tube, Ammonia Converter)
  - 14, 16 or 18 awg (chosen based on length of travel)
  - Color coded? (black, white, green perhaps))
  - Jacket material? (Teflon (< 400ºF) | PVC (< 220ºF)

- Pass thru Signal Wires (e.g., BB SOV, Alarm)
  - 16 or 18 awg (chosen based on length of travel)
  - Color coded or all black (all black unless you ask for multi colors)
  - Jacket material? (Teflon (< 400ºF) | PVC (< 220ºF)

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Installation and Routing – Lots to Consider

- Plan the installation with the appropriate number of qualified personnel
- Will we need a crane or man lift
- Use Kellum style grips to pull vertical sections
- Post personnel at all bends/turns to avoid damage
- Do not twist the tubing bundle
- Allow extra length for each installed run
- For tracer power and end termination
- Enough scrap for tube routing
- To account for zones on power limiting tracer
- Use wide bands or clamps to hold in final position
- Horizontal runs require a maximum of 6ft spacing between supports
- Vertical runs require a maximum of 15ft spacing between supports
- Use a downward slope to the enclosures
- Supports need to be rigidly held
- Do not over-clamp or deform the sample line
- Fully support all bends
- Do not exceed the minimum bend radius (8” or 12” depending on design)
- Avoid running near external heat sources
- Keep a minimum of ½” air gap between lines
- Do not run in an enclosed tray, air must be allowed to circulate
- If asymmetrical (finished end, factory temp sensor, etc.), make sure and install in the correct orientation
- Once installed and clamped, complete a visual inspection to look for damaged jacket, unsupported areas, or tight bends

Protect from moisture ingress/seal ends

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While this again was brief, I hope I shared some food for thought. Please reach out if you have any specific questions that I didn't cover or if you have a nagging CEMS Sample Line issues and often think to your self…

…"there's got to be a better way!"

THANK YOU FOR YOUR TIME!!!
…AND A BIG THANKS TO CISCO…SHANE, WALT AND THE TEAM FOR ALLOWING ME THE OPPORTUNITY TO ADDRESS Y'ALL!...

BOB BERTIK
UNIVERSAL ANALYZERS
+1(805) 218-2746