



Perma Pure – Baldwin – Clayborn Lab



Introduction

For over 40 years, Perma Pure Nafion® Gas Sample Dryers have been successfully designed into a wide range of CEMS and analysis equipment and are used in many scientific experiments.

The main application is the replacement of Desiccant or the Peltier or Compressor Gas Cooler to solve water problems.

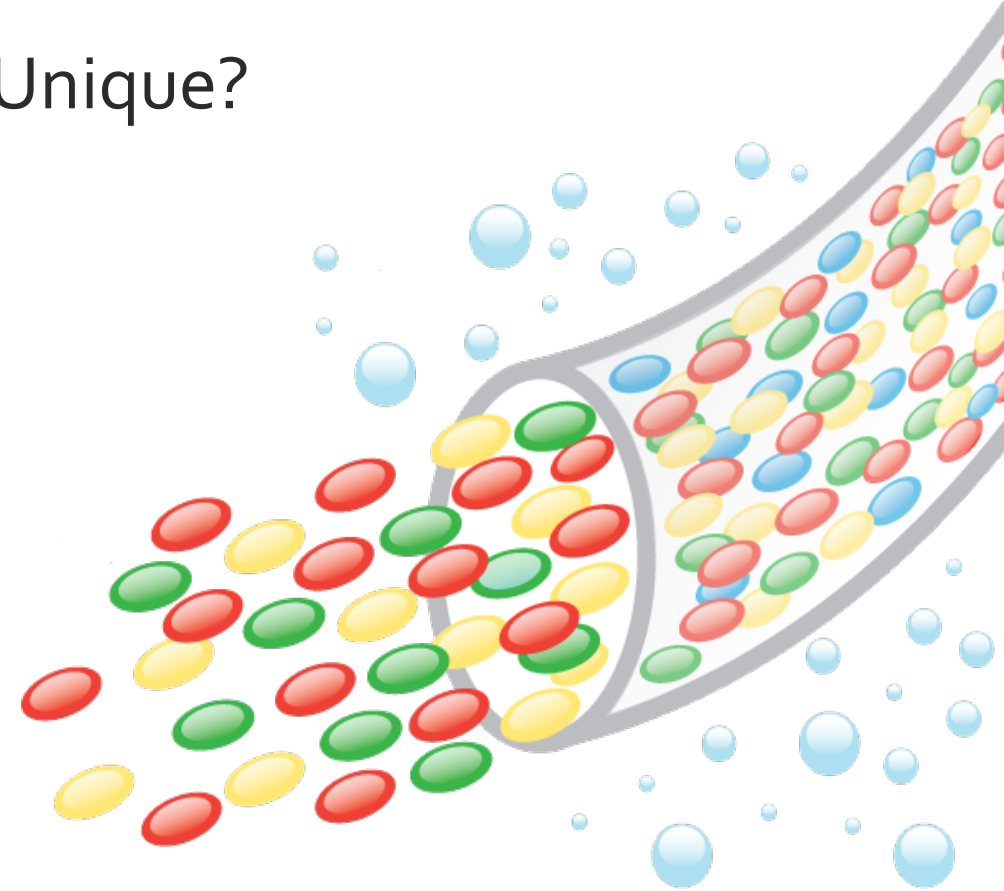
This training will have four parts:

1. Introduction to Nafion® Tubing & Dryers for Scientific Applications
2. Benefits of Perma Pure Systems for CEMS and Process Analysis
3. Baldwin Coolers, Probes, and Systems for CEMS
4. Clayborn Lab Heated Sample Lines

What is Nafion?

Why is Nafion® Selectivity so Unique?

- Nafion® is a copolymer of Teflon and Sulfonic acid and is highly resistant to chemical attack.
- Nafion® removes water by a First Order Kinetic reaction so equilibrium is reached very quickly (typically within milliseconds).
- The transfer of moisture is driven by the differential water vapor pressure between the membrane sides.
- Nafion® permeation selectivity is based on chemical reactivity, not the size of the molecule – not traditional permeation.
- Only compounds that chemically associate with sulfonic acid permeate through Nafion®. Because this is a specific chemical reaction with water, the process is very selective and many gases being dried are entirely unaffected.



Nafion® Im-Permeability

Totally Retained in Sample

Atmospheric Gases

Ar He H₂ N₂ O₂ O₃

Halogens

Br₂ Cl₂ F₂ I₂

Hydrocarbons

Simple forms (alkanes)

Inorganic Acids

HCl HF HNO₃ H₂SO₄

Other Organics

Aromatics Esters Ethers

Oxides

CO CO₂ SO_x NO_x

Sulfur

COS H₂S Mercaptans

Toxic Gases

COCl₂ HCN NOCl

Typical Combustion Analytes

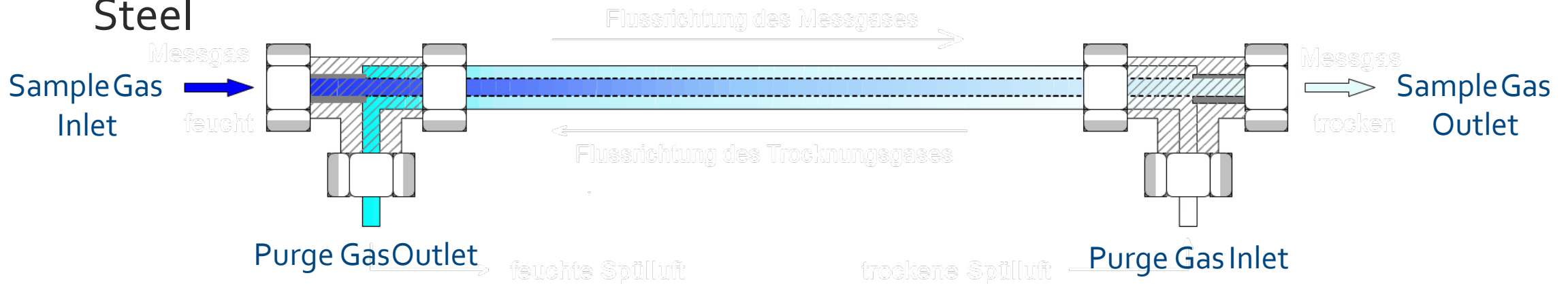
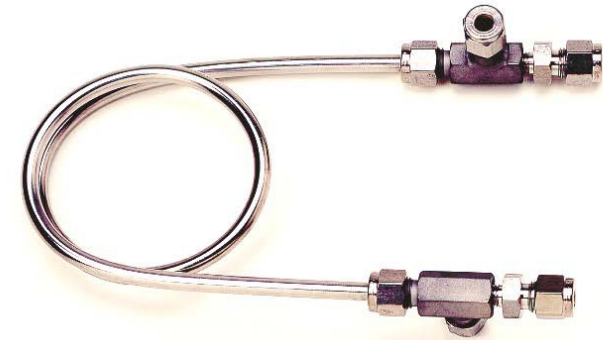
BE Series (Braided Exchangers)

- Braided Nafion® Tubing is exposed to the atmosphere
- Ultimate performance is a function of the dew point of atmosphere where unit is operating
- Often used to equalize humidity of a Cal gas stream with the sample gas
- Available in a variety of lengths and tubing diameters
- Flow rates up to 2 lpm

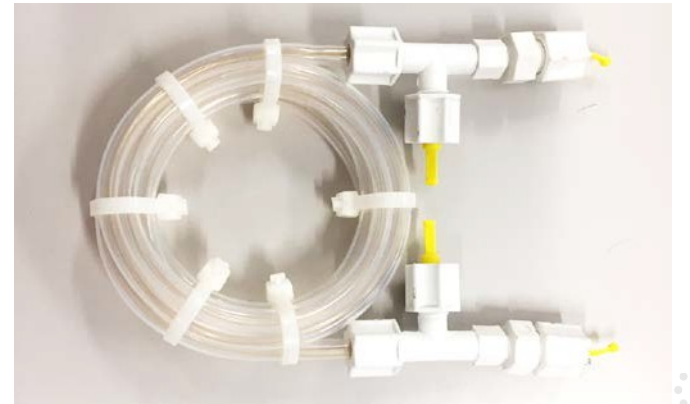
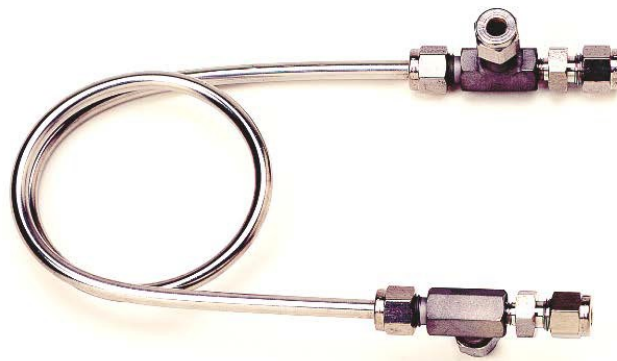


MD Series (Monotube Dryers)

- Simple tube in shell design functions with water vapor similar to how a heat exchanger transfers heat.
- Available in a wide range of dryer lengths and tubing diameters
- Materials in in PP, Fluorocarbon and Stainless Steel



MD Series (Monotube Dryers)



MDH Heated Dryer

Heated MD in a coiled enclosure

- First 12" heated to 80C
- For sample streams with higher than ambient dew point, up to 70 C dew point (30% water by volume)
- Up to 1 lpm
- Faster moisture transfer at inlet
- Use 10x purge flow
- 110 and 220VDC

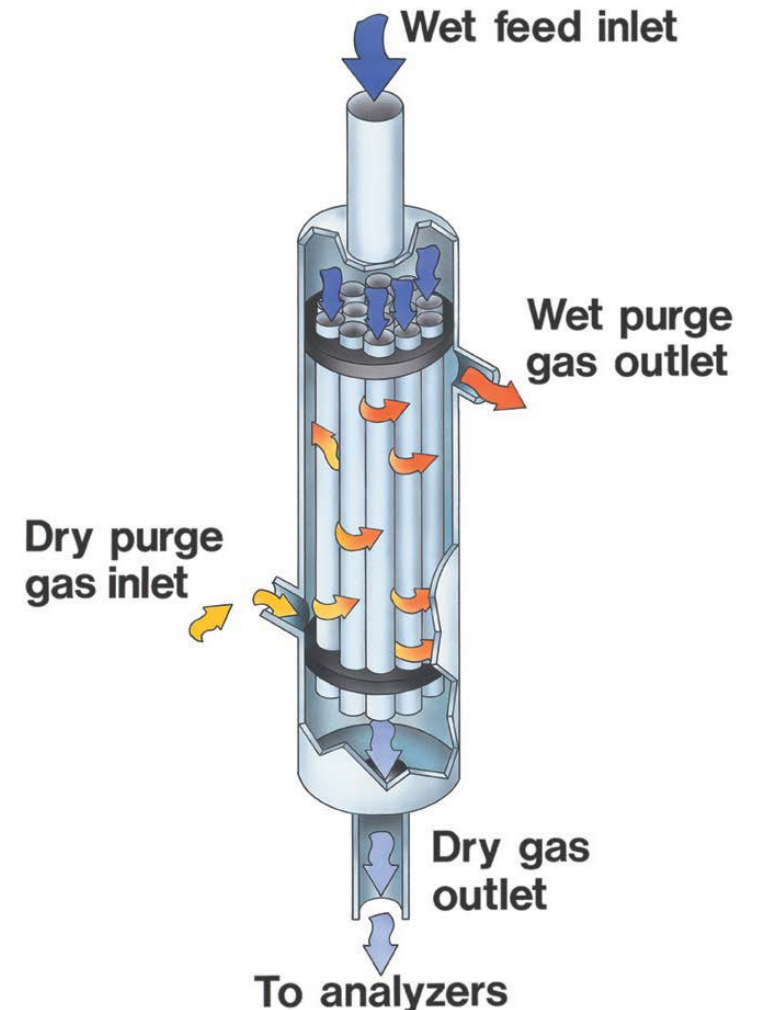


PD Series



PD Series Dryers

- Simple tube in shell design functions with water vapor similar to how a heat exchanger transfers heat
- Multiple tubes in parallel to increase flow rate capability and efficiency
- Dryers are corrosion-resistant and rugged, making them long lasting and tolerant of very harsh samples
- No routine maintenance required
- Reliable and easy to operate
- Most common dryer used with CEMS



Typical Drying Applications

- Sample gas conditioning to remove water
 - Protection of equipment
 - Higher accuracy
 - Retain water soluble compounds
 - Continuous stream or batch water removal
- Sample Gas Conditioning Systems for CEMS
- Continuous drying of ambient air for use in other processes
- Aerosol & Particulate Analysis
 - Maintain RH for consistent measurements during the daily RH cycle
 - Replace desiccant column
 - Flow rates < 1 lpm

Benefits of Using Perma Pure Nafion Systems for CEMS

What We Will Cover Today

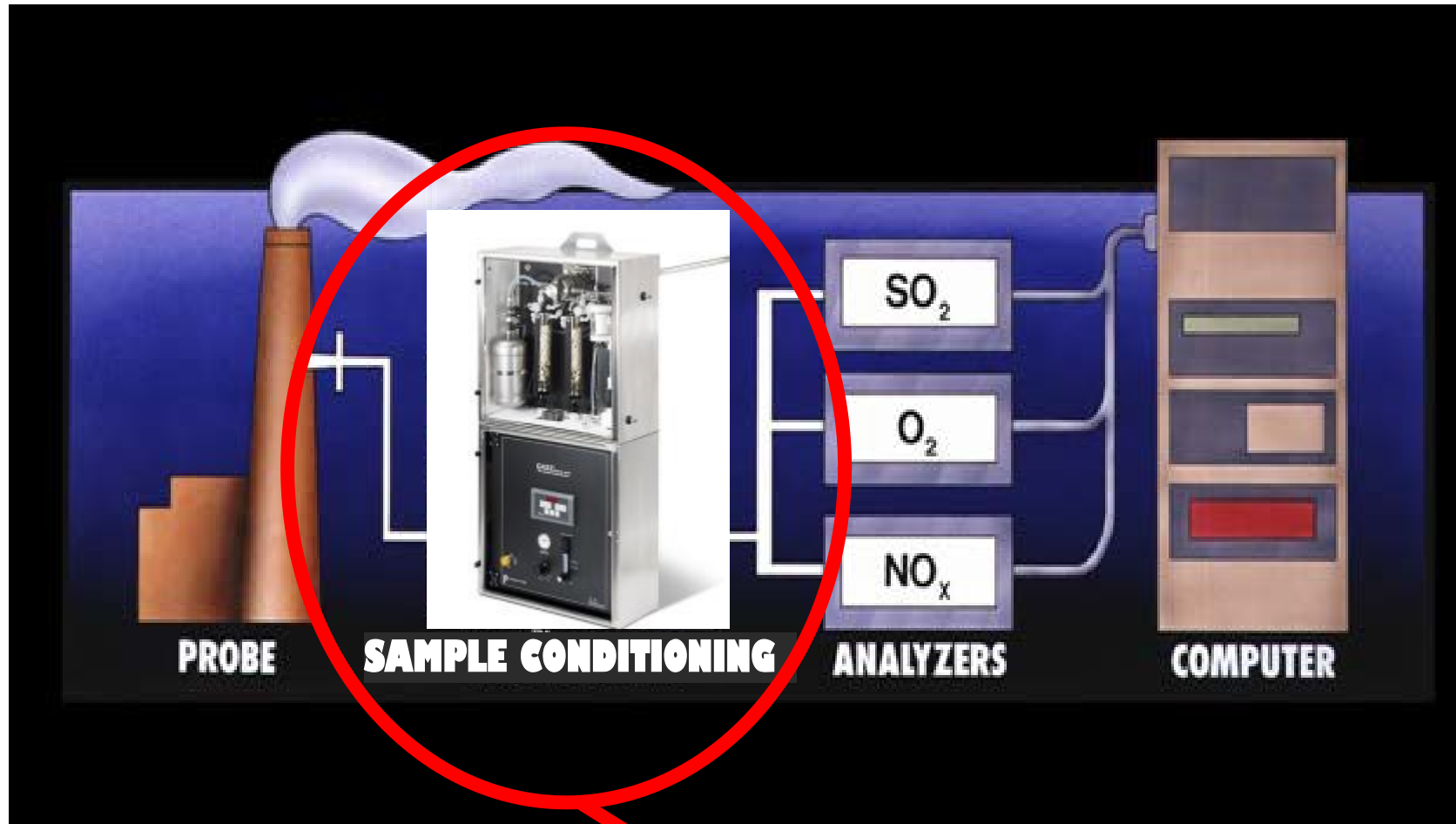
How Perma Pure's Nafion Based Sample Conditioning Systems for Cold Extractive and other CEMS...

- **Slash** Installation, Maintenance, and Operating Costs
- **Increase** System Reliability
- **Solve** Common Application Problems

The Proven Solution for CEMS Sample Conditioning



Combustion Gas Analysis



Perma Pure Systems
Perma Pure
Breathe Easier. Be Healthier.
maxtec

Key Technology Differentiators

1. Slash operating costs from removing water in the vapor phase and drying the gas to a lower dew point
2. Increase system reliability from the elimination of the potential for catastrophic failure
3. Reduce costs further by mounting the system on the stack to eliminate the heated line and drop calibration gas usage
4. Add Ammonia scrubbers to further cut costs

Result: Nafion Systems Can Pay for Themselves In Less Than 12 Months

Consequences of Drying CEMS Samples to a Lower Dew Point in the Vapor Phase

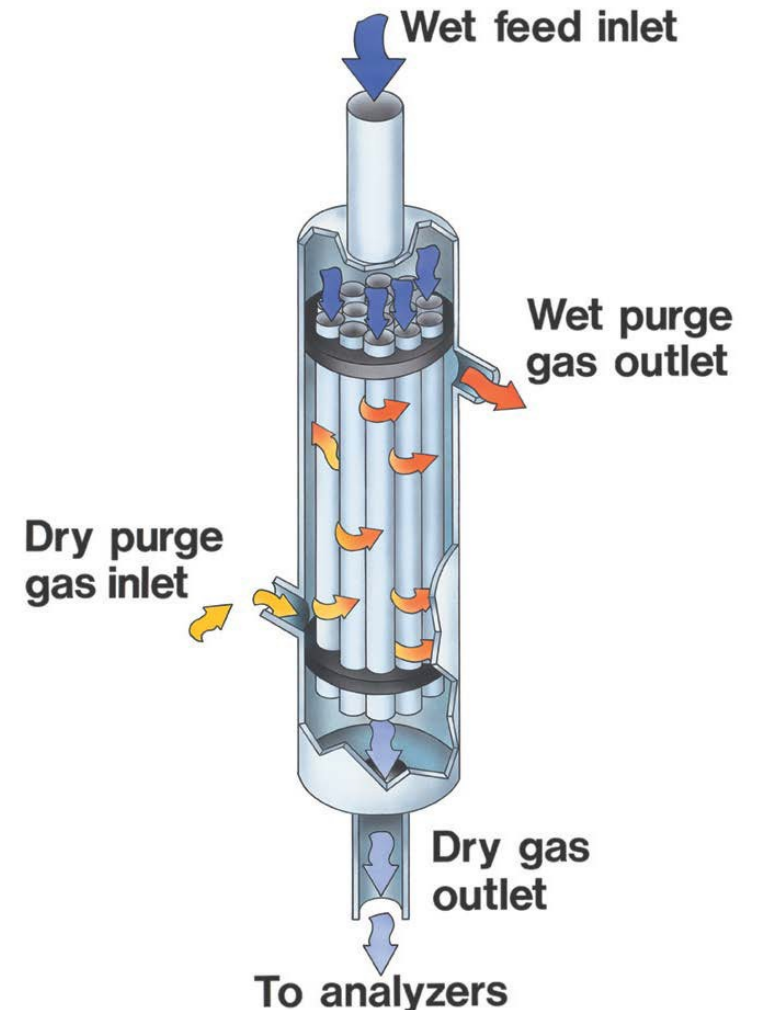
Drastically Lower CEMs Maintenance and Operation Costs

- Protection of analyzers - reduction of acid mists that condense on analyzer optical bench
- Eliminate damage to analyzer or system components
- Potential to solve many application issues stemming from the presence of water
- Loss of water-soluble analytes (SO₂, NO_x, Cl, etc.)
- Interference in infrared or other measurements
- Clogging of line or system components



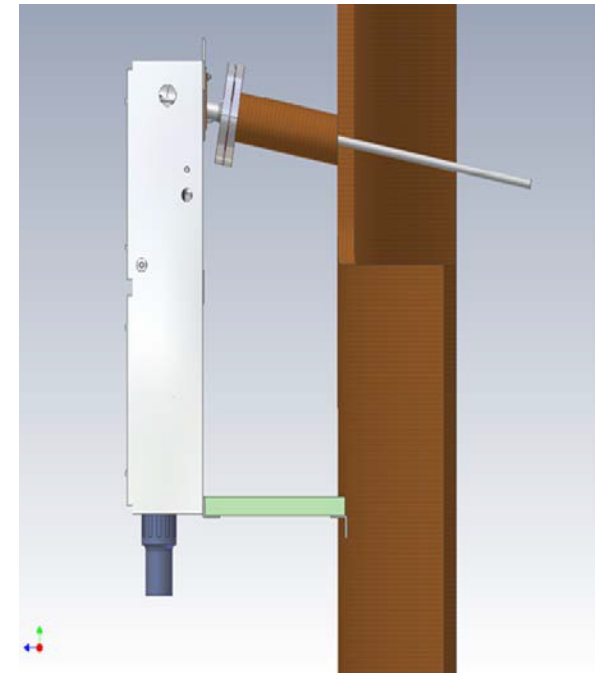
Nafion Dryers = No Catastrophic Failure Mode

- Tube in shell design with multiple tubes in parallel to increase flow rate capability and efficiency.
- Final dew point can be as low as -15°C to -25°C
- Dryers are corrosion-resistant and rugged, making them, long lasting and tolerant of very harsh samples
- Flow rates to 20 l/m, pressures to 80 psi (5 bar) in the tube when dry
- No routine maintenance required
- Reliable and easy to operate
- Most common dryer used with CEMS



Where to Mount the Sample Conditioning System: On the Stack!

- Further Huge Reductions in Installation and Maintenance Costs
- Elimination of the heated line
 - By drying and treating sample gas at the stack, you are now transporting dry sample gas, so the heated sample line is no longer required.
 - Savings: Heat-traced sample line at \$30-\$60 per foot can be replaced with freeze-protect or simple multi-line umbilical at one fourth to one third the cost.
 - Total savings: depends on sample line length – from \$5,000 up to \$30,000+



Where to Mount the Sample Conditioning System: On the Stack!

- Further Huge Reductions in Installation and Maintenance Costs
- Eliminate clogging of line or system components
 - Elimination of unwanted chemical reactions downstream
- Shortening response time due to adsorption/desorption = Greatly reduced calibration gas consumption
 - Teflon sample lines absorb water and SO₂ will bleed in and out of it, when cal gas sucks moisture out of the Teflon. So it takes forever to get to zero.

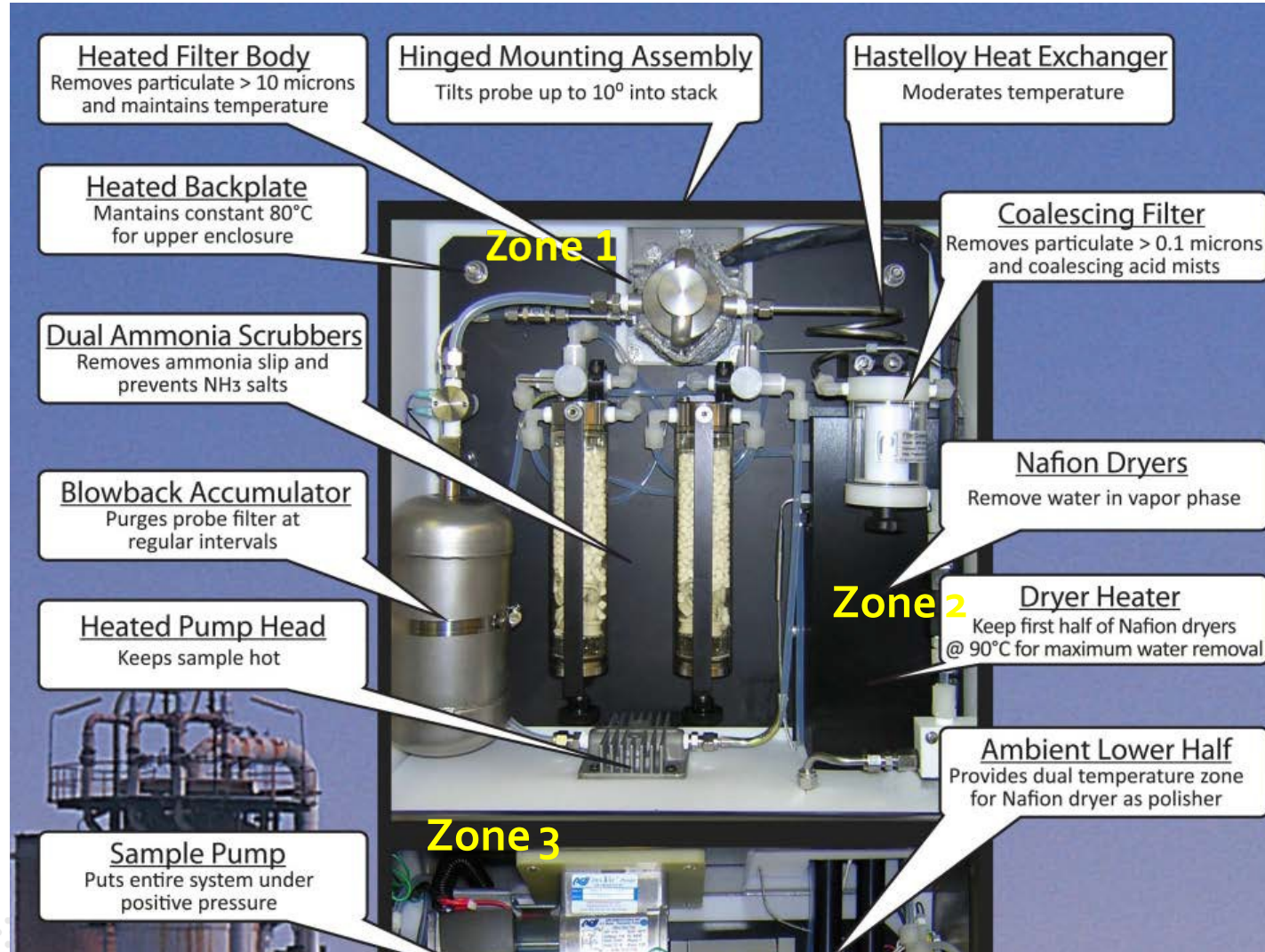
How Perma Pure Systems Work

The Proven Solution for CEMS



Perma Pure's CEMS Tri-Zone Nafion Management System

Zone 1 Heated Enclosure



Zone 2 Heated Dryer Inlet

Zone 3 Ambient Dryer Exit

The Tri-Zone Nafion Management System

Nafion[®] Sample Conditioning Systems have three zones to enable Nafion[®] Gas Sample Dryers to be used effectively for long term CEMS operation.

Zone 1 – Heated Cabinet – Here the sample is maintained at a temperature to prevent condensation – from the probe, the sample flows through a heated 0.1 micron coalescing filter and an ammonia scrubber (if required) before it is sent to the Nafion[®] Dryer.

Zone 2 – Heated Dryer Entrance - the sample is flowed through the heated portion of the dryer to maintain the water in the vapor phase where the bulk of the water is removed

Zone 3 – Ambient Dryer Exit – the sample moves to the second half of the dryer in the unheated portion of the system. It is cooled and polished to the end dew point as low as -25 C. The clean and dry sample then exits the system and is routed to the analyzer.

GASS Series Nafion® Sample Systems

- Low final dew point of -10°C to -45°C
- Non-corrosive components accept high concentrations of strong acids or organics
- No moving parts in standard system for low maintenance and high-reliability
- Flow rates from 1 lpm to 25 lpm
- Water content up to 75% by volume
- Handles and dries samples that would overwhelm a chiller system
- Choose the system based on flow rate requirement and sample gas components



GASS Series

- GASS 2040 / GASS 6000– up to 25 liters per minute (lpm), very wet gases, blowback, stack-mounted,
 - GASS 6000 includes a special humidity sensor
- Mini-GASS 1228 – up to 5 lpm
- IndiGASS – up to 5 lpm, no ammonia scrubber
- ReadigASS – up to 5 lpm, no clean instrument air available
- GASS 35 – portable unit, up to 2 lpm, no instrument air required
- Micro-GASS – heated, 1 liter per minute
- ACES – Ambient temperature, 1 lpm, using reflux vacuum.

Portable
Mini-GASS
System



Hybrid Cooler Design – Internal View



Solutions to Benefit Existing Cooler Based Systems

Lowering Costs and Increasing System Reliability



Supplemental Drying System (SDS)

Install a Perma Pure Drying System between the Cooler and Analyzer.

Benefits:

- 1) Protection of analyzer against cooler catastrophic failure
- 2) Lowers the dew point of sample gas
 - SDS – “Cooler Booster”
 - Single or double 12” PD Nafion dryer
 - Reduces dew point from 4°C to -15°C or -20°C
 - Flows up to 10 lpm



Ammonia Scrubbers and How They Help Lower CEMS Operating Costs



Solution: Ammonia Scrubber for Coolers

- Protects analyzers and downstream components
 - Eliminates ammonia salt deposition
- Very selective reagent
 - Phosphoric acid removes only bases
- Very high corrosion resistance
 - Housing: stainless steel, polysulfone
 - Element: H_3PO_4 on inert ceramic
- Reliable and low maintenance
 - No moving parts, only periodic refills

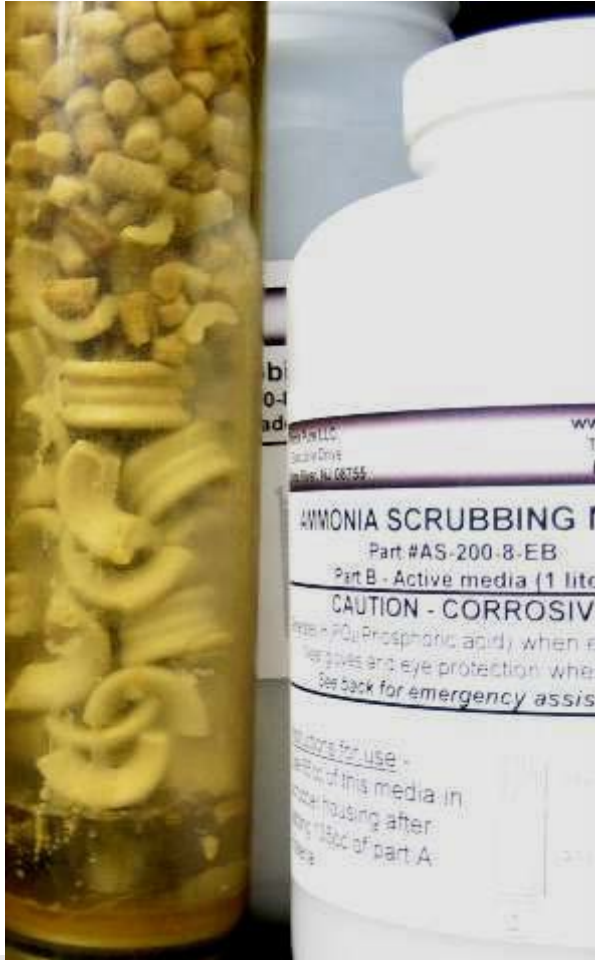


Hot, Wet Chemistry

- Target Temperature 80-90°C
- Ammonia reacts in vapor form
- Water remains in vapor form
 - Otherwise, bottom fills with liquid
 - Heater blanket maintains 90°C
- Or, maintain 80-90°C in heated enclosure
- Phosphoric acid anhydride reacts with water, then forms ammonium phosphate salts on inert ceramic



Ammonia Scrubber Maintenance



Refill media every 40,000 liter/ppm/hours

Hand tighten mounting screw

Example:

- Flow rate = 10 lpm
- Slip = 5 ppm
- Change Media every 33 days

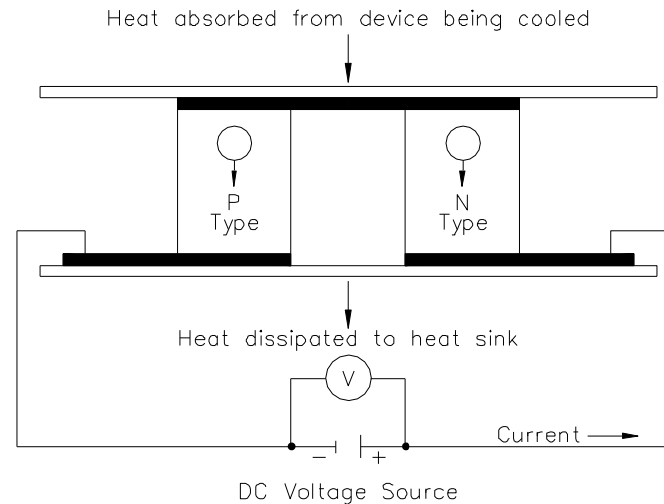
Baldwin™ Digital Coolers - Features

Baldwin's Classic and M Series cooler lines have been redesigned with the following world class features:

- Reliable dedicated Digital Control System keeps your system operating efficiently
- Advanced P.I.D. control algorithm increases temperature control precision to maintain analysis accuracy
- Continuous display of temperature eliminates guess work – a quick look tells it all
- Alarm outputs provide alarm interface capability for your data acquisition system as well a direct control of sample pumps

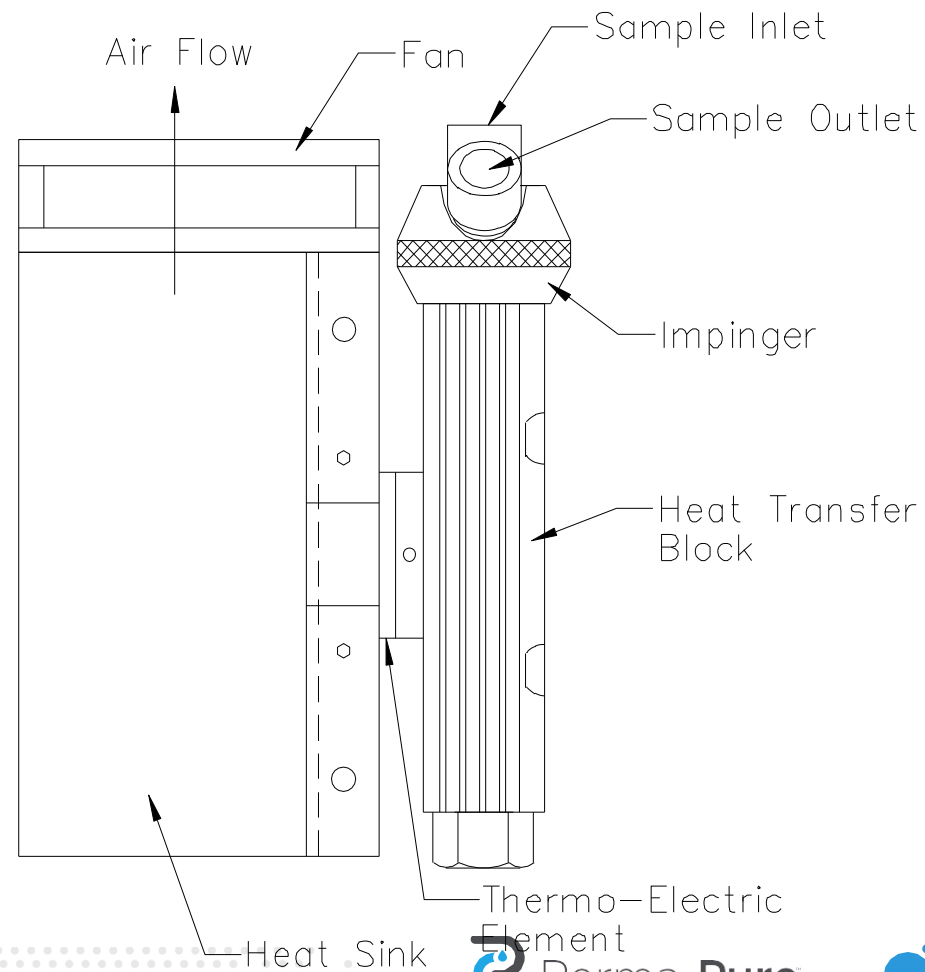


Thermoelectric Principle

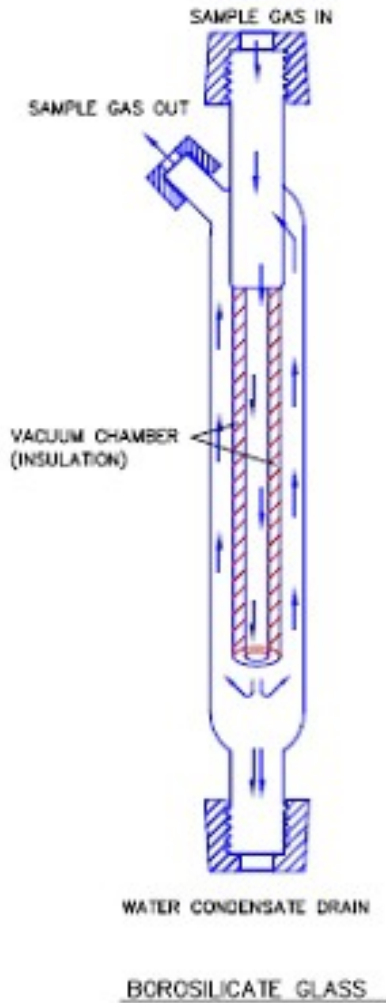
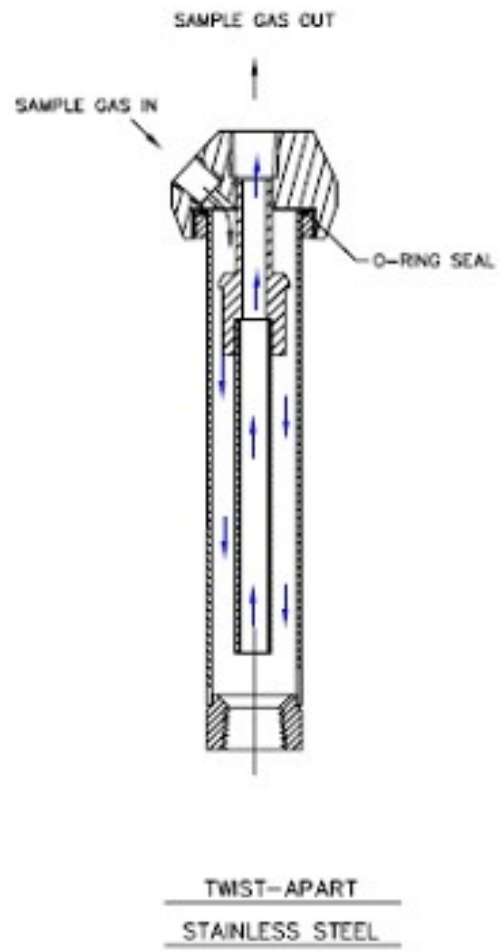
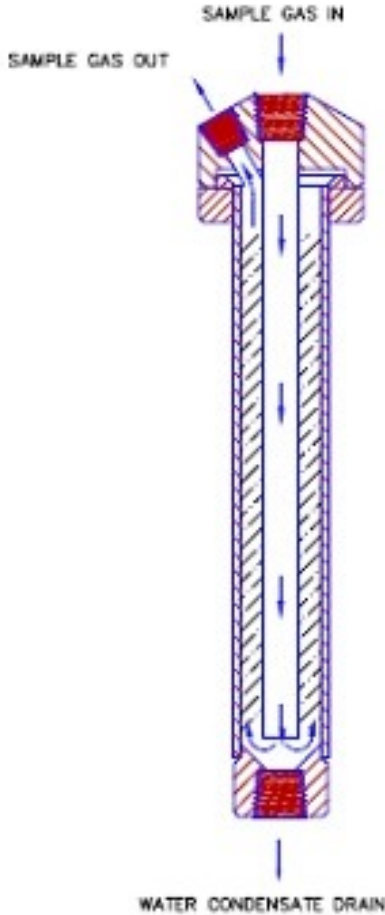


A Peltier element is a type of electrical device that acts like a miniature heat pump. When power is applied to it, the device will transfer heat from one side of the device to the other. The cold side is used to cool the sample stream. There are no moving parts in this device, so it is considered a 'solid state' component, therefore making it very rugged and reliable.

Basic Cooler Components



Impinger Designs

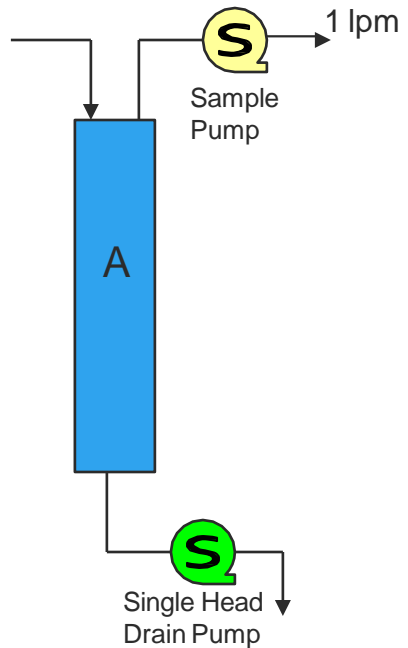


Chiller Configurations

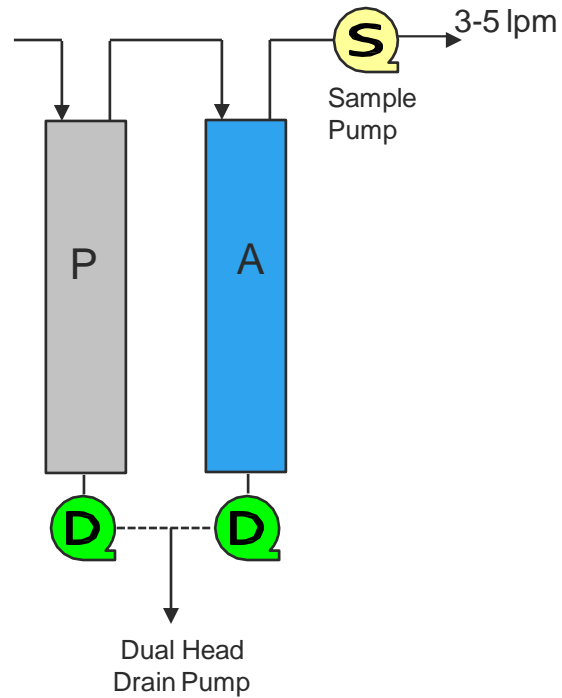
- **Heat Exchangers**
 - Active=Has TE cooling
 - Passive=No TE cooling
- **Passive Heat Exchangers**
 - Advantage is it needs no power
 - Drops sample gas temperature to heat sink temperature
 - Drops inlet water concentration from 20% down to 2%
- **Active Heat Exchangers**
 - Limited to 62 Btu/Hr
 - Precise Outlet Dewpoint Control
 - Increase Thermal Efficiency by Mixing Active and Passive

Cooler / Pump Configurations

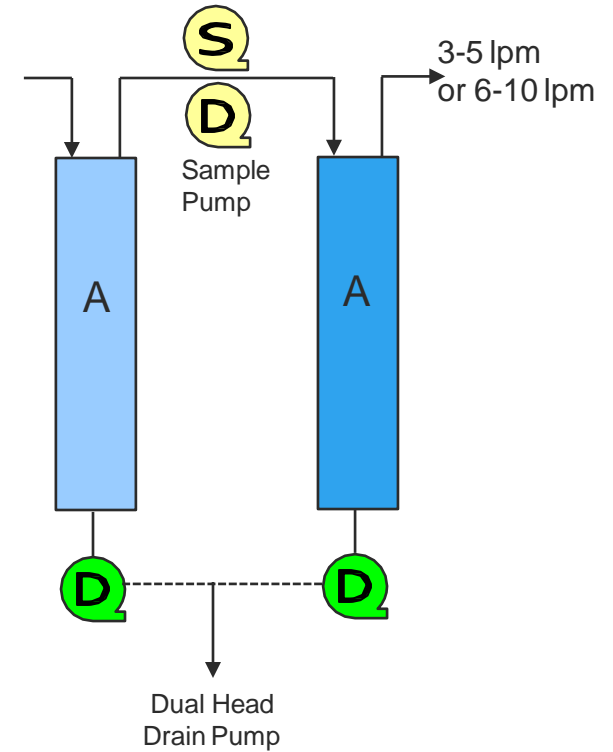
**Classic Cooler
Model 115**



**Classic Cooler
Models 325, 5210**



**Classic Cooler
Models 225, 425, 8210***



Cooler Model Number System

- Classic Cooler Model 1 1 5

1 = Nominal Flow Rate: lpm

1 = Number of Heat Exchangers

5 = Length of Heat Exchanger

- eCool Model 5 3 0

0 5 = eControl

Cooler

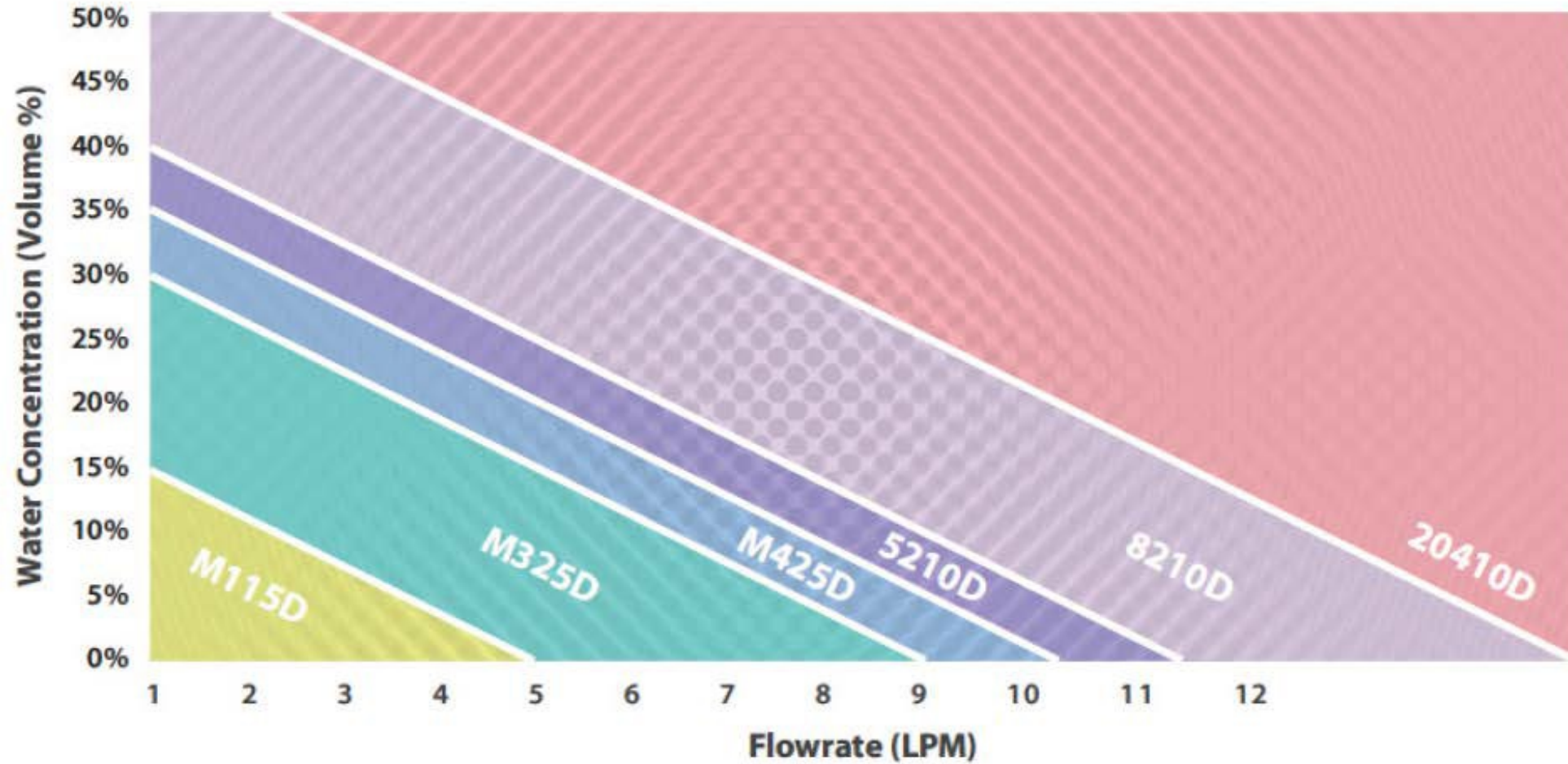
3 = Nominal Flow Rate: lpm

00 = Future Use

Baldwin™ Digital Coolers & Systems

MODEL	FLOW RATE	IMPINGER (HE)	LENGTH	SYSTEM
M115D	2 lpm	1 Active	5"	4S-9A
M325D	3 lpm	1 Active	5"	4S-9PA
M425D	4 lpm	1 Active 1 Passive	10"	4S-9AA
5210D	5 lpm	2 Active	10"	4S-9PA
8210D	8 lpm	2 Active	10"	4S-9AA
20410D	20 lpm	2 Passive 2 Active	10"	4S-9PAPA

Digital Cooler Model Selector



Baldwin™-Series Coolers – Complete Range

- Characteristics
 - A history of reliable performance
 - High quality construction
 - EZ-clean twist-apart heat exchangers
 - High ambient, high water applications
- Range of Models
 - Digital Series (5210, 8210, 20410)
 - OEM Series Digital (115, 325, 425)
 - 10410 SO₃ removal
 - eCool Digitally controlled
 - Only cooler with CSA Class I Div II rating



Catalog Sheets for Our Water Slip Sensor & Filter Assembly



Baldwin™-Series In-Line

Sample Conditioning System



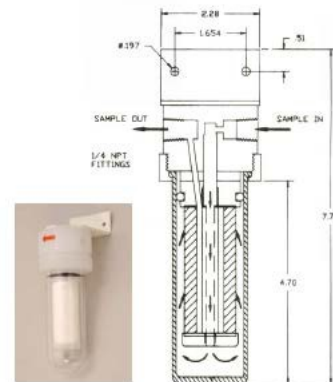
In-Line Sample Filter Assembly

The in-line sample filter assembly, 3kFA-001, is used on all Baldwin-Series wall/rack mounted and Testers' Choice portable sample conditioning systems to provide fine particulate filtration. It includes a PVDF filter head and lock ring, o-ring, borosilicate glass bowl, mounting bracket, and a standard 2-micron ceramic filter element. The inert materials used in construction the in-line filter assembly do not absorb gases of interest. Sample flows through the outside of the filter element indicating filter contamination.

Key Features

- Sample Connection: 1/4" NPT Female
- Maximum pressure: 60 PSIG
- Max Inlet Temperature: 280 °F (138 °C)
- Maximum Flow Rate: 60 lpm
- Pressure Drop at 6 lpm: 1" H₂O Column
- O-Ring Seal: Viton®
- Construction Materials: PVDF, Borosilicate Glass 65
- Dead Volume: cc
- Filter Surface Area: 12 sq in
- Mounting: Surface with Integral Bracket
- Weight: 11 oz (0.31 kg)
- Filter Element Material: (TF) TFE Teflon
(TA) PFA Teflon
(PP) Polypropylene
(SS) 316 Stainless Steel
(HS) Hastelloy C-276
(CR) Ceramic
(GF) Glass Fiber
(GT) Glass Frit

Outline & Mounting Dimensions



Baldwin™-Series Water Slip

Sample Conditioning System



Water Slip (Moisture Carry-Over Sensor) Assembly

The Baldwin™-Series water slip sensor is designed to provide gas sample pump shut down to protect analyzers in the event of water slipping past the thermo-electric cooler. The water slip assembly includes a sensor with Hastelloy® pins (3CWG-001), water slip holder (3CWG-002), holding pin and retainer chain. This contact sensor is used in the Baldwin-Series gas conditioning systems with thermo-electric coolers with relay/alarm capabilities.

(right) Water Slip Sensor 3KCW-002



Inert PVDF material is used in constructing the water slip sensor to prevent absorption of relevant gases. The water slip sensor is often used in conjunction with the Baldwin™-Series in-line sample filter assembly (3kFA-001), which is used on all Wall/Rack mounted and Testers' Choice portable sample conditioning systems to provide fine particulate filtration.

Includes

- PVDF Filter Head
- O-Ring
- Mounting Bracket
- Locking Ring
- Borosilicate Glass Bowl
- 2-Micron Ceramic Filter Element (Standard)

(left) Water Slip Sensor 3KCW-002
Shown with in-line filter assembly p/n 3kFA-001

New Product Introduction

Baldwin's Sample Conditioning Systems featuring our latest Digital Cooler



New! Digital Control System, Same Reliable Performance

The new Baldwin™-Series 9AA Sample Conditioning Systems by Perma Pure are a powerful combination of the proven track record of Baldwin™-Series classic coolers with a new digital control system. The systems are pre-assembled and tested to ensure immediate, reliable performance. All components are mounted and plumbed, system tested and checked for leaks, and ready to mount on a wall or in a rack.

Key Features

- **Baldwin Digital Cooler:** Newest, high quality design provides extended service life
- **Two active impingers with one or two sample streams**
- **Drain Pump:** Steel housing and all metal gear box ensure lasting performance
- **Tubing:** Heavy-duty, thick wall does not "set", significantly reducing replacement costs
- **Sample Pump:** Invert disk valve does not corrode, providing reliable performance
- **Sample Filter:** High purity, 2 micron ceramic element does not absorb NO₂
- **Communication:** RS 485 Modbus Standard on all systems



Components Include

- Baldwin-Series Thermo-Electric Cooler (Model M426D or 8210D)
- In-line sample Filter(s) with easy access exchangeable cartridge(s)
- Water Slip Sensor(s)
- Peristaltic Pump(s)
- Sample Pump(s)

All Baldwin™ Series Coolers Include:

- Dependable water removal
- Single or dual sample streams
- EZ-Clean twist-apart impingers (Optional)
- Low maintenance
- Alarm relays protect analyzers
- Durinert coated impingers (Optional)

- New Baldwin Sample Conditioning Systems
 - 4S-9A – One Active Impinger
 - 4S-9PA – One Passive, One Active Impinger
 - 4S-9AA – Two Active Impingers
 - 4S-9PAPA- Two Active, Two Passive Impingers
- Wall or Rack Mount Versions
- Complete Documentation
 - New Sales Literature for each model
 - Complete Submittal Drawings
 - Specs for Water Slip Sensors, Sample Pumps, Peristaltic Pumps & Filters
- Many Options Available

Clayborn Lab Overview



OUR ENVIRONMENTAL BUSINESS IS HEATING UP!

Agenda:

- Heated Lines
- Difference between types of heating elements
- Introduction to Clayborn Heated Lines
- Applications
 - Emissions Monitoring
 - Viscosity Control
 - Small Lab Use
 - OEM
- Open Discussion

A Little About Heated Lines

What are heated lines?

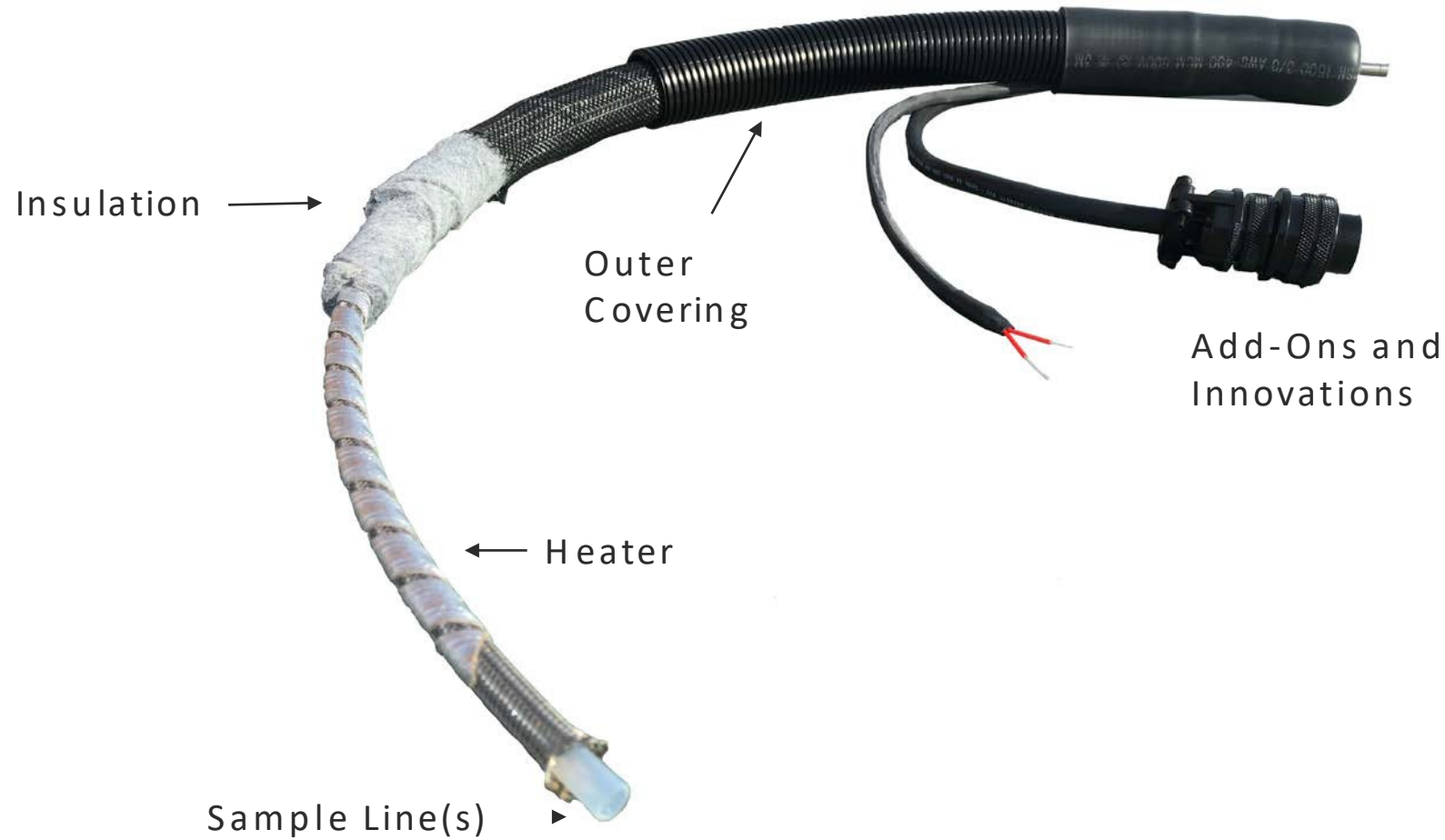
- Electrified transport tubes used to control or maintain temperature of a sample gas or material

Where are they used?

- Transport the sample gas from the sample source to the gas conditioning system or analyzer
 - Ensure the temperature of the sample gas stays above the dew point to prevent condensation from occurring in the samples
 - Moisture can distort the analytical measurement and damage the equipment
- Temperature maintenance in process control
 - Viscosity control (glues, adhesives resins)
 - Freeze protect



Anatomy of a Heated Line



Anatomy of Different Heating Elements

Electrical Resistance Heat Tape



Layer 1: Outer, radiant heat reflective surface

Layer 2: Thin, flexible dielectric

Layer 3: Resistive heating element

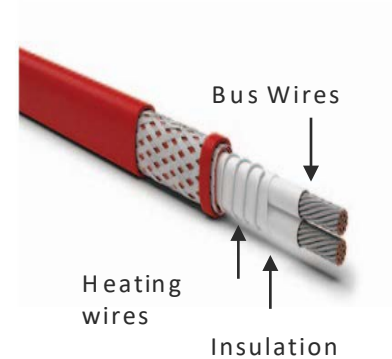
Layer 4: Thin, flexible dielectric

Layer 5: Adhesive

Heated tube material

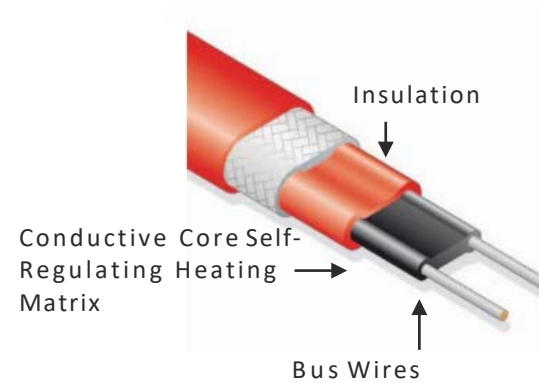
Thermal Energy is transferred to the tube through both conductive and radiant modes of heat. Radiant energy emitted away from the tube is reflected back on to the tube.

Constant Power Density (CPD)



- Alternating bus contacts at fixed intervals
- Produces constant foot to foot power output

Self-Regulating (SR)



- Bus contacts surrounded by a conductive self-regulating heating matrix
- Adjusts output heat in respect to increase and decreases in sample temperature

Consistent Heating – Which Heater is Best?



Electrical Resistance Heat Tape



- Heat Tape is precisely wound around the sample tube to provide consistent sample temperature along the entire circumference and length of the line

Constant Power Density & Self-Regulating



- Heaters lay on one side of the sample line creating a temperature gradient in the sample along the whole length of the line

Durability and Flexibility – Which Heater is Best?

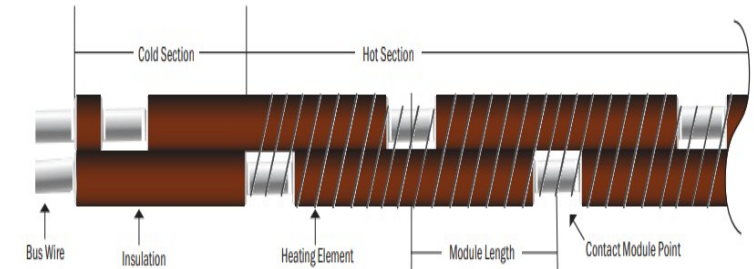


Electrical Resistance Heat Tape



- Flexible even when energized
- Frequent movement does not damage the heating element
- Ideal for rugged applications like portable stack testing (RATA) and industrial processes

Constant Power Density



- Heating wire can break if flexed
- Section would be left unheated
- Zonal dropout producing a cold spot

Self-Regulating

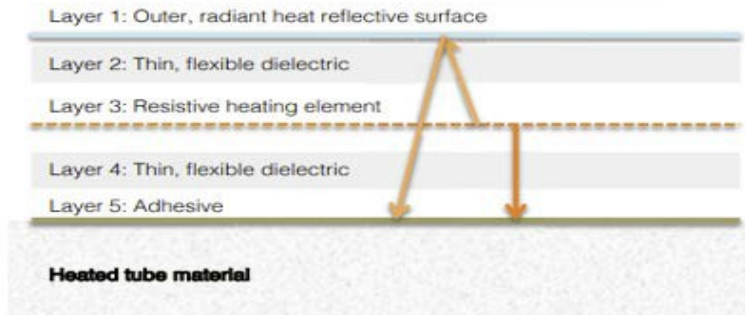


- Least flexible
- Heating matrix can crack leading to cold spots
- Prone to bus wire breakage; complete failure

Customized Power Output – Which Heater is Best?



Electrical Resistance Heat Tape



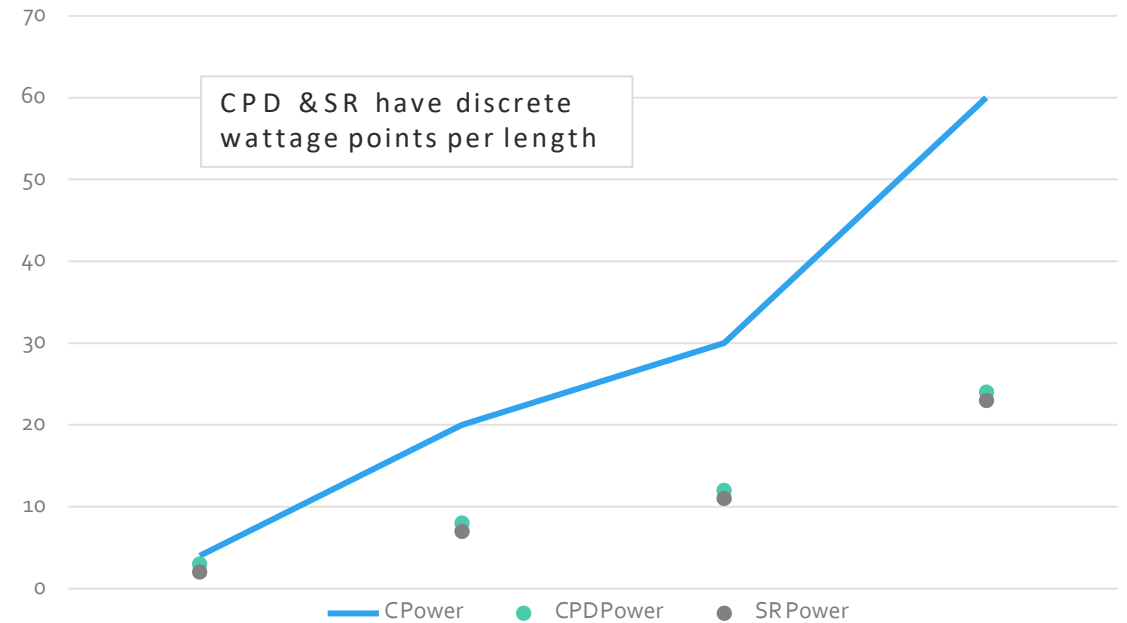
Power output can be customized for each application

Factors affecting power output:

- Length
- Metallurgy
- Number of wires
- Electrical Circuitry

Constant Power Density & Self-Regulating

Wattage is static per length and cannot be adjusted



Comparison of Heaters

	Electrical Resistance Heat Tape	Constant Power Density	Self-Regulating
Consistent Heating	✓	X	X
Customizable Power Output	✓	X	X
Ability to be Flexed when energized	✓	X	X
Resistant to Zonal Dropout/Breakage	✓	X	X
High Temperature Applications	✓	✓	X
Wattage Regulation	Customizable/Application	Static/Length	Static/Length
External Controller	Frequently	Always	Optional
Cost	\$\$	\$	\$
Ease of length adjustment in field			
Lightweight			



Clayborn Heat Electrical Resistance Heat Tape

Heating Element

- Electrical resistance heating tape
 - Highly efficient architecture
 - Rapid heat-up time
 - Precise wrapping for consistent heating
 - Customizable to achieve specific temperature /length /input voltage combinations
 - AC or DC operation
 - 12v, 24v, 120v, 208v, 240, 277v, and 480v input
 - 3-phase operation



Customizable Design Configurations

Sample Line Materials:

- Teflon
 - Various Grades
 - Smooth bore or convoluted
- Stainless Steel
 - Welded or Seamless
 - Electropolished
 - Large ID convoluted
- Polyethylene
- Nylon

Insulation Materials::

- Standard Nomex
- High performance Aerogel
- Closed/Open cell foam

Up to 6 Heated Sample Lines
Up to 6 Unheated Sample Lines
24 pass through wires



Customizable Design Configurations

Cover Options

- Tuffguard
- Nylon Braid
- Silicone
- Heat Shrink

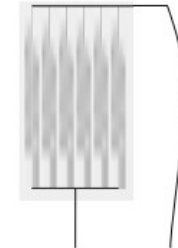
Innovative Design

- Integrated strain relief loops at customizable locations
- Finished ends standard from factory
- Armored Ends
- Embedded Thermostats
- Thermocouples
- On/OFF indicator lights
- “Run Wild” Temperature of sample line will fluctuate with ambient

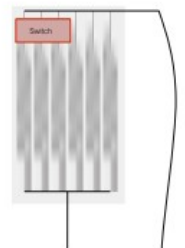


Sample / Calibration 'Tee' fitting (far left)
Early calibration line breakout (middle)
Strain relief (far right)

Standard
Circuit



Kick / Hold
Circuit

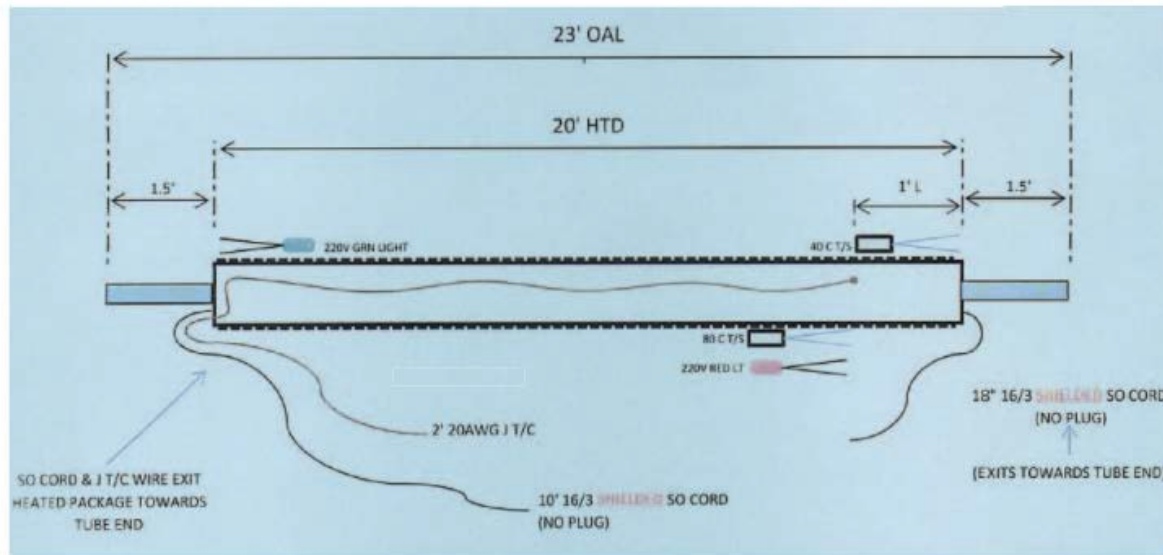


Customization Options Help to Serve Many Applications

- Emissions Stack Testing
 - CEMS
 - RATA
- Viscosity Control
 - Water (freeze protection)
 - Plastics
 - Epoxy
 - Glues/Adhesives
 - Fiberglass
- Chemical Analysis
 - pH analysis
 - Particle analysis
 - Liquid extraction
 - Stability testing
- Natural Gas:
 - Midstream
 - Chemical processing
 - Power generation
 - Refineries
 - Fertilizer production
 - Hydrogen production

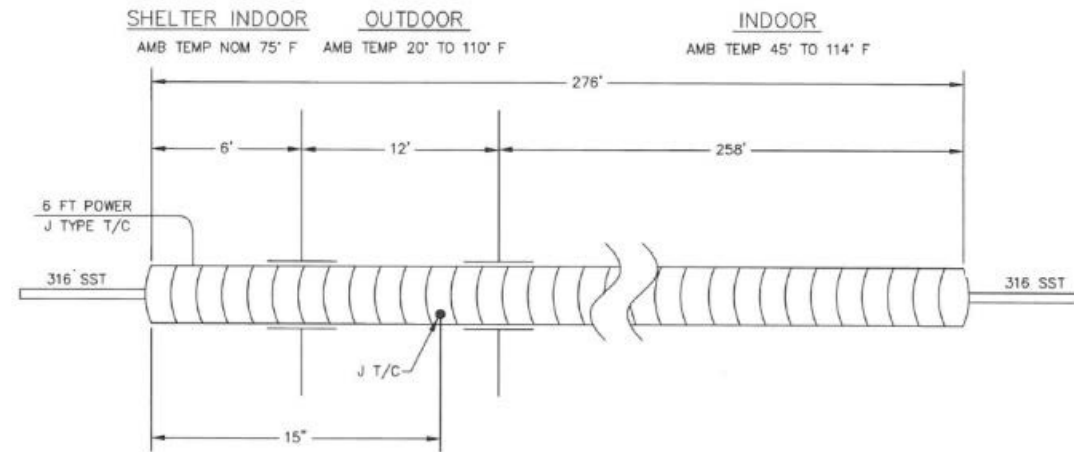
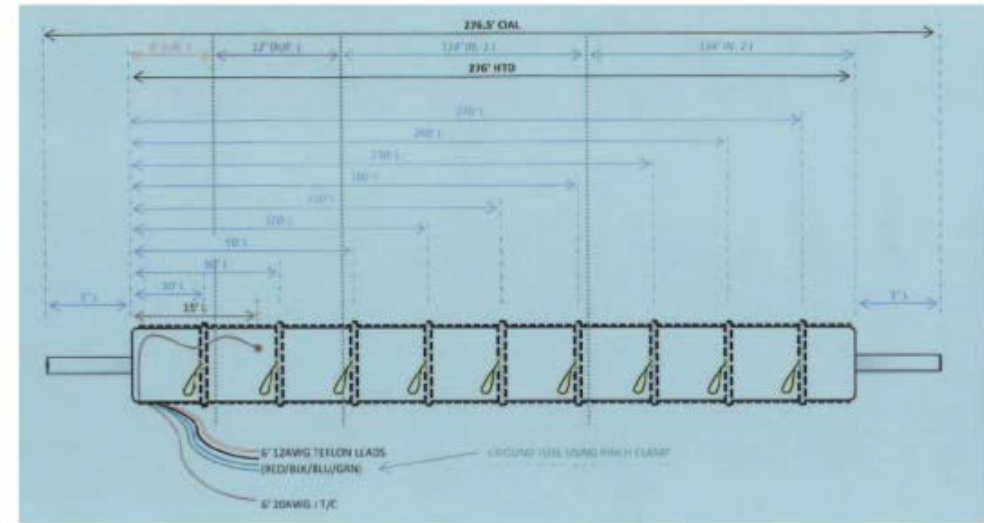
Application: Viscosity Control

- Indicator lights
 - Green indicates power is applied
 - Red indicates over-temp protection is active
- Hose cores of almost any size and length



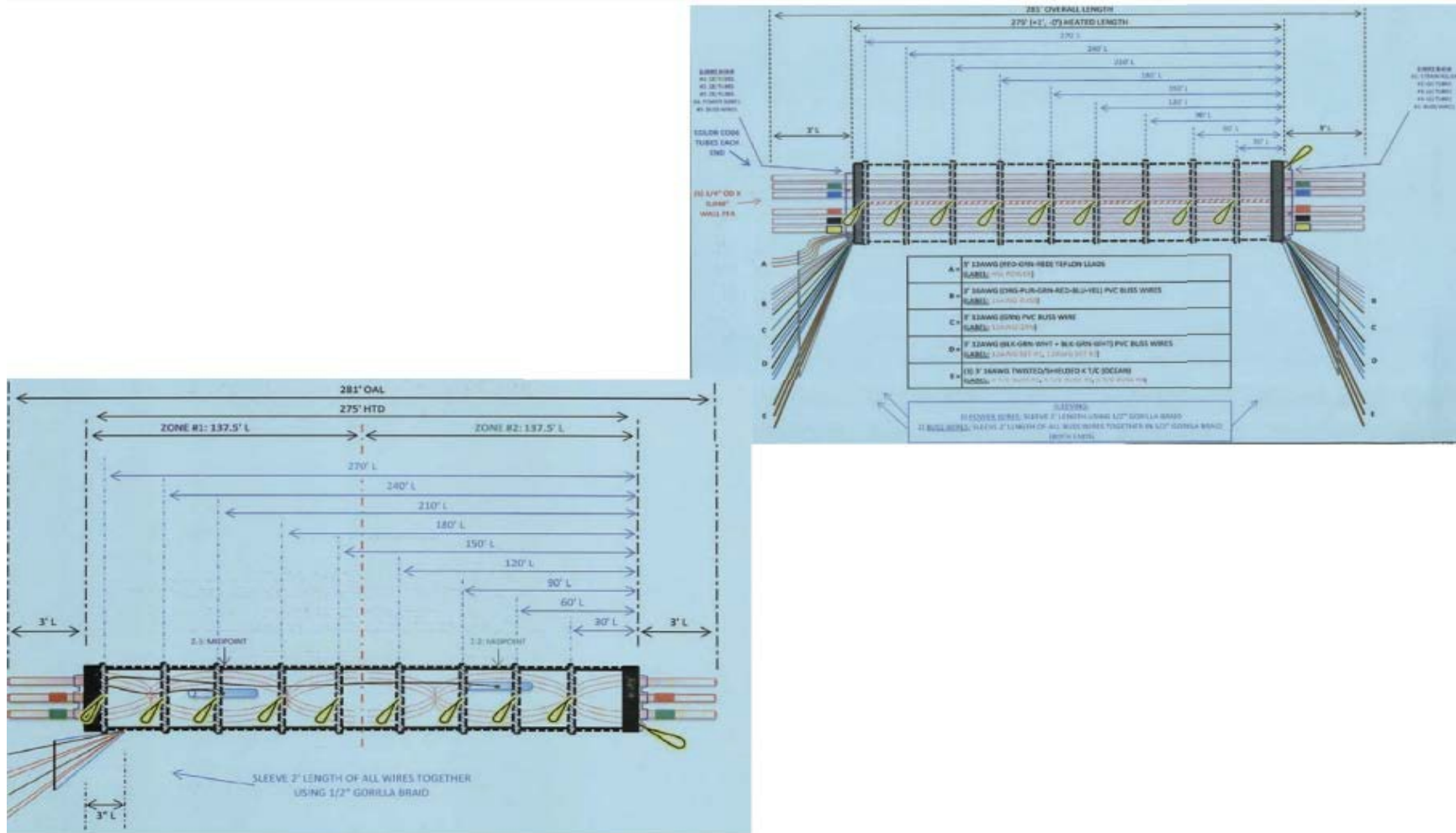
Application: Clayborn CEMS Collaborations

- Three-phase, three zone



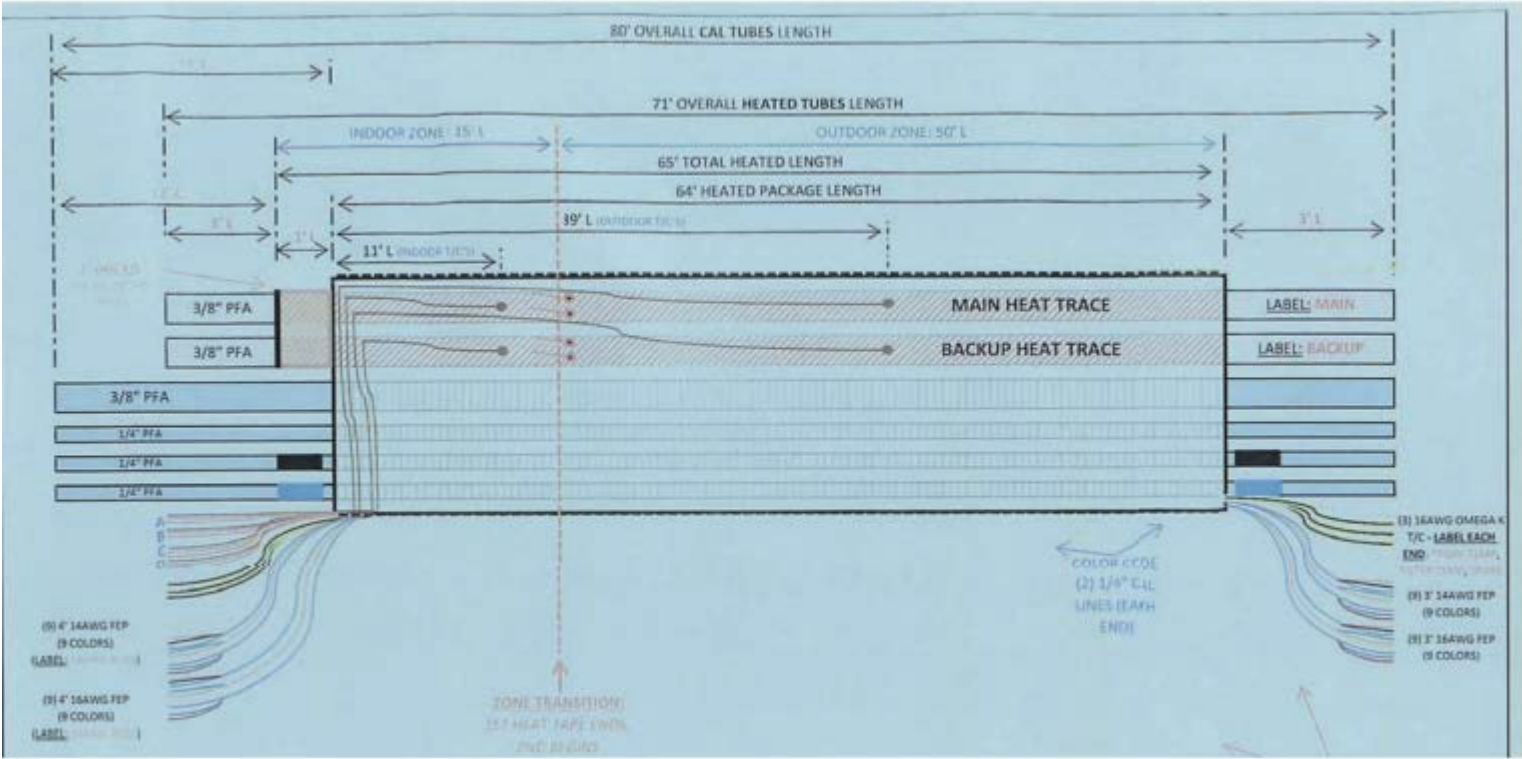
Application: Clayborn CEMS Collaborations

- Separate heated, unheated umbilical cords



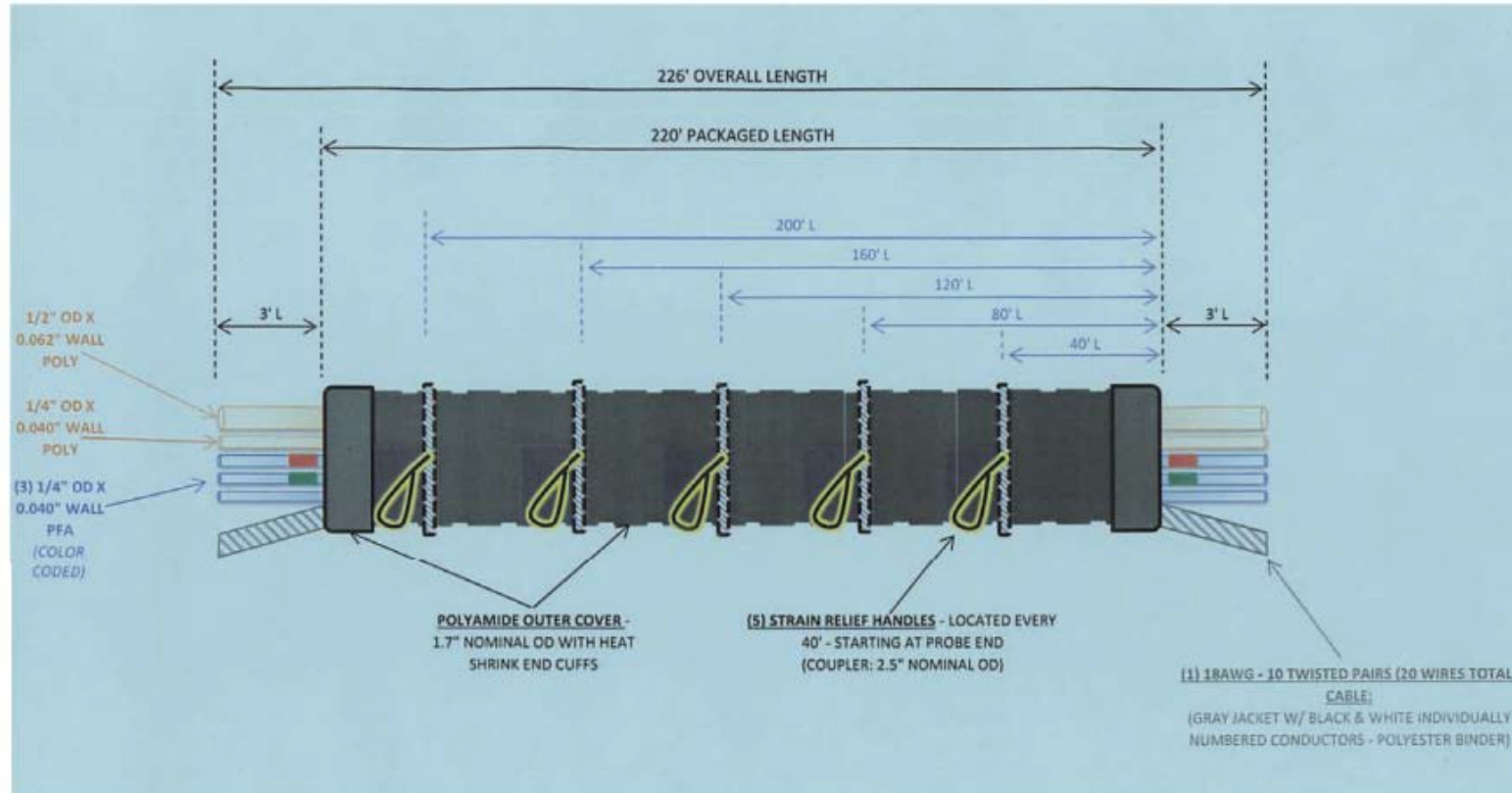
Application: Clayborn CEMS Collaborations

- Primary/spare umbilical with reduced heated section



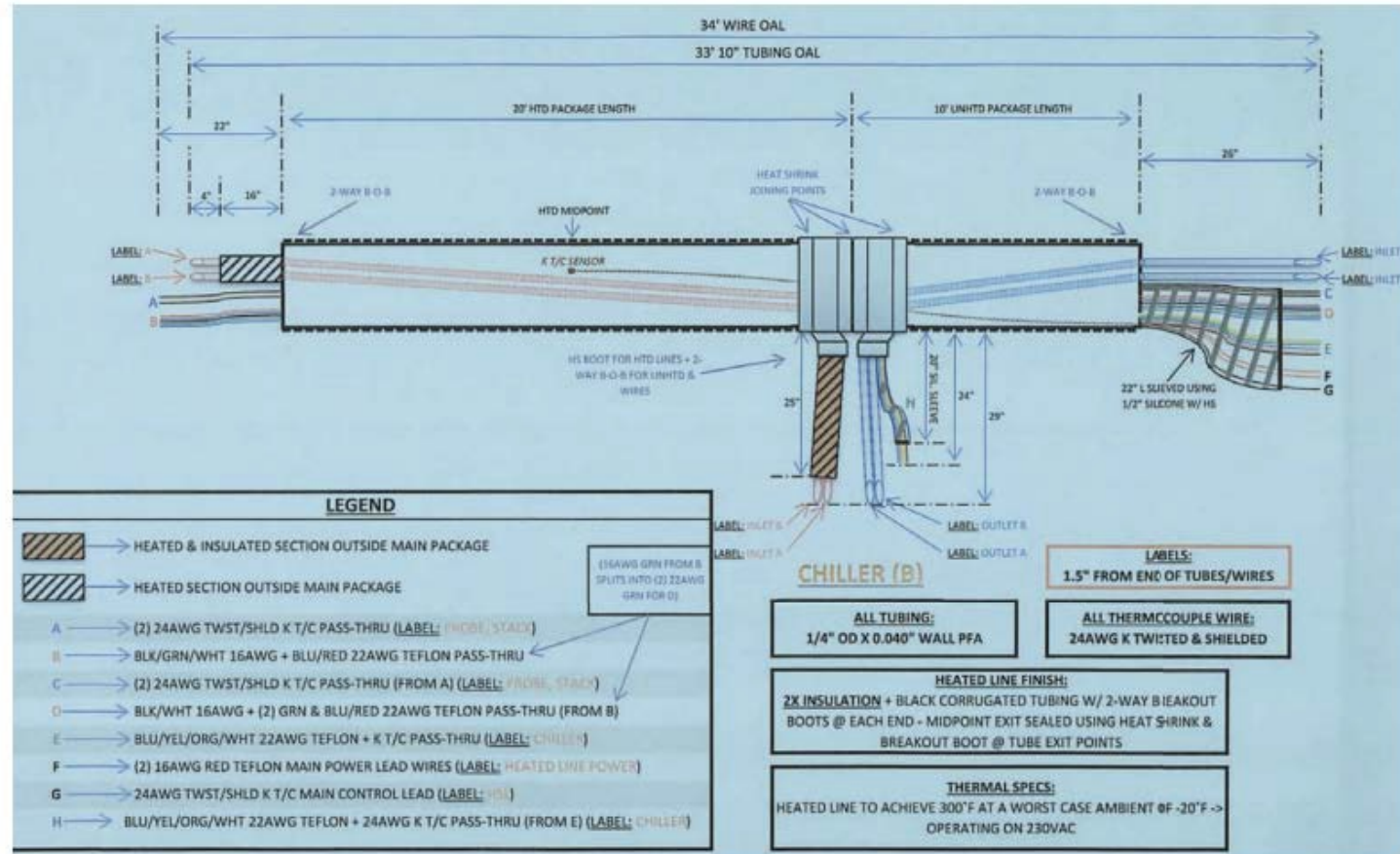
Application: Clayborn CEMS Collaborations

- Unheated (with freeze-protect option) umbilical with custom wire bundle pass-through



Application: Clayborn CEMS Collaborations

- Heated sample line with “tee” in-line connections

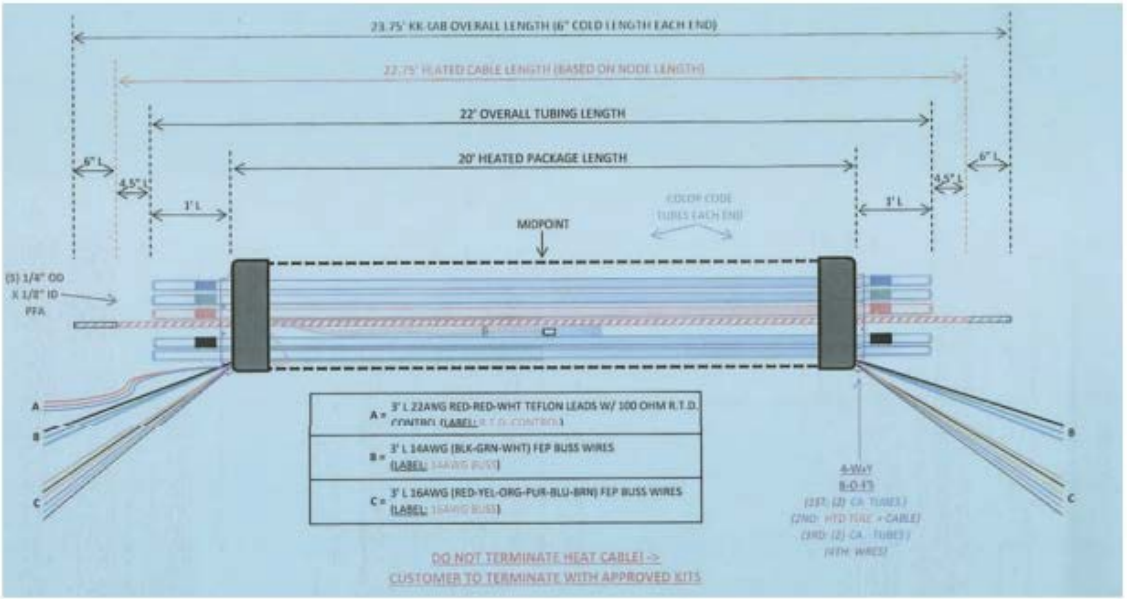


Application: Class 1, Division 2

- Unheated umbilical with custom pass through wire bundle



Approvals:
 Ordinary Locations
 Hazardous Locations:
 Class I, Division 2, Groups B, C, & D
 Class II, Division 2, Groups F, & G
 Class III, Division 2

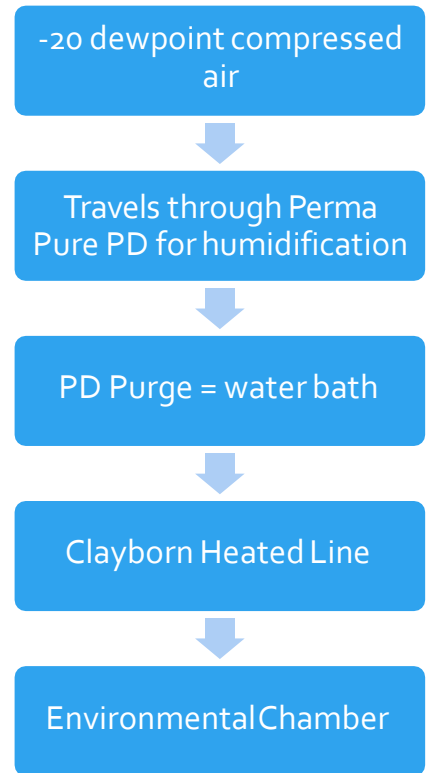


Application: Small Lab Use

Perma Pure's
Own
Lab

Why Selected:

- Short 3 ft line used in a variety of Applications
 - Environmental Chamber testing
 - Prior to FTIR
- Moved often
- Rugged, durable
- Flexible for various uses and applications



Application: OEM

- AC or DC Operations
- Input voltage from 1v – 480V
- Thickness less than 1/64"
- Temperatures up to 450 degrees F
- **Short to Long Length: 6" – 300 Ft**

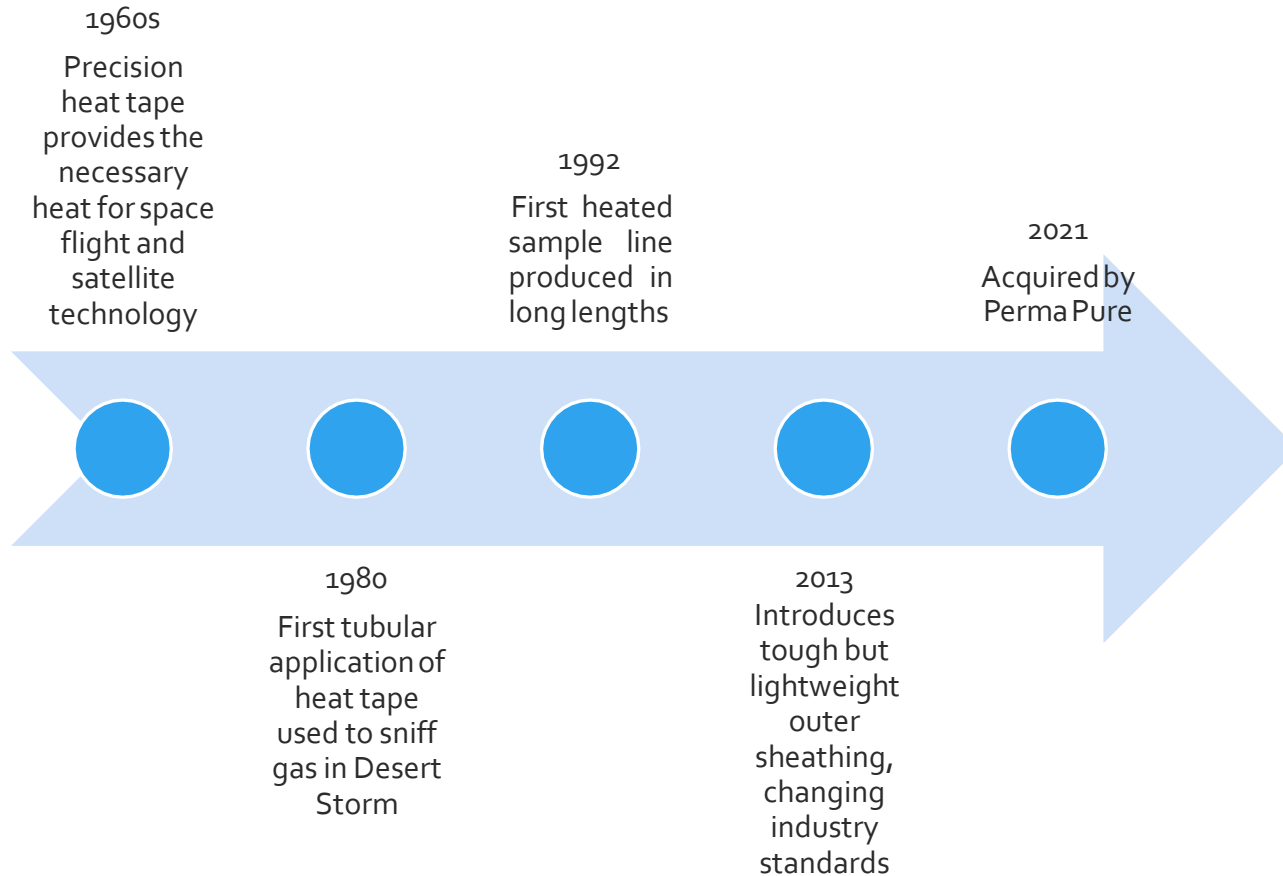
Configurable Circuitry

- Manage input current
- Maintain wattage as temperature increases
- Reduced wattage holding circuit
- Over-temp protection
- One tape designed for multiple temperatures
- 3-Phase Operation



OUR ENVIRONMENTAL BUSINESS IS HEATING UP!

About Clayborn Labs



- Expertise
- Design Capabilities
- Industry Leading Innovation
- Proven Durability – Nearly every satellite has Clayborn Heat Tape!

Questions and Discussion

