DP Level Measurements –

Improving Performance & Reducing Installation Costs

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International Society of Automation
Setting the Standard for Automation™

Agenda

- Gage Pressure vs Differential Pressure
- Balanced vs Tuned Systems
- Electronic Remote Sensors (ERS)
- Fill Fluids
- Thermal Range Expander

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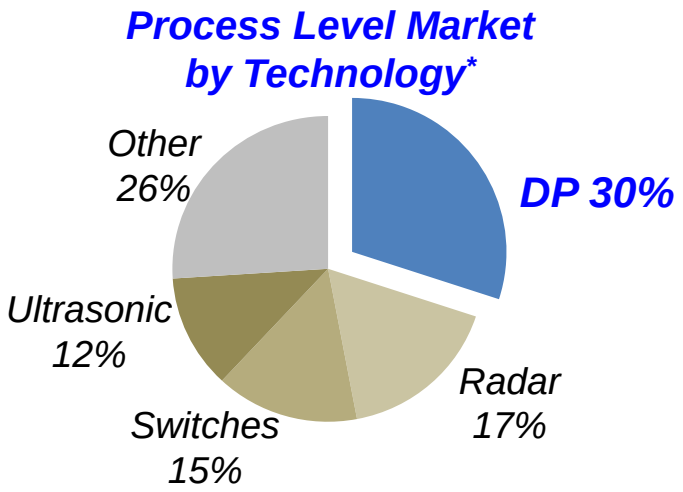
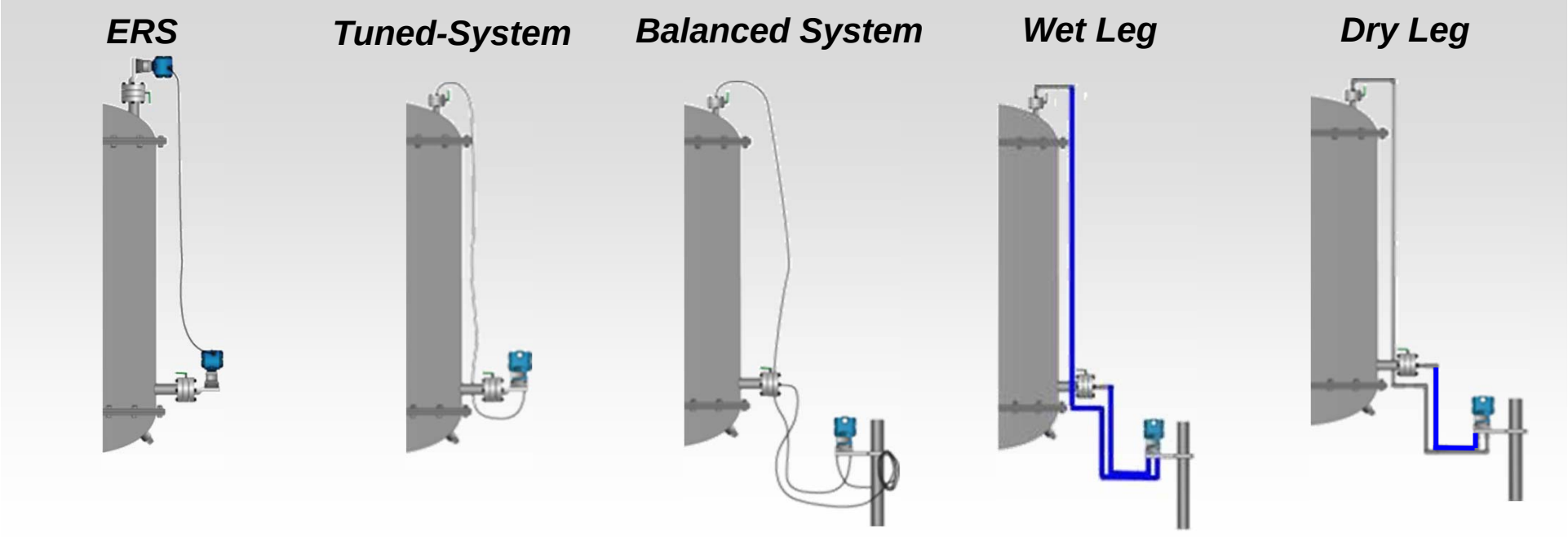
DP Level is a Proven and Successful Technology

$$\text{Level} = \frac{\text{Pressure}}{\text{Specific Gravity}}$$

- Straightforward measurement technique
- Easily verified and calibrated
- Flexibility enables use in variety of applications (mass, density, interface)





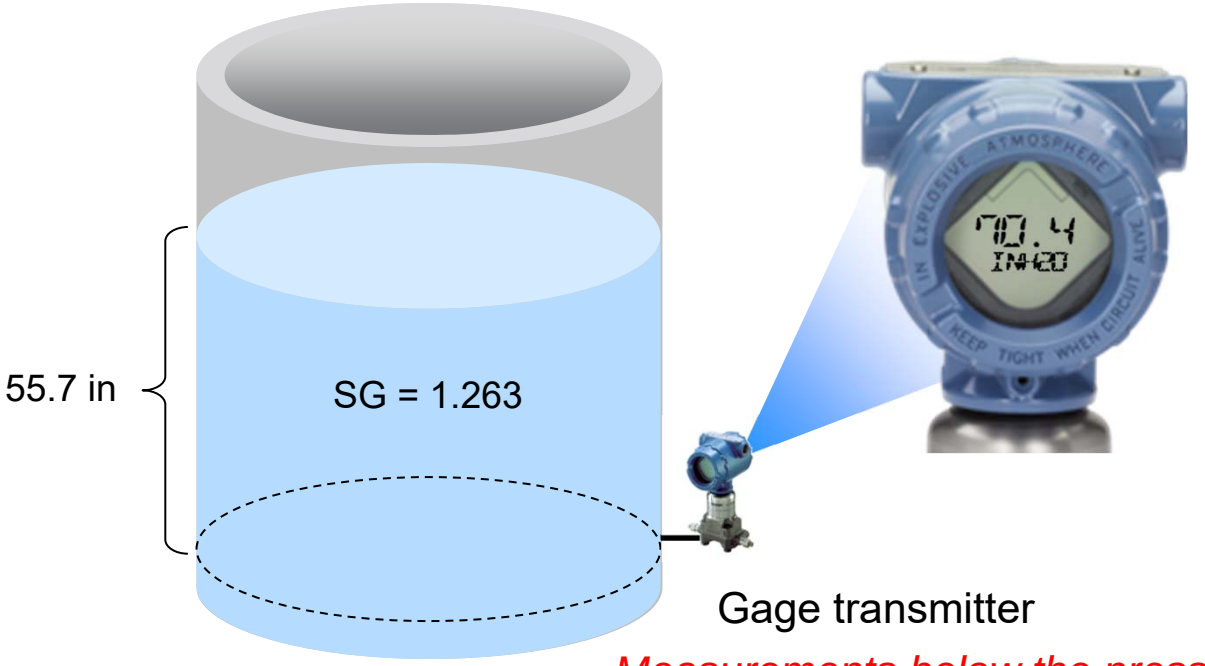
Open / Vented Tank Measurement Can Easily Be Made with a Gage Transmitter

- Level can be measured if density (specific gravity) of fluid is known
- Higher level = more pressure at bottom of vessel

$$Level = \frac{Pressure}{Specific\ Gravity}$$

Open Tank Example

Specific Gravity of Process Fluid = 1.263



Gage transmitter

$$Level = \frac{Pressure}{Specific\ Gravity}$$

$$= \frac{70.4\ inH2O}{1.263}$$

$$= 55.7\ inches\ of\ level$$

Measurements below the pressure transmitter?

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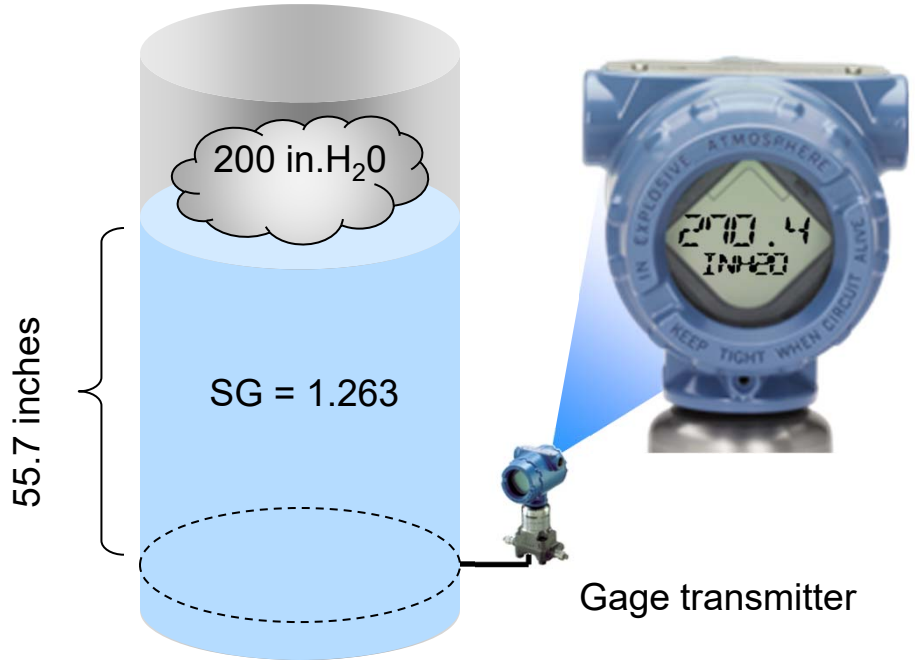
DP Measurements are Required for Pressurized/Vacuum Vessel Applications

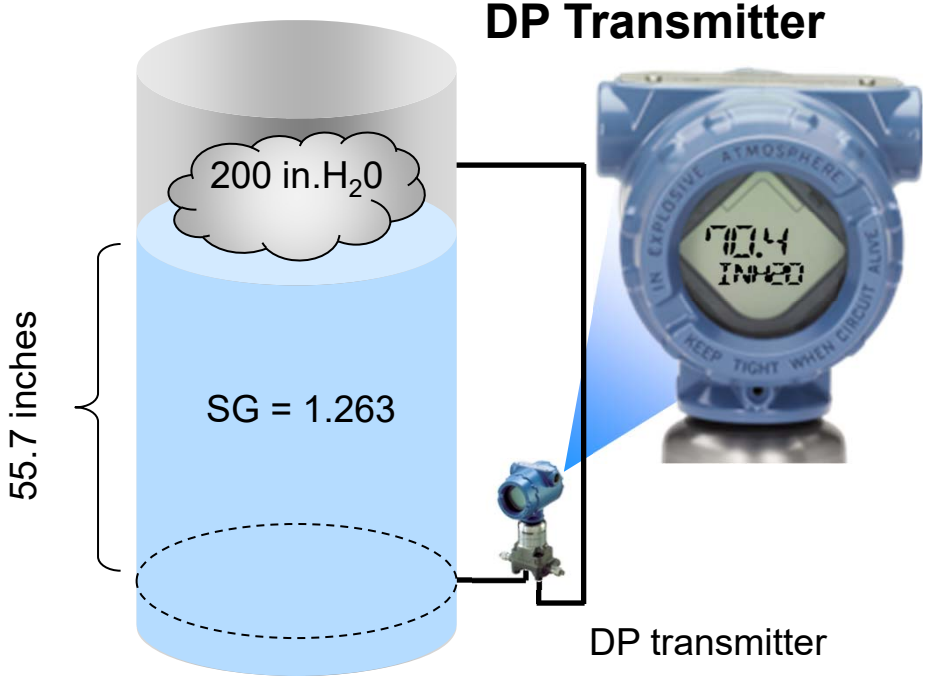
- Gage pressure transmitter measurements cannot distinguish pressure from the liquid level vs vapor pressure/vacuum
- DP measurement compensates for vapor pressure/vacuum changes

Closed Tank with GP Transmitter



- 270.4 inH_2O ≠ 55.7 inches of level
- Changes in vapor pressure/vacuum will result in further measurement errors

Closed Tank with Dry Leg DP Transmitter



- $DP = P_{BOTTOM} - P_{TOP}$
  $= (P_{LEVEL} + \cancel{P_{VAPOR}}) - (\cancel{P_{VAPOR}})$
- DP is unaffected by vapor pressure!

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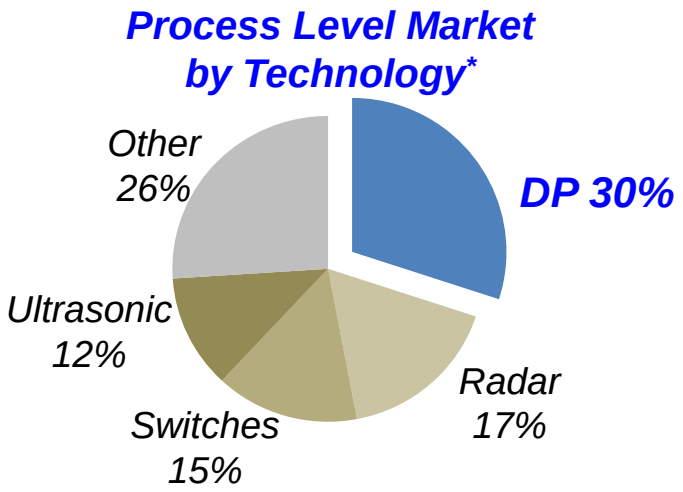
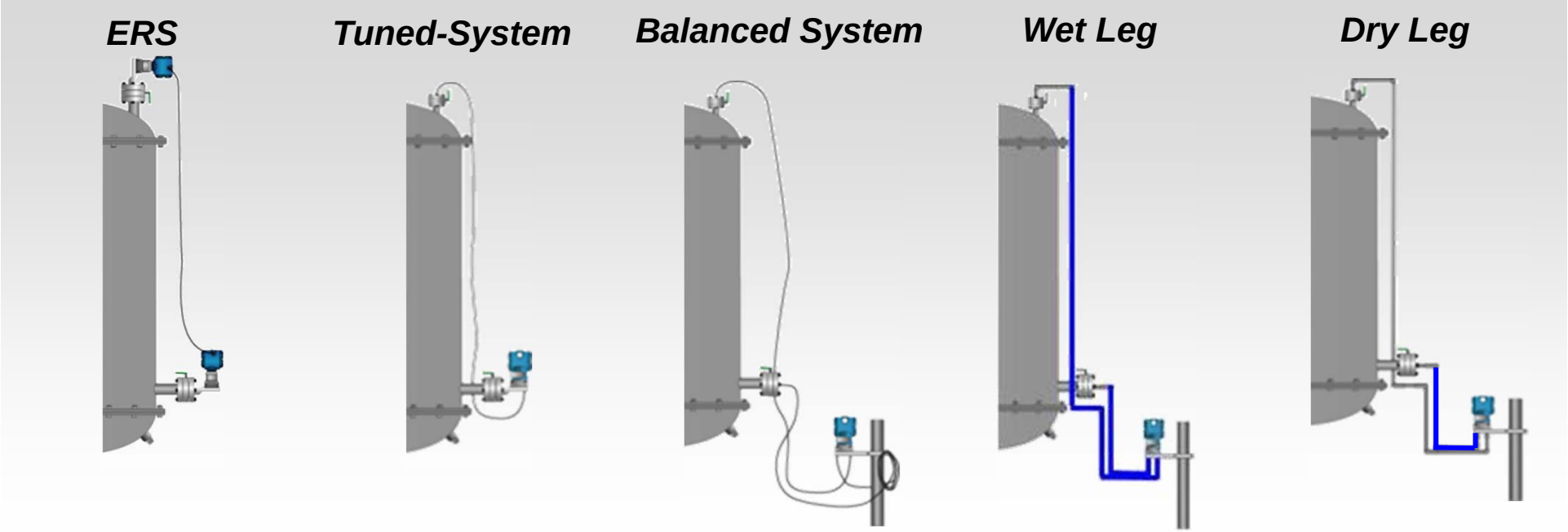
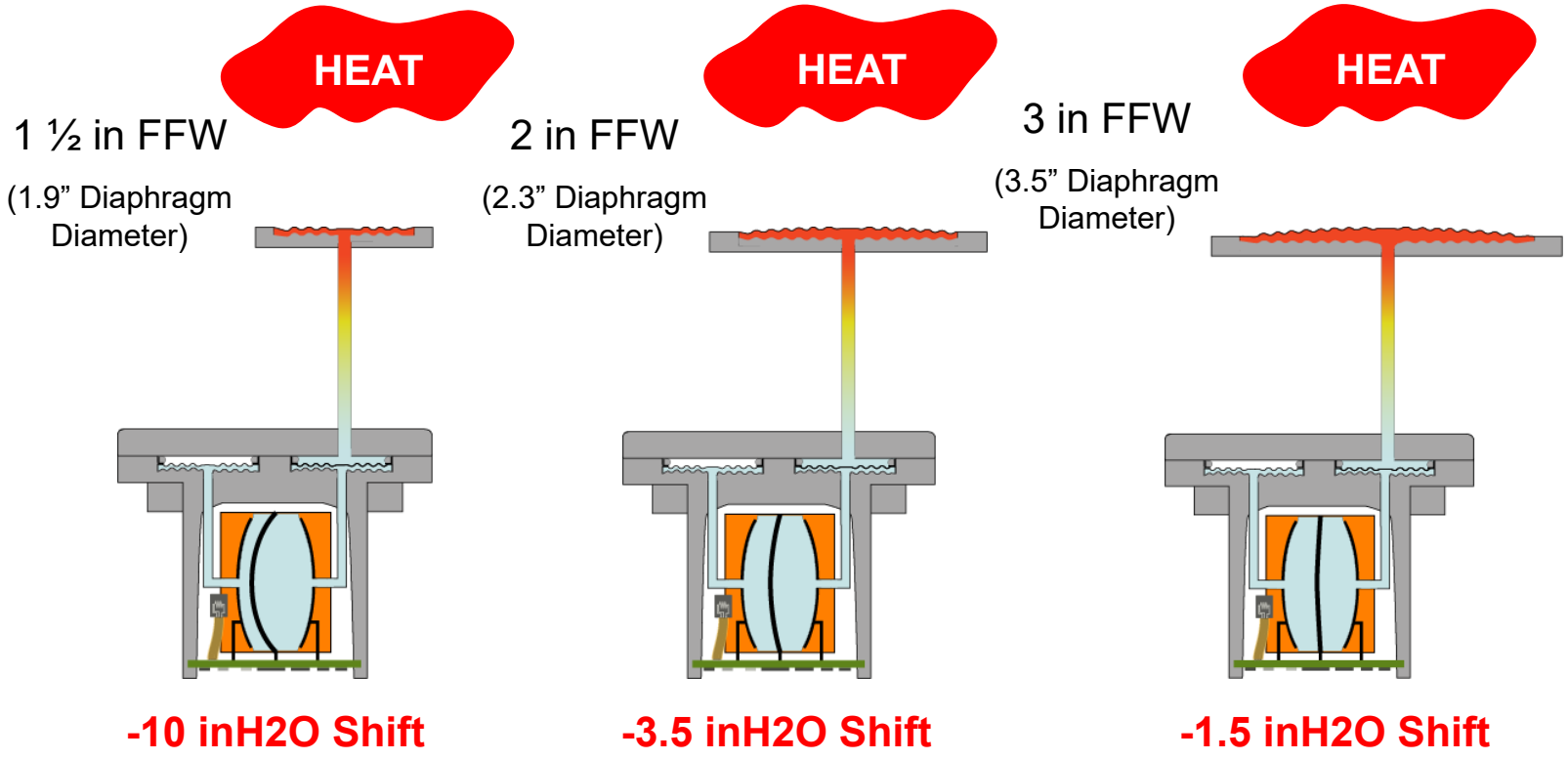




*VDC Global Process Level (2005), ARC Global Radar Study (2008), F&S Global Level Sensors (2005)

Temperature Effects on Capillary DP Systems

- **Seal Effect**: Process temperature changes: 75 degF at installation, current process temperature = 450 degF, fill fluid expands



Seal temperature effect decreases as diaphragm size increases

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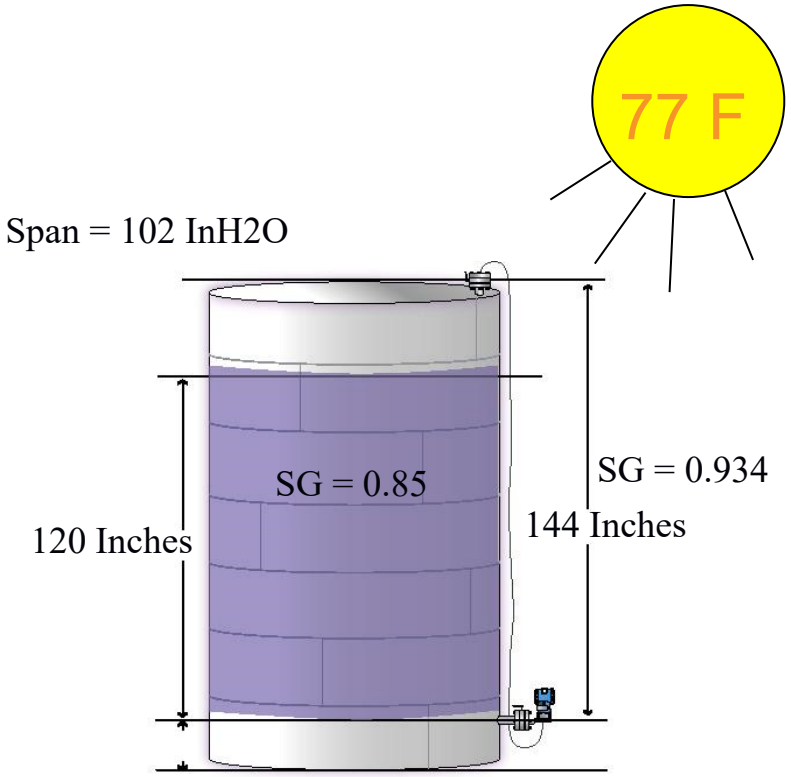
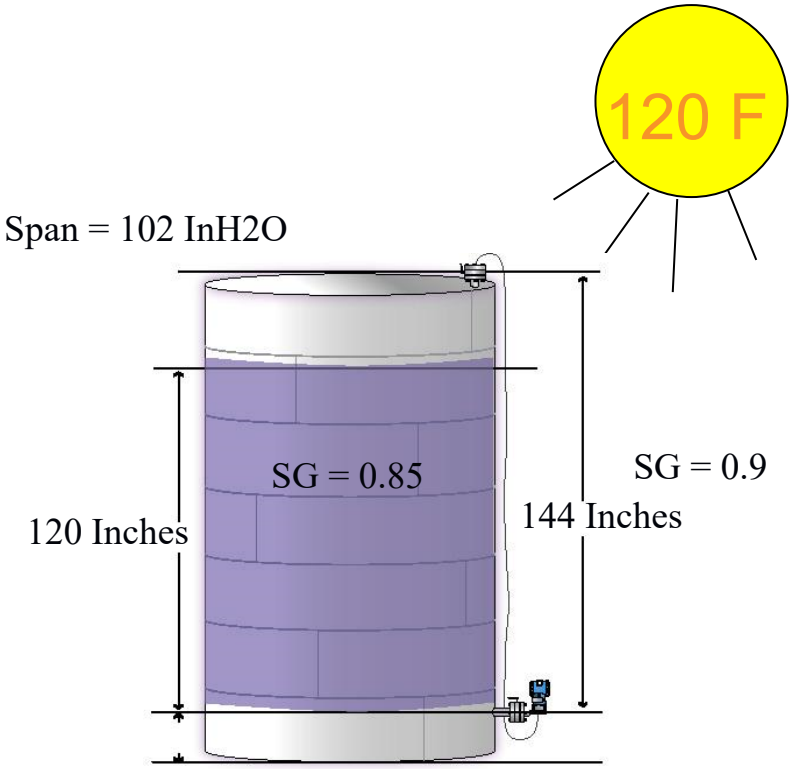
Temperature Effects on Capillary DP Systems

- **Head Effect**: Ambient temperature changes: 77 degF at installation, 120 degF later in the day, fill fluid density changes



144 * 0.934 = 134.496 inH2O
LRV = -134.496 inH2O
URV = -32.496 inH2O, PV = -134.496 in H2O

+4.896 inH2O Shift



144 * 0.9 = 129.6 inH2O
LRV = -134.496 inH2O
URV = -32.496 inH2O
PV = -129.6 in H2O

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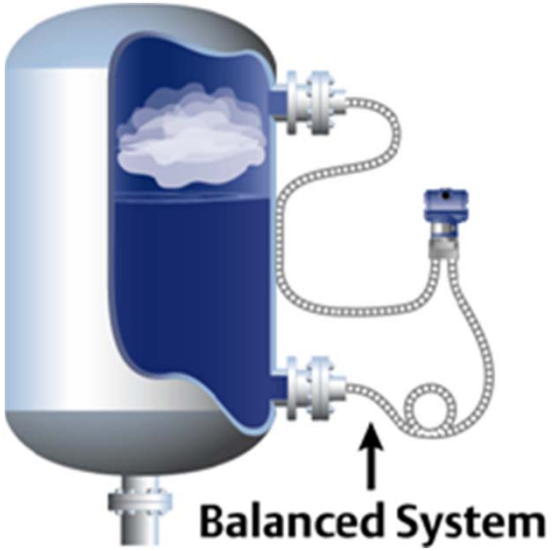
Older Practice for Remote Seal Systems: The "Balanced System"

- Practice was to specify identical seals on the high and low sides of the transmitter
- Equal capillary length and equal amounts of fill fluid
- Back pressure on high side equals back pressure on low side – no seal temperature effects
- Excess length of capillary typically coiled near bottom seal – response time?
- Transmitter mounting?



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Existing Practice: The “Tuned System”

- Use knowledge of:
  - Seal Temperature Effect
  - Head Effect
  - Fill Volumes
  - Diaphragm Properties
- Predict and document system performance with a computer model
- Easier installation, less material with only 1 capillary, faster response time with direct mounted transmitter

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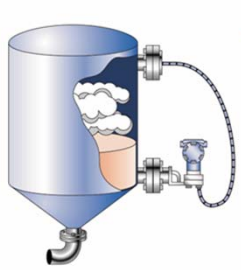
Understanding DP System Total Temperature Effects

With all conditions equal, what happens when temperature increases?



Performance Considerations	Balanced		Tuned System
Seal Temperature Effect (Effect due to Expansion of Fill Fluid)	No Error		-3.5 inH2O
Head Temperature Effect (Effect due to Change in Fill Fluid Density)	+4.9 inH2O	=	+4.9 inH2O
Total Temperature Effect	+4.9 inH2O	>	+1.4 inH2O

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- Electronic Remote Sensors (ERS)
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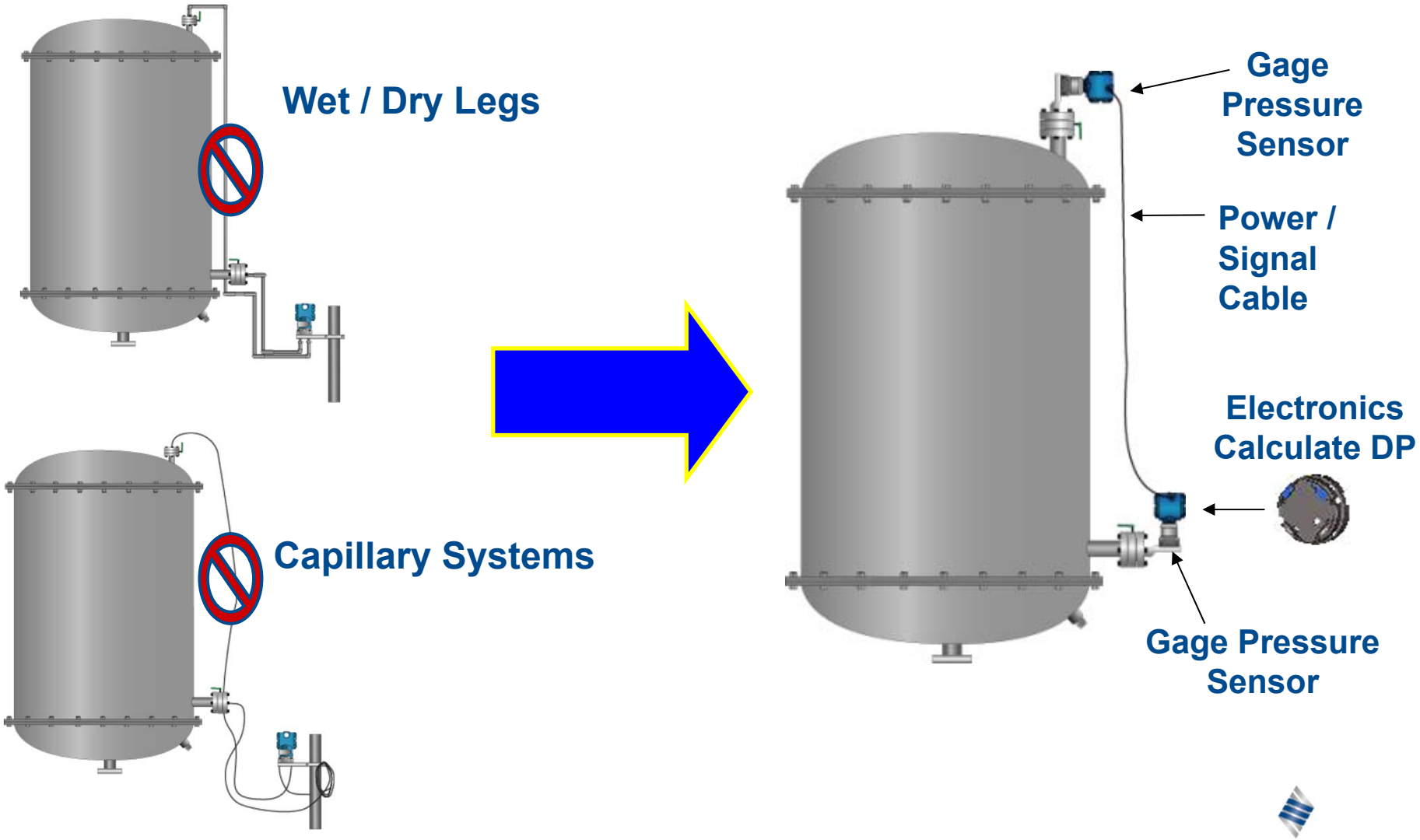
Electronic Remote Sensors - Replace Capillaries & Wet/Dry Legs



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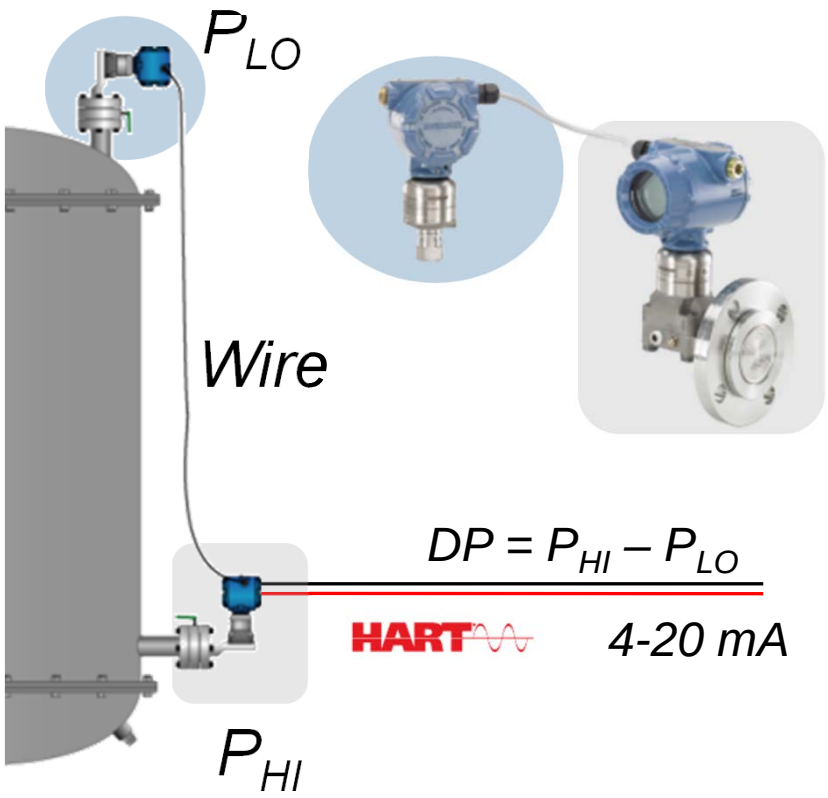
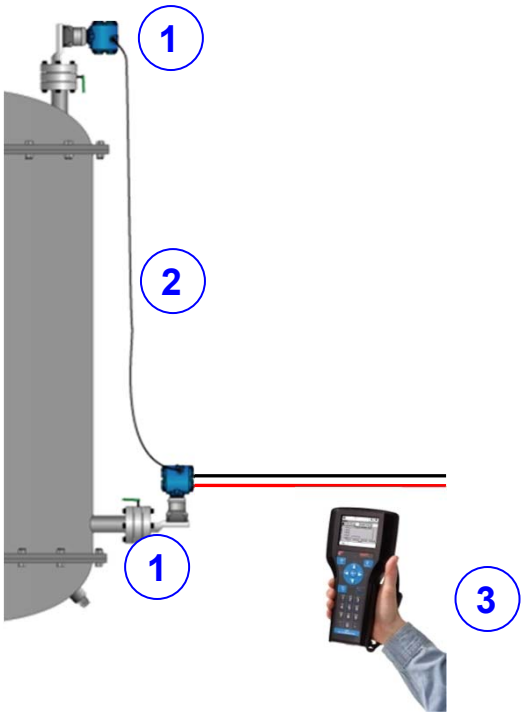
Electronic Remote Sensors Provide Additional DP Level Capabilities



Electronic Remote Sensors Simplify Installation Practices



1. ***Independently install each sensor***
   - Direct-mount without pipe stand, brackets, and other hardware
   - Can be installed by a single instrument tech
2. ***Wire sensors together***
   - Non-proprietary electrical wire (4 conductor)
   - Easy to install around catwalks, on distillation columns, etc.
   - Eliminate insulation and heat tracing
3. ***Perform a system zero trim***
   - Establishes true zero-based DP measurement
   - No zero elevation calculation required

3051S ERS Architecture Supports Flexible Installations

Electronic Remote Sensor Digital Architecture Delivers Improved Performance

Direct Connection to Tank Reduces Time Response

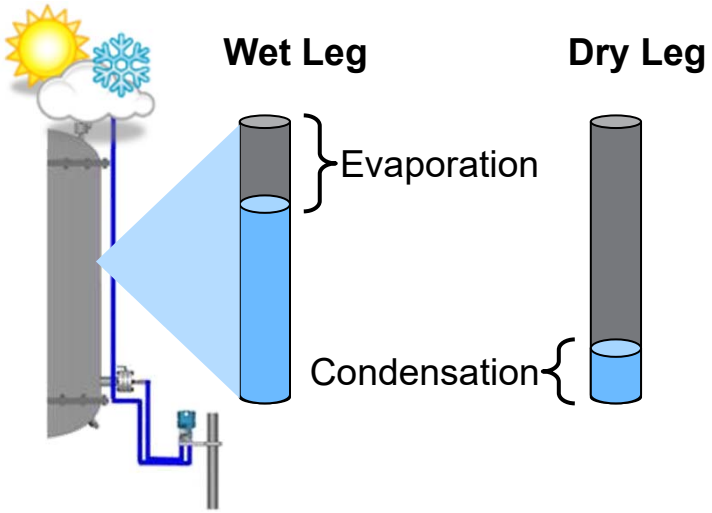
2.5 sec.

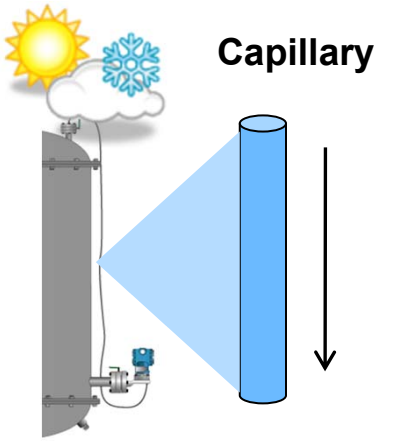
Transmitter with
10 ft (3 m) Capillary

0.5 sec.

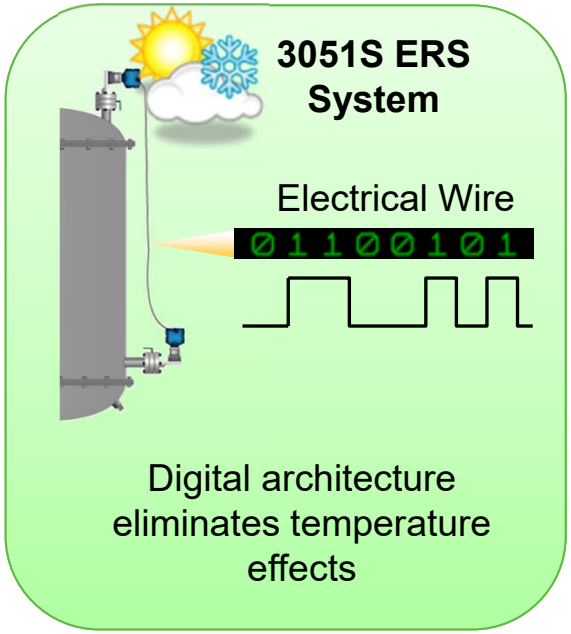
Direct-Mounted ERS
Transmitter

Digital Architecture Eliminates Measurement Drift





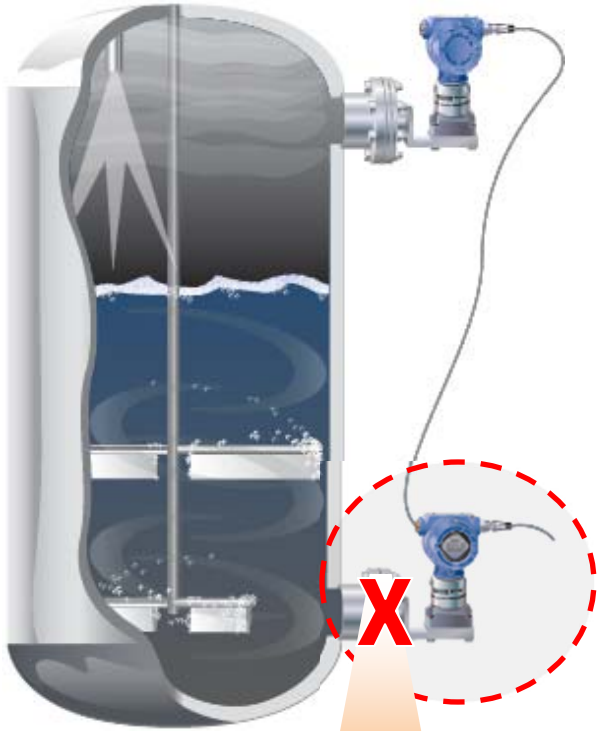
Fill Fluid Density &
Volume Changes with
Temperature

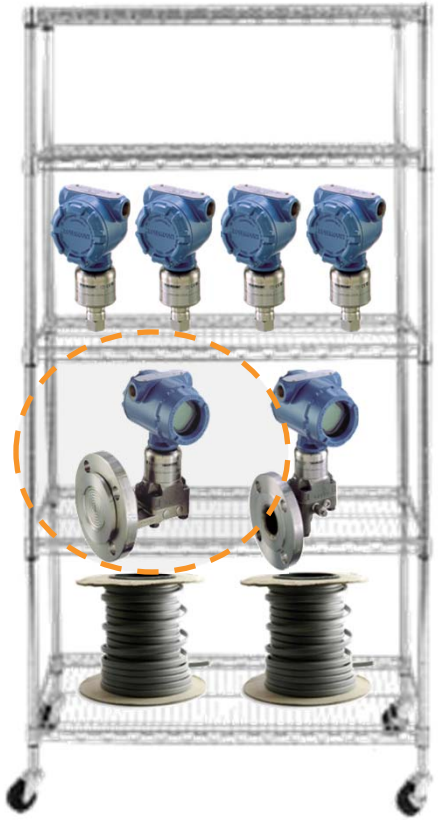


Electronic Remote Sensors Simplify Maintenance and Spares Inventory

Replace one transmitter vs entire capillary assembly

Simplify spares inventory & standardize on common ERS components





- Corrosion/erosion
- Process-coated diaphragm
- Hydrogen permeation

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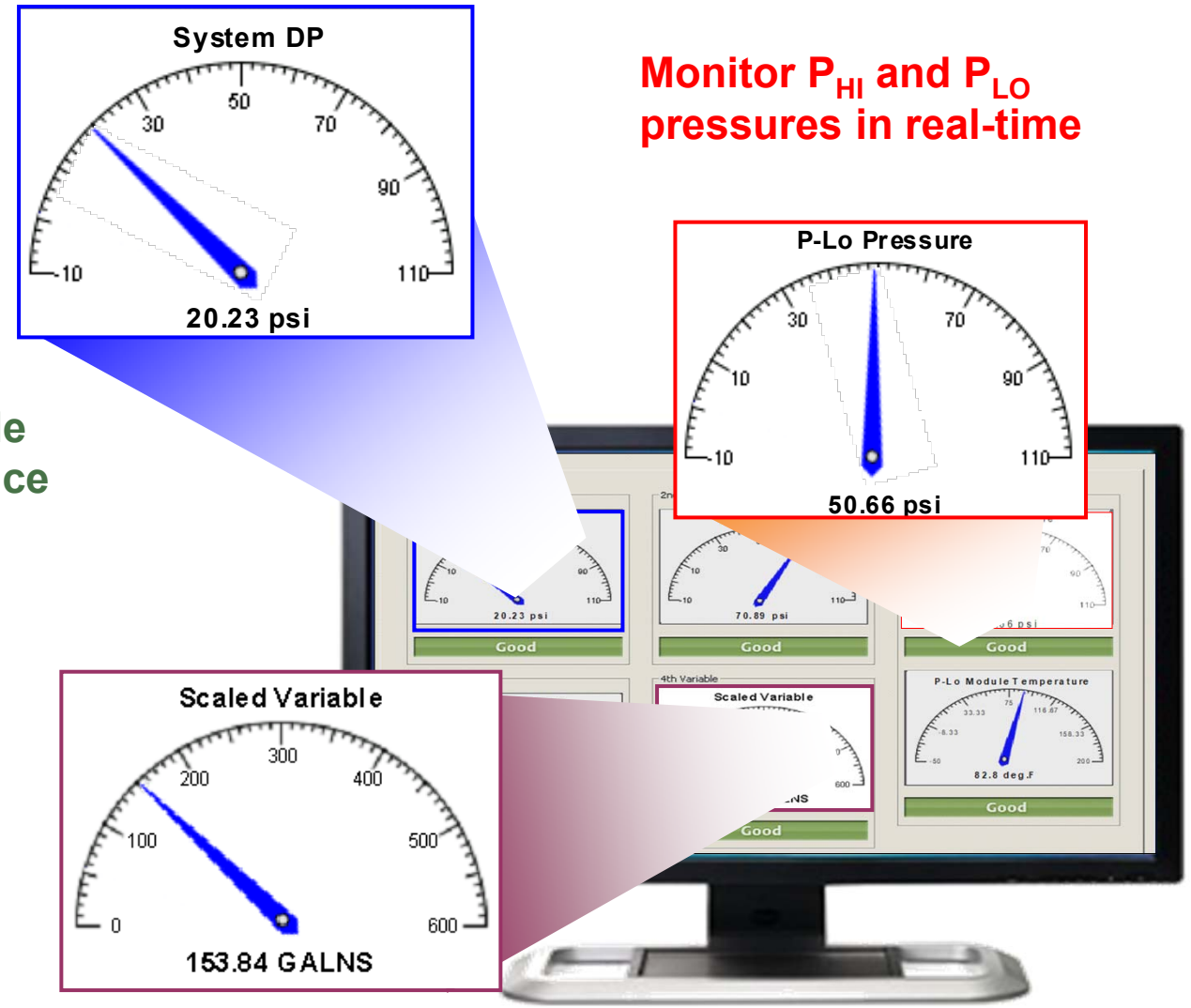
Electronic Remote Sensors Provide Greater Insight Into Your Process

Automatic & synchronized DP calculation

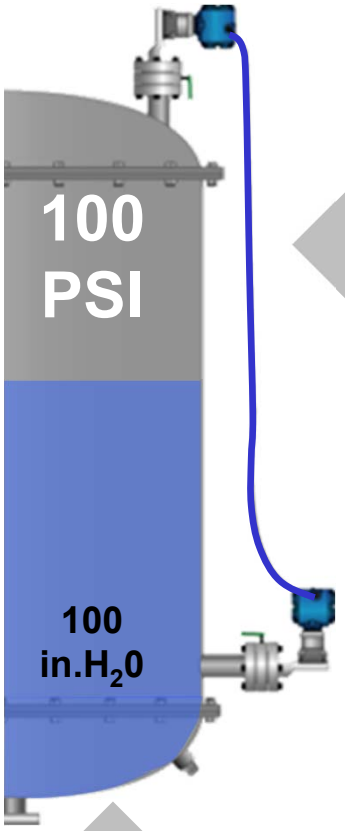
Monitor P_{HI} and P_{LO} pressures in real-time

Process alerts enable proactive maintenance practices

Scaled Variable converts DP into level & volume measurements



Electronic Remote Sensors Compliments Traditional DP Level Technology

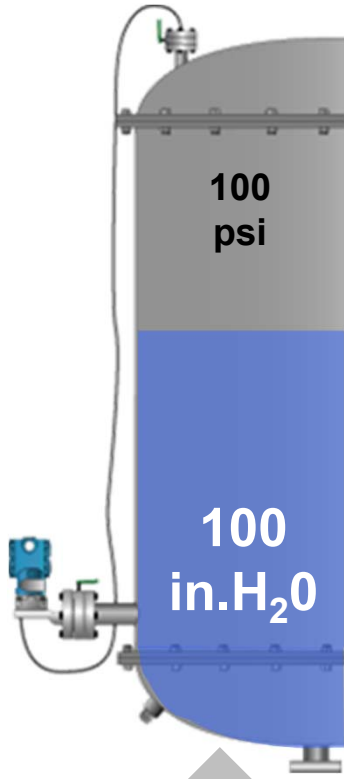


Electronic Remote Sensors

- Sensors sized on amount of static pressure + DP column
- GP Sensor Span = 103.6 psi (2868 in.$H_2$0)

Tuned-System™ Assembly

- Sensor sized on DP column only
- DP Sensor Span = 100 in.$H_2$0



High Pressure Application Example

ERS ±2.8 in.$H_2$0 **VS** **Tuned-System** ±1.4 in.$H_2$0

25 F Ambient Temperature Change

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The Enhanced Performance Class Makes it Easier to Know Performance

A.1.2 Reference accuracy

Table A-1. DP Total Accuracy for Enhanced ERS System Performance[1]

Sensor type	3051SAM__G2, 3051SAL__G2 250 inH_2O (622,1 mbar)	3051SAM__G3, 3051SAL__G3 1000 inH_2O (2488,4 mbar)	3051SAM__T1, 3051SAL__T1 30 psi (2,1 bar)	3051SAM__T2, 3051SAL__T2 150 psi (10,34 bar)	3051SAM__G4, 3051SAL__G4 300 psi (20,7 bar)	3051SAM__T3, 3051SAL__T3 800 psi (41,4 bar)
Rosemount 3051SAM[2]	0.2 inH_2O (0,5 mbar)	0.6 inH_2O (1,4 mbar)	0.9 inH_2O (2,2 mbar)	1.5 inH_2O (4,0 mbar)	6.2 inH_2O (15 mbar)	7.8 inH_2O (19 mbar)
Rosemount 3051SAL with direct mount seal types and sizes below[3]: • FF, FC, PF ≥ 2-in./DN50 • EF ≥ 3-in./DN80 • All RT, RF, RC, SS • SC ≥ 2.5-in.	2.2 inH_2O (5,5 mbar)	2.3 inH_2O (6,0 mbar)	3.0 inH_2O (7,5 mbar)	3.2 inH_2O (8,0 mbar)	6.5 inH_2O (16 mbar)	8.3 inH_2O (21 mbar)
Rosemount 3051SAL with other seal types and sizes	Consult Instrument Toolkit™ for performance.					

Performance class[1]		
1	Ultra: 0.025% span accuracy, 200:1 rangedown, 15-year stability, 15-year limited warranty	★
2	Classic: 0.035% span accuracy, 150:1 rangedown, 15-year stability	★
4	Enhanced ERS System performance, 15-year stability, 15-year limited warranty	★

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Complete Fill Fluid Offering for the Application

Seal fill fluid		Specific gravity at 77 °F (25 °C)	Temperature limits[13][14]				
			No extension	2-in. (50 mm) extension	4-in. (100 mm) extension	Thermal range expander[15]	Capillary
D	Silicone 200	0.934	–49 to 401 °F (–45 to 205 °C)			N/A	–49 to 401 °F (–45 to 205 °C)
F	Silicone 200 for vacuum applications	0.934	For use in vacuum applications below 14.7 psia (1 bar-a), refer to vapor pressure curves in Rosemount DP Level Fill Fluid Specification Technical Note.				
J[16]	Tri-Therm 300	0.795	–40 to 401 °F (–40 to 205 °C)	–40 to 464 °F (–40 to 240 °C)	–40 to 572 °F (–40 to 300 °C)	N/A	-40 to 572 °F (-40 to 300 °C)
Q[16]	Tri-Therm 300 for vacuum applications	0.795	For use in vacuum applications below 14.7 psia (1 bar-a), refer to vapor pressure curves in Rosemount DP Level Fill Fluid Specification Technical Note.				
L	Silicone 704	1.07	32 to 401 °F (0 to 205 °C)	32 to 464 °F (0 to 240 °C)	32 to 572 °F (0 to 300 °C)	Up to 599 °F (315 °C)	32 to 599 °F (0 to 315 °C)
C	Silicone 704 for vacuum applications	1.07	For use in vacuum applications below 14.7 psia (1 bar-a), refer to vapor pressure curves in Rosemount DP Level Fill Fluid Specification Technical Note.				
R	Silicone 705	1.09	68 to 401 °F (20 to 205 °C)	68 to 464 °F (20 to 240 °C)	68 to 572 °F (20 to 300 °C)	Up to 698 °F (370 °C)	68 to 698 °F (20 to 370 °C)
V	Silicone 705 for vacuum applications	1.09	For use in vacuum applications below 14.7 psia (1 bar-a), refer to vapor pressure curves in Rosemount DP Level Fill Fluid Specification Technical Note.				
Y[17]	UltraTherm 805	1.20	N/A			Up to 770 °F (410 °C)[18]	N/A
Z[17]	UltraTherm 805 for vacuum applications	1.20	For use in vacuum applications below 14.7 psia (1 bar-a), refer to vapor pressure curves in Rosemount DP Level Fill Fluid Specification Technical Note.				
A	SYLTHERM XLT	0.85	–157 to 293 °F (–105 to 145 °C)			N/A	-157 to 293 °F (-105 to 145 °C)
H	Inert (Halocarbon)	1.85	–49 to 320 °F (–45 to 160 °C)			N/A	-49 to 320 °F (-45 to 160 °C)
N[16]	Neobee M-20	0.94	5 to 401 °F (–15 to 205 °C)	5 to 437 °F (–15 to 225 °C)		N/A	5 to 437 °F (-15 to 225 °C)
G[10][16]	Glycerin and water	1.13	5 to 203 °F (–15 to 95 °C)			N/A	5 to 437 °F (-15 to 225 °C)

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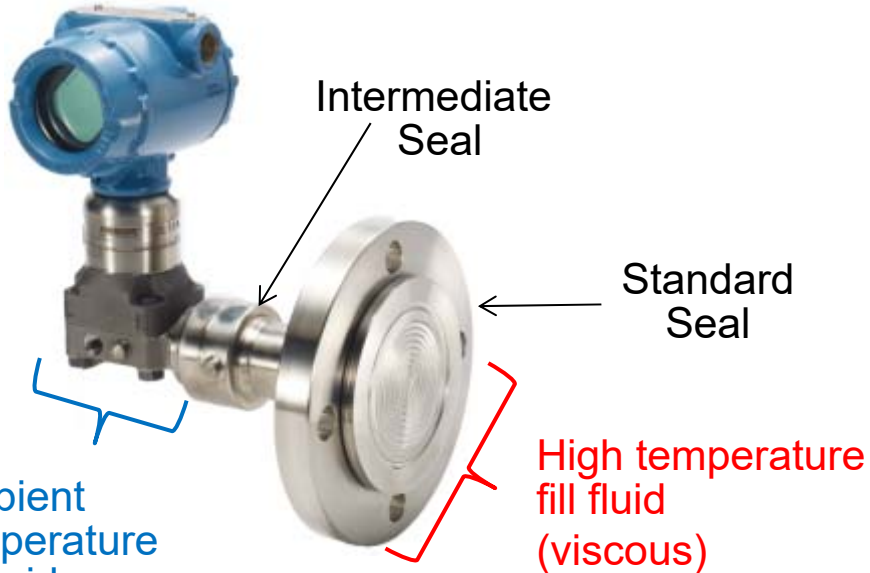
Thermal Range Expander

Challenge

- Hot applications (above 400° F) require highly viscous fill fluids
- Heat tracing and other complicated installations are used to keep fill fluids in operating range

Thermal Range Expander

- Maximize performance of high temperature fill fluids
  - Silicone 704
  - Silicone 705
  - UltraTherm 805
- Reduce response time



Value

- Eliminates the need for expensive heat tracing
- Ability to measure extreme processes

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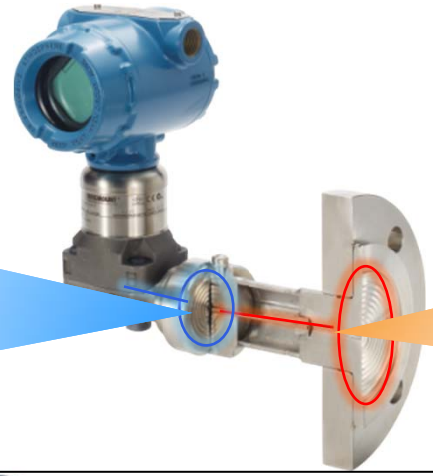
Thermal Range Expander Combines Two Fill Fluids with an Intermediate Diaphragm

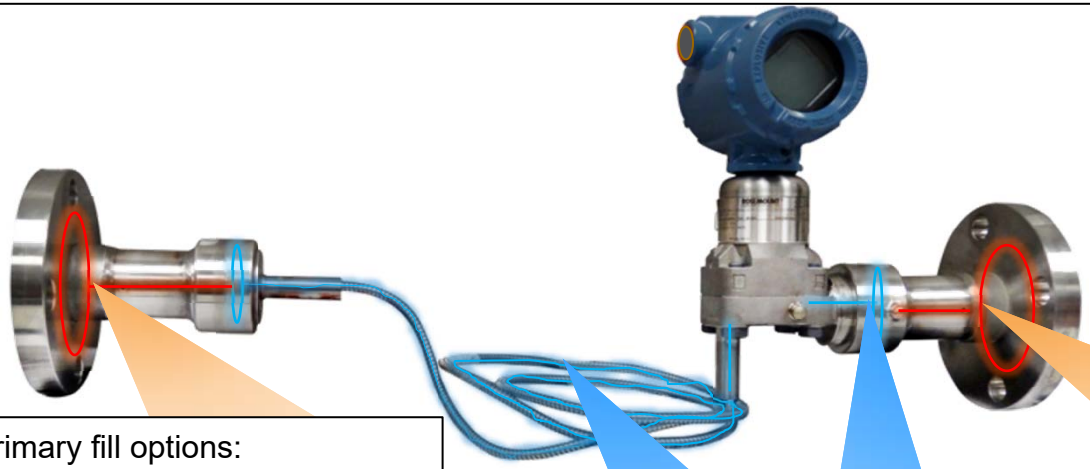
Direct Mount Capabilities:

- In-line or Coplanar style
- ERS™ system capability
- One primary and one secondary fill fluid

Secondary fill options:
- Silicone 200
- SYLTHERM XLT



Primary fill options:
- Silicone 704
- Silicone 704 for vacuum
- Silicone 705
- Silicone 705 for vacuum
- UltraTherm 805
- UltraTherm 805 for vacuum



Remote Mount Capabilities:

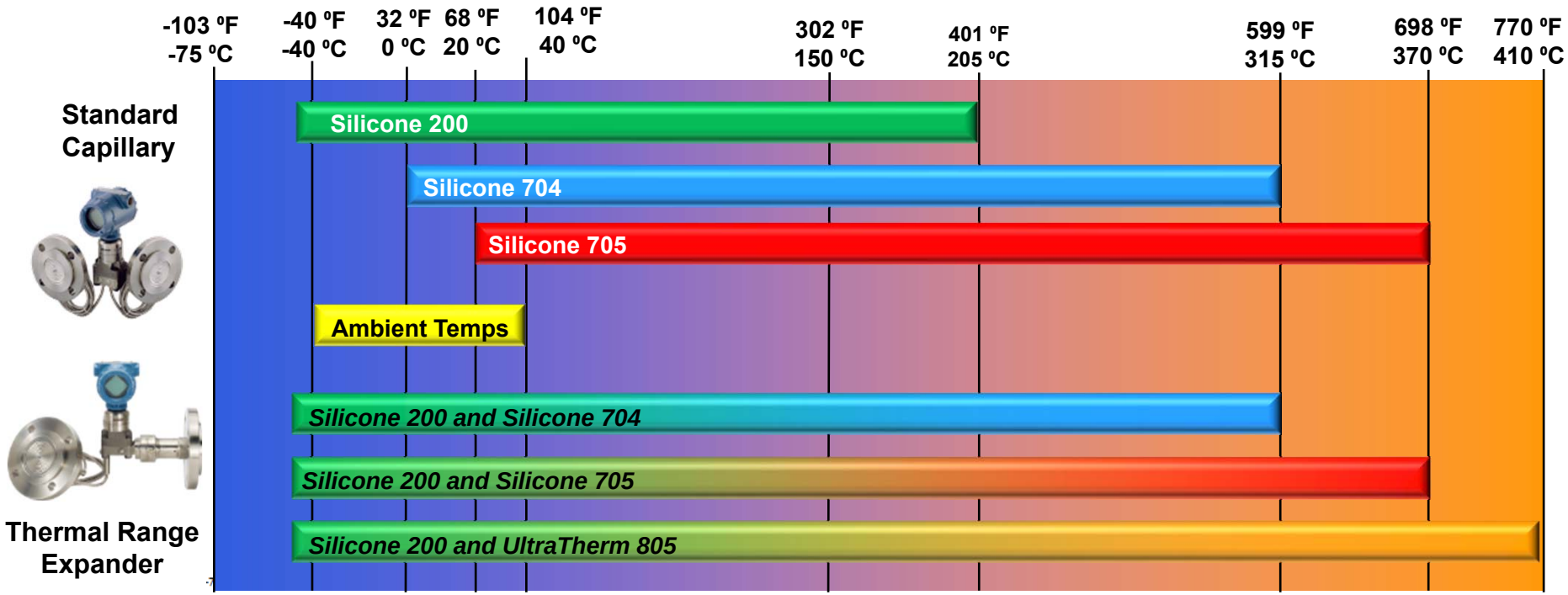
- In-line or Coplanar style
- Tuned-System assemblies or Balanced systems
- Select primary and secondary fill fluids for high and low side

Primary fill options:
- Silicone 704
- Silicone 704 for vacuum
- Silicone 705
- Silicone 705 for vacuum
- UltraTherm 805
- UltraTherm 805 for vacuum

Secondary fill options:
- Silicone 200
- SYLTHERM XLT

Primary fill options:
- Silicone 704
- Silicone 704 for vacuum
- Silicone 705
- Silicone 705 for vacuum
- UltraTherm 805
- UltraTherm 805 for vacuum

Thermal Range Expander Will Close the Hot Process / Cold Ambient Temperature Gap



Note: temperature ratings will be de-rated in vacuum applications

- Thermal Range Expander enables use of UltraTherm 805
  - Thermal Range Expander allows direct mounting up to 770˚ F
    - Previous limit at 500˚ F with 4 in. extension and Silicone 704/755
  - Extends operating ranges in vacuum applications

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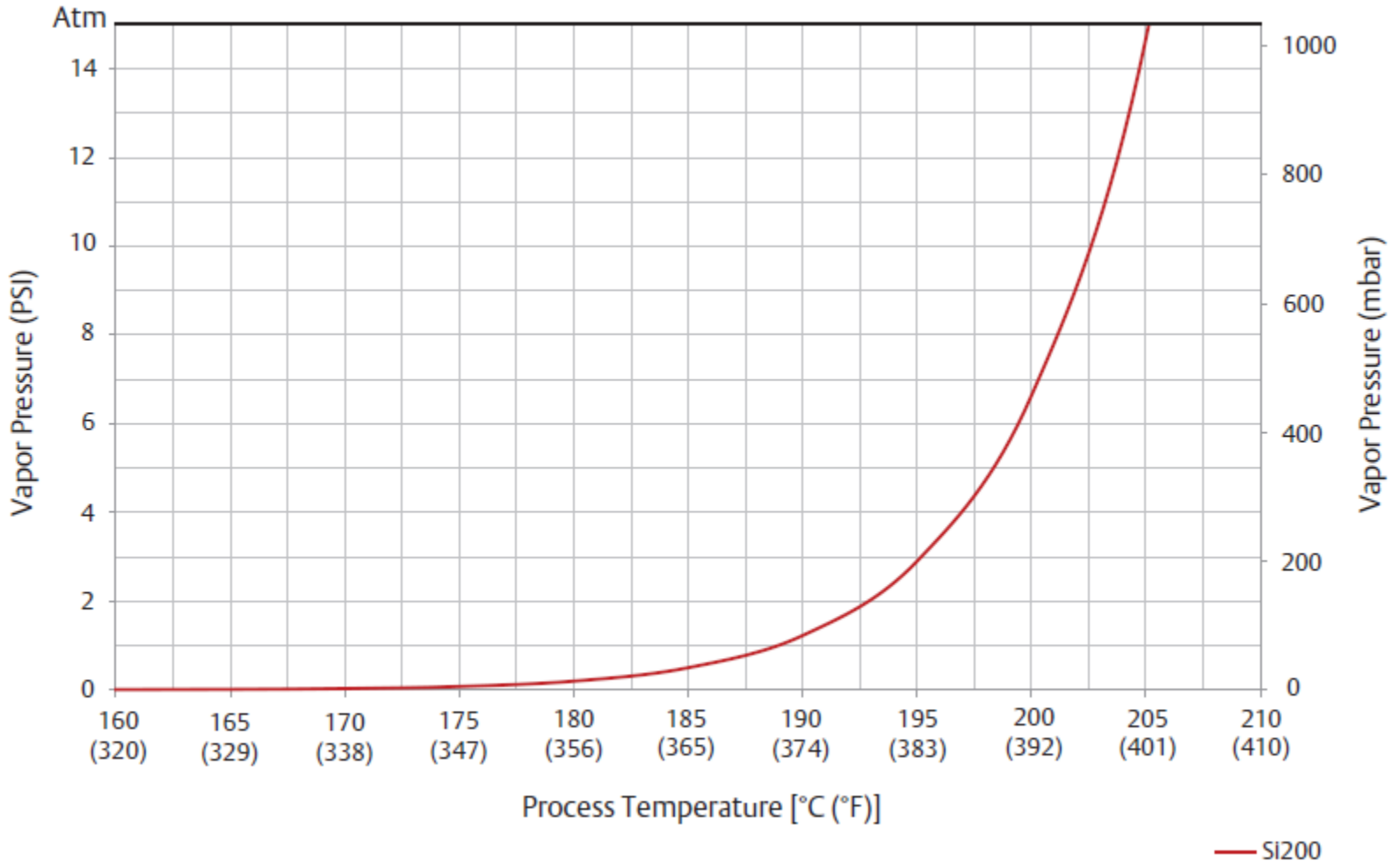
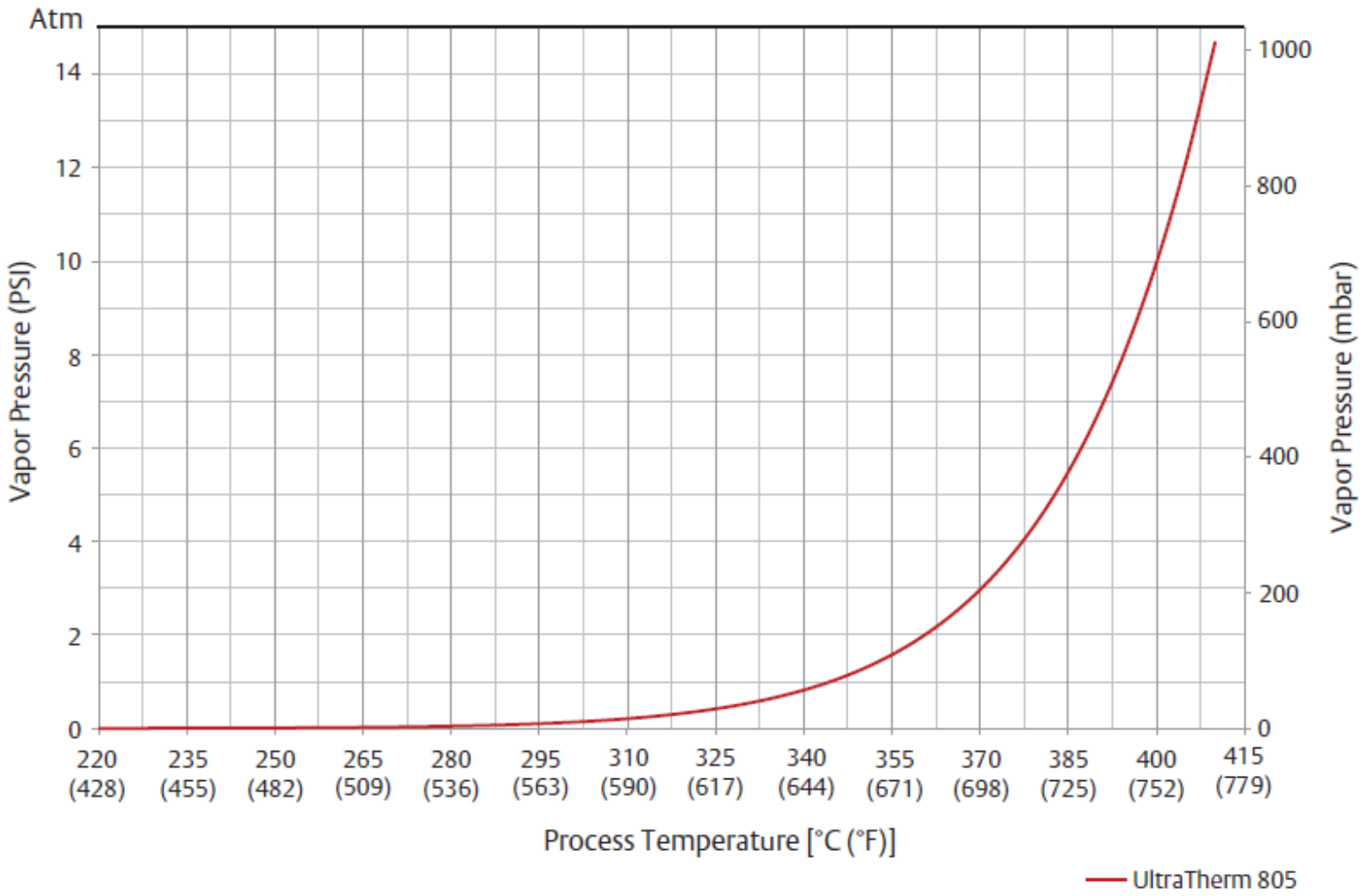
Vacuum Applications – Silicone 200

Figure 1-1. Silicone 200 for Vacuum Applications Vapor Pressure Curve



Vacuum Applications – UltraTherm 805

Figure 1-4. UltraTherm 805 for Vacuum Applications Vapor Pressure Curve



Eliminate Added Cost Associated with Heat Trace Capillary or Steam Trace

- Up to 60% cost savings when compared with heat tracing
  - No onsite wiring or setup required with Thermal Range Expander
  - Eliminate the need for a temperature controller
- Eliminate maintenance and ongoing operating costs
  - Stable measurement, no need to control heat trace
  - No continuous electricity or steam required

Heat Traced Balanced System with Temperature Controller

Questions?

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