Not Just a Lot of Hot Air!

In-line calibrating an Annubar® Primary Flow Element in unconventional ductwork or plumbing.

Short Course: 6A-4890

COMBINING THE ELEMENTS

EMERSON GLOBAL USERS EXCHANGE

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EmersonExchange@Emerson.com

Thank you.

Presenters

- Dave Winters
- Nate Kenyon

Dave Winters: Bio

- Field Service Engineer
- Based out of Rosemount DP Flow in Boulder, CO
- 35 years of service to Rosemount DP Flow
- Experience
  - Drafting
  - Design
  - Field Service: Experiences include flowmeter installations, start-ups, and in-line calibration

Nate Kenyon: Bio

- Product Development Engineer
- Also based out of Rosemount DP Flow in Boulder, CO
- Experience:
  - Skid design
  - Antifreeze/coolant processing plant
  - Flowmeter configuration management
  - Rosemount DP Flow projects outside standard product offering

In-Line Calibration - Introduction

- Focusing on air flow:

  – You will learn how an Annubar® Averaging Pitot Tube works.

  – You will learn how an S-Type (Stauscheibe) Pitot Tube works.

  – You will learn how to perform an in-line calibration.

  – You will learn how to obtain an accurate reading from an Annubar® APT installed in less than ideal conditions.

In-Line Calibration - Introduction

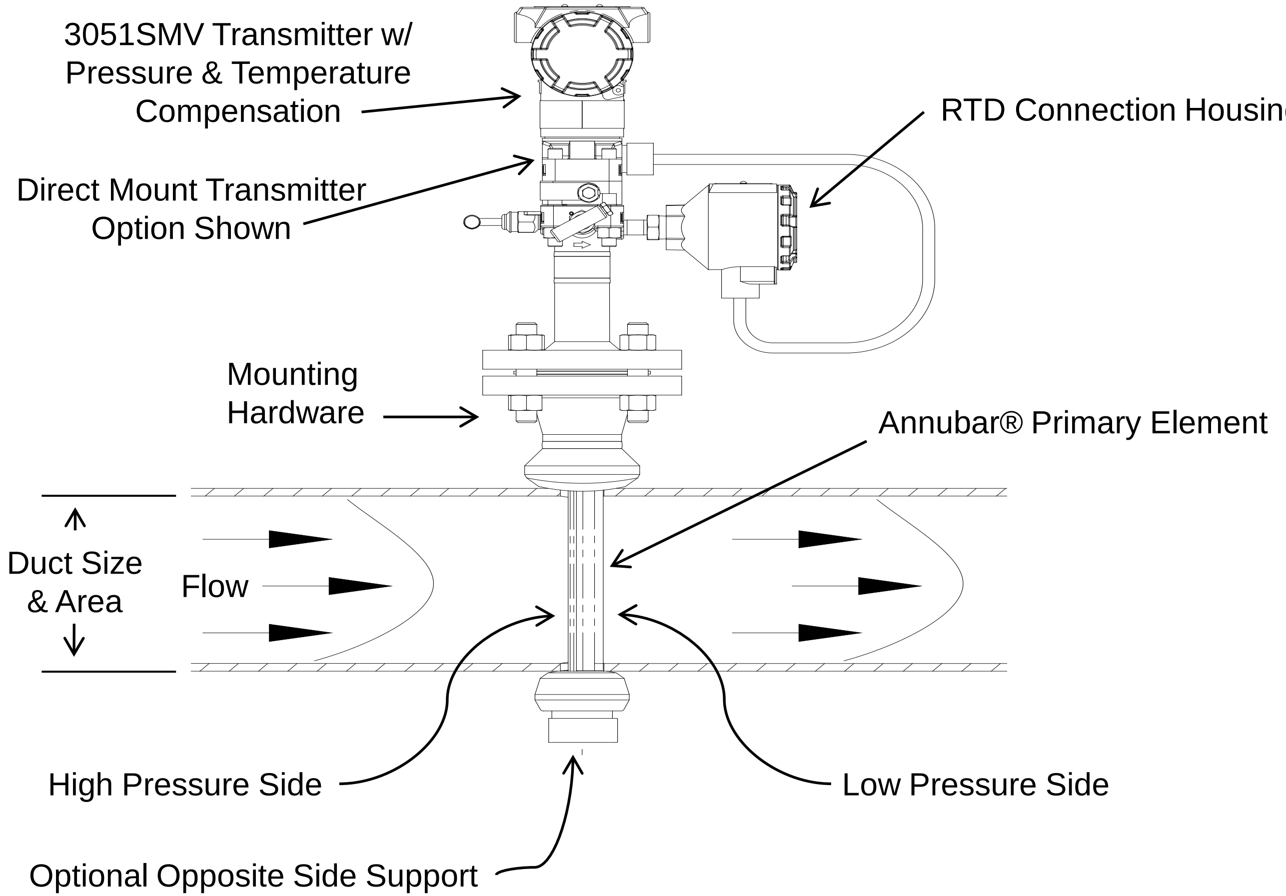
- We may inadvertently use the following terms interchangeably:

In-Line Calibration
Pitot Traverse
Flow Test
In-Situ Calibration
In-Line Flow Calibration

Flow Coefficient
K-Factor
Blockage Coefficient

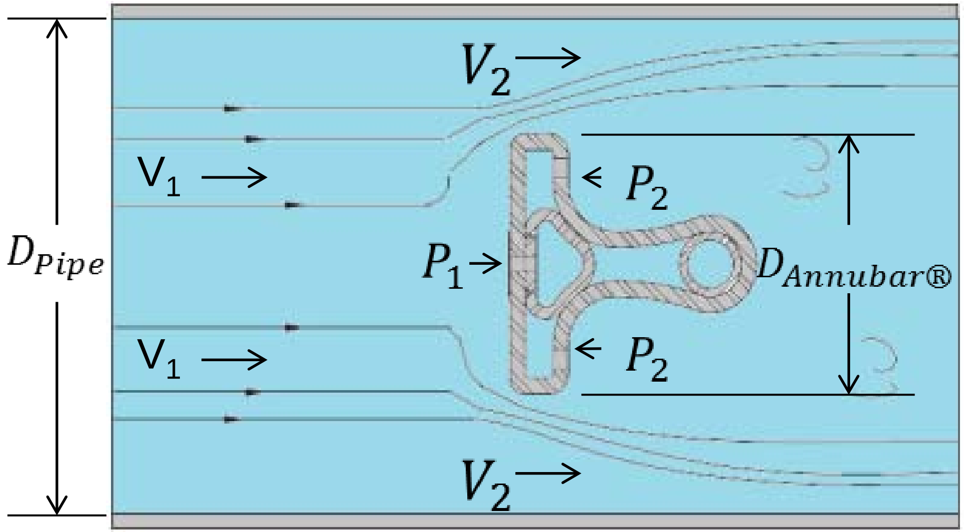
Annubar® Primary Element
485
Annubar® APT (Averaging Pitot Tube)

Annubar® Primary Element Basics



Annubar® Primary Element Basics

$V_2 > V_1$



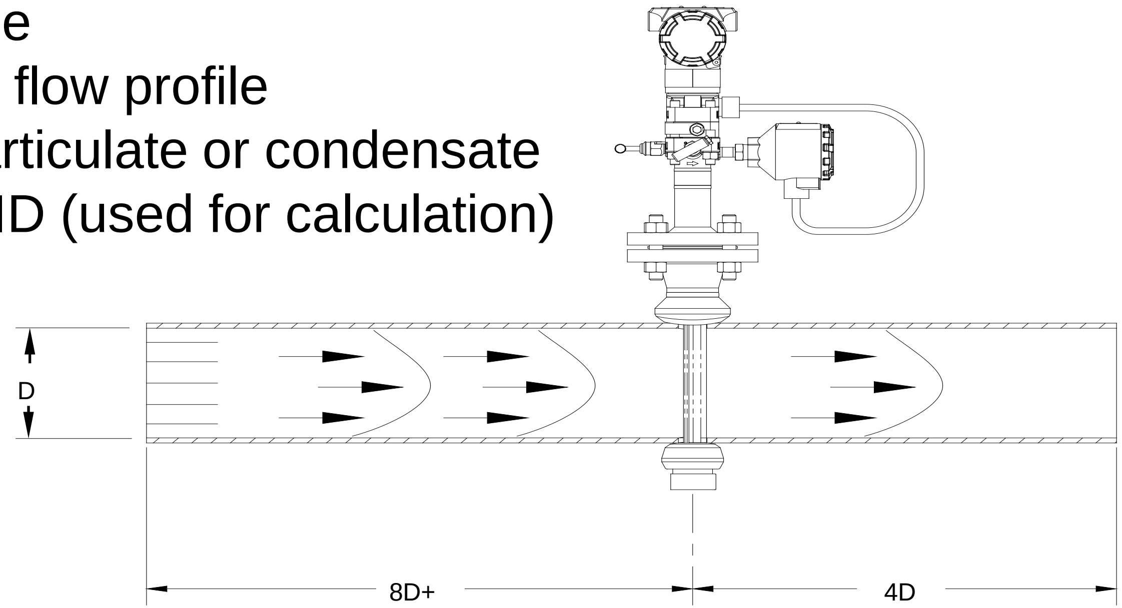
$P_2 < P_1$

- The Annubar® primary element creates a blockage in the process piping (Model 485 is shown).
- Process fluid accelerates to fit the same amount of fluid flow through the smaller area.
- Since energy must be conserved the process pressure decreases as velocity increases.
- The transmitter measures the difference in pressure and calculates flow rate.

Any Questions?

Annubar® Primary Element Installation

- Dream Conditions
  - 8 upstream and 4 downstream diameters of straight pipe (or more)
  - No valves, elbows, reducers, holes, expanders, etc. in front of measurement point
  - Annubar® APT installed perpendicular to pipe axis within 3°
  - Smooth wall pipe
  - Fully developed flow profile
  - No moisture, particulate or condensate
  - Measured pipe ID (used for calculation)



In-Line Calibration - Introduction

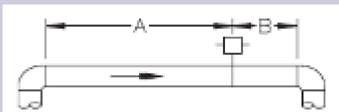
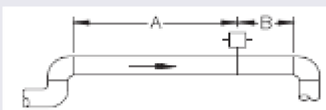
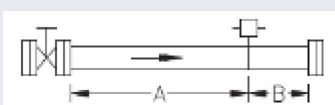
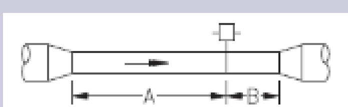
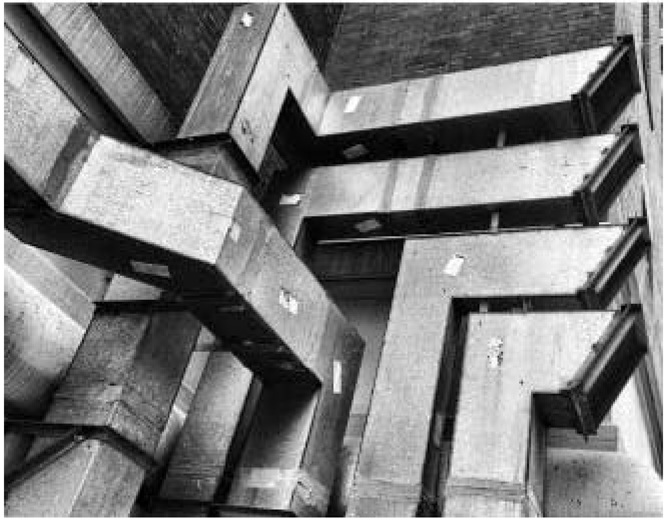
Upstream/Downstream Condition	Recommended 'A'	Recommended 'B'
	8D in plane 10D out of plane	4D
	11D in plane 16D out of plane	4D
	23D in plane 26D out of plane	4D
	30D in plane 30D out of plane	4D
	12D in plane 12D out of plane	4D

Table taken from the 485 QIG (Quick Installation Guide)

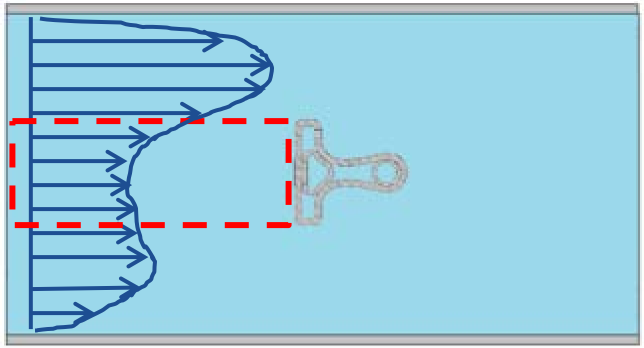
In-Line Calibration - Introduction

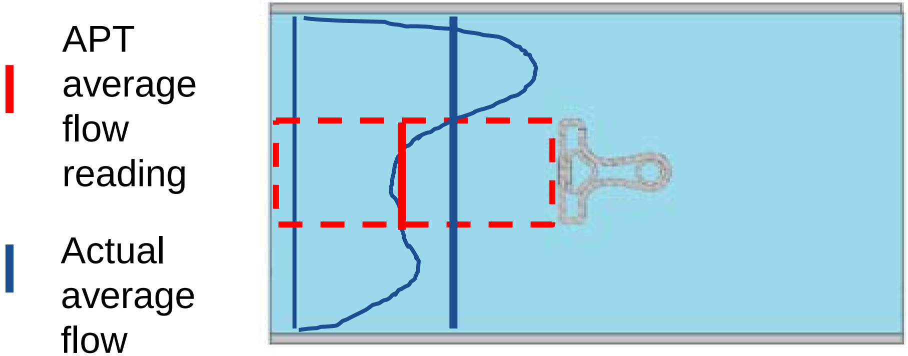
- Why do you need an In-Line Calibration?
  - Annubar® APT is installed in less than ideal conditions
    - Lack of straight run
    - Odd-shaped or large ducting
    - Non-standard mounting
    - Fan or dampers in close proximity
    - ‘Manifold’ of primary elements
    - Temperature gradient in flow
  - Flow reading is not representative of actual flow



In-Line Calibration

- Introduction: An in-line flow calibration is used to adjust the K-Factor (or flow coefficient) of the Annubar® APT so that the DP reading from the bar matches the actual, non-standard flow through the pipe or duct.

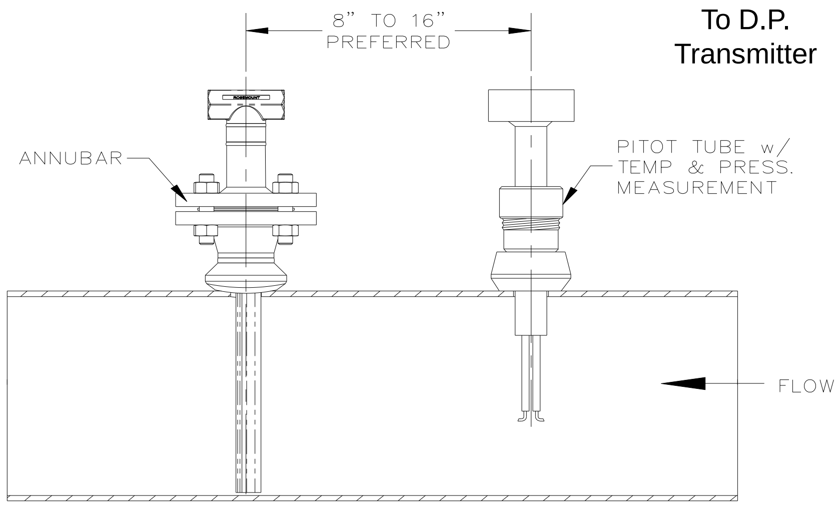




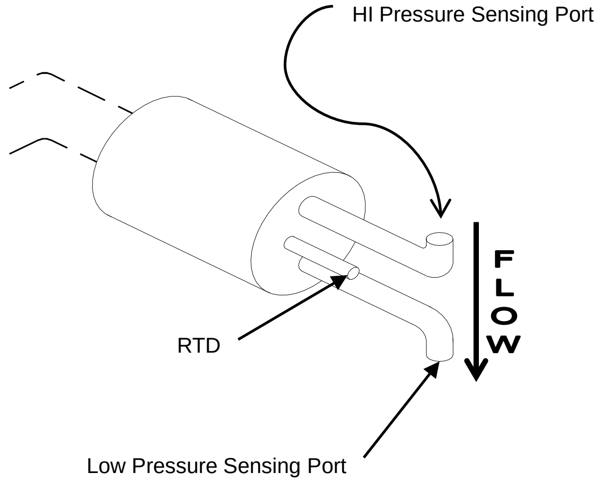
- First, we determine the actual flow through the pipe.
- Then we adjust the K-Factor that has been programmed into the transmitter (or customer’s control system) to account for the non-standard flow profile.

In-Line Calibration

- Where did it come from?
  - The actual Pitot Traverse is done following the guidelines of <u>Code of Federal Regulations</u> (CFR) number 40, part 60
- Where does the Pitot Traverse take place?
  - At or near the location of an existing Annubar® primary element, the Pitot tube is used to determine the actual flow rate, compensating for any special conditions.



<u>Preferred Flow Testing Location</u>



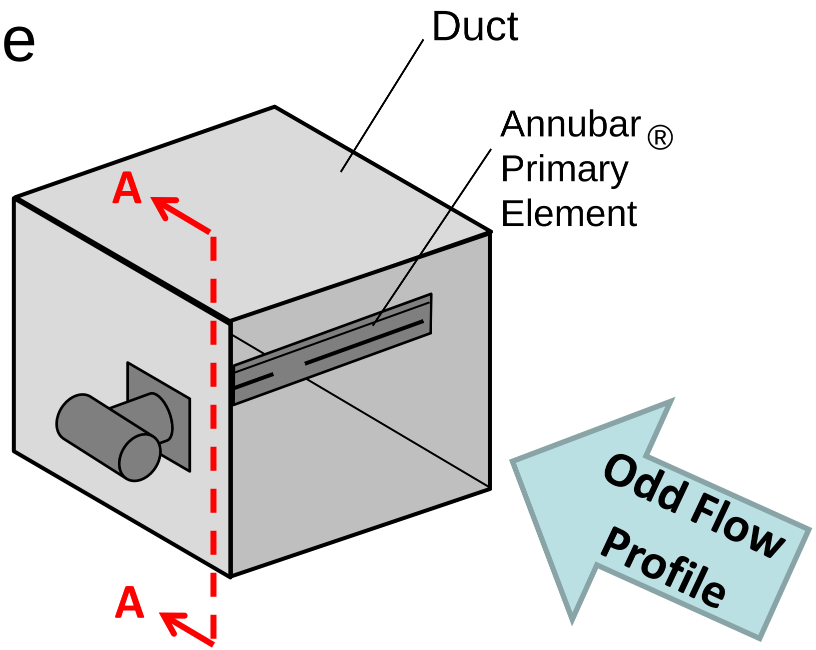
<u>Stauscheibe Pitot</u>

(aka: "S-type" or open face)

Any Questions?

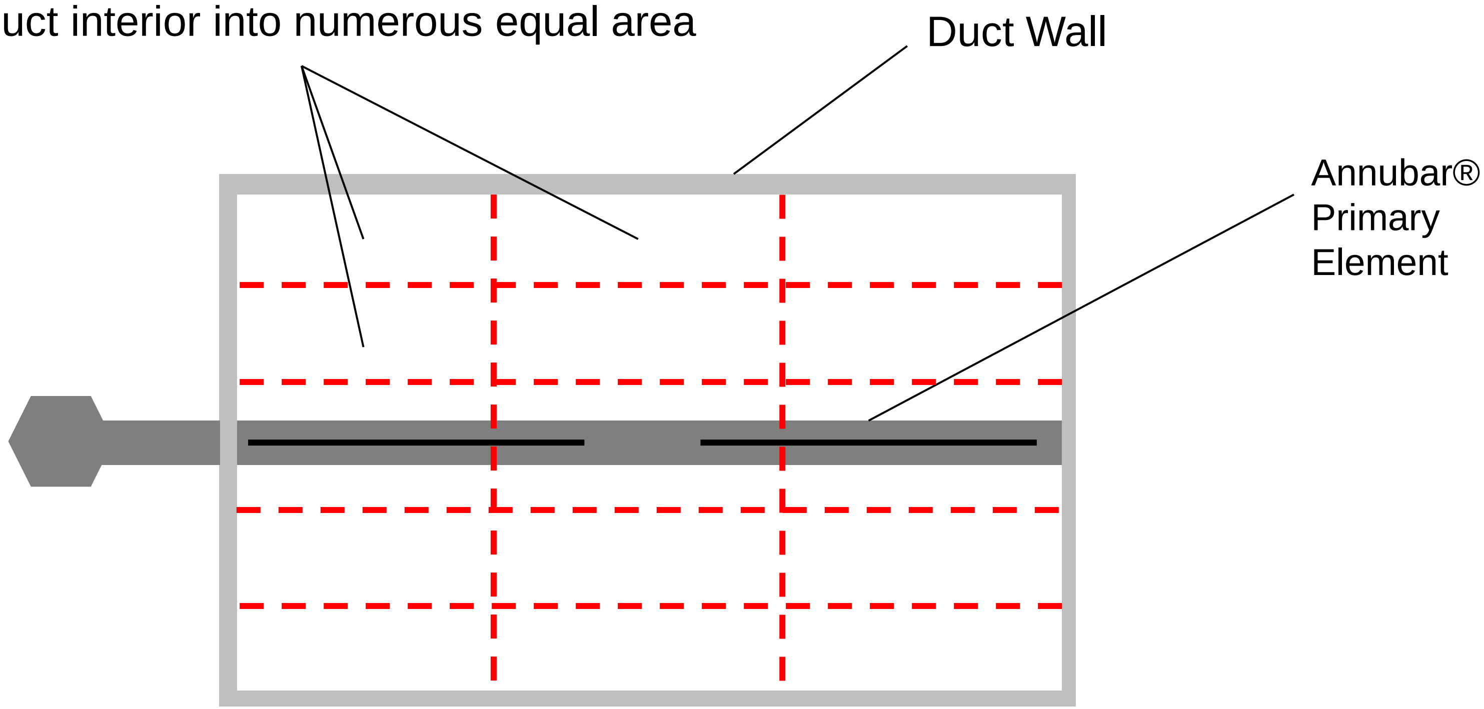
In-Line Calibration - Introduction

- What are the steps to an In-Line Calibration?
  - Split the pipe or duct into numerous equal area segments near the Annubar® APT
  - Use an S-type Pitot tube to measure the DP (flow) through each segment
  - Adjust the Annubar® APT flow coefficient to make the flow or DP reading match the total flow determined from the Pitot Tube measurements



In-Line Calibration - Introduction

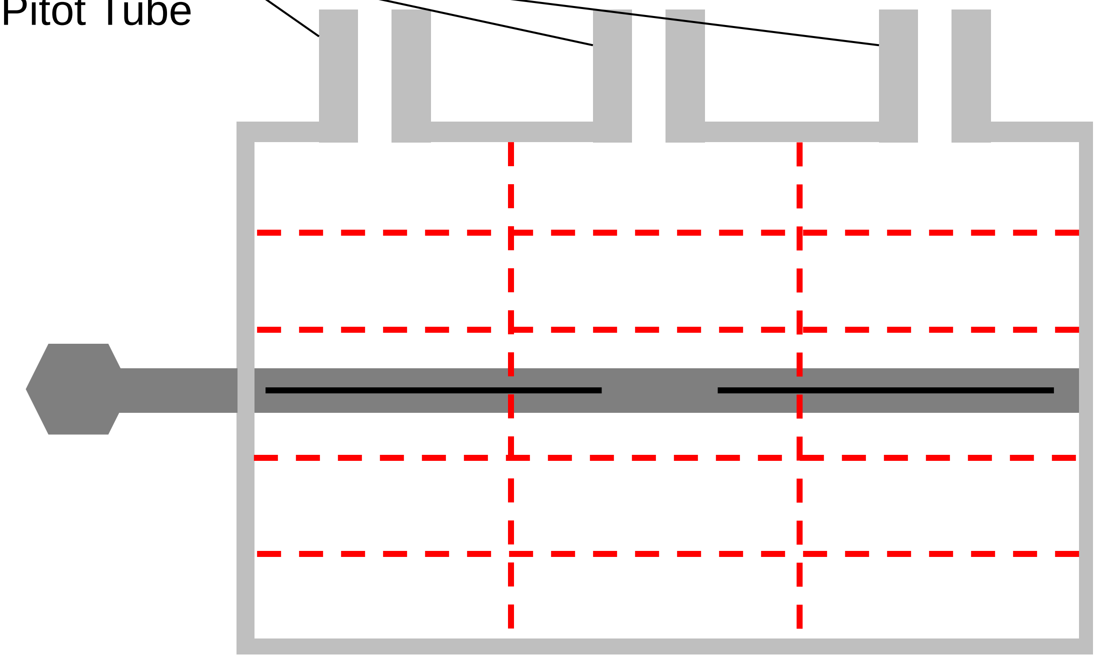
Divide the duct interior into numerous equal area segments



Section A-A from previous slide

In-Line Calibration - Introduction

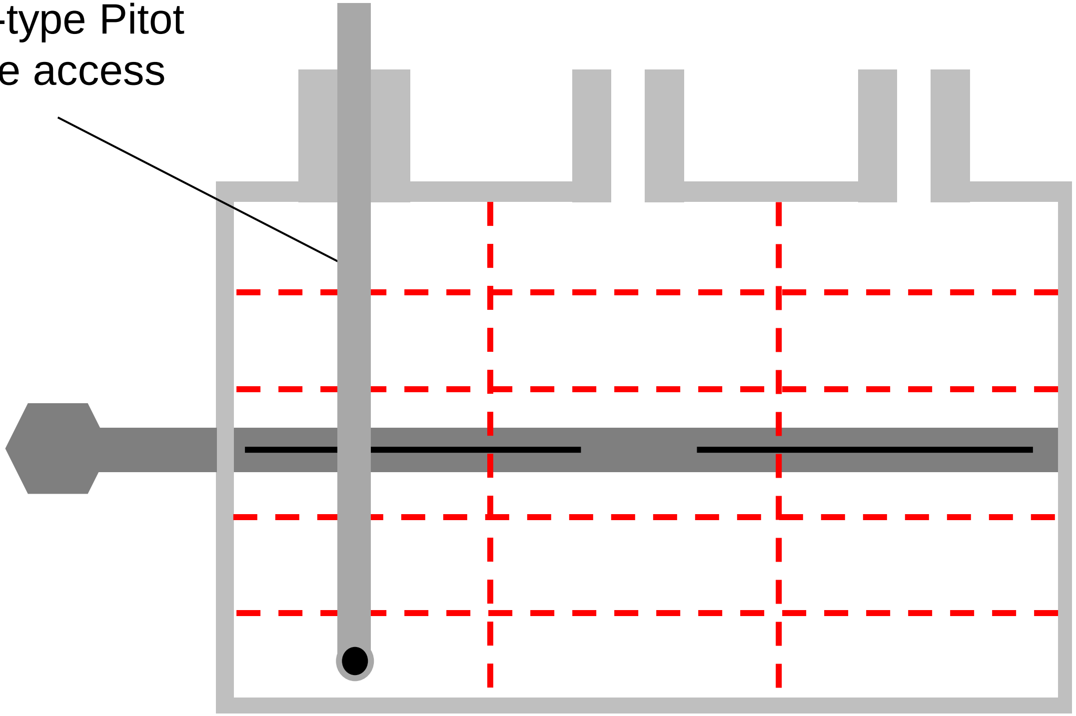
Add access ports for the S-type Pitot Tube



Section A-A from previous slide

In-Line Calibration - Introduction

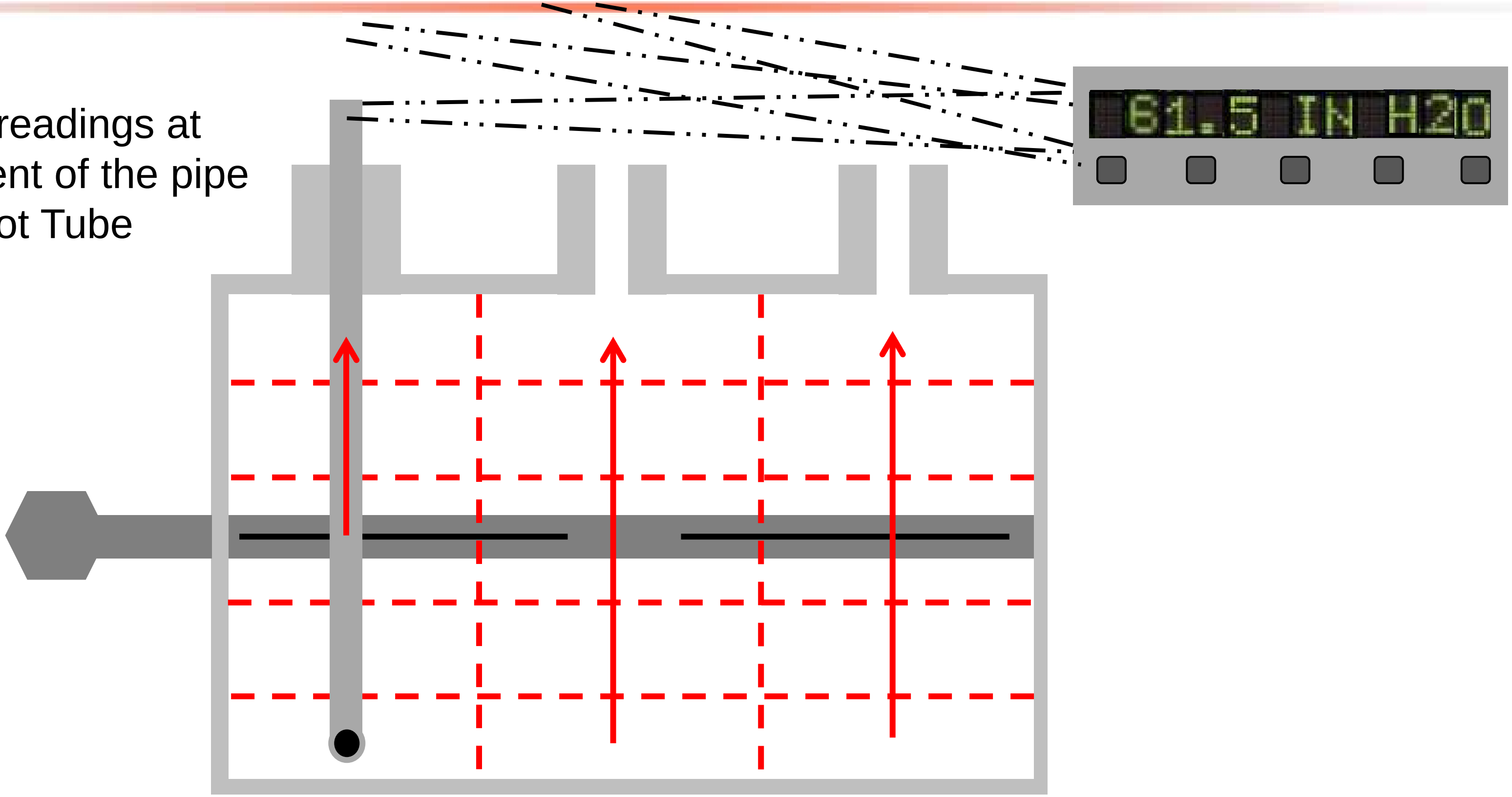
Insert the S-type Pitot Tube into the access port



Section A-A from previous slide

In-Line Calibration - Introduction

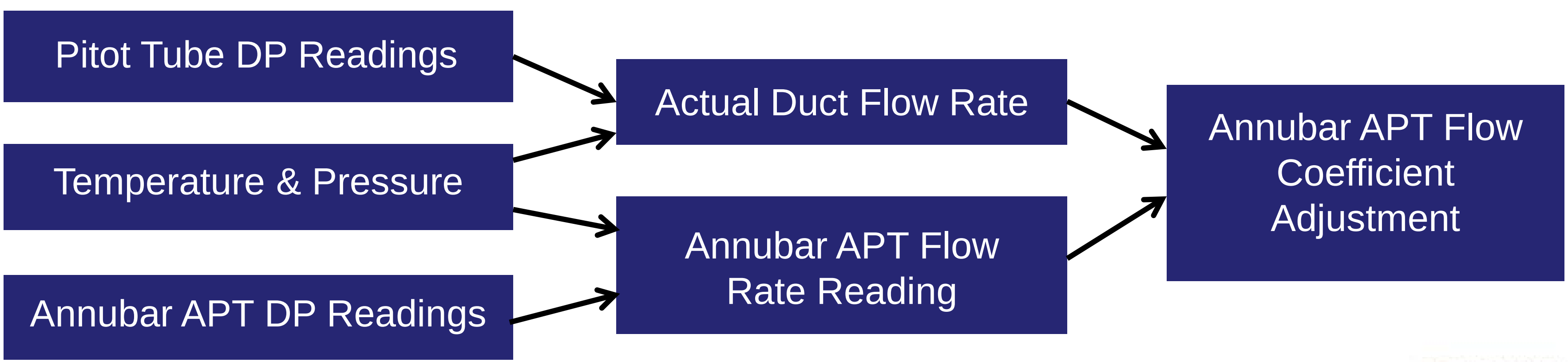
Record DP readings at each segment of the pipe from the Pitot Tube



Section A-A from previous slide

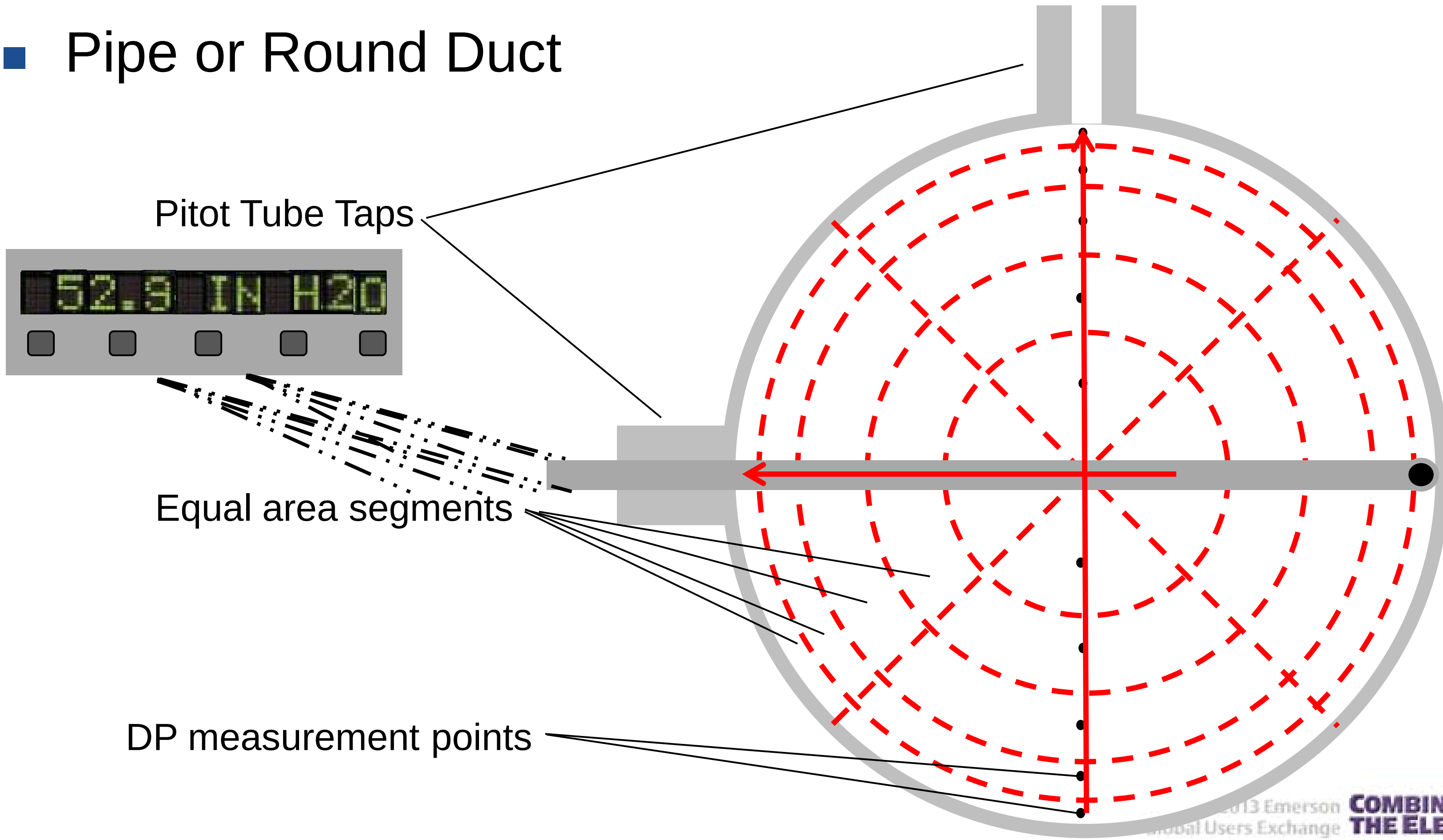
In-Line Calibration - Introduction

- Use area, temperature, pressure, blockage and recorded DP from the S-type Pitot Tube in each segment to determine actual flow
- Compare to Annubar® APT's reading
- Adjust the primary element's flow coefficient to match

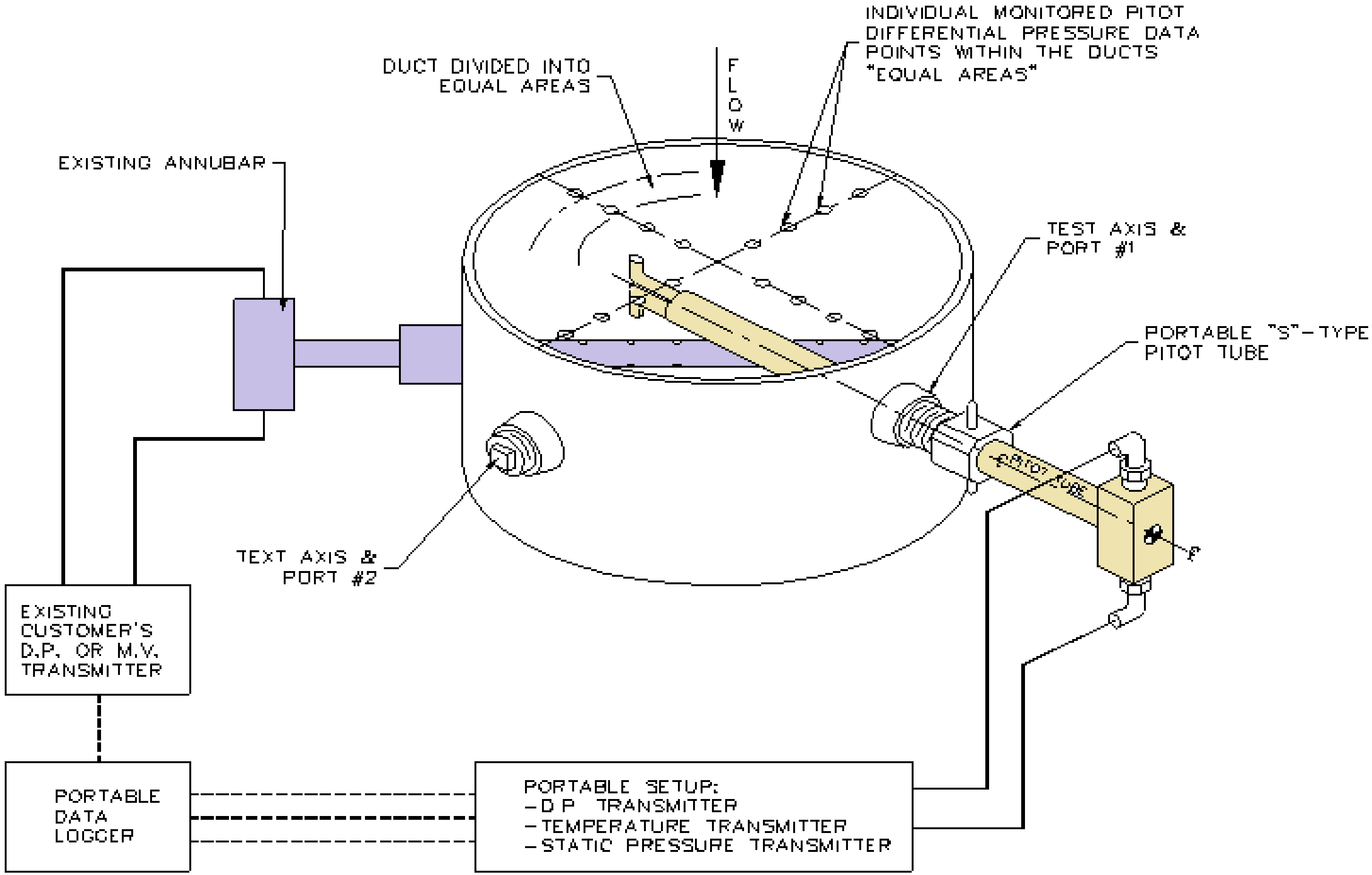


In-Line Calibration - Introduction

- Pipe or Round Duct



In-Line Calibration - Introduction



Prior to In-Line Calibration

- Obtain customer information
  - Fan curve
  - Line/Duct size and wall thickness
  - Mounting information
  - Fluid information
    - Type of fluid: Air, natural gas, steam, etc.
    - Temperature of fluid
    - Process pressure on fluid
- Enter this information into a quoting and calculation program called “Instrumentation Toolkit” to predict the DPs and K-factor

Prior to In-Line Calibration

ROSEMOUNT INC.
485 - Annubar Primary Element
CALCULATION DATA SHEET

EMERSON
Process Management

GENERAL DATA

Customer:	Various
Project:	Nate Kenyon
S. O. No:	
P. O. No:	
Calc. Date:	
Model No:	485G080Z0HP01T100R7RL
Tag No:	EMEX-DEMO-AIR-430F

PRODUCT DESCRIPTION

Product Type:	Pak-Lok	Instrument Valve:	
Sensor Size:	Sensor Size 1	Valve Material:	
Wetted Material:	316 Stainless Steel	Line Size:	8-in. (200 mm)
Transmitter Conn.:	Remote-Mount NPT Connections	Pipe Sch.:	
Mounting Conn. Material:	316 Stainless Steel	Pipe Orientation:	Horizontal
Mounting Type:	Compression/Threaded Connection		

INPUT DATA

Fluid Type:	Gas	Wall:	0.100 Inch
Fluid Name:	AIR		
Pipe I.D. (Span):	8.250 Inch	Equivalent Pipe ID:	7.064 Inch
Body I.D.:	8.250 Inch	Base Pressure:	14.696 psia
Duct Width:	4.750 Inch	Base Temperature:	60.00 F
Pressure at Flow:	0.200 InH2O@60F-g		
Temperature at Flow:	430.00 F		
Absolute Viscosity:	0.02660 cP	Base Density:	0.0764 lb/ft3
Isentropic Exponent:	1.390	Atmospheric Pressure:	14.696 psia
Compressibility at Flow:	1.0002		
Density at Flow:	0.0446 lb/ft3	[Primary Dimension]:	

Flow Rates

Minimum:	400.00 ACFM
Normal:	600.00 ACFM
Maximum:	800.00 ACFM
Full Scale:	800.00 ACFM

CALCULATED DATA (Calculation Performed at Normal Conditions.)

DP at Min Flow:	0.258 inH2O@68F	Flow Coefficient:	0.5967
DP at Normal Flow:	0.581 inH2O@68F		
DP at Max Flow:	1.034 inH2O@68F	Rod Reynolds Number (Minimum):	3005
DP at Full Scale Flow:	1.034 inH2O@68F	Rod Reynolds Number (Normal):	4507
Resonant Frequency:	404 Hz	Gas Expansion Factor:	0.9999
Wake Frequency:	149 Hz	Permanent Pressure Loss:	
Blockage:	0.12	at Normal Flow:	0.07 inH2O@68F
		at Maximum Flow:	0.13 inH2O@68F
		Velocity at Max Flow:	48.65 ft/sec

GUIDELINES

Primary Element Min Limit:	865.37 ACFM		Recommended Min Rod Reynolds Number:	6500
Structural Limit (Flow):	13984.11 ACFM		Recommended Min DP:	0.100 inH2O@68F
Structural Limit (DP):	315.8 inH2O@68F			
Max. Allow. Pressure@Temp.:	27818.1 InH2O@60F-g	430 F	Max. Allow. Temp.:	850 F
Design Pressure/Temperature:	0.20 InH2O@60F-g	430.00 F		

WARNINGS

* Flowrate is below recommended minimum value of 865.367568 ACFM.

NOTES

This report is provided according to the terms and conditions of the Instrument Toolkit(TM) End-Use Customer License Agreement.
Version: 3.0 (Build163D) Printed On: 26-Aug-2013

- Instrument Toolkit Calculation Datasheet
  - Customer inputs
  - Calculated outputs
  - Warnings, structural failure information

Prior to In-Line Calibration

- Sizing the Annubar® Primary Element in Instrumentation Toolkit:

ROSEMOUNT INC.
485 - Annubar Primary Element
CALCULATION DATA SHEET

EMERSON. Process Management

GENERAL DATA

Customer:	Various
Project:	Nate Kenyon and Dave Winters
S. O. No:	
P. O. No:	
Calc. Date:	August 26, 2013
Model No:	485G080ZSHPS1T100R7RL / 3051SFA1G080ZSHPS1T100T31DA1A5RLQ4M5
Tag No:	EMEX-DEMO-AIR-430F

PRODUCT DESCRIPTION

Product Type:	485 Duct Mount	Instrument Valve:	
Sensor Size:	Sensor Size 1	Valve Material:	
Wetted Material:	316 Stainless Steel	Line Size:	8.25" X 4.75"
Transmitter Conn.:	Remote-Mount NPT Connections	Pipe Sch.:	
Mounting Conn. Material:	316 Stainless Steel	Pipe Orientation:	Horizontal
Mounting Type:	Duct Flange		

Prior to In-Line Calibration

- Sizing the Annubar® Primary Element in Instrumentation Toolkit:

We field verify duct dimensions prior to in-line calibration

INPUT DATA

Fluid Type:	Gas	Wall:	0.100 inch
Fluid Name:	AIR		
Pipe I.D. (Span):	8.250 inch	Equivalent Pipe ID:	7.064 inch
Body I.D.:	8.250 inch	Base Pressure:	14.696 psia
Duct Width:	4.750 inch	Base Temperature:	60.00 F
Pressure at Flow:	0.200 inH2O@60F-g		
Temperature at Flow:	430.00 F		
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Isentropic Exponent:	1.390	Atmospheric Pressure:	14.696 psia
Compressibility at Flow:	1.0002		
Density at Flow:	0.0446 lb/ft3	[Primary Dimension]:	

Flow Rates

Minimum:	400.00 ACFM
Normal:	600.00 ACFM
Maximum:	800.00 ACFM
Full Scale:	800.00 ACFM

From Customer's Original Order

Prior to In-Line Calibration

- Sizing the Annubar® Primary Element in Instrumentation Toolkit:

Customer's original flow coefficient from initial Toolkit sizing calculation. This is the flow coefficient in the transmitter "out of the box".

CALCULATED DATA (Calculation Performed at Normal Conditions.)

DP at Min Flow:	0.258	inH2O@68F	Flow Coefficient:	$\boxed{0.5567}$	
DP at Normal Flow:	0.581	inH2O@68F			
DP at Max Flow:	1.034	inH2O@68F	Rod Reynolds Number (Minimum):	3005	
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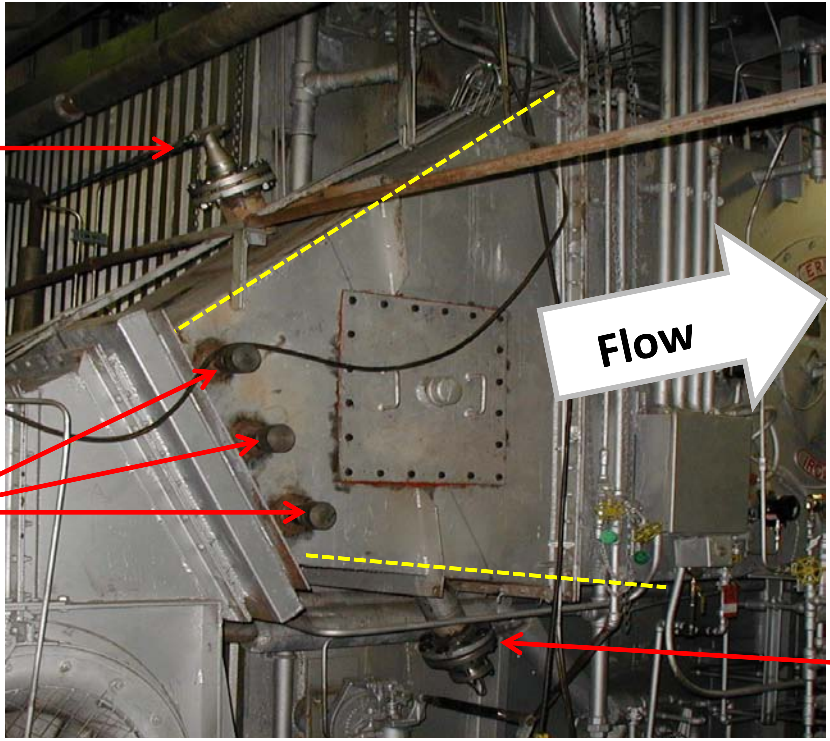
Max. Allow. Pressure@Temp.:	27818.1	inH2O@60F-g 430 F	Max. Allow. Temp.:	850	F
Design Pressure/Temperature:	0.20	inH2O@60F-g 430.00 F			

Any Questions?

Annubar® APT Installation: Real Condition 1



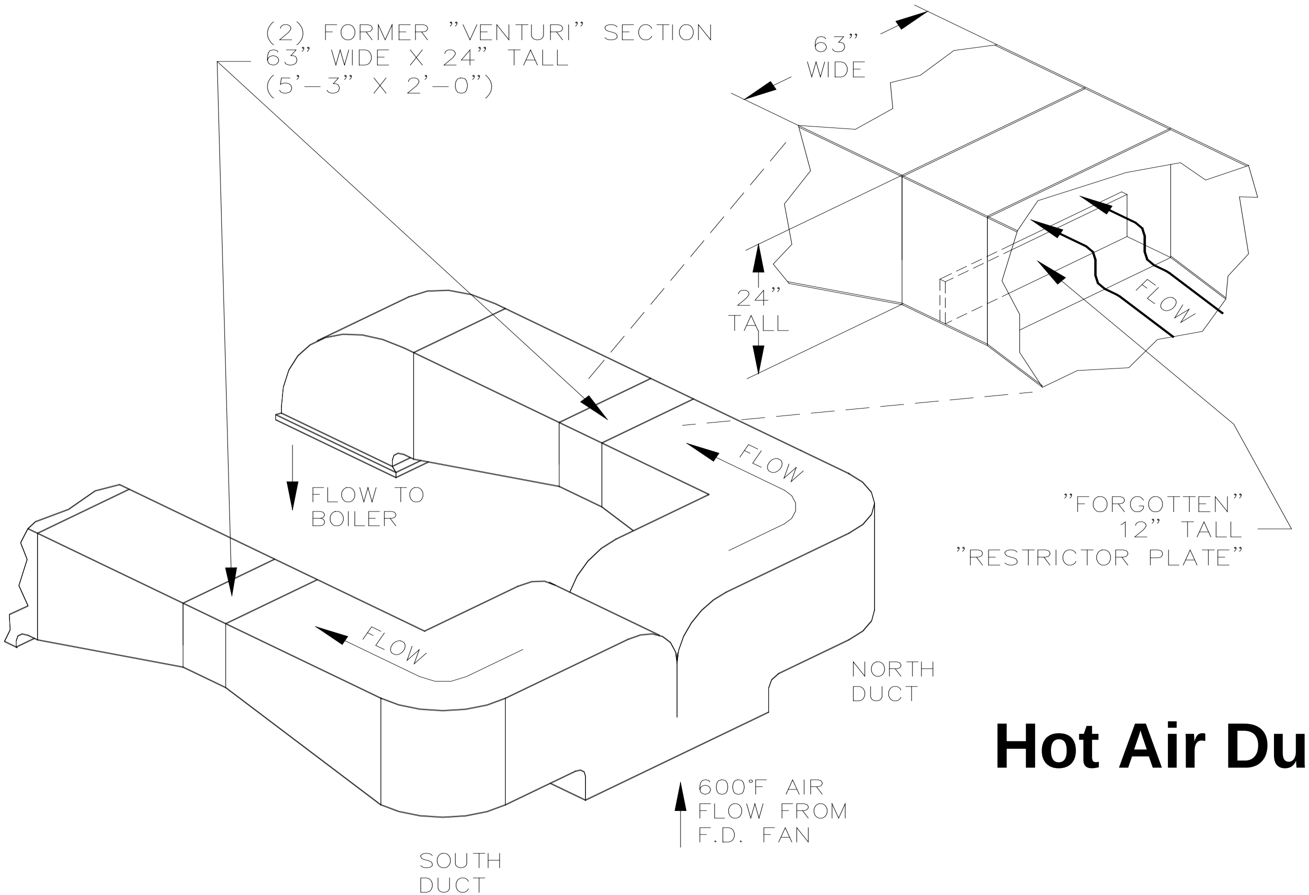
Annubar® Head

In-Line Calibration Test Ports

Annubar® Tip

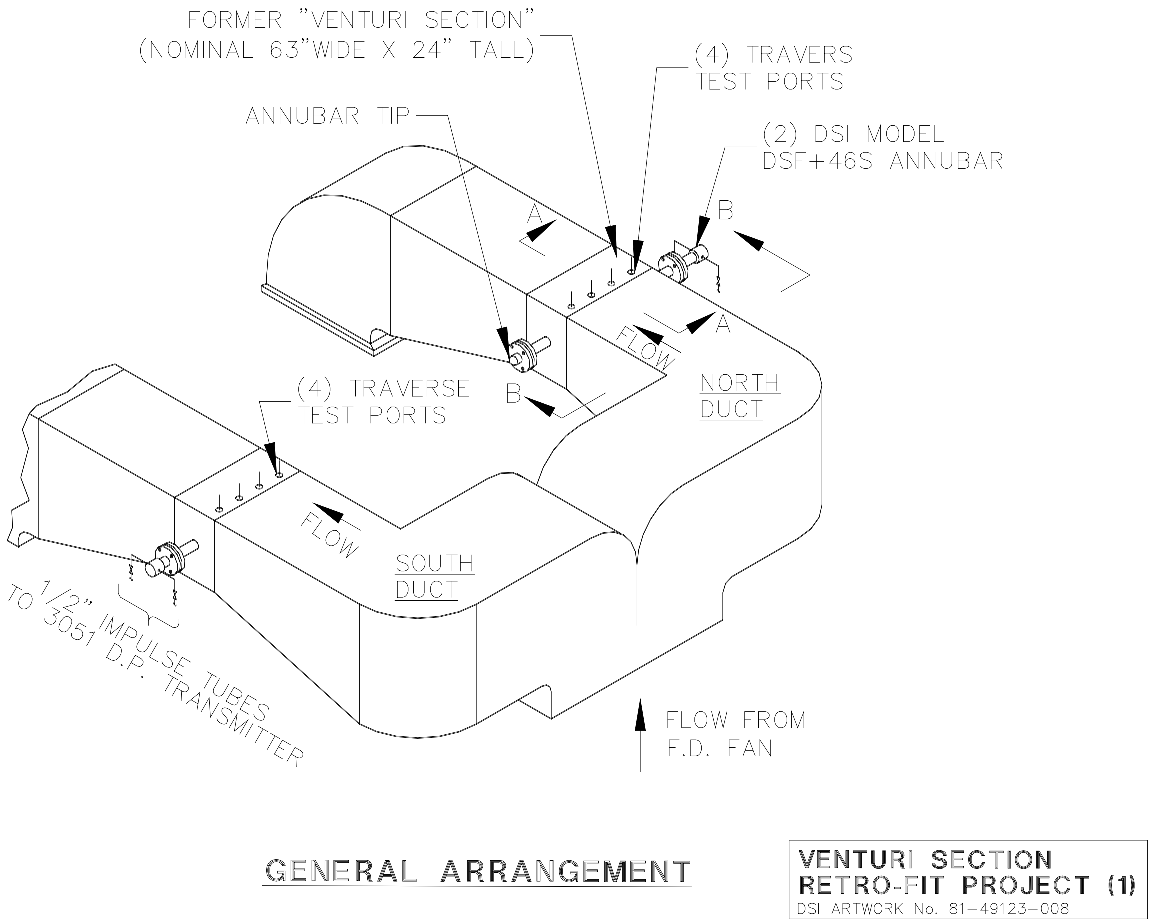
Annubar® installed directly after Fan in Windbox Expansion/Transition Duct

Annubar® APT Installation: Real Condition 2

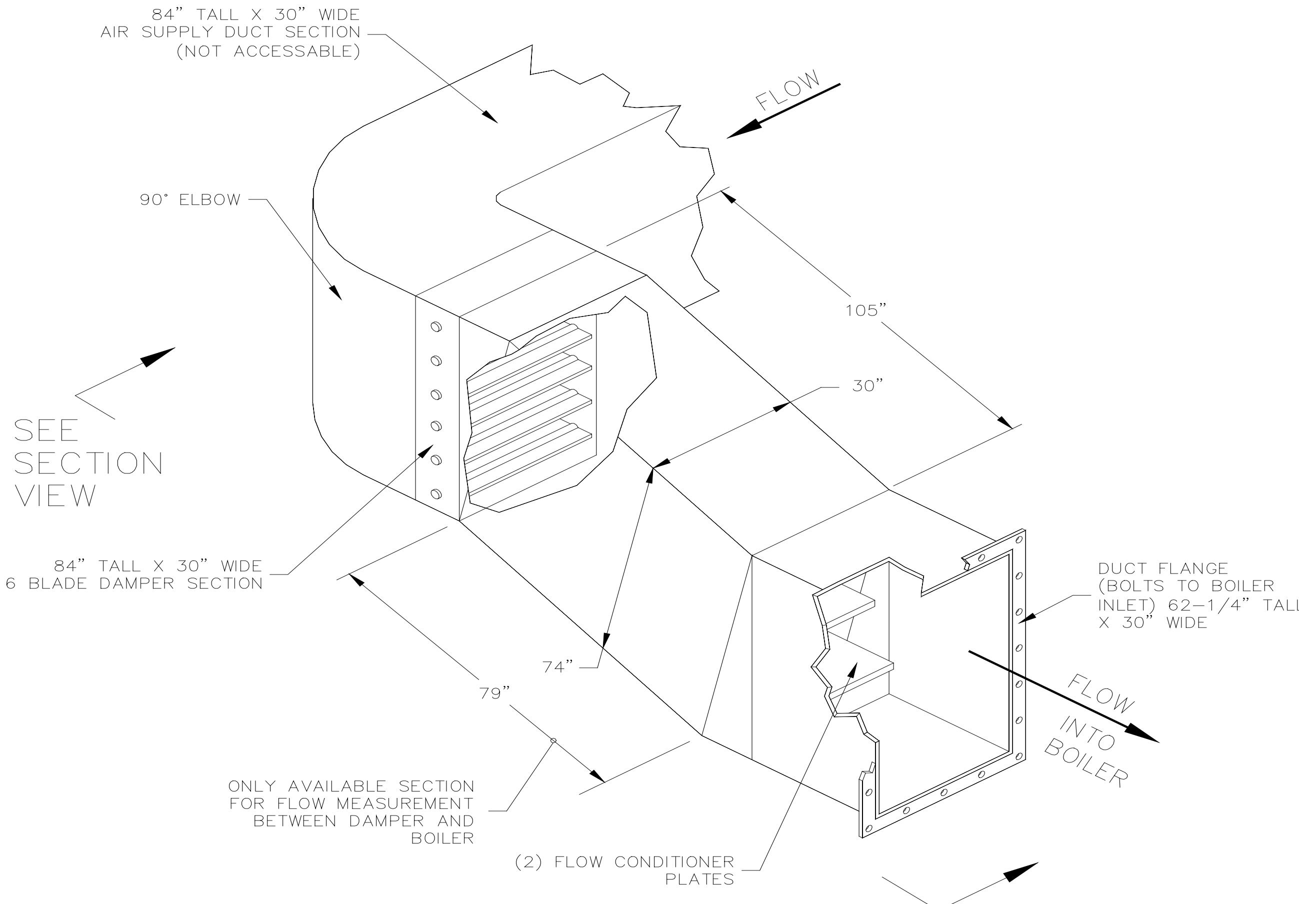


Hot Air Ducting

Annubar® APT Installation: Real Condition 2

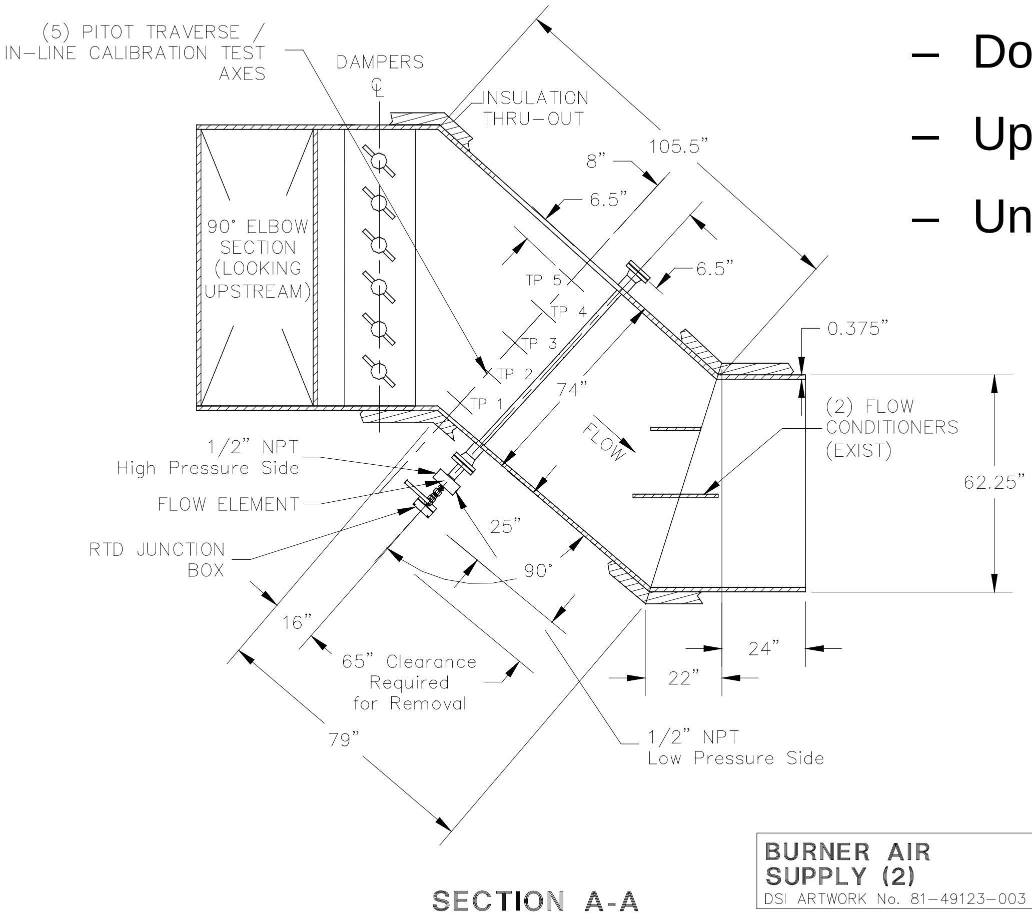


Annubar® APT Installation: Real Condition 4

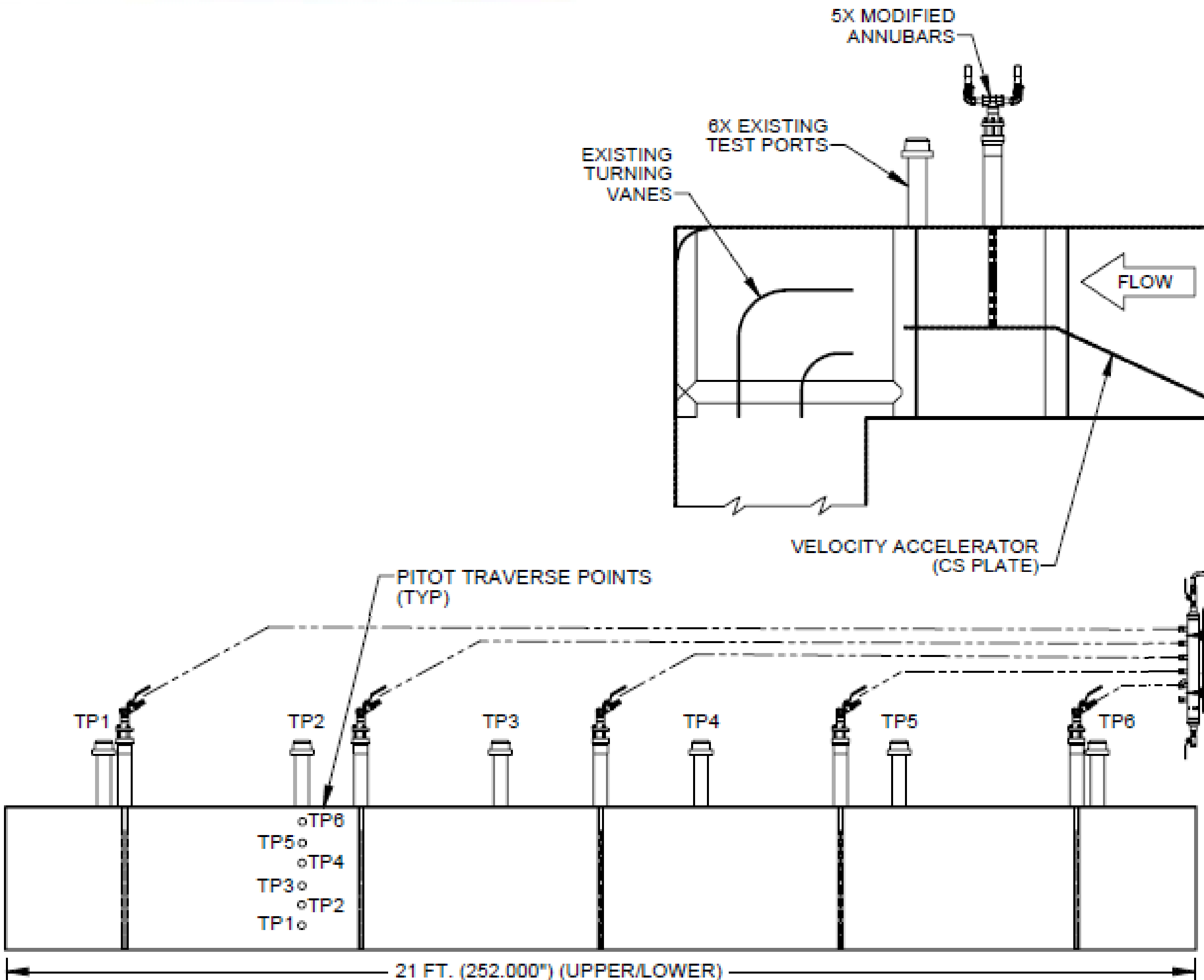


Annubar® APT Installation: Real Condition 4

- Conditions:
  - Downstream of dampers and elbows
  - Upstream of conditioners and elbow
  - Unknown velocity profile

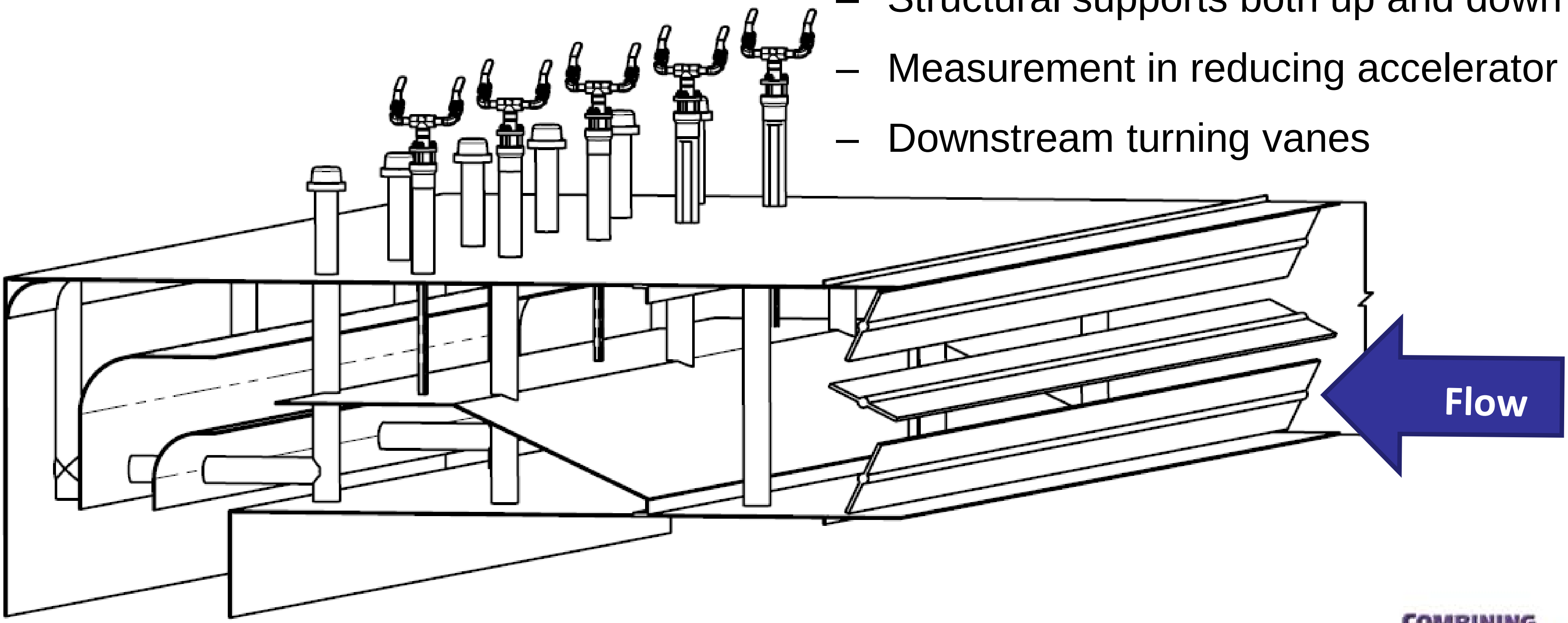


Annubar® APT Installation: Real Condition 5

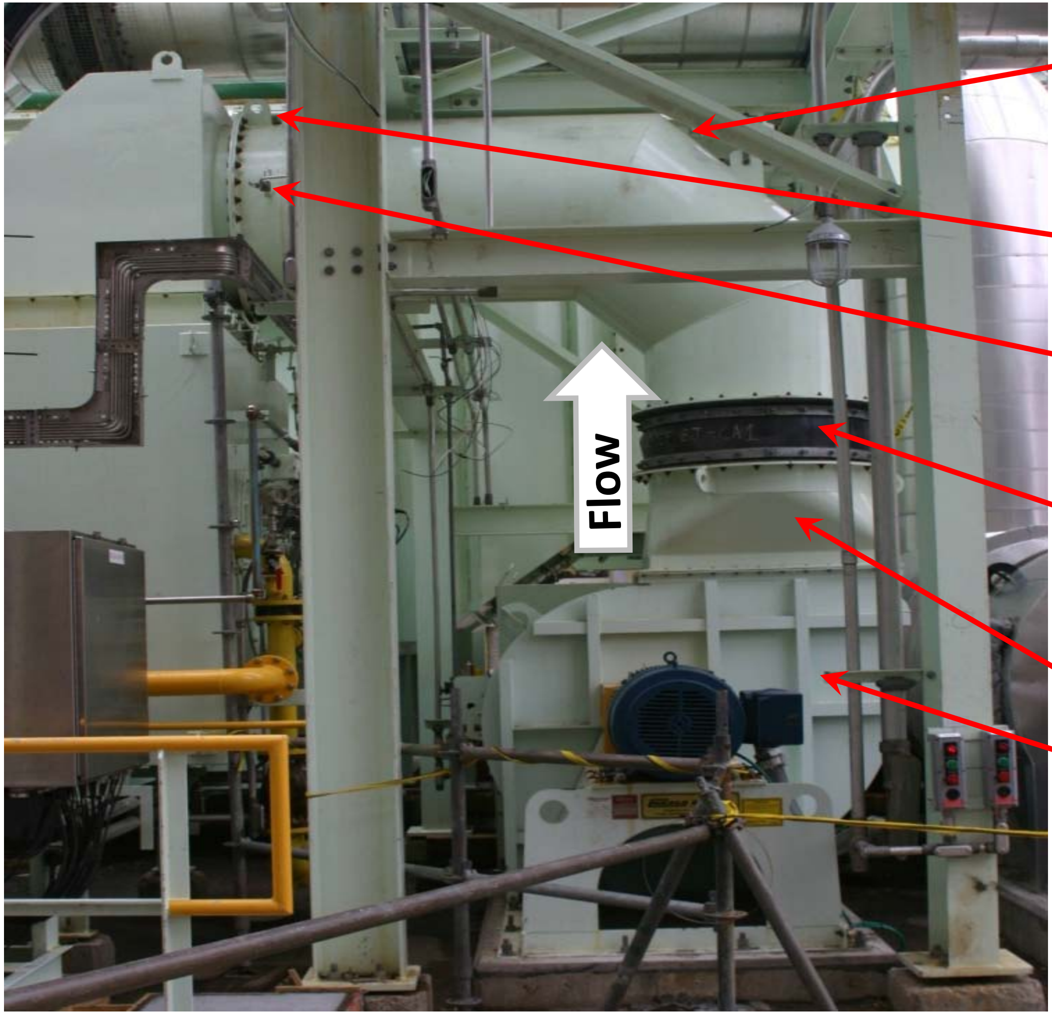


Annubar® APT Installation: Real Condition 5

- Conditions:
  - Upstream dynamic dampers
  - Structural supports both up and down
  - Measurement in reducing accelerator
  - Downstream turning vanes



Annubar® APT Installation: Real Condition 6



MITERED ELBOW

ANNUBAR FLOW ELEMENT

(2) IN-LINE CALIBRATION PORTS

DUCT BELLOW

SQUARE TO ROUND TRANSITION

FAN

Any Questions?

Annubar® APT Installation

Are you sure?

Demonstration Unit

3-Pitot Tube Test Ports

Viewing Windows

Annubar® & Pitot RTDs

Mitered Elbow

Expanding Width Duct

Actual or Adjustable Temperature (0-1000°F) Continuous for both RTDs

Decreasing Height Duct

Annubar®

Inside:

- Diverter Plate
- Structural Support
- Turning Vane

3051S D.P. Transmitter For Pitot Tube

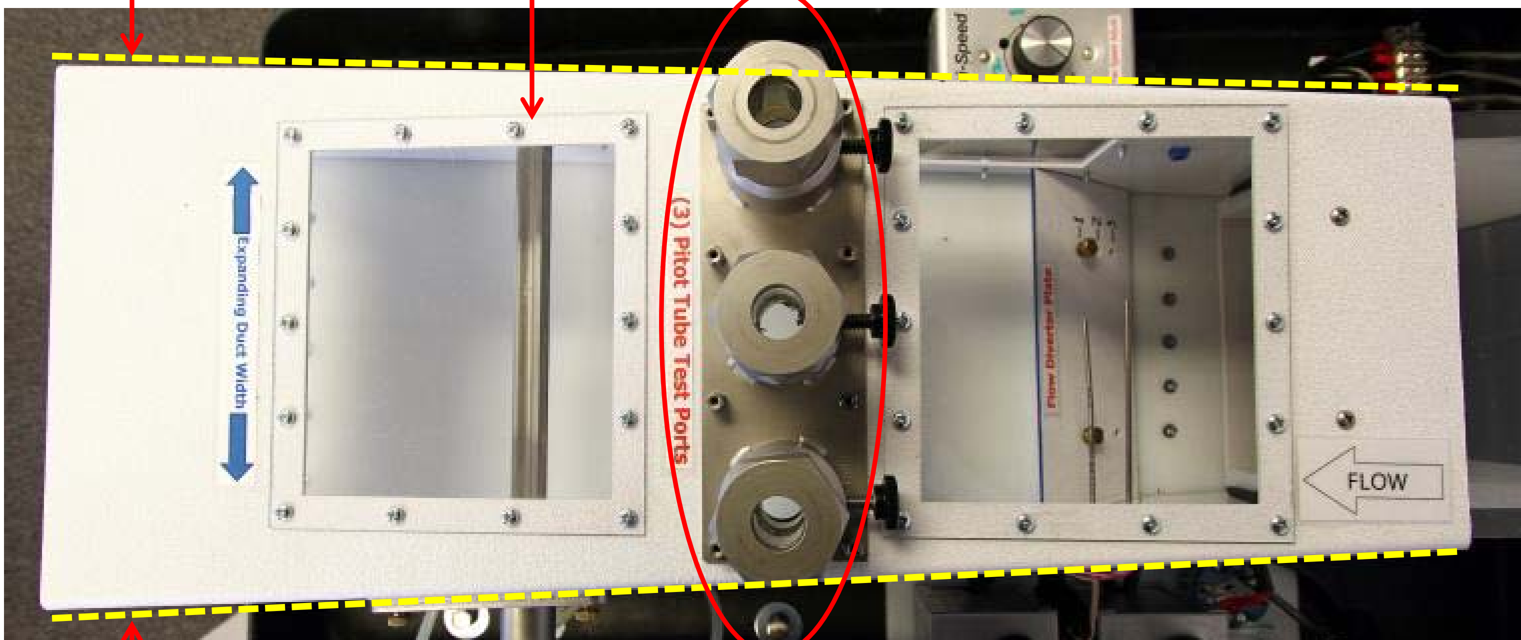
3051SMV D.P. Transmitter For Annubar® APT

Fan with Speed Control

Demonstration Unit

Top View:

Annubar® Primary Element



Expanding Duct Width

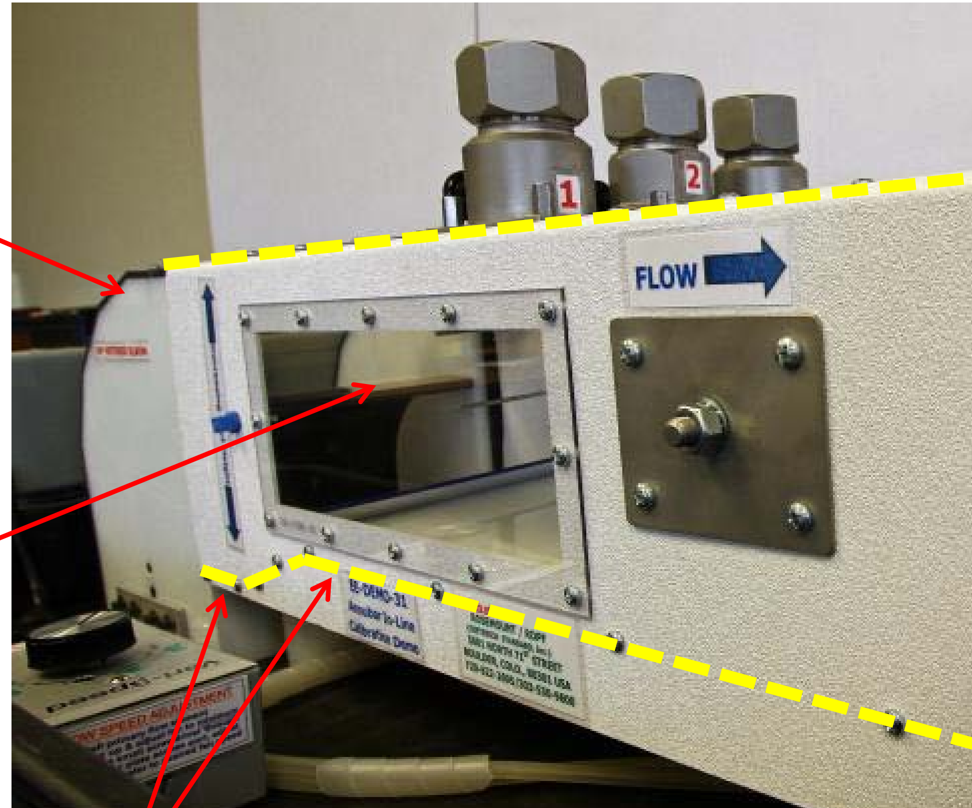
Pitot Test Ports

Demonstration Unit

Side View:

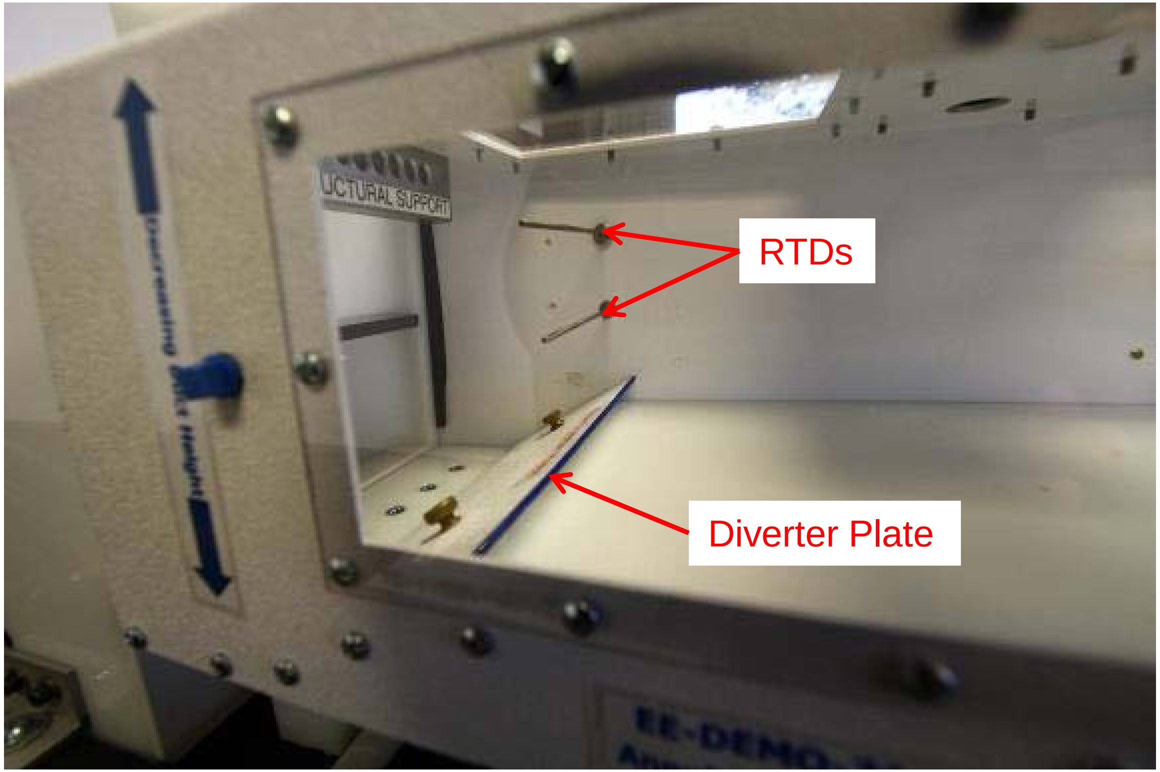
Mitered Elbow

Turning Vane



Decrease in Duct Height

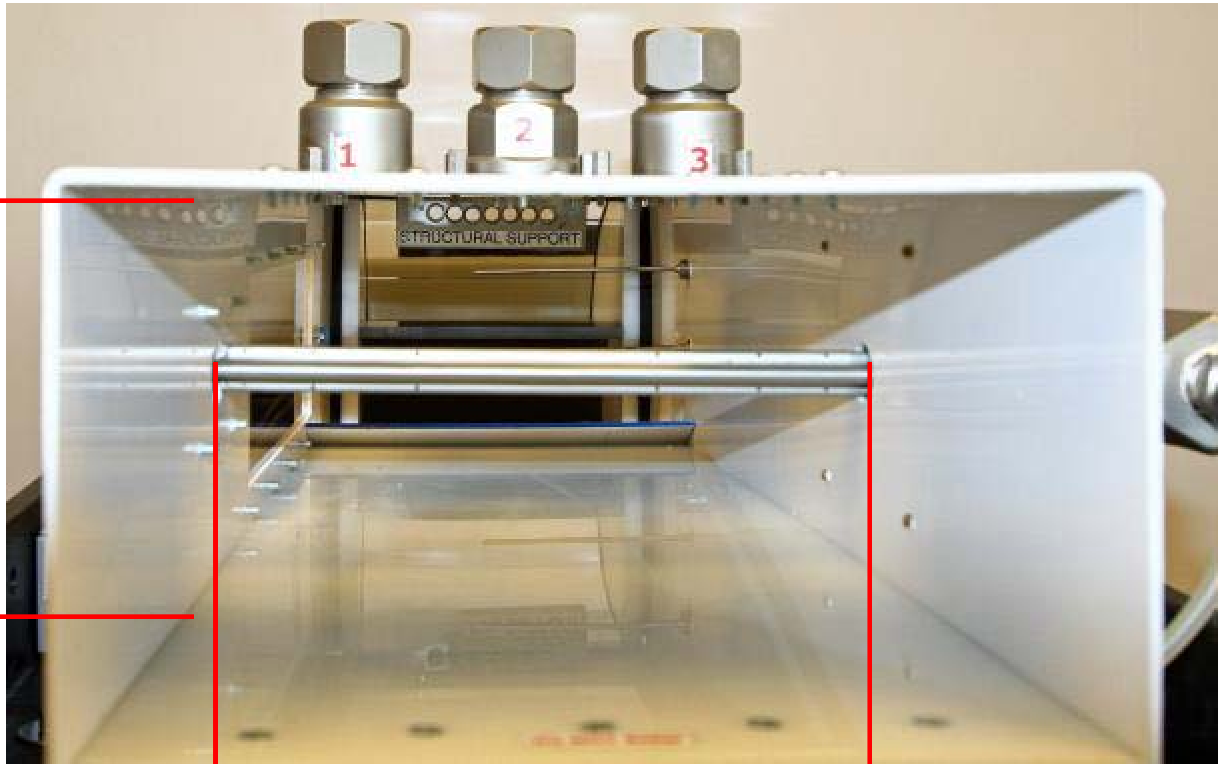
Demonstration Unit



Demonstration Unit

Looking Inside:

Duct Area at Annubar® 485 = Width at Annubar® 485 Center Line x Height of Duct



Duct Height

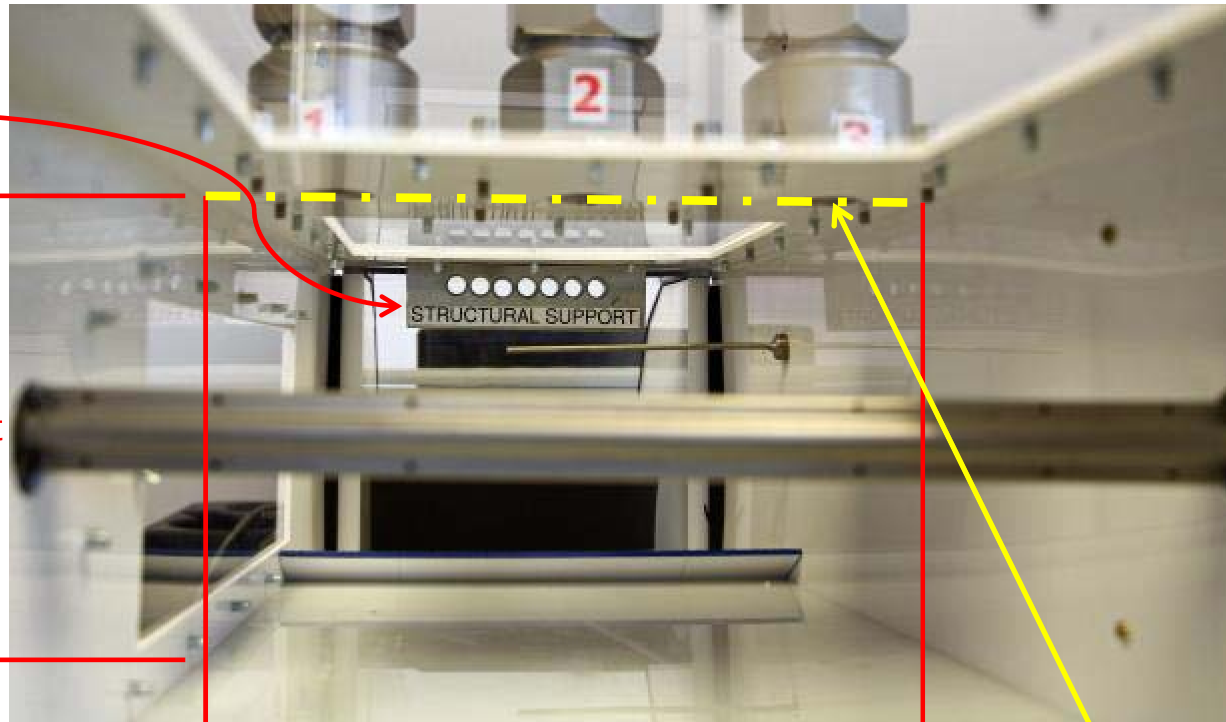
Duct Width at Annubar® 485

Demonstration Unit

Looking Inside:

Duct Area at Pitot Test Ports = Width at Test Port Center Line x Height of Duct

Structural Support Creates Additional Disturbance



Duct Height

Duct Width at Test Ports

Test Port Center Line

Demonstration Unit

Any Questions?

Live In-Line Calibration

- Traverse Set-Up:
  - Duct dimensions at Annubar® Primary Element are verified to match the original customer order:
    - Annubar® APT is a Rosemount Model 485/T1 size installed in a 8.25”(209.6mm) Wide x 4.75”(120.6mm) Tall Duct
    - Duct area at the Annubar® APT is 39.2in^2 (25,277.8mm^2)
  - Duct dimensions at Pitot test ports:
    - Duct size at the Pitot tube test ports is 7.75”(196.8mm) x 4.75”(120.6mm) Tall
    - Duct area at the Pitot tube test ports is 36.8in^2 (23,748.3mm^2)

Live In-Line Calibration

- Traverse Set-Up Continued:
  - For the Pitot traverse the duct area is divided in to 15 equal areas
  - The Pitot traverse will take place with the fan speed set at maximum
  - Factory Fan Rating, 747 SCFM
  - Process temperature will be set at 430^{O}F
  - All transmitter calibrations, output and signal loops are verified

Live In-Line Calibration

DIETERICH STANDARD - PITOT TRAVERSE DATA | JOB

Customer EMERSON EXCHANGE, 2013. Date OCT 2013 DS Tech DCW BK

Site GRAPEVINE, TEXAS Contact THE BARTENDER

Description IN-LINE CALIBRATION OF 8.25" MODEL 485/T-1 ANNUBAR IN FAN DISCH. DUCT Tag No. EE-DEMO-31

Primary S/N

No. of Axes 3 Pts./Axis 5 Time (Start/Finish)

Pipe/Duct Dimensions 8.25"x4.75" (209.6x120.6mm) Primary Span ▲▼8.25" (209.6mm)

Pitot Type 5/8"φ S-TYPE K = 0.84 S/N PSFS400019 (8") Barom 24.87 Hg

Ref. Flow Rate/Load MAXIMUM FAN MW (or Ms) 28.965 SG

Test Port/Axis No. 1, 2 & 3 $\%O_2$ $\%CO_2$

Test No. AVERAGING @ 15 SECONDS $\%O_2$ % AIR

Pt. No.	Axis	Point Dim. From Opposite Wall ●	Primary 485/T-1 * INCHES		Pitot 5/8" S-TYPE INCHES		Temp. °F	Press.	
1	1	.48" / 1/2"							
2	1	1.43" / 1 1/2"							
3	1	2.38" / 2 3/8"							
4	1	3.38" / 3 3/8"							
5	1	4.28" / 4 1/4"							
●									
1	2	.48" / 1/2"							
2	2	1.43" / 1 1/2"							
3	2	2.38" / 2 3/8"							
4	2	3.38" / 3 3/8"							
5	2	4.28" / 4 1/4"							
●									
1	3	.48" / 1/2"							
2	3	1.43" / 1 1/2"							
3	3	2.38" / 2 3/8"							
4	3	3.38" / 3 3/8"							
5	3	4.28" / 4 1/4"							

NOTES: * - 3051SMV OUTPUT TO SA-DART SET @ 0-4" W.C.
▲ - EQUIVALENT PIPE INSIDE DIAMETER: 7.064 DIA.
▼ - AREA @ ANNUBAR 39.2 SQ. IN.
● - DUCT INSIDE DIMENSIONS @ PITOT: 7.75" x 4.75" (36.8 SQ. IN.)

1 AUG 13

DS-8018 (02/13/96)

- Data Collection Sheet Ready for test

Live In-Line Calibration

- Almost Ready
  - Now, plant operations will hold fan speed/damper to desired flow rate
  - Avoid discharge end of duct for safety reasons
  - For this demonstration some assumptions or simulations may be made such as barometric pressure, process temperature, etc.
  - If we start running out of time we will use pre-prepared data
  - ANY QUESTIONS?
  - Don’t throw objects in the fan!
  - Finally! . . Lets turn the fan on and record some numbers!

“CLICK...”

“WIRRRRR....”

Live In-Line Calibration

DIETERICH STANDARD - PITOT TRAVERSE DATA | JOB

Customer EMERSON EXCHANGE, 2013. Date OCT 2013 DS Tech DCW BK

Site GRAPEVINE, TEXAS Contact THE BARTENDER

Description IN-LINE CALIBRATION OF 8.25" MODEL 485/T-1 ANNUBAR IN FAN DISCH. DUCT Tag No. EE•DEMO•31

~~Primary S/N~~ ORIG. "K"=.557Ø

No. of Axes 3 Pts./Axis 5 Time (Start/Finish)

Pipe/Duct Dimensions 8.25"x4.75" (209.6x120.6mm) Primary Span ▲▼8.25" (209.6mm)

Pitot Type 5/8"Φ S-TYPE K = 0.84 S/N PSF54ØØØ19 (8") Barom 24.87 Hg

Ref. Flow Rate/Load MAXIMUM FAN MW (or Ms) 28.965 SG

Test Port/Axis No. 1,2 & 3 %O_2 %CO_2

Test No. AVERAGING @ 15 SECONDS %O_2 % AIR

Pt. No.	Axis	Point Dim. FROM OPPOSITE WALL ●	Primary 485/T-1 * INCHES		Pitot 5/8" S-TYPE INCHES		Temp. °F	Press. INCHES	
1	1	.48"/1/2"	.56"		.40"		430°	.Ø75"	
2	1	1.43"/1 1/2"	.56		.61"		↓		
3	1	2.38"/2 3/8"	.56		.73		430°	↓	
4	1	3.38"/3 3/8"	.56		.72			.075	
5	1	4.28"/4 1/4"	.56		.58		↓	↓	
	← AXIS №								
●									
1	2	.48"/ 1/2"							
2	2	1.43"/ 1 1/2"							
3	2	2.38"/ 2 3/8"							
4	2	3.38"/ 3 3/8"							
5	2	4.28"/ 4 1/4"							
●									
1	3	.48"/ 1/2"							
2	3	1.43"/ 1 1/2"							
3	3	2.38"/ 2 3/8"							
4	3	3.38"/ 3 3/8"							
5	3	4.28"/ 4 1/4"							

NOTES: * - 3051SMV OUTPUT TO SA-DART SET @ 0-4" W.C.
▲ - EQUIVALENT PIPE INSIDE DIAMETER: 7.Ø64 DIA.
▼ - AREA @ ANNUBAR 39.2 SQ. IN.
● - DUCT INSIDE DIMENSIONS @ PITOT: 7.75"x4.75" (36.8 SQ. IN.)

1 AUG 13

- Completed Traverse in Axis 1

Live In-Line Calibration

DIETERICH STANDARD - PITOT TRAVERSE DATA | JOB

Customer EMERSON EXCHANGE, 2013. Date OCT 2013 DS Tech DCW BK

Site GRAPEVINE, TEXAS Contact THE BARTENDER

Description IN-LINE CALIBRATION OF 8.25" MODEL 485/T-1 ANNUBAR IN FAN DISCH. DUCT Tag No. EE•DEMO•31

~~Primary S/N~~ ORIG. "K"=.557Φ

No. of Axes 3 Pts./Axis 5 Time (Start/Finish)

Pipe/Duct Dimensions 8.25"x4.75" (209.6x120.6mm) Primary Span ▲▼8.25" (209.6mm)

Pitot Type 5/8"Φ S-TYPE K = 0.84 S/N PSF54ΦΦΦ19 (8") Barom 24.87 Hg

Ref. Flow Rate/Load MAXIMUM FAN MW (or Ms) 28.965 SG

Test Port/Axis No. 1,2 & 3 $\%O_2$ $\%CO_2$

Test No. AVERAGING @ 15 SECONDS $\%O_2$ % AIR

Pt. No.	Axis	Point Dim. FROM OPPOSITE WALL ❹	Primary 485/T-1 * INCHES		Pitot 5/8" S-TYPE INCHES		Temp. °F	Press. INCHES	
1	1	.48"/ 1/2"	.56"		.40"		430°	.075"	
2	1	1.43"/ 1 1/2"	.56		.61"				
3	1	2.38"/ 2 3/8"	.56		.73		430°		
4	1	3.38"/ 3 3/8"	.56		.72			.075	
5	1	4.28"/ 4 1/4"	.56		.58				
	AXIS Nº								
•									
1	2	.48"/ 1/2"	.55"		.28"		430°	.075	
2	2	1.43"/ 1 1/2"	.56		.39"				
3	2	2.38"/ 2 3/8"	.55		.27"				
4	2	3.38"/ 3 3/8"	.56		.20			.075	
5	2	4.28"/ 4 1/4"	.54		.18"		430°		
•									
1	3	.48"/ 1/2"							
2	3	1.43"/ 1 1/2"							
3	3	2.38"/ 2 3/8"							
4	3	3.38"/ 3 3/8"							
5	3	4.28"/ 4 1/4"							

NOTES: * - 3051SMV OUTPUT TO SA-DART SET @ 0-4" W.C.
▲ - EQUIVALENT PIPE INSIDE DIAMETER: 7.064 DIA.
▼ - AREA @ ANNUBAR 39.2 SQ. IN.
❹ - DUCT INSIDE DIMENSIONS @ PITOT: 7.75"x4.75" (36.8 SQ. IN.)

1 AUG 13

- Completed Traverse in Axis 2

Live In-Line Calibration

DIETERICH STANDARD - PITOT TRAVERSE DATA JOB

Customer EMERSON EXCHANGE, 2013. Date OCT 2013 DS Tech DCW BK
Site GRAPEVINE, TEXAS Contact THE BARTENDER

Description IN-LINE CALIBRATION OF 8.25" MODEL 485/T-1 ANNUBAR IN FAN DISCH. DUCT Tag No. EE•DEMO•31
~~Primary S/N~~ ORIG. "K"=.557Ø

No. of Axes 3 Pts./Axis 5 Time (Start/Finish)
Pipe/Duct Dimensions 8.25"x4.75" (209.6x120.6mm) Primary Span ▲▼8.25" (209.6mm)
Pitot Type 5/8"Ø S-TYPE K = 0.84 S/N PSF54ØØØ19 (8") Barom 24.87 Hg
Ref. Flow Rate/Load MAXIMUM FAN MW (or Ms) 28.965 SG
Test Port/Axis No. 1, 2 & 3 %O2 %CO2
Test No. AVERAGING @ 15 SECONDS %O2 % AIR

Pt. No.	Axis	Point Dim. FROM OPPOSITE WALL ❷	Primary 485/T-1 * INCHES		Pitot 5/8" S-TYPE INCHES		Temp. °F	Press. INCHES	
1	1	.48"/1/2"	.56"		.40"		43Ø°	±.Ø75"	
2	1	1.43"/1 1/2"	.56		.61"		↓	↓	
3	1	2.38"/2 3/8"	.56		.73		43Ø°	↓	
4	1	3.38"/3 3/8"	.56		.72		↓	.Ø75	
5	1	4.28"/4 1/4"	.56		.58		↓	↓	
	← AXIS No								
●									
1	2	.48"/1/2"	.55"		.28"		43Ø°	±.Ø75	
2	2	1.43"/1 1/2"	.56		.39"		↓	↓	
3	2	2.38"/2 3/8"	.55		.27"		↓	↓	
4	2	3.38"/3 3/8"	.56		.2Ø		↓	.Ø75	
5	2	4.28"/4 1/4"	.54		.18"		43Ø°	↓	
●									
1	3	.48"/1/2"	.55"		.22"		43Ø°	±.Ø75"	
2	3	1.43"/1 1/2"	.55"		.4Ø				
3	3	2.38"/2 3/8"	.56"		.54		↓		
4	3	3.38"/3 3/8"	.55"		.55		43Ø°		
5	3	4.28"/4 1/4"	.55"		.38		↓	↓	

NOTES: * - 3051SMV OUTPUT TO SA-DART SET @ 0-4" W.C.
▲ - EQUIVALENT PIPE INSIDE DIAMETER: 7.Ø64 DIA.
▼ - AREA @ ANNUBAR 39.2 SQ. IN.
❷ - DUCT INSIDE DIMENSIONS @ PITOT: 7.75"x4.75" (36.8 SQ. IN.)

1 AUG 13

- Completed Traverse in Axis 3

Live In-Line Calibration

- Acquisition of “raw-test-data” is now complete
- At this point, plant operations would be notified to adjust fan to another speed or return to normal operations.
- Raw data will be entered in to the calibration spreadsheet
- The calibration spreadsheet will calculate new “K-Factor”

Live In-Line Calibration

Dieterich Standard - Pitot Traverse Data

Customer:Emerson Exchange 2013	Job Number:	Tag Number:EE-DEMO-31-72F-Calibrated	DSI Tech: Dave Winters & Nate Kenyon
Site: Grapevine, Texas	Job Contact: Bartender	Pitot S/N: PSFS400019	Date: October 2013
Discription: Emerson Exchange "Not Just a Lot of Hot Air"		Comments/Notes: Original K-Factor: 0.5567	

PITOT INPUTS

Pitot Type	5/8" S-Type	
Calibrated K =	0.84	
Strut Dia =	0.625	inch
Tip Dia =	0.188	inch
Tip Length =	3	inch
Pitot Strut Cd =	1.2	
Duct Height @ Pitot:	4.75	inch
Duct Width @ Pitot:	7.75	inch
No. of Axes:	3	
Pts./Axis:	5	
Rate Units:	ACFM	
Pitot Direction:	OUT	

PITOT OUTPUTS

Pipe Area:	36.81	Inch^2
Eqiv. Diameter Dep:	6.846	inch
Avg Corr. Vel-Trav:	50.700	ft/sec
Calc'd Flow Rate:	778.9	ACFM
Calc'd Flow Rate:		SCFM

ANNUBAR INPUTS

Sensor Size:	T1	
Probe Width:	0.59	inch
Blockage Coeff. C1:	-1.515	
Blockage Coeff. C2:	1.4229	
Duct Height @ Annubar:	8.25	inch
Duct Width @ Annubar:	4.75	inch
Conversion Factor Fna:	5.9823	
Therm Expan Factor Faa:	1	
Toolkit Flow Coeff. Kpub:	0.5570	
Toolkit Normal DP:	0.973	inH2O
Toolkit Full Scale DP:	1.73	inH2O
Toolkit Normal Flow:	600	ACFM
Toolkit Full Scale Flow:	800	ACFM
Toolkit Flow at Max DP:	800	ACFM
Calculated K:	0.5569	

ANNUBAR OUTPUTS

Duct Area:	39.1875	inch^2
Eqiv. Diameter Des:	7.064	inch
Blockage B:	12.42%	
Ave Measured DP:	0.55	inH2O
Ave Measured Flow:	644.93	ACFM
Ave Measured Temp:	430	F
Ave Density:	0.03685	
Ave Gas Exp. Yap:	1.000	
Calib. Flow Coeff Kadj:	0.6727	from flow ratio

Calibibrated "K-Factor": 0.6727 from flow eqn.

FLUID PROPERTY INPUTS

Fluid:	Air	
Density:	0.076358	lb/ft^3
Density Temp	60	F
Density Press:	14.73	PSIA
Barometric:	24.87	inHg
inH20/PSI @ 60F	0.036139633	Conversion
inHg/PSI @ 60	0.489770685	Conversion
Isentropic Exp:	1.40213	

Axis 1 - Point No.	Pt Distance-in	Pitot Area-in^2	Blkage-%	Air Temp - F	Static Pressure inH2O	Compressibility	Air Density-Lb./ft^3	Pitot DP-in H2O	Calc'd Vel-ft/sec	Blkg Corr	Annubar DP	Gas Exp.Factor Annubar Yap	Annubar Rate - ACFM	Flow Rate-Corr
1	4.275	1.359	3.69%	430	0.075	1.0026	0.03685	0.40	50.59	0.978	0.56	1.000	648.03	0.995
2	3.325	0.766	2.00%	430	0.075	1.0026	0.03685	0.61	62.48	0.988	0.56	1.000	648.03	0.995
3	2.375	0.445	1.21%	430	0.075	1.0026	0.03685	0.73	68.35	0.993	0.56	1.000	648.03	0.995

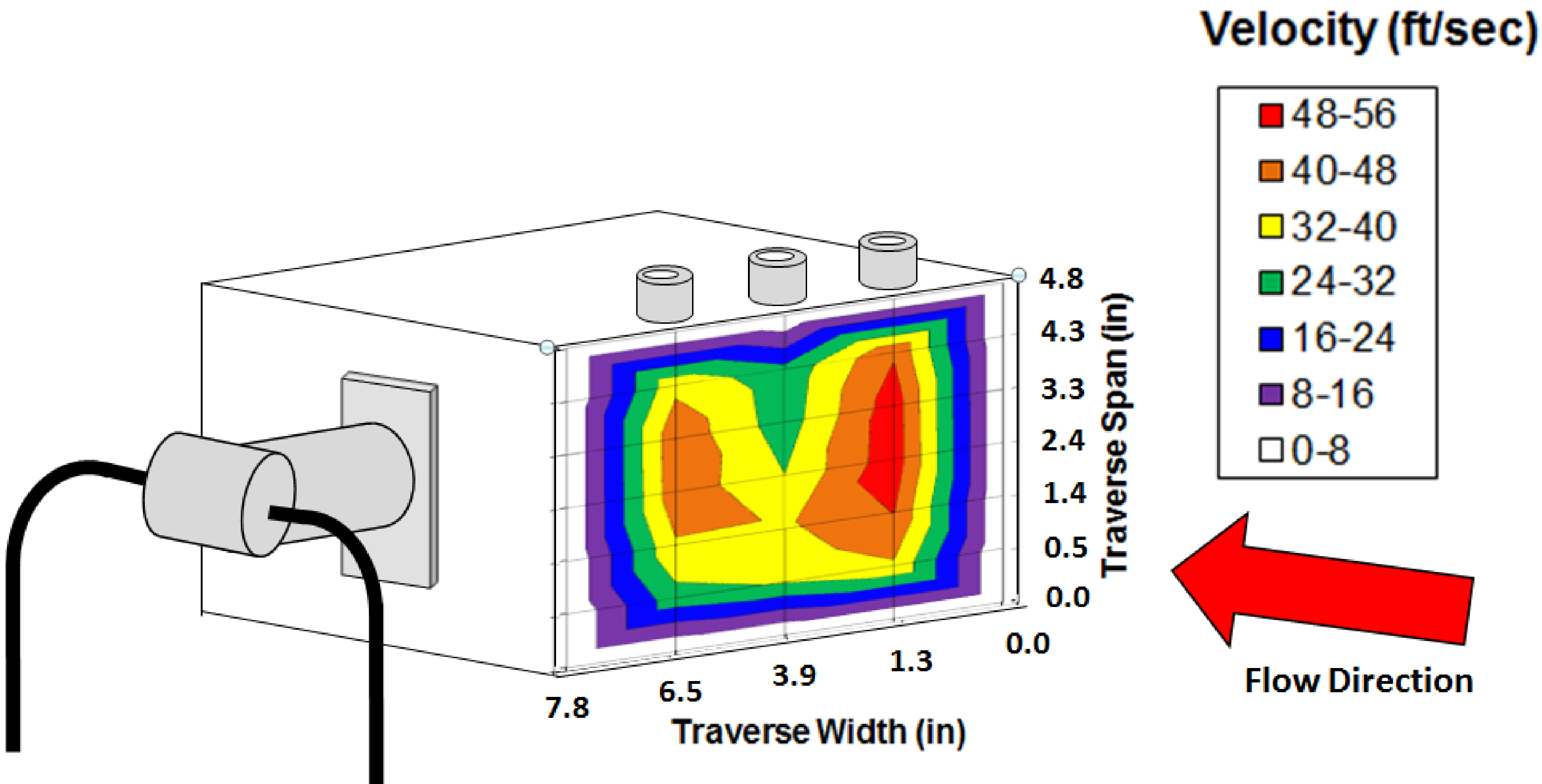
Original K-Factor (From Toolkit): 0.5567

New K-Factor (From Pitot Traverse): 0.6727

% Change in K-Factor: 21%

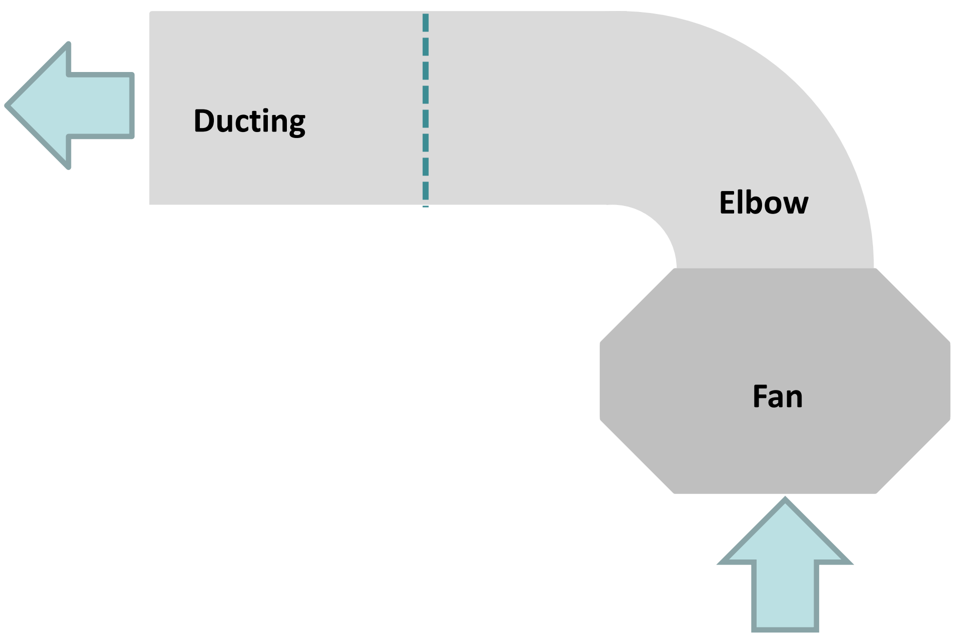
1	4.275	1.359	3.69%	430	0.075	1.0026	0.03685	0.22	37.52	0.978	0.55	1.000	642.22	1.004
2	3.325	0.766	2.00%	430	0.075	1.0026	0.03685	0.40	50.59	0.988	0.55	1.000	642.22	1.004
3	2.375	0.445	1.21%	430	0.075	1.0026	0.03685	0.54	58.78	0.993	0.56	1.000	648.03	0.995
4	1.425	0.267	0.73%	430	0.075	1.0026	0.03685	0.55	59.32	0.996	0.55	1.000	642.22	1.004
5	0.475	0.089	0.24%	430	0.075	1.0026	0.03685	0.38	49.31	0.999	0.55	1.000	642.22	1.004

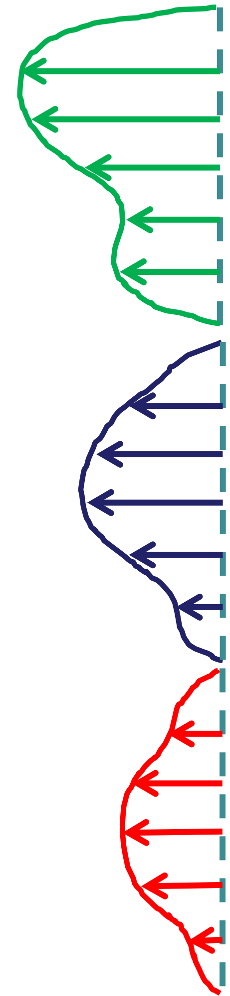
Flow Profile



Flow Profile

- Different fan settings, damper settings, and all around flow conditions could result in different associated K-Factors





Full Scale Flow K=0.672

Normal Flow K=0.646

Minimum Flow K=0.593

In-Line Calibration

- Almost Finished!

  – Need to reconfigure the transmitter

    - Using Engineering Assistant (E.A.) the new Corrected Flow coefficient “K-Factor” will be entered in the 3051SMV multi-variable transmitter

    OR

    - Using a Field Communicator (like a 475 Handheld) the output signal (HART, 4-20mA, etc.) signal can be reconfigured to match the new Flow Coefficient.

    OR

    - If the customers data acquisition system is performing the flow calculation from the transmitter output, the new corrected Flow Coefficient will simply be provided to the customer.

Summary

- You have now learned:
  - Annubar® primary element basics
  - Many of the real Annubar® 485 duct installation challenges
  - The process of an in-line flow calibration
  - Performing an in-line flow calibration on an Annubar® allows for repeatable and accurate flow measurement in otherwise impossible to measure process situations

Any Questions?

Where To Get More Information

- More information on Annubar® Primary Elements and Flowmeters can be found:
  - Annubar Flow Handbook
    - http://www2.emersonprocess.com/siteadmincenter/PM%20Rosemount%20Documents/00809-0100-1191.pdf
  - Annubar® Flow Test Data Book
    - http://www2.emersonprocess.com/siteadmincenter/PM%20Rosemount%20Documents/00821-0100-4809.pdf

Thank You for Attending!

Enjoy the rest of the conference.