

Multipath Ultrasonic Flow Monitoring Systems

- Ultrasonic Flow Monitoring Fundamentals
- Installation Considerations
- Multipath Configurations
- Advantages of Each Configuration

Ultrasonic Flow Monitor



1900-0090		REVISONS		
ZONE	SYM.	DESCRIPTION	DATE	APPD.
A		PER DCV M90P-0090A	10-14-02	ELM

TIE MOTHERBOARD W/COMPUTER MODULE 1903-D100

LCD DISPLAY 1803-1400

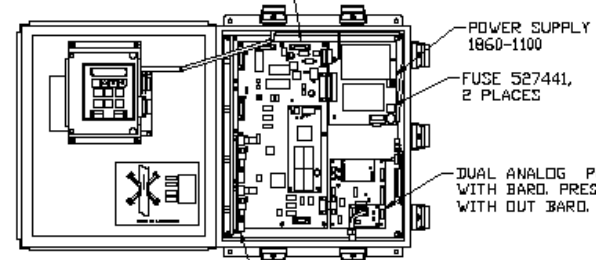
PC BOARDS 1803-0200, 1003-0500 AND 1803-0300 MOUNT INTERNALLY



FRONT VIEW



REAR VIEW
FUSE 52743B, 2 PLACES



POWER SUPPLY 1860-1100

FUSE 527441, 2 PLACES

DUAL ANALOG PC BOARD ASSY WITH BARD. PRESS. OPTION 1903-0300-01, WITH OUT BARD. PRESS. OPTION 1903-0300-02

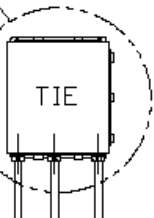
PREAMPS 1903-0200 (50KHz) OR 1903-0400 (20/14KHz) PLUG INTO MOTHERBOARD

TRANSDUCER INTERFACE ENCLOSURE 1/4 SCALE

J-BOX BUFFER PC BOARD 1906-D100 20/14KHz ONLY

PURGE AIR FILTER 620202

PURGE FAIL SWITCH 1001-0700 OR 1901-0600



PURGE BLOWER 980142, DUAL 42CFM OR SINGLE 42CFM BLOWER SYSTEM
PURGE BLOWER 980111, SINGLE 110CFM BLOWER SYSTEM

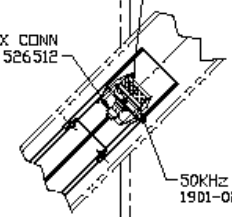
ENHANCED REMOTE PANEL 1/4 SCALE

STACK OR DUCT

FLOW

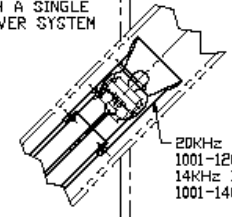
BNC COAX CONN 526512

ACOUSTIC FOAM INSERT 1001-0103



VIEW A
50KHz XDUCER 3/8 SCALE

IS NOT SUPPLIED WITH A SINGLE BLOWER SYSTEM



VIEW A
20/14KHz XDUCER 3/8 SCALE

50KHz XDUCER ASSY 1901-0200

20KHz XDUCER ASSY 1001-1200 OR 14KHz XDUCER ASSY 1001-1400

SPARE PARTS LOCATION

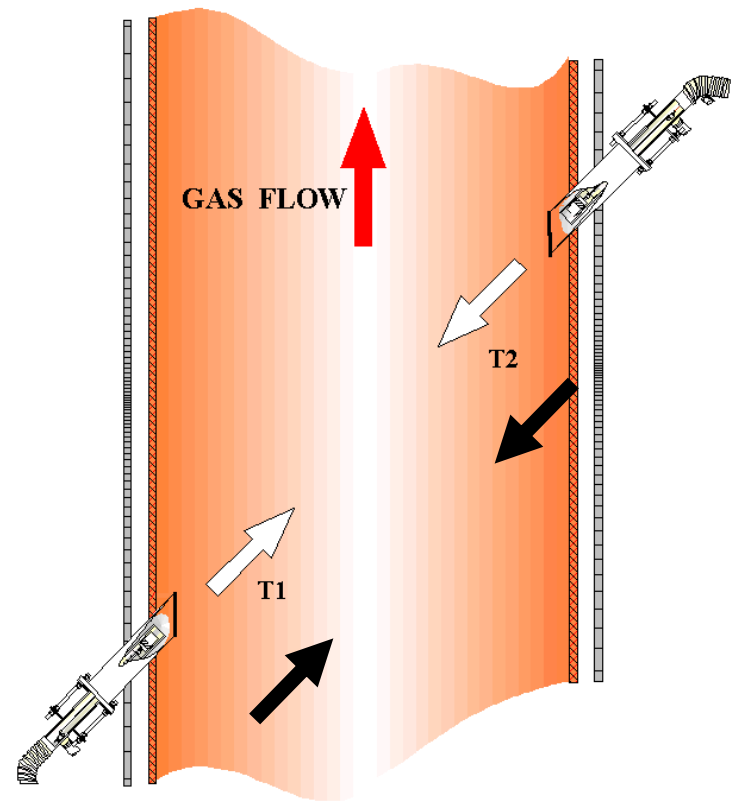
CONFIDENTIAL TOLERANCES UNLESS OTHERWISE SPECIFIED		LIGED ON		TELEDYNE INSTRUMENTS	
DESIGN AND MFG. ACCORDING TO -001 PARTIAL		MATERIAL		ULTRAFLOW 150 FLOW/TEMPERATURE MONITOR SYSTEM	
ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED		DATE		FINISH	
AUTHORIZATION		BY		DATE	
DESIGNED	EAS	5-3-02			
ENGINEERED	EAS	02-02-02			
MANUFACTURED	EAS	04-01-02			
INSPECTED	ELM	10-26-02			
PRODUCTION	PD	10-26-02			
PREPARED	AS	10-26-02			
SCALE		1/8		1 of 1	
PART NUMBER		1900-0090		REV. A	

⚠ 1901-0600 IS USED WITH SINGLE 42CFM BLOWER SYSTEM ONLY.

ACADEMIC FILE NUMBER

Overview

- What is an Ultrasonic Flow Monitor?
 - It is a device that measures velocity based on the time-of-flight of signals t_1, t_2
 - By determining t_1, t_2 , the monitor calculates velocity, volumetric flow and temperature

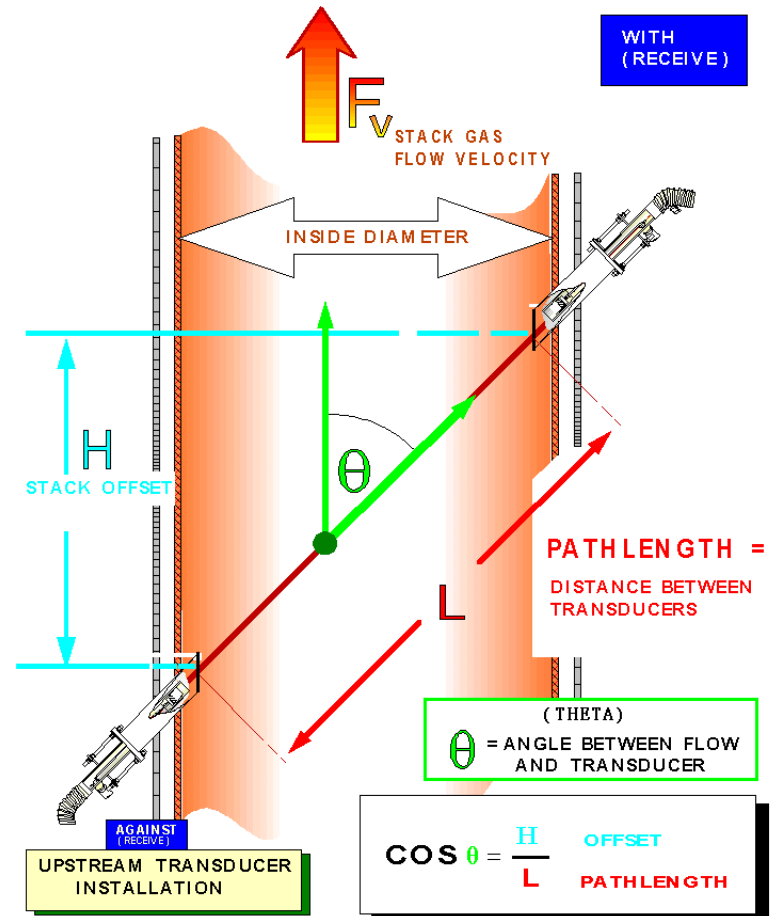


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Stack Geometry

- **Typical Installation:**
 - $\theta \geq 45^\circ$ angle but depends on:
 - pitch angle
 - # diameters down
 - # flues feeding the stack
 - Gas temperature
 - Gas velocity
 - **Need Vertical Offset (H) to be No Less Than 4-5 Ft.**
 - **Max. Temp 650°F**
 - **Min. Diameter 3 Ft.**
 - **Max Diameter 45 Ft.**



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Time of Flight Principle

- What are the governing equations that model the time-of-flight of the tone bursts?

Velocity (With Gas Flow)

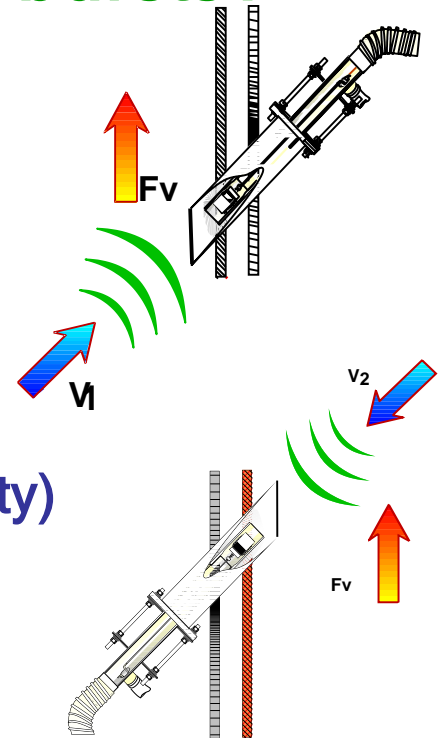
$$V1 = Cs + Fv \cos \theta \quad (\text{added velocity})$$

Velocity (Against Gas Flow)

$$V2 = Cs - Fv \cos \theta \quad (\text{subtracted velocity})$$

- Where

- Cs is the speed of sound
- Fv is Nominal flow velocity up stack
- θ is the angle of installation



Velocity (Fv) Calculations

- Cs falls out of the subtracted equations
- Substitute Pathlength/Time for V_1 &

$$V_2 \quad Fv = \frac{L/t_1 - L/t_2}{2(\cos \theta)}$$

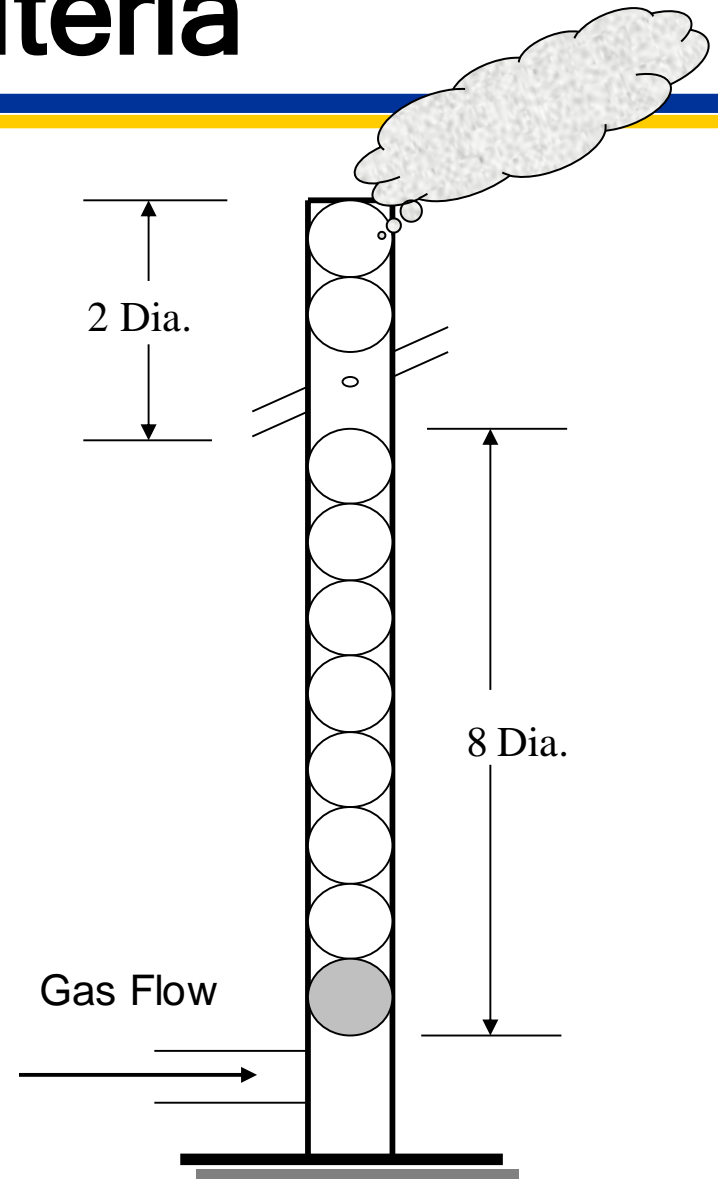
- Rearrange

$$Fv = \frac{L}{2(\cos \theta)} \left[\frac{t_2 - t_1}{t_1 t_2} \right]$$



General Criteria

- **Measurement Location**
 - **In general**
 - 8 Duct Diameters downstream and 2 duct diameters upstream from flow disturbance
 - Usually pass the resultant Angle test of $<20^\circ$
- **For Rectangular Ducts**
 - $De = 2LW/(L+W)$



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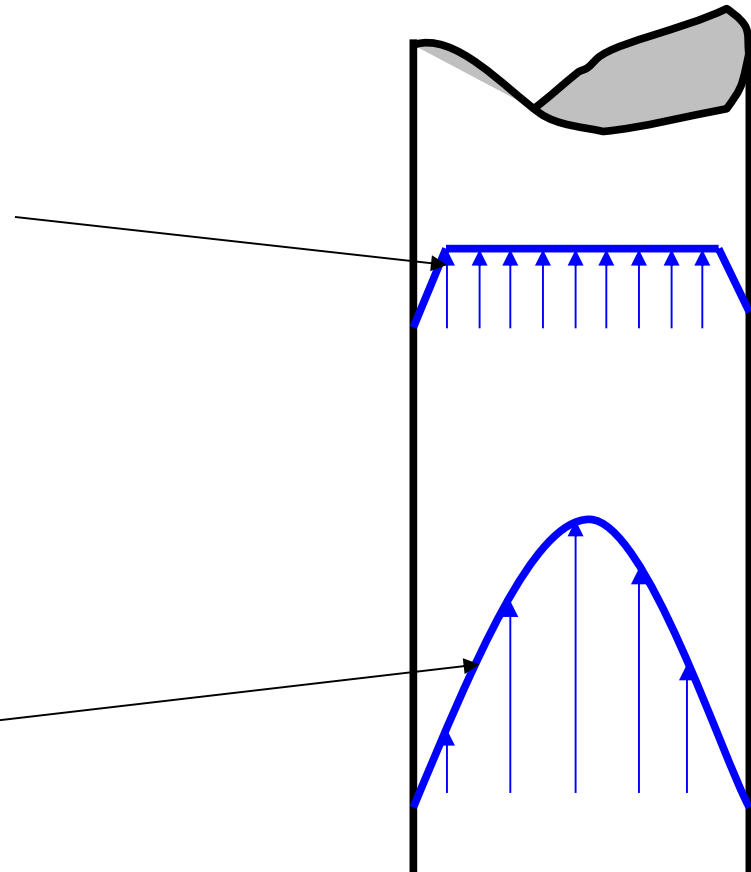
General Criteria

- Flow monitor is installed where **fully developed turbulent flow** is present;

- Reynolds # > 4000

$$Re = \text{Dia.} \times \text{Vel} / \mu$$

- Where μ is kinematic viscosity
- $\mu = 27.3 \times 10^{-5}$ ft²/sec for air @ 250°F
- Rarely is flow laminar

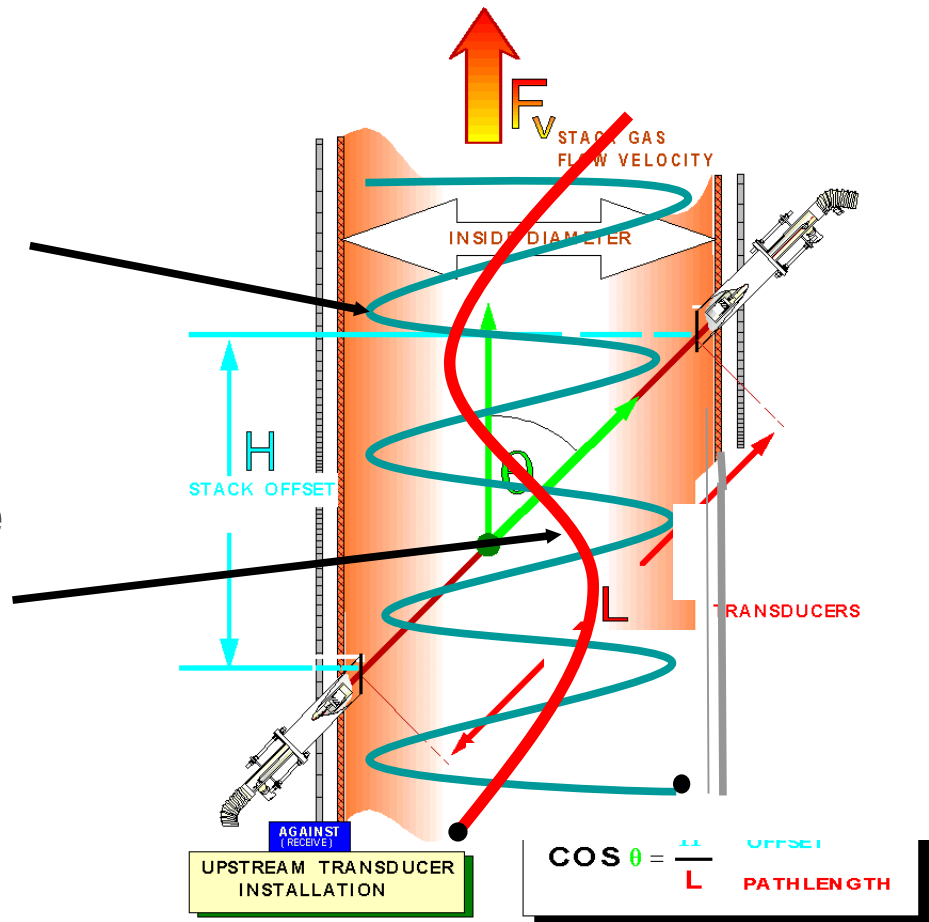


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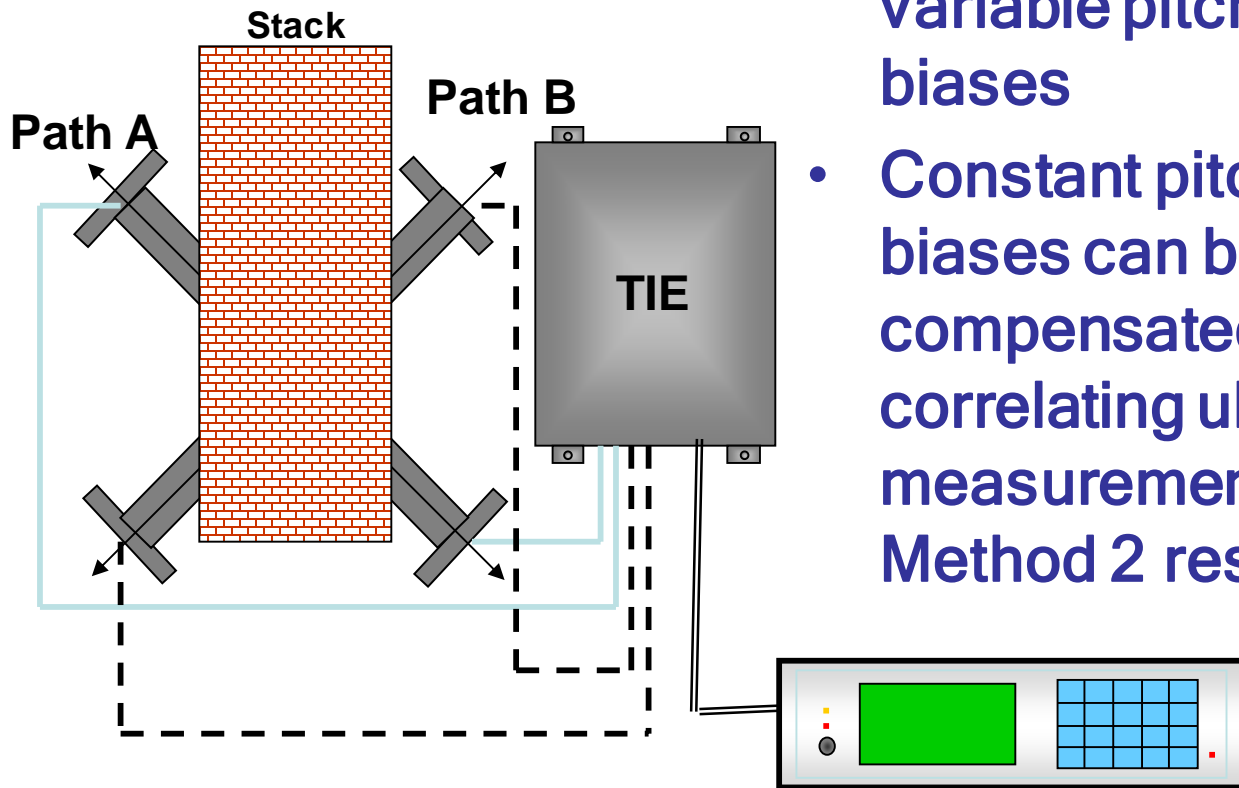
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Non-axial Flow Patterns

- There Are Two Types:
 - Cyclonic Flow is the **whirlwind pattern**
 - Pitch Flow is the **fishtail pattern**
- (*) Note: Cyclonic Flow Has No Impact on Flow Calculations In Most Cases



True X-Pattern



- Used to cancel out variable pitched flow biases
- Constant pitched flow biases can be compensated for by correlating ultrasonic measurement to EPA Method 2 results

Enhanced Remote Panel

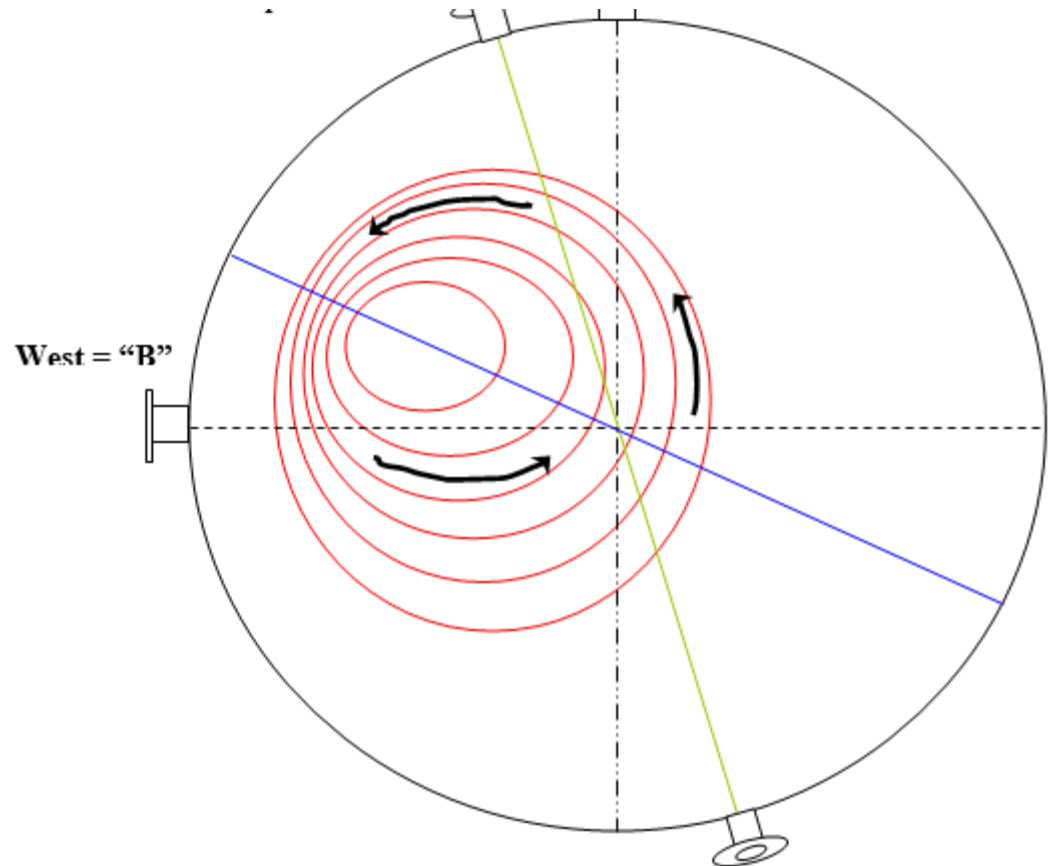


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Case Where Ultrasonic Measurement is Not Immune to Cyclonic Flow

- Cyclonic flow does become a problem when the axis of the cyclone is not concentric with the stack centerline.
- Remedied by installing the measurement path directly through the cyclone or installing a true X-pattern



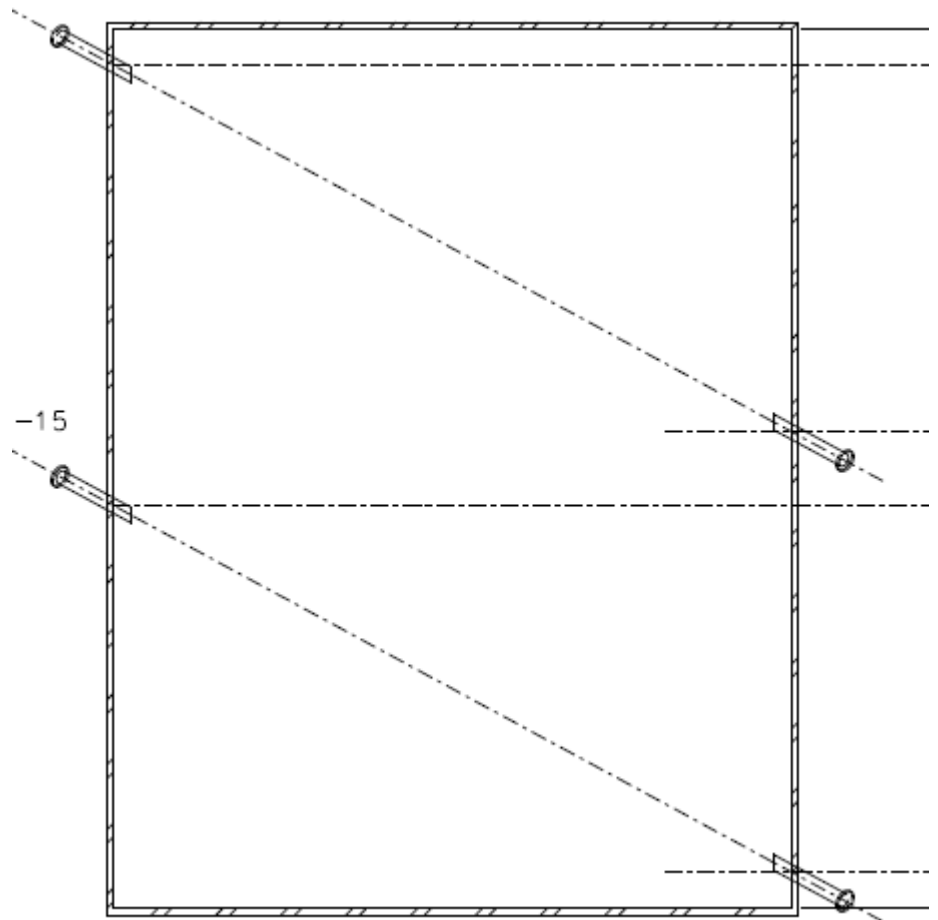
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Two Independent Compound Angle Measurement Paths

- Multiple paths used to get a more representative sample of the duct.
- Certified flow measurement is an average of the two paths

[Attachment 2 CEMS Ports Revised Layout 3D R4 No Platform.pdf](#)

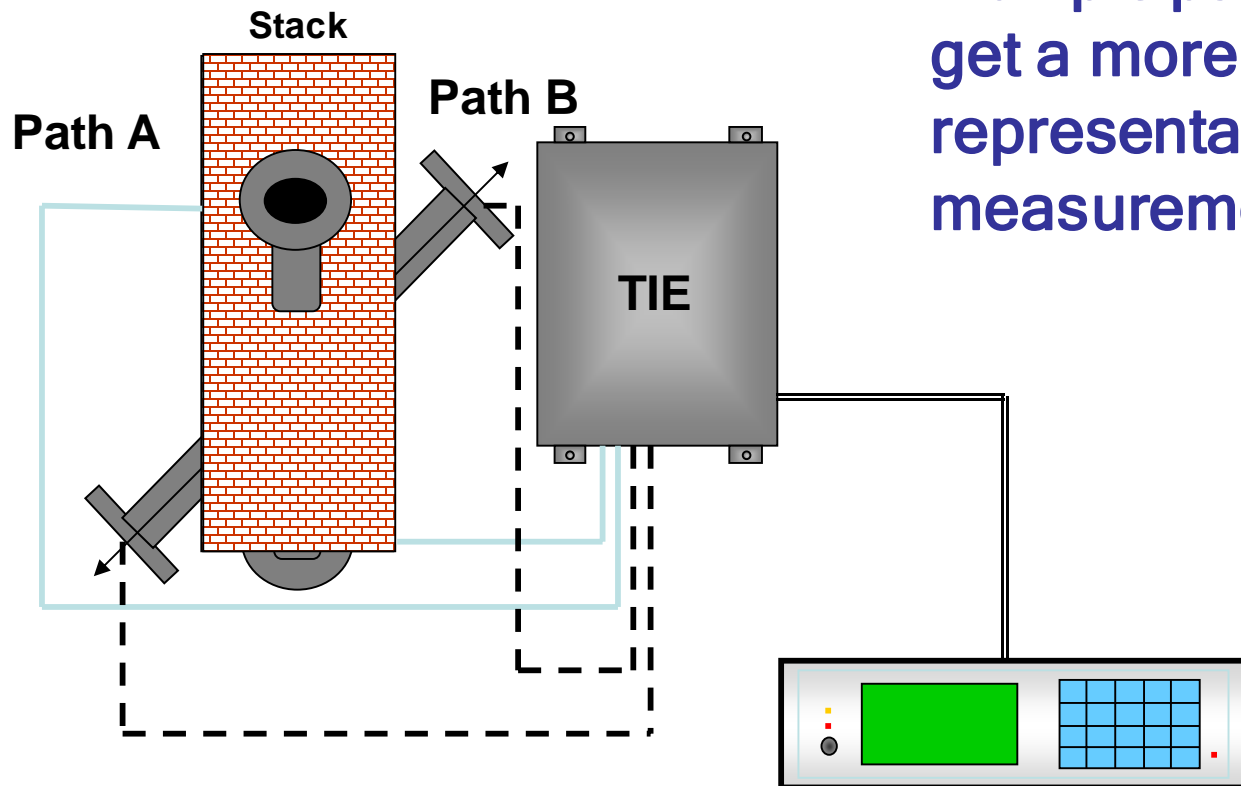


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Lazy X-Pattern

- Multiple paths used to get a more representative measurement



Enhanced Remote Panel



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Redundancy

- Usually uses a true X-pattern
- Each measurement path is certified independently
- The degree of redundant assets is flexible
- Can use one or two TIE boxes
- Can use one or two ERPs

