

Comparative Blinded Flare Gas Flow Measurement Study

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Wait a minute...I thought this was a Workshop on Smokestack Gas Measurement?



**Flare
Gas**



**Smoke
Stack**



It just so happens the same flow meters that measure smokestacks also measure flare gas.



Smokestack vs. Flare How Are They Different:



- Smokestacks are usually larger.
 - Full-bore meters are not an option.
- Smokestacks have smaller flow ranges:
 - Flare gas can range from 0.1 to 500 feet/sec.
- Smokestacks have more stable flows.
- Flare gas can have transient flow with wide flow swings.
- Flare gas can have large gas composition & density changes.



Smokestack vs. Flare How Are They Similar:



- Very little or no straight run of piping.
- Lots of distorted velocity profiles, skews & swirls.



- In 2011, Chevron contracted a blinded study to test various flow meters used in flare gas measurement.
- The goal was to shed some light on different flare gas flow measurement technologies.
- Improve:
 - API-14.10 (Measurement of Flow to Flares)
 - API-22.3 (Testing Protocol for Flare Gas Metering)
- Data presented at the GPA (Gas Producers Association), April, 2013, San Antonio, Texas.

Thank you:

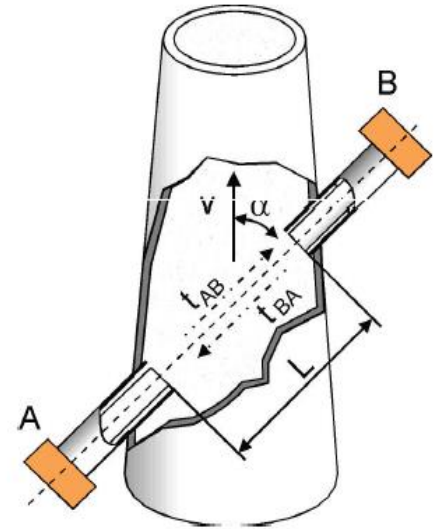
Steve Baldwin, Chevron
Houston, Texas, U.S.A.

Thank you:

Eric Estrada, Targa Resources
Houston, Texas U.S.A.

The comparative blinded study ran from 2011 to 2013 and included the following meters:

- USM (4-path Chordal)
- USM (2-path, Diametral)
- USM (1-path, Diametral)
- USM (1-path, Partial Insertion)
- Optical Flow Meter
- Tracer Gas Dilution Methodology



Wanted to test Pitot Tube Technology but time & money didn't allow it.

Rules of the Game:

Fluid:	Air
Temperature:	70°F (Ambient)
Pressure:	12 PSIA (Ambient)
Velocity:	1 to 150 FPS (feet/second)
Pipe size:	10" (6" pipe for 4-path chordal USM)
Pipe orient:	Horizontal
Piping Config:	Ideal straight-run Swirling flow after an elbow In-Plane & Out-of-Plane

- Manufacturers were expected to:
- Supply, install, operate, zero and record meter outputs.
 - Must be present during testing.
 - Blinded from reference data.
-
- Had an opportunity to review their data prior to submission.
- ...many nervous manufacturers.



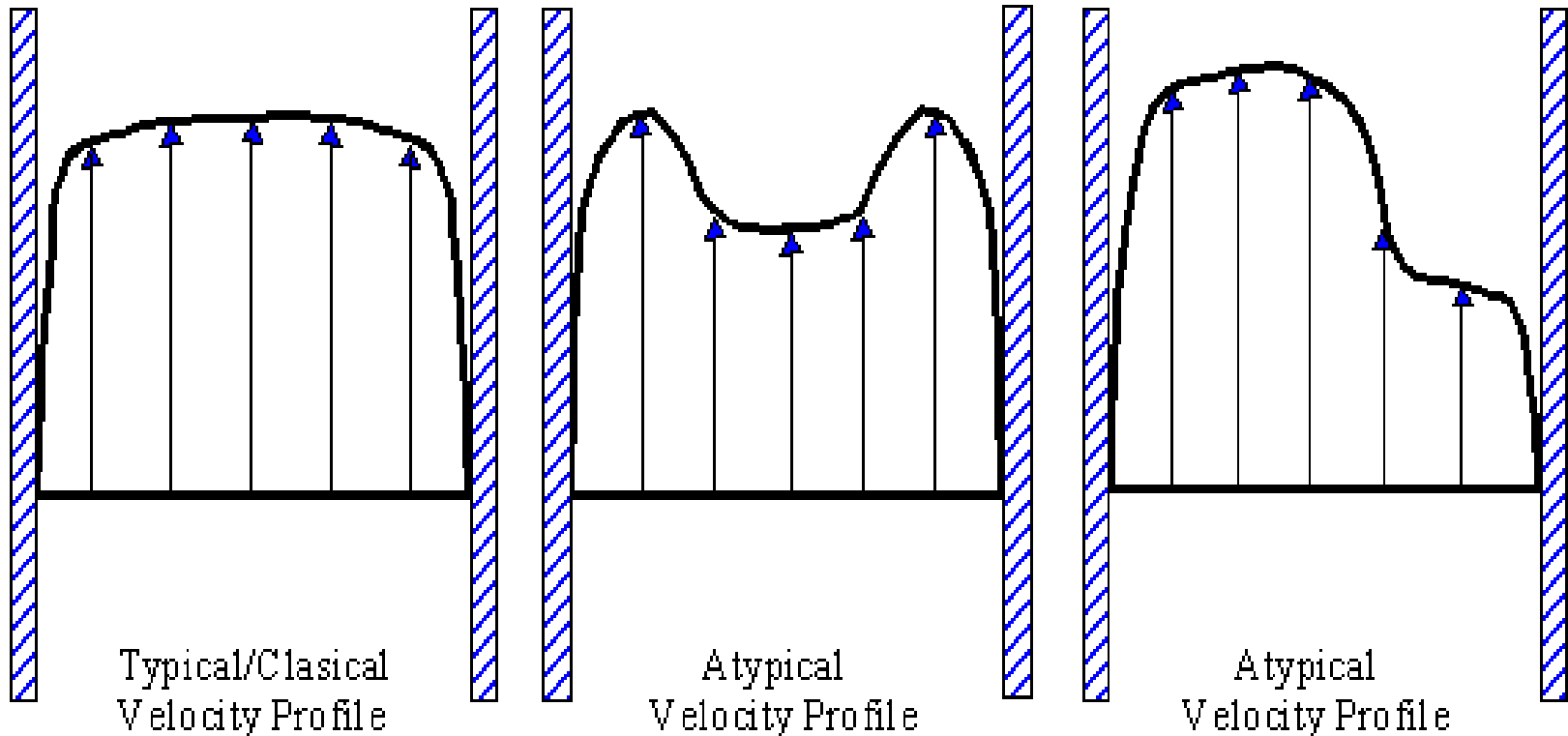
Warning!

Test results based on:

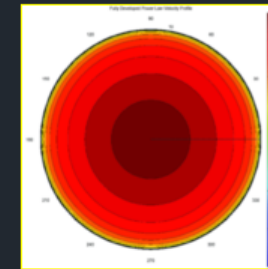
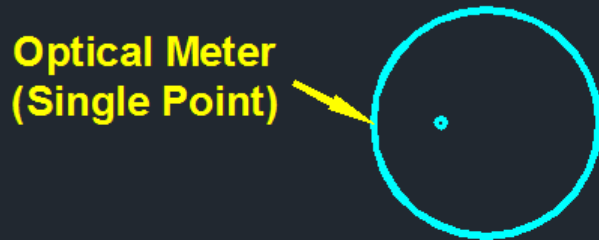
- Limited testing with a small sample size in 6" and 10" pipes.
- Extreme caution should be exercised when extrapolating these results to other
 - Pipe sizes
 - Different piping configurations
 - Different fluids
 - Different meters types



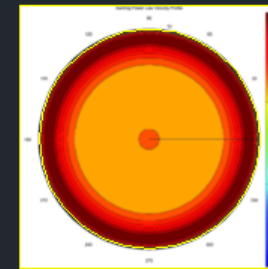
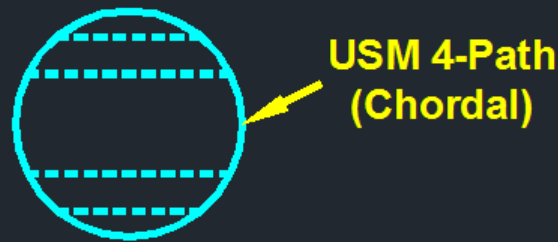
Consider Flare Gas & Smokestack Velocity Profiles:



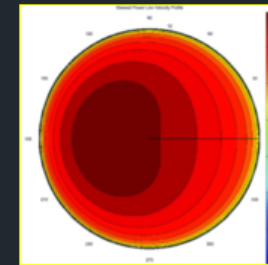
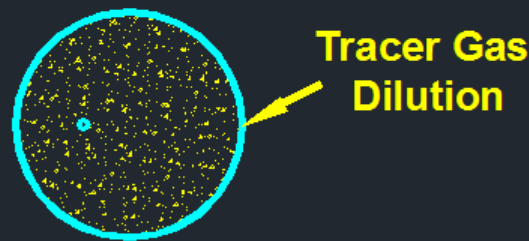
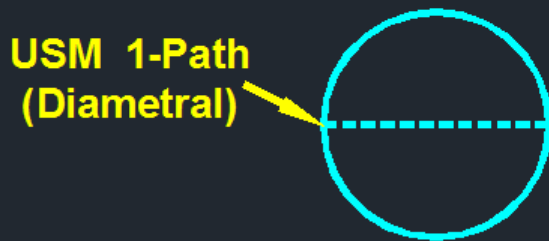
Consider How a Meter Senses the Flow:



Fully
Developed
Velocity
Profile



Swirling
Velocity
Profile



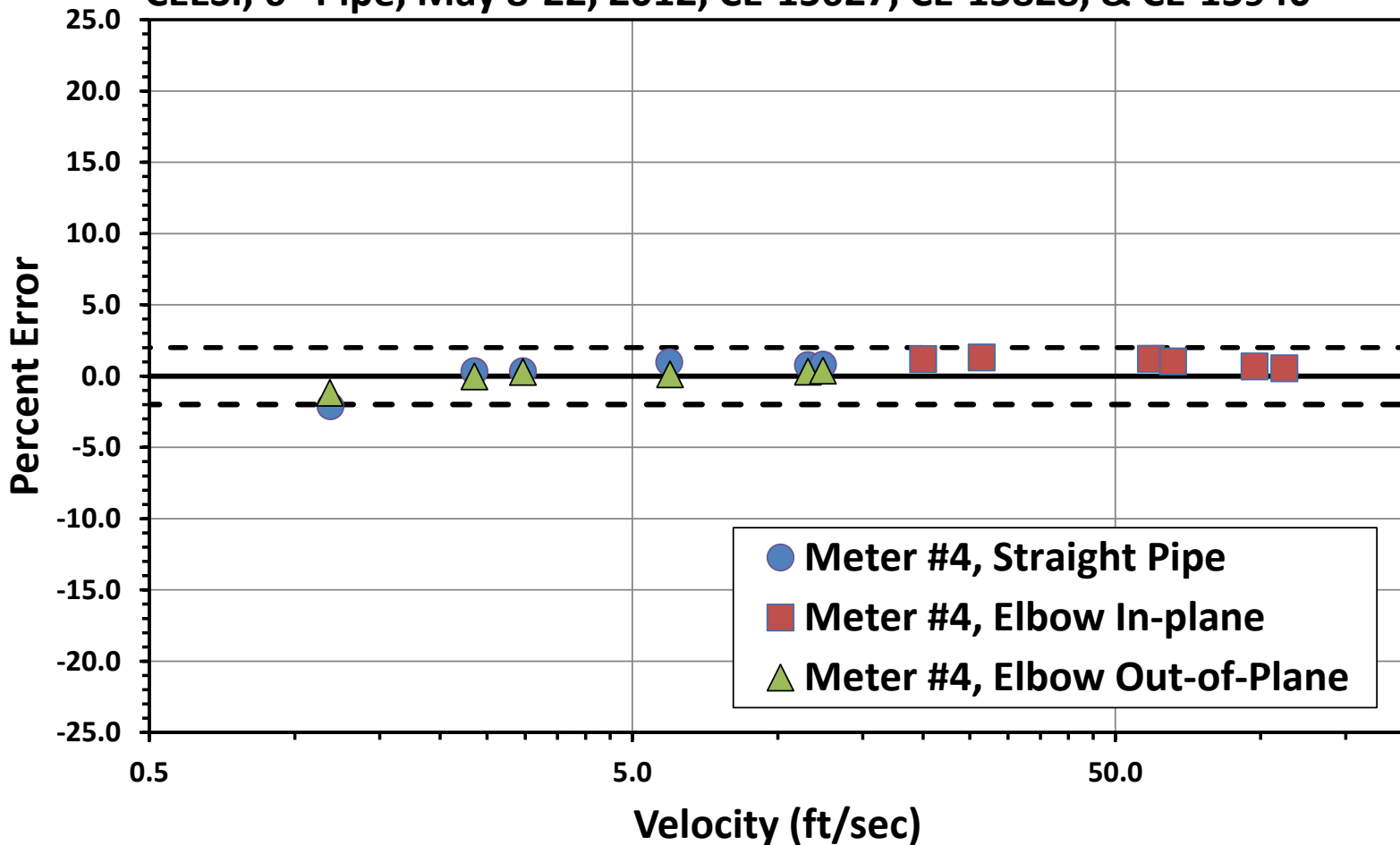
Skewed
Velocity
Profile

Comparative Blinded Flare Gas Flow Measurement Study

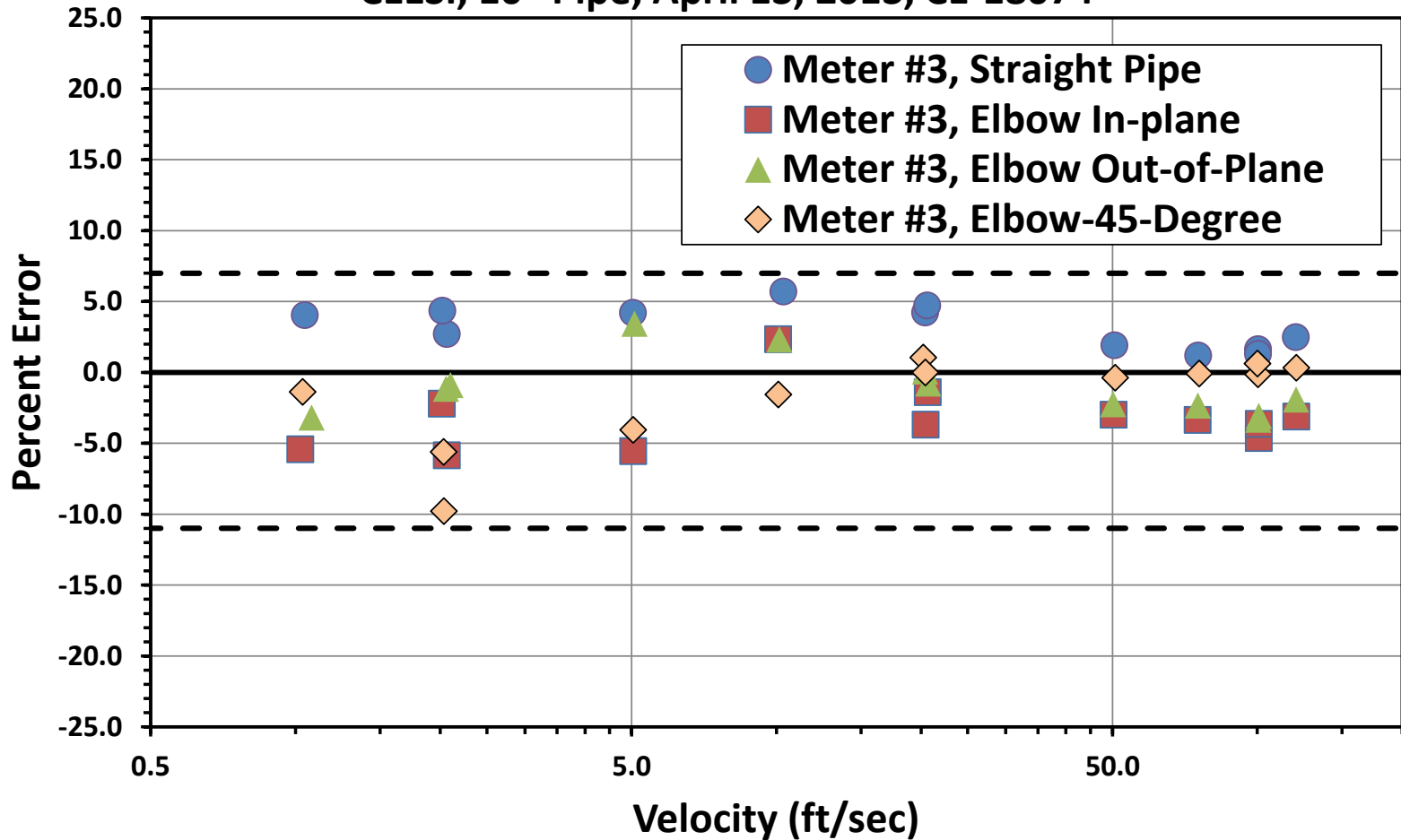
USM Meter #4, 4-Path Chordal

Straight Pipe, Elbow In-Plane, Elbow Out-of-Plane

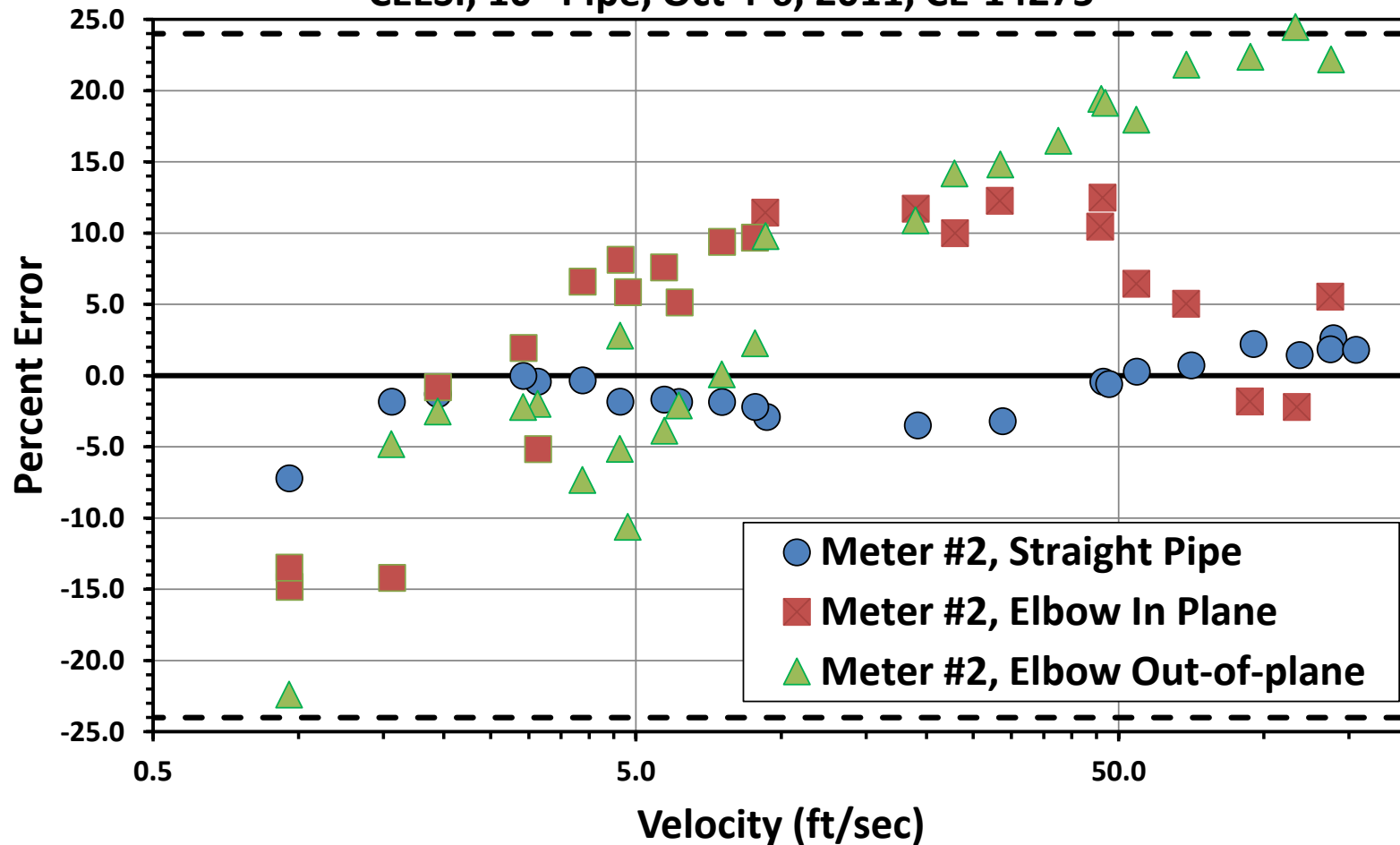
CEESI, 6" Pipe, May 8-22, 2012, CE-15627, CE-15828, & CE-15940



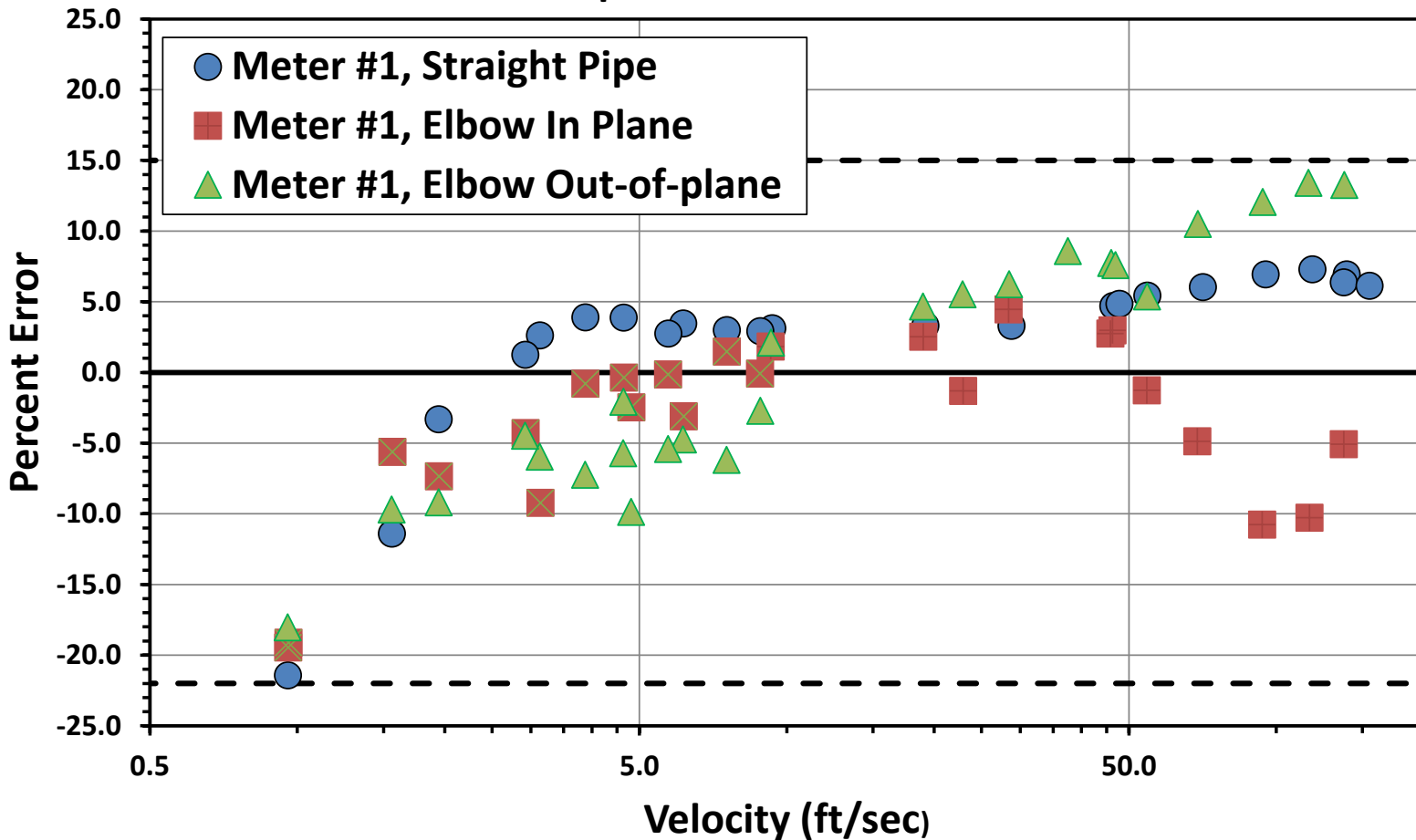
Comparative Blinded Flare Gas Flow Measurement Study
USM Meter #3 , Two-Path Diametral,
Straight Pipe, Elbow In-Plane, Elbow Out-of-Plane
CEESI, 10" Pipe, April 13, 2013, CE-18074



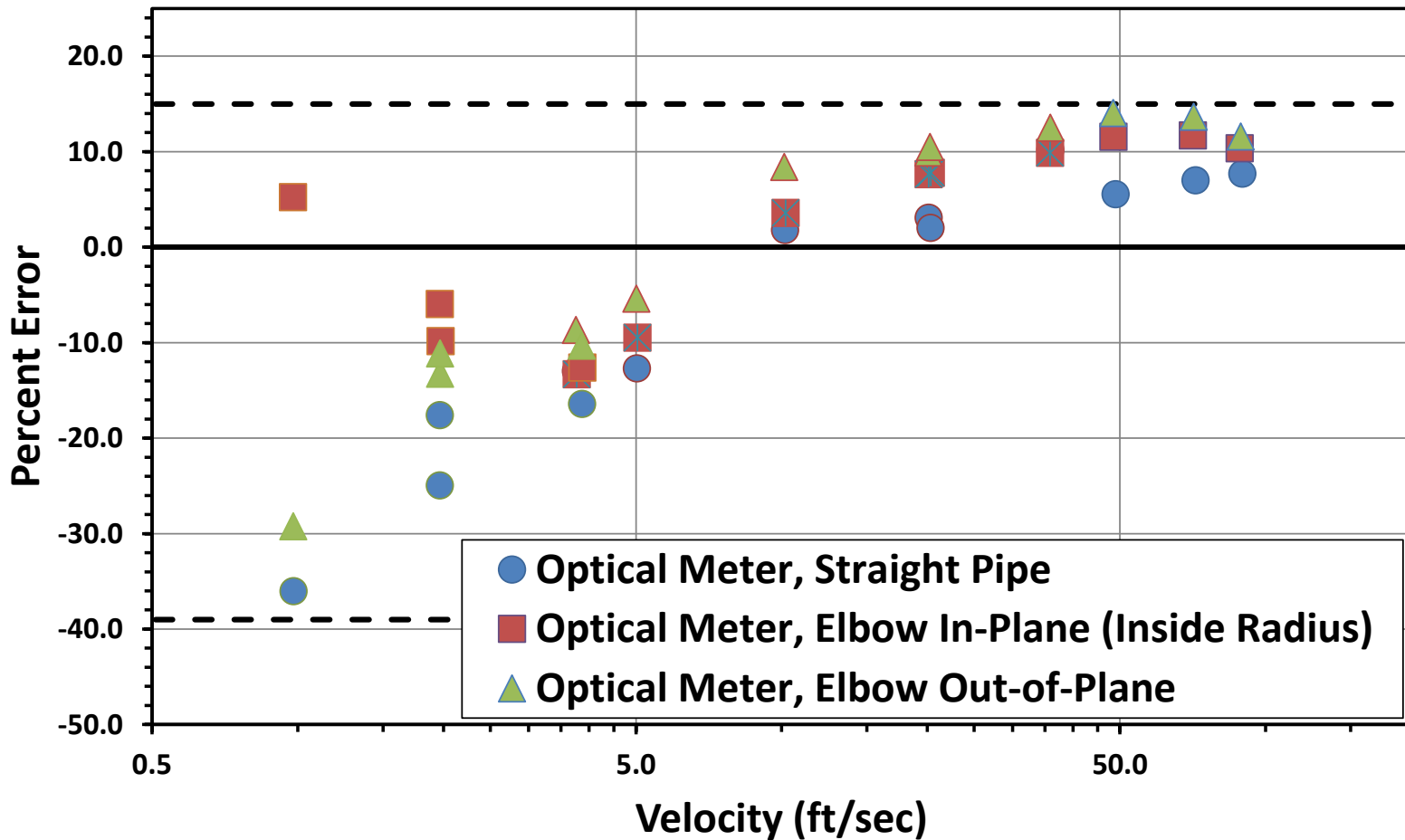
Comparative Blinded Flare Gas Flow Measurement Study
USM Meter #2 , Single-Path Diametral,
Straight Pipe, Elbow In-Plane, Elbow Out-of-Plane
CEESI, 10" Pipe, Oct 4-6, 2011, CE-14275



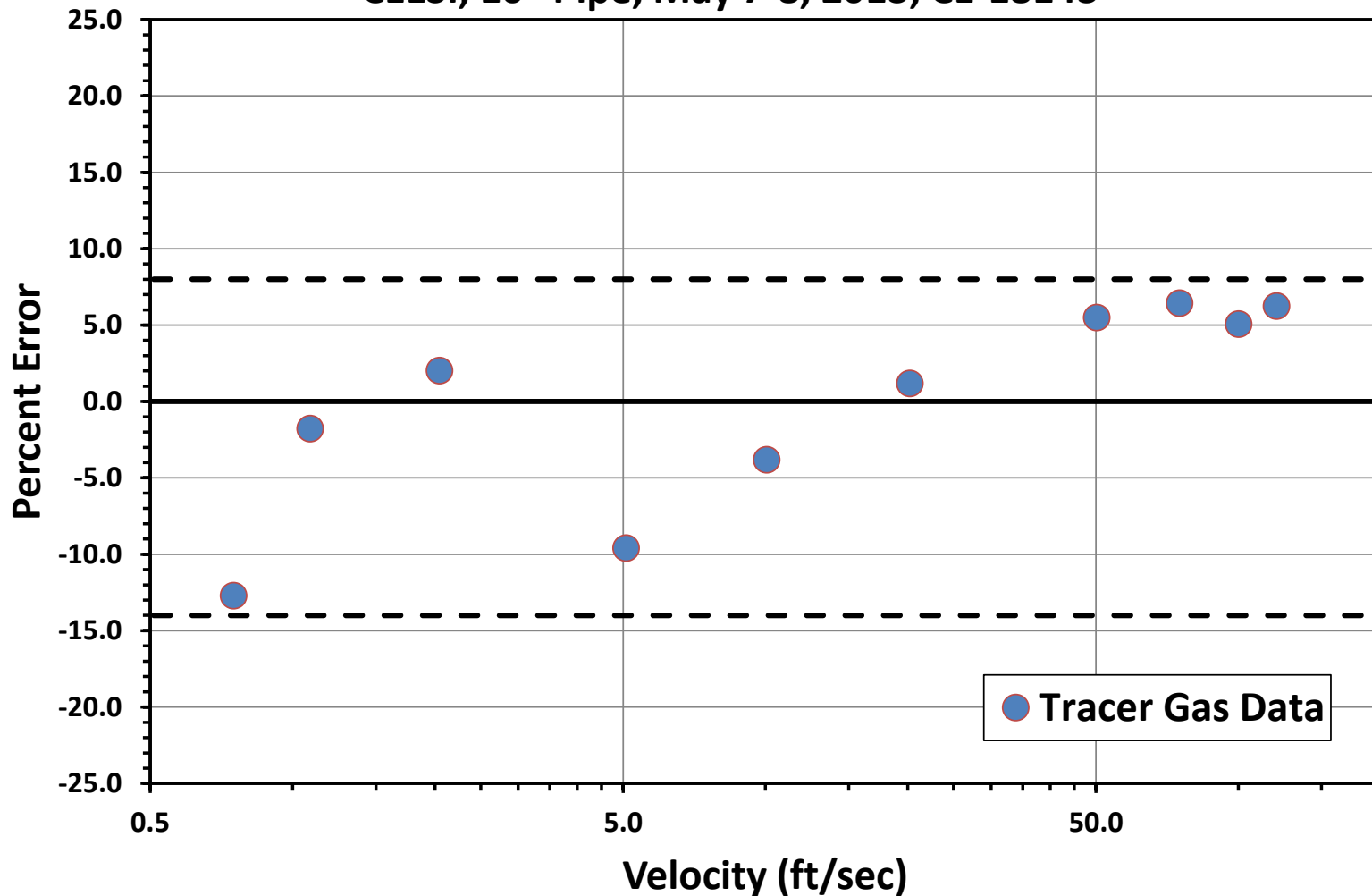
Comparative Blinded Flare Gas Flow Measurement Study USM Meter #1 , Single-Path, Partial Insertion Straight Pipe, Elbow In-Plane, Elbow Out-of-Plane CEESI, 10" Pipe, Oct 4-6, 2011, CE-14275



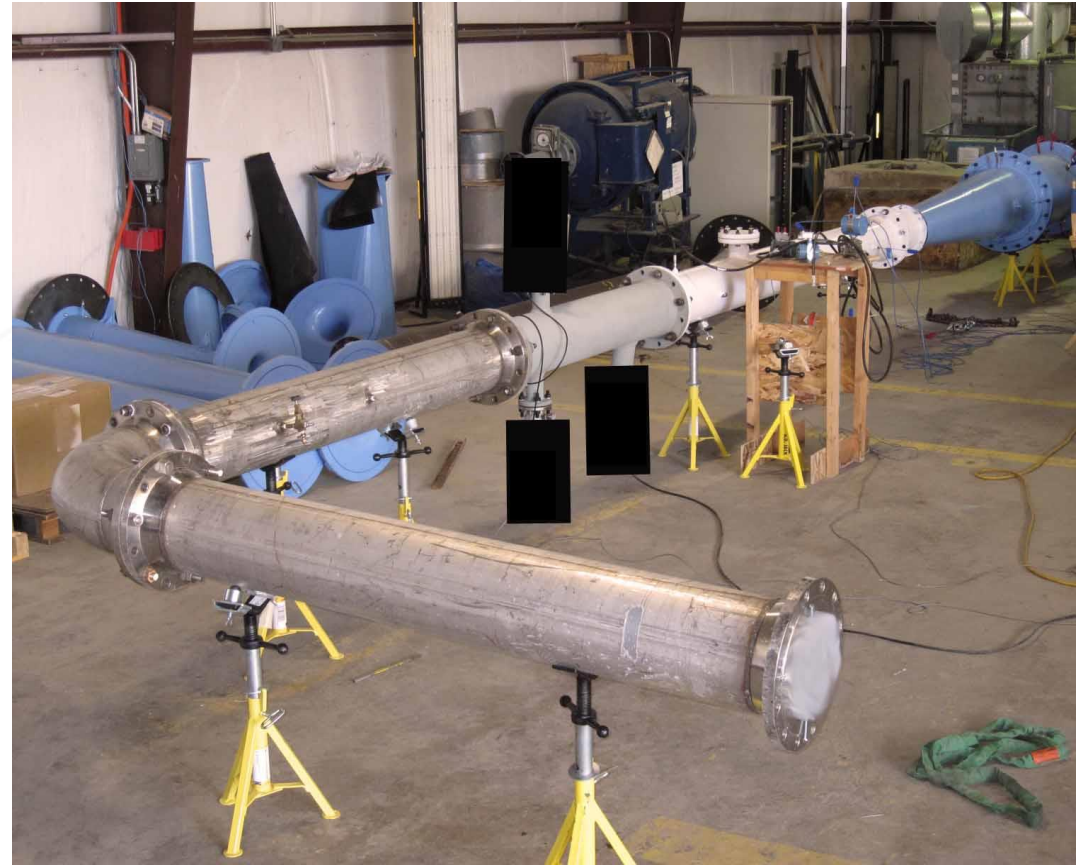
Comparative Blinded Flare Gas Flow Measurement Study Optical Meter Straight Pipe, Elbow In-Plane, Elbow Out-of-Plane CEESI, 10" Pipe, June 4-6, CE-14275



Comparative Blinded Flare Gas Flow Measurement Study Tracer Gas Dilution Method CEESI, 10" Pipe, May 7-8, 2013, CE-18143



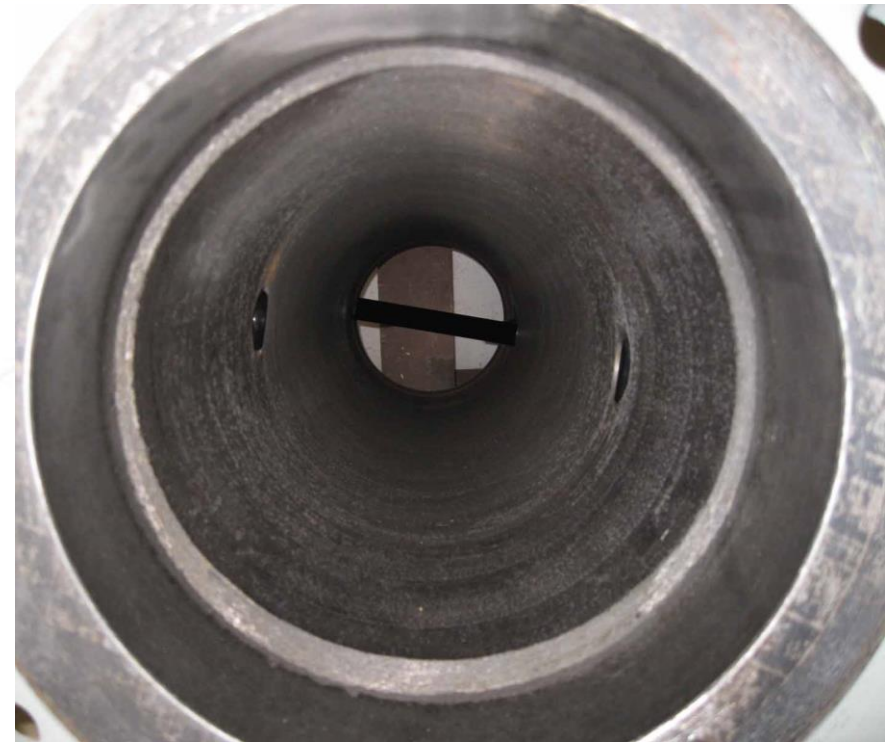
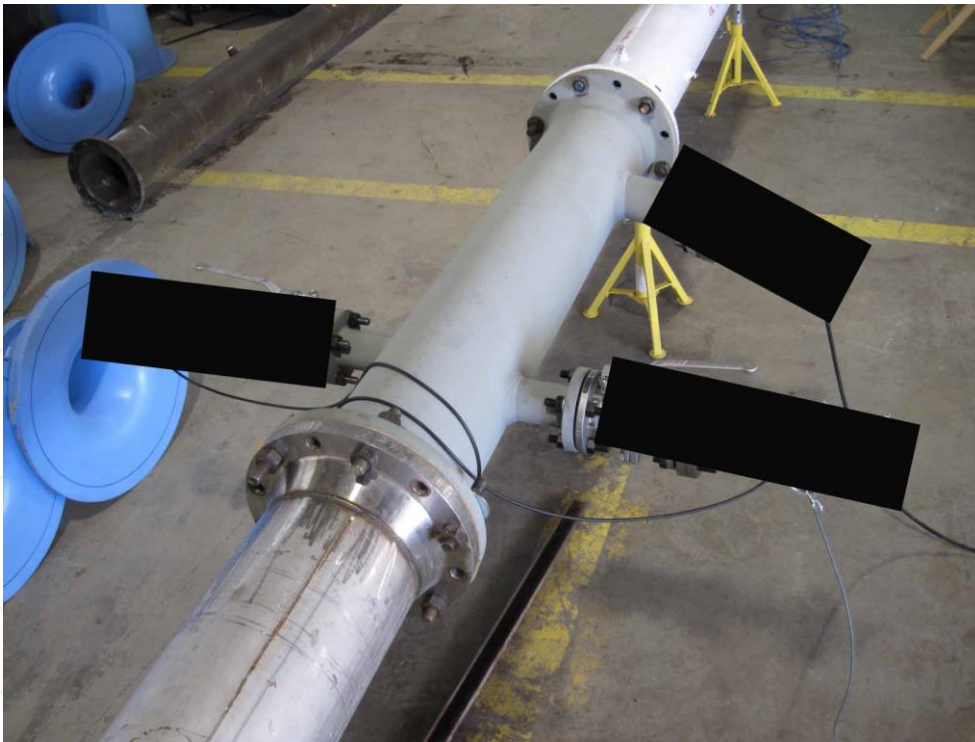
A Few Pictures:



Test Facility & Test Piping



Test Facility & Test Piping



USM (1-Path & Partial Path) Installation



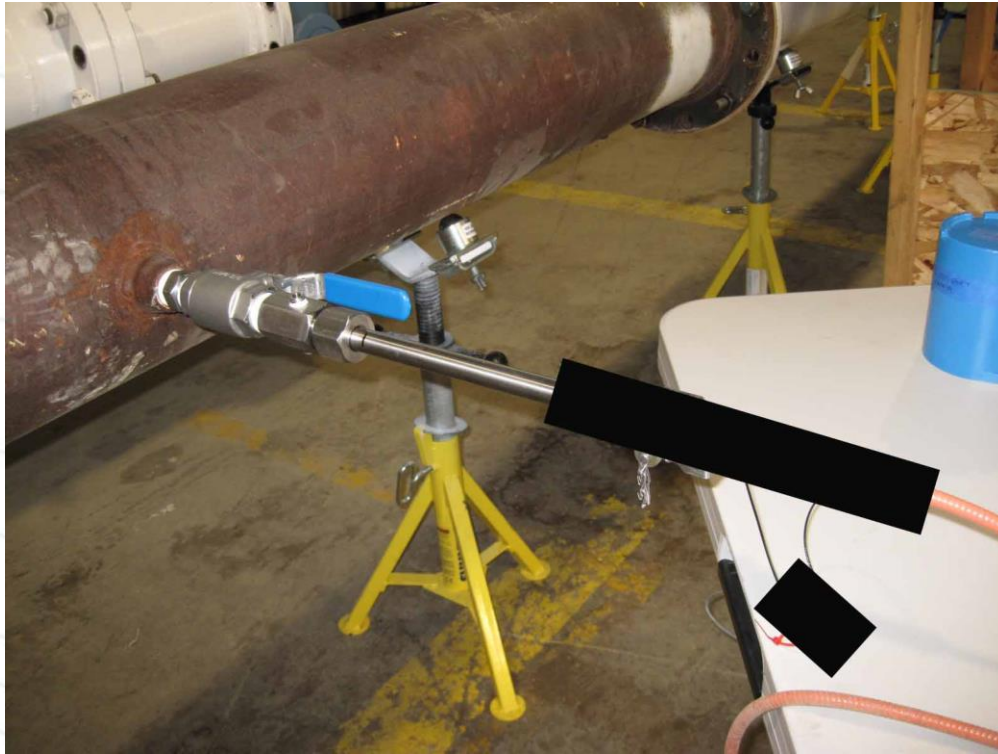
USM (2-Path) Installation



USM (4-Path Chordal) Installation

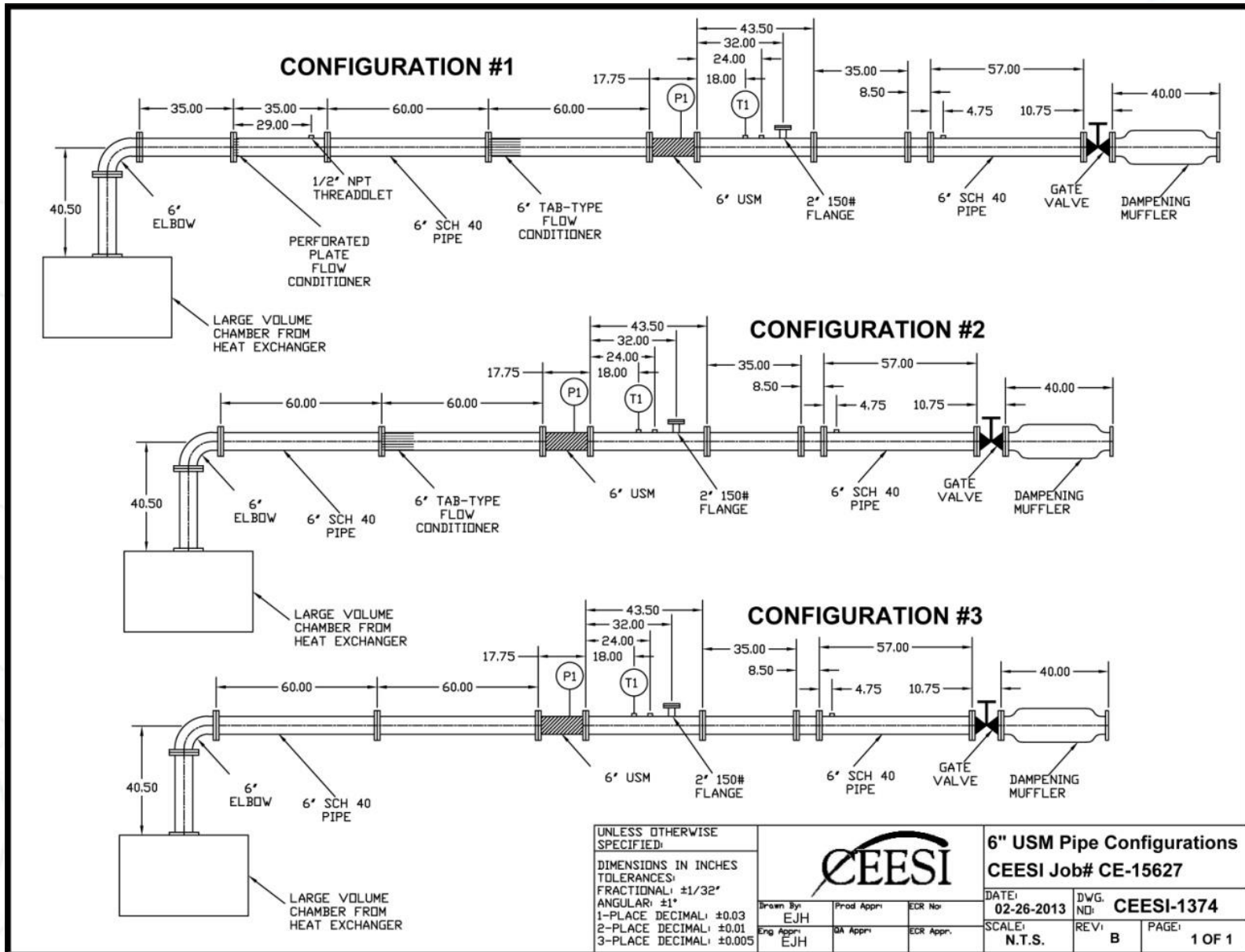


Tracer Gas Dilution Installation

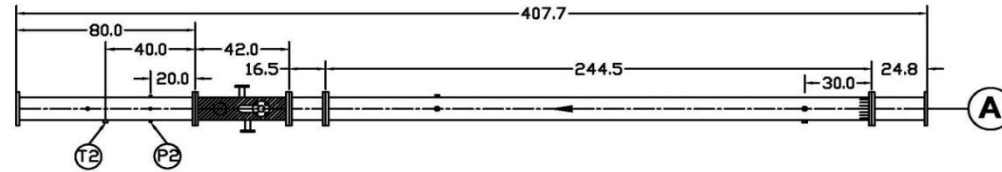


Optical Meter Installation

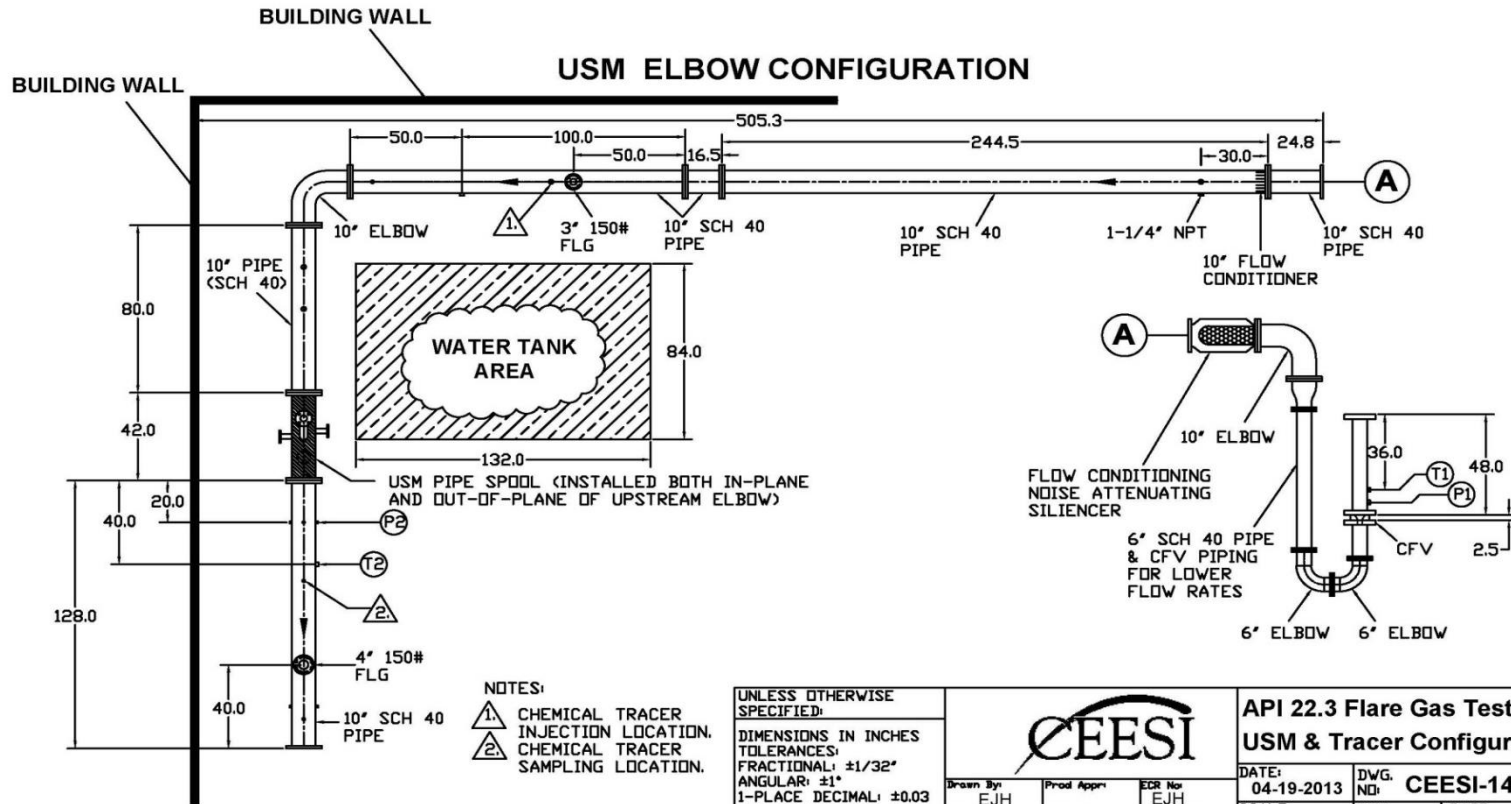
Comparative Flare Gas Flow Measurement Study



USM STRAIGHT RUN CONFIGURATION



USM ELBOW CONFIGURATION



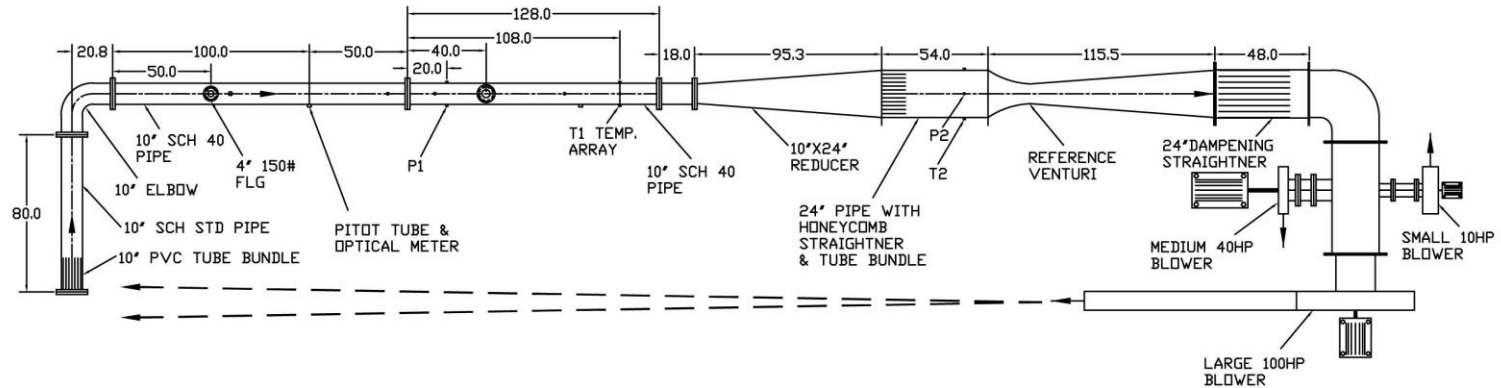
- NOTES:
- CHEMICAL TRACER INJECTION LOCATION.
 - CHEMICAL TRACER SAMPLING LOCATION.

UNLESS OTHERWISE SPECIFIED:
 DIMENSIONS IN INCHES
 TOLERANCES:
 FRACTIONAL: ±1/32"
 ANGULAR: ±1°
 1-PLACE DECIMAL: ±0.03
 2-PLACE DECIMAL: ±0.01
 3-PLACE DECIMAL: ±0.005

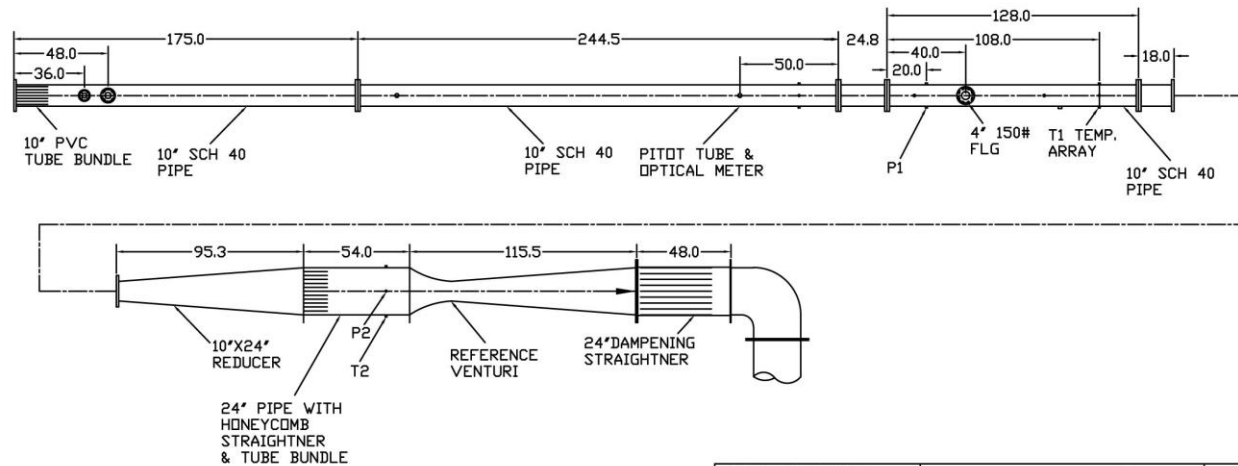
Drawn By: EJH	Prod Appr: EJH	EDR No: EJH
Eng Appr:	QA Appr:	EDR Appr:

API 22.3 Flare Gas Testing USM & Tracer Configuration		
DATE: 04-19-2013	DWG. NO.:	CEESI-1425
SCALE: N.T.S.	REV: B	PAGE: 1 OF 1

PITOT & OPTICAL METER ELBOW CONFIGURATION



PITOT & OPTICAL METER STRAIGHT RUN CONFIGURATION



UNLESS OTHERWISE SPECIFIED:
 DIMENSIONS IN INCHES
 TOLERANCES:
 FRACTIONAL: $\pm 1/32$ "
 ANGULAR: $\pm 1^\circ$
 1-PLACE DECIMAL: ± 0.03
 2-PLACE DECIMAL: ± 0.01
 3-PLACE DECIMAL: ± 0.005



Drawn By: EJH	Prod Appr: DA	ECR No:
Eng Appr: EJH	ECR Appr:	

Flare Gas Test
 Pitot & Optical Meter Config.

DATE: 12-10-2011	DWG. NO: 1264-2 OF 3
SCALE: N.T.S.	PAGE: 1

Results:

USM(4-path Chordal)

- Straight: $\pm 1\%$
- Elbow: $\pm 2\%$

USM (2-path, Diametral)

- Straight: $\pm 5\%$
- Elbow: $\pm 10\%$

USM (1-path, Diametral)

- Straight: ± 3 to 7%
- Elbow: $\pm 25\%$

USM (1-path, Partial Insert.)

- Straight: $\pm 3-7\%$ (3-150 FPS)
- Straight: $\pm 7-22\%$ (1-3 FPS)
- Elbow: $\pm 20\%$

Optical Flow Meter

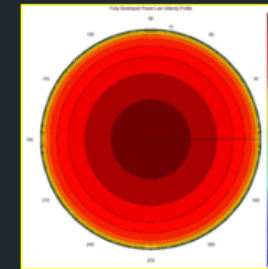
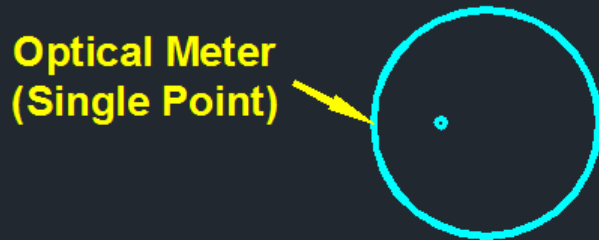
- Straight: $\pm 35\%$
- Elbow: $\pm 35\%$

Tracer Gas Dilution

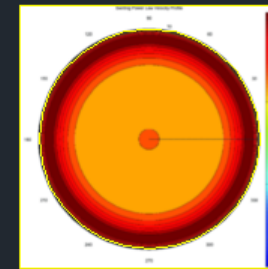
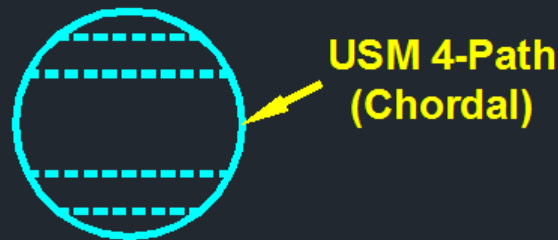
- All Installations: $\pm 6-10\%$



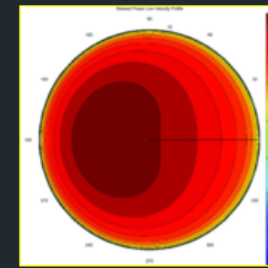
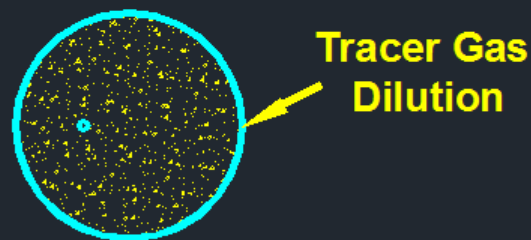
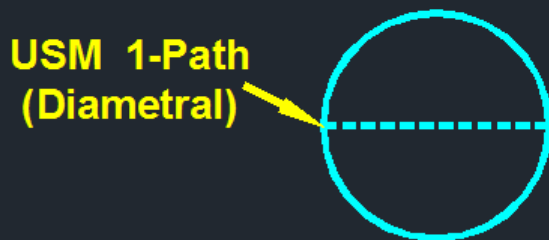
Consider How a Meter Senses the Flow:



Fully
Developed
Velocity
Profile



Swirling
Velocity
Profile



Skewed
Velocity
Profile

Conclusions:

- Chordal 4-Path best.
- Diametral USM's struggle.
- 2-Path USM's better than 1-Path in elbow.
- Optical Meter not a viable meter.
- Tracer Gas Dilution a viable solution when there is no straight pipe.

The more non-diametral paths the better!

Comments & Questions?

Thank you!

