Flare Measurement: A look at API MPMS 14.10 and API MPMS 22.3

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Agenda

Provide an overview of **API MPMS 14.10, Measurement of Flow to Flares** including the historical drivers that led to its creation.

Examine the newly revised companion document, **API MPMS 22.3, *Testing Protocol for Flare Gas Metering.***

Review the implementation of **API MPMS 22.3** from a manufacturers view.

API MPMS 14.10

Measurement of Flow to Flares

History of API MPMS 14.10

- A Working Group was established to develop a standard on flare measurement as a result of the TCEQ HRVOC regulation.
- API MPMS 14.10 was Introduced as a standard in 2007.
- A Working Group was formed to review/revise the standard in late 2010
- API MPMS was Reaffirmed in 2012
- Additional 2 year extension approved
- The second edition was balloted in the Spring 2018 with 170 comments
- New revision published in 2021
- SRRR To open 14.10 approved in May 2024.

Upcoming Revisions

The standard will be up for a 5-year review at the end of 2026 and based on discussions within the proposed working group membership, the standard could benefit from addressing the following:

- Review guidance provided by EI HM58 and consider addressing inconsistencies.
- Consider discussing the uncertainty of pipe effects.
- Explore the use of CFD to develop correction factors.
- Explore addressing analytical parameters required for calculations.
- Develop more detail on ultrasonic metering based on the different probe configurations used in flare measurement.
- Determine what is informative and should possibly be moved into an informative annex.
- Consider addressing flare controllers used by flare meter vendors which contain intellectual property and may not follow international standards and leverage API MPMS 22.3.
- Investigate the calculation of the flare tip efficiencies as an informative annex.

Target completion date is 12/1/2027

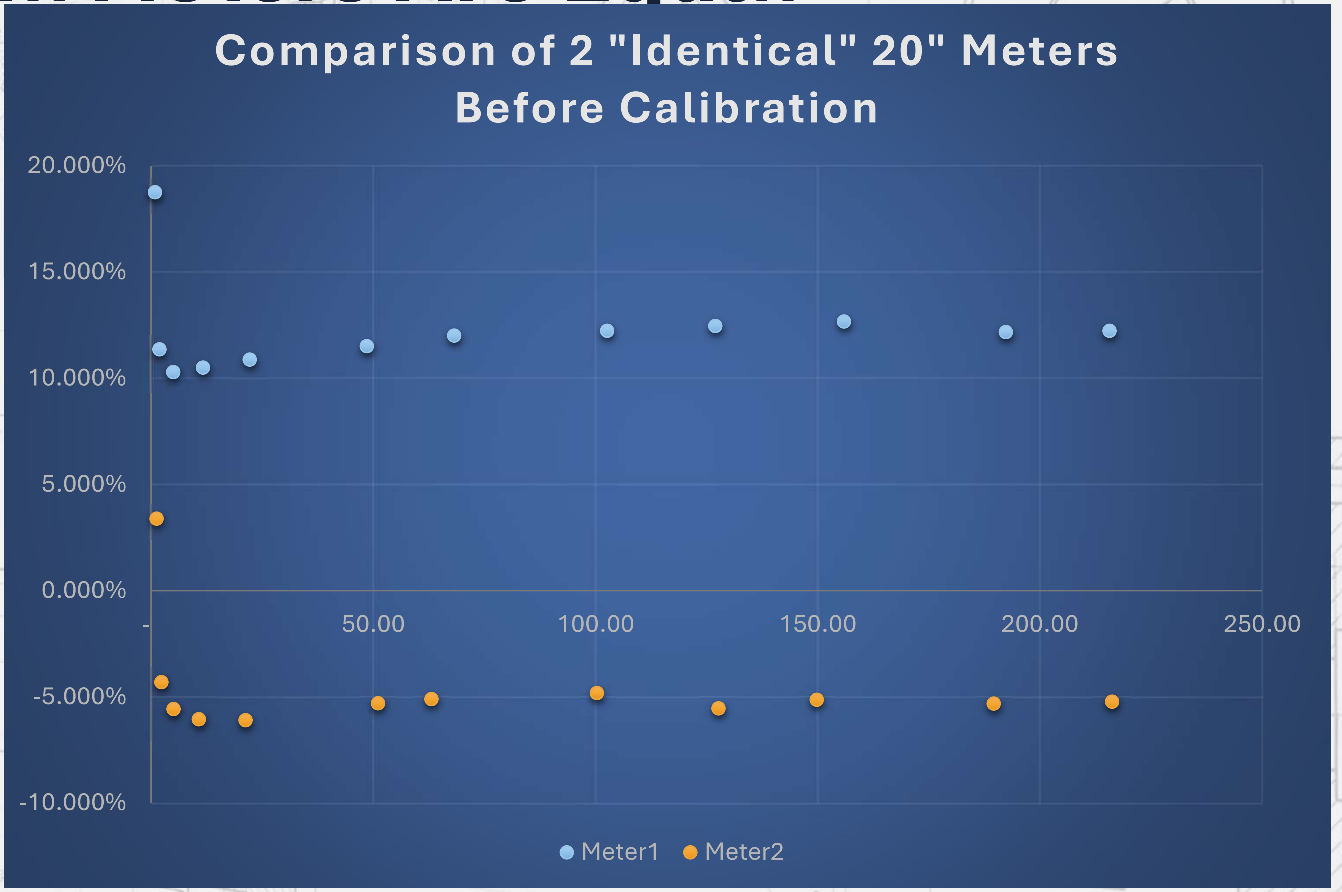
Technologies

- Differential Pressure Flow Meters
  - Pitot tube
  - Venturi
  - Orifice meters
- Optical Meters
  - Optical scintillation
  - Laser 2-focus
- Thermal Flow Meters
- Ultrasonic Flow Meters
- Vortex Shedding Meters
- ~~Tracer Technology~~

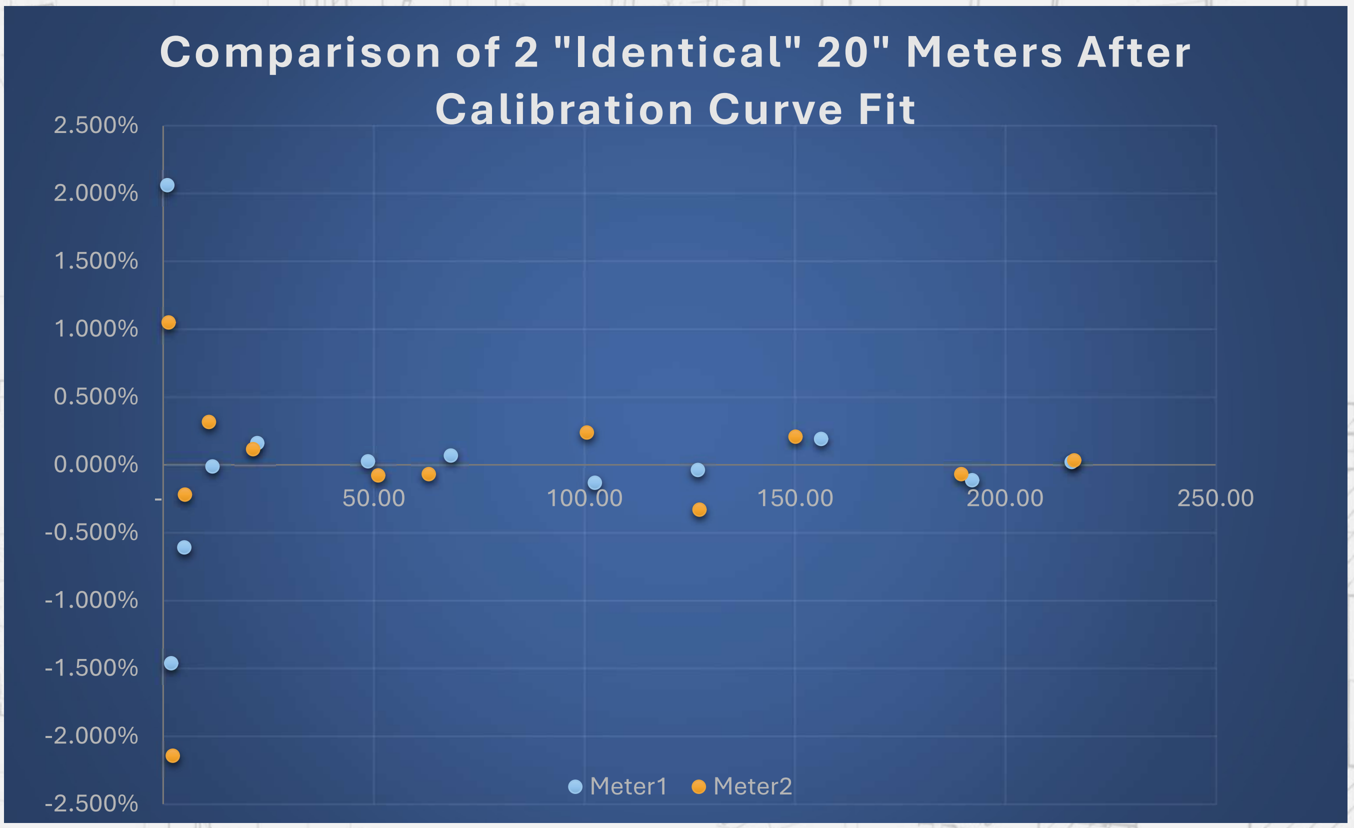
API MPMS 22.3

Testing Protocol for Flare Gas Metering

Why is calibration important?
Not All Meters Are Equal



After Calibration/Curve Fit



2nd Edition – Published December 2025

- Limited revision
- SRRR opened in March 2023
- Purpose
  - Review and provide clarity to section 6 and Annex A
  - Complete work asap in order to meet potential BLM regulation timing

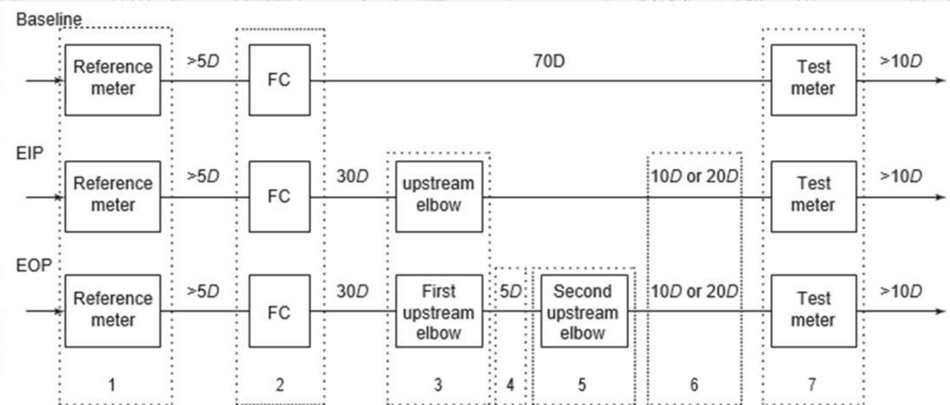
Mandatory Tests - General

Revised

- The tests presented in this section are <u>not considered pass/fail</u> tests but rather are intended to allow the manufacturer to present the performance of their meter over varying velocities and in ideal and non-ideal installations in a consistent manner. This allows the end-user to thoroughly evaluate a technology and manufacturer in order to determine which device(s) best fit their application.

Process Piping Connection

- Original



Components:

1 Reference meter
2 Facility flow conditioner (FC)
3 Elbow for 1 EIP and 2 EOP tests
4 Separation straight run length between elbows
5 Elbow for 2 EOP tests
6 Variable test meter upstream lengths
7 Test meter

NOTE 1 Reference device may be upstream or downstream of the test meter. Applicable pipe lengths should be used in the case of a downstream reference to ensure accurate measurement and no effect on the test meter.

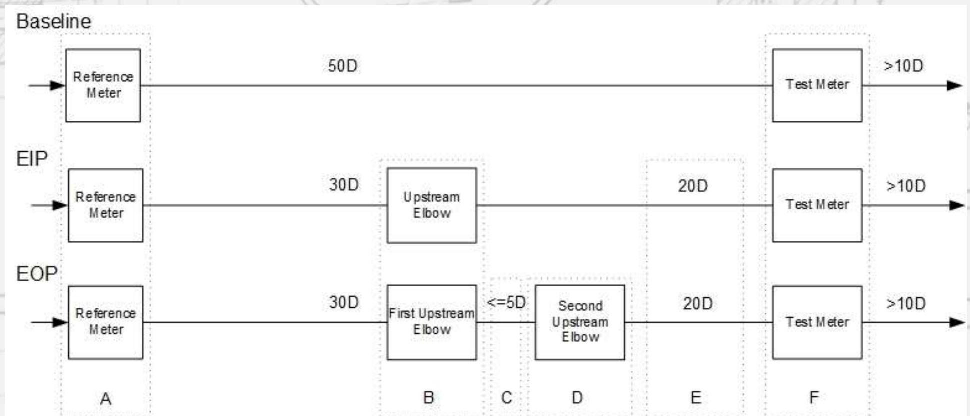
NOTE 2 For the mandatory tests, a perforated plate flow conditioner with at least 5*D* upstream and 30*D* downstream is required.

NOTE 3 The elbows are only inserted for the flow disturbance tests.

NOTE 4 The test meter upstream length is adjusted per the test program when elbow(s) are installed.

NOTE 5 The downstream straight length is at least 10*D* for all tests.

- Revised



Components:

A) Reference Meter
B) Elbow for 1 elbow in plane (EIP) and 2 elbow out of plane (EOP) tests
C) Separation straight run length between elbows
D) Elbow for 2 EOP Tests
E) Variable Test Meter Upstream Lengths
F) Test Meter

NOTE 1 Reference device may be upstream or downstream of the test meter. Applicable pipe lengths should be used in the case of a downstream reference to ensure accurate measurement and no effect on the test meter.
NOTE 2 The elbows are only inserted for the flow disturbance tests.
NOTE 3 The test meter upstream length is adjusted per the test program when elbow(s) are installed.

Special Testing

The end user should consider that there are many other factors that can influence and affect flare flow meters including the items listed in Section 5. In lieu of performing additional tests to address those items, the manufacturer may provide data to show how their meter is affected by these items. This additional data does not necessarily have to be performed by a 17025 accredited facility.

The Special Tests can include the following:

- supplemental data showing compositional effects;
- other installation effect testing.

In addition, in the event the manufacturer has historical data that shows performance of the meter either beyond the minimum and maximum velocities or not explicitly meeting the velocities tested in Section 6.12, the manufacturer may make such data available to the end user.

Testing Procedure - Revised

- Determine the Qmax_tested. The Qmax_tested may be determined as either the Qmax of the test facility or may be based on prior test data for the device.
  - Qmin - The manufacturer stated minimum measurable velocity of the fluid through the meter under test.
  - Qmax - The manufacturer stated maximum measurable velocity of the fluid through the meter under test.
  - Qmax_tested - The lesser of the manufacturer stated maximum measurable velocity and the maximum measurable velocity achievable by the test facility through the meter under test.

Testing Procedure - Revised

- The test points should cover the following velocities: 0.5, 1, 5, 10, 25, 50, 100 ft/s (0.15, 0.30, 1.5, 3.0, 7.6, 15, 30 m/s), and Qmax_tested.
- At least one additional point should be taken between 100 ft/s and Qmax_tested to demonstrate linearity.
- If any of the points are not tested, it shall be documented why the points were not tested and supplemental data should be provided per Section 6.11.
- The test points should be conducted over a statistically significant period. Each individual measurement (at a single flow rate) should last long enough to minimize the influence of random fluctuations and limitations in display resolution. Typically, three to five repeat measurements are taken per flow rate test point for a combined duration of no less than 300 seconds. See Annex A for examples of data reporting.

Annex A

- Removed reference to Ultrasonic Meter
- Removed meter picture
- Changed example tables to match revised Section 6 requirements

API 22.3 & API 14.10

- Overview of API 22.3
- Test Facility - Force
- Test Protocols Required by API 22.3
- API 22.3 Testing Results
  - FLOWSIC600 DRU-S / Two Path 3” SN 22248916, ANSI 600 Meter
  - FLOWSIC100 Flare-XT / Single Path 8” SN 2115813, ANSI 150 Meter
    - Interface Unit S/N 19080017
  - FLOWSIC100 Flare-XT / Two Path 26” SN 21028524, ANSI 150 Meter
  - FLOWSIC100 Flare-XT / Two Path 20” SN 23038670, ANSI 150 Meter
  - FLOWSIC600-XT / Four Path 6” Meter
  - FLOWSIC600-XT / Four Path 4” Meter
- Q&A

Flare Regulations / Composition Effect API 14.10

10.4.3.1 Three Examples of the Composition Effect

The approximate measurement error caused by using a fixed composition of 1% CO_2, 0.9% H_2S, 97% methane, 1% ethane and 0.1% propane when the flare composition changes to:

- Case 1—0.53% CO_2, 0.47% H_2S, 51.08% methane, 0.53% ethane and 47.39% propane.
- Case 2—0.4% CO_2, 0.36% H_2S, 38.8% methane, 0.4% ethane and 0.04% propane and 60% hydrogen.
- Case 3—12% CO_2, 0.8% H_2S, 86.22% methane, 0.89% ethane and 0.09% propane are shown in Table 5. (To simplify the calculation all flowing conditions are held constant and only the composition is changed.)

Table 5—Errors Related to Use of Fixed Composition for Different Meter and Calculations Types (Absolute Value of Error)

Case 1—Propane Increased	Actual Volume	Standard Volume	Mass
Differential Pressure Meter	~34%	~34%	~25%
Thermal Flow Meter	~2% to 15%	~2% to 15%	~35% to 45%
Velocity Meter (Optical, Ultrasonic, Vortex)	~0%	~0%	~44%

Case 2—Hydrogen Added	Actual Volume	Standard Volume	Mass
Differential Pressure Meter	31%	31%	45%
Thermal Flow Meter	~100% to ~300%	~100% to ~300%	~300% to ~700%
Velocity Meter (Optical, Ultrasonic, Vortex)	0%	0%	112%

Case 3—CO_2 Increased	Actual Volume	Standard Volume	Mass
Differential Pressure Meter	~9%	~9%	~8%
Thermal Flow Meter	~2% to ~5%	~2% to ~5%	~15% to ~20%
Velocity Meter (Optical, Ultrasonic, Vortex)	~0%	~0%	~15%

Notes:

1. Based on composition errors caused by using fixed composition, the user needs to evaluate the need for composition measurement and correction.
2. Thermal flow meter errors are expressed as a range due to the composition effect being velocity dependent.

Test Facility

Test Facility Information

Parameter	Information
Name	FORCE Technology, Bulderbaan – open-loop air calibration facility
Location	Navervej 1, 6600 Vejen, Denmark
Dates of the test	10.12. – 12.12.2024
Uncertainty (CMC)	U(CMC) = 0.23%
Accreditation for testing and calibration	DANAK Reg. No. 9, valid till 30-06-2027, acc. to ISO 17025:2017 [Appendix 1]

Test Conditions Information

Parameter	Information
Test Fluid	Air
Test temperature	20C +-5C
Test pressure	atmospheric
Velocity range	0.65...52.96 m/s (2.1 ... 173.8 ft/s)
Flow range	10...820 m3/h
Reynolds numbers range	3346...274339

The Bulderbaan operates using atmospheric air in the flow range of 65-25000 m3/h, Ucmc 0,23%.

API 22.3 Testing Results – Force Technology

Force Technology DS/EN ISO/IEC 17025:2017 accreditation

DANAK
Member of EA MLA

ACCREDITATION

for testing and calibration

Reg. No 9

Company

FORCE Technology
Metrologi & Gas Flow Teknologi
Park Allé 345, DK-2605 Brøndby
CVR: 55117314

Scope of accreditation

- Testing, as specified in annex 1
- Calibration, as specified in annex 2
- Reverification of measuring instruments, as specified in annex 3

Validity 12-06-2023 to 30-06-2027

Replaces document of 21-06-2019

Basis for accreditation **DS/EN ISO/IEC 17025:2017**

The laboratory complies with the requirements in DS/EN ISO/IEC 17025:2017 - General requirements for the competence of testing and calibration laboratories, together with the relevant provisions as an accredited body for the above mentioned scope of accreditation.

12-06-2023

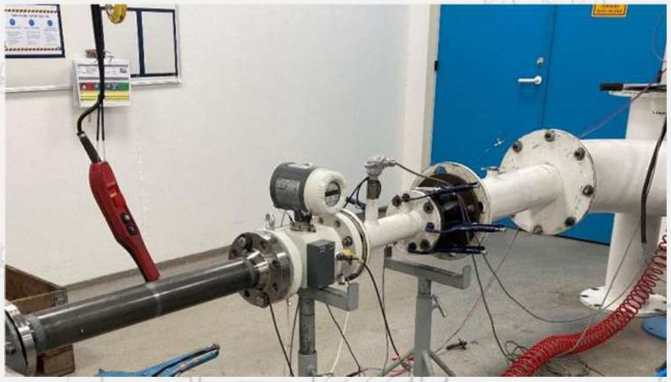
Director

Lead Assessor

DANAK | Den Danske Akkrediteringsfond | Dyregårdsvej 7 | 2740 Skovlunde | Tlf: +45 77 33 95 00 | CVR-nr. 26 89 93 89 | Bank: Reg. nr. 9370 | Kontonr: 2480 231 115 | danak@danak.dk | www.danak.dk

API 22.3 Testing Results
FLOWSIC600 DRU-S / Two Path 3” Meter

Parameter	Information	
Name of manufacturer	Endress+Hauser SICK GmbH+Co.KG	
Meter type/technology	FLOWSIC600 DRU-S Ultrasonic transit-time-difference technology Path layout: 2-path diametral	
Serial number	S/N 22248916	
Nominal pipe size	3”	
Flange connection	ANSI CL600, RF, Schedule 40	
Outputs	Frequency output, RS485, DO	
Flow rate Qmin...Qt...Qmax	8...40...1000 m3/h	280...1400...35000 ft3/h
Gas temperature range	–40 °C ... 100 °C	–40 °F ... 212 °F
Pressure range	0 bar(g) ... 100 bar(g)	0 psi(g) ... 1450 psi(g)
Previous calibration	factory adjustment	



Test Protocols Required by API 22.3 FLOWSIC600 DRU-S / Two Path 3” Meter

Figure 2: Summary of the requirements [1].

In relation to the requirements of the API (see Fig 2), the following meter setups were tested:

1 Baseline Test:

>|-FC-||----30 D----||-Meter-||-3D-||---->

2 Installation effects testing 20D EIP:

>|-FC-||----5 D----||–Elbow 90 in plane---||---20 D---||-Meter-||-3D-||---->

3 Installation effects testing 10D EIP:

>|-FC-||----5 D----||–Elbow 90 in plane---||---10 D---||-Meter-||-3D-||---->

4 Installation effects testing 20D 2xEOP (separated 5D):

>|-FC-||----5 D----||–Double Elbow 90 out of plane---||---20 D---||-Meter-||-3D-||---->

5 Installation effects testing 10D 2xEOP (separated 5D):

>|-FC-||----5 D----||–Double Elbow 90 out of plane---||---10 D---||-Meter-||-3D-||---->

API 22.3 Testing Results
FLOWSIC600 DRU-S / Two Path 3” Meter

Baseline Test

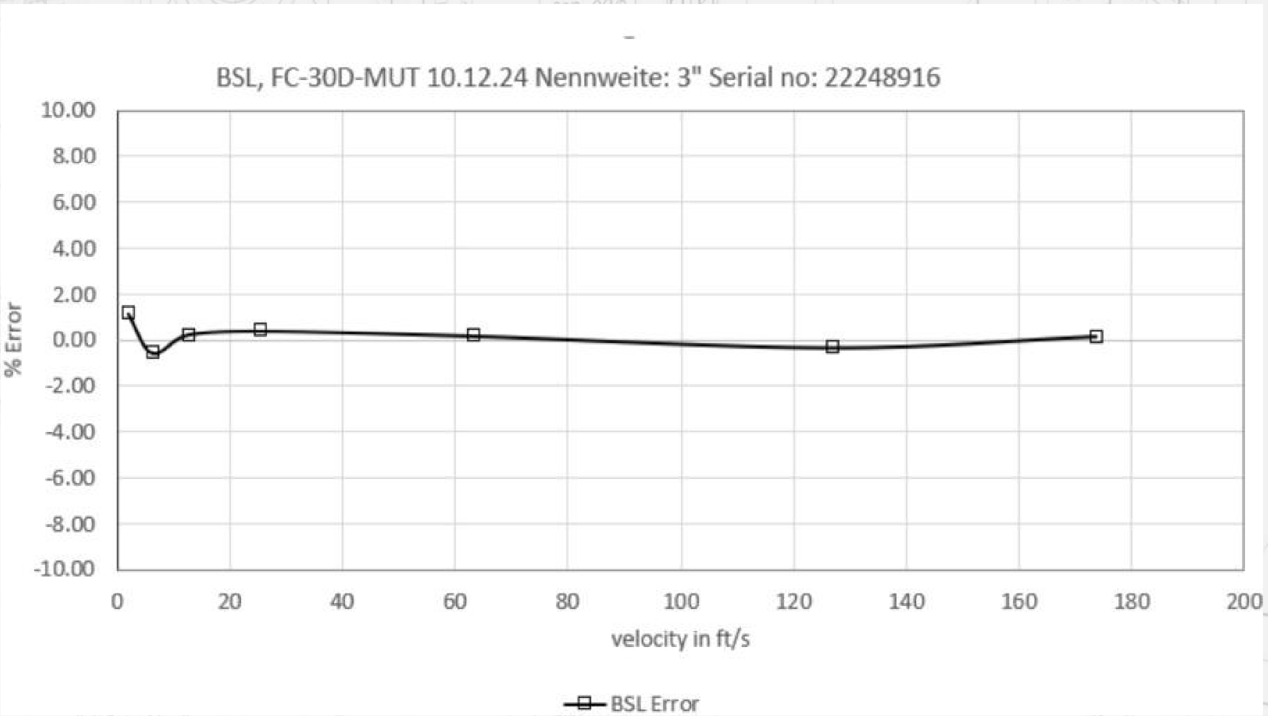
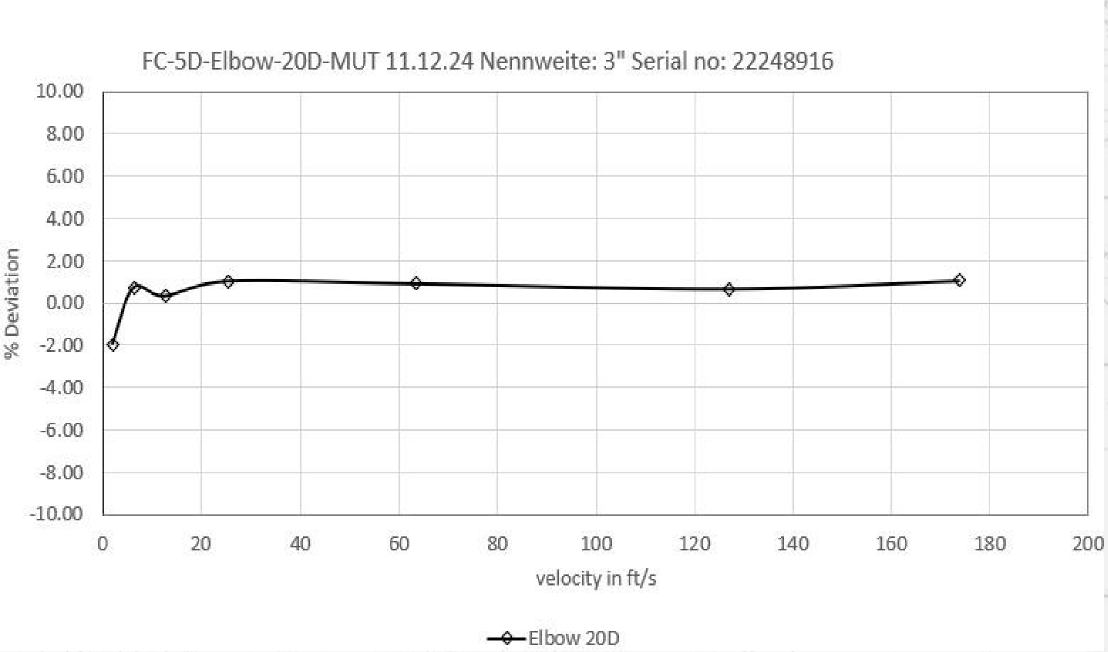


Figure 4: Baseline test results.

Figure 3: Setup Baseline BSL 30D inlet length.

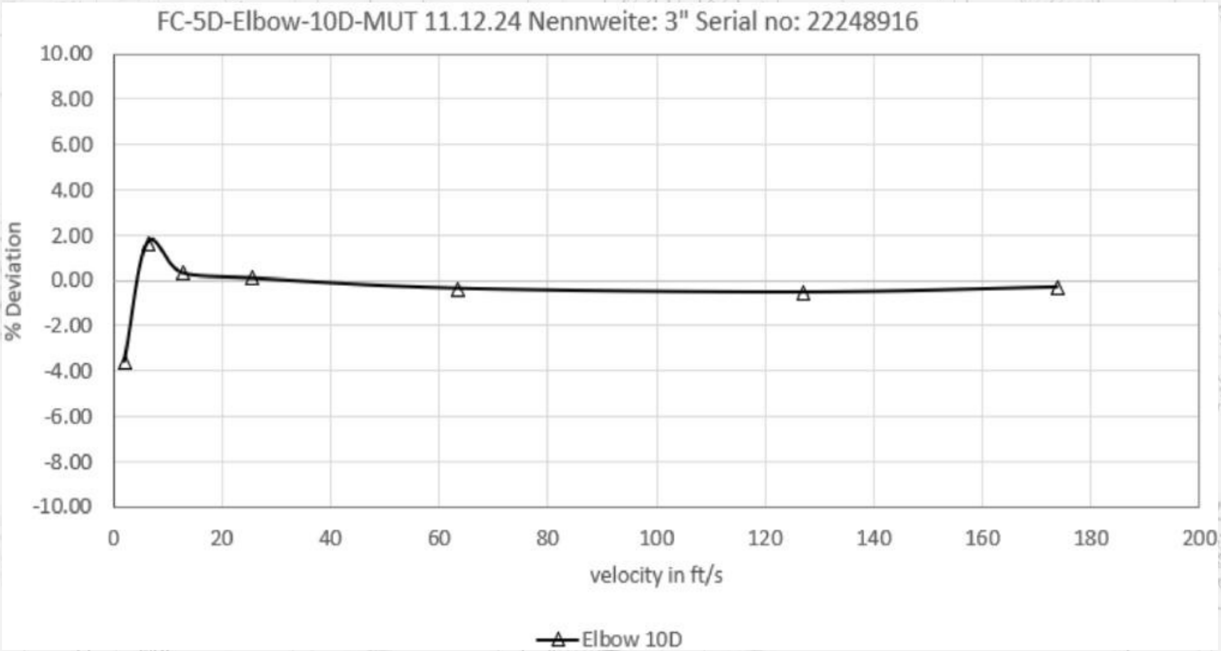
API 22.3 Testing Results
FLOWSIC600 DRU-S / Two Path 3" Meter

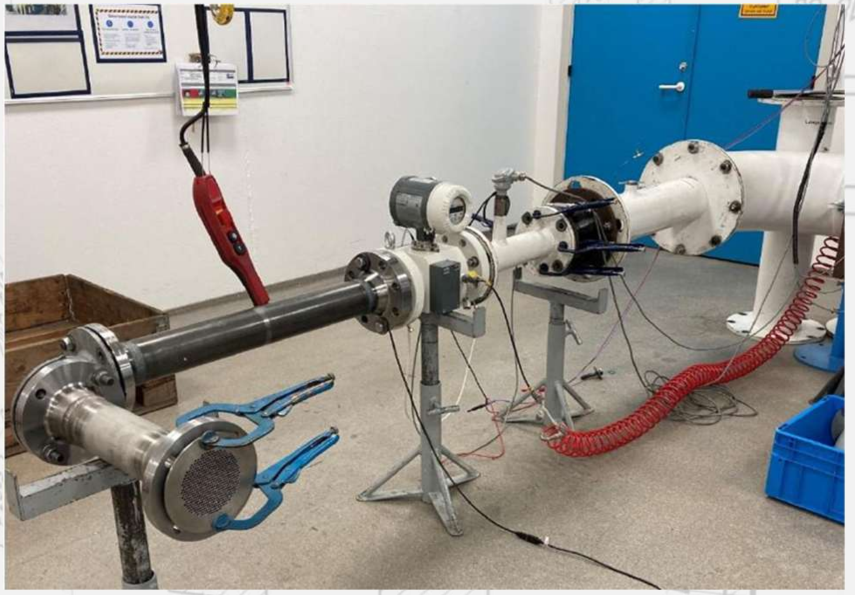
Elbow In Plane Test (EIP) 20D



API 22.3 Testing Results
FLOWSIC600 DRU-S / Two Path 3” Meter

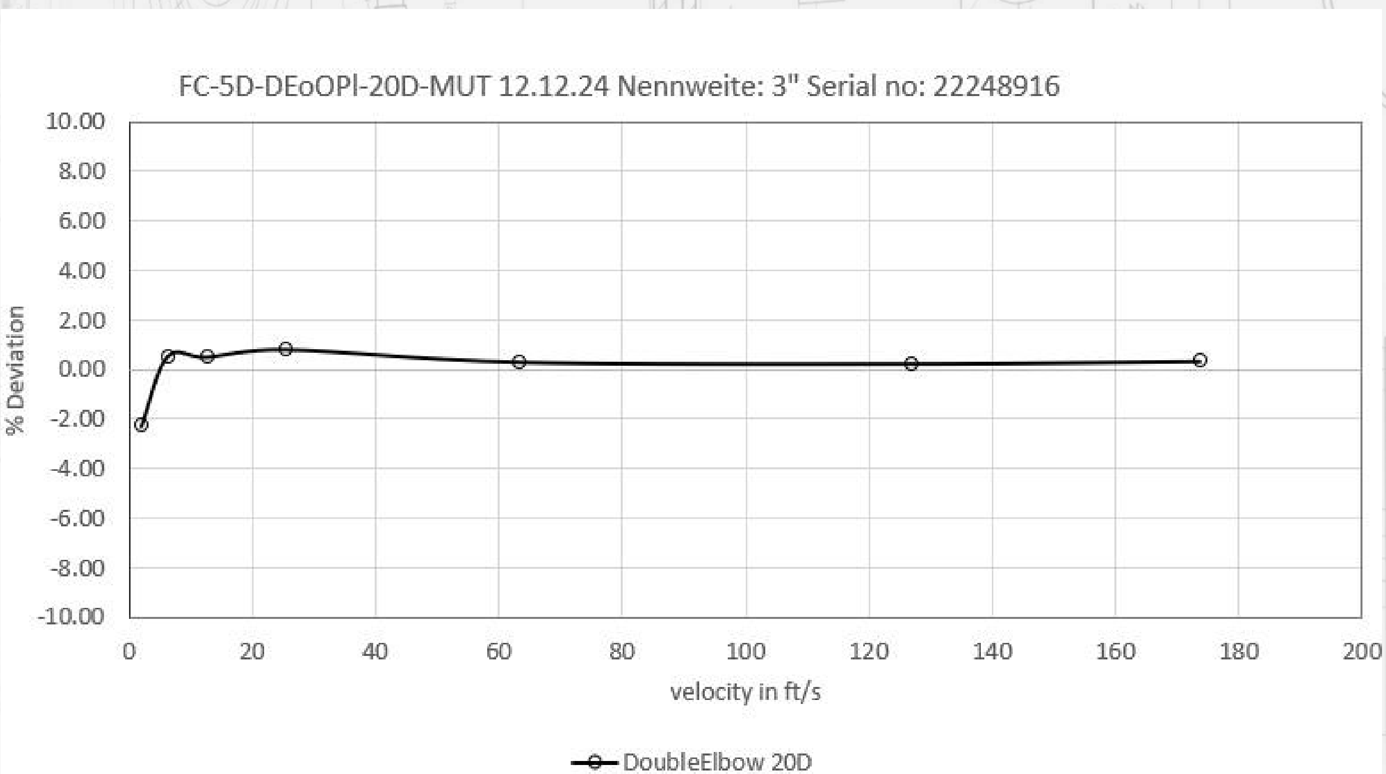
Elbow In Plane Test (EIP) 10D





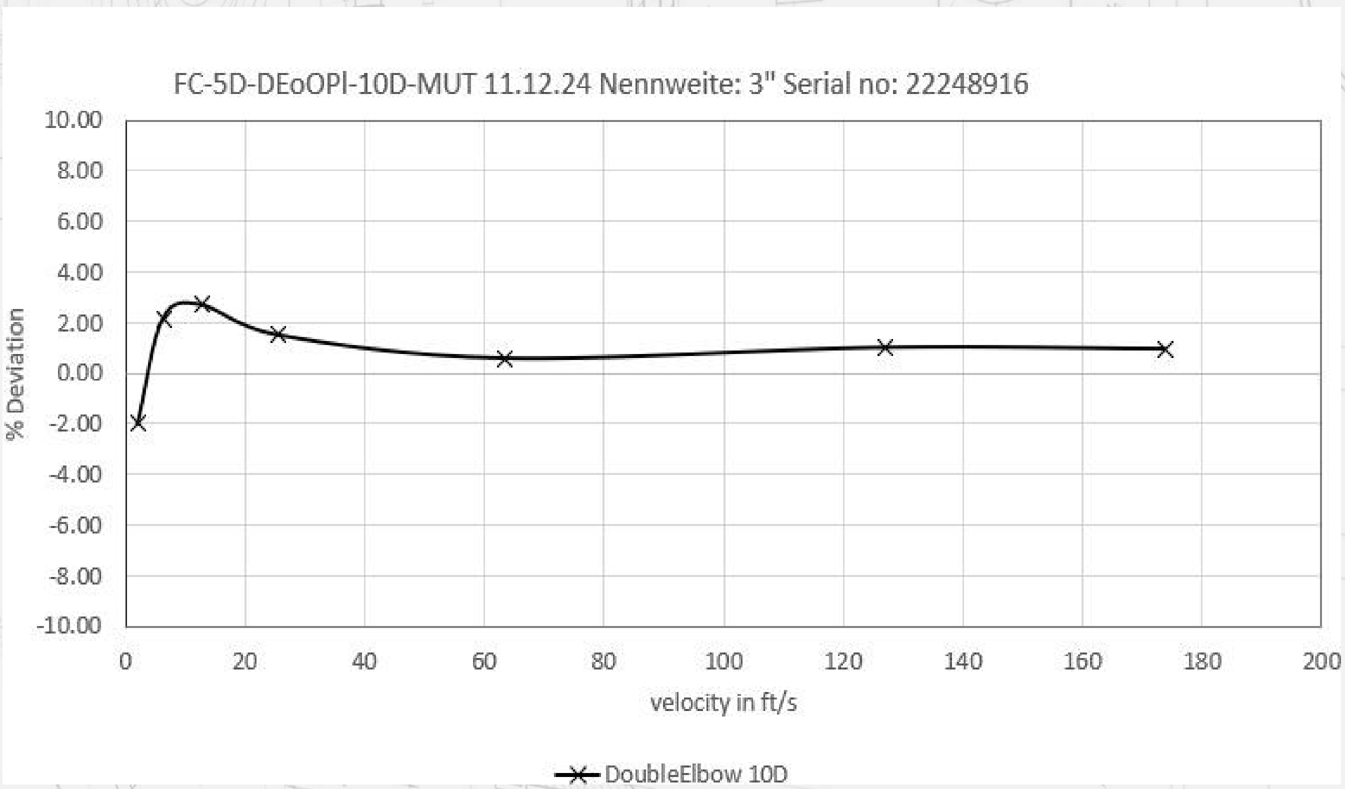
API 22.3 Testing Results
FLOWSIC600 DRU-S / Two Path 3” Meter

Elbow Out of Plane Test (EOP) 20D



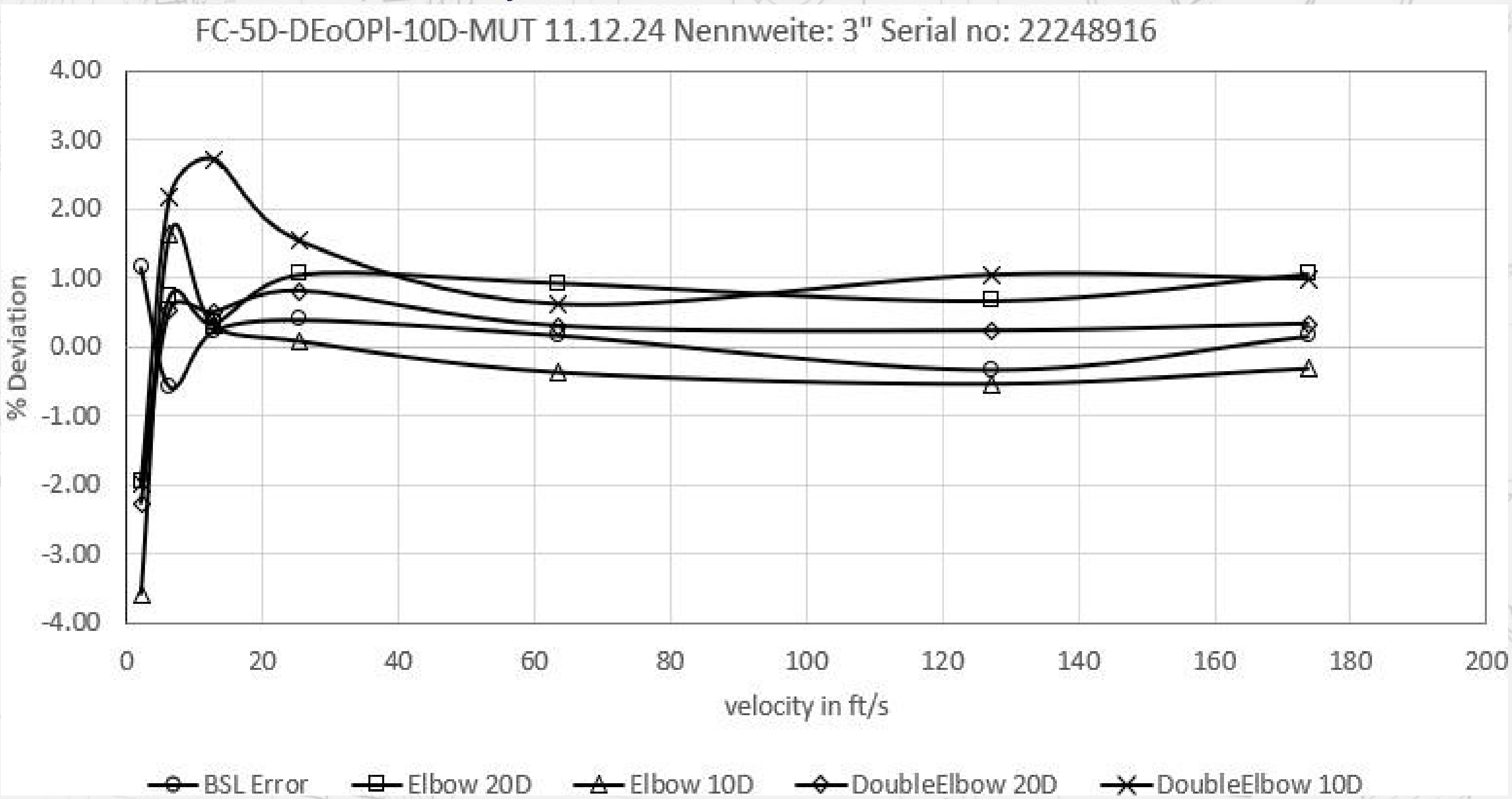
API 22.3 Testing Results
FLOWSIC600 DRU-S / Two Path 3” Meter

Elbow Out of Plane Test (EOP) 10D



API 22.3 Testing Results
FLOWSIC600 DRU-S / Two Path 3" Meter

Summary - Test Installation Effects Overview



API 22.3 Testing Results
FLOWSIC100 Flare-XT / Single Path 8” Meter

Parameter	Information	
Name of manufacturer	Endress+Hauser SICK GmbH+Co.KG	
Meter type/technology	FLOWSIC100 Flare-XT Ultrasonic transit-time-difference technology	
Serial number	Interface Unit S/N 19080017 (FW 1.04.00) F1F-H probes S/N 2115813 (FW 1.07.00)	
Nominal pipe size	8”	
Flange Connection	ANSI CL150, RF, Schedule 40	
Outputs	Frequency output, RS485, DO	
Meter geometry	Internal diameter: 202.7mm (7.98”) Path length: 206.4mm (8.13”) Path angle: 75° Path layout: 1-path diametral Transmitter location: center of circular transmitter membrane in line with pipe wall tangent	
Flow rate Qmin...Qmax	3.5...14000 m3/h	123...494739 ft3/h
Gas temperature range	–70 °C ... 280 °C	–94 °F ... 536 °F
Pressure range	0 bar(g) ... 20 bar(g)	0 psi(g) ... 290 psi(g)
Factory adjust	Constant Factor adjust = 0.927	

Test Protocols Required by API 22.3

Figure 2: Summary of the requirements [1].

In relation to the requirements of the API (see Fig 2), the following meter setups were tested:

1 Baseline Test:

>|-FC-||----30 D----||-Meter-||-3D-||---->

2 Installation effects testing 20D EIP:

>|-FC-||----5 D----||—Elbow 90 in plane---||---20 D---||-Meter-||-3D-||---->

4 Installation effects testing 20D 2xEOP (separated 5D):

>|-FC-||----5 D----||—Double Elbow 90 out of plane---||---20 D---||-Meter-||-3D-||---->

API 22.3 Testing Results
FLOWSIC100 Flare-XT / Single Path 8” Meter

Baseline Test

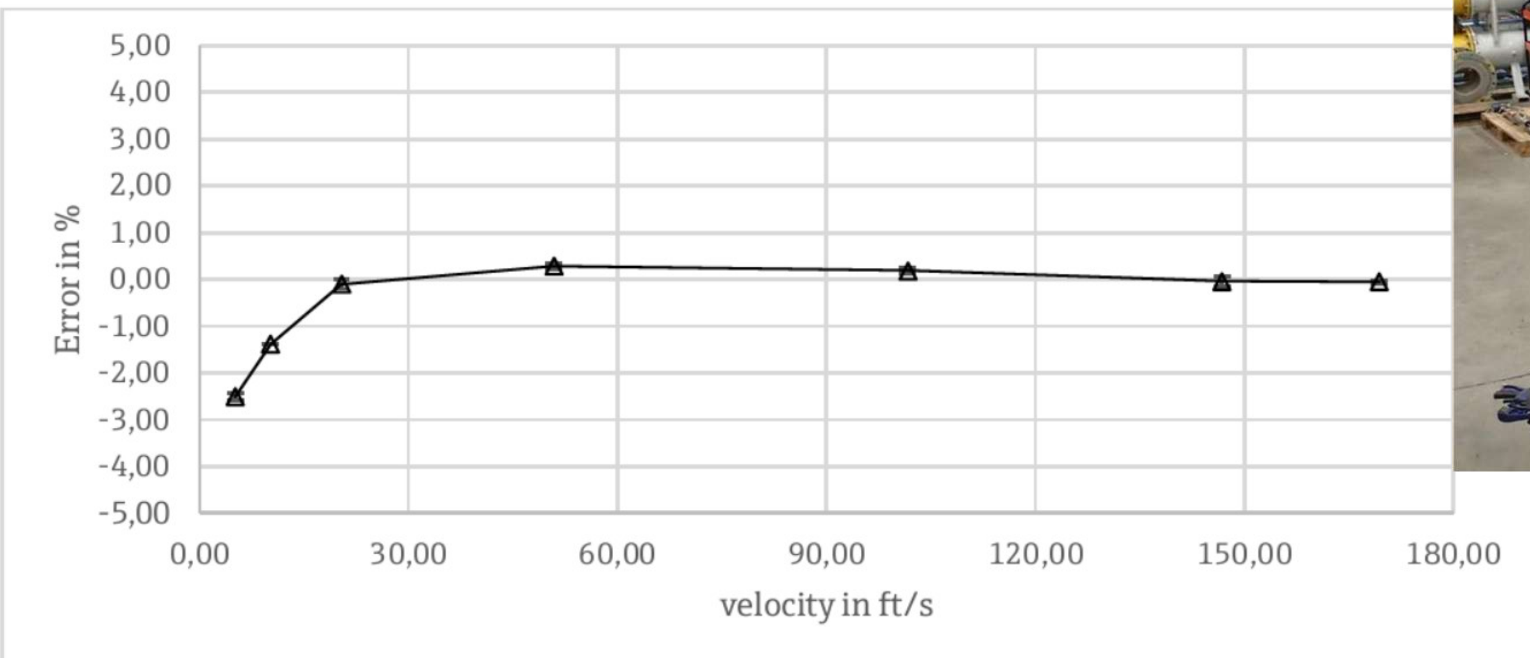


Figure 4: Baseline test results.

API 22.3 Testing Results
FLOWSIC100 Flare-XT / Single Path 8” Meter

Elbow In Plane Test (EIP) 20D

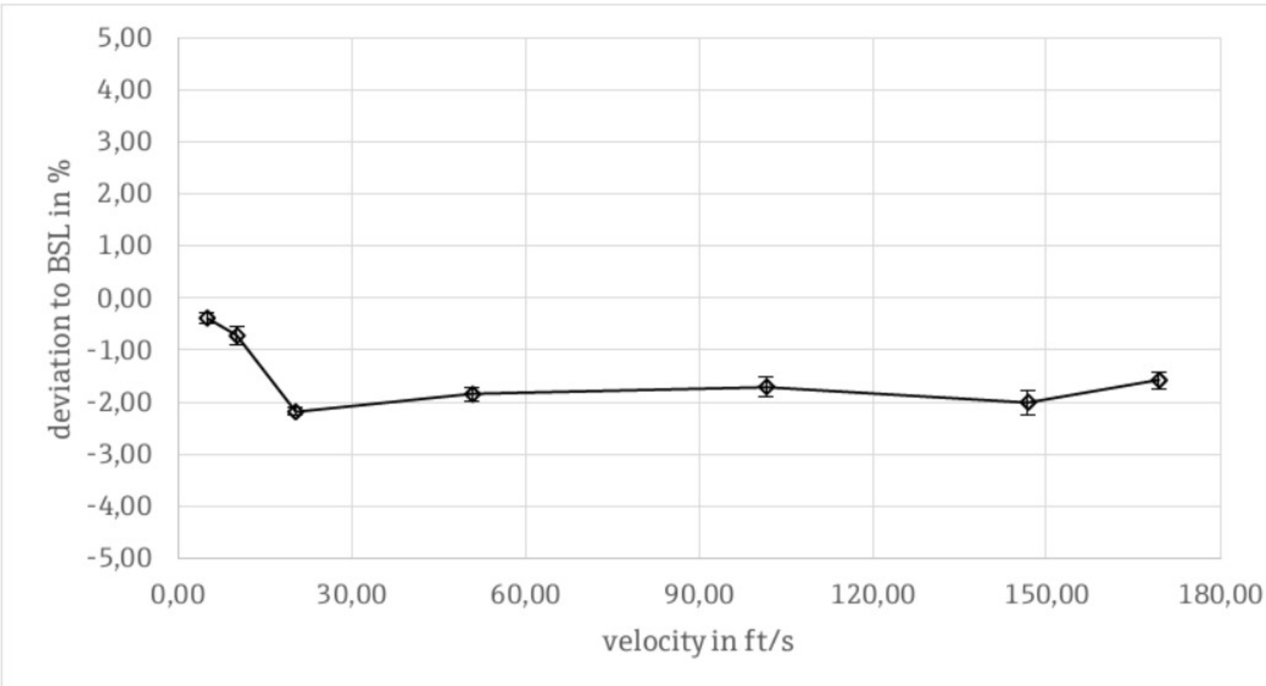
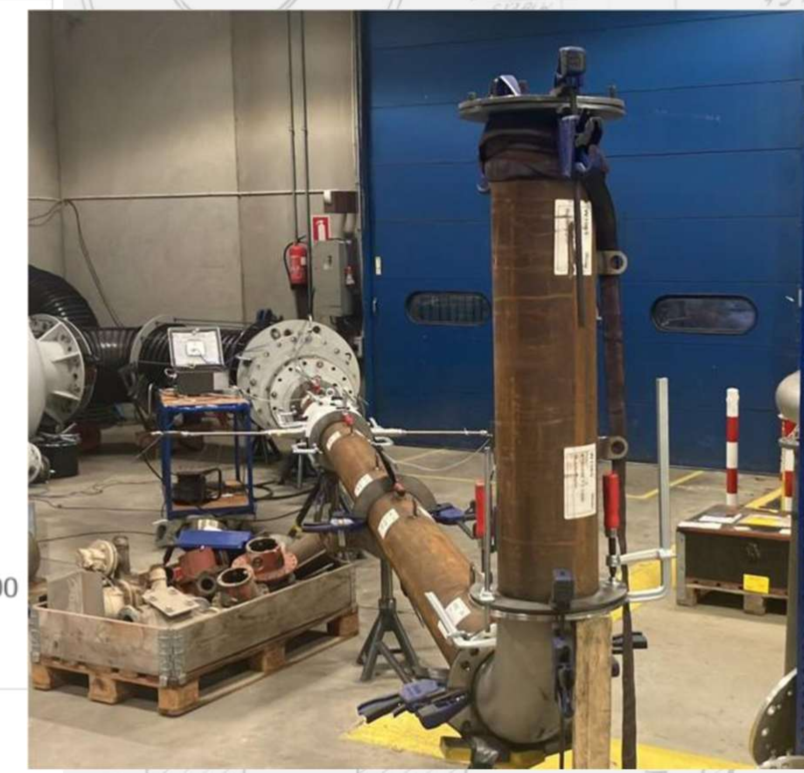


Figure 6: Elbow in Plane test results.



API 22.3 Testing Results
FLOWSIC100 Flare-XT / Single Path 8” Meter

Elbow Out of Plane Test (EOP) 20D

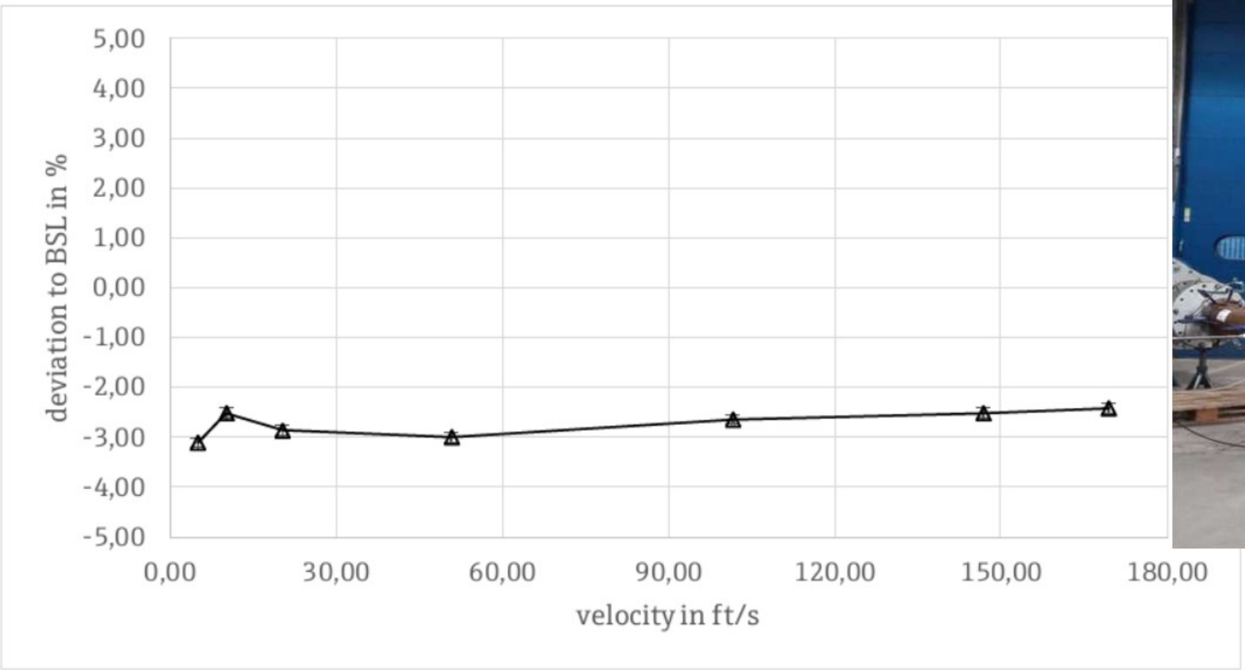
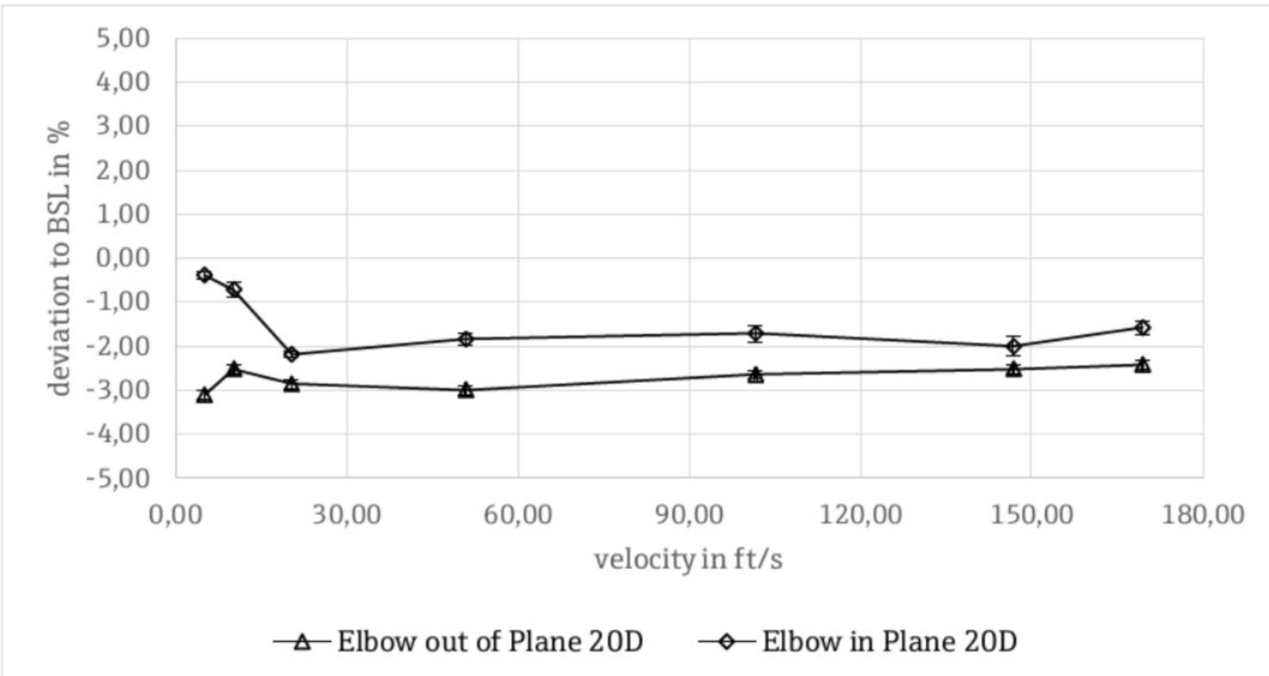


Figure 8: Elbow out of Plane test results.

API 22.3 Testing Results
FLOWSIC100 Flare-XT / Single Path 8" Meter

Summary Test Installation Effects Overview

5.4 Test installation effect overview



API 22.3 Testing Results
FLOWSIC100 Flare-XT / Two Path 26” Meter

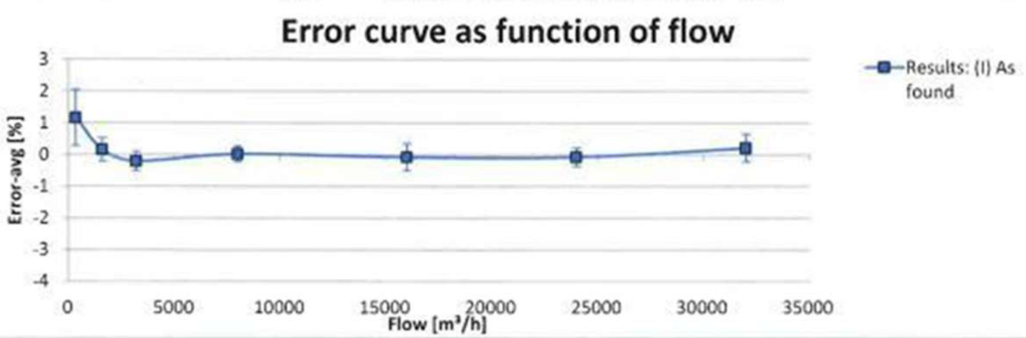
Summary 26” Diameter Test Overview
SN 21028524-2021
ANSI 150
Calibrate Date – 08/06/2021

WME: Results: (I) As found **0,00** %

WME is calculated according to OIML R137-1&2 point 3.2.5. The Qmax used for calculation of WME is the used/calibrated Qmax and not necessarily the Qmax of the meter.
The calibration uncertainty (Utot), includes the accredited accuracy (Ucmc) and the repeatability of the meter (Udut).
CMC: (Calibration and Measurement Capability)

The reported expanded uncertainty ±Utot, is the standard uncertainty of the measurement multiplied by a coverage factor k=2. The coverage factor corresponds a coverage probability of approximately 95%. The standard uncertainty of measurement is in accordance with EA-4/02:

Error = (Indicated Volume - Real Volume)/Real Volume * 100%



Measure points are connected with smooth lines.

Task no. : 120-31709
Certificate no. : 9.8-23954 Rev.A
Page : 2 of 3

Meter data:

Ultrasonic meter USM
26INCH/ANSI150/DN650
21028524-2021

Pulse function					As found		
		Qmax	32000	m³/h.			
		Qt	-	m³/h.			
control	calibration	Qmin	348	m³/h.			
-	*OK*	Imp. Factor (HF)			200	-	pulses/m³
-	-				-	-	pulses/m³
-	-				-	-	pulses/m³
-	-				-	-	pulses/m³
-	-				-	-	pulses/m³
-	-				-	-	pulses/m³
		Static calibration pressure			3		bar g.

Results: (I) As found **Forward direction** **3 bar g.** **Calibration at HF**

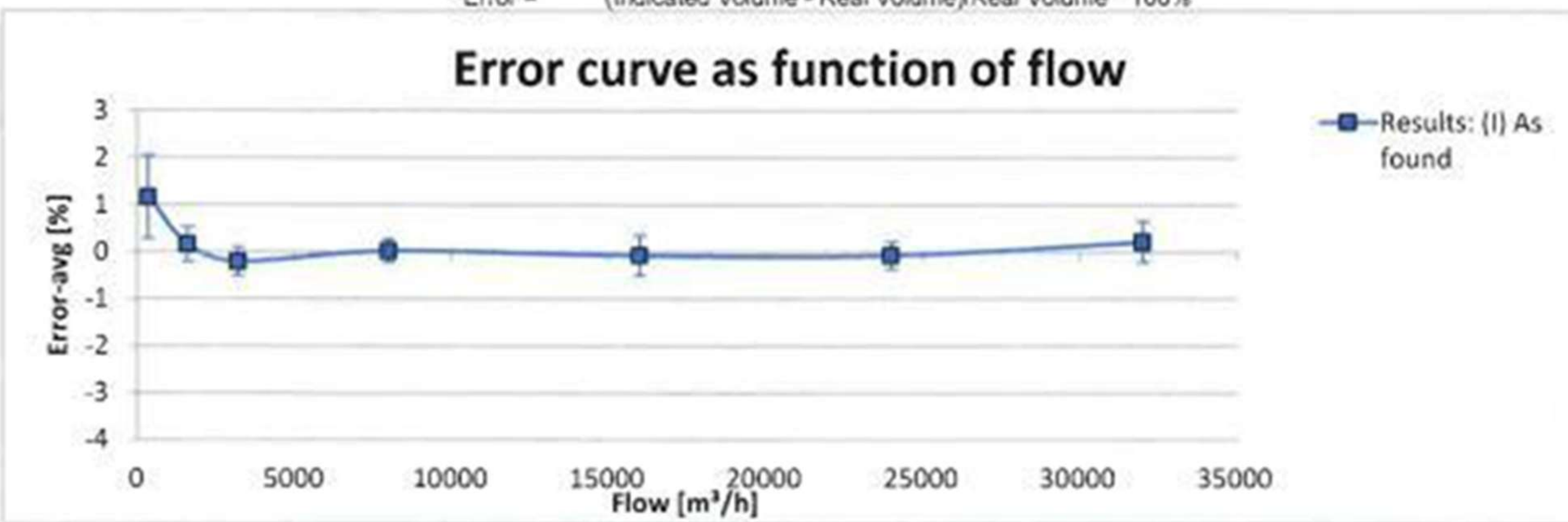
Qi/Qmax. %	1,1	5	10	25	50	75	100
Flow [m³/h]	348	1600	3200	8000	16000	24000	32000
Error-avg [%]	**1,17**	**0,16**	**-0,20**	**0,02**	**-0,08**	**-0,08**	**0,22**
±Utot [%]	0,88	0,37	0,30	0,24	0,43	0,28	0,44

API 22.3 Testing Results
FLOWSIC100 Flare-XT / Two Path 26” Meter

Summary Test 26” Diameter Installation Effects Overview

The reported expanded uncertainty ±Utot, is the standard uncertainty of the measurement multiplied by a coverage factor k=2. The coverage factor corresponds a coverage probability of approximately 95%. The standard uncertainty of measurement is in accordance with EA-4/02:

Error = (Indicated Volume - Real Volume)/Real Volume * 100%



Measure points are connected with smooth lines.

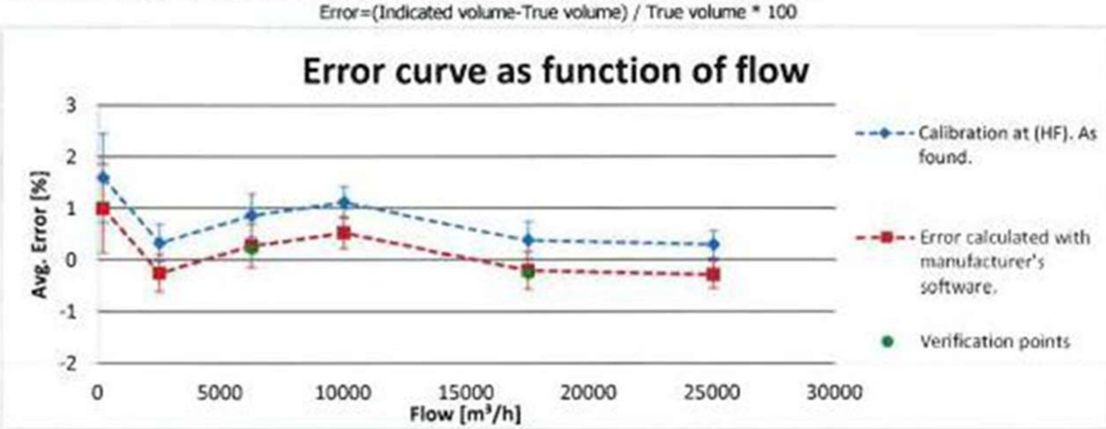
API 22.3 Testing Results
FLOWSIC100 Flare-XT / Two Path 20” Meter

Summary 20” Diameter Test Overview
SN 23038670-2022
ANSI 150
Calibrate Date – 04/05/2023

WME	As found. :	0,59	%
WME	Calculated error :	0,00	%

WME is calculated acc. OIML R 137-1 & 2 point 3.2.5. WME is calculated on the basis of a 6 point calibration.
The Qmax used for calculation of WME is the used/calibrated Qmax and not necessarily the Qmax of the meter.
The expanded uncertainty for the calculated error is equal to the uncertainty found before adjustment.

Error=(Indicated volume-True volume) / True volume * 100



Points of measurement are interconnected with straight lines.

Meter data:

Serial number:	23038670-2022	Task:	122-32482
Meter type:	Ultrasonic meter USM	Certificate:	9.8-27925
Size:	20INCH/ANSI150/DN500	Page:	2 of 4

FORCE TECHNOLOGY

Meter plate:

Qmax	25000	m³/h
Qt	-	m³/h
Qmin	200	m³/h

Flow counter	
Start	-
Stop	-

Adjustment type:	K-factor adjustment			Function was / or used for:	
Pulse output:	before adj.	after adj.	Unit	Controlled / Calibration	
(HF)	288	288	pulses/m³	-	Yes
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
K-factor	1,0000	0,9942			

Results:

Calibrated error: Calibration at (HF). As found.
Calculated error: Error calculated with manufacturer's software.

Qi/Qmax [%]	Flow [m³/h]	Calibrated Avg. Error [%]	±	U [%]	Calculated Avg. Error [%]	Verification Point	±	U [%]
1	200	1,59	±	0,86	1,00			
10	2500	0,33	±	0,36	-0,26			
25	6250	0,86	±	0,42	0,28	0,21	±	0,26
40	10000	1,11	±	0,30	0,53			
70	17500	0,38	±	0,36	-0,20	-0,27	±	0,27
100	25000	0,29	±	0,26	-0,29			

API 22.3 Testing Results
FLOWSIC100 Flare-XT / Two Path 20” Meter

Summary 20” Diameter Test Overview

WME As found. : 0,59 %

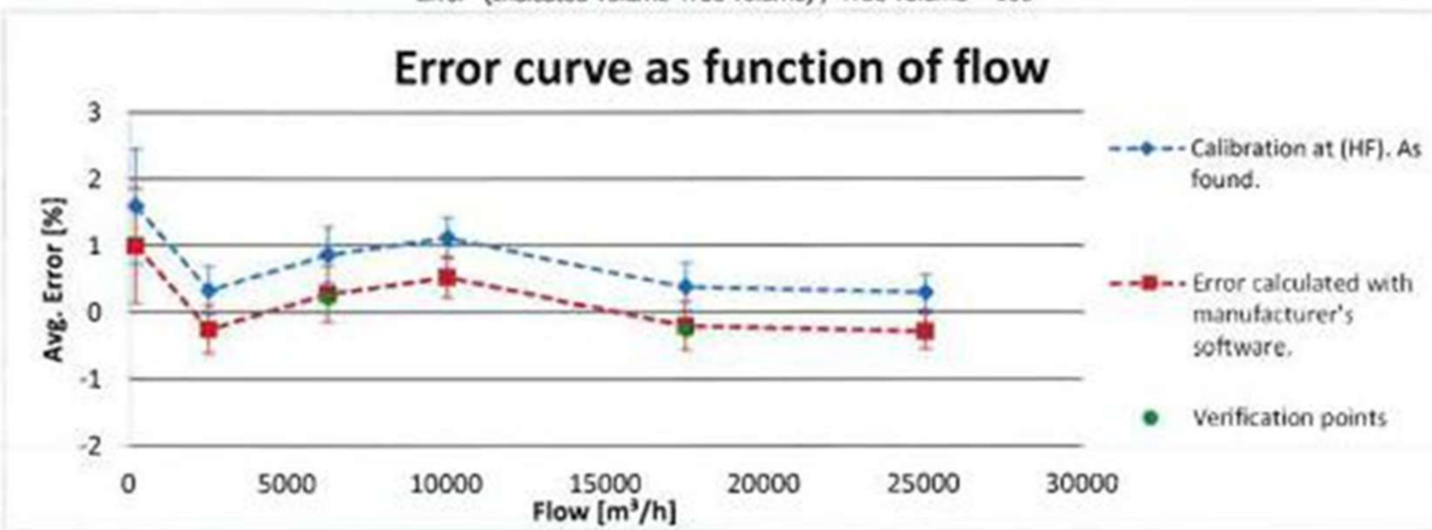
WME Calculated error : 0,00 %

WME is calculated acc. OIML R 137-1 & 2 point 3.2.5. WME is calculated on the basis of a 6 point calibration.

The Qmax used for calculation of WME is the used/calibrated Qmax and not necessarily the Qmax of the meter.

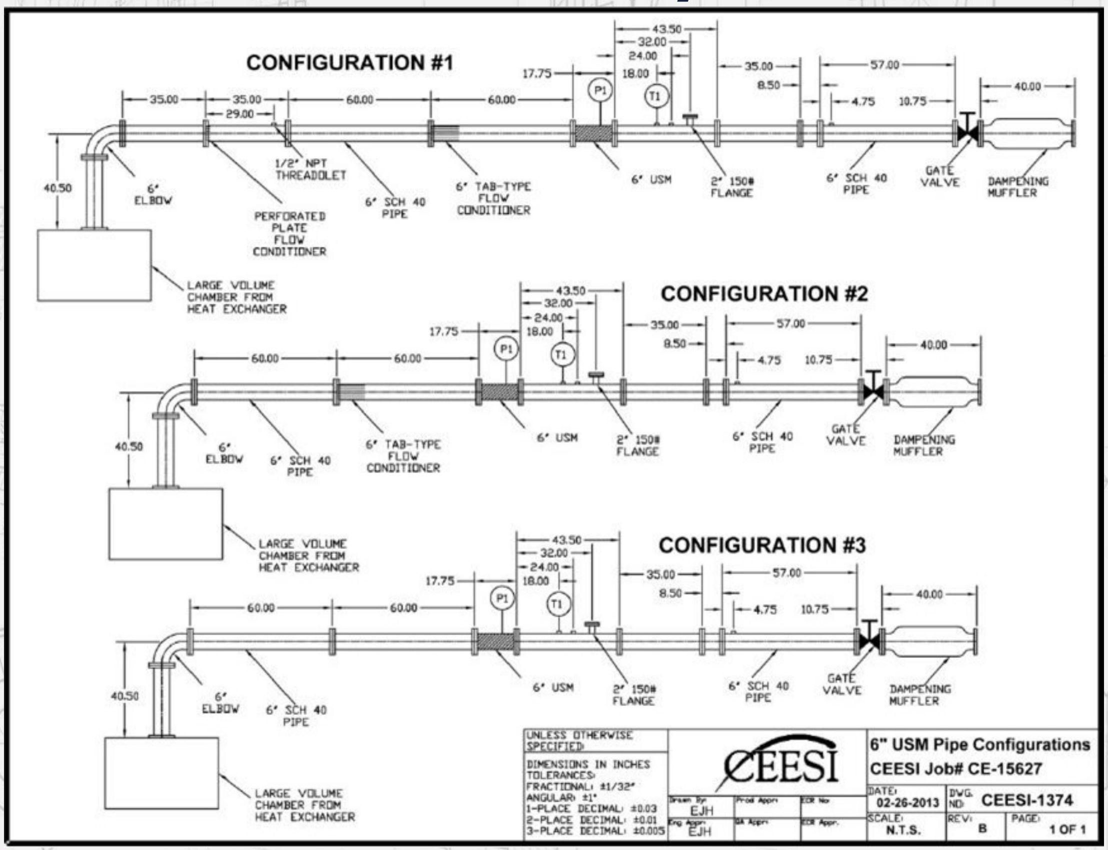
The expanded uncertainty for the calculated error is equal to the uncertainty found before adjustment.

Error=(Indicated volume-True volume) / True volume * 100



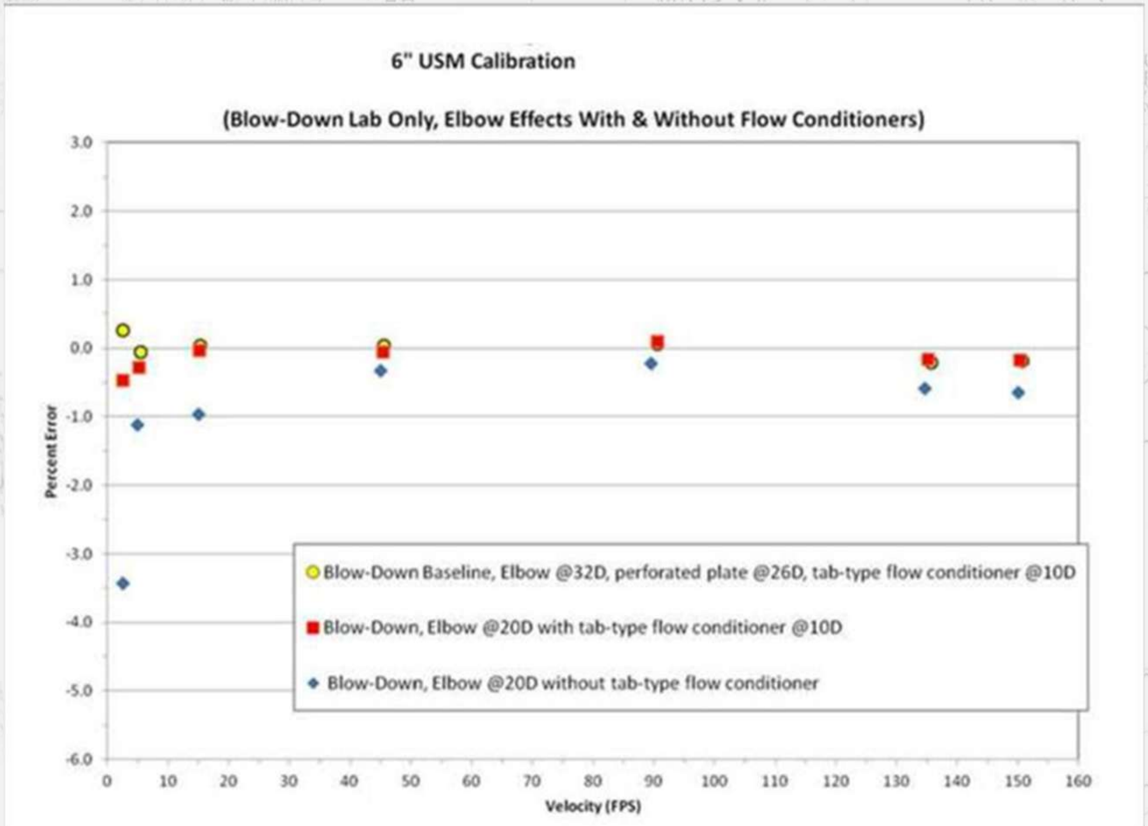
Points of measurement are interconnected with straight lines.

API 22.3 Testing Results
FLOWSIC600-XT / Four Path 6” Meter



4-Path USM Piping Configuration Blow Down Lab

API 22.3 Testing Results FLOWSIC600-XT / Four Path 6” Meter



Result Summary

With Flow Conditioning: The 2-sigma standard deviation uncertainty was 0.3% in tests 1 and 2

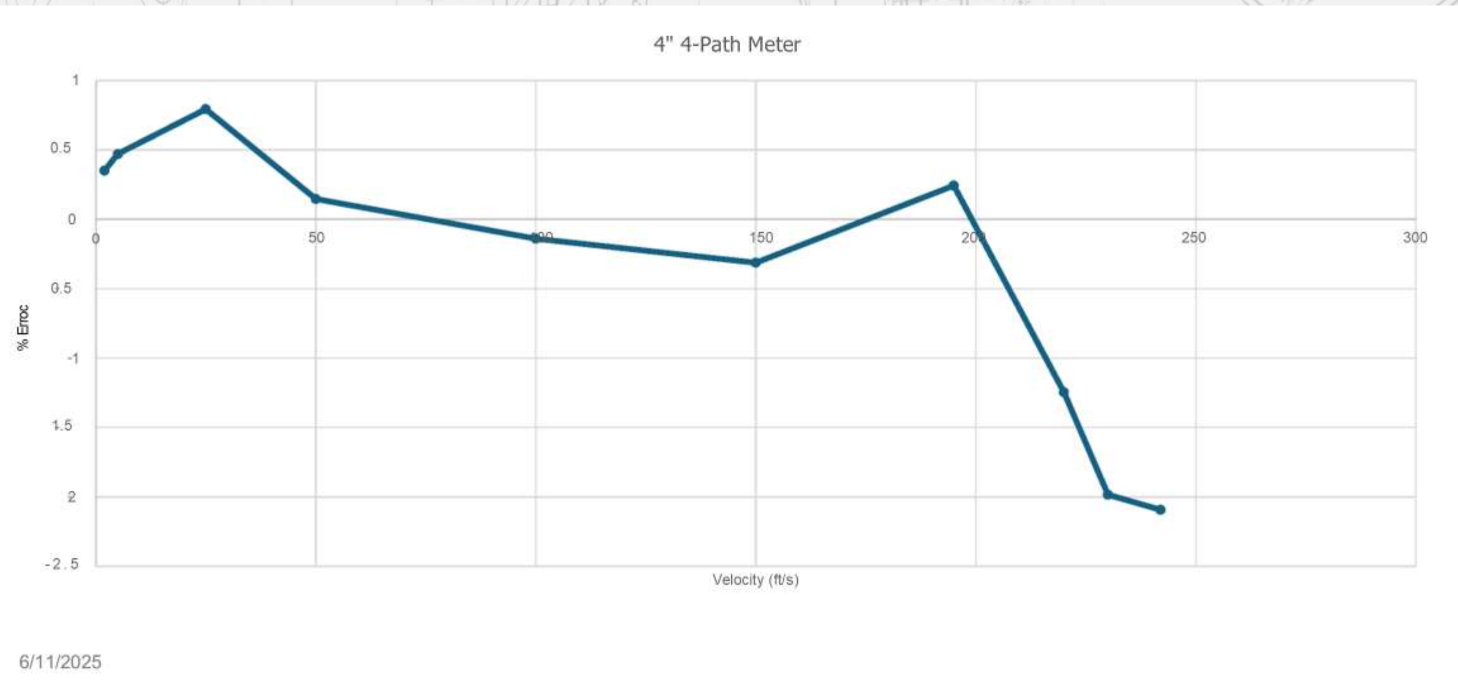
With no flow conditioning: the maximum uncertainty was 0.75% at 2.5 fps with the overall uncertainty being 2.0%

Conclusion

The 4-path meter, even without flow conditioning, had no problem handling the swirl while still meeting the 5% requirement found in many regulations

API 22.3 Testing Results
FLOWSIC600-XT / Four Path 4” Meter

4” 4-Path Meter Calibrated 6/3/2025



Q & A

Flare Measurement: A look at API MPMS 14.10 and API MPMS 22.3

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