TechnipFMC

Flow Research and Test Center

Creating resource technology for today and tomorrow.

"The Measurement Solutions' Flow Research and Test Center in Erie is certainly one of the gems of our corporation's technological capability. The ability to demonstrate product functionality, reliability, and accuracy on a full-scale, real time basis to our engineers, regulators, and customers is a world class best practice."

Bradley D. Beitler
EVP Technology and R&D

Measurement Solutions' test center guarantees optimum verification of meter performance.

To ensure that a meter can operate accurately over a wide flow and viscosity range it is important that the meter is tested over the dynamic operating range. Measurement Solutions' comprehensive flow research and test center located in Erie, Pennsylvania is capable of testing meters over the widest dynamic measurement range of any test facility in the world.

PD meters, conventional turbine meters, helical turbine meters, and ultrasonic meters can be tested under dynamically similar operating conditions to guarantee performance in any crude oil application.

Measurement Solutions' High Flow (HF), Multi-Viscosity (MV), and Low Flow - MV Test Systems can provide dynamic testing on petroleum products over a 5 to 42,000 bph (1 to 6,680 m^3/h) flow range; 2 to 500 cSt (2 to 500 mm^2/s) viscosity range; meter sizes 1 to 30 inches (25 to 750 mm). This translates to a dynamic Reynolds Number range of 100 to 1,000,000.

Flow Research and Test Center Features

- NVLAP (Lab Code 200939-0) accredited to ISO/IEC 17025:2005
- ISO 9001:2008 Certified – Quality Management System
- Flow to 42,000 bph (6,675 m^3/h)
- Viscosity 2 to 500 cSt (mm^2/s)
- Traceable to international standards
- Dynamic range 100 to 1,000,000 Reynolds Number


HIGH FLOW LOOP

Provers

The “Meter Under Test” (MUT) can be directly proven with the Master Prover or with Master Meter Prover(s), which are calibrated with the Master Prover. The Master Provers are calibrated gravimetrically.

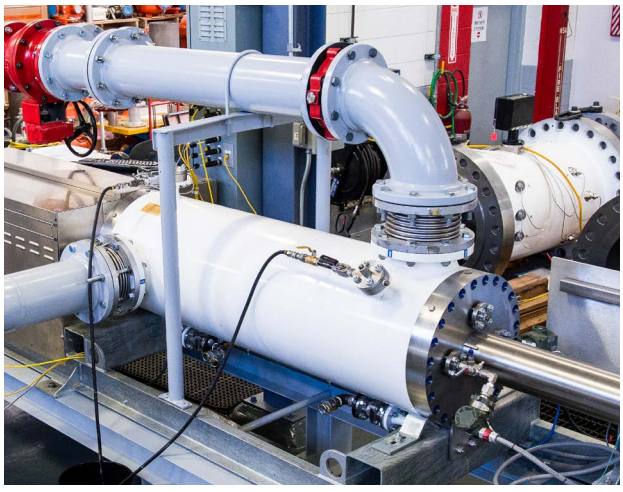
High Volume Master Meter Prover	
Model	SYNCROTRAK S120
Type	Small Volume Displacement Prover
Flow Max.	17,500 bph (2,775 m^3/h)
Inside Diameter	32" (813 mm)
Volume	120 gallons (454 liters)

Low Volume Master Meter Prover	
Model	SYNCROTRAK S35
Type	Small Volume Displacement Prover
Flow Max.	1,700 bph (270 m^3/h)
Inside Diameter	17.625" (324 mm)
Volume	25 gallons (95 liters)

M16 Master Meter Prover	
Model	Smith Meter® M16
Type	Rotary Vane Positive Displacement Prover
Flow Max.	14,000 bph (2,220 m^3/h) 170 bph (27 m^3/h)

K12 Master Meter Prover	
Model	Smith Meter® K12
Type	Rotary Vane Positive Displacement Prover
Flow Max.	8,000 bph (1,270 m^3/h) 170 bph (27 m^3/h)

SYNCROTRAK S120 SVP Master Prover



SYNCROTRAK S35 SVP

Smith Meter® M16 Master Meter Prover

Gavimetric Calibration Facility for Small Volume Provers

The Measurement Solutions' Gravimetric Calibration Facility is used to accurately establish the base volume of the master provers and to establish direct traceability to the National Institute of Technology (NIST), the US National Meteorology Institute. The provers are then used to calibrate the Master Meter Provers or to directly prove a meter. The room, environment, instruments, and techniques have been selected to provide the highest level of accuracy. The calibration procedures are per API MPMS 4.9.1 "Calibration of Small Volume Provers" and NIST SOPSVP, which address the gravimetric calibration of small volume provers via a mass comparison method.

Main components of the facility

- Environmentally controlled to ΔT +/- 1°C/h, ΔH +/- 10%/4h
- Air density determination – Vaisala PTU 300
- Accuracy – temperate 0.1°C humidity 1%
- Mass comparator – Metler Toledo KC500
- High capacity RoDI system
- Stainless steel piping
- Temperature and pressure measurement equipment

Instruments and References

Weights: The tolerance class for the used weights is ASTM E617 Class F. The tolerance can be found in document ASTM E617 (1997) standard specification for laboratory weights and precision mass standards [14].

Mass comparator: Maximum capacity 600 kilogram (kg)

Readability: 100mg

Temperature instruments: 0.1°C

Pressure instruments: Interval is 0.1 psig

Reference water: NIST GLP 10

High Flow Test System

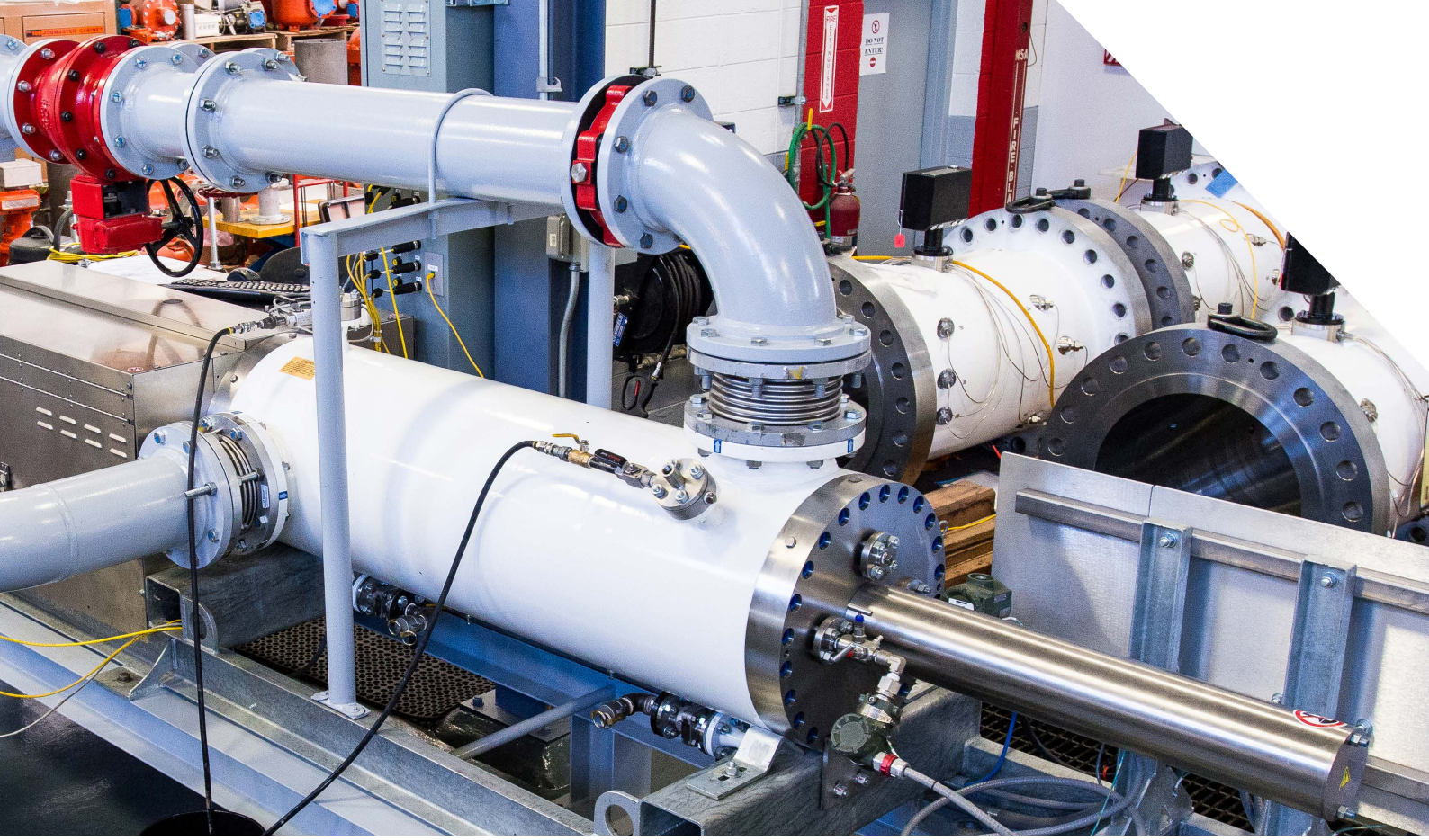
The Measurement Solutions' High Flow (HF) Test System is a high accuracy open loop system used to validate the performance of liquid meters on a hydrocarbon fluid. This system includes a master small volume displacement prover that is traceable to NIST (USA - National Institute of Standards and Technology), three master meter provers, one hydrocarbon fluid ranging in viscosity from 10 cSt to 25 cSt, and one test loop that can accommodate meters in sizes 6 to 30 inches.

Specifications	
Type	Open Loop System
Flow Range	170 to 42,000 bph (30 to 6,675 m^3/h)
Meter Sizes	Positive Displacement Meters (PD): 6 inch to 16 inch (150 mm to 400 mm) Turbine and Ultrasonic Meters Standard: 6 inch to 30 inch (150 mm to 760 mm) *For additional technologies consult factory.*
Pumps/Drives	Two multi-stage vertical turbine pumps with 500 HP motors One multi-stage vertical turbine pump with 75 HP motor
Tank	One 30,000 gallon (114 m^3)
Chiller	160-ton chiller system
Fluids	Brad Penn blend oil with an ideal range from 9 cSt to 25 cSt where the viscosity of the blend is varied by a temperature over a 70°F to 110°F (21°C to 43°C) range
Master-Meter Prover	Three Smith Meter® 16 inch PD meters
Master Prover	SYNCROTRAK SVP 120 gallon (454 liter)

Multi-Viscosity Test System

Measurement Solutions' Multi-Viscosity (MV) Test System is a high accuracy closed loop system used to validate the performance of liquid meters on a range of hydrocarbon fluids. This system includes a master small volume displacement prover that is traceable to NIST (USA - National Institute of Standards and Technology), two master meter provers, four hydrocarbon fluids ranging in viscosity from 2 cSt to 500 cSt, and two test runs that can accommodate meters in sizes 3 to 30 inches.

Specifications	
Type	Closed loop system with approximately 5,000 gallon (18.9 m^3) capacity
Flow Range	170 to 8,000 bph (30 to 1,270 m^3/h)
Meter Sizes	Positive Displacement Meters (PD): 6 inch to 16 inch (150 mm to 400 mm) Turbine and Ultrasonic Meters Standard: 6 inch to 30 inch (150 mm to 762 mm) Smaller: 3 inch and 4 inch (75 mm to 100 mm) with special 6 inch inline master meter prover
Pumps/Drives	Two positive displacement pumps with 200 HP variable speed drives
Tanks	Four 15,000 gallons (94.6 m^3 each)
Chiller	25-ton chiller system
Fluids	Four blended oils with an ideal range from 2 cSt to 500 cSt where the viscosity of each blend is varied by temperature over a 70°F to 110°F (21°C to 43°C) range
Master-Meter Prover	Smith Meter® PD meters: one 12 inch and one 16 inch meter
Master Prover	SYNCROTRAK SVP 120 gallon (454 liter)



Low Flow Multi-Viscosity Test System

The Measurement Solutions' Low Flow Multi-Viscosity (MV) Test System provides dynamic testing on petroleum products over a 5 to 1,700 bph (1 to 270 m^3/h) flow range; 2 to 225 cSt (2 to 225 mm^2/s); meter sizes 1 to 6 inches (25 to 150 mm) and based on size and Low Flow - MV capacity a Reynolds Number range of 50 to 500,000.

Specifications	
Type	Open loop system with approximately 2,000 gallon (7.6 m^3) capacity
Flow Range	5 to 1,700 bph (1 to 270 m^3/h)
Meter Sizes	Positive Displacement Meters (PD): 2 inch to 6 inch (25 mm to 150 mm) Turbine and Ultrasonic Meters: 1.5 inch to 4 inch (40 mm to 100 mm)
Pressure	Less than 100 psig (6.9 bar)
Pumps/Drives	Two vertical turbine pumps one 15 HP and one 40 HP motors
Tanks	Five 2,500 gallons (7.6 m^3 each)
Chiller	30-ton chiller system
Fluids	Five blended oils with an ideal range from 2 cSt to 225 cSt where the viscosity of each blend is varied by temperature over a 70°F to 110°F (21°C to 43°C) range
Master-Meter Prover	Four Smith Meter® 2 inch to 6 inch PD meters (not illustrated)
Master Prover	SYNCROTRAK Model 535

Unsurpassed Dynamic Test Range

Validating a meter's accuracy over its operating range is an essential part in the manufacture of high performance custody transfer meters. The key parameters that determine the performance of flowmeters and other hydrodynamic devices are size, flow rate, and viscosity. While these parameters affect the performance of all metering technologies, turbine and ultrasonic meters are especially sensitive to high viscosity fluids.

To ensure performance of Smith Meter® turbine and ultrasonic meters for crude oil service, these meters are tested dynamically over a range of fluids from 2 to 500 cSt depending on the required service. This method uses the concept of Dynamic Similitude allowing the performance to be validated for service on a higher or lower viscosity than the test fluid.

To do this, the testing method relies on a well established fluid dynamic parameter – Reynolds Number (Re No), which (illustrated by the equation below) defines the relationship between the flow rate, meter size, and viscosity. Simply stated, performance at a given Reynolds Number is the same no matter the combination of flow, meter size, and viscosity.

Re No[1] = Flow Rate / (meter size x viscosity)

Therefore, by utilizing the three (3) test systems, Dynamic Tests can be run to determine measurement accuracy over a wide range of conditions. The below table illustrates the Dynamic Test for the three meters with high viscosity operating conditions.

The below Reynolds Number Test illustrates a four (4) product dynamic test of a helical turbine meter utilizing the HF Test System for the high flow / high Reynolds Numbers and the MV Test System for the high viscosity / low Reynolds Numbers.

1 Re No = (2,214 x flow in bph) / (meter size in inches x viscosity in cSt)
Re No = (13,925 x flow in m^3/h) / (meter size in inches x viscosity in mm^2/s)
Note: 1 mm^2/s = 1cSt

Field Operating Conditions

Meter (Inches)	Flow Range			Viscosity (cSt)	Reynolds Number Range	
6	bph	1,500	4,500	800	690	2,080
	m^3/h	240	720			
12	bph	6,330	19,000	1,000	1,170	3,510
	m^3/h	1,010	3,020			
20	bph	14,000	42,000	1,000	1,550	4,650
	m^3/h	2,230	6,680			

Dynamic Test

Meter (Inches)	Flow Range			Viscosity (cSt)	Reynolds Number Range	
6	bph	560	1,690	300	690	2,080
	m^3/h	90	270			
12	bph	1,900	5,710	300	1,170	3,510
	m^3/h	300	910			
20	bph	4,200	12,600	300	1,550	4,650
	m^3/h	670	2,000			

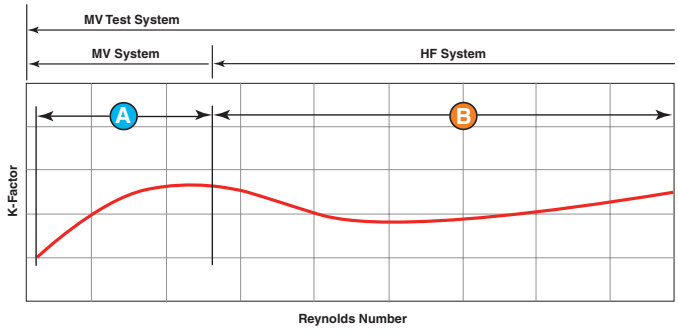
Dynamic Test Example

Field Operating Conditions:

Flow Range
Actual:
6,330 to 19,000 bph
(1,010 to 3,020 m^3/h)

Viscosity Range
10 to 1,000 cSt

Reynolds Number Range
1,170 to 350,550



Dynamic Number Test

Meter (In)	Test System		Flow (bph)		Viscosity		Reynolds Number	
			min	max	min	max	min	max
12	A	MV	1,900	8,000	18	300	1,170	82,000
	B	HF	6,330	19,000	10	18	64,880	350,550
Total Range			1,900	19,000	10	300	1,170	350,550

Laboratory Accreditation

Accredited to ISO/17025 through NVLAP (Lab Code 200939-0)

Factory calibrating high performance ultrasonic or helical turbine meters to operating conditions requires a technically capable high-accuracy test laboratory. The National Voluntary Laboratory Accreditation Program (NVLAP) run by the US National Institute of Standards and Technology (NIST) ensures that a laboratory fully meets international laboratory standards defined by ISO/IEC 17025. All measurements must be traceable through a National Metrology Institute (NMI) such as NIST that is member of the International Organization of Legal Metrology (OIML). The accreditation addresses factors relevant to a laboratory's calibration data, and quality management system including the:

- Technical competence of staff
- Validity and appropriateness of test methods
- Traceability of measurements and calibration to national standards
- Suitability, calibration and maintenance of equipment under test
- Handling and transportation of test items
- Quality assurance of test and calibration data

To ensure continued compliance, accredited laboratories are regularly reassessed to check that they are maintaining their standards of technical expertise.

The uncertainties of the test systems in the Measurement Solutions' Flow Research and Test Center have been assessed based on the international "Guide to the Expression of Uncertainty of Measurement" or GUM as it is often called. The analysis estimates the expanded uncertainty of meter calibration based on the statistical combination of all related instrumentation, equipment, and process uncertainty estimations.

The laboratory accreditation status and current Scope of Accreditation is publicly available by searching the laboratory code (NVLAP Lab Code 200939-0) at **www.nist.gov/nvlap**.

The Measurement Solutions' Flow Research and Test Center is the only petroleum test laboratory in the world that can ensure true calibration over a dynamic Reynolds Number range of 100 to 1,000,000.

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