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And keep you ahead.

Calibration, adjustment, fluid dependency and long term stability of liquid ultrasonic meters

Presented by:
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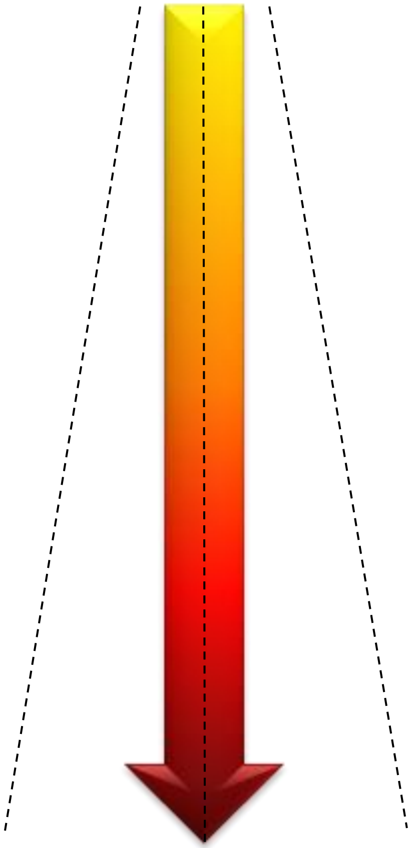
Topics

- Ultrasonic meter calibration options
- Offsite laboratory calibration
- Dynamic Testing over Reynolds No. Range
- Using diagnostics verify offsite laboratory calibration

Liquid flow meter calibration

Less uncertainty
(smaller error band)



More uncertainty
(larger error band)

Direct proving method

Conventional pipe prover

Small volume piston prover

Direct master meter proving method

MM and line meter proved on-site

Indirect master meter proving method

MM Proved at Off-Site (different flow and conditions)

Meter proved off-site/lab calibration (API 5.8)

Meter Proved Off-Site / Lab Verification (API 5.8)

API MPMS 5.8 Section 8.2.1: "In-situ proving is normally preferred because it verifies the meter's accuracy under actual operating conditions. Operating conditions can affect a meter's accuracy and repeatability. In-situ proving at stable operating conditions compensates for variations in performance caused by flow rate, viscosity, density, temperature, pressure, as well as flow conditions, piping configurations, and contaminants"

API MPMS 5.8 Section 8.2.2: "Laboratory proving is normally not preferred because laboratory conditions may not duplicate the piping and operating conditions. While there are more measurement uncertainties associated with laboratory proving, under certain conditions, it may provide the best alternative."

Off site Laboratory Calibration

- When no site proving is available, lab proving (such as the one done at the FMC FRTC) is the best alternative
- In this situation, an accurate meter over the entire operating (Re #) range is key to providing good flow meter characterization

Calibration at the Flow Research and Test Center

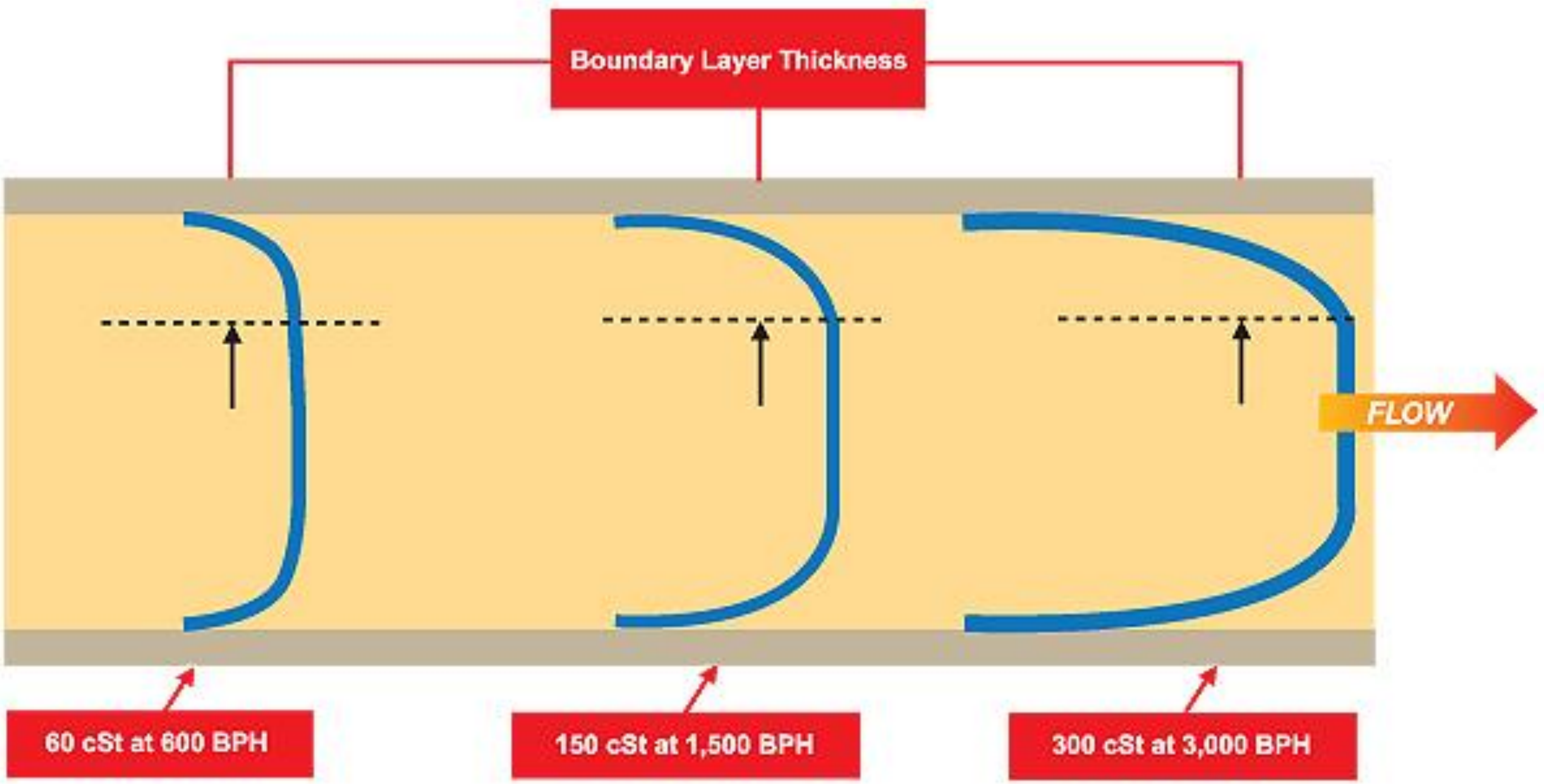
Matching Flowing Conditions

Reynolds # testing is a simulation over the Reynolds Number range determined from the field application parameters. It provides a test range for ultrasonic flow meters based on the concept
of dynamic similitude.

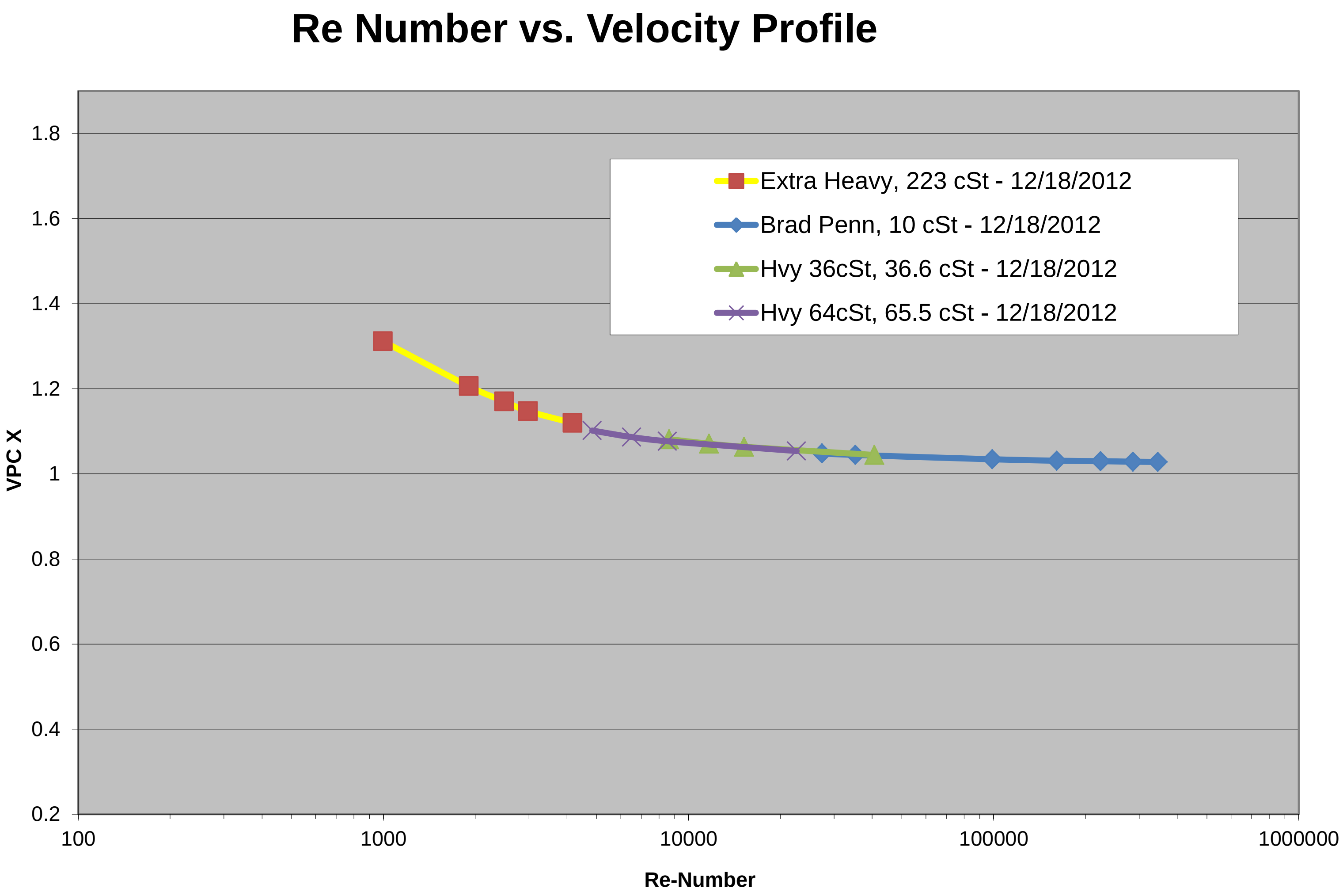
Dynamic Similitude, when performance at a given Reynolds Number is the same with various combinations of flow rate and viscosity.

Therefore meter performance on a test system can be validated on a higher or lower viscosity and/or flow rate than the field operating conditions.

Flow Profile at Equivalent Reynolds Numbers

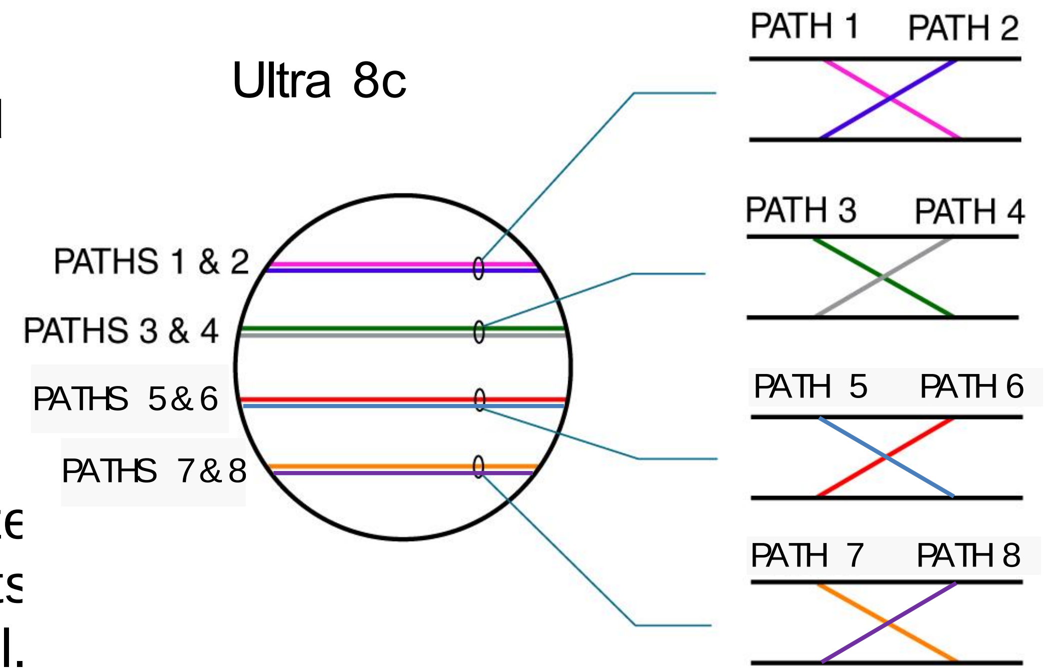


Measured Velocity Profile Factor, Ultra 8c



Ultra 8c measurement path design

- The Ultra 8c has eight measurement paths and sixteen transducers.
- Crossing measurement paths in all 4 chordal planes
- All measurement planes are designed to maximize cancellation of the effects from cross flow and swirl.



Dynamic factory testing using dynamic similitude

- The Flow Research and Test Center Lab located in Erie PA can reproduce the same Re No. range as the actual field operating conditions
- The limits are the minimum fluid velocity & flow rate in the meter and its maximum flow rate
- Remote witnessing of all testing is now possible via web cams

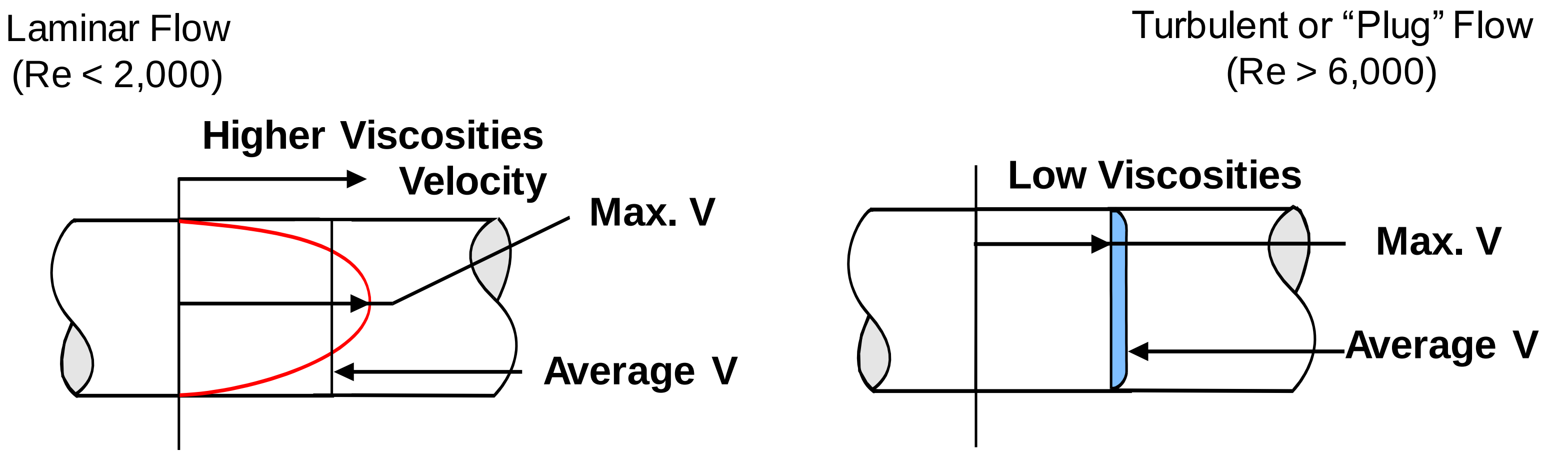
Field Operating Conditions

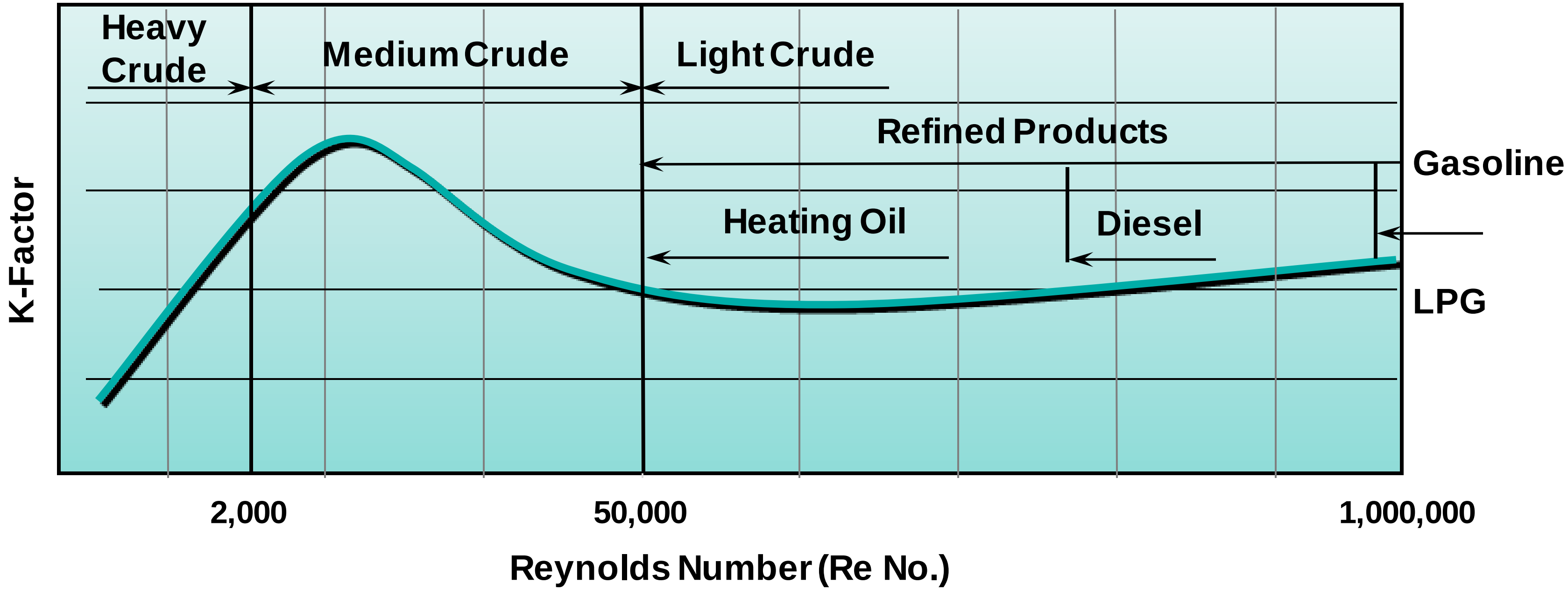
Meter (Inches)	Flow Range			Viscosity (cSt)	Reynolds Number Range	
6	bph	1,500	4,500	800	690	2,080
	m³/h	240	720			
12	bph	6,330	19,000	1,000	1,170	3,510
	m³/h	1,010	3,020			
20	bph	14,000	42,000	1,000	1,550	4,650
	m³/h	2,230	6,680			

Dynamic Test

Meter (Inches)	Flow Range			Viscosity (cSt)	Reynolds Number Range	
6	bph	560	1,690	300	690	2,080
	m³/h	90	270			
12	bph	1,900	5,710	300	1,170	3,510
	m³/h	300	910			
20	bph	4,200	12,600	300	1,550	4,650
	m³/h	670	2,0000			

Dynamic Test Range: Petroleum Products





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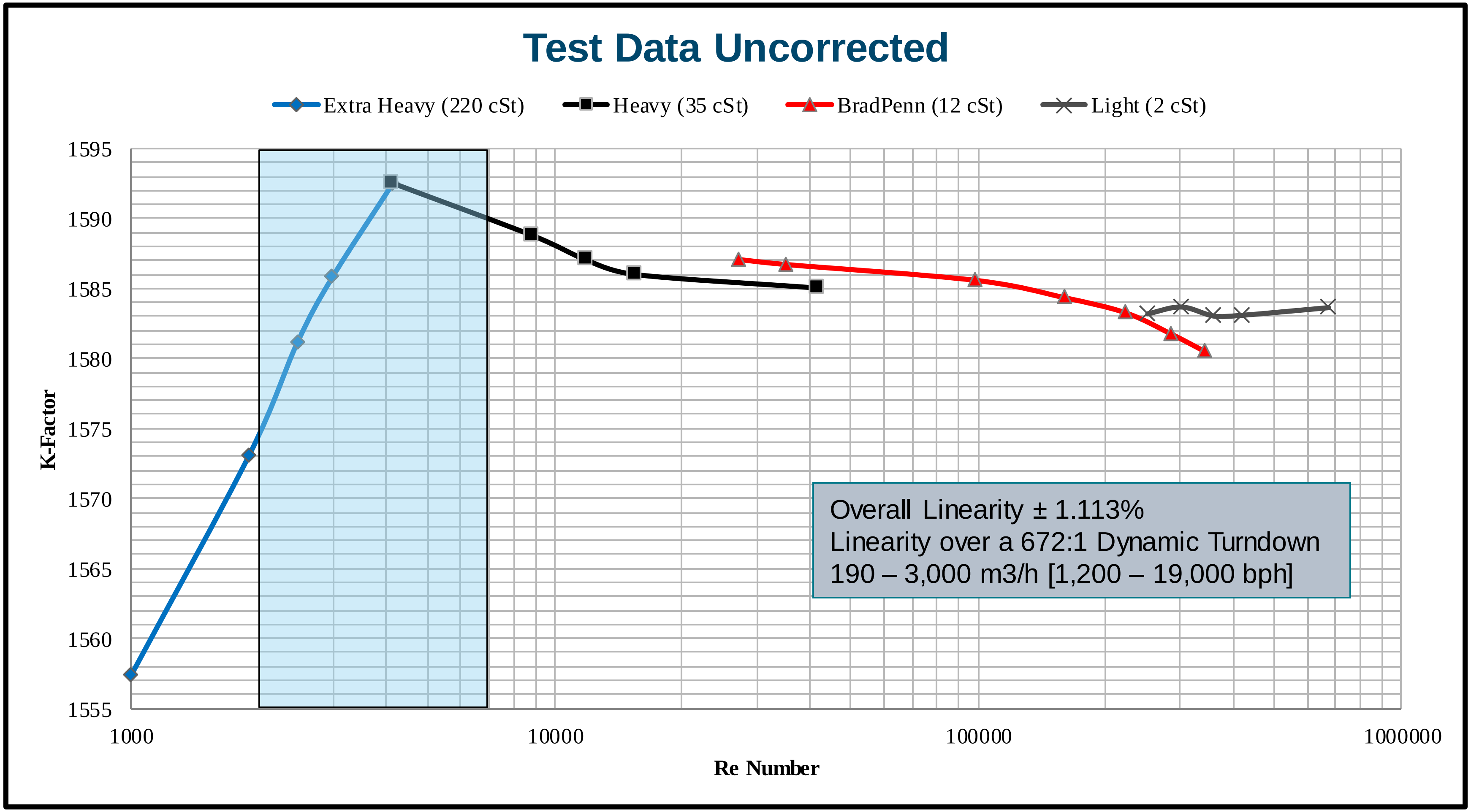
12 Inch Multi-path Meter Uncorrected

Testing Over an Extended Range
(Re# Range 1,000 to 672,746)

$$Q_{total} = A * \sum_{i=1}^{n} w_i v_i$$



12 Inch Multi-path Meter Corrected

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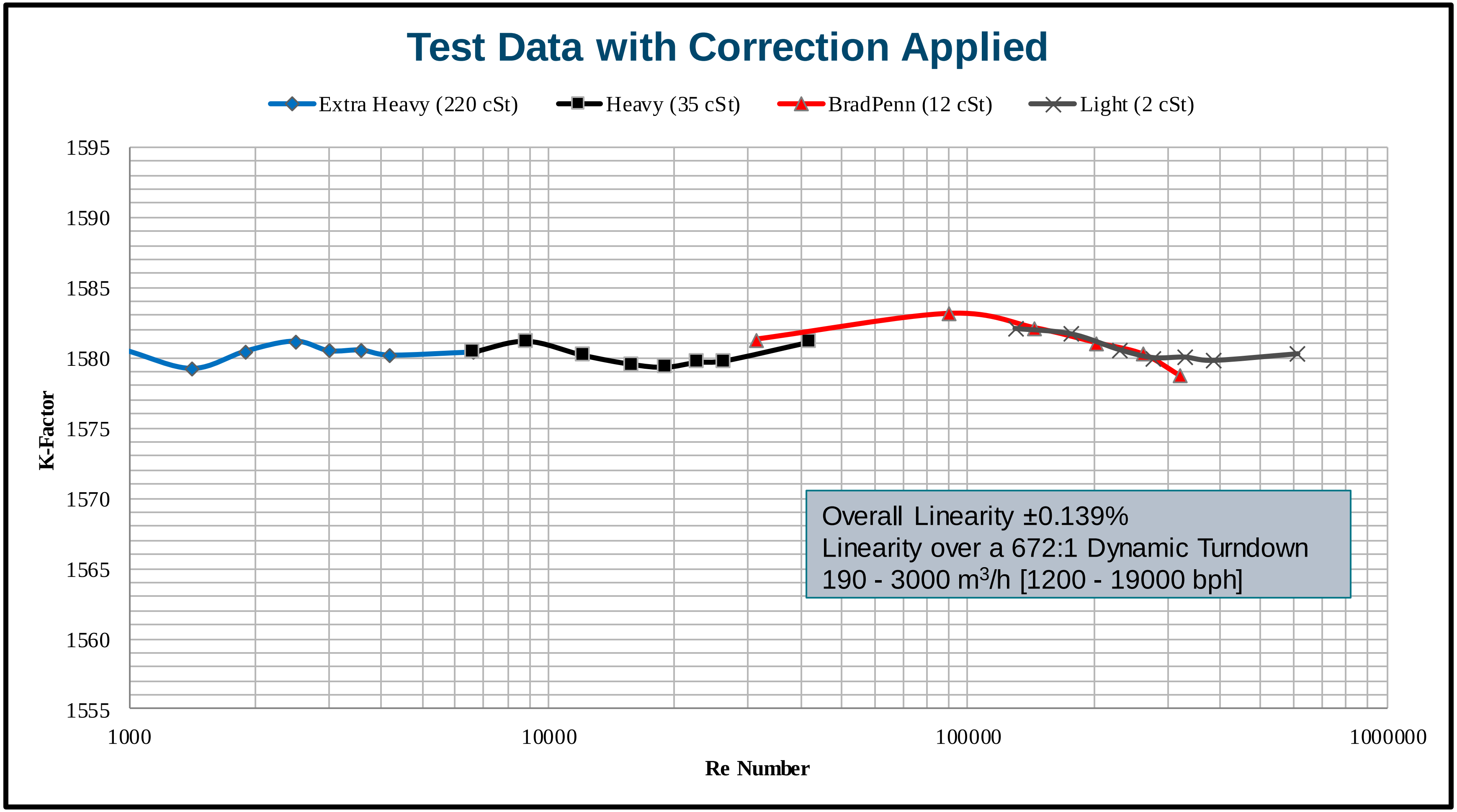

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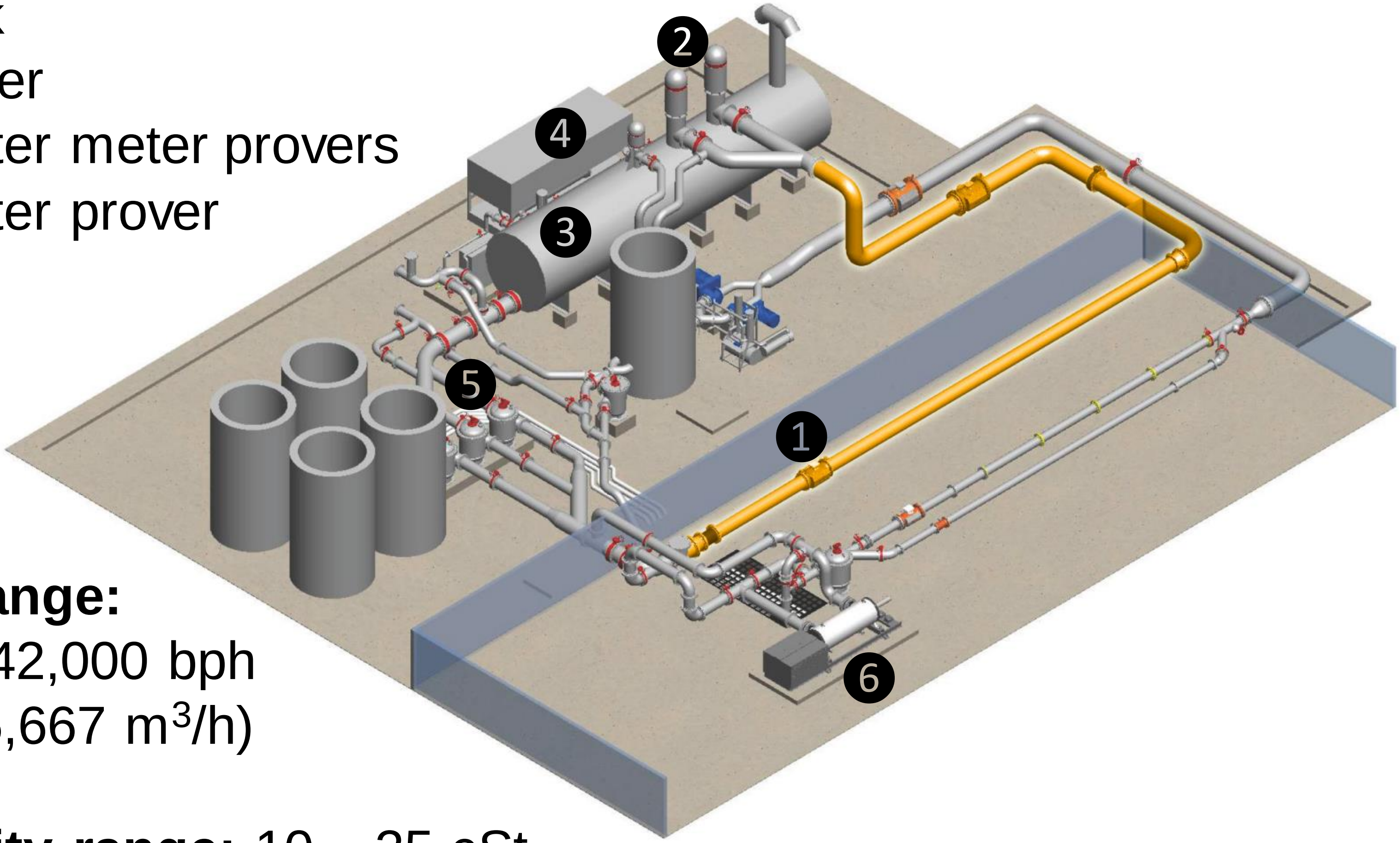
High Flow (HF) Test System

1. Test run / Meter Under Test (MUT)
2. Pumps
3. Tank
4. Chiller
5. Master meter provers
6. Master prover

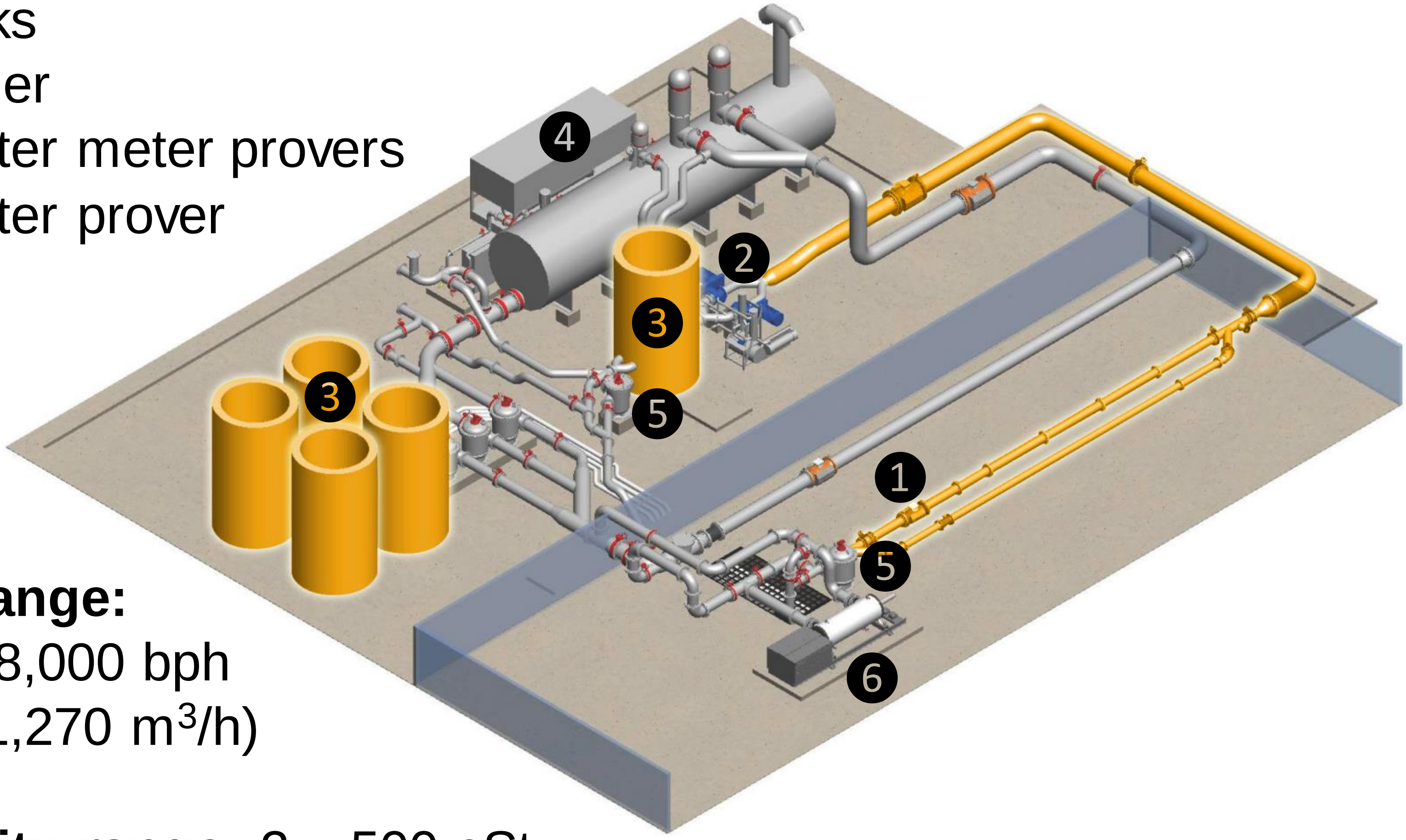


Flow range:
200 to 42,000 bph
(30 to 6,667 m^3/h)

Viscosity range: 10 – 25 cSt

Multi-Viscosity (MV) Test System

1. Test run / Meter Under Test (MUT)
2. Pumps / drives
3. Tanks
4. Chiller
5. Master meter provers
6. Master prover



Flow range:
200 to 8,000 bph
(30 to 1,270 m^3/h)

Viscosity range: 2 – 500 cSt

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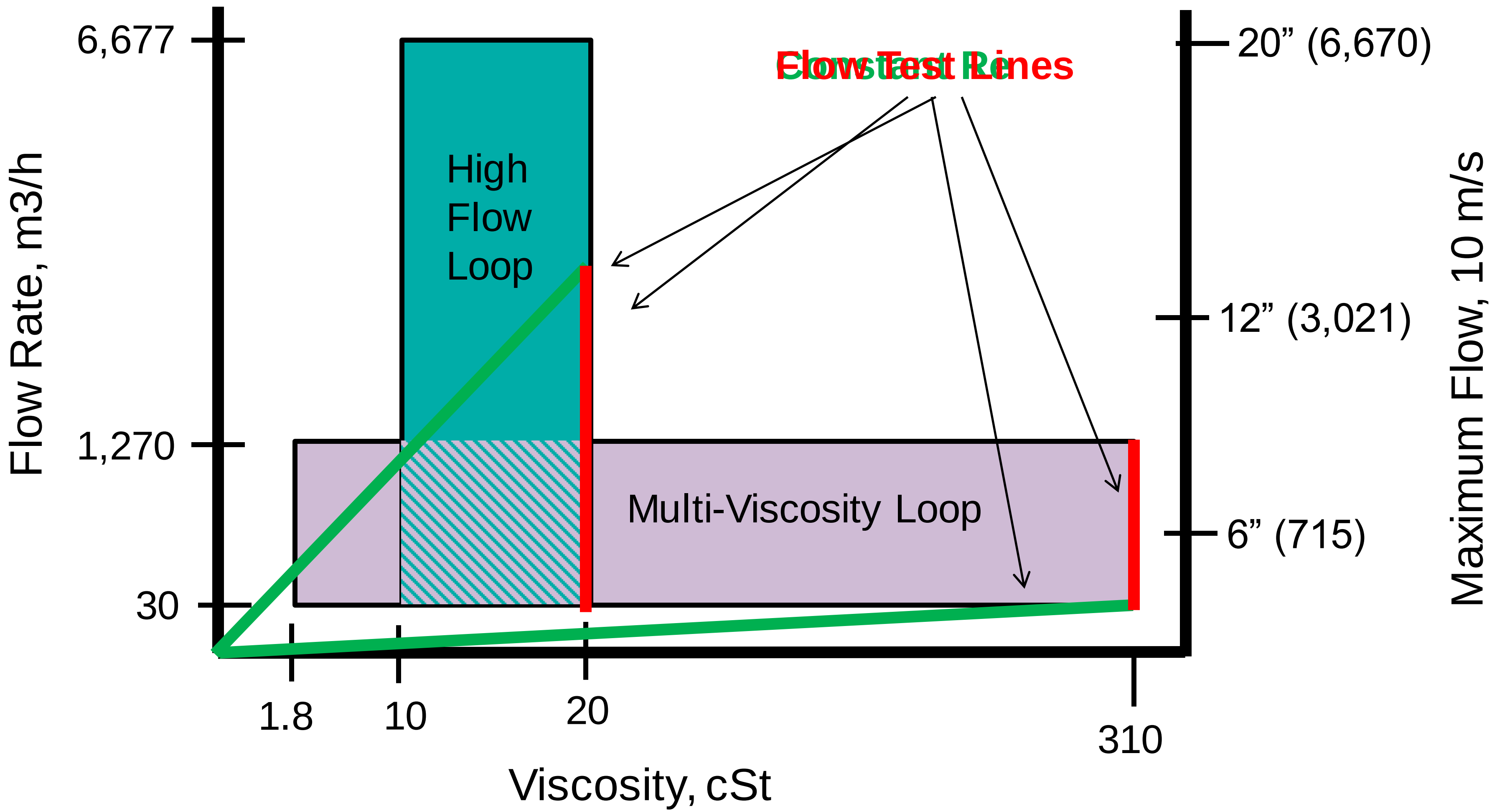
FMC Technologies Testing Capabilities



Diagnostic **N**umerical **A**nalysis

Process of Validating Installation Effects

1. **Calibrate** the meter on site A (Laboratory)
2. **Record** the conditions and meter diagnostics
3. **Install** the meter at site B
4. **Compare site results** – meter factors & diagnostics
   - Meter factor differences are due to installation effects – less the uncertainty of the proving systems
   - Meter diagnostics could define the installation conditions

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Diagnostic Parameters – Flow Profile Parameters

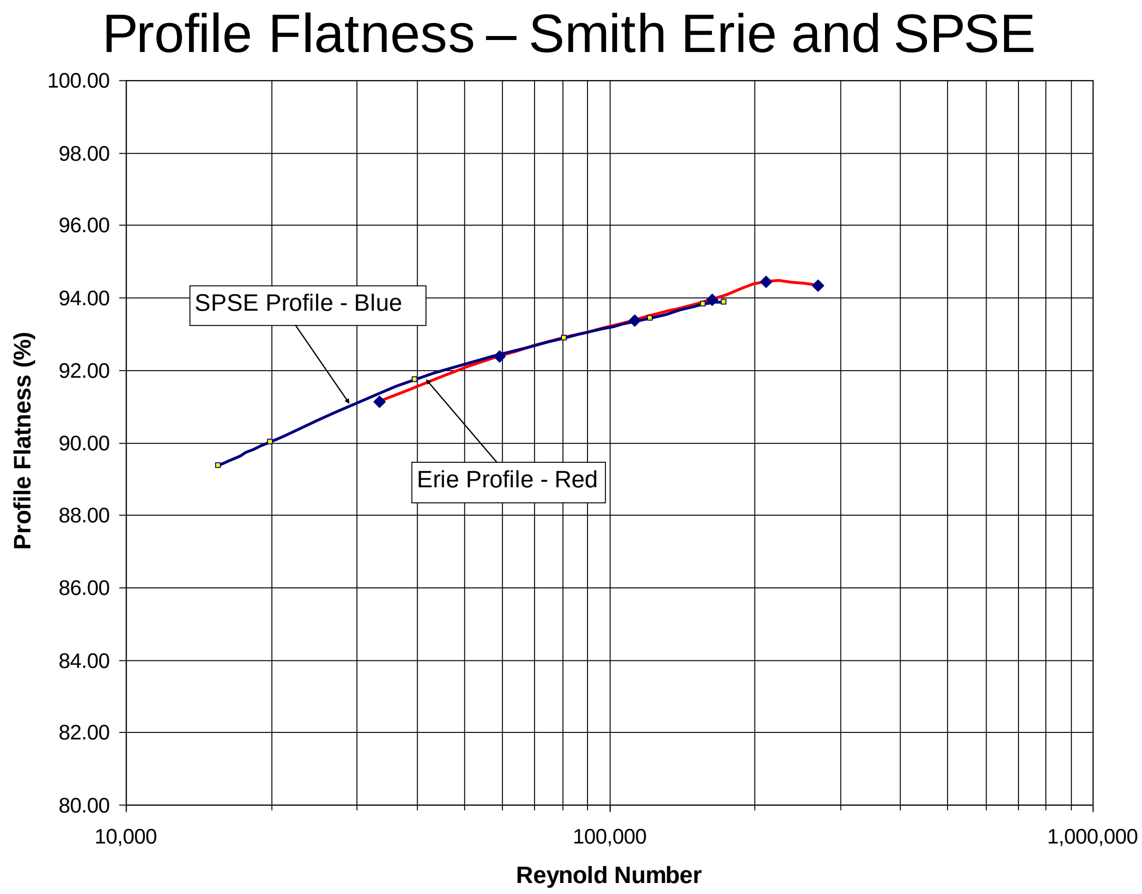
Profile Flatness	Axial flow velocity of outer paths compared to the center paths. Reynold's number dependant. Deviation at similar conditions < 1.0%
Profile Symmetry	Velocity of top paths compared to the bottom paths. Installation dependant. Deviation at similar conditions < 2.0%
Swirl Flow	Amount of transversal flow that is rotating in the pipe. Installation dependant. Deviation at similar conditions < 2.0%
Cross Flow	Amount of transversal flow that has two rotating vortexes Installation dependant. Deviation at similar conditions < 2.0%
Turbulence	Describes the stability of the flow measurements on each path. Reynolds number dependant. Deviation at similar conditions < 1.0%

Diagnostic Analysis – Signal Parameters

Velocity of Sound (VOS)	Measured on each path to ensure correct measurement of ultrasonic pulses. Density dependant. Recording possible. Deviation < 1.5m/s
Gain	Indicates signal strength. Influenced by density, viscosity and impurities. Recording possible. Deviation < 200
Signal %	Designates the signal quality. Should > 50%. Drop in performance on similar conditions should be examined.
Signal to Noise Ratio (S/N)	Measures the signal strength and noise. Should be > 20dB. Drop in performance on similar conditions should be examined.

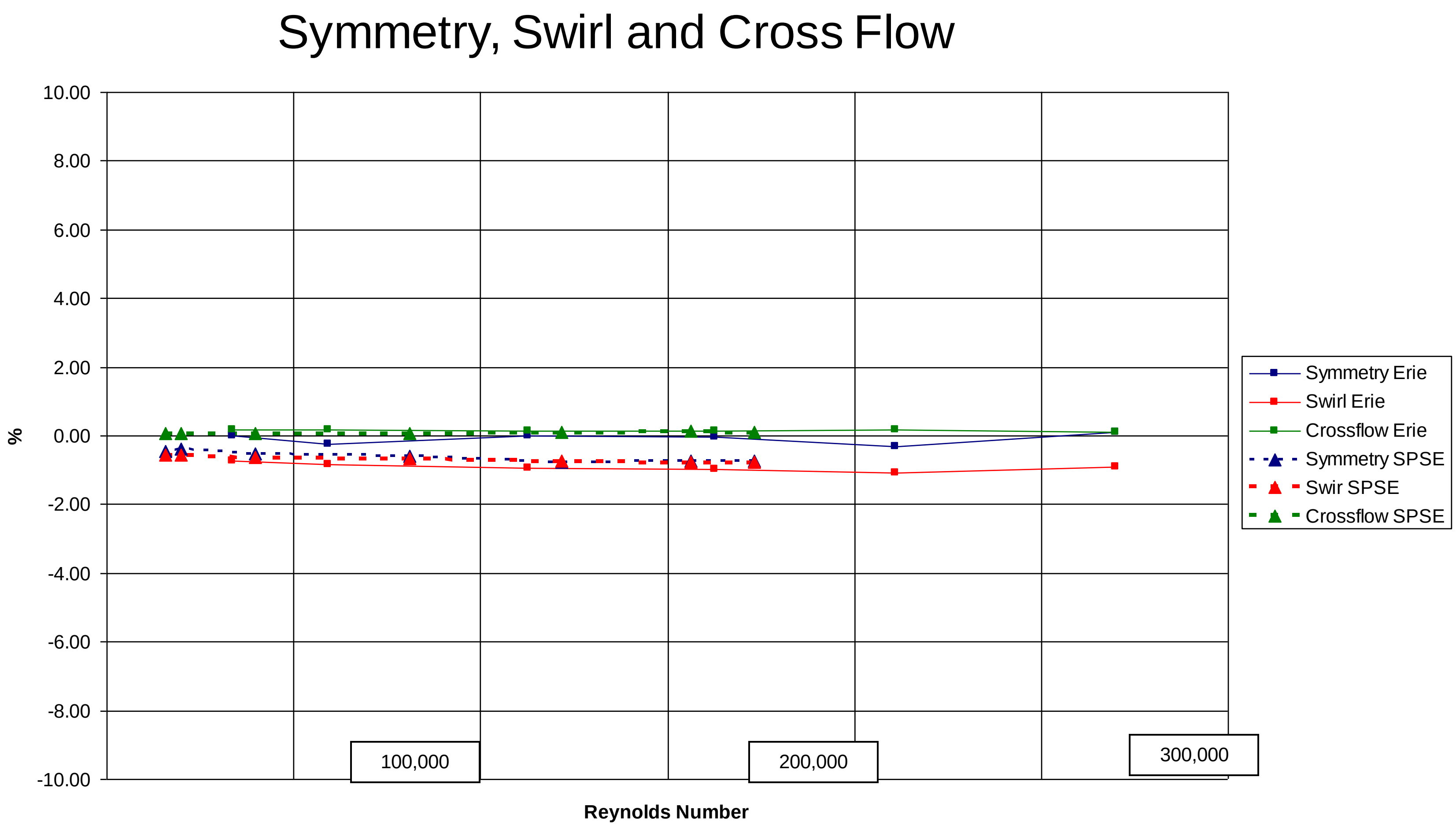
Diagnostic Analysis – Inter laboratory Comparison

Deviation < 1%; Actual 0.04% to 0.73%



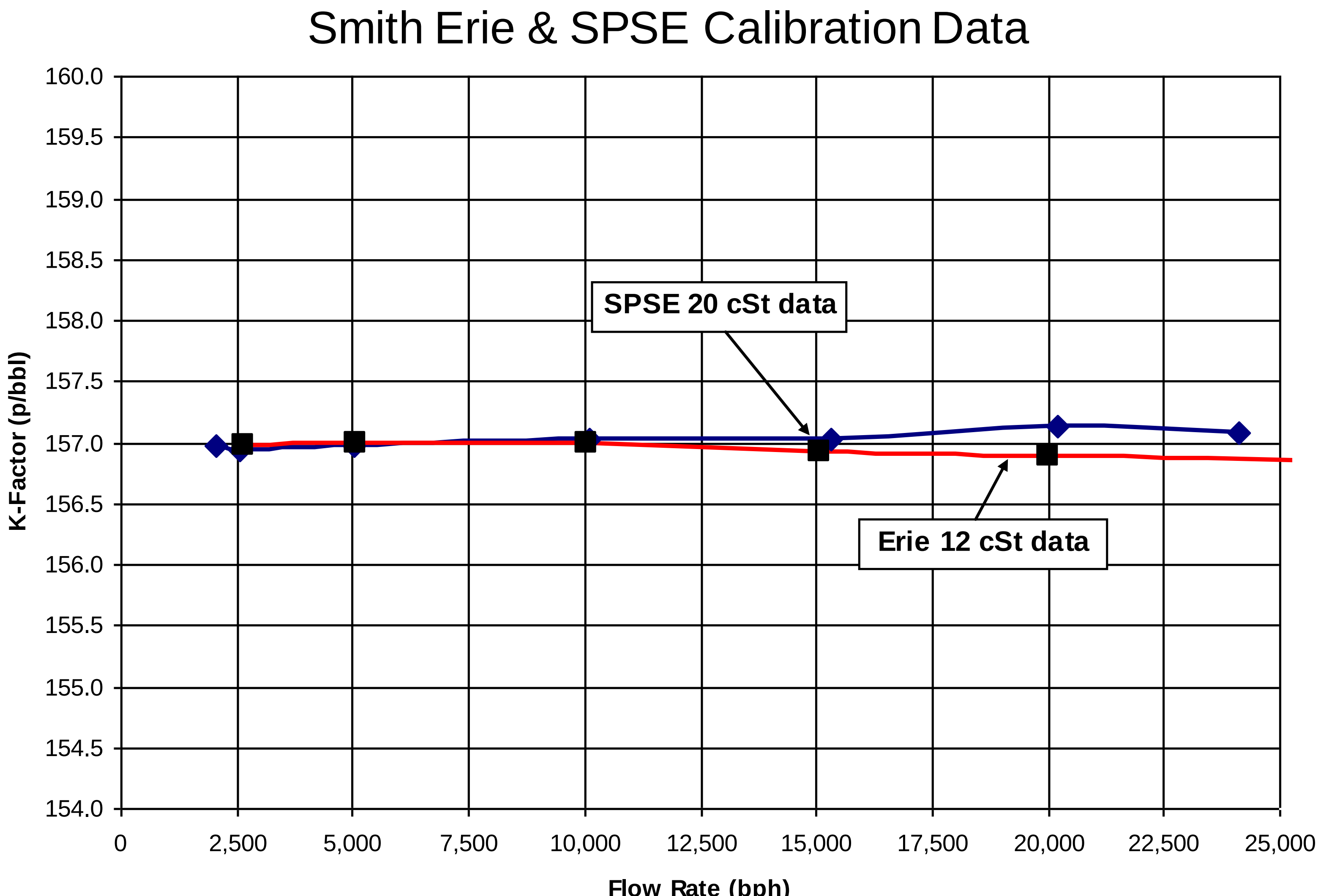
Diagnostic Analysis – Inter laboratory Comparison

Tolerance: < 2%



Ultra^6 Inter laboratory Comparison

Deviation < 0.02 to 0.17



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Thank You

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