A Differential Pressure Meter for Low Reynolds Numbers

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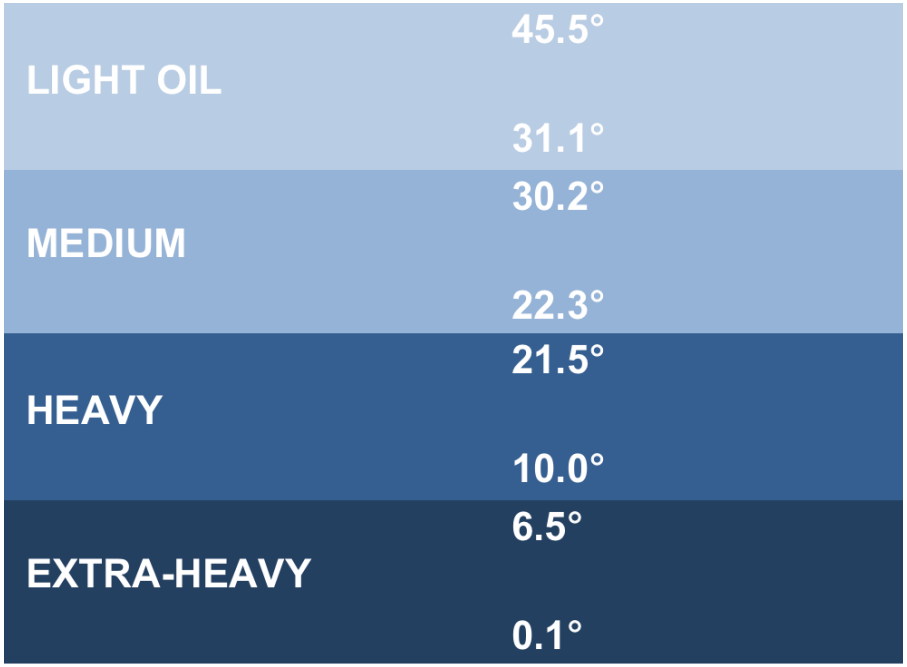
Introduction

World energy demands continue to grow putting emphasis on energy security

In oil and gas industry around 70% of remaining oil reserves are classed as ‘Heavy Oil’

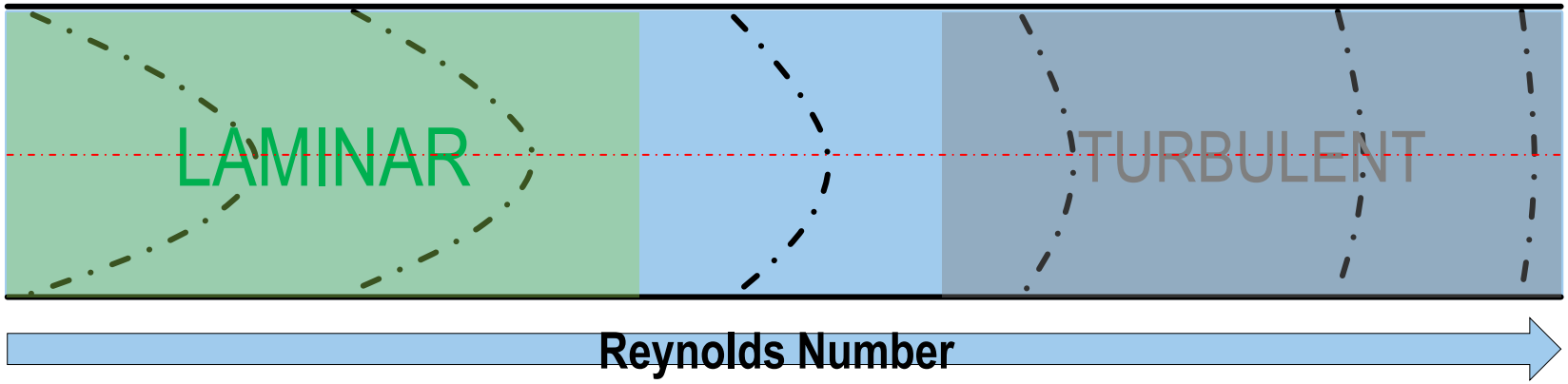


Introduction

There are measurement issues associated with these fluids which have important financial considerations

In general, the fluid mechanics is still not fully understood:

- Laminar/Transition/Turbulent flow
- Critical Reynolds numbers
- Velocity profile



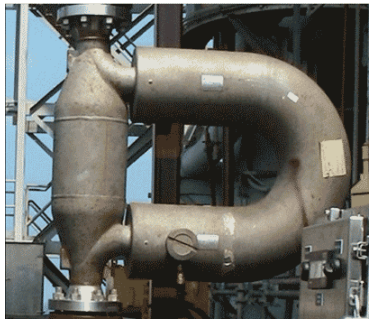
Current Technology

Most applicable technology is positive displacement:

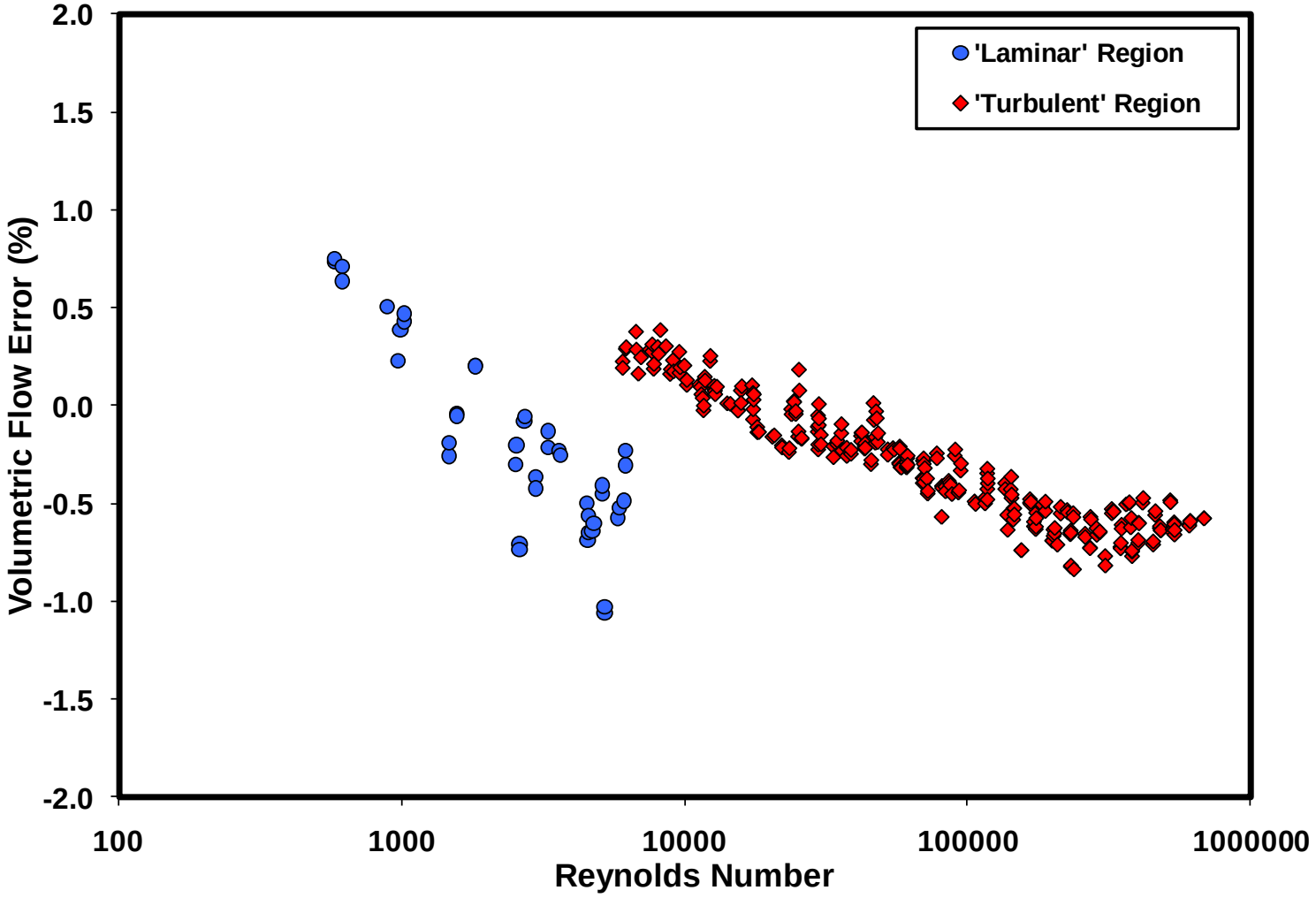
- Reduced Slip
- No profile effects

However, Coriolis, Ultrasonic and Turbine meters are sometimes used

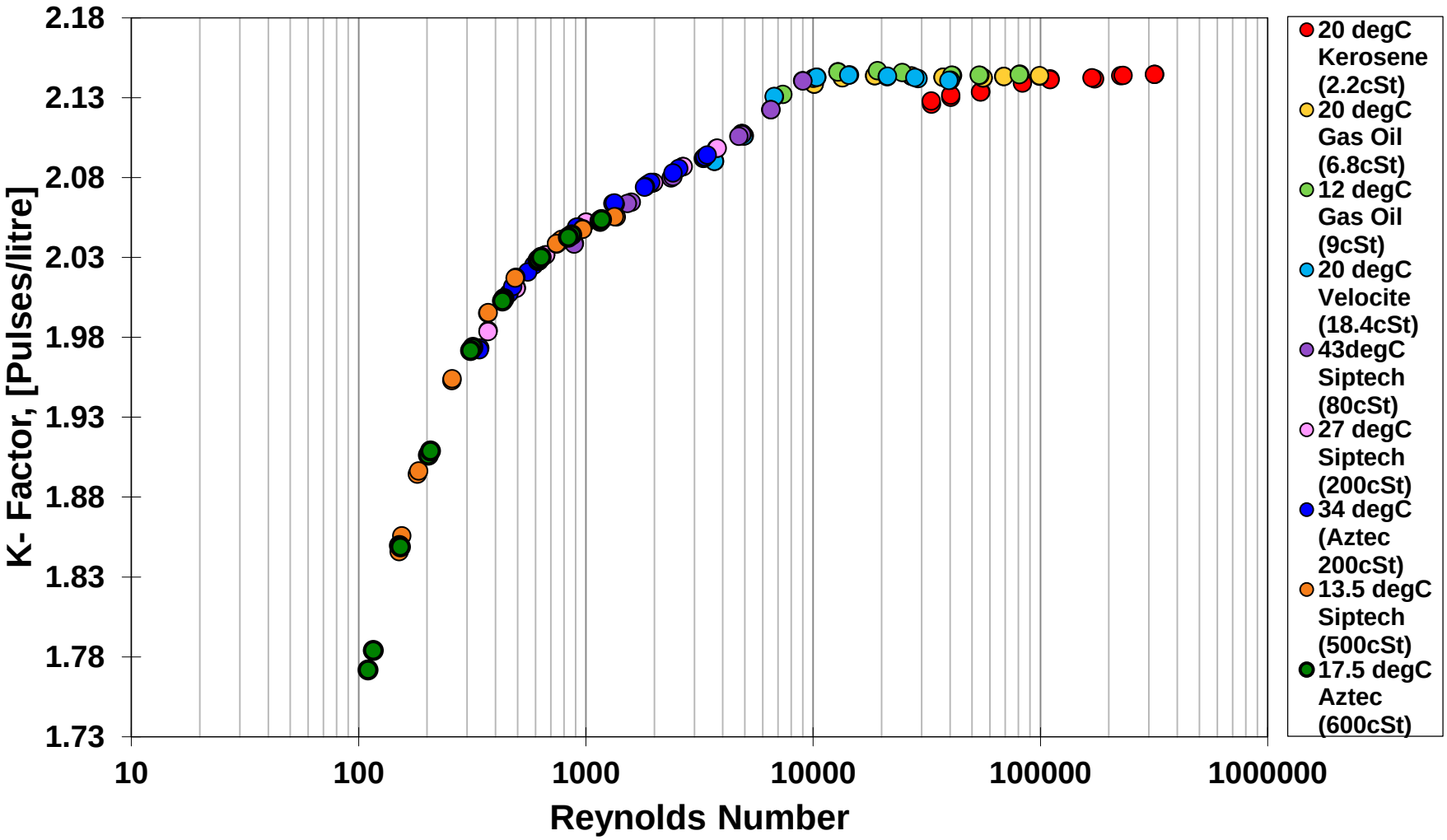
- Can offer diagnostics
- But have Reynolds number effects



Ultrasonic Meters

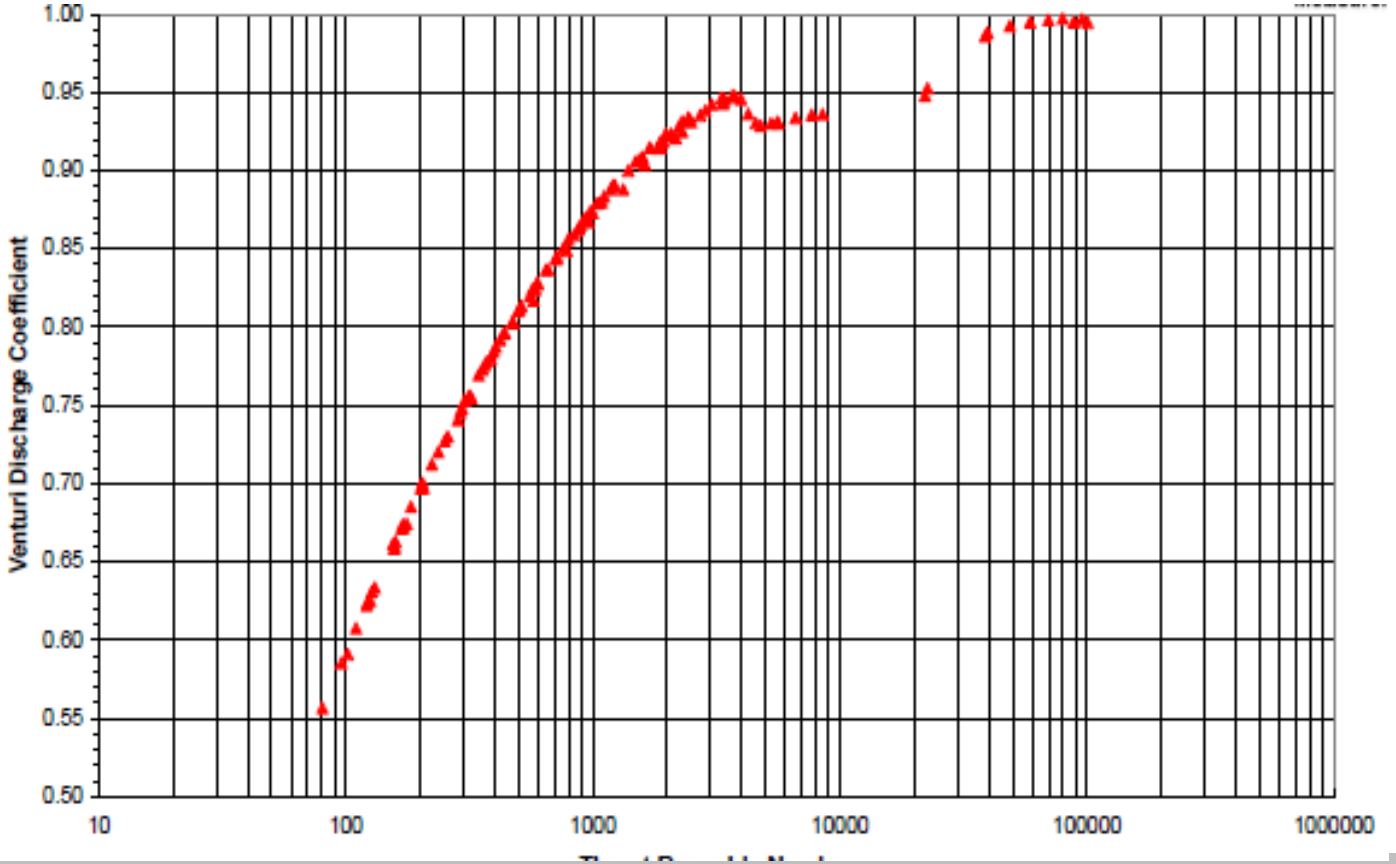


Turbine Meters



Current Technology

Differential pressure meters have a large market share in other applications but standard orifice plates, Venturis etc tend not be used in high viscosity



Current Technology

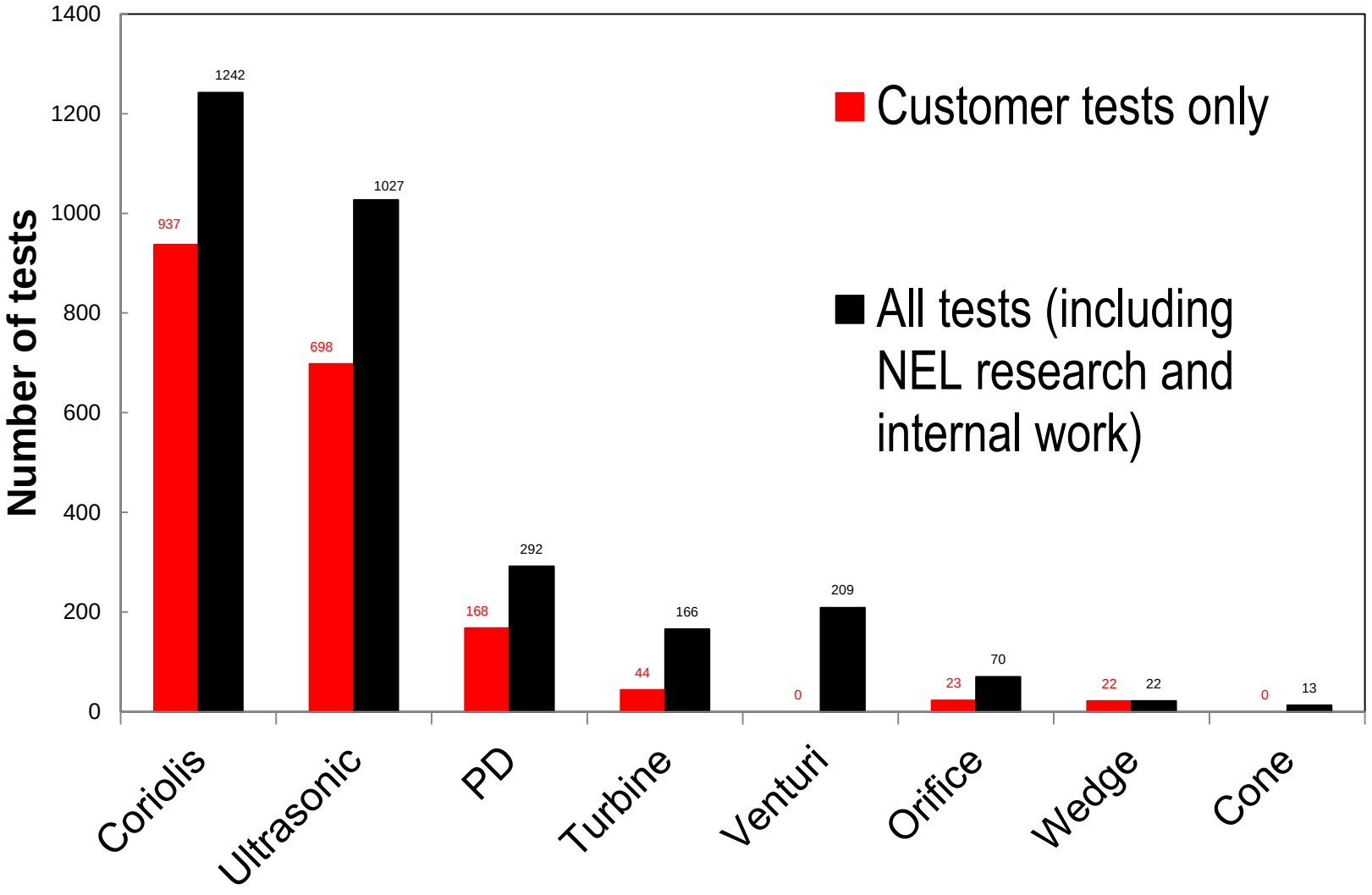
Quadrant Edge and Conical Entrance type orifice plates can be used for low Reynolds numbers – ISO 13577:2007

However, there is some evidence that these devices do not meet the specifications in that standard

It is believed ISO 13577:2007 was developed based on work completed in 1940's

Currently, many users follow the equations in the standard as opposed to performing calibrations over their operating range e.g. large number of meters in refineries

Calibrated at NEL



Application Need

Is there a need for a differential pressure meter with improved performance in low Reynolds numbers?

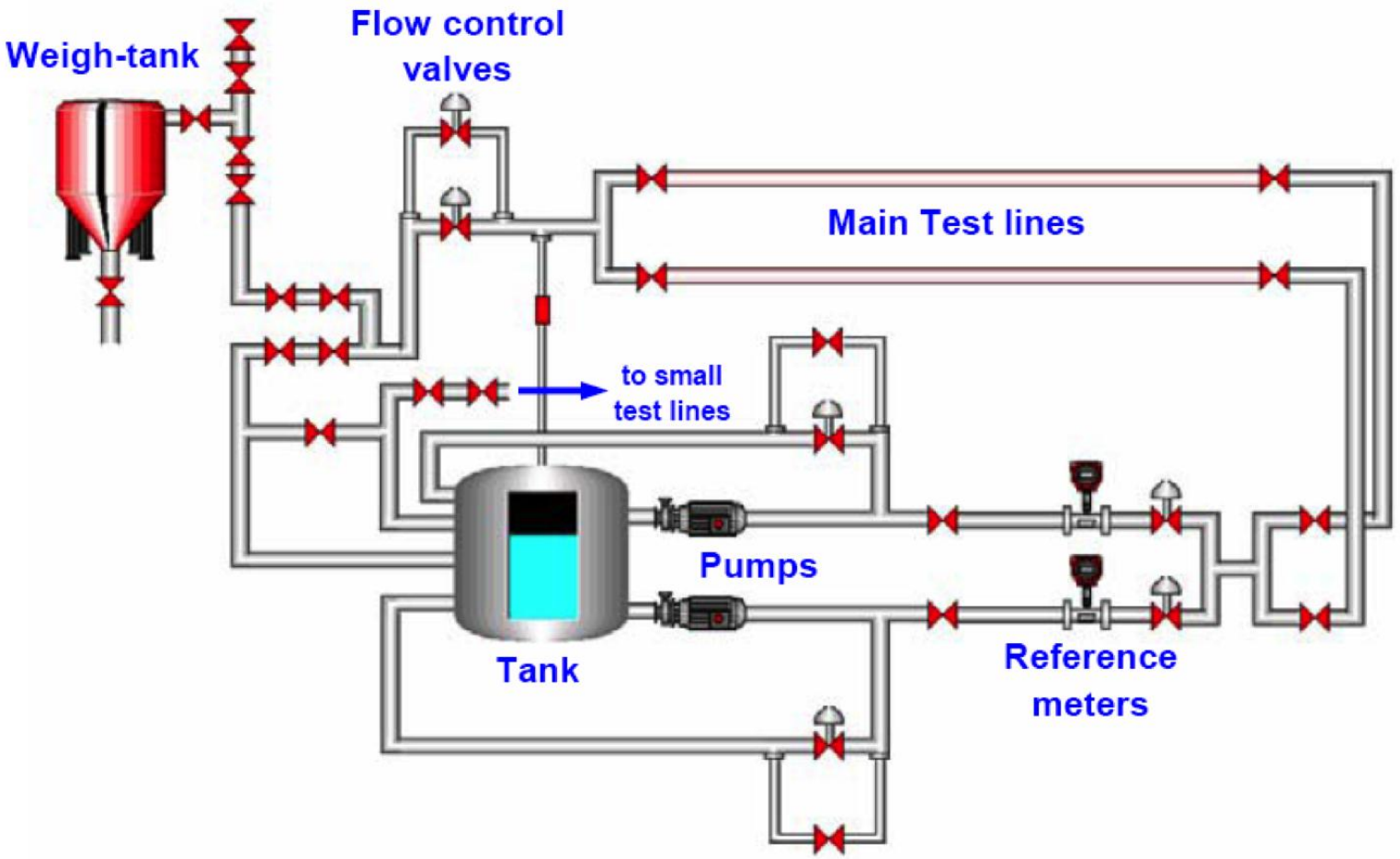
For custody transfer or fiscal measurements (0.25% uncertainty), current technology can achieve the high accuracy required and it is unlikely that a DP meter will match this.

For general process measurement, DP meters can be used and most likely with around 2% uncertainty (ISO). Improving this to 1% or 0.5% could offer significant advantages especially if the current standard may not be fully correct.

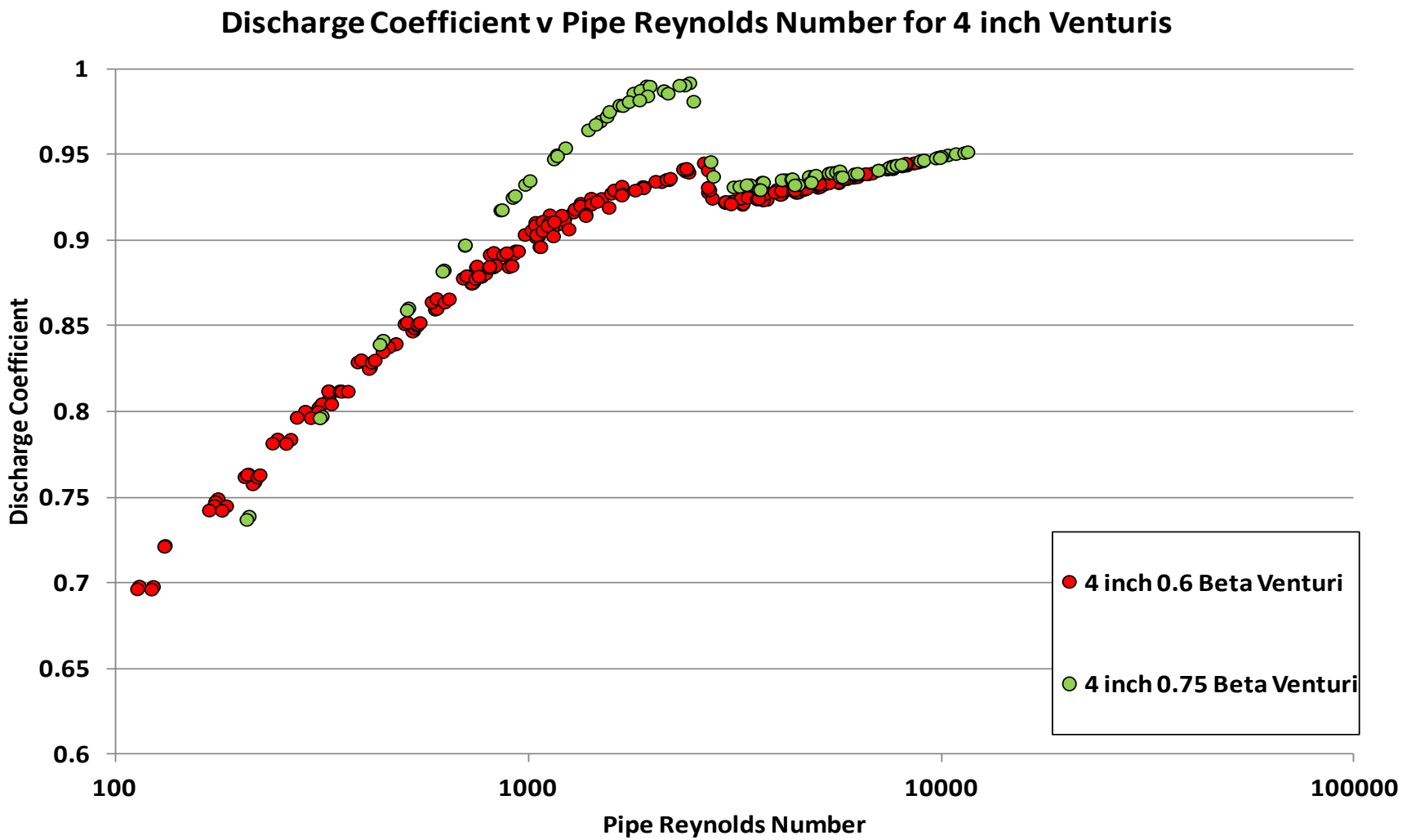
NEL Test Work

Meter Number	Meter Type	Nominal Size	Nominal Beta	Min Re	Max Re
-	-	inch	-	-	-
1	Venturi	8	0.4	94	8268
2	Venturi	8	0.6	84	9213
3	Venturi	6	0.4	285	6081
4	Venturi	6	0.75	391	9781
6	Venturi	4	0.6	88	11404
7	Venturi	4	0.75	208	14600
8	QE Orifice	8	0.45	647	9140
9	QE Orifice	8	0.6	240	7681

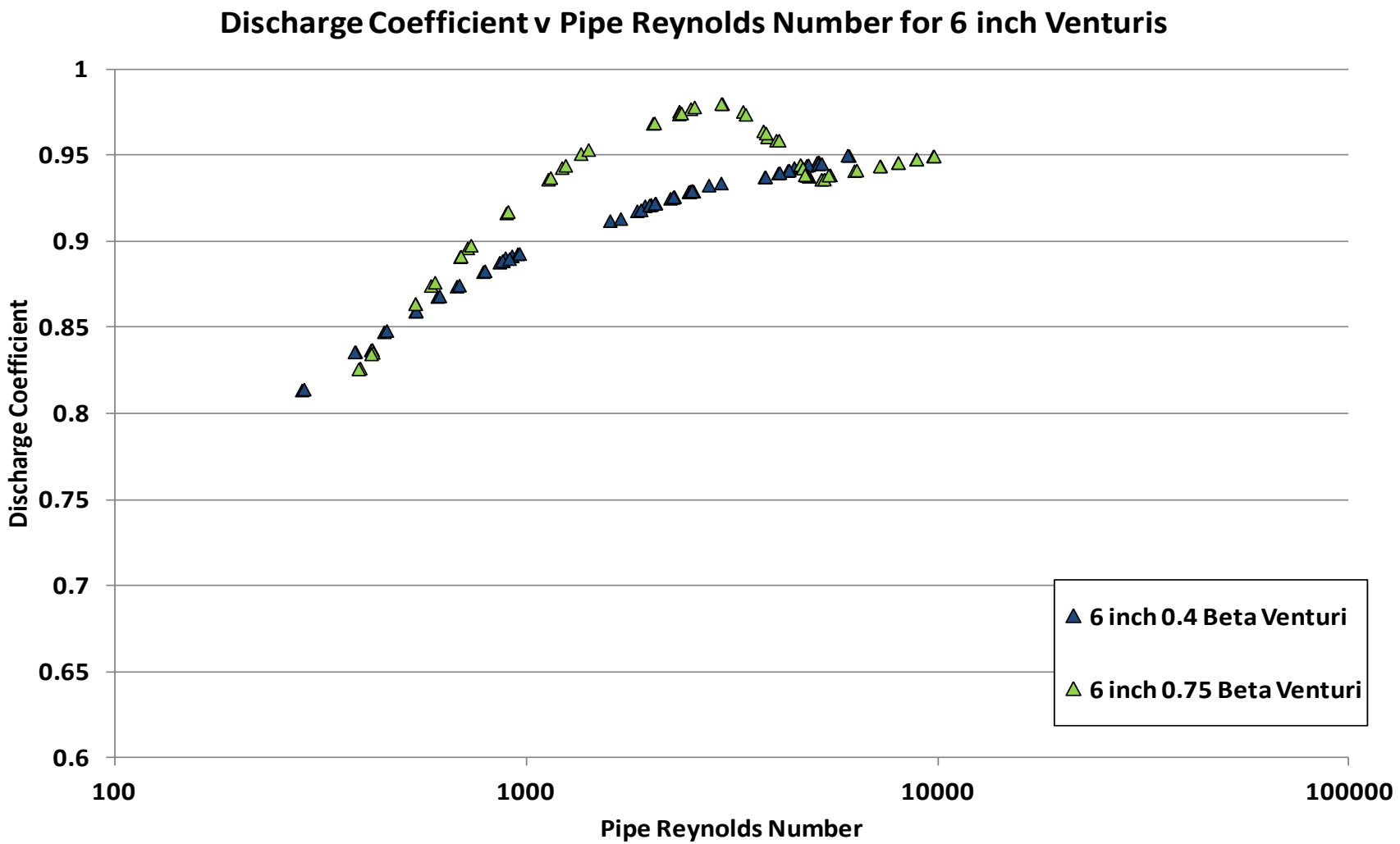
NEL Test Work



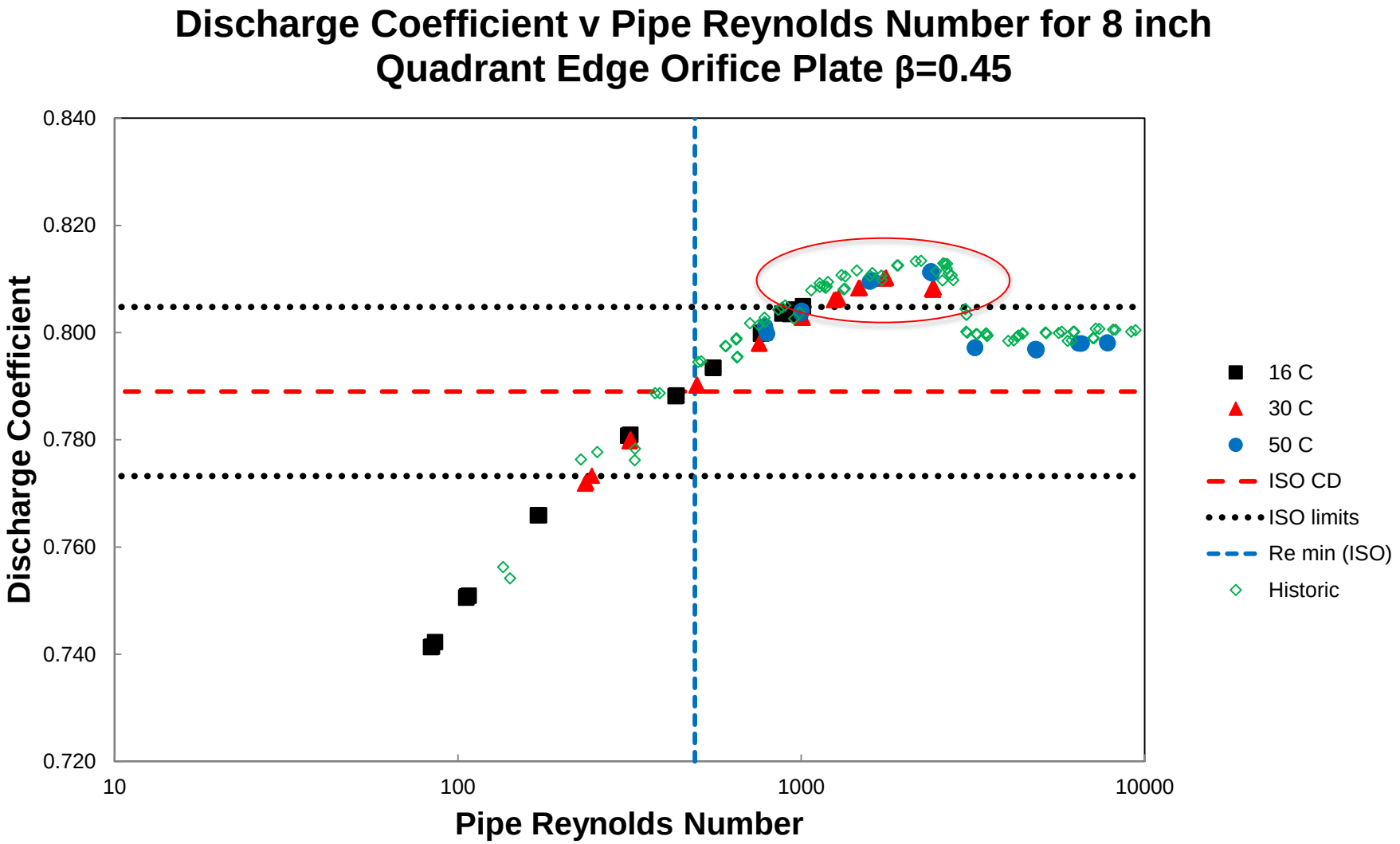
Venturi Results



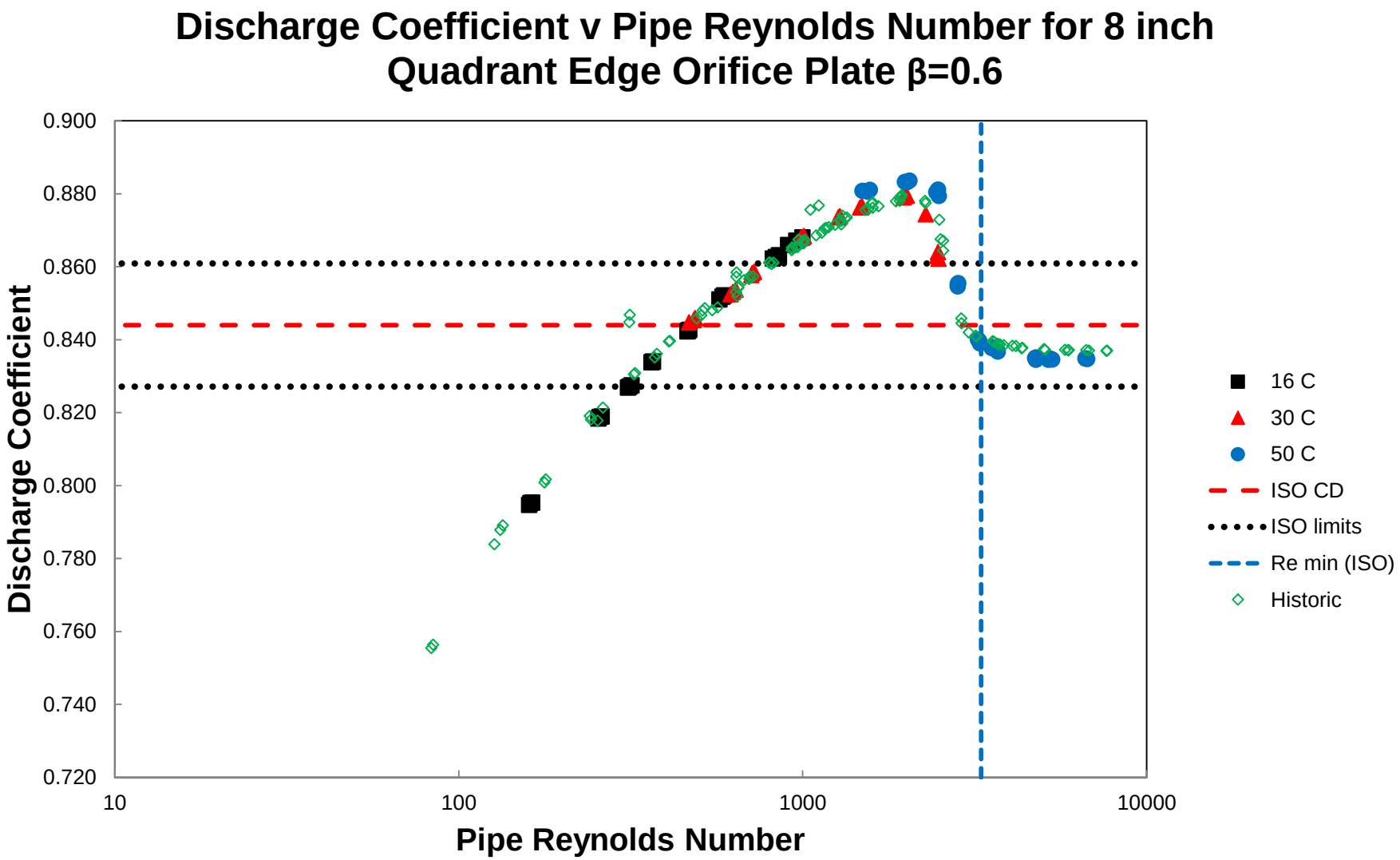
Venturi Results



Quadrant Edge Orifice Results



Quadrant Edge Orifice Results



NEL Method

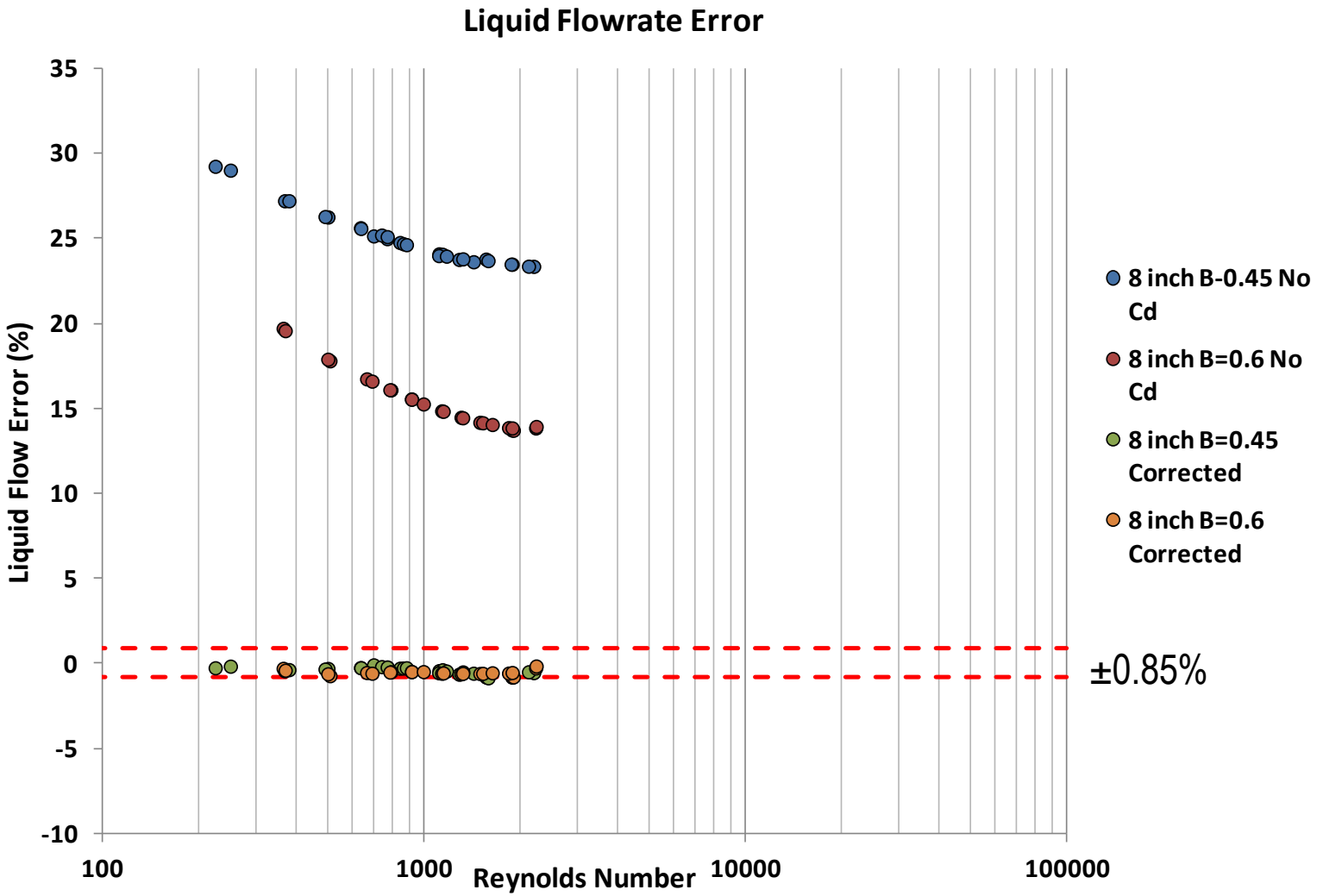
Based on this work, NEL has developed a method of correcting discharge coefficient and calculating physical properties in real-time (after a calibration)

This provides a full solution for the measurement of flowrate in low Reynolds number applications for DP meters

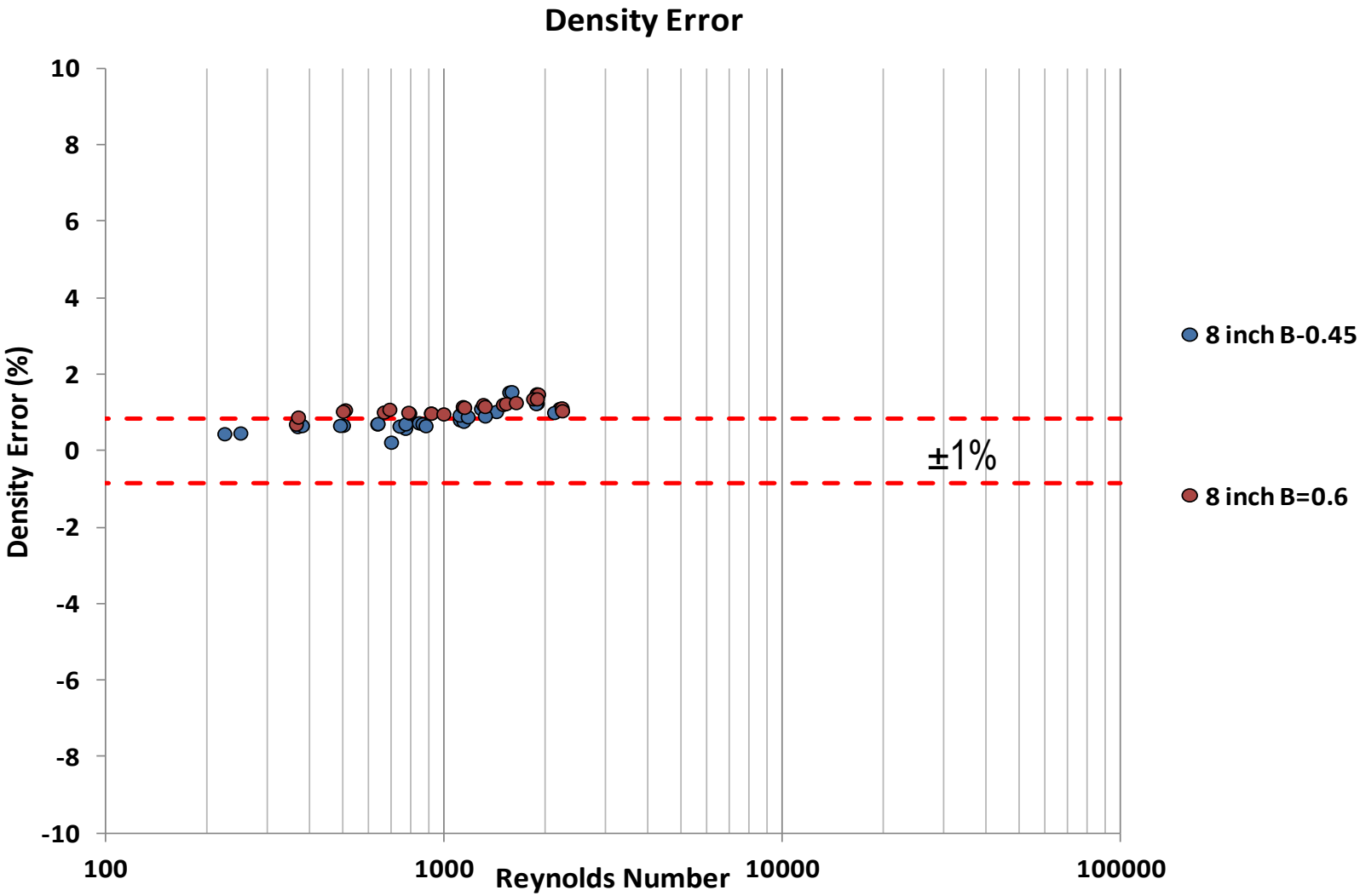
Unfortunately, I am unable to reveal the detail of the method and how the improvement works at present

Preliminary results appear to show a significant improvement in flowrate and density measurement for laminar flow

Quadrant Edge Orifice Plate Corrected Flow Error



Quadrant Edge Orifice Plate Density Error



Conclusions and Further Work

Flow measurement of high viscosity fluids is a challenging application with the majority of technologies having Reynolds number affects.

There is evidence of the industry used standard for DPs having errors

We believe there is a need for a lower cost device to meet user requirement for general process measurement

A new measurement method has been developed to help correct errors in differential pressure meters in low Reynolds number flows

A number of meters have been tested and show proof of concept in laminar flow

Further Work

There are areas of continued research that need to be investigated before a full solution can be claimed for this technology:

- Effect of different fluids
- Effect of changing transition Reynolds number
- Development of generic curve
- Deviations from ISO 15377:2007

Further work is also being carried out in terms of the market need for this technology. I would appreciate any feedback on craig.marshall@tuv-sud.co.uk

Acknowledgements

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- ICURe

Question Time

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