Raising the Bar for Fair Measurement

Measurement Technologies' Solution to more Accurate Turbine Meters

Contact Information

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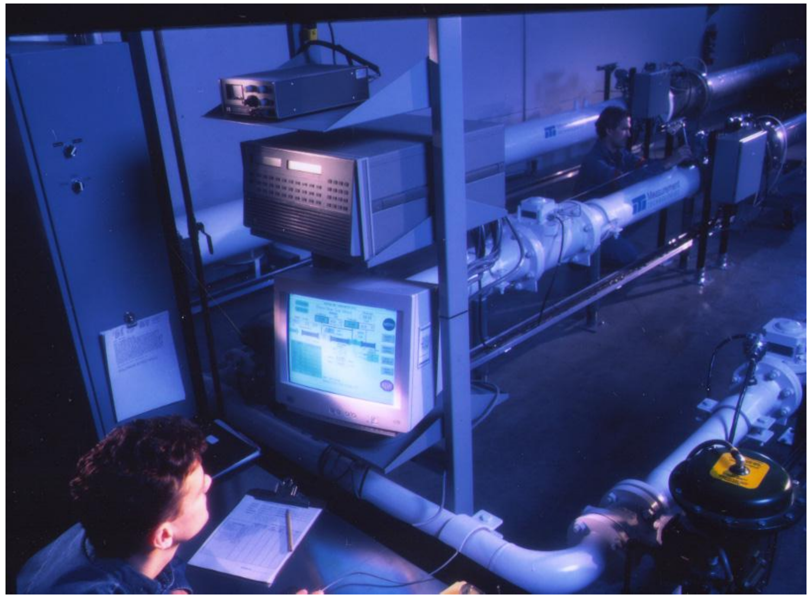
Terasen Gas

Terasen Measurement Technologies

- Located in Penticton, BC, Canada.
- Serves its main client, Terasen Gas and external customers.
- Provide turbine meter calibration for over 15 years.



The People Making it Happen:

Presiding over the Meeting

Kevin Harms

Meter Shop Manager

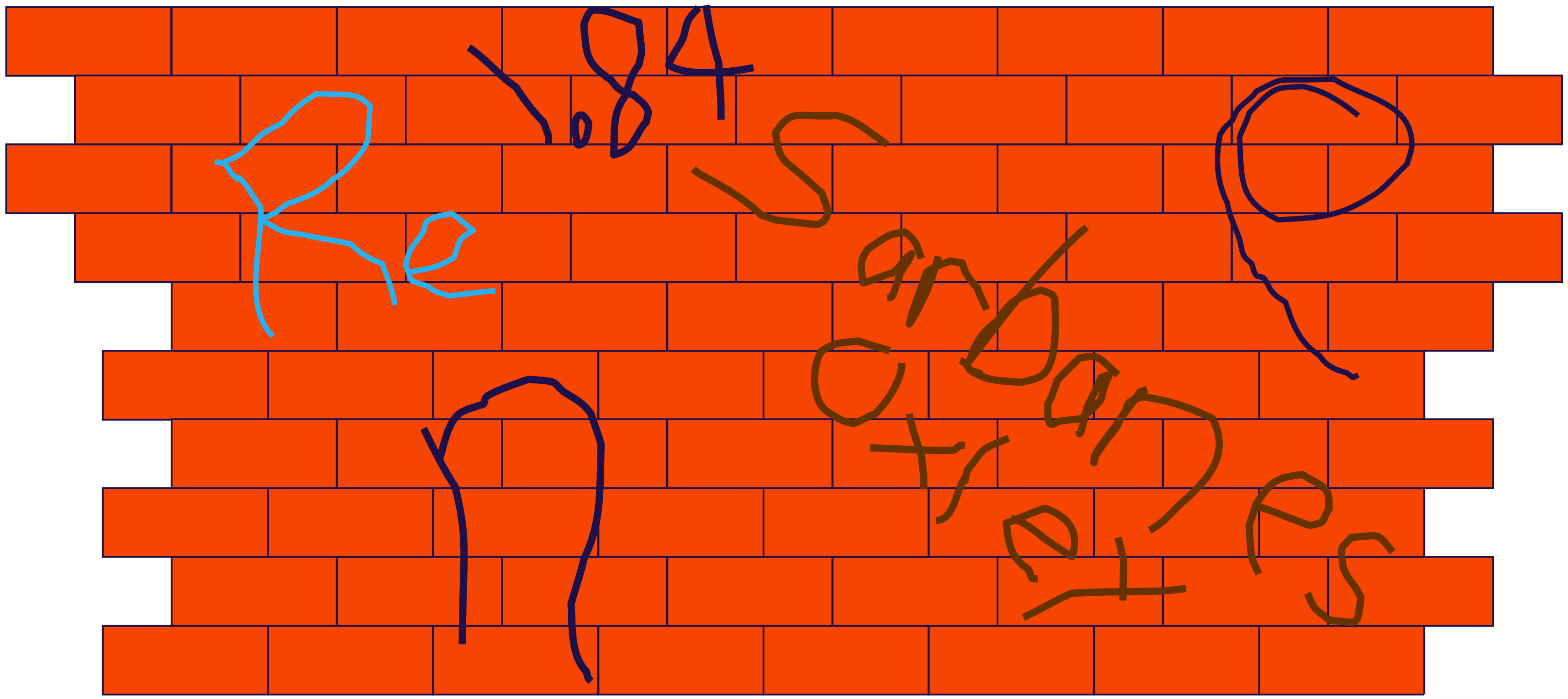
Inventing and Project Managing

Paul Tang

Inventor/

Project Manager

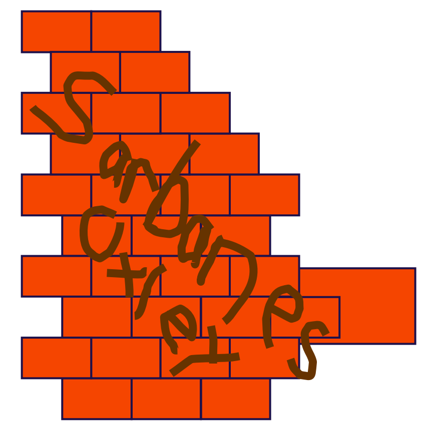
Terasen Gas



The Changing Environment

Due Diligence

- Sarbanes-Oxley
  - Criminally Accountable if knowingly overselling gas!
  - 10 year prison terms
  - Fines can be $1,000,000



The Issue

- In 2003, Gas Research Instituted (GRI) commissioned Southwest Research Institute (SwRI) to assess the accuracy of Turbine Meters
  - Some test meters were out by **5%!**

What if something like this got into the papers?

Utility charged with breaching Sarbanes-Oxley for overcharging customers for natural gas.

Somewhere, United States: A well established utility was recently charged with overbilling its customers due to its maintenance program of turbine meters which did not include a more accurate calibration system. The catalyst for the investigation and the recent charges were due to a discovery by auditors at a local public hospital which were currently having their budget cut due to lack of funding…………………………..

Details Page A4

The way it is….

- The best way to test a meter to gain accuracy is to test it at its **intended** operational pressure.
- Turbine meters generally measure more at higher pressures. It's overcharging for gas!
- Most meters in North America are tested at atmospheric pressure using **air** due to a scarcity of high pressure facilities and the $.

A One Per Cent Error looks like this….

Terasen Gas

			1% Meter Error	
Meter Size	max flow (scfh)	$/year (25% Average flow rate)	Annual Billing Error (25% average flow rate)	GJ/yr.
4"	86000	$ 1,440,000	**$ 14,000**	**2100**
6"	143000	$ 2,400,000	**$ 24,000**	**3500**
8"	285000	$ 4,801,000	**$ 48,000**	**6800**
8"HC	428000	$ 7,201,000	**$ 72,000**	**10300**
12"	665000	$ 11,201,000	**$ 112,000**	**16000**
12"HC	1093000	$ 18,402,000	**$ 184,000**	**26300**
Operating Pressure (psia)			70	
Delivery Charge ($/GJ)			$ 1.00	
Commodity Charge ($/GJ)			$ 6.00	
Usage Factor (% max flow)			25%	

Our Industry has a problem

- Here is how Terasen Measurement Technologies is addressing this problem for its main customer, Terasen Gas…

MT's Objectives

- Enhanced accuracy for Terasen Gas' turbine meters
- Good return on investment for the utility.
- Less expensive than a typical high pressure facility
- Accountability and Compliance for its management and executive

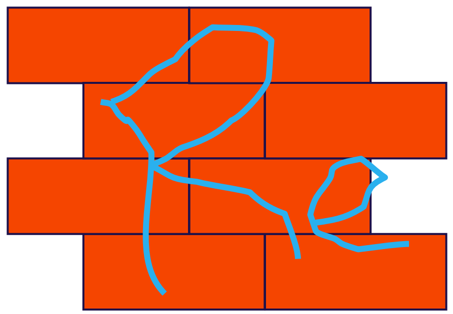
MT's research

- MT has gone through many scenarios for an optimum test method:
  - Straddling pipeline (Line Pack)
    - Seasonality, inability to serve in peak demand.
  - Closed Loop
    - High Pressure Facility expensive to build, operate.
    - Land footprint would be large.

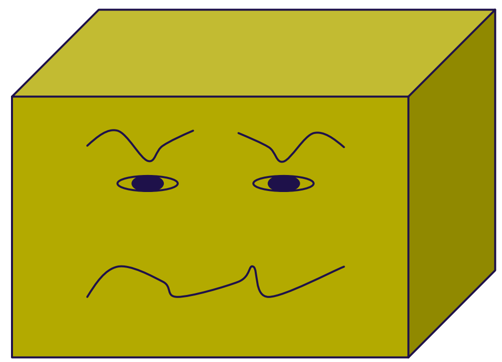
Research by Others

- Mechanical design changes
- Nose cone configurations
- Piping configurations

"Out of the Box" Thinking

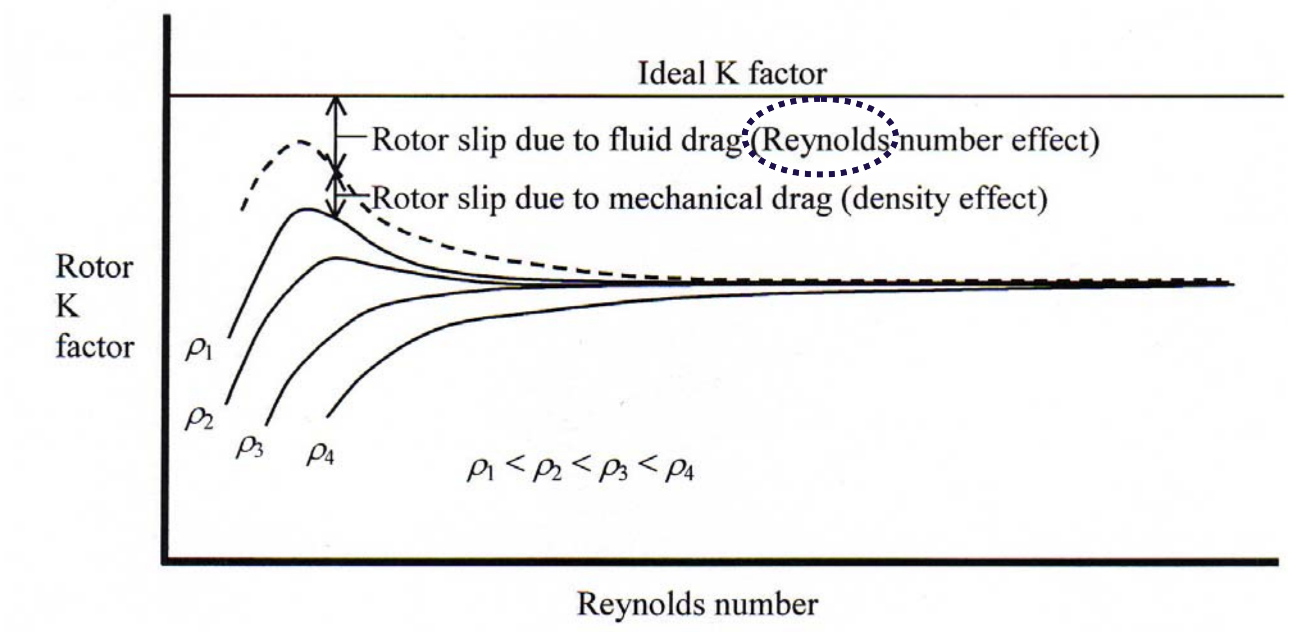


Reynolds Number



The Reynolds Number effect

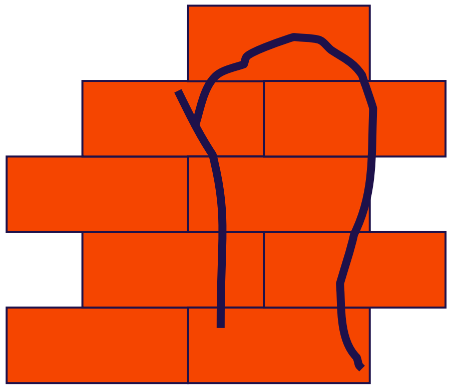
MT wanted to be at a higher Reynolds Number to reduce the error.



Reynolds Number

- A well established technique used in fluid dynamics applications.

Reynolds Number



$$R_e = \frac{\rho v D}{\eta}$$

Where

ρ	=	density of gas
v	=	average velocity over a fixed cross section of pipe
D	=	diameter of pipe
η	=	dynamic viscosity of gas

Reynolds Number

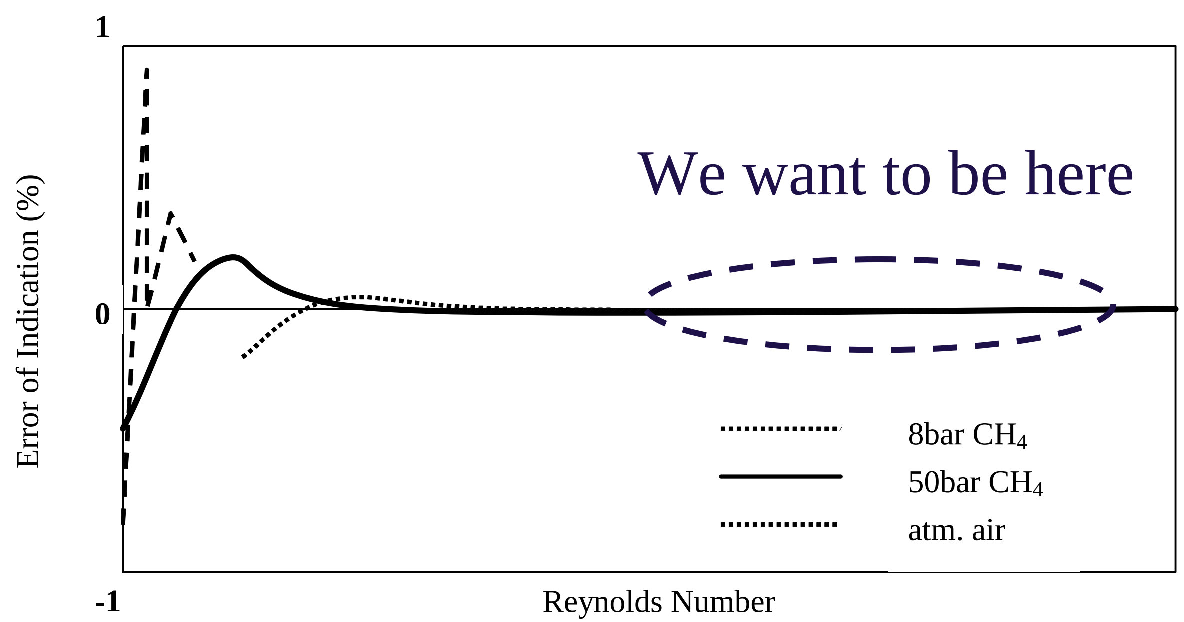
The kinematic viscosity η_k of a gas is defined as:

$$\eta_k = \frac{\eta}{\rho}$$

Therefore the Reynolds number can be rewritten as:

$$R_e = \frac{vD}{\eta_k}$$

Higher Reynolds Number Yields Less Error



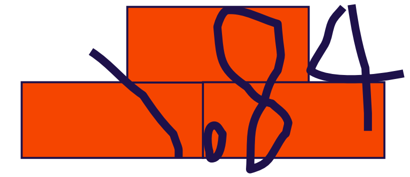
What can we do?

1. ~~Increase the average velocity *v* of the flow;~~
2. ~~increase the diameter D of the pipe;~~
3. increase the density *ρ* of the gas; or
4. ~~use a gas with lower dynamic viscosity *η*.~~

$$R_e = \frac{\rho v D}{\eta}$$

Where
ρ = density of gas
v = average velocity over a fixed cross section of pipe
D = diameter of pipe
η = dynamic viscosity of gas

The Answer: Carbon Dioxide



$$\frac{R_{e(CO2)}}{R_{e(CH4)}} = 1.84$$

This means that if CO_2 is used at a pressure of 10 bars, it would be as if the meter was seeing 18.4 bars of CH_4. The result is a lower effective test pressure required.

Carbon Dioxide Properties

Pressure (bars)	Carbon Dioxide		Methane		Density Ratio	Reynolds Ratio
	Dynamic viscosity (µPa·s)	Density (kg/m^3)	Dynamic viscosity (µPa·s)	Density (kg/m^3)		
1	14.69	1.82	11.02	0.66	2.76	2.07
8	14.76	15.10	11.12	5.34	2.83	2.13
10	14.79	19.10	11.15	6.70	2.85	2.15
20	14.97	40.77	11.32	13.67	2.98	2.26

Why Carbon Dioxide?

- CO_2 is readily available.
- CO_2 is inexpensive.
- CO_2 is non-toxic.
- CO_2 is non-explosive.
- CO_2 is non-combustible.
- CO_2 extracted from the atmosphere has no environmental impact.
- “Manufactured Gas” which is taken from other processes.

The Implications for Terasen Gas

Operational Implications	Financial Implications
Safer testing facility operations due to using carbon dioxide versus natural gas.	Smaller testing facility with smaller footprint is less cost.
Less infrastructure (i.e. pipe sizing) required to operate the facility due to lower pressure.	Greater accuracy versus atmospheric pressure testing can avoid excess costs due to Unaccounted For Gas (UAF).
Quicker turnaround due to greater heat transfer and efficiency gains.	Keeps us out of jail and reduces expensive legal fees.

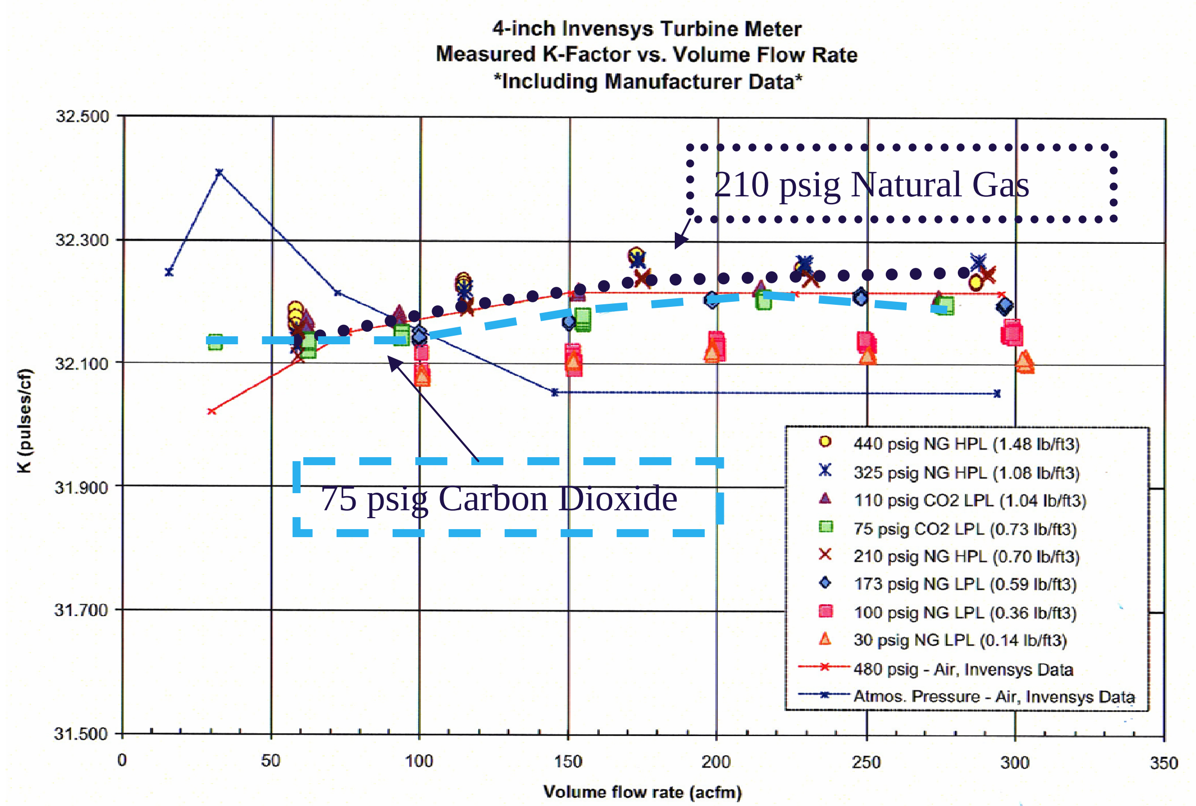
Now…does it work?

Terasen Gas

- Proof of Concept performed at Southwest Research Institute (SwRI) in late 2004.
- 4”, 6”, 8” and 12” meters were tested both with Natural Gas and Carbon Dioxide.
- Generally, the correlations between both gases at equivalent calculated pressures were within acceptable range….15%.

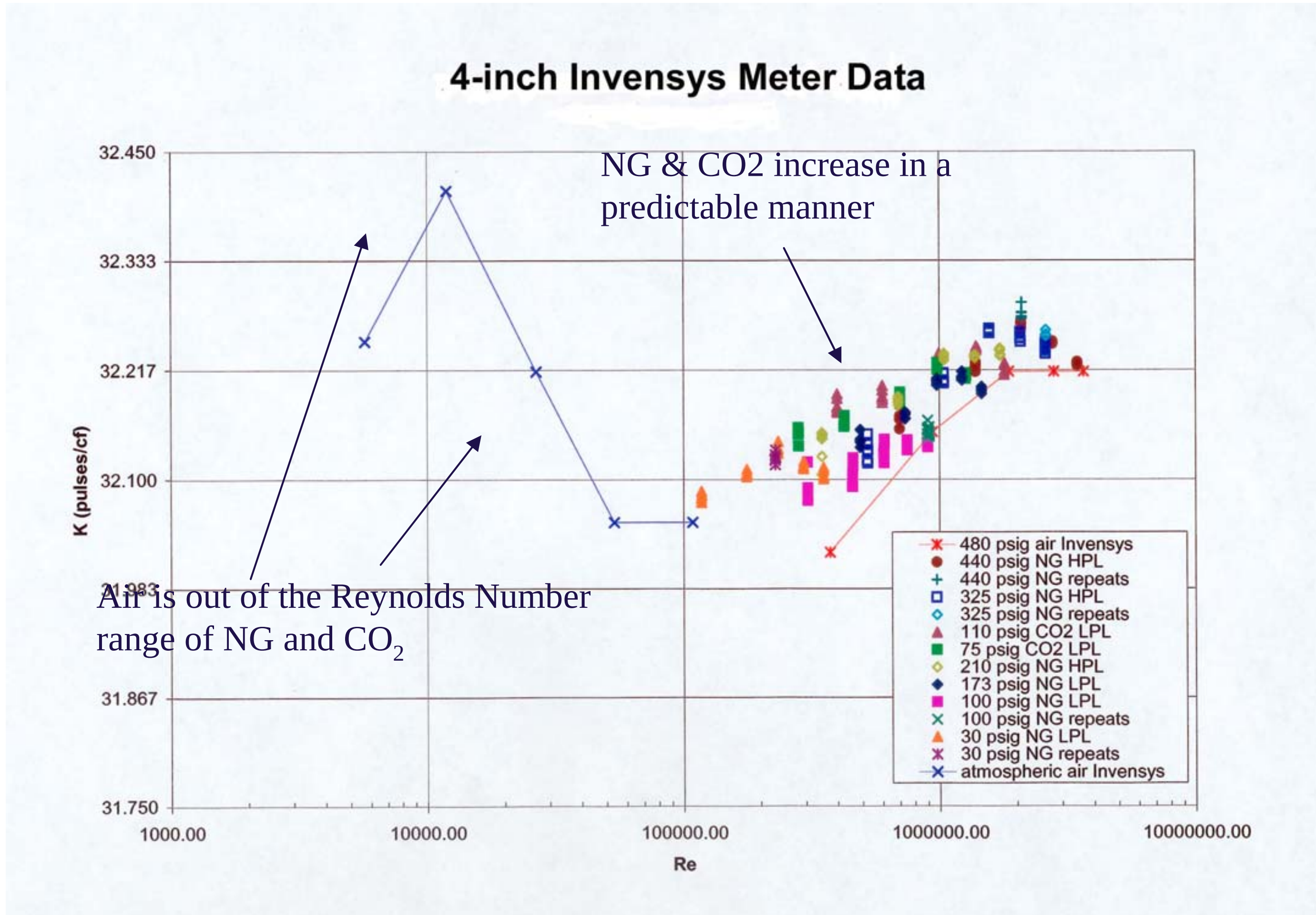
K Factor vs. Flow

terasen Gas

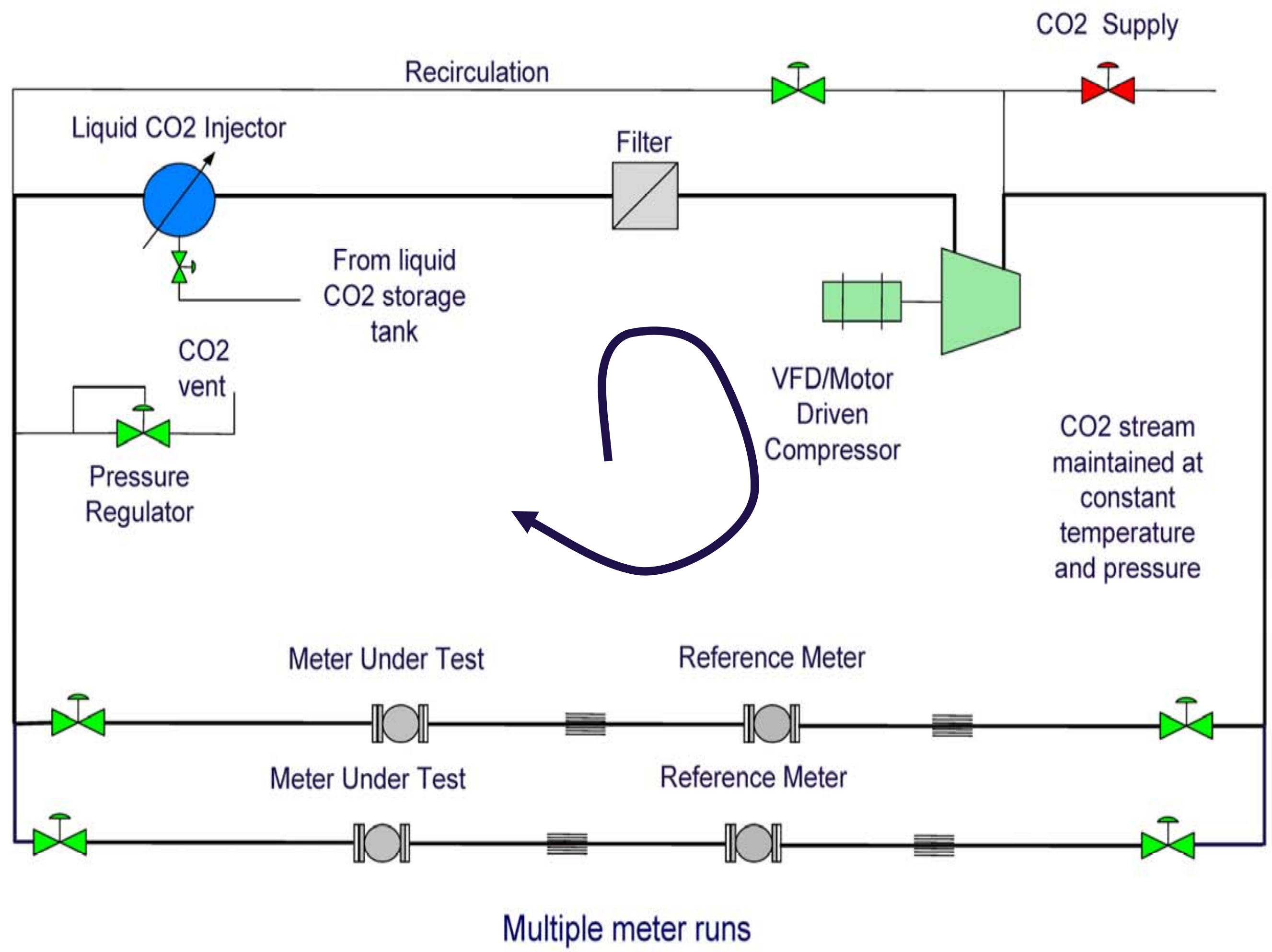


The two are equivalent pressures but different gases.

K Factor vs. Reynolds Number



MT’s Patent Pending Process



The Facility: Construction in Progress

Terasen Gas

CO_2 Tank

Indoor Piping to Reference Meters and Test Meters

Serving Terasen Gas and Others

- Will use this innovation to serve Terasen Gas, the utility using recall programs such that core service operations are not hindered.
- Will be able to serve external customers in early 2006

The Contacts

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References

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- George, D. L., GRI Topical Report GRI-03-0172, “Metering Research Facility Program: Effects of Line Pressure and Gas Density on Turbine Meter Measurement Accuracy at Conditions from Atmospheric Air to 700 psig in Natural Gas”. Gas Research Institute, Des Plaines, Illinois, USA, August 2004.
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- Alan Ranseth, “Reynolds Number Calibration of Turbine Meters”, Canadian School of Hydrocarbon Measurement, March 2005.

- Measurement of Gas by Turbine Meters, American Gas Association Transmission Measurement Committee Report No. 7, AGA, Arlington, Virginia, USA, 1996.

Questions?