Carbon Dioxide Flow Metering and Prognosis™

There are many high carbon dioxide (CO_2) content natural gas flows and pure CO_2 flows in industry. The metering of carbon dioxide is considered challenging due to some unusual CO_2 characteristics. For example, e.g. when CO_2 is present at certain flow conditions an ultrasonic meter may lose the signal due to 'wave energy absorption by molecular thermal relaxation'. CO_2's unusually low compressibility caused some concern regards DP meters ability to meter CO_2 flow, and for Prognosis™ to operate normally.

1. Natural Gas / CO_2 Mixture Flows at CEESI

Fig 1. 8", 0.564β Orifice Meter With Prognosis™.

Fig 2. 8" Turbine Meter.

CEESI carried out an 8", 0.564β orifice meter with Prognosis™ (Figure 1) test against a reference turbine meter (see Figure 2) with high CO_2 content natural gas flow. Nominal pressures of 13.5 and 49 Bar and a $2\% \leq CO \leq 40\%$ content were tested. A Gas Chromatograph was calibrated with the appropriate test gas and AGA8 & RefProp software independently calculated the gas density for the read pressure & temperatures to < 0.02%. Figure 3 shows the orifice meter performance results, i.e. the orifice meter had no problem metering the high CO_2 content natural gas flows.

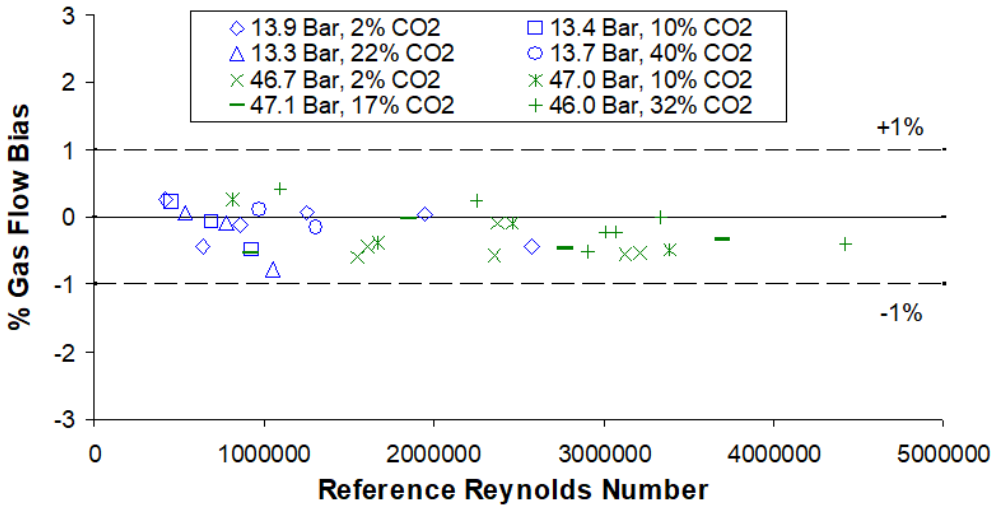

Fig 3. Orifice Meter Natural Gas / CO_2 mix Flow Prediction vs. Turbine Meter.

Figures 4 & 5 show sample Prognosis results from the orifice meter. For all data taken, the diagnostic system 'Prognosis' continued to operate normally for natural gas / CO_2 mixture with $CO_2 \leq 40\%$. DP meters used with high CO_2 concentration natural gas flows operate normally, and so does the DP meter diagnostic suite 'Prognosis^{TM}'.

These results are discussed in the technical paper "Advanced DP Meter Diagnostics – Developing Dynamic Pressure Field Monitoring (& Other Developments)".

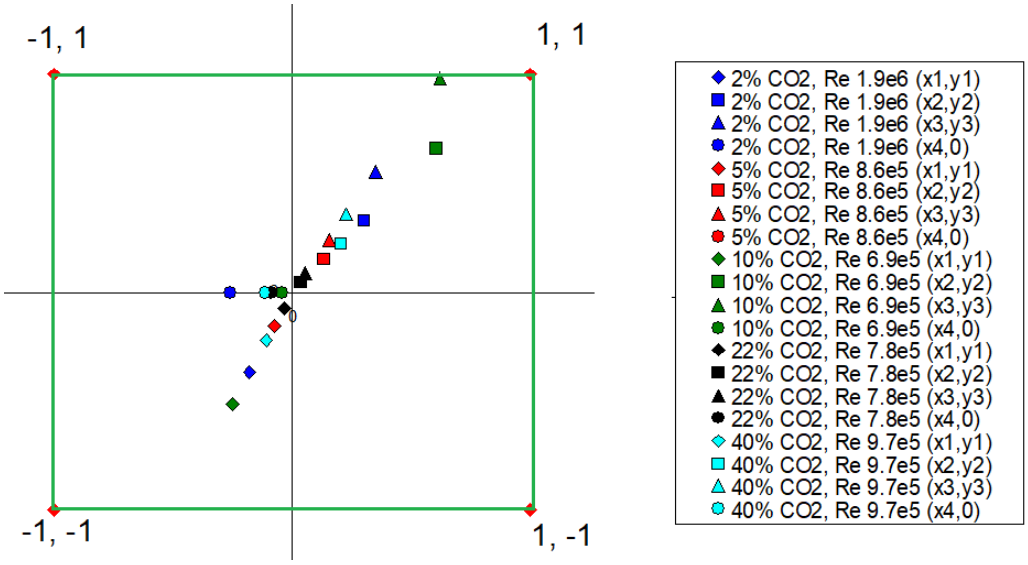

Fig 4. Orifice Meter Natural Gas / CO_2 Mixture 14 Bar Prognosis Results.

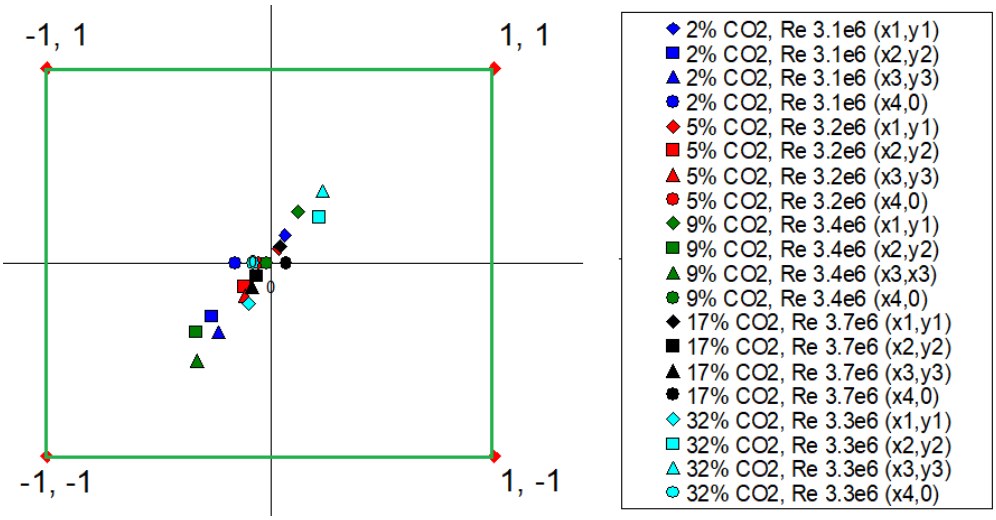

Fig 5. Orifice Meter Natural Gas / CO_2 Mixture 49 Bar Prognosis Results.

2. <u>CO_2 Flows at TUVNEL</u>

TUVNEL and the UK National Grid tested an ISO compliant 8", 0.4β orifice meter with Prognosis^{TM} with a flowing fluid of > 99.6% CO_2. The pressure range was $13 \leq P\ (BarA) \leq 20$. The test facility is shown as Figure 6. The reference meter was an ultrasonic meter which operated correctly in the small thermodynamic condition range of the tests. The standard orifice meter tests showed that the orifice meter and ultrasonic meter agreed within the root sum square of the ultrasonic and orifice meter uncertainties.

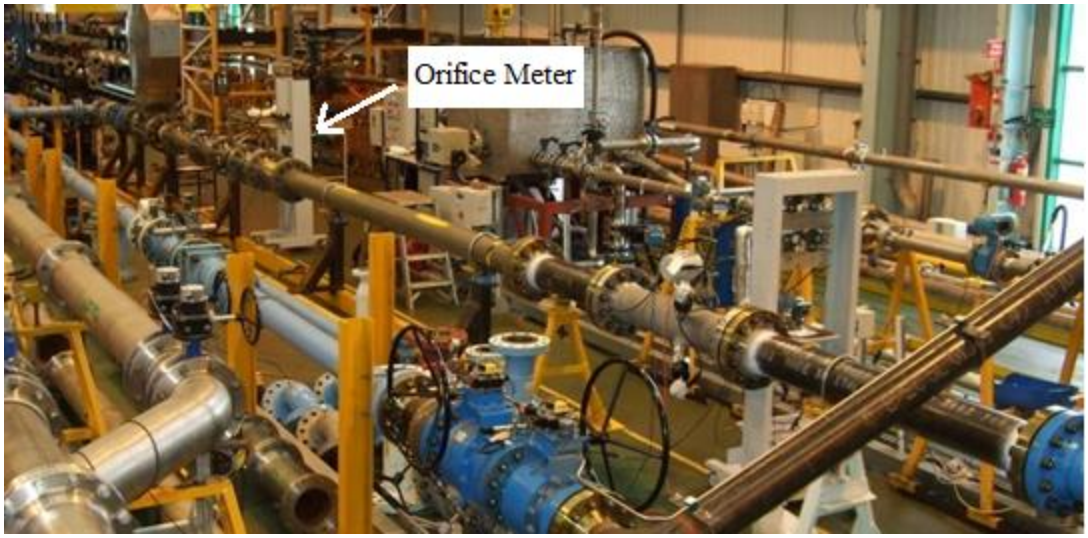

Fig 6. 8", 0.4β Orifice Meter with Prognosis™ Under Carbon Dioxide Flow Tests at TUVNEL.

TUVNEL and National Grid discussed the theoretical prediction of the Prognosis parameter 'Pressure Loss Ratio' ('PLR'). The data showed the theoretical and data fitted orifice meter PLR were very similar. Details of this research is can be found in the following technical paper: Link 1. But the fundamental result was again, the orifice meter and Prognosis operated as normal with a CO_2 flow. Figure 7 shows a typical Prognosis result for the orifice meter running with CO_2.