

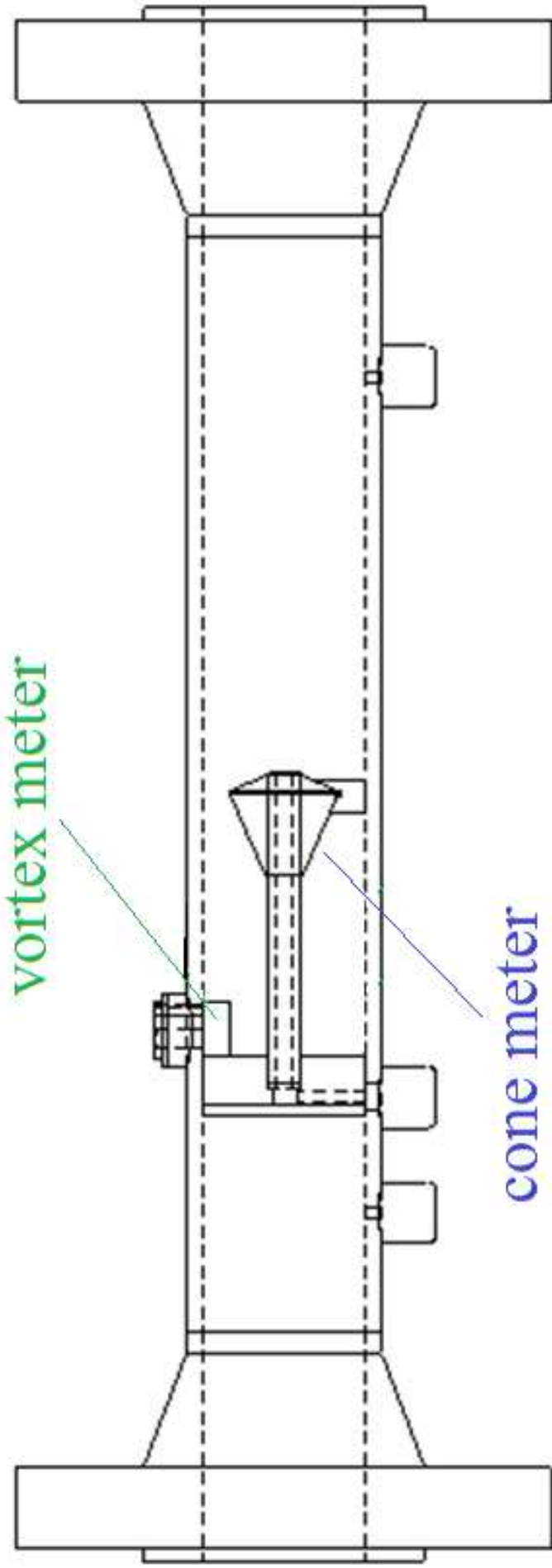
A Hybrid Wet Gas Meter Design for Marginal Fields

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Introduction

- Saturated steam & wet natural gas metering are both examples of wet gas metering.
- Most saturated steam and wet gas flows are metered by standard gas meters. But...
- *All* gas meters are adversely affected by wet gas
- The VorCone meter is designed as a gas mass meter, i.e. it predicts gas mass flow and density.
- It can also be applied to wet gas metering..



vortex meter

cone meter



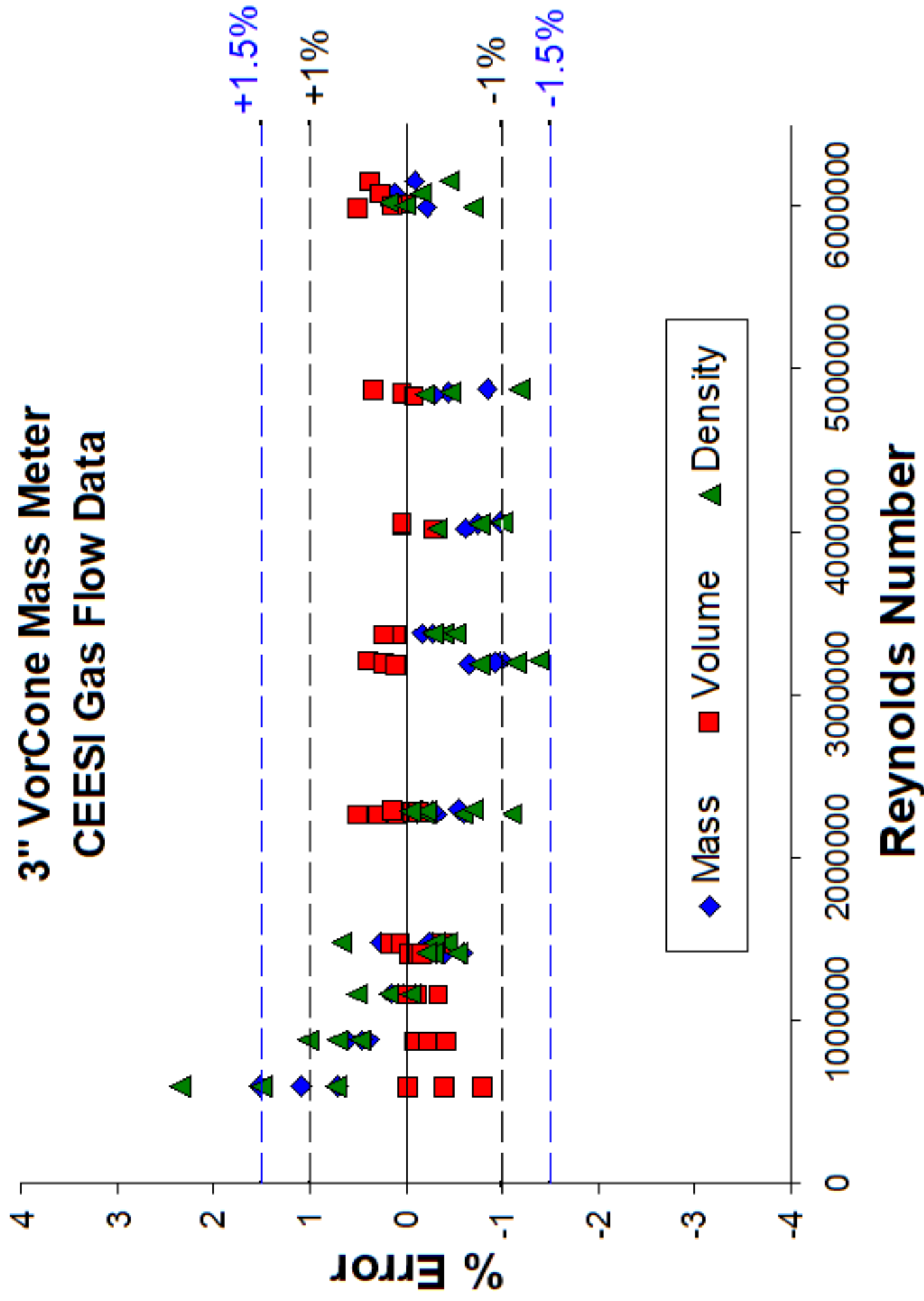
The VorCone Meter as a Mass Meter

- Coupling density insensitive & density sensitive volume meters gives mass flow & density.
- A vortex meter predicts gas volume flow ' Q_v ' without needing to know the fluid density.
- A cone DP meter can predict density from a known volume flow rate Q_v . Therefore:

$$\rho = f(Q_v, \Delta P)$$

$$Q_m = \rho * Q_v$$

3" VorCone Mass Meter CEESI Gas Flow Data



VorCone Meter and Saturated (Wet) Steam

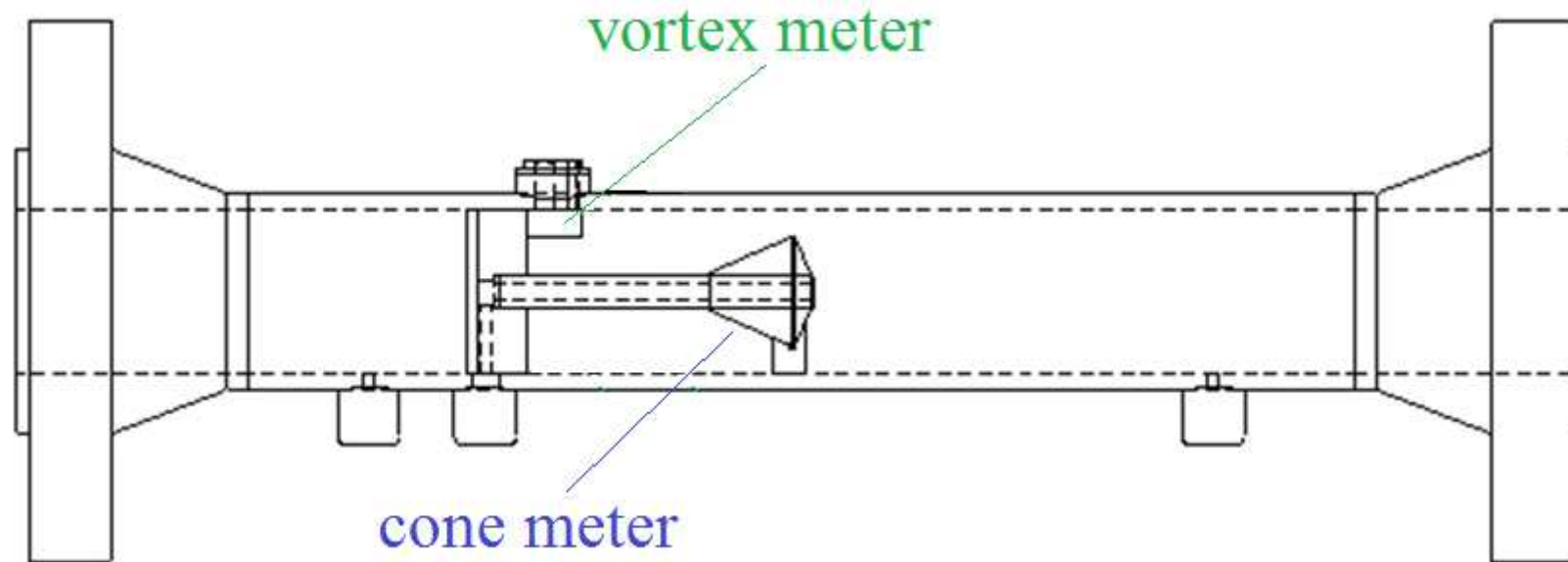
- For known water and steam densities (from steam tables), wet gas flow metering has two unknowns:

$$m_g \text{ \& } m_l,$$

i.e. m_l & the quality 'x'

$$x = \frac{m_g}{m_l + m_g}$$

VorCone Meter with Saturated Steam



- Model the 2-phase flow as a homogenous mist flow, i.e. a pseudo-single phase mixture flow.
- Vortex meter predicts homogenous mixture volume.
- VorCone then meter predicts homogenous density.
- Phase densities known from steam tables....

from vortex meter

$$\rho_{\text{hom}} = f(Q_{\text{hom}}, \Delta P_{\text{hom}})$$

from steam tables from
combined meter

$$x = \frac{\rho_g(\rho_l - \rho_{\text{hom}})}{\rho_{\text{hom}}(\rho_l - \rho_g)}$$

found

from
combined meter

from steam tables

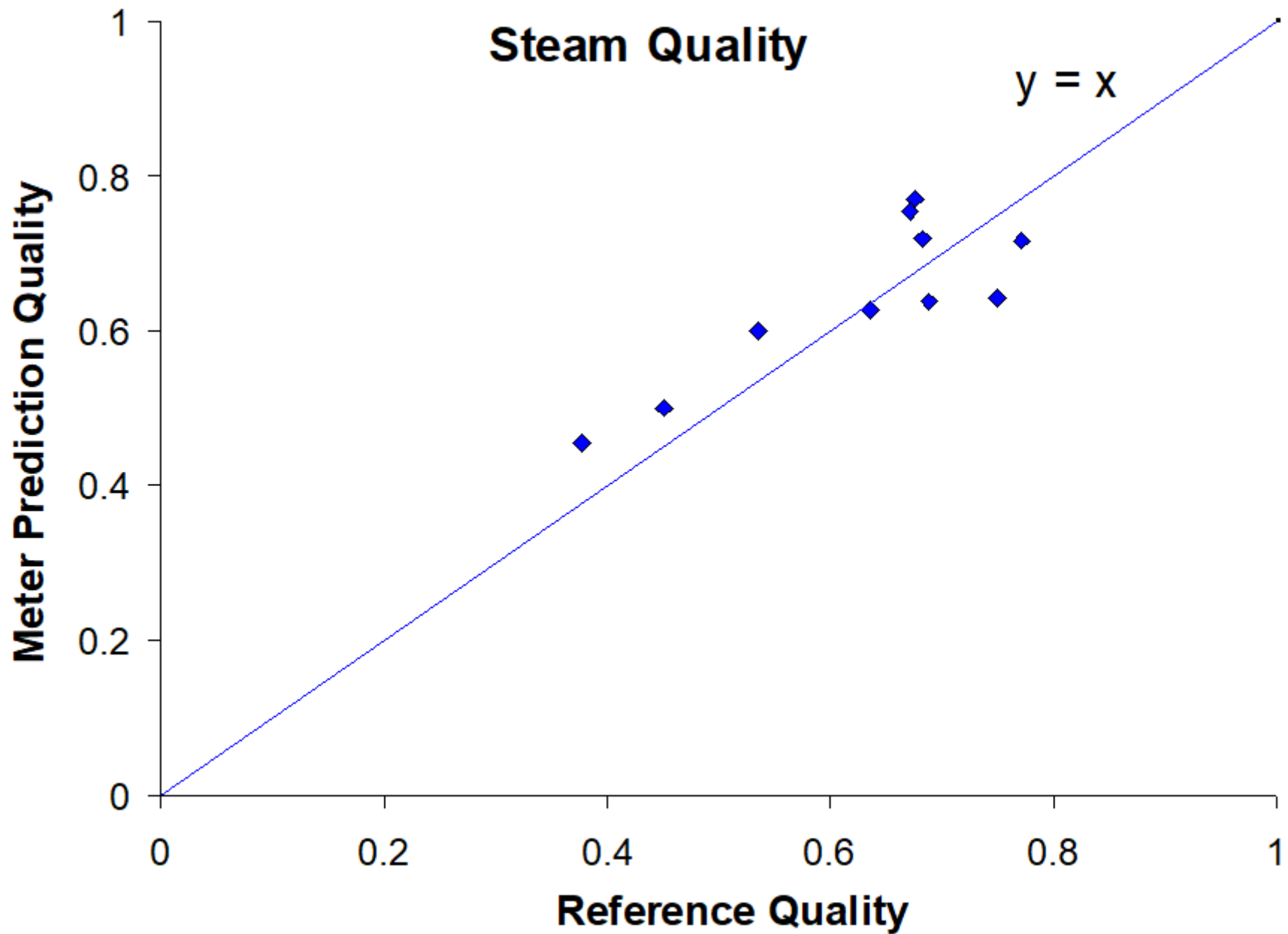


- 2" VorCone Meter installed at saturated steam oil well injection point. (82 Bar)

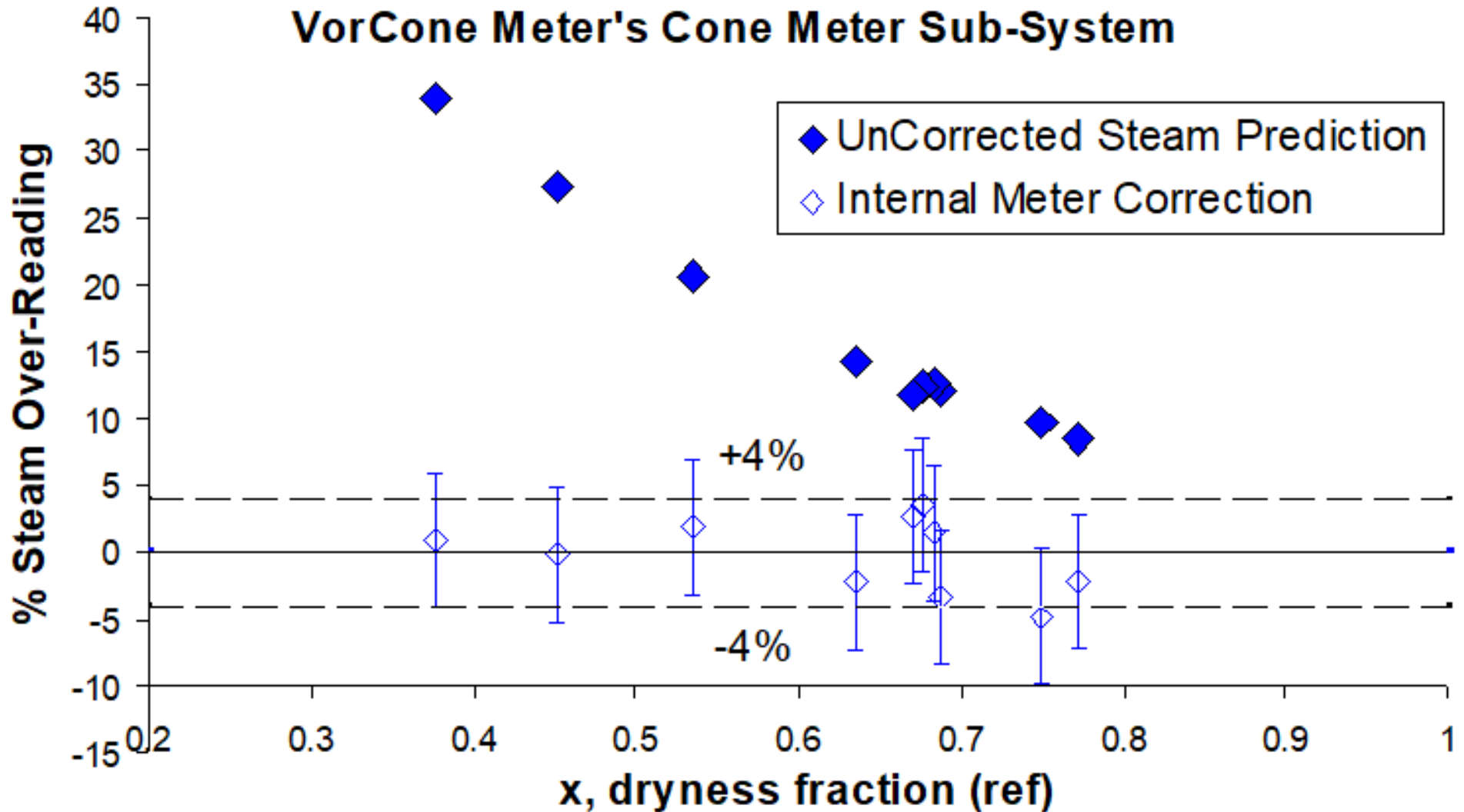
- Portable truck compact separator with Coriolis gas and liquid reference meters.



As Found (no data fitting)



Applying ISO TR 12748 Cone Meter Wet Gas Correction with VorCone Meter Predicted x



← getting wetter

3" VorCone Meter Boiler Outlet Location

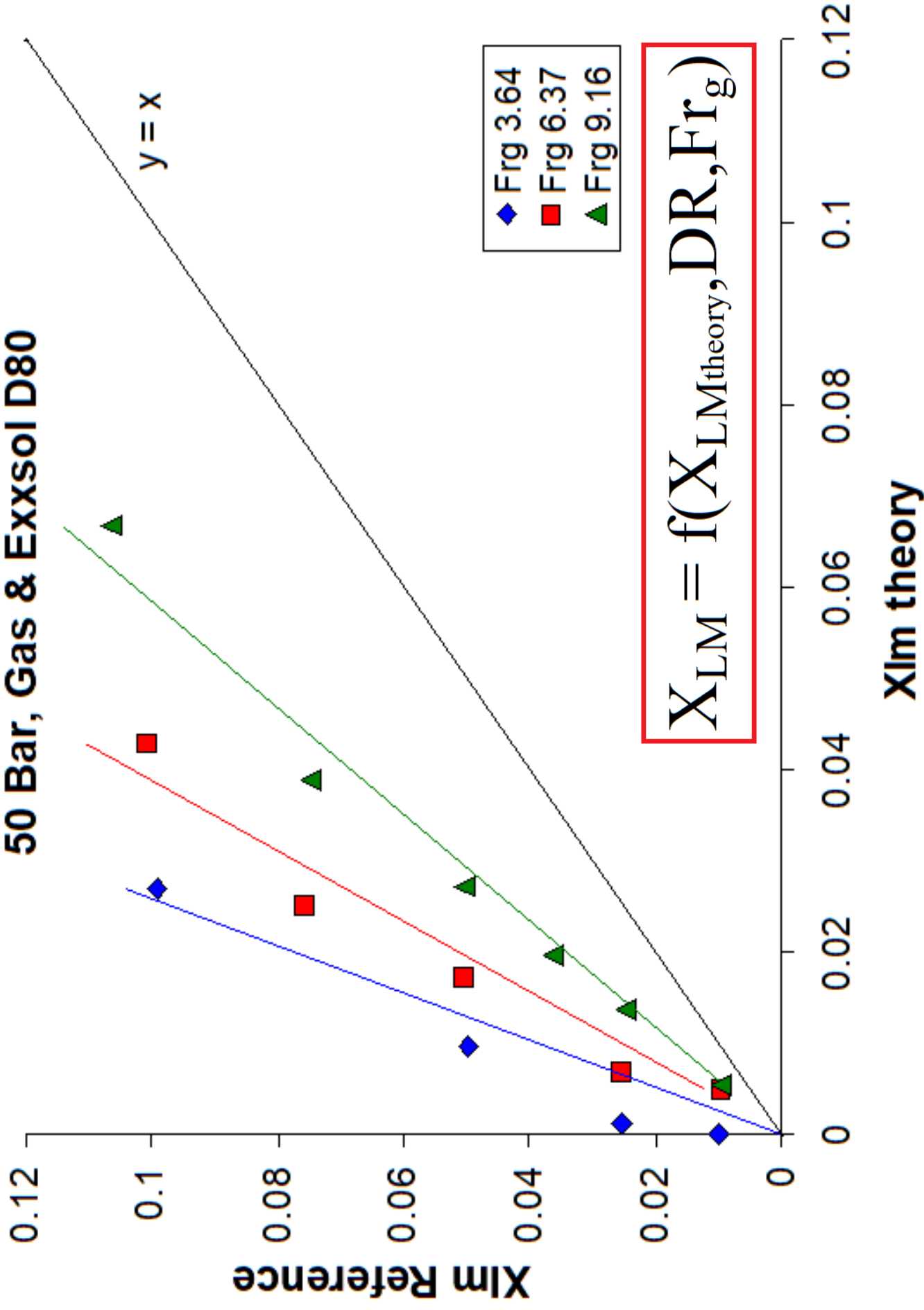


3" VorCone Meter Wet Natural Gas Testing



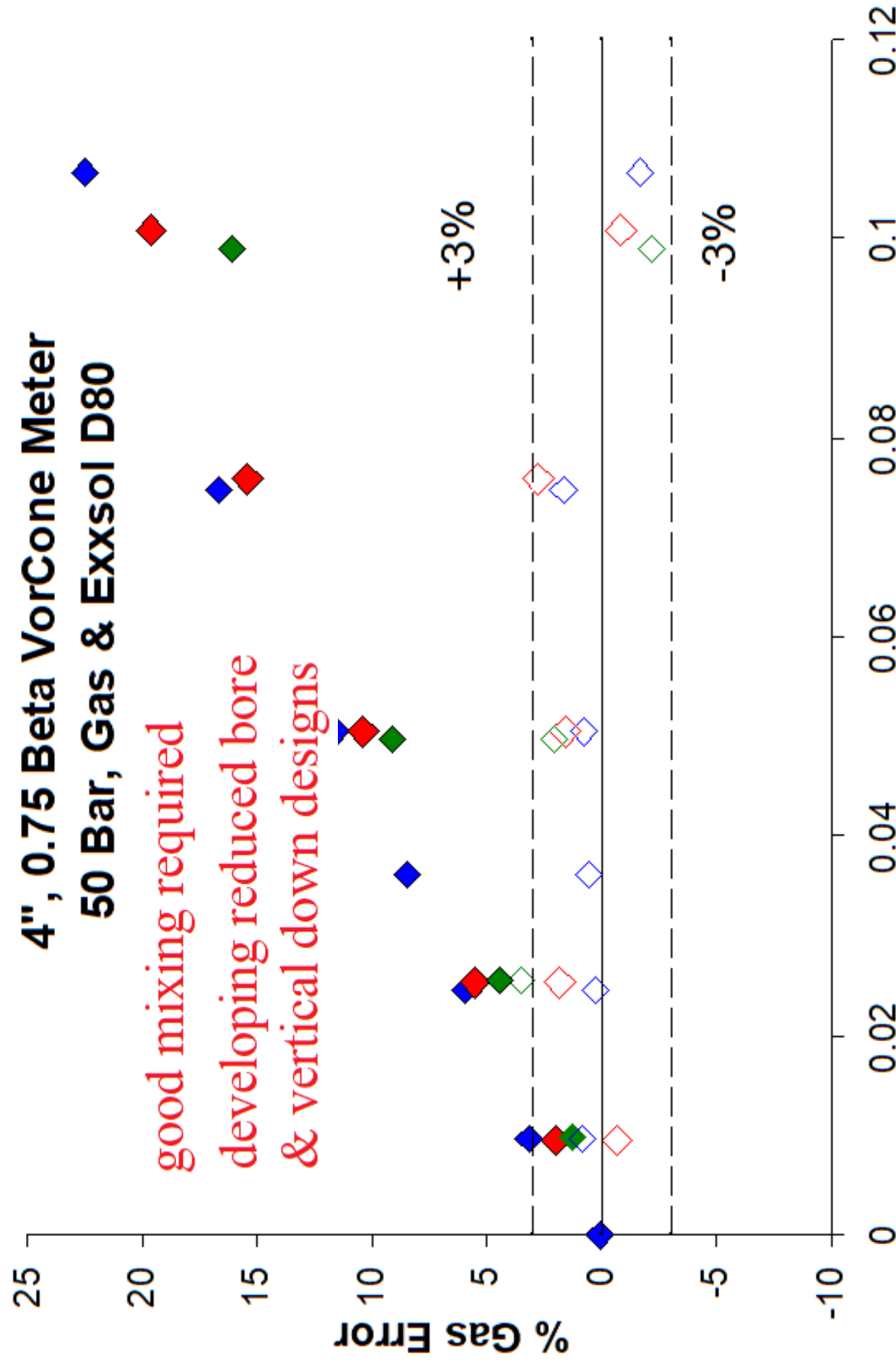
- The higher liquid surface tension means the flow through the VorCone meter can't be modelled as homogenous, a data fit is required.

4", 0.75 Beta VorCone Meter 50 Bar, Gas & Exxsol D80



4", 0.75 Beta VorCone Meter 50 Bar, Gas & Exxsol D80

*good mixing required
developing reduced bore
& vertical down designs*



Conclusions

- In single phase service the VorCone meter predicts gas mass flow to $< 1\%$ with no density input.
- Saturated steam flows are usually metered by gas meters, giving liquid induced gas prediction biases.
- Correction factors (if they exist for a given meter) require an externally supplied liquid loading – *which is usually not known*.
- The VorCone meter can internally predict the liquid loading, then apply a 2-phase flow correction factor, thereby also predicting the gas (and liquid) flow.

Thank you Questions?



MONITOR, VERIFY, AND TRUST YOUR DP METER



Azbil North America, Inc.