

Wellhead Metering Using V-Cone® Technology

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Abstract:

In the areas of Hydrocarbon Exploration and Production, removal of hydrocarbons are becoming increasingly dependent on injected and re-injected fluids to facilitate hydrocarbon release; as new smaller wells and existing well life spans are being forced to increase with age.

A large part of the fluids used in this process are fresh and salt (sea) water, natural gas, and some man made fluids.

Management of these fluids can be critical, when written contracts for the supply are based on unit volume costs. Correct loading of the well injection rates has to be implemented so peak production is maintained.

Too much fluid can result in poor gas quality (e.g. wet gas) and possible sub-surface geological change, whereas, too little can result in poorer production and product volumes. There is a fine line between these two states.

Good repeatable measurement of the constituent parts of the process can save money and time and also improve the production and life span of a hydrocarbon well through better fluids management.

Different technologies exist to achieve the goal.

This paper describes the McCrometer V-cone D.P. meter as currently used by the Oil and Gas industry in the role of wellhead injection and allocation metering in on-shore, topside and sub-sea production applications.

U.S. Mainland Oil and Gas Development:

The USA has been synonymous with Oil and Gas production for many years. Since the first wells were drilled in the early 1900's, the expansion has been dramatic with U.S. holdings controlling approximately 60% of the worlds O&G production and exploration.

It is hardly surprising to learn that the U.S. resources are dwindling at a high rate due to the early start and exploitation of the reserves.

New hydrocarbon product finds are being forced to more costly world regions with smaller yield rates and return on investment. New ideas are being conceived to help produce the energy requirement. Now major hydrocarbon supply companies are involved in producing both mineral wealth and energy wealth, the two being interlinked by a common factor - Natural Gas. This product is now in reduced supply so new ideas and concepts are needed to maintain these future supplies.

Fig 1.0 shows the volatile changes in the supply chain from a 50's baseline

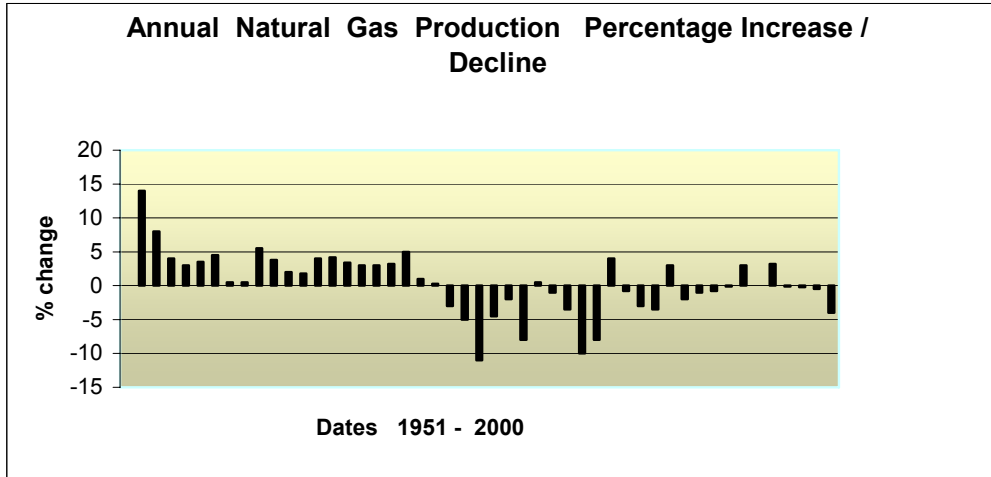


Fig 1.0 USA Gov Data

Coal Bed Methane:

Land based gas production in the U.S. is currently experiencing a boom in a new area Coal Bed Methane (CBM) Production. De-regulation of land has allowed various independent companies to set up and exploit this simple bio-generated product. Demographically Wyoming and Montana have the greatest coal deposits and largest production possibilities. The Powder River Basin in Wyoming is a region with one of the largest gas deposits due to bio-generation.

Fig2: CBM region indicated



Fig 2

During the land deposition and compaction over time of organic material which ultimately becomes coal, large quantities of Methane gas are generated. Methane gas produced from coal has a lower energy (BTU) content than other natural gases produced from hydrocarbon wells. Methane is trapped by “adsorption” in the coal’s micro pores.

Extraction is simple and effective. Cash flow to the producer returns more quickly with joint venture alliances being set up. Gas production has increased 18 fold from about 55 MMcf/day in 1998 to greater than 1,000 MMcf/day and is increasing as wells are brought on-stream.

Well Methodology:

A simple well is drilled using a truck-mounted drill assembly (potable water drill equipment is normally utilized). This allows a quick turn-around/completion and easy movement of the equipment at low cost. The depth of the wells may vary from 400 - 1000 feet, or more.

A well-head manifold is fitted at the surface with twin piping return systems:

- a) Water Extraction Line with topside metering and submersible water pump;
- b) Gas Emission Line with either local well-head meter or a lateral line to a multiple meter system and pod building. (See Fig 3)

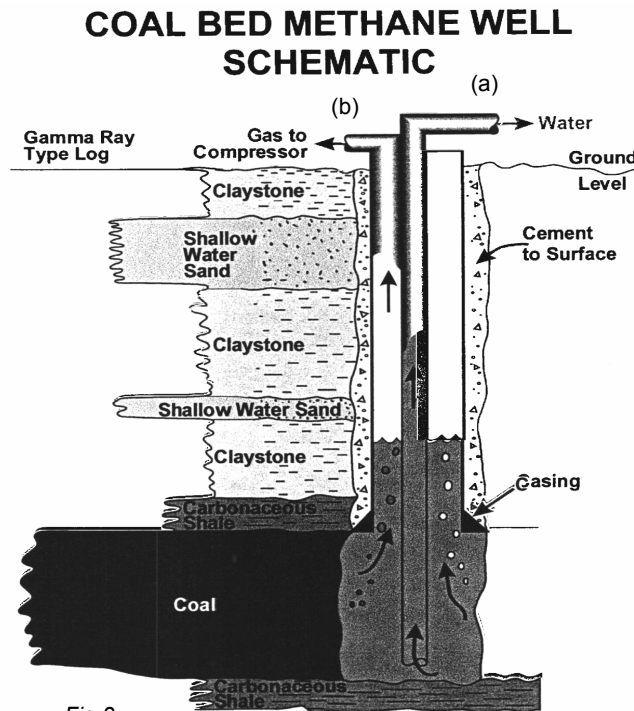


Fig 3.

Gas Production is generated by creating a partial pressure drop above a water column down-hole. By pumping water from the well column, gas is released into the well cavity which then is piped through a meter system or single well head meter. The water drains into the column naturally from the local ground aquifer into the well. Advancement in small P.L.C. controllers has allowed the method to be successful with monitoring and control of fluid level using a down-hole variable speed drive pump and liquid level sensing technology.

Metering Methodology

Two metering methods are currently used and approved locally: a single well approach with Small Housing /Frost box, or a Multi-Stream system with larger pod building and multi-stream meter runs.

The systems comprise:

1.0 V-Cones with EFM & Charts: (Single wellhead & Pod system) *See Fig 4*

2.0 Orifice with EFM & Charts: (Pod system only due to straight run requirement).
See Fig 5 and Fig5a

Gas Production Philosophy

Meters used 2 and 3 inch diameter, McCrometer Wafer-Cone[®] or Orifice (pod style only).

Volume Measured 250 – 1000MSCF/day/well.

'BLM' System approval or waivers needed for 65% of the U.S. areas.

V-Cone has approval in these areas.

Measurement is well head allocation.

Accuracy requirement at +/- 1.5% with +/- 0.1 % repeatability.

Well Production Life is usually about 5-10 years (from start up).

'BLM' = Bureau of Land Management.

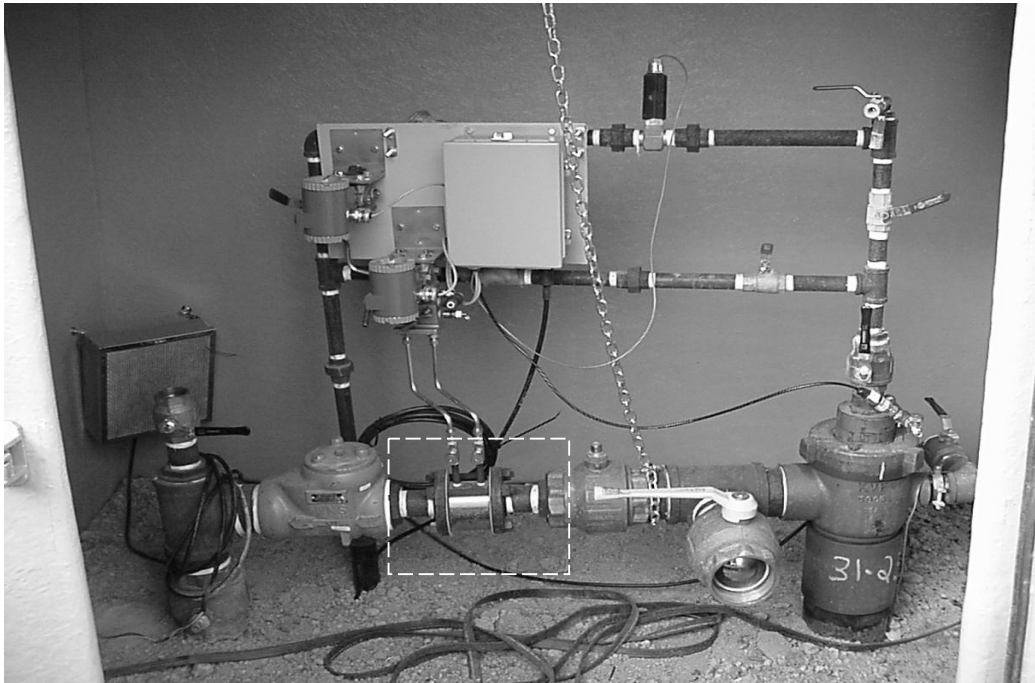


Fig4: Typical Single Well-head Manifold Wafer-Cone design

Note: Single wellhead metering is deployed to keep installation costs down.

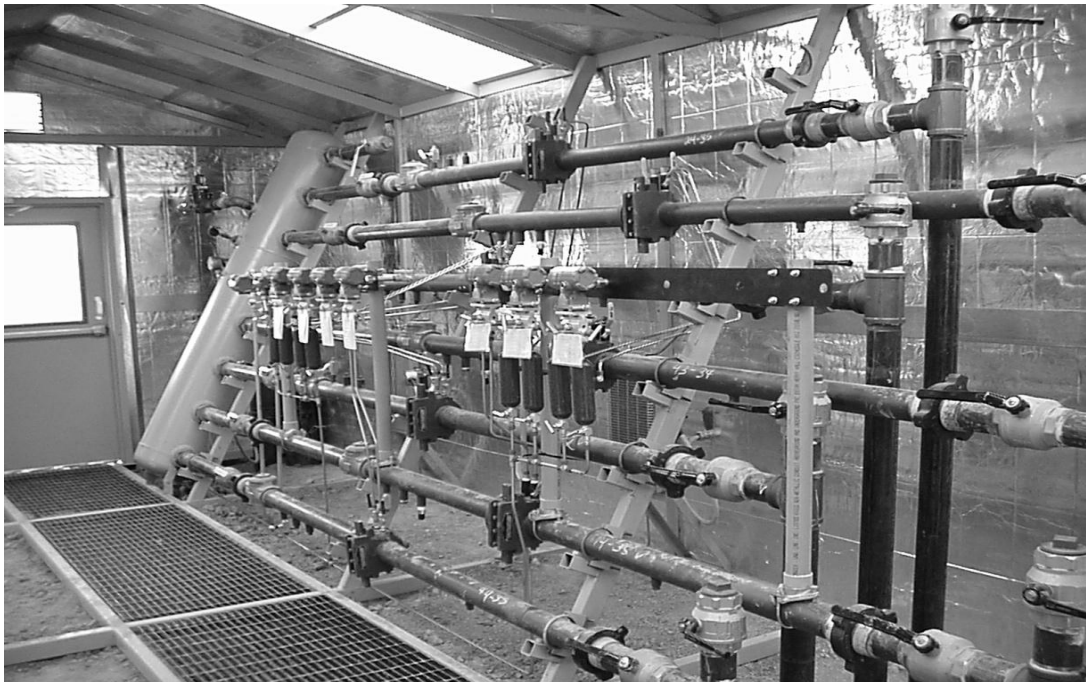


Fig 5: Pod Building Design Using Orifice Meters (envelope for 7 units)



Fig 5a: Pod System Wafer-Cone (16 units in same envelope as 7 orifice)

Well Production and Reserves WY/CO:

By 2006 it was estimated there were over 35,000 functioning C.B.M wells in place in the Wyoming/Rocky Mountain region of the U.S. A further 35,000* planned wells are also being considered. This will enhance the energy supply market two fold particularly since the CBM gas is used for electricity production in the main, and currently accounts for approximately 6-8% of the U.S. gas production*. The key to rapid growth has been government support in spite of environmental concerns, teaming up with independent producers in the Powder River Basin of Wyoming who can move the product to market quickly. Producer cash flow is more rapid since a quick ROI is shown with pay off in under 6 months on multiple well systems. Recently the UK government reviewed C.B.M. as an alternate fuel source and is encouraging companies to look at extraction methods. (* U.S. Gov't. data.)

Meter Performance and Wet Gas:

When the BLM reviewed the V-Cone, it had no API/AGA paper standard currently written. They used a common sense approach to giving local usage waivers. This was a milestone, since generally only equipment to API/AGA approved design standards were allowed on BLM royalty/ fiscal sites.

The evidence of wet gas performance and long term usage in this environment was a major factor in the acceptance process for the V-Cone. Data was collected from various test sites, as well as from lab test data with wet gas, and historical data from Europe. Real time field data was also collected at numerous sites to prove the congruency of the systems.

Orifice carriers with suitable installation and straight run where used in series with the wafer v-cones for many months over the late 1990's. The AGA orifice being accepted as a baseline standard allowed a judgment to be made for Wafer-Cone acceptance.

The U.S./BLM guidelines for these types of installations allow an accuracy of the primary elements to be within a 3% spread per well, over the total number of well sites per block, determined against a final measurement point on a daily basis. This is usually an API/AGA installed orifice plate run and carrier with a water knock-out system usually controlled by the buyer of the Coal Bed Methane.

Producers/Sellers use the well-head meters as an allocation and monetary control method. The BLM have Royalty issues with the land when the producer's property is under BLM mineral rights control, and have the authority to inspect the metering stations on a three month or sooner basis.

One advantage which is being pursued is an extension of the inspection time periods due to the V-Cone's stability and resistance to contamination effects. This being primarily because the V-Cone's beta edge is downstream of the flow and offers a smaller "hold-up" effect than some other devices used. The BLM indicated a benefit to lower man hour and intervention costs from this premise.

V-Cone Comparison with Orifice Plate

During May 1999 data was collected over 12 days to substantiate and prove the V-Cone in the field, this was just one of many initial tests performed.

See: "Fig6" Comparison Data

Some data was kept confidential by the independent producers. It was interesting to see the tracking of the V-Cone at the lower range, since the turndown from previous experiments show the unit to be able to track at 10-1 with good transmitter electronics. Data from other non-CBM hydrocarbon gas wells were also taken under BLM control. The results of these tests were significant from a contamination issue and are shown below.

MSCFH "Methane"

V-Cone	Orifice
13.49714	13.57075
12.87945	12.62116
12.78973	12.66047
12.85667	12.65072
12.45696	12.61632
12.30934	12.57247
12.35687	12.57234
12.60535	12.52417
13.34383	12.98792
13.24761	13.36709
13.23957	13.33471
13.14056	13.22961

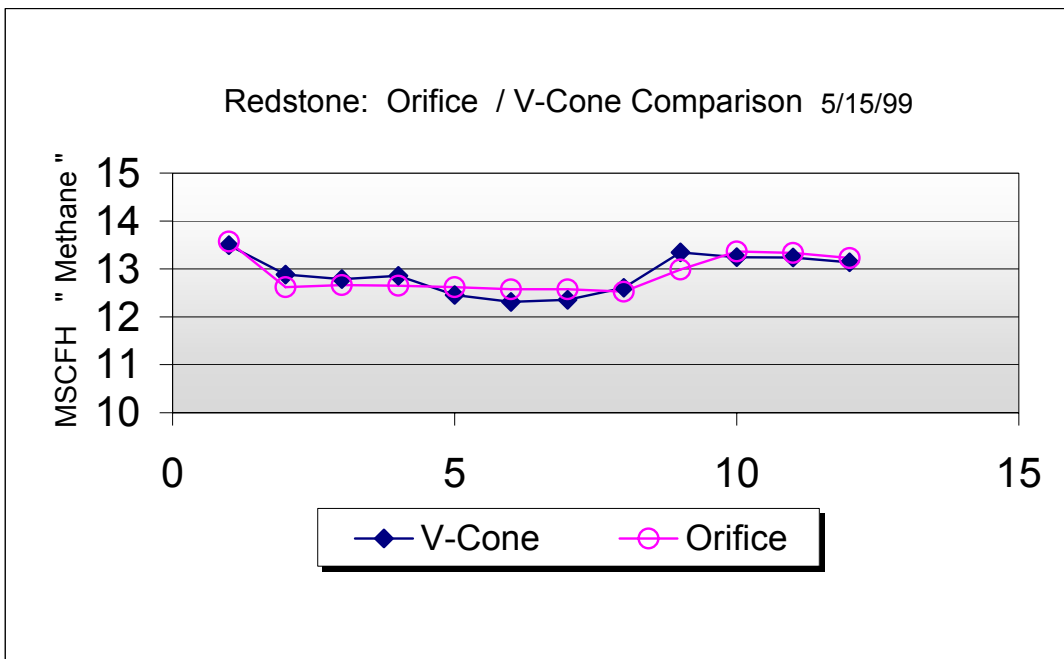


Fig 6 Comparison Data

Wet Gas Lab Test At CEESI, Nunn CO.

Recent testing at CEESI indicated a low susceptibility to Cd change with a liquid load. Base line values were plotted against numerous test loop instruments in a dry condition. Flow rates from 7 –70 feet/second in a 4 inch line size were used. The liquid rate was added to a maximum of 1 and 2 Bbl per MMSCF. The liquid hydrocarbon was a Decane derivative acceptable for use in closed surroundings.

The results were plotted and the effects noted. Further work is underway to see the effect of low D.P. ranges on repeatability and accuracy and Y factor changes.

(See Fig 7a & Fig 7b) - (CEESI = Colorado Experimental Engineering Station).

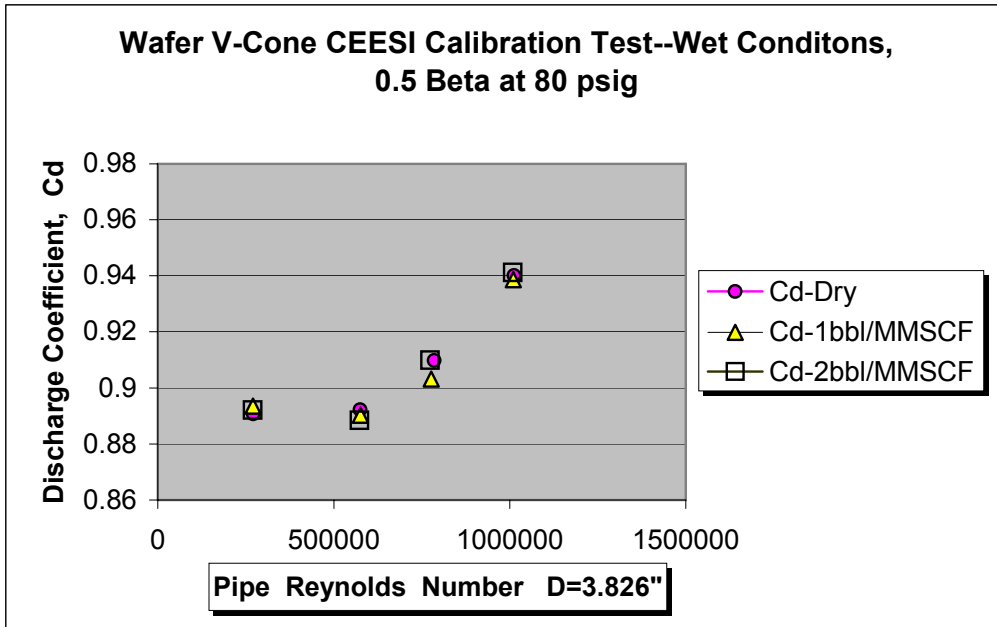


Fig 7a

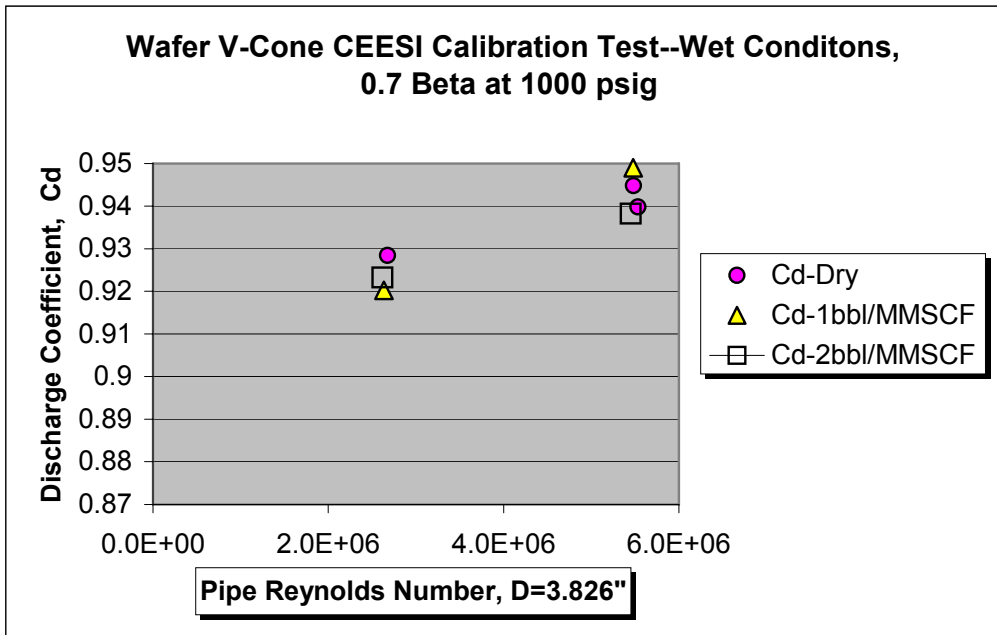


Fig 7b

Longevity, Contamination, and Beta Edge Damage Lab Test

During late 1998 and early 1999 test meters were installed at an on-shore hydrocarbon facility in central Wyoming. The site was producing dirty wet gas with H₂s and asphaltene contaminants. The result on the existing measurement system was not very pleasing to the client or to the local BLM office that collects royalties from these gas systems. The use of the Wafer-cone was to see if the contamination would affect the meter. The assumption that it would work was a driving force to implement the installation. Three-inch (3") inch meters were fitted and the most severe well used as a test site. See Fig 8a & Fig 8b - "Orifice Trash Deposits"

Front and Back of Plate after 3 months in service (Nat Gas + H₂s)

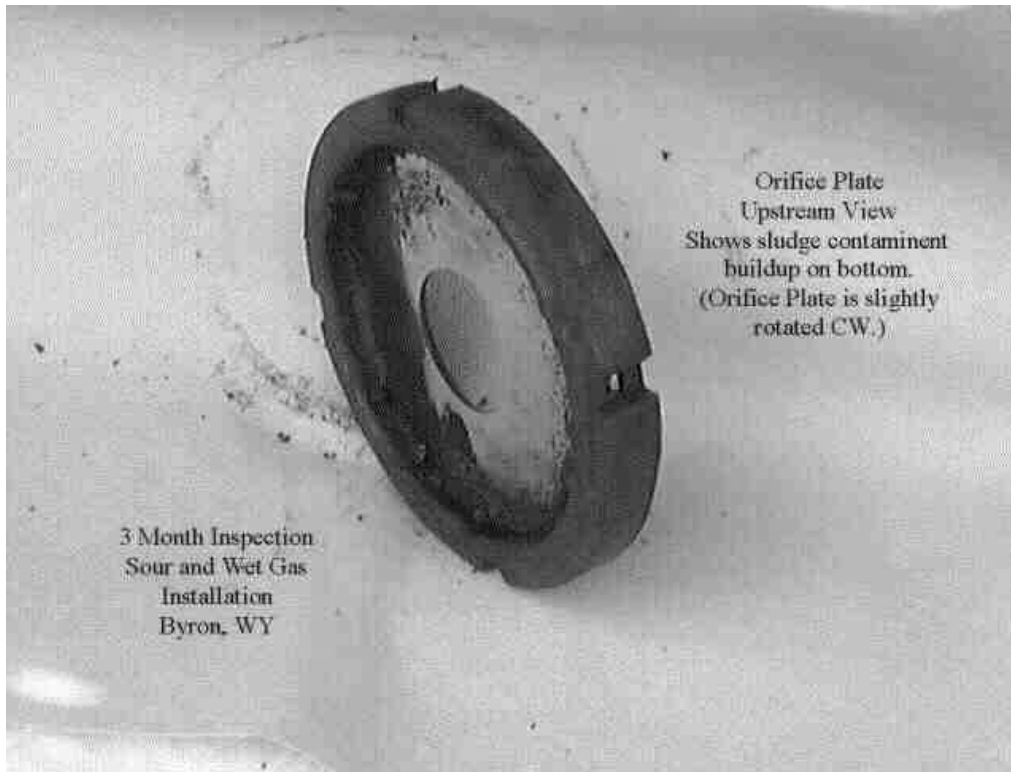


Fig 8a

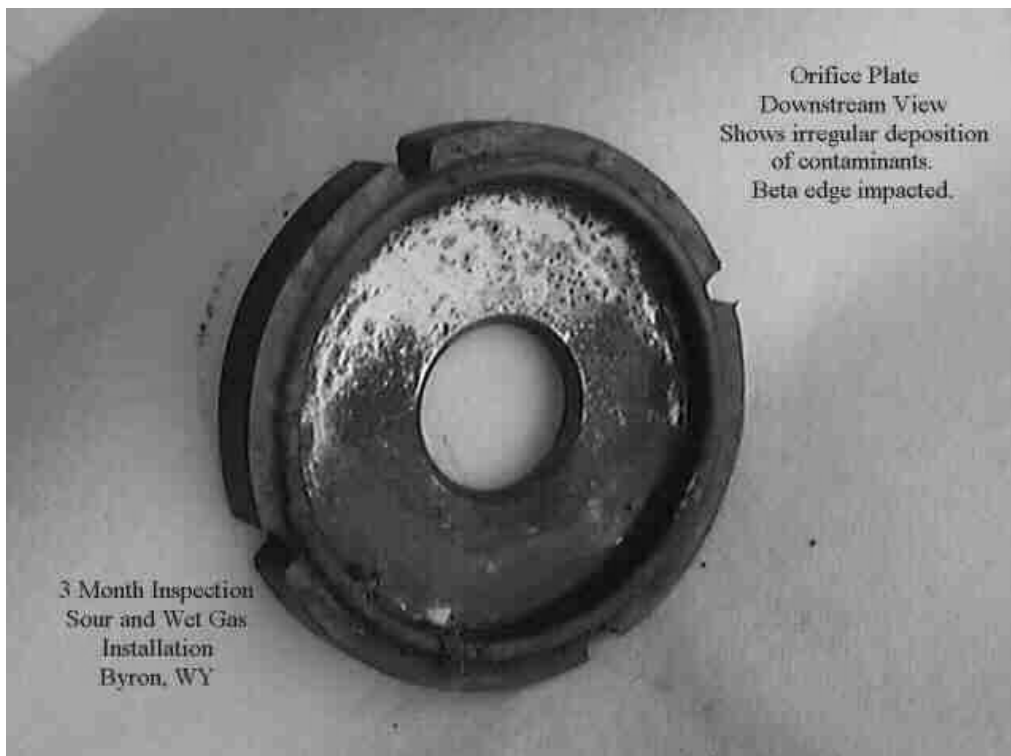


Fig 8b

Wafer-Cone after 9 months of service in the same line (Nat Gas +H2s)

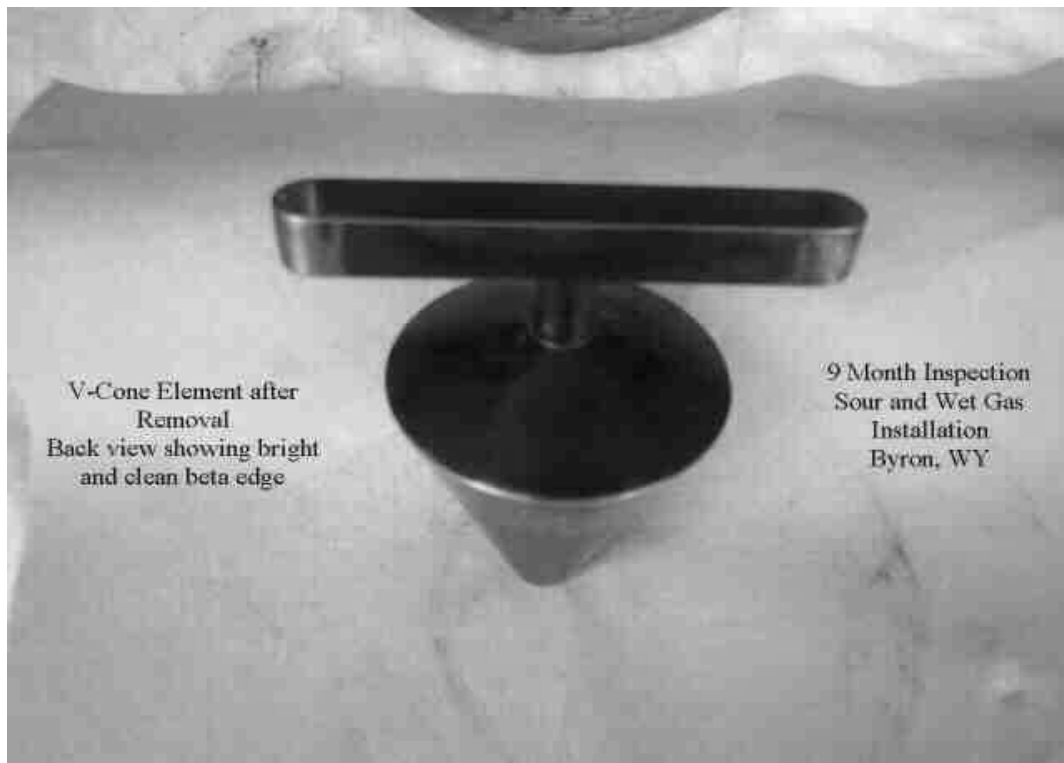


Fig 9



Fig 10

On inspection, the orifice plate units showed build up after only three month's usage with Asphaltene/Paraffin deposition at the up-stream inlet to the meter and contaminants after the plate in the low pressure region.

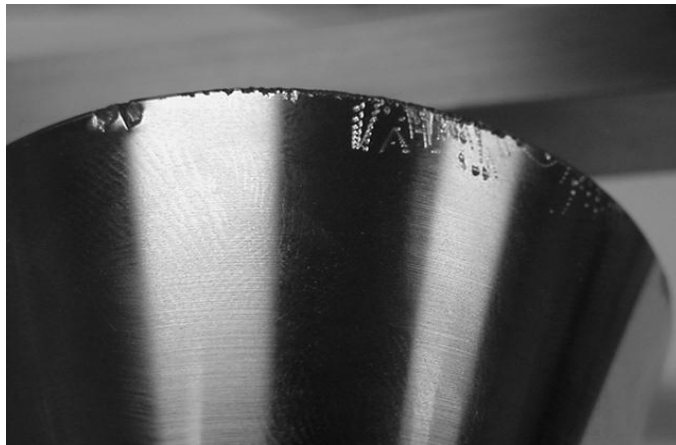
The Wafer-cone unit, on inspection, did not show the same problem severity, probably due to accelerated flow around the cone element. (Fig 9 & Fig 10) This seemed to keep the cone and sensing ports clear of deposition, thus maintaining a consistent D.P. across the meter. The entrained condensate liquid moved into slug flow condition periodically, which caused liquid to enter the orifice sensing lines and also be retained after the plate. The Wafer-Cone meter did not show this problem due to the straight through design. The regular blowing off of the plate was deemed a severe problem in man hours and traveling to the site, plus the effect on accuracy this caused. With the lack of liquid retention using the V-cone, the system now runs within the BLM guidelines.

Damage Test

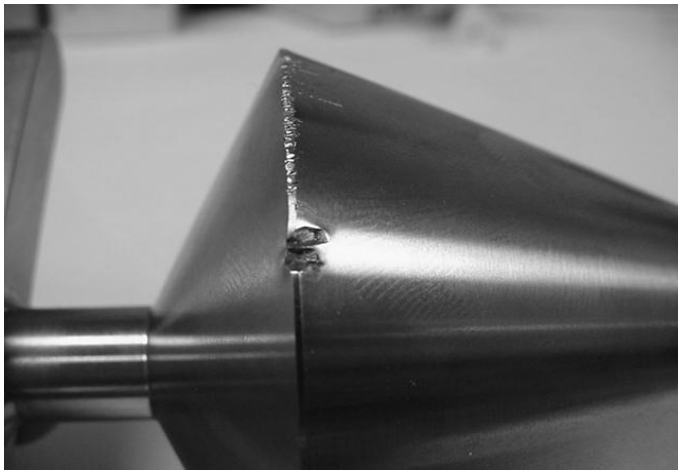
Damage testing of the Wafer-Cone was recently performed, this involved determining a base line on a calibration rig over several flow rates, after which intentional damage to the cone beta edge was performed in a somewhat severe manner.

The photographs and data * are shown below. (Fig 11 through Fig 12)

Front view of cone



Figs: 11 & 11a



Side view of cone

(*Lab Work and Test Data by Robert Pinkerton, McCrometer Inc Flow Lab, Hemet, Ca.)

Test Results

The deviation from the test shows the C_d shifted upwards by approximately 0.3% which is within the uncertainty of the McCrometer calibration station. This initial test is currently being superseded by further tests with multiple damage regimes to view the effect per incident. This work is a pre-courser to the use of the meter in a sub sea "non-intervention" environment.

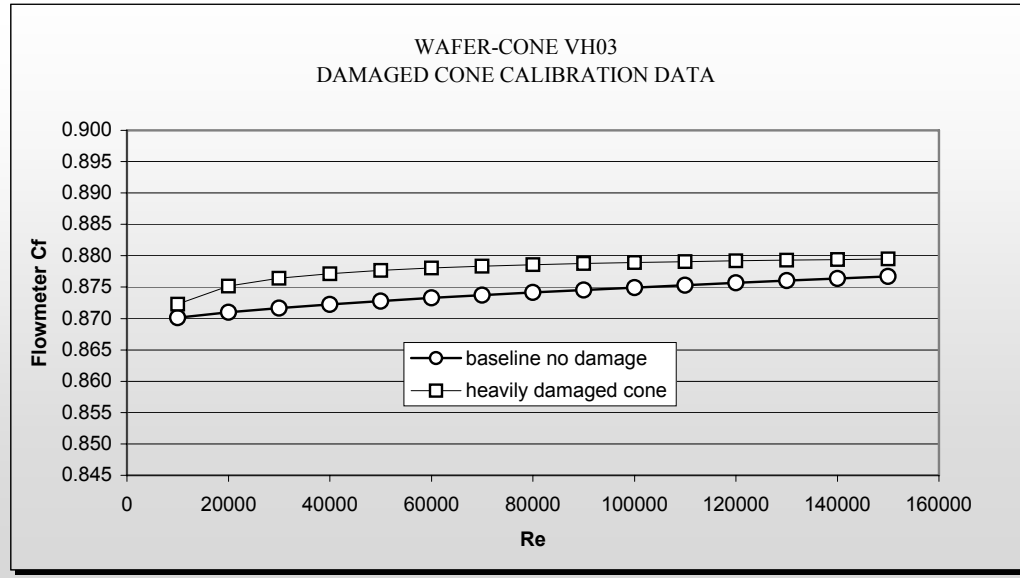


Fig 12

Sub Sea Implementation and Design

Currently 35 precision tube units are in service in a sub-sea wellhead marine environment, in the U.K., Norway, Angola, and the South China Sea area. The main usage has been water injection metering; however, allocation gas metering has been a recently accepted philosophy with the device. Implementation to >12000 feet is acceptable with a new configuration and special sensor housing. (See Fig 13)

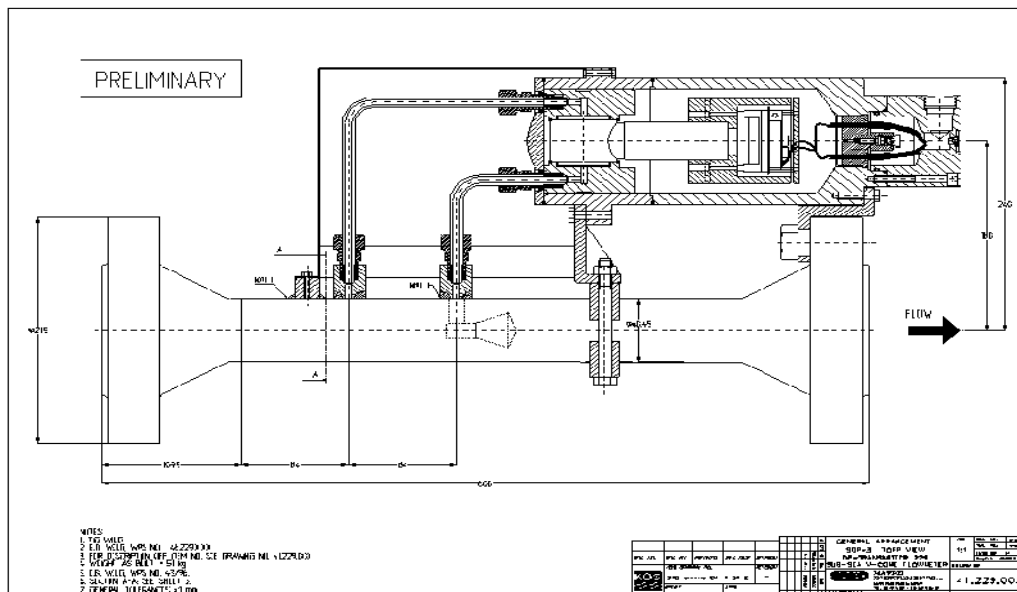


Fig 13

Conclusion

As mentioned in the abstract, different technologies exist to solve different problems in different situations. The devices mentioned in this paper all help to solve aspects of measurement situations. The use of many technologies is needed if shareholder /stakeholder requirements to maximize profits and minimize losses are the ultimate goals. It is hoped that in the future metering problem solving may become easier with the adaptation of new devices.

Reference Documents

Hayward	A Basic Guide and Source Book for Users	1973
Szabo / Winarski Hypnar	V-Cone Meter for Natural Gas Flows	1992
Miller	Flow Measurement Handbook	(Latest Edition)
GRI	Wet Gas Research V-Cone 4 inch Diameter	1997