

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, re-injected, and extracted mediums 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 and if 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 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.

US 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, (in Beaumont and Humble Texas) the expansion has been dramatic with US holdings controlling approximately 65% of the worlds O&G production and exploration.

It is hardly surprising to learn that the US 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 both producing 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.

Figure 1 shows the volatile changes in the supply chain from a 50's baseline.

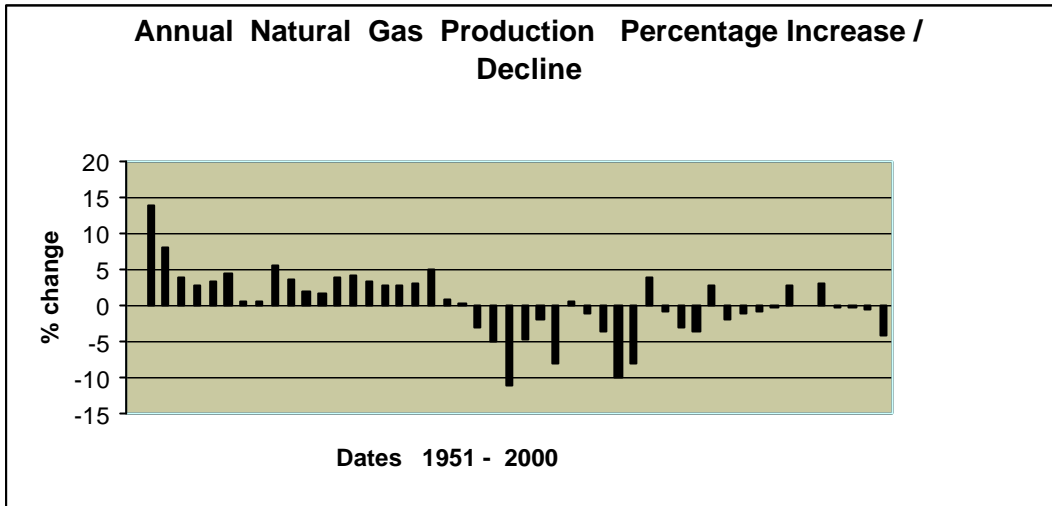


Figure 1 - USA GoV Data

COAL BED METHANE

Land based gas production in the USA 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 USA have the greatest coal deposits and largest production possibilities. The Powder River Basin WY is a region with one of the largest gas deposits due to bio-generation. Fig 2 - 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 gasses produced from hydrocarbon wells. Methane is trapped by “adsorption” in the coal micro pores, and porosity.

Extraction is simple and effective. Cash flow to the producer returns more quickly with joint venture alliances being set up. Gas production has increased 10 fold from about 55 MMcf/day in 1998 to 700 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. Circa: \$25,000.00 per drilling with completion cost for a fully functional gas producing well at about \$60,000.00. The depth of the wells may vary from 400 - 1000 feet.

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 Figure 3)

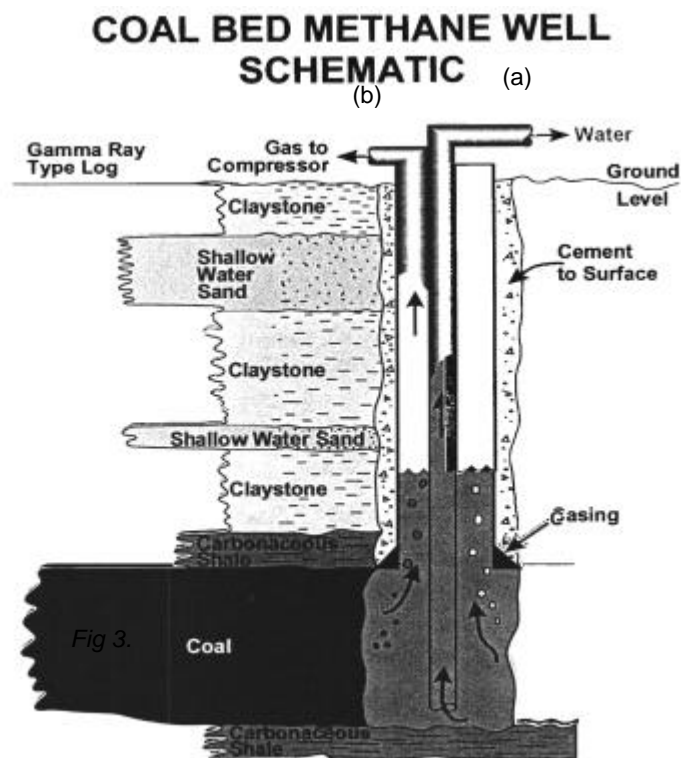


Figure 3

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 *Figure 4*.
- 2.0 Orifice with EFM & Charts : (Pod system only due to straight run requirement). See *Figures 5 and 5a*.

GAS PRODUCTION PHILOSOPHY

Meters used 2 and 3 inch diameter, Wafer V-Cone or Orifice (pod style only).

Volume Measured 250 – 1000MSCF/ day / well.

'B.L.M'. System approval or waivers needed for 65% of the US 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 usually about 5-10 years (from start up).

'BLM '= Bureau of Land Management

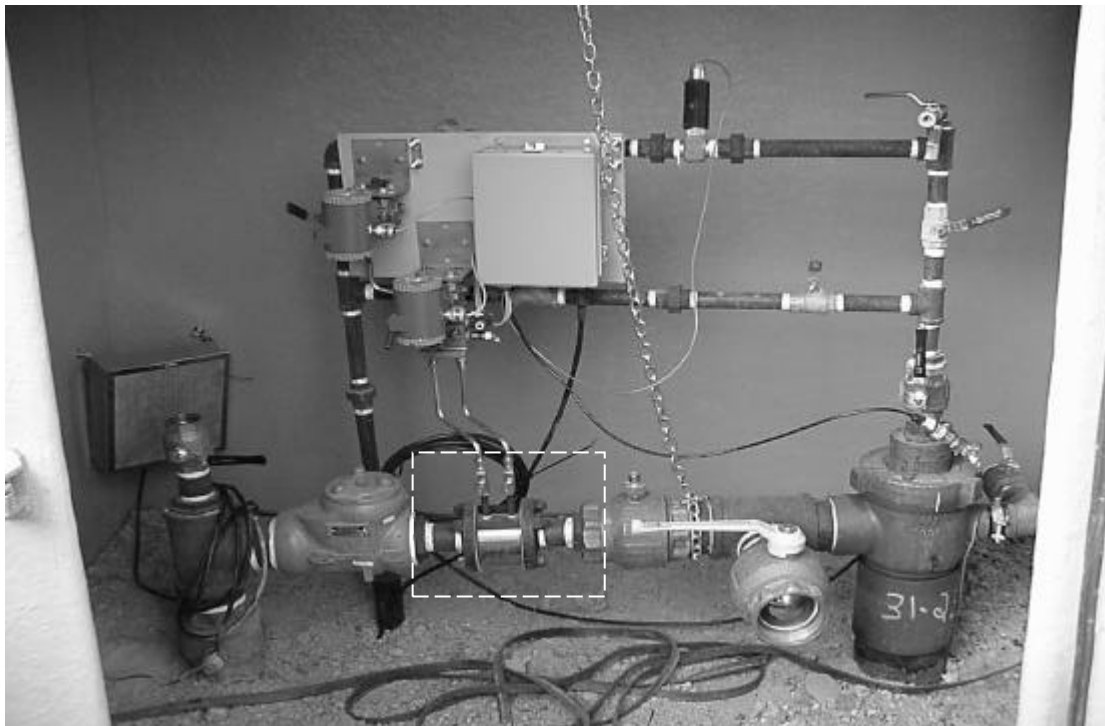


Figure 4 - Typical Single Well-head Manifold V- Cone design

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

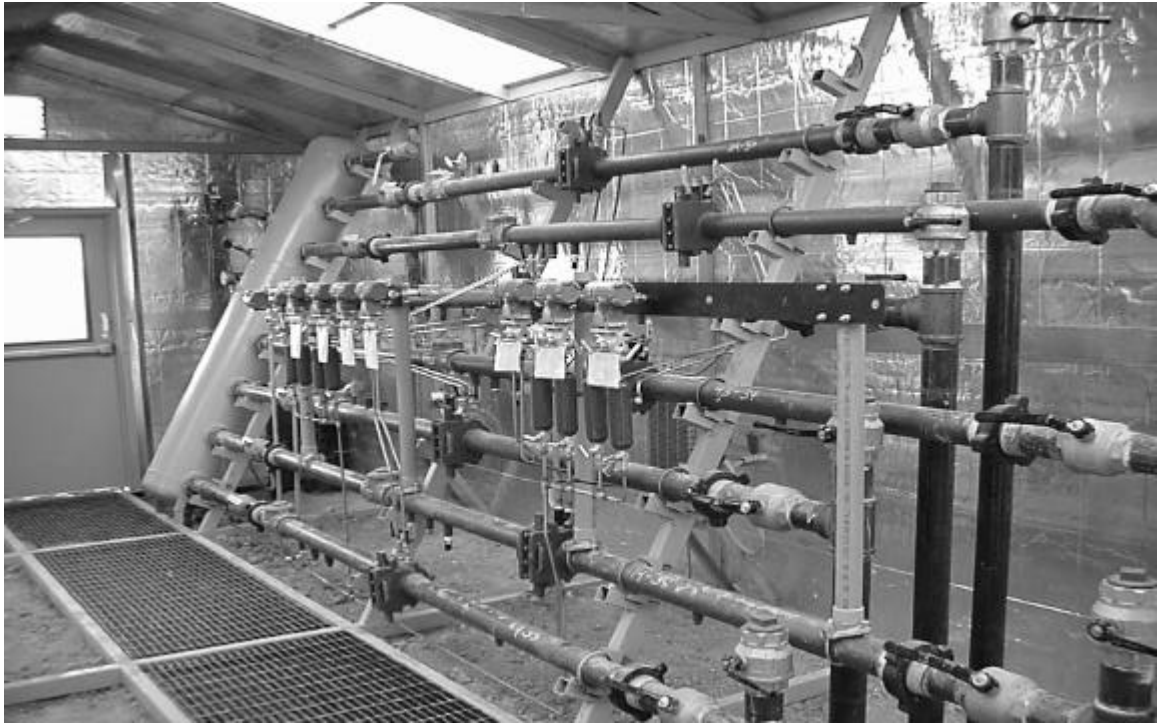


Figure 5 - Pod Building Design Using Orifice Meters (envelope for 7 units)



Figure 5a - Pod System V-Cone (16 units in same envelope as 7 orifice)

WELL PRODUCTION AND RESERVES WY / CO

By the year 2006 it is estimated to have 35000 functioning C.B.M wells in place in the Wyoming / Mid West Area of the USA .

After this a further 35000* 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 app. * 6-8% of the US gas production. The key to rapid growth has been government support in spite of environmental concerns ,teaming up with independent producers such as Barrett and Western Gas Resources and Penneco / CMS in the Powder River Basin of Wyoming, whom both 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 ways to extract. A major player from the USA is Evergreen resources whom have various exploratory land based wells in the South of England.
(* USA Gov 'data)

METER PERFORMANCE AND WET GAS

When the BLM reviewed the V-Cone which has 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 90's. The AGA orifice being accepted as a baseline standard to spring from, allowed a judgment to be made for V-Cone acceptance.

The US / BLM guidelines for these types of installation 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, which is usually an API/AGA installed orifice plate run and carrier with a water knock out system usually controlled by the buyer of the 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 producers property is under BLM mineral rights control, and have the authority (and do) to inspect the metering station 's on a three month or sooner basis.

One advantage which is being pursued is a 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 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 99 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 "Figure 6" 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 was also taken under BLM control. The results of these tests where 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

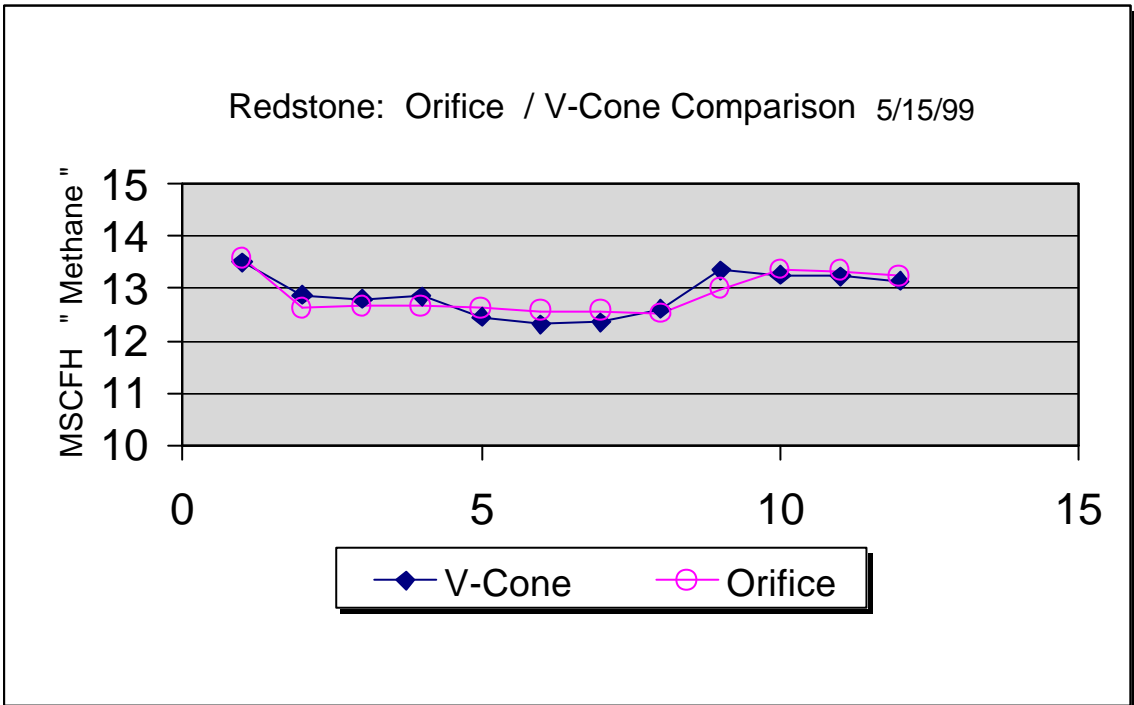


Figure 6

WET GAS LAB TEST, CEESI, NUNN, C.O.

Recent testing at CEESI indicated a low susceptibility to Cd change with liquid load, base line values where plotted against numerous test loop instruments in a dry condition. Flow rates from 7 –70 feet / second in a 4 inch line size where 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 where 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 Figures 7a& 7b) - (CEESI = Colorado Experimental Engineering Station).

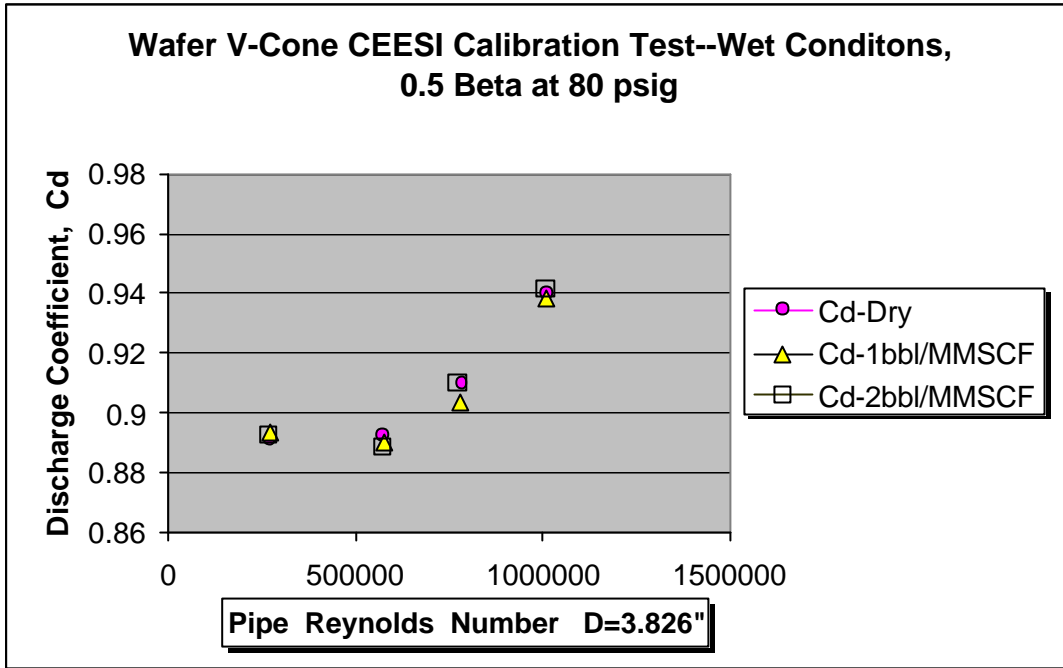


Figure 7a

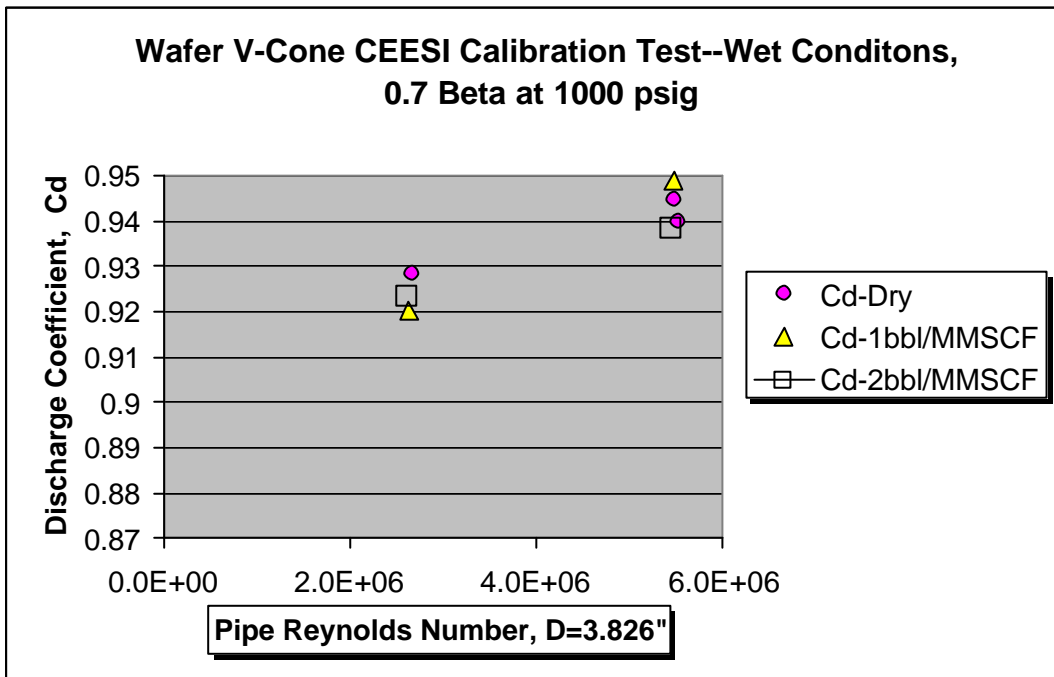


Figure 7b

LONGEVITY, CONTAMINATION, AND BETA EDGE DAMAGE LAB TEST

During late 98 early 99 Marathon Oil installed test meters at there 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 nor the local BLM office whom collect royalty from these gas systems. The use of the V-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. 3 inch meters where fitted and the most severe well used as a test site. See Figures 8a & 8b "Orifice trash deposits".

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

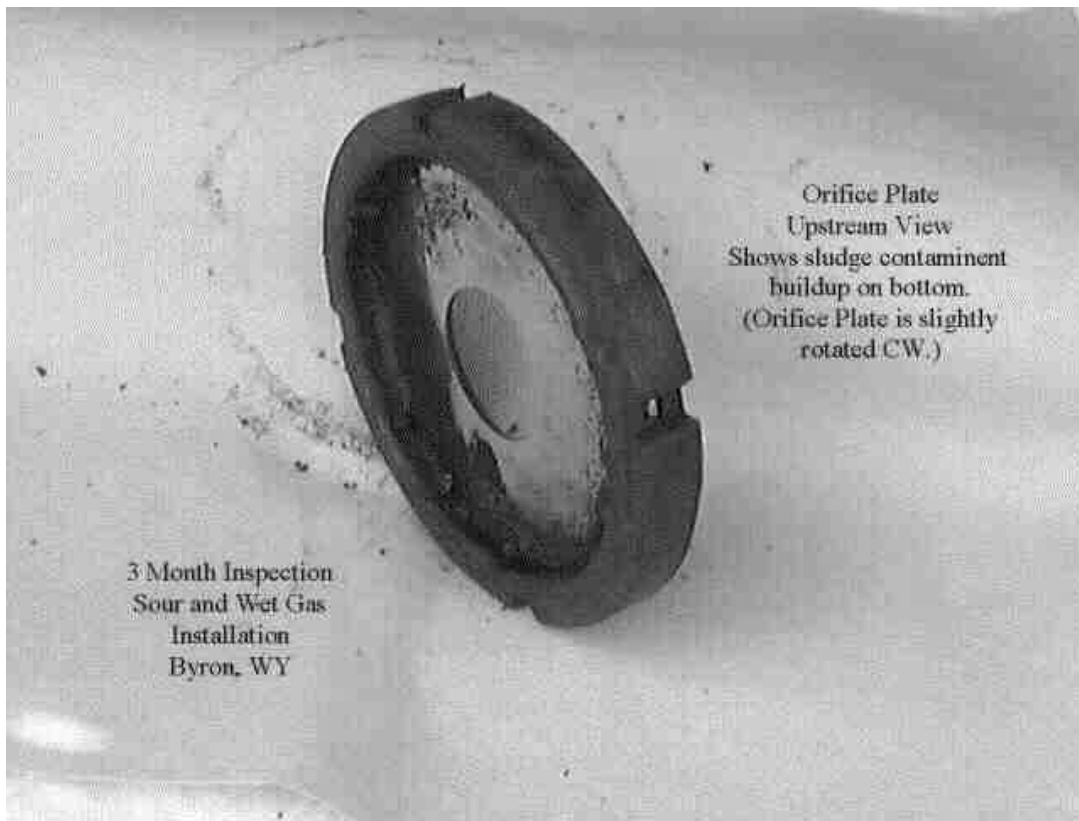


Figure 8a

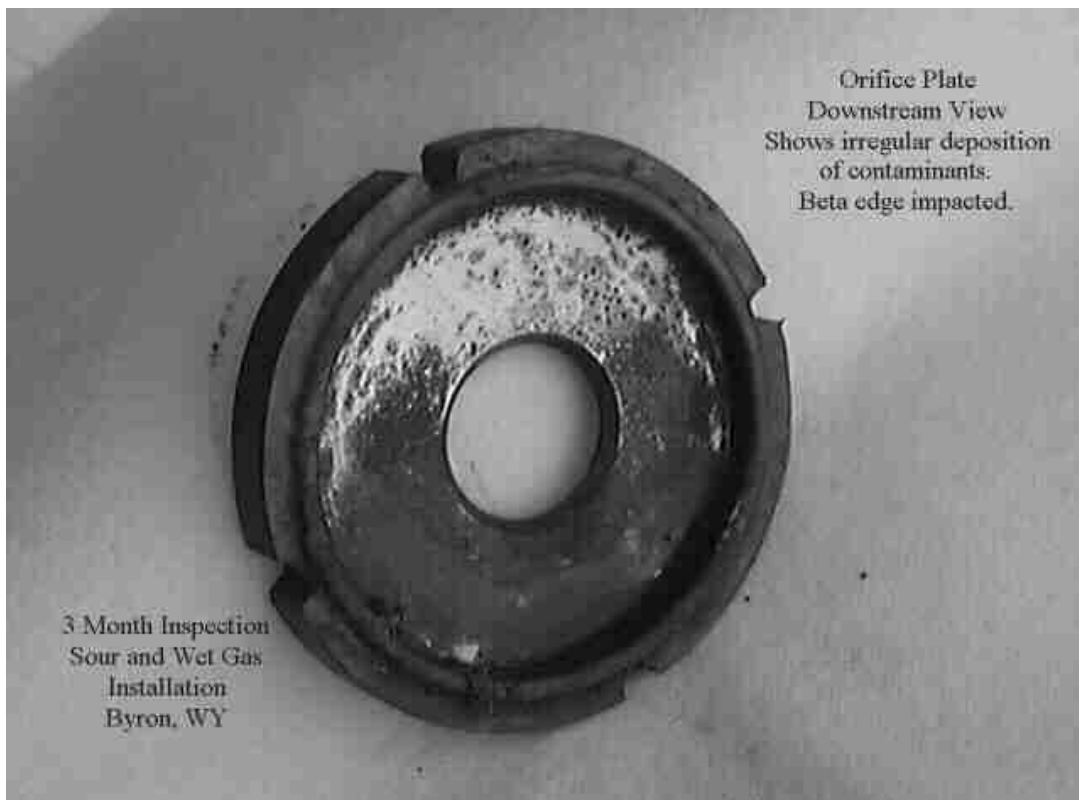


Figure 8b

Wafer Body of V-Cone 3 inch Diameter

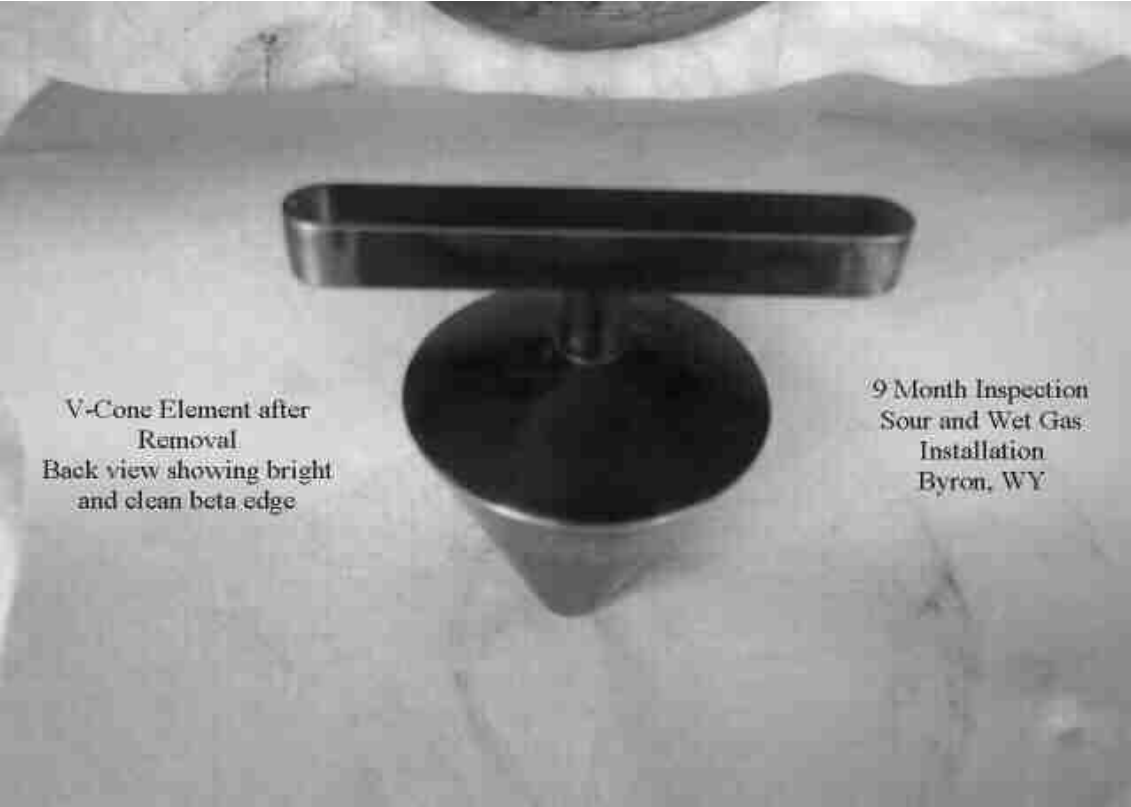


Figure 9



Figure 10

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

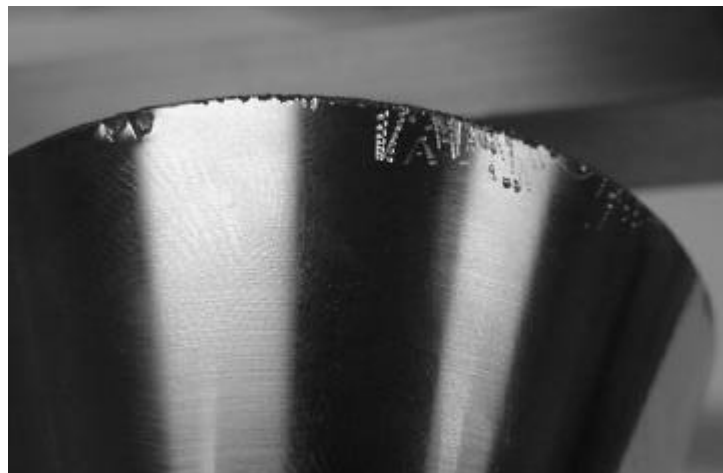
The V-cone unit on inspection (*Figures 9 & 10*) did not show the same problem severity, probably due to accelerated flow around the cone element. This seemed to keep the cone and sensing ports clear of deposition, thus maintaining a consistent D.P. across the meter. The entrained condensate liquid moved into slug flow condition periodically, which caused liquid to enter the orifice sensing lines and also be retained after the plate. The 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 V-cone wafer meter 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 (*Figures 11-12*):

Front view of cone



Figures 11 & 11a



Side view of cone

(*Lab Work and Test Data by Robert Pinkerton, McCrometer Inc, Flow Lab, CA)

TEST RESULTS

The deviation from the test shows the Cd shifted upwards by app. 0.3% which is within the uncertainty of the McCrometer calibration station. This initial test is currently being superceded 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.

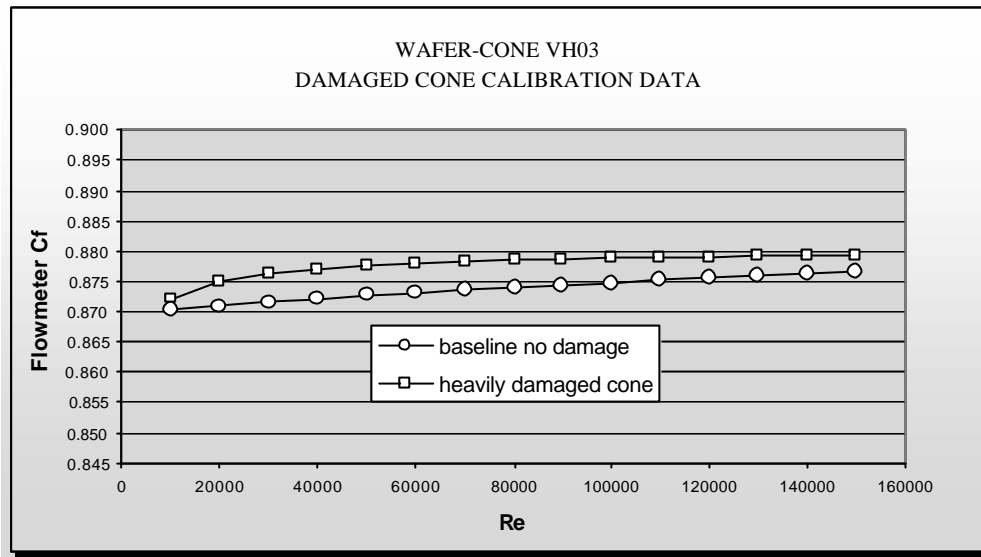


Figure 12

SUB SEA IMPLEMENTATION AND DESIGN

Currently 35 precision tube units are in service in a sub-sea wellhead marine environment, in Norway, Angola, and South China Seas. 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 Figure 13).

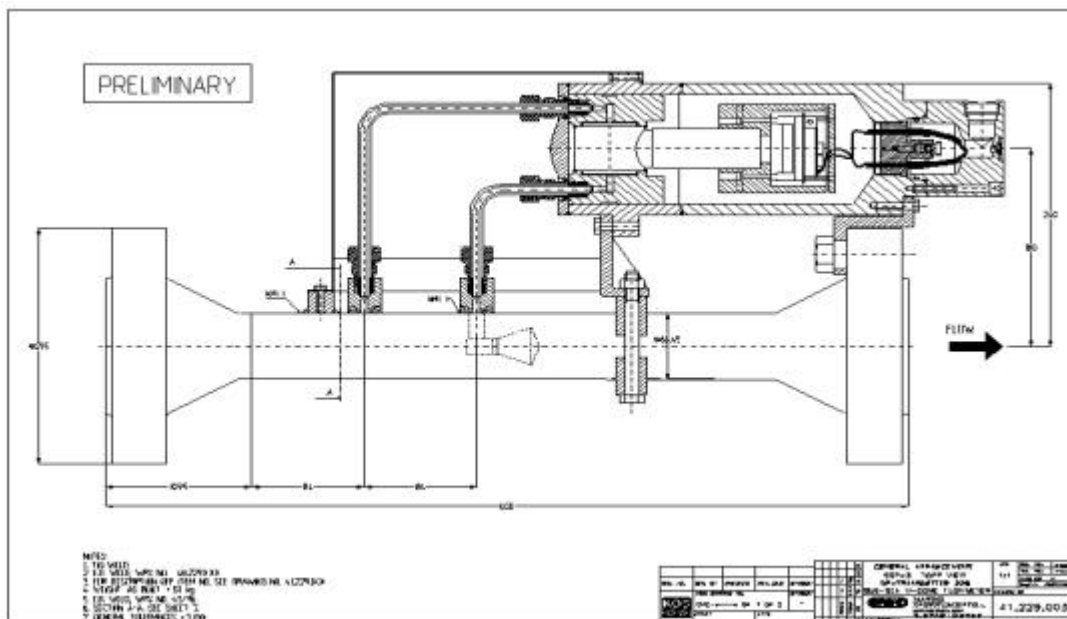


Figure 13

CONCLUSIONS

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 in this fast moving world we live in. The use of many technologies are 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 adaptation of new devices.

“We will have to wait and see ! ”

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