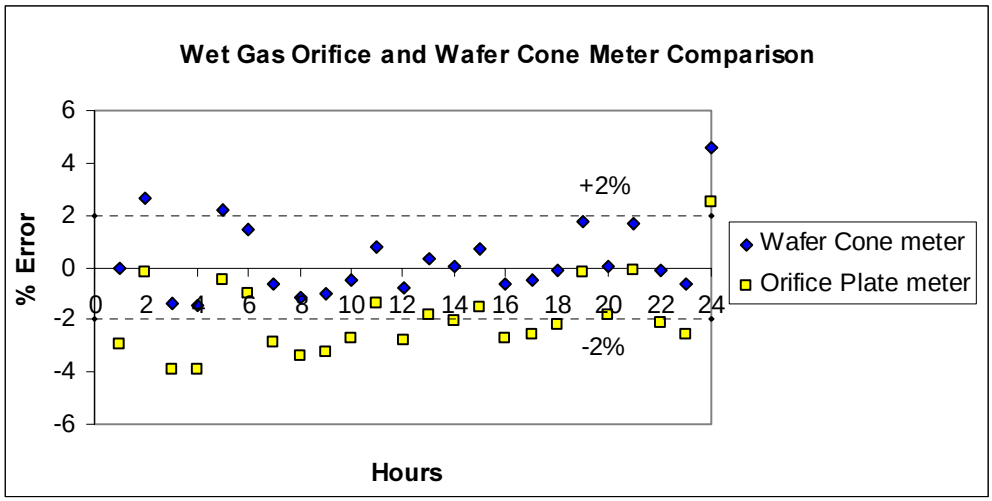

Figure 24. The relative error of the wet gas Orifice Plate and Wafer Cone meters compared to the dry gas reference meter.

within dry gas metering acceptability. In Figure 24 the points out with the ±2% lines show the Wafer Cone meter over-reading as would be expected with liquid presence. As the data is from a field test and the conditions are not therefore held precisely these points represent averaged values and it is assumed that over each hour the higher over-readings of the Wafer Cone meter are due to periodic small increases in the Lockhart-Martinelli parameter. The Orifice Plate meter appears to have a more significant negative error with many points below -2%. Therefore, in this test it is shown that for no correction applied the wet gas Wafer Cone meter successfully tracked the Orifice Plate dry gas reference meter whereas the wet gas Orifice Plate meter did not. Over the course of the 24 hour test the Orifice Plate dry gas reference meter read a total 11.737 million SCF, the wet gas Orifice Plate meter read a total of 11.509 million SCF and the wet gas Wafer Cone meter read 11.771 million SCF. Therefore the wet gas Orifice Plate meter read 228,100 SCF low an over all difference of -1.9%. The wet gas Wafer Cone meter read 33,900 SCF high an over all difference of +0.3%. Hence, if the Wafer Cone meter was installed in this application alone rather than an Orifice Plate meter the meter operator would avoid registering 228,100 SCF/day of gas low and register 33,900 SCF/day high thus vastly reducing the exposure to error for buyer and seller. In particular the producer would not be giving away a free 228,100 SCF/day. Therefore, the Wafer Cone meter is a good choice for use in unprocessed wet natural gas flows with low Lockhart-Martinelli parameter values. The results are summarised in Table 1.

	Dry Gas Orifice Plate Meter	Wet Gas Orifice Plate Meter	Wet Gas Wafer Cone Meter
Total Volume Flowrate (Million SCF)	11,737,000	11,509,000	11,771,000
Absolute Difference Between Dry and Wet Meters (Million SCF)	N/A	-228,100	+33,900
% Error Between Dry and Wet Meters	N/A	-1.9	+0.3

Table 1. The wet gas Orifice Plate and Wafer Cone meters performance over 24 hours compared to the dry gas reference meter.

The raw data collected by BP is shown in Table 2.

		Dry Gas Orifice Plate Meter	Wet Gas Wafer Cone Meter	Wet Gas Orifice Plate Meter	Upstream Pressure	Upstream Temperature
--DATE--	--TIME--	MCFH	MCFH	MCFH	-PSIA-	-DEGF-
1/22/2001	17:00:00	504.41	504.053	489.526	373.5	119.9
1/22/2001	18:00:00	496.5	509.756	495.586	375.6	119.9
1/22/2001	19:00:00	526.25	519.024	505.496	374.9	119.6
1/22/2001	20:00:00	504.04	496.692	484.337	371.7	119.5
1/22/2001	21:00:00	484.87	495.705	482.686	371.9	119.4
1/22/2001	22:00:00	493.45	500.691	488.556	373.2	119.4
1/22/2001	23:00:00	506.04	502.829	491.551	373.8	119.4
1/23/2001	0:00:00	503.08	497.401	485.979	369.8	119.3
1/23/2001	1:00:00	496.79	491.94	480.75	369.4	119.3
1/23/2001	2:00:00	490.04	487.84	476.625	371.2	119.3
1/23/2001	3:00:00	491.04	495.004	484.341	371.5	119.2
1/23/2001	4:00:00	504.5	500.487	490.445	372.3	119.2
1/23/2001	5:00:00	486.87	488.422	477.947	370.7	119
1/23/2001	6:00:00	484.45	484.779	474.372	369	119
1/23/2001	7:00:00	479.67	483.022	472.455	368.4	119
1/23/2001	8:00:00	483	479.931	469.689	366.5	118.9
1/23/2001	9:00:00	479.58	477.279	467.129	367.8	118.9
1/23/2001	10:00:00	476.83	476.231	466.232	370.9	118.8
1/23/2001	11:00:00	478.54	486.98	477.817	361.3	118.6
1/23/2001	12:00:00	481.29	481.302	472.392	362.8	118.6
1/23/2001	13:00:00	463.2	470.997	462.513	376.7	118.7
1/23/2001	14:00:00	471.2	470.623	461.351	373.2	118.7
1/23/2001	15:00:00	474	470.861	461.711	373	118.7
1/23/2001	16:00:00	477.33	499.061	489.357	355.3	118.6
Total Flow		11736.97	11770.91	11508.84		

Table 2. Raw data from BP wet gas field test (reproduced with permission).

5 CONCLUSIONS

It is concluded from repeat tests at NEL of a 6", 0.75 beta ratio V-Cone meter that the previously published wet gas performance [5] is repeatable and that a disturbance 10 diameters upstream of the V-Cone meter inlet has no noticeable effect on the performance of the V-Cone meter with wet gas flows. From analysis of the CEESI wet gas 0.75 beta ratio V-Cone results it is concluded that the previously published wet gas correlation [5] can be applied to neighbouring pipe sizes, fluid types and gas flowrates than were not in the correlations data set. It is further concluded that NEL and CEESI wet gas loops produce similar DP meter behaviour even though the pipe size, gas flowrate range and fluid types are different.

From consideration of the known wet gas flow performances of different DP meters it is concluded that the V-Cone meter shows advantages over other DP meter designs when employing the tracer injection technique to form a system that meters both the liquid phases flowrates and the gas phase flowrate.

Finally, it is concluded that for unprocessed natural gas flows with low Lockhart-Martinelli parameter values the Wafer Cone meter is a good choice of meter.

Notation

X	The Lockhart-Martinelli parameter
$\dot{m}_g$	The actual gas mass flowrate
$\dot{m}_l$	The actual liquid mass flowrate
$\dot{m}_{g(tp)}$	The over estimated gas mass flowrate using the read wet gas differential pressure
ρ_g	The gas density
ρ_l	The liquid density
ΔP_{tp}	The read wet gas (or "two-phase") differential pressure
ΔP_g	The gas superficial differential pressure
C_d	The discharge coefficient
Fr_g	The gas densiometric Froude number
U_{sg}	The superficial gas velocity
g	The gravitational constant
D	The meter inlet diameter
A	The meter inlet cross sectional area
E	The DP meter Velocity of Approach
Y	The DP meter expansibility factor
M	The Murdock gradient
MSCF	Thousand standard cubic feet
SCFH	Standard cubic feet per hour

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