North Sea
FLOW
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PAPER 25

FOCUS DISCUSSION GROUP B

MULTIPHASE 1 - TESTING & STANDARDS FOR MULTIPHASE METERS

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Discussion of issues in multiphase flow metering - laboratory experience and practice

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1. Introduction

There are a number of issues relating to the acceptance and use of multiphase flow meters - this short document sets out some of these as a basis for discussion in the multiphase metering discussion group at the North Sea Flow Measurement Workshop under the following general titles:

- Analysis of meter accuracy
- Standards for multiphase metering
- Relationship of laboratory testing to field practice
- Further technical challenges

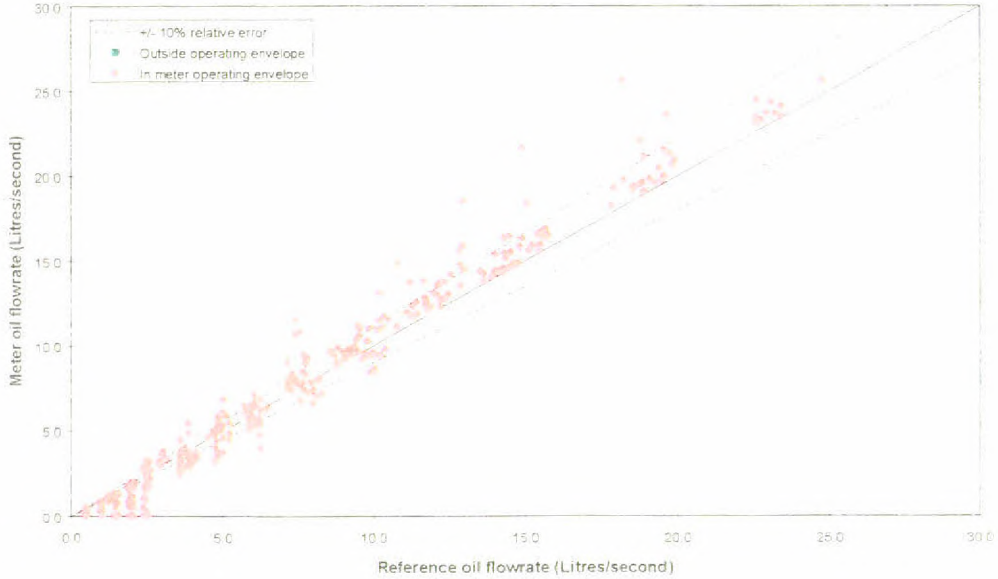
2. Analysis of meter accuracy

2.1 Graphical presentation

By way of example, a set of meter performance data has been constructed which does not relate to any real multiphase meter. The discussion below is based on the oil flowrate from this example meter.

One method to present data is to plot the meter flowrate against the reference flowrate:

Figure 1: Meter oil flowrate vs. reference oil flowrate



This figure shows that there are a large number of conditions where the meter flowrate lies within ±10% of the reference value, and that there are two areas where the meter errors are significantly worse: at low values of oil flowrate and a number of points at high flowrates. However, there is little further useful information which can be obtained from this graph.

More instructive is to look at the meter error, and it is useful to plot this against either the reference gas volume fraction (GVF) or water cut:

Figure 2: Meter oil flowrate error vs. reference GVF

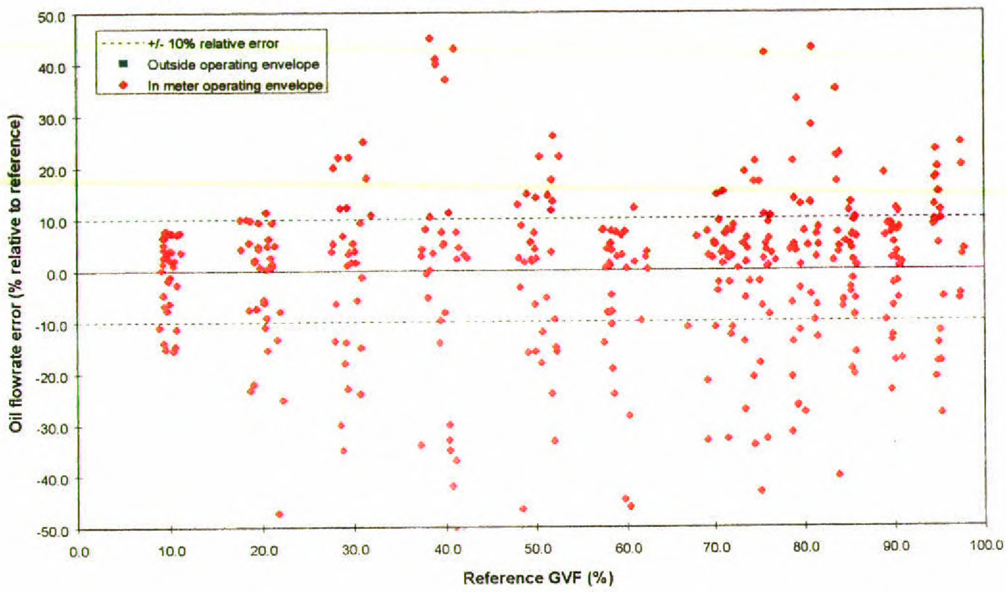
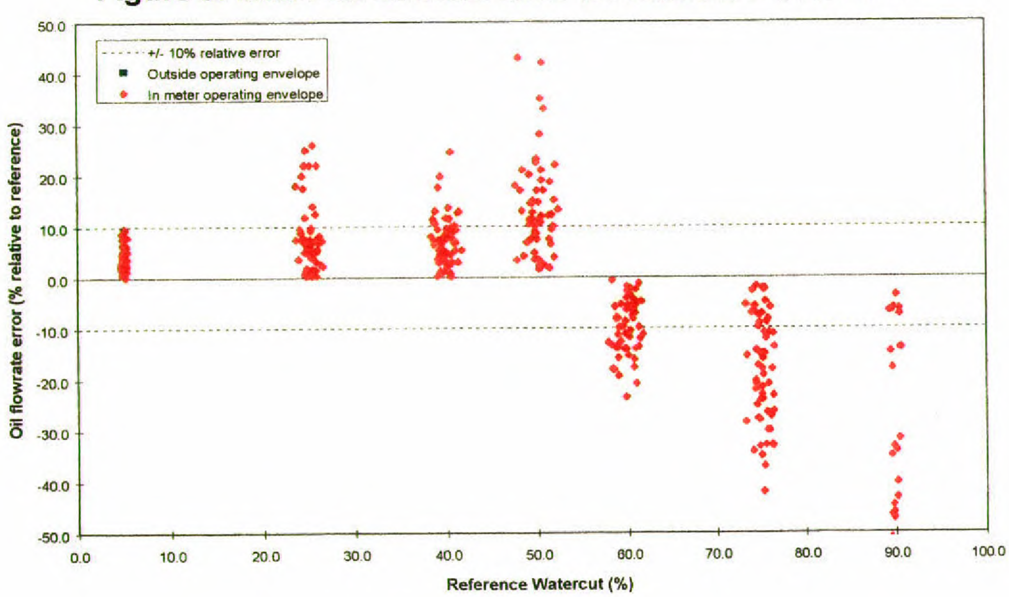


Figure 3: Meter oil flowrate error vs. reference water cut



Of these figures, it is clear that the plot of errors against water cut is beginning to show the strengths and weaknesses of the performance of this meter. The behaviour changes markedly between 50% and 60% water cut. It may be surmised that the spread in errors at each water cut is influenced by the gas fraction and therefore a plot which shows performance in terms of both water cut and gas fraction would be useful. One way to do this is to plot points on a GVF vs. water cut graph where the colour or symbol used for the points indicates the error, as shown in Figure 4.

Table 5 - Natural Gas Mixture 99.5% Un-normalised/ Normalised 0.5% Component Uncertainty

Input	Temperature °C	Pressure bar a	Nitrogen mol%	Carbon Dioxide mol%	Methane mol%	Ethane mol%	Propane mol%	n-Butane mol%	i-Butane mol%	n-Pentane mol%	Total Composition mol%	Line Density Kg/m3	Standard Density Kg/Sm3	Calorific Value 15/15 Sup Real Mj/Sm3	Wobbe Index Real(AGA8) Mj/Sm3
Input (Mean)	45.000	100.00000	0.920	0.970	92.790	4.290	0.390	0.060	0.030	0.050	99.500	74.160850	0.725692	38.457864	49.974627
Uncertainty (% Input)		0.150%	0.500%	0.500%	0.500%	0.500%	0.500%	0.500%	0.500%	0.500%					
Uncertainty (Units)	0.25000	0.15000	0.00460	0.00485	0.46395	0.02145	0.00195	0.00030	0.00015	0.00025					
Normalised (mol%)	45.000	100.00000	0.925	0.975	93.256	4.312	0.392	0.060	0.030	0.050	100.000	74.635648	0.729355	38.651987	50.100601
											Method Uncertainty % Reading	1.0000%	0.1000%	0.1000%	0.1000%
											Monte Carlo Uncertainty %Reading	0.5939%	0.439164%	0.459989%	0.240652%
											Monte Carlo inc Method Uncertainty %Reading	1.1631%	0.4504%	0.4707%	0.2606%
											Normalised Monte Carlo Uncertainty %Reading	0.216241%	0.036619%	0.020065%	0.014052%
											Normalised Monte Carlo inc Method Uncertainty %Reading	1.0231%	0.1065%	0.1020%	0.1010%
Log Rule Uncertainty (%Reading)	0.1000%	0.1500%	0.1001%	0.1000%	0.4871%	0.1400%	0.1167%	0.2493%	0.3319%	0.2693%	Log Rule Uncertainty inc Method Uncertainty %Reading	1.2521%			
Weighted Uncertainty (%Reading)	0.1000%	0.1500%	0.0046%	0.0049%	0.4640%	0.0215%	0.0020%	0.0003%	0.0002%	0.0003%	Weighted Uncertainty inc Method Uncertainty %Reading	1.1173%			

Line density distribution for un-normalised and normalised results in Figure 5 clearly shows a decrease in uncertainty from 0.59% to 0.22%, before applying the AGA8 method uncertainty, due to normalisation. Figure 5 also shows an increase of 0.48 kg/m^3 (0.65%) in line density from 74.16 kg/m^3 to 74.64 kg/m^3, again due to normalisation.

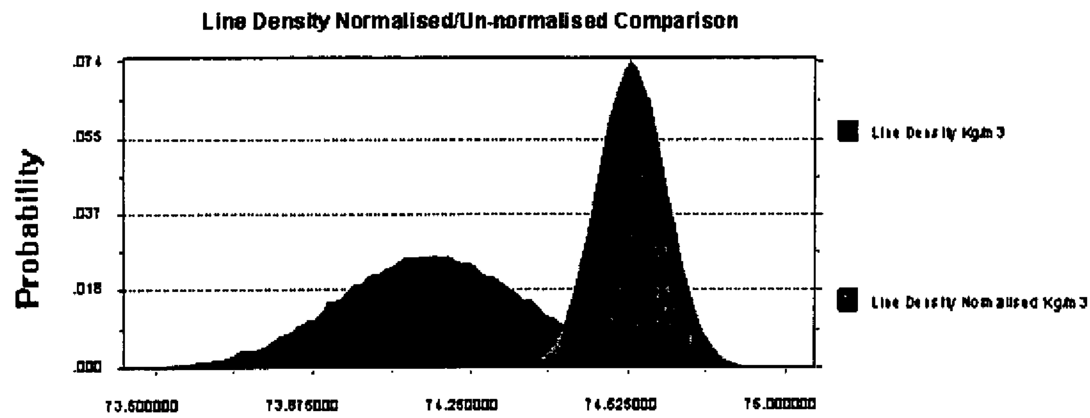


Figure 5 - Effect of Normalisation on Line Density

Figure 6 shows the same for standard density with a more pronounced reduction in uncertainty from 0.44% to 0.04% and with an increase in standard density of 0.5%.

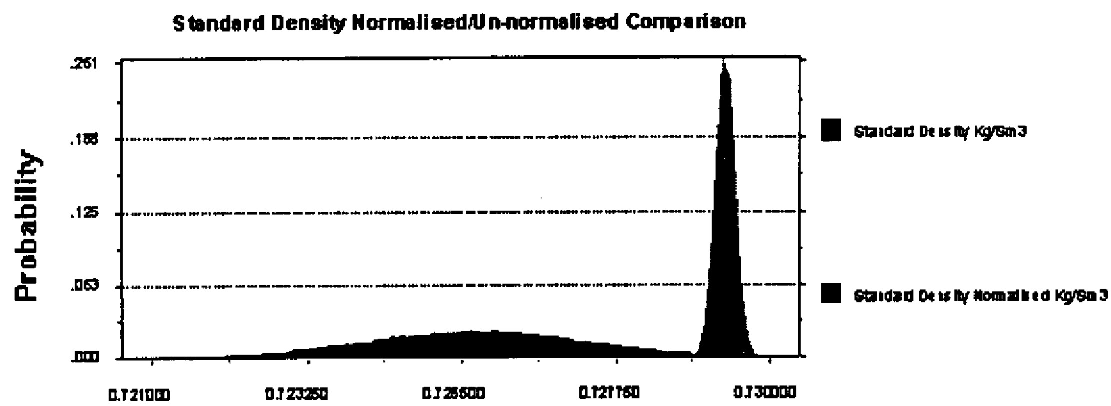


Figure 6 - Effect of Normalisation on Standard Density

5 CONCLUSIONS

Monte Carlo Simulation is a suitable method for determining the uncertainty of simple and complex measurement systems. MCS can be readily applied to verify uncertainties found by conventional analytical methods and to serve as a means of detecting errors to ensure confidence in the results.

When estimating the uncertainties of complex measurement systems particular care must be taken in identifying all uncertainty sources and how they propagate through the measurement process. Monte Carlo simulation is a fundamental approach that simulates the true characteristics of a measurement system, and implicitly the propagation of uncertainties through the system.

In the second example MCS allowed the impact of normalisation to be observed highlighting the change in the spread of results and the offset of the mean value. Conventional analytical methods do not provide this degree of insight.

The availability of powerful desktop computers means that engineers can readily apply MCS methods to finding the uncertainty of measurement systems.

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