FLOW MEASUREMENT - THE LAST TEN YEARS

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Summary

A review of developments within North Sea flow metering is given.Most of the issues reviewed here are those which were brought up at the first Workshop ten years ago. In addititon the development of Coriolis massmeters,ultrasonic gasmeters and multiphase meters are reviewed.

The first North Sea Flow Metering Workshop

This first Workshop took place in Stavanger in 1983 where the idea of a yearly metering seminar ,alternating between Norway and UK,had been conceived at a more local seminar the year before.

A copy of the program is included on the last page of this paper.

Let's have a look at the main issues of this program and use them as a basis for reviewing what has happened from then and up till to-day.

Dr. Spencer

Among the names on the program you will probably notice Dr. Spencer.

No review of flow measurement for the last ten years can be said to be complete without commenting on the significant role played by this man.

Anybody working with flowmeasurement in the 1980s would inevitably become aware of Dr. Spencer: As an author of papers,as chairman of seminars and conferences,always having a prominent position in whatever he took part.
Also, he was one of the key persons in the process of establishing the North Sea flow Measurement Workshop
Dr. Spencer was pensioned from NEL some time late in the 1980s and then seemed to drop out of sight for most of us.From what I understand,however,he has kept himself busy by working for UN and for the EEC.
Hopefully,he is still in activity with the same energy and enthusiasm as he displayed at the past Workshops.

ISO 5167

The first lectures,given by Dr. Spencer, was about the development of ISO flow measurement standards,measurement uncertainty and comparisons between ISO 5167 and AGA Report No. 3 .

ISO 5167 was relatively "new" at that point of time.It had been issued in 1980 to replace ISO R-541 and had some significant improvements,such as the Stolz equation for calculation of flow coefficients.ISO 5167 had become the standard to which all new orifice metering stations for North Sea flow measurement now were designed .In the years to come it was "retro-fitted" on those metering systems which had beeen originally designed to ISO R-541.
In America,however,there seemed to be less enthusiasm for ISO 5167 and they still seemed to put their trust in AGA Report No. 3 with the "old" flow coefficient formulas.

In addition,a lot of the measurement engineers with a practical job were aware that ISO 5167 was not perfect. Its scope was so that it was not the complete document they would have liked to have available to use as a basis for for design and operation of industrial orifice metering systems.
ISO was aware of this and had already,as early as 1977 initiated work with a separate document,"Code of practice for ISO 5167".
Also ,right after the issue of ISO 5167 in 1980 a working group in ISO had already started its work to revise it.

On this background,a lot of metering engineers probably would have predicted the following development within the next ten years from 1983 onwards:

-The flowcoefficients of ISO and AGA would not be different.

-ISO 5167 will be supplemented by a "Code of Practice Document" to cover the more practical sides of orifice metering.

To-day,however,there is still some way to go.The COP has not been issued and there is still a conspicuous difference between the 1992 revision of ISO 5167 using the Stolz-formula and the AGA 3 now using the new Reader-Harris-Gallagher formula.

Metering Regulations

Metering regulations was the second subject at that first measurement workshop.The lecture was given by Mr. Øglænd of NPD.

At the time of the workshop a draft of the NPD fiscal metering regulations had been completed and had been sent out for comments to the industry.The regulations were put into force in 1984.

Although everybody were not always happy with everything that these regulations implied,I think that they had a positive effect in terms of setting a standard to be met by the industry .In addition they implied that NPD had to give their specific approval of a metering system when all documentation had been provided and all the required tests had been sucessfully completed .

As the years went on the industry got used to live with the regulations.If the oil companies should initiate a revision,a relaxed regulation for metering of smaller streams with less fiscal importance would probably have been on the top of their wishing list.

It was, however,NPD who initiated a revision of their metering regulations in 1990.Their main objective were to make the fiscal metering regulations consistent with the other regulations they had issued for other areas,i.e. introducing more "functional" requirements and to a larger extent rely on the internal control of the oil companies.

The revised NPD fiscal metering regulations were put into force last year.

About the same time , work on other metering regulations started .As a new tax on gas burnt as fuel or flare on offshore platforms on the Norwegian continenetal shelf was imposed in 1989,regulations for measurement of this gas had to be made.The draft of these regulations has now been completed and it is expected that they will be put in force in a few months from the time of this workshop.

Gas Turbine Meters

Two lectures ,titled " Gas Metering at high Reynolds Number" and "New Standard for Gas Turbine Meters" respectively,were given by Joe Bonner .

Both of these lectures focused on gas turbine meters.

Although the first lecture also deals with orifice meters,one of the issues of the lecture is a discussion about plotting the calibration curves of turbine meters as error against Reynoldsnumber instead of flowrate.

The second lecture was about an ISO standard for gas turbine meters .At that time, a draft was being made by Working Group 15 of ISO TC 30, 90% of the draft was completed and only the difficult last 10% remained to be made.Although not stated directly,I think the audience got a feeling that Mr. Bonner was very worried about the progress in the last phase of drafting this standard.

Sometime between now and then things must have stopped up as I can find no standard for gas turbine meter in the 1992 ISO catalogue.

Liquid Densities

Already from the start,the North Sea Flow measurement Workshop managed to attract lecturers from overseas.

A lecture with the title "Calculation of Liquid Densities and their Mixtures" was given by Risdon W. Hankinson from Phillips Petroleum Company's headquarters in Bartlesville,Oklahoma.

Because there seemed to be an increasing number of fiscal metering systems for unstabilised oil,LPG and LNG in the North Sea area at that point of time,there was a great interest in methods to calculate densities and volume correction factors for other liquids than stabilised crude oils.

Hankinson's lecture was partly about the the then new temperature correction factors of the ASTM/IP/API Petroleum Measurement Tables.
These tables had been issued in 1980,replacing the very old table 6 of API 2450.
This was a very big step forward as the old tables had been issued in 1940 based on a limited number of crude oils produced before 1930.

After the workshop the Petroleum Measurement tables were further extended in 1984 and 1986 by new sections for compressibility factors.

The part of Hankinson's lecture that attracted most interest,however,was the part about the **COSTALD** compressed liquid density correlation.At that stage,in 1983,the Costald correlation was being used in fiscal measurement,but not by many and only for "offline" calculations.
At seminars later during the 80s,Phillips personell promoted the use of COSTALD and outlined their plans to improve the correlation to be valid for temperatures near to the critical temperatur and for higher pressures.

Up till to-day, COSTALD has gained increased acceptance and is being used as an "online" density calculation method in the flowcomputers in several North Sea metering systems.

Calculation of Gas density

This was the second lecture by R.W.Hankinson.

The paper is missing in my folder but I think the main topic of the lecture was about what was called at that time the " GRI method" for compressibility calculation.

Two years later,in 1985,this method was introduced as a standard,in AGA report no. 8.It is now the most commonly used calculation method for gas compressibility in the North Sea gas metering.

On Line Gas Densitymeters

Two lectures were given on this subject.

Jim Stansfeld gave a lecture on the basic details of the Solartron 7810/7811 gas densitometers.

The second lecture ,by Paul Wilcox ,was about practical experience with gas densitymeters.

The lectures and the comments from the audience highlighted two problems:

The **velocity of sound** correction method for this kind of densitymeter and

The effects of any temperature difference between the instrument's chamber and the gas in the meter-run.

The first of these problems became a hot subject at one of the later workshops.There was a lot of different opinions on which calibration and correction methods would give a correct density reading.
However,the discussions gave a positive result,the manufacturer started to offer nitrogen calibration for the instrumennts and the users started to use the complete VOS correction formula and went into the 90s with new confidence in their densitymeters.

Piston-type Compact Provers

The last day of the first Flow Measurement Workshop was, in practice,entirely entitled to compact provers.

Bill Pursley gave the first lecture.Although this lecture was about conventional provers,its final remarks was about compact provers probably taking over a lot of the role of the conventional prover on the future offshore platforms.

Also,Bill Pursley's lecture on pulse interpolation techniques must be said to have a direct tie to compact provers.

Terry Noble gave a lecture on what was later named the Brooks Compact Prover.

This was followed up by Peter Jelffs who gave a lecture on compact provers in general and a short description of what MBR saw as desirable design features for this kind of prover.

To my knowledge there was only one compact prover in use in the North Sea activity in 1983.Phillips Petroleum Norway/Basic Resource Services were using their "Ballistic Flow Prover" as a transportable calibration unit for provers in the Ekofisk Area.This had been very sucessful and the prover is still in use for the same purpose at Ekofisk.

As time went by,most of the companies offering prover calibration services in the North Sea started to operate one or more transportable compact prover. But up till now the compact provers have not been used on a large scale as permanently installed units.

To my knowledge only 3 units have been installed for this purpose:One in each of the Danish ,Dutch and Norwegian Sector.Reportedly,all these units operate satifactorily.

However , most people present at the first Workshop would probably have guessed a higher number of compact provers in 1992.

Significant Developments 1983-1992

Although not brought up at the first Flow Measurement Workshop,I cannot finish this review of flow measurement for the last ten years without saying a few words about Coriolis mass meters,ultrasonic transit time gas flowmeters and multiphase metering .

Coriolis Mass Meters

The existence of the Coriolis mass meter was probably known to most of us in 1983 but not much attention was paid to it.One of the reasons for this may have been that ,at that stage, flowrates were big and mass meters were small.
As time went on, the streams to be metered have tended to get smaller while the massmeters have grown bigger.Also, an extensive evaluation activity were started to evaluate the massmeters' operational characteristics.
To-day, a number of manufacturers offer Coriolis massmeters,the largest have a capacity in excess of a 6-inch liquid turbinemeter .Standards are being drafted by ISO and other bodies and we have even got a Coriolis-based fiscal metering system for condensate at Total's shore terminal in St. Fergus.
Being aware of that there is a lecture tiltled "The next 10 Years" at the end of this Workshop, I should not try to make any predictions about the future of the massmeters in the North Sea.But I think that these meters will have a great potential for crude oil measurement if it turns out that their calibration is so stable that they may be installed without a permanent prover.

Ultrasonic Gas Meters

At the time of the first Workshop, a development to use ultrasonic transit time meters for gas measurement had already started.Among the challenges they had at that time was to make the ultrasonic transducers powerful enough to send their signal through gas and to develop methods to calculate flowrate from a number velocity readings along chords of a cross section of flow.
To-day,ten years later, the manufacturers offer both multipath ultrasonic gas meters for fiscal applications and flare gas meters with less accuracy but very wide flowranges.A number of ultrasonic flare meters have been installed in the North Sea .No fiscal meter is in operation yet but we will see them in the very near future.

Multiphase Flowmeters

Even before the 1983 Workshop the North Sea oil companies were aware that some of the fields found were too small to be developed with dedicated platforms,separation equipment and conventional fiscal metering.

New technology in terms of subsea wells,multiphase pumps and multiphase metering was needed .As a result of this a lot of the oil companies started or sponsored development projects to provide the technology to measure muliphase flow.The objective was to get a meter that could measure the flow of each of the components oil,water and gas .

Generally ,not much of concrete information was given to outside world.At the Offshore Northern Seas Conference in Stavanger in August 1992,however,a number of multiphase measurement devices were on display.Some impressions of state of the art from the ONS were:

Very large amounts of money had been spent during a number of years on the development of each device.

Although one got the impression that the meters were for sale,most of them had not yet been out in the field.

The "readout" varied between the various meters,one could get one or more of actual cubic meters ,standard cubic meters or mass of the full stream,each phase or each component of the liquid phase.

The main impression were,however, that the oil companies involved now definitely had moved from the stage when they limited themselves to pay for development and tests in a laboratory to a stage where they also would let the meters be installed in the field for testing .

References

[1] Paper presented at the North Sea Flow Measurement Workshop, a workshop arranged by NFOGM & TUV-NEL

Note that this reference was not part of the original paper, but has been added subsequently to make the paper searchable in Google Scholar.