PETROLEUM MEASUREMENT: SOME EXPERIENCES AND PROGRESS

by

G. Paul-Clark ISO
Department of Energy, UK

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G PAUL-CLARK, I.S.O

Natural gas and associated condensate was first licensed to come ashore in the Southern Basin of the North Sea from the West Sole field in October 1965. To some extent these were considered as secondary products in anticipation of oil being discovered. Accurate measurement and acceptability of quantities were considered burdensome requirements and early discussions appear to have been concerned with explaining the Departments involvement under the Regulations and the establishing standards and procedures to be applied in fiscal measurement. Further discoveries off the Norfolk coast soon followed and British Gas decided, in 1966, to convert the whole of Britain to the direct useage of natural gas and to develop an integrated transmission system from the coastal terminals to areas of demand.

Model clauses under the Petroleum and Submarine Pipe Lines Act and the Petroleum Production Act, 1934, require that a licencee, among other things, measure or weigh the petroleum by a method or methods customarily used in good oil field practice and from time to time approved by the Minister. Measurement is required for fiscal and reservoir engineering purposes that are concerned with economic recovering and conservation of the country's natural resources.

Petroleum production licenses are granted on behalf of the Secretary of State at an early stage and these include details of the principle of measurement and the requirements to produce dossiers giving details of the measurement system, their location in the measurement chain and the calibration and verification procedures for maintaining accuracy in service. GOMB analyses these dossiers when submitted to assess the equipment proposed, the method of calculations used and the accuracy and uncertainty attainable in measurement. The Branch attends various factory acceptance tests of meters and secondary instrumentation, commisioning tests after installation and then witnesses routine calibrations of the equipment in service to ensure that meters are operating to agreed standards. The main specification for measurment was that it should be carried out to the highest accuracy attainable in practical application.

The large gas quantities at high pressure dictated the use of sharp-edged orifice meters with parallel streams, multi-ranged differential pressure transducers and differential pressure transducers and different orifice plates to cover a range of flows. In-house fuel and compressor consumptions were a small proportion of the total flow and some relaxation of tolerances were permitted. Test facilities for direct calibration of the orifice meters were not available in the early days and the design, installation and operation of the meters were controlled according to agreed specifications from British Standards, ISO and AGA which imposed limitations within the range of parameters given in these standards, for example the β ratio was restricted to 0.6% and the maximum Reynolds number was 3.3×10^7 etc. Not a very popular set of specifications but all were selected to reduce the uncertainty of measurement. Besides, auditors were pointing out that small errors, eg. 0.3°C in temperature measurement gave approximately 0.1% error in flow which could result in a loss, or gain, in excess of one million pounds over a period; 0.007% error on the computer because of software differences was a systematic bias, etc.

Essential differences between the three standards mentioned above, particularly those concerned with developing the flow profile in the meter tubes, dimensions of pressure tappings, eccentricity of the orifice plate fitting, etc., created some difficulties and pointed to the necessity of additional practical work being done in order to revise and unify the standards. Happily, considerable work has been done and I note that a paper is being given in the 5th session on the further development of equations. Installation effects on meters have also received considerable attention and a conference held as recently as yesterday at the National Engineering Laboratory has reported on some of that work. These workshops have served as a useful forum for reporting on various stages of developments.

Development of secondary instruments has also kept abreast and the uncertainty of differential pressure transducers has decreased from 0.5% to 0.1% for transducers with intelligent electronics, ie., with temperature compensation and linearisation etc. It would be helpful however if uncertainties could be defined on actual readings and not full scale, as is general. This will enable an increase in the rangeability of the meter and a possible reduction in the number of transducers that are required. Investigations of the performance and calibration of density systems have been carried out and reported on in these workshops. Internal inspection of meter tubes and orifice plates in their field installations is possible and small volume displacement provers for in-situ calibrations of gas meters is a feasibility.

The exploitation of marginal fields and the growing pressure to cut costs in the development of such fields are pointing to the requirement for multi-phase transportation of hydrocarbon and possibly the measurement of multi-phase streams. The measurement of such streams appears to be too variable for fixed measurement purposes and preliminary separation of the phases to obtain single phase homogenous streams for separate measurement is necessary. Three papers in the 3rd session deal with some developments in this subject and it would be interesting to mark the progress of such measurements.

A new generation of meters based on ultrasonics, Coriolis and other types of mass measurement are appearing and being proposed for fiscal measurement of hydrocarbons. Two essential problems arise in such applications; viz the lack of data regarding the field performance of these meters and the need to calibrate these meters in service. A number of papers in this workshop appear to address these problems and the "dimensional" or "dry" calibration of ultrasonic meters is being investigated. The maintenance of accuracy in service may still be dependent on removing the meter and replacing it with a certified one and sending the one removed to a central calibration facility. Installing these meters in series with primary meters would add to the data required to establish the requirements for a "method or methods used in good oil-field practice".

Coming to the subject of field calibrations and the maintenance and accuracy in service, it is interesting to note that Quality Assurance and Control techniques are being more generally applied. Registration to various Quality Assurance Standards is generally an indication that products/equipment comply with recognised and relevant standards, components and product assessment are caried out, procedures are documented and carried out under established QC systems, personnel, etc. Self certification and mutual recognisation of standards, sampling techniques, etc, are becoming familiar jargon. In this context, inspectorate procedures in general now appear to be developing in the direction of placing very much greater reliance on suppliers, manufacturers and operators if they register with the National or International authorities dealing with Quality Assurance, in the UK case, for example to BS 5750. Such suppliers, manufacturers and operators must then abide by the detailed requirements of these formal QA systems, which must clearly give any purchaser or indeed any inspection authority much more confidence.

The objective, as always, is to measure to the highest practical accuracy attainable with the application of new technology as soon as it is proved.

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.