

Field evaluation of large in-line flow meters*†

EH Johnson*

Stewart Scott Inc., PO Box 784506, Sandton 2146, South Africa

Abstract

The combined application of a portable insertion flow meter, a velocity-area method of flow determination together with the use of a velocity profile function provides a cost-effective method for the *in situ* evaluation of the accuracy of large in-line flow meters within the water supply and distribution network.

The calibration of large in-line flow meters in the field is required because of differing site conditions which affect a flow meter's performance, the expense of testing on off-site facilities and the practical problems associated with the removal and testing of some types of flow meters.

Research has indicated the relative accuracy of velocity-area methods for both axisymmetric and asymmetric flow profiles. The log-linear method appears to be relatively more accurate and cost-effective in its application than other velocity-area methods of flow determination.

The modified Pao equation is a function which is independent of the friction factor and which describes the velocity profile within a pipe. It is dependent, however, on the actual positions where the mean axial velocity occurs and the value of the centre-line velocity. These characteristics facilitate the practical application of the function in establishing a flow reference standard.

The position of the mean axial velocity in a pipeline varies and this position has to be determined for each situation and application.

Practical guidelines given in this paper ensure the cost-effective application of a portable insertion flow meter, the log-linear method and the modified Pao equation for providing a flow reference standard.

Research is required to establish the accuracy of this flow reference standard with respect to the national flow standard.

Introduction

As flow data collected from potable water supply and distribution systems are used for various forecasting and revenue purposes, it is important to know the degree of accuracy of the data obtained. Generally, the less the error in the data, the greater the accuracy of the forecast and possibly the reduction in lost revenue.

Flow meters can be evaluated on test facilities where the meter under test is compared against a standard. This standard could either be another flow meter of better accuracy or a technique utilising weighing methods or volumetric methods. Ideally, this standard should be traceable to an appropriate national standard.

In South Africa, the National Calibration Services (NCS) of the CSIR facilitates a national system for the calibration of instruments which then have an accuracy traceable to national measuring standards as required by law. The NCS therefore verifies a test facility's stated accuracy, the values of which have been determined by SABS, British or International Standards. The NCS specifies requirements such as which documentation should be kept, the competence of the staff undertaking the tests, the intervals with which the test facility itself should be recalibrated (i.e. reference meters), etc. On compliance with these requirements, the test facility is certified by the NCS as an approved laboratory.

The two better known NCS-approved flow laboratories are those of Eskom and the Johannesburg Municipality which can test flow meters up to 1 000 mm and 400 mm dia. respectively.

These test facilities have reference accuracies of 0.1 % which

is not a necessary requirement for all flow-meter calibrations.

On these types of test facilities the evaluation of in-line flow meters obviously requires their removal from site which can be expensive considering the labour, transport and testing costs.

On installation, a calibrated flow meter's performance will differ from its performance as evaluated on a test facility. This difference cannot be verified unless the meter is calibrated *in situ* (Furness, 1991).

There is, therefore, also a need to determine the flow rate to a known degree of accuracy within large pipelines by means of a portable flow meter so that those in-line meters which cannot be easily removed for testing can be evaluated or, previously calibrated flow meters can be calibrated *in situ* to take into account particular site conditions.

Guidelines for the reduction and control of unaccounted-for water give high priority to the *in situ* testing of source (production) and district meters in an unaccounted-for water investigation (Jeffcoate and Saravanapavan, 1987). These guidelines were designed for use by managers of water authorities in developing countries.

By using a portable insertion meter to measure the velocity at various points in the pipe, and the velocity-area method to determine the flow, a suitable reference standard can be established for calibrating flow meters *in situ* (Johnson, 1987).

The basic assumption in deriving most of the velocity-area methods for velocity profile integration is that the velocity curve assumed approaches the real velocity profile in the line of traverse. This is reasonable for axisymmetric flow profiles (Salami, 1971).

This paper provides a brief review of previous studies on the subject of velocity-area methods for flow determination, and suggests some practical guidelines as to the application of insertion meters to ensure that a suitable *in situ* reference standard can be established for the calibration of large in-line flow meters within a water supply and distribution network.

(011) 780-0743; [F] (011) 883-6789

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