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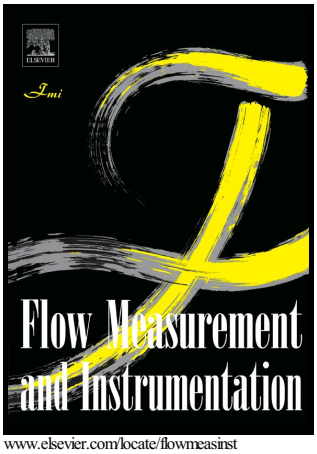

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An alternative gravimetric measurement standard for calibration of liquid flow meters

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Abstract

This paper discusses the conception, construction and validation of a gravimetric system conceived as an alternative measurement standard for calibrating liquid flow meters. The ability to evaluate a large mass of a working fluid by measuring, with much lower uncertainty, a smaller quantity of it, reflects the innovative character of the proposed calibration system. In this work, the mass of water (over 10 tons) retained in a large squared (1.50 m x 1.50 m) cross section reservoir (5 m high) is evaluated by weighing a mass of water confined in a much smaller reservoir (0.0835 m diameter, 5 m high), hydraulically connected to the first. A low capacity weigh scale (full scale: 32 kg; resolution: 0.10 g) is used to weigh, under static condition, the water in the smaller reservoir, whose liquid level is the same of the large storage reservoir. The metrological reliability of the proposed gravimetric system —assessed through the propagation of all impacting measurement uncertainties— falls in the range 0.018 % to 0.055 %, depending on the volume of the working fluid transferred throughout the calibration process (varying from a minimum of 0.001 m^3 to a maximum of 0.022 m^3).

Keywords: metrology; measurement standard; calibration of liquid flow meters; gravimetric flow system.

1. Introduction

The current practice of flow measurement becomes increasingly important to the oil and gas sector, particularly to meet national and international regulatory requirements, certainly a metrology challenge. Hence the need to evaluate and validate transfer standards that can reliably be used to calibrate flow meters within a level of measurement uncertainty that fully satisfy the needs of professional users. Currently, there are many measurement instruments and techniques used for measuring flow rate. In the oil and gas industry, differential pressure meter (orifice plate, venture tube, flow nozzle, Pitot tube); positive displacement meters (gear, rotary piston, vane, lobe) and linear meters (turbine, vortex, electromagnetic, Coriolis, ultrasonic) are commonly used [1, 2].

The choice of the flowmeter for a particular application will depend on the physical-chemical nature of the fluid, the pipe diameter and levels of pressure and temperature of the fluid, whose flow rate is to be measured. Other aspects to be considered are related to the pressure drop introduced by the meter in the pipeline, the location of the meter installed upstream of a straight non-disturbed flow; costs associated with the operation, maintenance and implementation of the calibration system and, of ultimate importance, compliance with the applicable measurement standards and recommendations stated by OIML, the International Legal Metrology Organization [3].

Concerning the custody transfer process and the fiscal metering aspects of it, another striking factor refers to the metrological reliability of the flow meter itself, whose calibration shall take into account the actual operating conditions by means of a transfer system which level of acceptable uncertainty is pre-defined in specific contracts that must reflect the applicable regulation [3].

The flow can be measured based on different measuring principles, among which the direct method that totalizes the amount of fluid discharged in a given period of time [4]. It can also be