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The positive displacement method for calibration of gas flow meters. The influence of gas compressibility

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ABSTRACT

An easy technique to calibrate small gas flow meters is the positive displacement method, whose application requires a simple setup and laboratory procedure. With this methodology there is an unknown gas flow coming from a given gas source that must be known by the action of a gas flow meter. The gas flow to be measured is sent to a reservoir with rigid walls and full of water. As gas enters the reservoir water flows out and the amount of water exiting the reservoir in a given time interval can be connected with the average gas flow in that same time interval. In simple terms the volume flow rate of water leaving the reservoir is equal to the gas volume flow rate entering it. The water being incompressible, the density variation is meaningless, however the same cannot be assumed for the gas.

Considerations on the simple techniques to be used to minimize the importance of gas compressibility are presented in the paper.

1. Introduction

A simple technique to calibrate small gas flow meters is the positive displacement method, whose application requires the setup shown in Fig. 1. With this methodology there is an unknown gas flow coming from a given source G, gas flow that must be known by the action of a gas flow meter MC. The flow meter can be a rotameter, an orifice plate, a venturi or another flow measuring device. The pressure on the gas flow coming from the source G has to be adjusted to a previously defined value, the working pressure of the flow meter. This pressure must be high enough to assure that pressure drops downstream the flow meter are unimportant for the measurement uncertainty, or in another words the gas absolute pressure while flowing through the gas meter must be well above the pressure drops to be expected. This pressure is regulated by means of the pressure regulator R and measured by pressure gauge M. After the flow meter there is the gas flow control valve and beyond it there is the normal gas consumer installation or alternatively the calibration setup. As the gas flow passing the flow meter increases with the opening of the controlling valve V1 the absolute pressure of the gas reduces, unless the pressure reducer acts to compensate its decrease. In the case of semi-automatic gas pressure reducers they are manually adjusted to account for pressure variations with changes in the gas flow.

Measured gas flow can be sent either through valve V4, in the case of normal operating conditions, or through valve V2 under calibration conditions. In the present situations it is the calibration procedure that is under analysis and then the gas flow is sent to a reservoir with rigid walls D, inside which there is water. As gas enters the reservoir water is pushed out of it through pipe T, provide valve V3, the water feeding valve, is closed. The amount of water exiting the reservoir can be easily weighted in a given time interval thus allowing the calculation of an average water mass and volume flow rate.

2. The importance of initial gas volume

In simple terms the volume flow rate of water leaving the reservoir is equal to the gas volume flow rate entering it. The water being almost incompressible, the density variation is meaningless, however the same cannot be assumed for the gas. The gas pressure inside the reservoir increases as the water level lowers and the liquid must be raised to a larger relative height before leaving the reservoir through the siphon shaped pipe T. To take into account gas compressibility effects its pressure is continuously measured through the manometer MU. Then, knowing the atmospheric pressure and the gas temperature, quite often assumed equal to ambient temperature, the thermodynamic state of the gas inside the reservoir is known and thus the gas density may be determined.

Considering ideal gas behavior but being careful enough to consider simple compressibility effects through the compressibility

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