Electric Control and Meterological Validation of Sensors in Dynamic Metering System of Fluids

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Article Info

Article history:

Received Sep 19, 2013
Revised Oct 29, 2013
Accepted Nov 17, 2013

Keyword:

Electric control
International standards
Metering system
Permissible Maximum Error
Sensor

ABSTRACT

The verification method of a metering system varies from one site to another, depending on the available equipment and the calibration equipment measuring instruments installed. However, the effectiveness of the verification and control (primary or periodic) requires a good control system and calibration process. This paper focuses on the errors of measuring instruments in a dynamic system of metering fluids and respect of the tolerance defined by the international standards and recommendations. In a first step, we describe the experimental methodology adopted for evaluating the effectiveness of different systems Dynamic count. Next we will compare the results of measurements between the simulated values and the values read from the computer. Finally, we conclude on the validity of the instruments according to the errors identified and the errors.

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1. INTRODUCTION

The Calibration involves determining the metrological characteristics of an instrument. This is achieved by means of a direct comparison against standards. The calibration allows you to convert an indication of a measurement result. In the case of a measuring instrument used in a range of values, this conversion is performed by a calibration function. The indication can be kept as is, but in general it is converted or corrected [1].

This paper starts by the analysis of metrological properties of measuring and comparing the measuring error for every instrument in the metering system with the MPE defined by specifications and international regulations. In the first part, it is about making a thorough study of dynamical systems counts of hydrocarbon products. This study will focus on issues concerning counting, control principle, calculation errors, the choice of counters and the influence of physical parameters (pressure, temperature, density, etc.).

Also we will describe all the steps to make a verification of a dynamic system of counting. The study will be done with standard references accorded with international laboratories. We will be interested in this paper particularly to the control and verification the different components of the metering system. This consist in realize tests exactitudes and the Repeatable tests. Comparing our verification tests with the reference standards used will certify and ensure traceability to primary standards [2-10].

Flow meters are an integral tool for measuring the flow of liquid, gas, or a mixture of both in applications used in the food and beverage industry, oil and gas plants, and chemical/pharmaceutical factories. The dynamic metering fluid industry offers a wide variety of metering devices [11-16]. However, the flow measurement by orifice elements, mainly devices orifice plate remains predominant (estimated at over 40%) [2]. This meter operates based on Bernoulli's principle. It measures the differential-pressure drop across a constriction in the flow's path to infer the flow velocity.

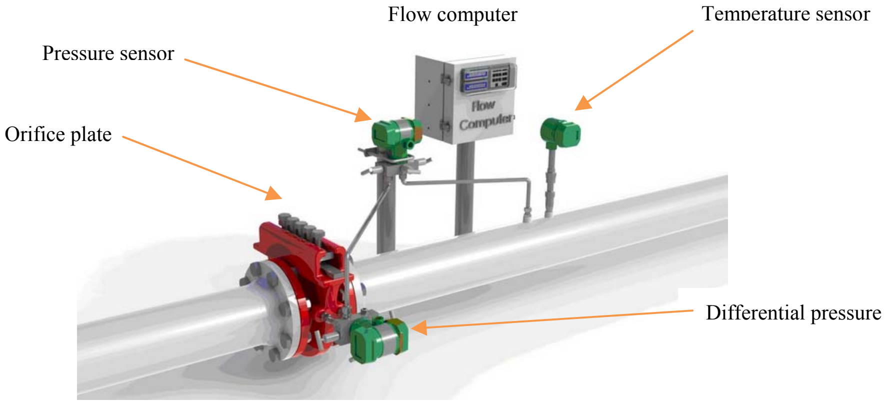


Figure 1. Metering system with all sensor and orifice flow meters

The orifice flow meter (Figure 1) is used to create a constriction in the flow path. As the fluid flows through the hole in the orifice plate, in accordance with the law of conservation of mass, the velocity of the fluid that leaves the orifice is more than the velocity of the fluid as it approaches the orifice [17]. By Bernoulli's principle, this means that the pressure on the inlet side is higher than the pressure on the outlet side. Measuring this differential pressure gives a direct measure of the flow velocity from which the volumetric flow can easily be calculated. The overall accuracy of a flow meter depends to some extent on the circumstances of the application [17]. The effects of pressure, temperature, fluid, and dynamic influences can potentially alter the measurement being taken.

2. RESEARCH METHOD

2.1. Orifice Plate Flowmeter

There are many types of flowmeter available; each of these flowmeter types has its own advantages and limitations. The orifice plate is one in a group known as head loss devices or differential pressure flowmeter. In simple terms the pipeline fluid is passed through a restriction, and the pressure differential is measured across that restriction. Based on the work of Daniel Bernoulli in 1738, the relationship between the velocities of fluid passing through the orifice is proportional to the square root of the pressure loss across it. Other flowmeter in the differential pressure group include venturis and nozzles.

With the orifice plate flow meter, the restriction is in the form of a plate which has containing a hole in the pipe. This is considered the main element. The general formule of calcul is:

$$Q = \frac{C}{\sqrt{1-\beta^4}}\,\varepsilon\,\frac{\pi}{4}\,d^2\sqrt{\frac{2g(P_2 - P_1)}{\rho}} \tag{1}$$

Where C: discharge coefficient, β: the ratio of the diameter of the orifice, ρ: density of the fluid (kg/m3), ΔP: is differential pressure between the upstream and downstream of an element Primary (diaphragm) in bar, ε: coefficient of expansion.

Correct sizing and installation of orifice plates is absolutely essential, and is well documented in the International Standard ISO 5167.

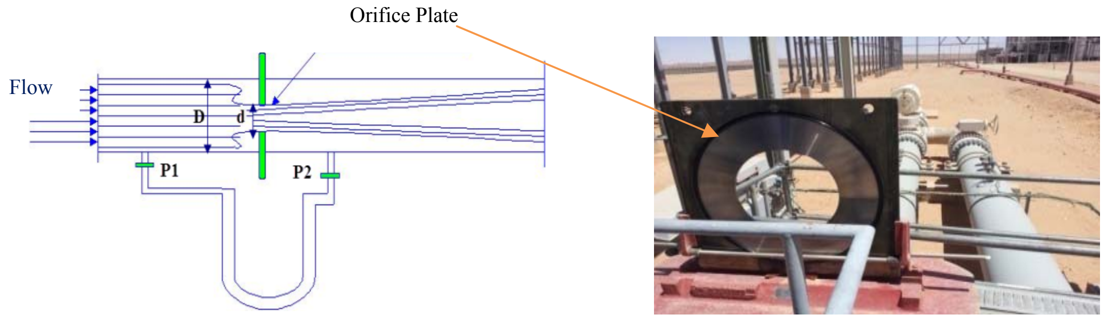


Figure 2. Orifice plate flowmeter

2.2. Pressure Sensor

The pressure differential sensor (differential pressure or cells) perform the DP / force conversion through a membrane or a thickness adapted to the pressure difference DP measuring capsule.This principle can be directly used for measurement of a differential pressure DP, for measuring a pressure relative to the atmosphere from one of the sensor inputs or for measurement of absolute pressure by sealing under empty one of the two inputs. The figure shows the connection of transmitter on the side of the flange in the horizontal flow. The tranditional pressure sensor based on Silicon (Si) material has not been suitable for operating in severe condition such as high-temperature (>500°C) [19].

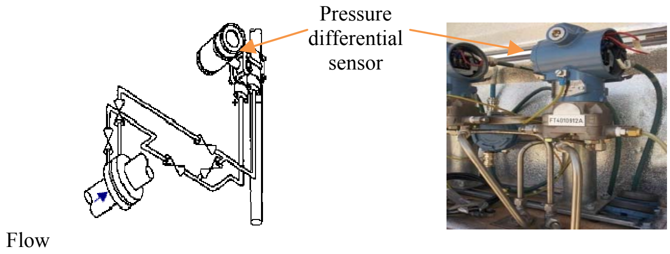


Figure 3. Differential pressure sensors connecting to metering system

2.3. Temperature Sensor

The temperature transmitters convert the resistance measurement of the PT100 in a current signal, eliminating the problems inherent in the signal transmission via lead resistance. Errors in the circuits of the PT100 (especially two and three probe son) are often caused by the increased resistance of lead wire between the sensor and the instrument [4]. The input signal transmitter, specifications, user interfaces, features, sensor connections, and environment are all important parameters to consider when searching for transmitter PT100 temperature.The equation of "linear" computing the resistance of a Pt100 sensor depending on the temperature:

$$R_t = R_0\left(1 + \alpha.T\right) \tag{2}$$

Where, R_t: resistance at t ° C, Ro: resistance at 0 ° C (100 Ω), α: coefficient of temperature.

The calibration is by comparison of the resistance tested with resistance values defined at specific temperatures. The values are defined by one of the current models such as the curve of ASTM specifications 1137 or IEC 60751. RTDs calibrated in this way are typically used in industrial applications where the indicator is not able to accept single coefficients but is preprogrammed with a common RTD [5] curve. The sensor must be tested to ensure compliance with the curve of interest.

Table 1. The Accuracy Calsses of Sensor Pt100

Classes	Nom CEI 60751	Nome ASTM 1137
A	± [0,15+ (0.002.t)] °C	± [0,13+ (0.0017.t)] °C
B	± [0,30+ (0.005.t)] °C	± [0,25+ (0.0042.t)] °C

The resistance values are defined by equation of Callendar-Van Dusen (CVD) and the specified values for the coefficients A, B and C (Table 2) [5]. These values can be determined using a published table or calculated by solving the equations. In this paper, the temperature values are given those of the International Temperature Scale of 1990 (ITS-90) [13].

Table 2. Equation for ASTM 1137 and CEI 60751

Range	Equation of Callendar-Van Dusen	Coefficient
$-200°C \leq t < 0°C$	$R_t = R0\,[1+At+Bt^2+C(t-100)\,t^3]$	$A = 3{,}9083 \times 10^{-3}$, $B = -5{,}775 \times 10^{-7}$
$0°C \leq t \leq 650°C$	$R_t = R0\,[1+At+Bt^2]$	$C = -4{,}183 \times 10^{-12}$

For accepting the calibration test of Pt100, they must fall within the tolerances defined resistance values for a given temperature, this result compared with the indication of the sensor to check with the indication of a temperature standard at several points in its range. The calibration to be used for this operation is only just a thermostatically controlled bath.

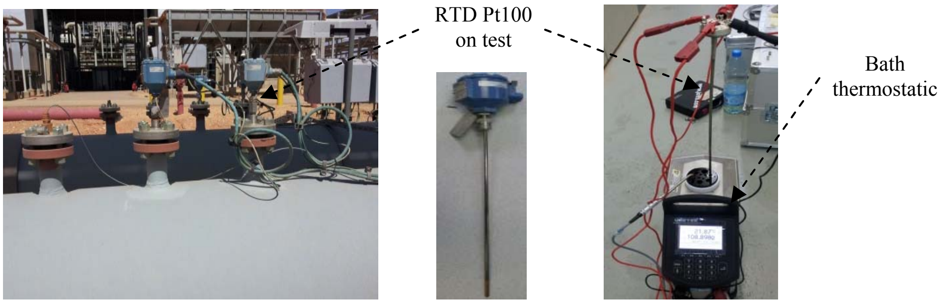


Figure 4. Verification of Pt100 by thermostatic bath

In order to verify the transmission-line method, which has been proposed to evaluate the temperature the method consists in verifying the value of the temperature reading on the computer with that of a temperature standard at various points in the measuring range, with increasing and decreasing resistance [7]. The instrument used for this operation is a box decades of resistance for six positions (potentiometers: 100, 10, 1, 0.1, 0.01 and 0.001 Ω). The operation with the standards used on site is summarized in Figure 5.

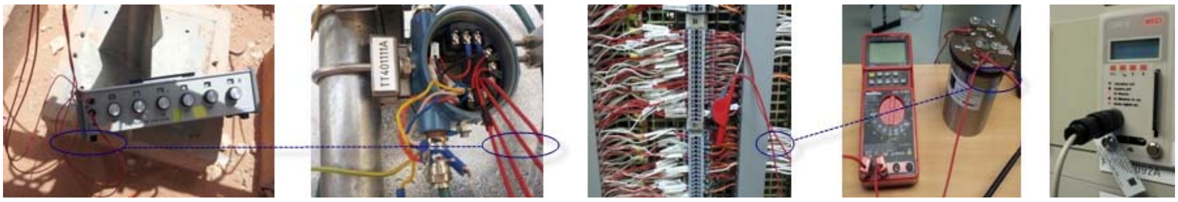


Figure 5. Verification of temperature transmission from ramp metering

We sending the standard values of temperature on the site of metering using box decade, then you look display of calculator these values on the computer at the metering cabinet in the room of supervision.

2.4. Chromatography

The chromatography is a technique for separating of chemical substances (liquid or gas blend) which is based on behavioral differences between a current mobile phase and stationary phase. The control of chromate is a test of accuracy and repeatability for the determination of the concentration of each gas component and its calorific value associated (PCS) [15]. We used a standard gas for direct comparison between the analyses of chromatographic and calculate specialized software (MON2000 software).

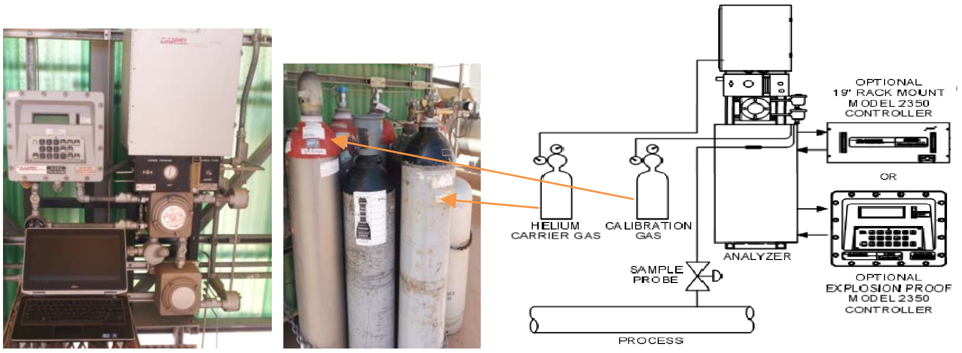


Figure 6. Analyzer functional block diagram

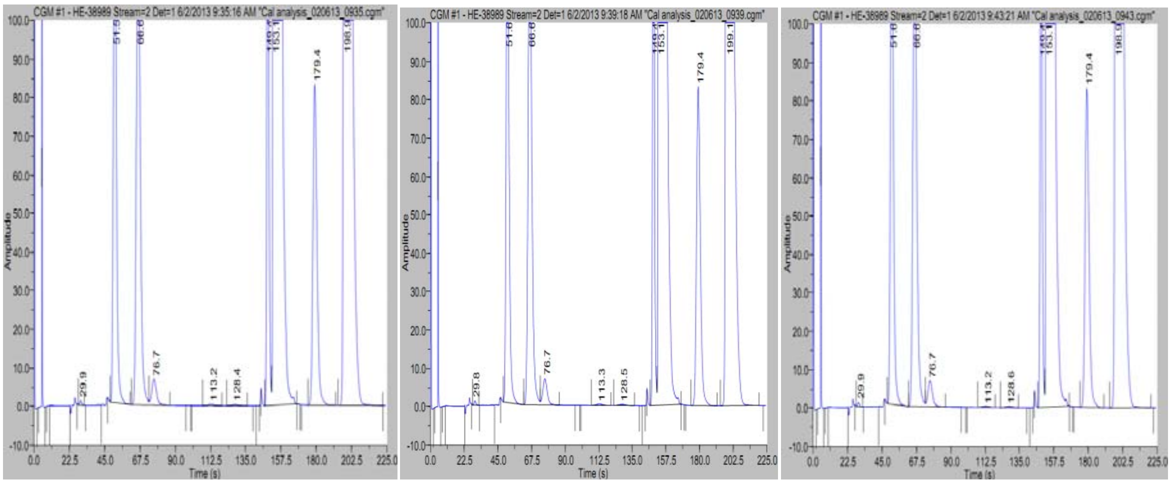
A functional block diagram of a typical Analyzer installation is shown in Figure 6. A sample of the gas to be analyzed is taken from the process stream by a sample probe installed in the process line. The sample passes through a sample line to the sample conditioning system where it is filtered or otherwise conditioned. After conditioning, the sample flows to the Analyzer for separation and detection of the components of the gas [18]. A detector located at the outlet of the analytical column senses the elution of components from the column and produces electrical outputs proportional to the concentration of each component. Outputs from the Analyzer detectors are amplified in the Analyzer electronics, and then transmitted to the Controller for further processing.

3. RESULTS AND ANALYSIS

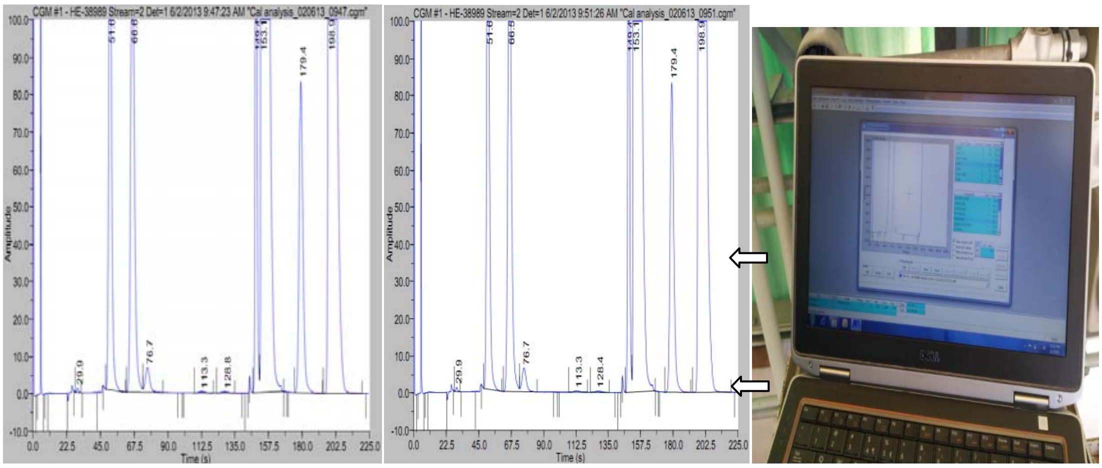
The verification is to provide a standard mixture gas chromatograph and then we done 5 analyzes of the molecular profile to confirm the repeatability and accuracy of the measurement. The PCS, Zb and MVb are calculated from the composition of the mixture according to the international standard ISO 6976 [15].

Table 3. Standard Muxture

Composition		Mol (%)
n-hexane	C6 plus	0.1600
Propane	C3H8	2.1000
I butane	iC4H10	0.3500
N butane	nC4H10	0.5300
Neo pentane	néoC5H12	0.1500
I pentane	iC5H12	0.1200
N pentane	nC5H12	0.1200
Nitrogen	N2	5.9000
Methane	CH4	83.4600
CO2	CO2	0.2100
Ethane	C2H6	6.9000
Total		**100.000**



(Analysis n°1) (Analysis n°2) (Analysis n°3)



(Analysis n° 4) (Analysis n°5) (Computer)

Figure 7. Validation chromate with 5 analyses (MON2000 software).

The control accuracy and reputability of the validation chromatography compard with standard international described on tow tables 4 and 5.

Table 4. Calibration of gaz chromatography

Standard mixture		Analysis chromatography					Accuracy		Reputability	
Component	mol (%)	Analysis (%) mol 1	Analysis (%) mol 2	Analysis (%) mol 3	Analysis (%) mol 4	Analysis (%) mol 5	Average Reading	Absolute Error (%) mol	Analysis Reputability	Reputability Tolerance
n-hexane	0.1600	0.1904	0.1892	0.1896	0.1884	0.1867	0.1888	0.0288	0.004	0.060
Propane	2.1000	2.0662	2.0575	2.0603	2.0561	2.0678	2.0616	-0.0384	0.015	0.060
I butane	0.3500	0.3493	0.3484	0.3486	0.3482	0.3507	0.3490	-0.0010	0.003	0.060
N butane	0.5300	0.5151	0.5124	0.5140	0.5134	0.5170	0.5144	-0.0156	0.005	0.060
Neo pentan	0.1500	0.1509	0.1498	0.1511	0.1525	0.1509	0.1511	0.0011	0.003	0.060
I pentane	0.1200	0.1168	0.1155	0.1176	0.1166	0.1178	0.1169	-0.0031	0.003	0.060
N pentane	0.1200	0.1104	0.1114	0.1119	0.1110	0.1086	0.1107	-0.0093	0.004	0.060
Nitrogen	5.9000	5.7344	5.7352	5.7377	5.7224	5.7496	5.7359	-0.1641	0.027	0.060
Methane	83.460	81.480	81.4784	81.494	81.394	81.609	81.4915	-1.9685	0.217	0.400
CO2	0.2100	0.1995	0.1982	0.1995	0.1973	0.1971	0.1983	-0.0117	0.003	0.060
Ethane	6.9000	6.5012	6.4998	6.5014	6.4955	6.5030	6.5002	-0.3998	0.008	0.060
Total	**100.00**	**97.415**	**97.396**	**97.426**	**97.296**	**97.558**				

Table 5. Test of base component from ISO 6976

Standard mixture		Analysis chromatography					Accuracy		Reputability	
Component	mol (%)	Analysis (%) mol 1	Analysis (%) mol 2	Analysis (%) mol 3	Analysis (%) mol 4	Analysis (%) mol 5	Average Reading	Absolute Error (%) mol	Analysis Reputability	Reputability Tolerance
PCS (MJ/m3)	40.0	40.04	40.04	40.05	40.04	40.044	0.01	0.50	0.014	0.04
PCI (MJ/m3)	36.2	36.20	36.20	36.20	36.20	36.201	0.01	0.50	0.013	0.04
ρb (kg/m3)	0.80	0.8081	0.8083	0.8082	0.8082	0.808	-0.02	0.50	0.000	0.03
Zb	0.99	0.9974	0.9974	0.9974	0.9974	0.997	0.00	/	0.000	0.00
PCS (MJ/m3)	40.0	40.04	40.04	40.05	40.04	40.044	0.01	0.50	0.014	0.04

The results of both tests accuracies and repeatability respect well the tolerances defined by standards, as is shown in Tables 4 and 5. Which certify the results given by the gas chromatography.

The resistance of the thermometer at a temperature t is measured in a thermally controlled bath compared with a resistance thermometer reference [12]. where *t* : Temperature test (ºC) ; T_1 : Temperature read on etalon (ºC) ; R_2 : Resistance of test Pt100 (Ω) ; T_2 : Temperature of test Pt100; *Error* : Error between (T_2 and T_1) on (ºC) ; *PME* : Permissible Maximum Error.

Table 6. Test of calibration sensor Pt100

t	T_1	R_2	T_2	Error	PME (±)
0.00	-0.14	99.936	-0.164	-0.024	0.150
20.00	19.88	107.750	19.89	0.008	0.190
40.00	39.93	115.502	39.90	-0.030	0.230
60.00	59.98	123.199	59.89	-0.092	0.270
80.00	80.02	130.857	79.90	-0.124	0.310

We see on Table 6 that the error of calibration of sensor Pt100 is always less than the MPE. We can validate the measurement of this test.

Table 6. Test of transmission temperature from ramp metering

Values Simulates		Resultat of test			Inducation of calculator		
Range (%)	Temperature (°C)	Tension read Matrixes (V)	Temperature Calculate (°C)	Error (°C)	Temperature Calculate (°C)	Temperature read (°C)	Error (°C)
0	**0.00**	0.9989	-0.0273	-0.027	-0.0273	0.000	0.027
25	**25.00**	2.0010	25.0254	0.025	25.0254	25.030	0.005
50	**50.00**	3.0038	50.0956	0.096	50.0956	50.090	-0.006
75	**75.00**	3.9967	74.9183	-0.082	74.9183	74.910	-0.008
100	**100.00**	4.9996	99.9910	-0.009	99.9910	99.980	-0.011
100	**100.00**	4.9990	99.9760	-0.024	99.9760	99.990	0.014
75	**75.00**	3.9967	74.9183	-0.082	74.9183	74.910	-0.008
50	**50.00**	3.0038	50.0956	0.096	50.0956	50.090	-0.006
25	**25.00**	2.0015	25.0379	0.038	25.0379	25.040	0.002
0	**0.00**	0.9987	-0.0323	-0.032	0.0201	0.000	0.010

The points simulated to the transmiter of tampurature on the site of dynamic metering system have given satisfactory results with errors respecting the standards. Therefore, the metering station is declared as conforming to international specifications for dynamic metering of the fluid.

4. CONCLUSION

In this paper, we have described a particular procedure exposing the steps to be followed for the verification of global dynamic metering system of gas products. The metrology method presented meets international standards and will be used as a function of means available and standards a mythologist proficient vis-à-vis the context of the calibration and knowledge to manipulate operator.

The procedure performed on a petroleum site to control and validation of dynamics metering system was conclusive. The results obtained are considered very satisfactory and correct; errors identified as measuring instruments are within the range of the permissible maximum errors PME by the regulations. It is possible to validate the use of the metering station.

The paper also, shows the interest for managers and leaders to know the errors associated with the measurement instrument used to identify and advance the level of uncertainty measurement results for the next periodic verification.

ACKNOWLEDGEMENTS

I would acknowledge GTFT for providing facilities for work also I would acknowledge my guide all those who helped me in preparing paper directly or indirectly.

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