Algerian Journal of Environmental Science and Technology
December edition. Vol.6. Nº4. (2020)
ISSN : 2437-1114
www.aljest.org

Control Study of the Liquid Volumetric Flow using the Dynamic Metering System

M. Oulhadj[1], A. Harrouz[2,*], A. Benatiallah[2]

[1]Department of Materials Sciences, Faculty of Sciences and Technology, LDDI Laboratory, University of Ahmed Draia, Adrar, 01000 Adrar-Algeria.
[2]Department of Hydrocarbons and Renewable Energies, Faculty of Sciences and Technology,LDDI Laboratory,University of Ahmed Draia, Adrar, 01000 Adrar-Algeria.

*Corresponding author: abd.harrouz@univ-adrar.dz; Tel.: +213 664 311 537

ARTICLE INFO

Article History :

Received ***:22/06/2019***
Accepted ***:15/12/2019***

***Key Words*:**

Control;Flow rate; Metering; Error; MTE.

ABSTRACT/RESUME

Abstract:*This paper presents control study of a liquid volumetric flow using the dynamic metering system, This subject is necessary especially in case of fiscal metering operation because of the transactional use between two different partners, which encompasses not only the quantitative study but also qualitative results of this control so those results are important. To accomplish this purpose, the authors of the paper propose to use the equations, which can calculate the correction factors of hydrocarbon mass flow. The article describes the measuring devices used in this control as well as the applied inspections on these devices and the uncertainty related to this measurement, it identifies also the maximum permissible errors of each element constituting the liquid metering system. The paper presents a comparative analysis of the obtained measurement error for each instrument with the MTE.*

I. Introduction

The oil andgas industry encompasses the production, treatment, distribution, and processing of a wide variety of hydrocarbon fluids, gases, contaminates and produced water. Each industry segment has unique measurement needs that are readily addressed with coriolis mass, volume and density measurement solutions [1, 2].

Conventional point-to-point wiring using discrete devices and analog instrumentation dominate today's computer-based measurement and automation systems. Twisted-pair wiring and 4─20 mA analog instrumentation standards work with devices from most suppliers and provide interoperability between other 4-20 mA devices. However, this is extremely limited because it provides only one piece of information from the manufacturing process.

Historically, measurement networks and automation systems have used a combination of proprietary and open digital networks to provide improved information availability and increased throughput and performance. Integrating devices from several vendors is made difficult by the need for custom software and hardware interfaces. Proprietary networks offer limited multi-vendor interoperability and openness between devices. With standard industrial networks, on the other hand, we decide which devices we want to use [3, 4 and 5].

In this work, the tolerable levels of accuracy for dynamic liquid flow meter is defined. Therefore, every type of flow meter will be checked with the use of standard standards and the necessary corrections to the requirements met.

In addition, we will appreciate the relative importance of potential errors not only in terms of relative or absolute error but also in economic terms where the transactional exchange between different partners becomes very essential.

II. Dynamic liquid metering system

A dynamic liquid metering system is defined as a system connected to the calculator, the correction device or the conversion device, which converts, during the measurement; the characteristic quantities of the liquid (temperature, pressure, density, viscosity, etc.) into signals intended for the calculatorto establish the correction and / or conversion. It includes an associated measurement sensor and an associated measurement transducer [6]. The flow meter of quantities of liquids is the instrument intended to measure continuously and to display the quantity of liquid, which passes through the measuring device under the measurement conditions.
By definition of the International Recommendation R117, the measuring device is a part of the meter which translates the flow, the volume or the mass of the liquid to be measured into signals, representative of the volume or the mass, intended for the computer. It consists of a sensor and a measurement transducer. A meter comprises at least one measuring device, a calculator (including adjustment or correction devices if present) and an indicating device [7, 8]. The most commonly used for dynamic counting of liquid products is the ultrasonic flowmeter [9].

Figure 1.*Dynamic liquid metering system of (source: GTFT-Algeria)*

Analogy 4-20 mA links the acquisition of the measurements to the calculator. Figure (1) shows all the metering system communicating equipment as well as all associated communication links. Our objective of this study is to harmonize and normalize the calculations related to the measurement of liquefied petroleum products and to clarify the terms and expressions by eliminating the variants of such terms specific to each oil site in Algeria. The object of the normalization of calculations is to arrive at the same result from identical data whatever the computing system used.

III. Maximum Tolerable Error (MTE)

The recommendation R 117 OIML [8] is a regulatory model setting the metrological characteristics of instruments in the dynamic metering system to measure the quantity of liquids other than water subject to legal metrological control. It presents methods and means of checking their conformity.
For the quantities greater than or equal to two litters (2 L) or two kilograms (2 kg), the Tolerated maximal error, plus or minus, on the quantities indicated (volume under the conditions of measurement, volume under the basic conditions or mass) are given in Table 1.

Table 1.*Class of accuracy*

Line	Class of accuracy			
	0.3	**0.5**	**1.0**	**1.5**
A	0.3 %	0.5 %	1.0 %	1.5 %
B	0.2 %	0.3 %	0.6 %	1.0 %
C	0.1 %	0.2 %	0.4 %	0.5 %

The absolute value of the MTE, whatever the quantity measured, is given by the greater of the following two values:

- Absolute value of the MTE given in Table 1.
- Specified minimaldifference for the quantity (e_{min}).

For the measuring system, the Minimum Error of the quantity (e_{min}).is given by the following equation:

$$e_{min} = (2MMQ)X\left(\frac{A}{100}\right) \quad (1)$$

Where:
MMQ: Minimal measured quantity.
A: It is the numerical value given by line A of the Table 1for the concerned accuracy class.

The MTE in line A of Table 1is applied to complete flow meters, under the rated operating conditions, without any adjustment between the various tests, during the approval type, initial verification and subsequent verifications [8].
The MTE in line B of Table 1 is applied when approving the type of a flow meter, under the rated operating conditions, and checking a flow meter prior to its initial verification. a flow meter [8].If the flow meter is equipped with an adjustment or correction device, during type approval, it is sufficient to check that the error curve (s) are within an interval equal to twice the value specified in line B of the Table (2).
When the type approval provides, the initial verification of a flow meter intended to measure several liquids may be carried out by means of a single liquid, or with a liquid different from one or more of the intended liquids. . In this case and if

Algerian Journal of Environmental Science and Technology
December edition. Vol.6. Nº4. (2020)
ISSN : 2437-1114
www.aljest.org

necessary, the type approval gives the information on the maximum tolerable errors to be applied for the measuring set of the intended liquids.

IV. Verification of the converted indications

There are two methods to check the conversion devices:

First method: General check of the conversion device with the associated measuring devices, the calculator and the indicating device.
This approach applies to mechanical conversion devices and can be applied to electronic conversion devices. When a conversion device is verified according to the first approach, the applicable MPE on the converted indication due to the conversion device, positive or negative, is the greater of the value specified in line C of Table 2, and half of the minimum error of the quantity (e_{min}).

The value of a significant fault on the converted indications is the greater than the two values:

- The fifth of the absolute value of the TME on the measured quantity, or
- The minimum error of the quantity of the measuring system (e_{min}).

Second method: It consists of checking separately the elements of a conversion device. This approach allows separate verification of the associated measuring sensors, associated measuring devices (consisting of an associated measurement sensor and associated measurement transducer) and the conversion function, using simulated inputs [8].

- ✓ **Utilization of digital input signals:** When a computer with its indicating device is checked separately using known "digital input signals" simulating the signals of the associated measuring devices, the TME and the critical value for faults Significant for temperature, pressure or density indications are limited to rounding errors.

- ✓ **Utilization of analogue input signals:** When a calculator with its indicating device is separately checked using known "analogue input signals" simulating the signals of the associated measuring devices, the EMTs and the critical value for faults significant for the temperature, pressure or density indications are specified in Table 2.

Table 2.*MTE on the indication of the quantities [8].*

Maximum Tolerable Error (MTE), and significant fault on measurement	**Class of accuracy of flow metering system**			
	0,3	0,5	1,0	1,5
Temperature	± 0,18 °C	±0,30 °C		
Pressure	Less than 1 MPa : ± 30 kPa Between 1 MPa and 4 MPa : ± 3% Greater than 4 MPa : ± 120 kPa			
Density in case of mass / volume conversion	± 0,6 kg/m^3	± 1,2 kg/m3		
Density in case of converted temperature or converted pressure	± 3 kg/m^3			

The indication of the converted quantity must correspond to the "true value" to the nearest tenth of the MPE line A of Table 2 for the corresponding accuracy class [8]. The "true value" is calculated from the quantities indicated for the simulated inputs taking into account:

- ✓ The unconverted quantity,
- ✓ The temperature, pressure or density determined by the associated measuring devices, or any characteristic quantity stored in the calculator (typically the density) and appropriate values given by the International Recommendations and applicable international standards.

V. Modeling and determination of the real volume of the liquid

The volume of oil under normal conditions, including water - standard gross volume. The standard gross volume (GSVM) for the flow meter is the volume of recordings indicated (IVM), corrected for the flow Meter Factor (MF) and the effect of temperature (CTL) and pressure (CPL) on the mass volume of the liquid. This can be expressed by the following equation:

$$GSVM = IV_m(CTLxCPLxMF) \quad (2)$$

The correction factors are necessary to correct the measured volume of petroleum liquid at its volume at reference conditions. The standard net volume (NSV) equation uses several types of correction factors depending on whether one is measuring in static or dynamic mode [10]. The following four correction factors are applied to the calculation of liquid quantities. They are imposed because of volume changes caused by temperature and pressure, both on the tank (usually mild steel) and on the liquid considered. These four correction factors are as follows [10]:

- (CTS) Correction flow metering factor for the effect of Temperature on Steel.
- (CPS) correction flow metering factor for the effect of pressure on steel.
- (CPL) correction flow metering factor that measures the effect of pressure on the liquid.
- (CTL) correction flow metering factor for the effect of temperature on the liquid.

The recommended method for correcting volumes with two or more methods is to first obtain an FCC (Combination Correction Factor), multiplying the various correction factors in a given order and rounding up each step. Multiply only then the volume by the FCC. The prescribed order is MF, CTS, CPS, CPL and CTL omitting any factor that would not be useful in the calculation [10, 11].

V.1 Pressure Correction on Steel (PCS)
If a metal tank such as a standard tank, a standard tube or a gauge is subjected to internal pressure, its walls will elastically deform and its volume will change accordingly.
Although simplified elements are included in the equations below, for practical reasons the correction factor accounting for the effect of the internal pressure on the volume of a cylindrical tank (PCS) can be calculated in the manner next:

$$\mathrm{PCS} = 1 + \frac{\mathrm{PD}}{\mathrm{ET}} \quad (3)$$

Where:
P: is the internal pressure, in kilo Pascal, at the pressure gauge;
D: is the internal diameter, in millimeters;
E: is the modulus of elasticity applicable to the material of the tank, namely 2.1 x 108 kPa for mild steel or 1.9 to 2 x 108 kPa for stainless steels;
T: is the thickness, in millimeters, of the tank wall.

International standard ISO 4267 gives tables giving the values (PCS) applicable to the specific wall dimensions and wall thickness of mild steel standard tubes as a function of pressure [10, 11]. If we know the volume of the tank at atmospheric pressure (V_{atmos}), zero relative pressure, we can calculate the volume at any other pressure (P) as follows:

$$V_p = V_{atms}.C_{ps} \quad (4)$$

V.2 Temperature Correction on Steel (TCS)
The volume of a metal tank, whether it is a standard tube, a reservoir or a standard gauge, undergoes changes when subjected to temperature variations. The variation of volume, whatever the form of the standard, is directly proportional to the variation of temperature of the material of which the reservoir is made. The correction factor applicable to the effect of the temperature on steel (TCS) is obtained from the following equation:

$$TCS = 1 + (t - 15)\gamma \quad (5)$$

Where:

t: is the temperature of the tank walls, in degrees Celsius;
γ: is the thermal expansion coefficient per degree Celsius of the material of which the tank is made.

SoTCS is greater than 1, if the temperature t is greater than 15 ° C and lower than 1 in the opposite case.

The value of γ is 3.3 x 10 -5 (or 0.000 033 per degree Celsius) for mild or low-carbon steels and has a range of 4.30 to 5.20 x 10 -5 per degree Celsius for the stainless steels of the series 300.

The value used in the calculations shall be that shown on the certificate issued by the calibration agency or by the manufacturer of the standard.

If we know the volume of the container at the normal temperature (15 ° C), we can calculate this volume at any other temperature (t) by applying the following equation:

$$V_t = V_{15}.V_{ts} \quad (6)$$

V.3 Temperature Correction on Liquid (TCL)
When the petroleum liquid is subjected to changes in its temperature, its density increases or decreases when the temperature rises or falls. This modification is proportional to the coefficient of thermal expansion of the liquid, which varies according to the base density and the liquid temperature.

V.4 Pressure Correction on Liquid (PCL)
When petroleum liquids are subject to change in pressure, their density increases or decreases as the pressure increases or decreases. This effect requires an adjustment for reference conditions, which is called Cpl [12]. This factor of Cpl is a function of the liquid compressibility Z, the base pressure (Pb), the equilibrium vapor pressure Pe and the weighted average pressure (PWA) [12].

Algerian Journal of Environmental Science and Technology
December edition. Vol.6. Nº4. (2020)
ISSN : 2437-1114
www.aljest.org

In turn, the Z compressibility is a function of the base density of the liquid (MVb) and the weighted average temperature (TWA). The Z factor equations and compressibility are specified in the Petroleum Measurement Standards (API) manual. The basic correction factor of the pressure effect on the liquid is calculated from the following equation:

$$C_{pl} = \frac{1}{1-(1-P_{WA}-(P_e-P_b).Z)} \quad (7)$$

Where:
P_b: is the basic pressure;
P_e: is the relative equilibrium vapour pressure;
P_{WA}: Weighted average pressure;
Z: Compressibility factor for the liquid.

The correction factor used to adjust the measured volumes for the effect of temperature is calledCtl, which are specified in either the physical properties standards of the MPMS Ch.11.1 API or the appropriate ASTM standard (D 1250) for oils. raw or refined products. Various other products, such as LPG, LNG, and Aromatic have different standards that define their thermal expansion (and / or) the amount of contraction.
The pressure correction on liquid is then multiplied by the net temperature compensated volume indicated by the meter to obtain a net reading "reduced to reference conditions and vapor pressure at 20 ° C". Table F.2 in Appendix F shows the correction factors for the effect of pressure (PCL) on liquid propane volume [13]
The pressure indicated in this table corresponds to the difference between the operating pressure and the equilibrium vapor pressure at this given temperature. In the case of knowing the volume of a liquid with low vapor pressure at any pressure (Vp), the volume equivalent to the reference pressure (relative pressure A 0 kPa or Vatmos) is obtained as follows:

$$V_{atmos} = V_p.C_{pl} \quad (8)$$

Or, if we know the volume of a liquid having a high vapor pressure at a temperature (t) and a pressure (P) of any measurement, the pressure correction is carried out in two steps. The volume equivalent to this equilibrium vapor pressure Pe of the liquid at the measurement temperature is given by:

$$V_{pe} = V_p.C_{pl} \quad (9)$$

V.5 Maintenance factors (MF)
The performance of a meter will change over time, this variation may be due to mechanical wear or a change in the physical properties of the liquid to be dosed. Therefore, a meter is proven or verified to establish its measurement factor (MF), which is used to adjust the indicated volume by one meter during a transfer [13].
During a proofing operation, the volume of one meter is indicated in relation to the volume accurately known in the test vessel, both brought back to normal conditions. This report is called the measurement factor (MF).
Generally, three or more consecutive tracks or passages of displacement, accepting within a range of 0.05%, constitute a province [13].
A correction factor is calculatedfor each test and, if within the specified tolerance, the means is the resulting correction factor used for this transfer [13]. Therefore, the measurement factor (MF) can be expressed by the following basic equation:

$$MF = \frac{V_{true}}{V_{measured}} \quad (10)$$

Where:

MF: Main factor;
V_{true}: is the true volume indicated by the standard (pilot meter, the standard loop ..);
$V_{measured}$: is the volume measured by the meter or the volume indicates turbine meter subjected to the control.

VI. Calibration of turbine flow meter

Transactionalmetering facilities are generally only approved if the meters can be calibrated. The aim of the calibration is to determine the meter's coefficient in the case in particular of its use at a constant flow rate or the variation of the coefficient as a function of the flow rate (at different viscosities) or the Reynolds number (Re) if it is desired to improve the accuracy of the measurement (or in the case of multi-product use) [14].

This calibration can be done on a previously calibrated standard and as follows:

- by comparison with the contents of a standard gauge;
- by pilot standard meter;
- by comparison with the indication of a standard tube placed in series.

VI. 1 Calibration methods
Generally, the flow meter is not set but it takes every period to do calibration, which means to calculate the meter coefficient. This coefficient is the number obtained by dividing the actual volume

of liquid that has passed through the meter during calibration by the volume recorded by the meter. Then, for all other measurement operations, the actual volume or gross volume measured is determined by multiplying the volume recorded on the meter by the counter coefficient. This method is most commonly used with turbine meters. When the meter is used with different liquids or at different flow rates, a different coefficient can be determined for each liquid, for each flow or for each liquid / flow combination.

VI.2 Conditions of calibration

By definition, the reference conditions are the set of specified values of influencing factors, set to allow valid intercomparisons of the measurement results [13]. For comparison with the basic conditions, the basic conditions are the specified values characterizing the conditions under which the measured liquid quantity is converted (example: temperature and base pressure).

VII. Calibration with standard tube

VII. 1 Description of standard tube

A referential tube consists of a tube or cylinder whose measured volume is used to calibrate a meter. Meter calibration is accomplished by circulating a movable member (generally a sphere or plunger) along the tube, which movable member actuates sensors defining the calibrated section. The known volume of the section is corrected for temperature and pressure, and compared to the reading of the turbine meter to determine the meter error.

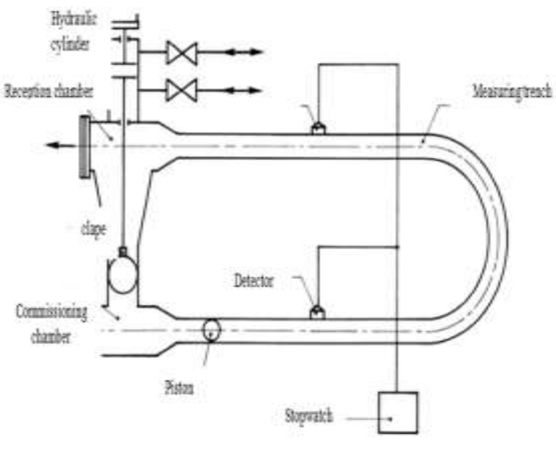

Figure 2. *Standard Tube with piston*

Calibrating the line meters can be carried out on site, when the partners have accepted it, in a centralized calibration station, under the supervision of an accredited and accredited laboratory. In this case, the meter must be calibrated with a serial tube placed in series (as shown in Figure 2). The calibration will end with the issuance of a calibration report certifying the counter coefficients.

In this case, the turbine meter is set so that the reading observed during a calibration reaches or approaches that of the volume measured in the calibration device. This method is used when it is desirable to have a direct reading of the meter without having to apply mathematical corrections to the indications carried on the flow meter. The calibration of the reference volume of a standard tube shall be performed in such a way that the overall calibration uncertainty is less than one-fifth of the maximum permissible error in the model approval test and one-third of the maximum permissible error in the verification test.

The estimation of global uncertainty must be made with a factor k = 2 [14]. The global uncertainty includes the uncertainty in the measurement standards, the uncertainty in the calibration operation, and the uncertainty on the calibration standard tube. When the calibration tube is calibrated, the overall calibration uncertainty shall be indicated in the calibration certificate.

VII. 2 Standard tube assembly

Prior to any calibration, the control of the correct operation of the equipment to be calibrated is carried out in the measuring range. A period of operation prior to a flow rate of Qmaxshall be carried out as far as possible.

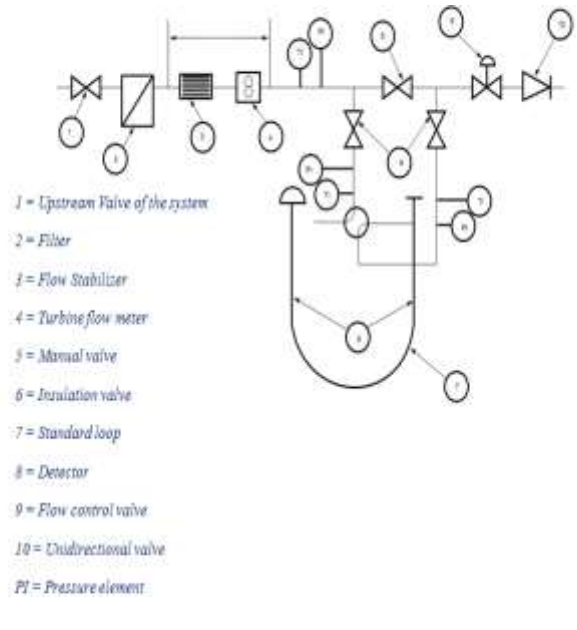

Figure 3. *Installation of a turbine flow meter with standard loop [18].*

VIII. Study

The authors made the calibrations whichare performed by comparing the volume seen by the

Algerian Journal of Environmental Science and Technology
December edition. Vol.6. Nº4. (2020)
ISSN : 2437-1114
www.aljest.org

flow meter to the reference volume through a standard tube (ISO7278).
The pulses delivered by the flow meter between the two passages of a sphere to the right of the "input" and "output" detectors of the standard loop are totalized in a flow meter.

VIII.1 Experimental results

For this volume test, which was carried out on a condensate-metering site exported to the north of Algeria, the turbine meter calibration is done with serial pipe placed in series. The equal flow measurement range: 500 m^3 / h to 2500 m^3 / h, the maximum pressure of the test: 55.15 bar and the nominal K-factor equal to 1670. Table (4) shows the conditions of test for control.

Table 3. *The conditions of calibration tests*

Standard Tube		***Parameters of the liquid***	
Internal diameter (mm)	730.25	Density (kg/m3)	714.7
Thickness (mm)	15.870	K1 = 0,	613.972
Coefficient of expansion of the material	0.0000335	Alpha	0.0012
Modulus of elasticity of the material (bar)	2068000	Standard Temperature (°C)	15
Standard volume (m3) at 15°C	14.031972	Standard Relative Pressure (bar.g)	0

When the standard tube placed in series with the turbine meter, we obtained in the same table results.

Table 5. *Standard Tube Correction Factors and MF Calculation*

Pressure (bar)	**Temperature (°C)**	**CPSP**	**CTSP**	**CPLP**	**CTLP**	**MF**
12.97	35.05	1.000 29	1.000 67	1.001 90	0.9757 1	1.005 1
12.90	35.05	1.000 29	1.000 67	1.001 89	0.9757 1	1.005 4
13.04	35.05	1.000 29	1.000 67	1.001 92	0.9757 1	1.005 1
13.06	35.05	1.000 29	1.000 67	1.001 92	0.9757 1	1.005 1
13.07	35.05	1.000 29	1.000 67	1.001 92	0.9757 1	1.005 1

The test shows that the repeatability of the tests for the 05 liquid flow points is (0.03%), the average MF factor calculation is 1.0052. This last value of MF will be configured at the computer for calculating the actual volume of liquid that passes through the metering station.

VIII.2 Calibration with pilot meter

The flow meter to be calibrated is compared with a pilot flow meter operating in series, a similar procedure compares the number of pulses delivered by the flow meter to be calibrated to the total of pulses delivered at the same time by pilot meters placed in series; this pilot counter has been calibrated beforehand with the standard loop at an accredited international laboratory.

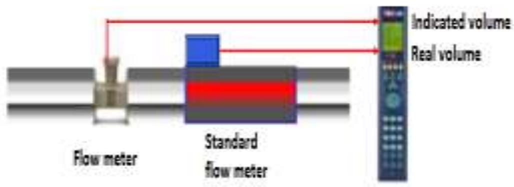

Figure 4. *Calibration with standard flow meter, which is placed in series*

VIII.3 General Description

The dynamic metering system studied consists of a double turbine metering bench; a calculator in the local control room; associated instruments for measuring the temperature, pressure and density of the counted products and a filter upstream of the counting bench.The liquid counting system consists of two instrumented lines, in series, equipped with a turbine. The proven line to a "pilot" turbine used for the verification of the metering turbine. In degraded (or exceptional) mode, both lines can be used at the same time.
Each line is equipped with redundant calculator. It consists of a turbine, 1 temperature transmitter and 1 static pressure transmitter. Fig. 5 shows the set of instruments of the global liquid count chain with the standard reference chain for the provincial mode.

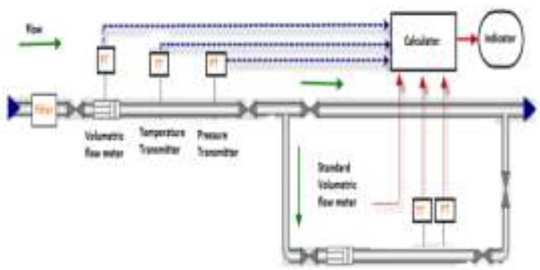

Figure 5. *Diagram of petroleum liquid metering system*

The pilot line is used to check and calibrate the meter line turbine periodically. By counting line, each transmitter is associated with the counting computer:

- The turbine flow meter sends frequency signals (measurement and control) in parallel to the computer;
- Each transmitter sends a 4-20 mA signal that will be wired in a loop at the computer level, to allow the acquisition of pressure and temperature.
- A 4-20 mA output assigned to the flow (raw or corrected) is made available to the DCS.

VIII.4Tests at the accredited laboratory

The calibration of the pilot turbine counter is carried out after disassembly of the counting site.In this case, the meters must be dismantled and transported with the usual precautions. Pilot meter calibration is performed when the partners have accepted it, under the supervision of an accredited and accredited laboratory. The calibration will end with the issuance of a calibration report certifying the counter coefficients, that is to say, certified is defined with new K-factor (Kf). This operation is periodically mandatory each (06 months).

The pilot turbine meter recalibration is done in accordance with EN-12261 (turbine flow meters) or ISO 17089-1 (ultrasonic meter). High pressure calibration is performed by a calibration company approved according to (ISO 17025). They ensure the traceability of the measurement according to the cubic meter of natural gas harmonized by the approved manufacturer or an international laboratory like (LNE, NMI, PTB, Westerbork, Trans-Canada Calibrations, ...), designated at the sole discretion of the Manager Storage.

After calibration of the condition of the line turbines used for the liquid count, it will be issued attached laboratory minutes certificates which indicate, an introduction specifying the identification of the meter (brand, type, serial no. , the name of the company for which it has been calibrated) and the date on which the calibration was carried out, a paragraph of the test conditions, recalling the purpose of the tests and whether it is a initial or periodic verification, specifying the reference conditions in which these tests were carried out, in particular: the number of straight lengths placed upstream and downstream of the meter and their diameter; pressure and reference temperature conditions; the type of fluid used; the principle of calculating the volume of the meter and the reference volume; calculating the value of the deviation or coefficient; a paragraph "results"; finally, a paragraph "observations" where are reported all the anomalies noted before and during the tests: (Anomalies not likely to alter the metrological quality of the meter, anomalies likely to affect the metrological quality of the meter (noted before, during and after tests) It will in particular be indicated for the verification considered (periodic or primitive) if the meter leaves the range of the maximum permissible errors specified in the regulations [18].

The turbine meter calibration report (attached with certificates) results from the accredited laboratory is summarized in Table 6:

Table 6. *Tturbine meter calibration results*

Flow (m^3/h)	Visc Pa.s	Freq (Hz)	MF	Error (%)	Kf	Reputability (%)
29.4	0.6	11.4	0.9992	0.08	1.47694	0.01
59.5	0.6	29.4	1.0007	-0.07	1.47469	0.02
121.4	0.6	45.9	1.0008	-0.08	1.47453	0.00
180.4	0.6	71.4	1.0006	-0.06	1.47476	0.02
240.5	0.6	96.7	1.0008	-0.08	1.47451	0.01
300.4	0.6	128.8	1.0003	-0.03	1.47528	0.01

Often, the recommended number of measurement points is usually 5 to 10 for each calibration fluid. The table 6 is summary of calibration of several points we calculated for each point flow means. The essence of this test is the coefficient 'K-Factor', since it will be configured to the calculator to make good linearity of controlled meter volume calculation.

The calibration curve of our controlled turbineflow meter is shown in Figure6.

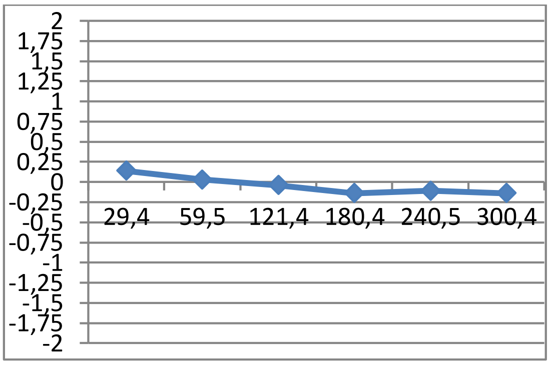

Figure 6. *The calibration curve of the turbine flow meter.*

It is clear from the calibration curve that the error has always remained in the range of (+/- 0.25%), or the meter falls within the range of maximum permissible errors specified in the regulatory texts and in the international recommendation of the OIML R117 [8]. As a result, the meter is declared compliant and can count the hydrocarbon products liquid.

VIII.5 On site transmission test

In order to control the volume of liquid flowing through the metering system and to ensure the exact acquisition of turbine impulse signals for the computer, standard values oftemperature, pressure and density (MV) are set.). The signallingcontrol procedures from the flow metering ramp to the control room are shown in Figure7.

Figure 7. *Volume control with the pulse generator*

Figure7 shows all the steps we followed to perform the volume control that passes through the liquid counting system. We look at the display of these values on the computer at the level of the counting cabinet in the supervision room.
To do this well, we used the reference conditions presented in table7

Table 7. *The reference conditions used for our case*

K-factor imp./m³	N° of pulses	Frequ. (Hz)	Main factor	Temp °C	Prs. bar
1500	30000	100	1	15.00	0.00

For the calculation of the volume under servicing conditions, we used the following equation:

$$V = \frac{Number_{\ impulsion}}{K_{Factor}}.MF \qquad (11)$$

Table 8. *Values configured with correction Factors*

Configur.	Simulated Values		Correctionfactor	
Density *(kg/m³)*	**Tempera.** *(ºC)*	**Pressure** *(bar)*	**CTL**	**CPL**
610	25.00	25.00	0.983418	1.005958
630	30.00	30.00	0.976302	1.006334
660	50.00	50.00	0.9481970	1.012110
700	30.00	30.00	0.9798770	1.004591
730	25.00	25.00	0.9874400	1.003114

Table 9. *The results of the volume simulations*

Volume conditions of service		
Calculated *(m³)*	**Luecalculator** *(m³)*	**Error** *(%)*
20.000	19.999	-0.005
20.000	19.999	-0.005
20.000	19.999	-0.005
20.000	19.999	-0.005
20.000	19.999	-0.005
Volume conditions of standards		
Calculated *(m³)*	**Read calculator** *(m³)*	**Error** *(%)*
19.786	19.781	-0.023
19.650	19.655	0.027
19.194	19.193	-0.003
19.688	19.687	-0.003
19.810	19.810	-0.002

The two tables 8 and 9 show the results of the liquid volume accuracy test, it is found that the controlled flow points remain within the range of the maximum permissible errors specified in the standard regulations. meter is not subject to anomalies that may affect its metrological quality.
After each check, a metrology marking plate is attached to the downstream flange of the meter using two lead rivets.
After the installation of these turbine meters either as pilot or in line, it is necessary to make the configuration again (K_f) in the computer to the supervision room. Based on the calibration certificate, apply linearization in the computer.

VIII.6 Measurement repeatability

There are different ways to evaluate if the repeatability of a set of readings is acceptable. Repeatability must not exceed the limits agreed by all parties [15]. In certain circumstances, the statutory measurement authorities will set the limits of the scope of a set of results.

By using Proven methodology, we did 03 meters in a row tracks in a range of (0.05%). It is defined as a value that must not be exceeded, when applying the following equation:

$$Repeatability = \frac{Valeu_{Max} - Valeu_{Min}}{Valeu_{Min}} X\ 100 \quad \textbf{(12)}$$

Table 10. *Random uncertainty in the average Meter Factor [19].*

Number ofProven to run, n	Error limited
3	**0.0002**
4	0.0003
5	0.0005
6	0.0006
7	0.0008
8	0.0009
9	0.0010
10	0.0012

For the case of our site, the volume is low since the counting station 'LACT' is small five tests in an interval of 0.0005 may not be practical nor profitable, three points in an interval of 0.0005 can be practiced [16].

IX. Conclusion

In this paper, we investigated the control of a liquid dynamic metering system. First we introduced the basic fundamentals of liquid counting. Second, we expanded our study, considering the case of volume correction with correction factors: MF, Cts, Cps, Cpl and Ctl. We have demonstrated the need for these correction factors for the calibration of turbine meters used in the petroleum liquid metering system.

We have experimentally presented the turbine meter verification by standard pilot meter or by comparison with the indication of a standard tube placed in series.

Finally, it was concluded that the procedure performed for the verification and validation of liquid dynamic metering system on this oil site was conclusive! Thus, the results obtained are considered very correct and satisfactory because the errors found in the measuring instruments are within the margin of the maximum errors tolerated by the regulations in force. It is then possible to validate the use of this liquid metering station.

X. References

1. Harrouz, A.; Benatiallah, A.; Harrouz, O.; Electric Control and Meteorological Validation of Sensors in Dynamic Metering System of Fluids. *International Journal of Power Electronics and Drive System* 3 (2013) 450-458.
2. Djiev, S.; *Industrial Networks for Communication and Control* 8 (2014) 2–39,.
3. Endress, H.; Flow Handbook, 9 (2006) 374–390.
4. Park, J.; Mackay, S.; Practical data acquisition for instrumentation and control systems. *Technologies punished Elsevier Academic* 1(2003) 1–11.
5. Harrouz, A.; Benatiallah, A.; Harrouz, O.; Practical Control of Dynamic Metering System and Data Acquisition. *International Journal of Industrial Engineering and Technology journal* 4 (2013) 49-56.
6. Griffeth, J.; Fundamentals of Electronic Flow Meter Design. *Application and Implementation Emerson Process Management Remote Automation Solutions* 2 (2013) 12-30.
7. Harrouz, A.; Harrouz, O.; Benatiallah, A. Communication and Calibration of Sensing Meters. *TELKOMNIKA Indonesian Journal of Electrical Engineering* 12 (2014) 4905–4914.
8. Recommandation 117; Dynamic measuring systems for liquids other than water, 2 (2007) 3-21.
9. Kosewicz, P. Calculation of Liquid Petroleum Quantities, *Petroleum Mesurments* 12 (2008) 164–173.
10. Pohanka, P.; Skladal, P.; Rapid Characterization of Monoclonal Antibodies using the Piezoelectric Immunosensor. *Sensors* (2007) 341–35.
11. Donnelly, S. E.; Fundamentals of gaz measurement. *NiSource Energy Distribution, American Meter* (2009) 25–27.
12. Elazar, J.; Schmelkin, P.; Measurement, Design, and Analysis: An Integrated Approach, 1st Ed., and Hillsdale. *Lawrence Erlbaum Associates* (1991) 15–29.
13. Harrouz, A.; Benatiallah A.; Harrouz O.; Technique of control flow measurements system and calibration; *16th International Power Electronics and Motion Control Conference and Exposition* (2014) Antalya.
14. Harrouz, A; Metrology and Research of Measurement Error. *Journal Journal of Institute of Electrical and Electronics Engineers* 8 (2016) 15–17,
15. Ellery, E.; Smart Meter and Smart Meter Systems.*Metering industry perspective, Edison electric institut* (2011) 21–27.
16. Smyth, E.; SCADA and Telemetry in Gas Transmission Systems. *The American School of Gas Measurement Technology* (2013) 55-108.
17. Harrouz, A.; Benatiallah A.; Harrouz O.; Signal Processing and Applications in Communication Metering System; *International Journal of Advanced Studies in Computer Science and Engineering;* ISSN: 2278 7917, 11 (2016) 405-416.
18. Loy, E.; Paul. Fluid Flow Measurement. *Practical Guide to Accurate Flow Measuremen*t. 2nd Ed., (2002) 226-230.
19. Harrouz, A.; Benatiallah, A.; Harrouz, O. Permissible Maximum Errors of Measurement Instruments in Metering Systems of Fluids. *Journal Of Electrical And Electronics Engineering* 8 (2014) 57-62.
20. Harrouz, A.; Harrouz, O.; Benatiallah, A. Techniques of control flow measurement system and calibration of sensors. *Journal of Journal of Institute of Electrical and Electronics Engineers* (2014) 48-52.
21. Oulhadj, M.; Harrouz, A.; Benatillah A. Analysis of industrial measurement uncertainty of the gas mass flow using the ultrasonic metering system. *Journal of Institute of Electrical and Electronics Engineers* (2018) 74-82.

Algerian Journal of Environmental Science and Technology
December edition. Vol.6. Nº4. (2020)
ISSN : 2437-1114
www.aljest.org

Please cite this Article as:
Oulhadj M., Harrouz A., Benatiallah A., Control Study of the Liquid Volumetric Flow using The Dynamic Metering System, ***Algerian J. Env. Sc. Technology, 6:4 (2020)*** **1620-1630**