Software for evaluation of uncertainty in liquid hydrocarbons flow measurement systems

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ABSTRACT

Flow measurement of liquid hydrocarbons and its resulting economic impact, creates the need to make the correct execution of measurements. With this, competitiveness and transparency of measurements operations are ensured and can help demonstrating through the measurement associated uncertainty, accuracy and reliability of achieved results, no matter if its end user or intermediate.

Even though many documents have been developed, in which methodology is described and in some cases, they simplify the evaluation problem and the measurement expression uncertainty, it is difficult for flow measurement systems users to develop this kind of tasks, as support in their activities, due not only knowledge and experience is required in the measurement systems operation, but also it is important the management of statistical and mathematical concepts (some basics some advanced). Because this situation, it is necessary to generate tools that can make easier the metrology application to the daily measurement activities, which is one of the objectives pursued with this software development. Using this application, there will be enough capacity to make calculations in order to obtain the uncertainty of liquid hydrocarbons flow measurement systems and which results, among other aspects, will serve as mechanism to evaluate decision making risks, and also to determine the systems conformity grade against established operations tolerance and standards accepted in commercial (fiscal) business.

A main goal of this tool is to facilitate end user practical interpretation of uncertainty results without a very deep knowledge of statistical or mathematical concepts, but with basics concepts to identify risks, make decisions and to have a reliable data for support its daily operation.

Nomenclature

X_i	Input
x_i	Input best estimate
$u(x_i)$	Standard uncertainty associated to xi of input Xi
$u_c(xi)$	Combined uncertainty
U	Expanded uncertainty
k	Coverage factor
$u(x_i,x_j)$	Associated covariance of x_i and x_j of inputs X_i and X_j
$r(x_i,x_j)$	Associated correlation coefficient to x_i and y_i

PDF	Probability density function
a	Difference between upper limit a_+ and a_-
c_i	Sensitivity coefficient
v_{eff}	Degree of freedom effective
v_i	Degree of freedom
r	Random number
Y	Output
Vn	Net Volume
C_d	Discharge coefficient
GSV	Gross volume
IV	Indicated volume
CCF	Combined correction factor
CTL	Correction factor due temperature
CPL	Correction factor due pressure
MF	Meter factor
Pulses	Accumulated pulses
KF	K-Factor
Tm	Measured liquid temperature
Pm	Liquid pressure
RHO	Observed density
Tobs	Observed temperature
GUM	Guide to the expression of uncertainty in measurement
MCM	Monte Carlo method
ISO	International Organization for Standardization
API	American Petroleum Institute
MPMS	Manual of Petroleum Measurement Standards
IP	Petroleum Institute
VIM	International Vocabulary of Metrology
IMNC	Instituto Mexicano de Normalización y Certificación A.C.
OIML	International Organization of Legal Metrology
NMX-CH-140-IMNC-2002	Mexican Standard "Guía para la expresión de la incertidumbre en las mediciones"

Introduction

Uncertainty evaluation has been considered as an activity only for calibration purposes which require a deep knowledge in statistical and mathematical concepts. This situation can be associated with absence of friendly computational tools that help end users to determine, understand and apply in its process information related with uncertainty. This paper describes methodology considered in GUM and Monte Carlo method in order to validate a spreadsheet calculation and group information in friendly screens. Some concepts directed related with uncertainty aren't developed in a deep way, but its reference documentation is indicated where it's necessary.

However, its necessary to develop more robust applications, that have international standards support for uncertainty evaluation, but also validate and guarantee reliability of obtained results through alternative methodologies, due nowadays trends require a deep knowledge of uncertainty associated to measurements, not only for quality system requirements, but also to improve performance and guarantee competitiveness of measurement process.

Methodology

Activities considered in scope of this job can be divided in next:

a. Definition of characteristics of flow measurement system
b. Uncertainty estimation of volume flow measurement system for liquids hydrocarbons using GUM Methodology:
    - Variable specification and measurement procedure
    - Determination of estimate values for input quantities
    - Uncertainty sources quantification
    - Consideration of correlations between uncertainty components
    - Calculation of measurement results
    - Calculation of measurement result standard uncertainty
    - Definition of coverage factor
    - Measurement result report
c. Spreadsheet elaboration
d. GUM Methodology validation using Monte Carlo methodology
e. Definition of characteristics to include in software development
f. Flow diagrams development for programming
g. Software Development
h. Software validation

a. Definition of characteristics of flow measurement system

Type of volume flow meters for hydrocarbons selected for purposes if this job is turbine meter. This was considered due is the type of meter of most applications for flow measurement of liquids hydrocarbons.

After this selection, proceeds to define: operation and performance characteristics, secondary instrumentation required for flow volume measurement and calculation equations to determine volume quantity. This information was obtained from international standards related to measurement of liquids hydrocarbons which is indicate in next figure:

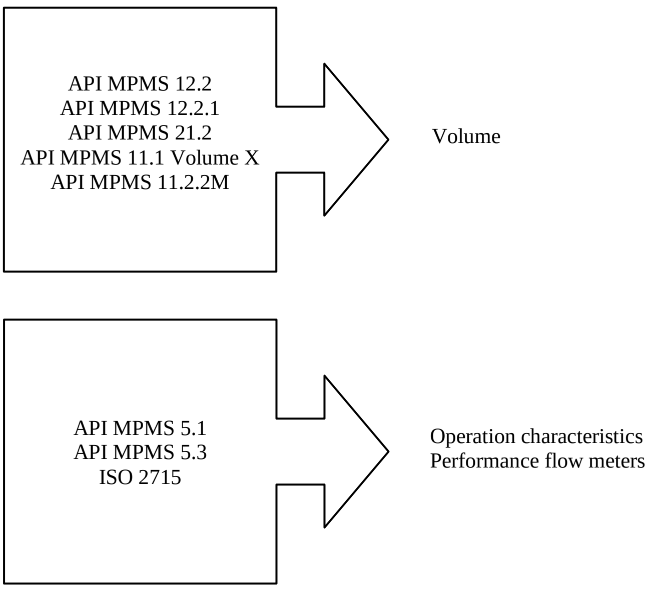

Figure 1. Standards related with flow hydrocarbons measurement

A flow measurement system with turbine meter it's covered by chapter 5, section 3 of API MPMS, which recommends installation and operation topics of meter arrangement. Its consider that flow measurement systems comply with recommendations established referring to erection and installation of elements for flow conditioning, valves, filter systems, protection dispositive for meter, accessories location, and others, assure an adequate performance which no affects exactitude of measurement system. Points considered for evaluation of uncertainty in a volume flow measurement system referring to installation is instruments location for temperature, pressure and density determination, due variations of this magnitudes most affect performance of turbine meter and therefore define exactitude of measurements.

Algorithms and equations for flow volume calculation using turbine meter are defined in chapter 12, section 2 and Appendix B of part 1 same chapter of API MPMS. This standard contents support for algorithms and equations for base density, pressure correction factors and liquid temperature determination. For determination of density and correction factor for temperature at reference conditions IP Report 3 was used.

An electronic flow measurement system is considered in order to compensate in real time effects of pressure and temperature, therefore determination of CTL and CPL is made during flow measurement. For this, flow measurement system include a tertiary measurement element (flow computer), which collect data from primary and secondary elements, store it and calculate flow.

A flow measurement system generally consists in a paralleled meter arrangement where total volume is obtained by sum of individual volumes. For purposes of this document, an arrangement of not more than four turbine meter run and all instrumentation (pressure, temperature and density) and equipment associated for flow measurement. Total volume is defined by:

$$V_N = Vn_1 + Vn_2 + Vn_3 + Vn_4$$

b. Uncertainty estimation of volume flow measurement system for liquids hydrocarbons using GUM Methodology.

I. Variable specification and measurement procedure

For flow volume liquid hydrocarbon measurement, API MPMS establish calculation procedures, measurement methods, calculation equations, operational recommendations and practices. For this reason in this paper proposed models by API were considered based on its experience and fundaments which assure exactitude and reliability of measurements.

Therefore, for definition of mathematical model begins form equations established in standards for flow volume calculation at reference conditions that can be described in next figure:

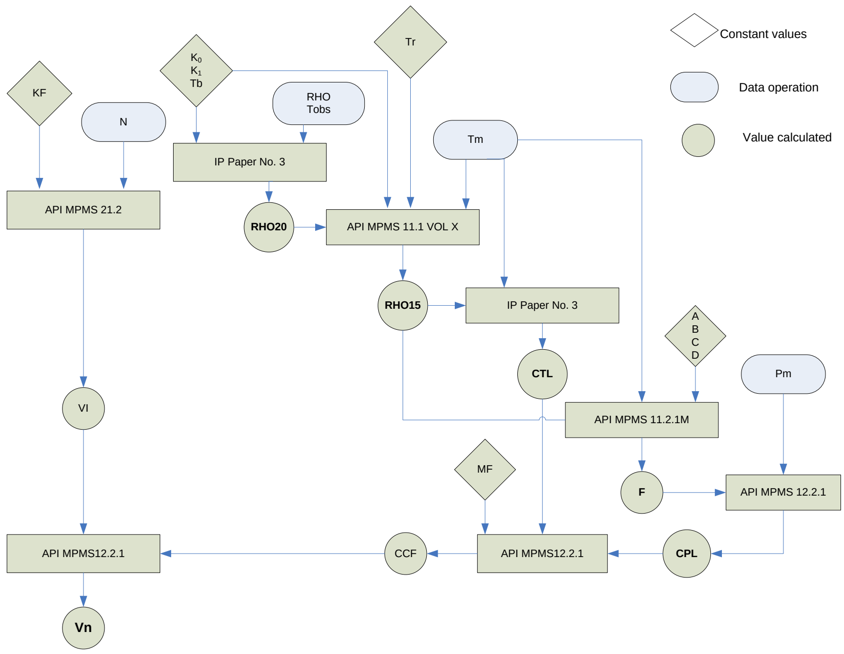

Figure 2. Volume at reference conditions for turbine meter

According this figure, input magnitudes which define Net Volume are:

N = Pulse emitted by turbine during transference
KF = K - Factor
MF = Meter factor
Tm = Fluid temperature
Pm = Fluid pressure
RHO = Fluid density at observed temperature T_{obs}
T_{obs} = Observed temperature
K0, K1 = Constants according fluid density
A, B, C, D = Constants

Once identified input magnitudes, an analysis in order to identify some other factor that affects measurement results was developed.

Pulses, N

Since some factors as: electromagnetic interferences, energy supply variances, noise, wiring problems, among others, can promote false pulses which can cause errors in measurement results.

K-Factor, KF

When in the mathematic model for net volume flow calculation is affected by meter factor, MF, so K-Factor, KF, doesn't affects net volume uncertainty, it mean, a constant value without variation possibilities is considered.

Meter factor, MF

As mentioned above, MF is used to correct volume registered by turbine meter to same value of reference meter, and it's obtained during meter calibration. For this, always it's important to consider calibration uncertainty and indicated in calibration report.

Sometimes, laboratories provide a calibration curve of MF, and if electronic system can made calculation on real time, so, coefficients for calibration curve (which generally is lineal) can be loaded, to correct MF according flow measured. It's important to consider this equation has an additional uncertainty source: adjust graph uncertainty due residual errors that have to be considered.

Temperature

Exact temperature determination its essential to determine flow volume of liquids hydrocarbons at reference conditions. Temperature measurement generally is affected by instrument resolution, temperature gradient, stability and instrument calibration.

First factor to consider is uncertainty obtained from calibration of measurement instrument. Always it's necessary to consider in order to evaluate uncertainty of any measurement obtained with this instrument.

According NMX-CH-140-IMNC-2002, sometimes and under some circumstances corrections of systematic errors are not applied to results of measurements, nevertheless, it's a practice that has to prevent and consider it during uncertainty estimation. One way to estimate it is increasing uncertainty associate to result, it mean, to expanded uncertainty in correspond measurement have to add arithmetically maximum error not corrected. This result in an increased uncertainty which compensate correction doesn't make. Also, it's common that measurements of secondary instruments associated to flow measurement (temperature, pressure and density) don't be affected by corrections of systematic errors obtained during calibration process; again it's important to consider this during calibration uncertainty process.

One of difficulties founded during any measurement process is the limited resolution of instrument, which causes no exact knowledge of measurement result. Usually, resolution its not considered as uncertainty source due it was included in instrument calibration process, but some authors (23) have determine that its correct consider resolution as uncertainty source. As well, GUM identifies finite resolution of instrument as source of measurement uncertainty.

Objective of determine temperature of fluid measured, to correction of thermal effects in liquid, is obtain an exact temperature of liquid inside body of meter. Generally, temperature sensor can't be installed in a flow meter for constructive characteristics, so according API MPMS 7.2 recommends install a temperature sensor downstream turbine meter. But, strictly, under this conditions a temperature gradient exists due temperature determination and volume metering are obtained in different points. In other hand, some factor relates with installation of temperature sensor can increase that gradient caused by an incorrect insertion length, bad heat transfer in instrument or bad lecture of fluid temperature.

All measurement instruments change its characteristics along time; therefore it's important to consider effects of time and frequency of usage, it mean, stability. Some of tools used to determine stability are control charts, which show variation between controls limits established.

Pressure

Effect of pressure change in flow volume for liquids hydrocarbons is less than effect due to temperature; nevertheless, it's important to consider effect of magnitudes that affect pressure determination, which are similar with those defined for temperature.

As well as temperature, it's important to consider uncertainty of calibration of pressure meter, in order to evaluate uncertainty of any measurement obtained with this instrument. Also, its necessary increase uncertainty if corrections to systematic error aren't made.

Its necessary to considerer also, resolution of pressure instrument, as measurement of limit knowledge of pressure value.

Performance of pressure instrument is affected by incorrect installation which can cause a pressure gradient, for example pressure sensor and meter location which can cause an increase o decrement of pressure value. Sometimes it's difficult to assure location of sensor and meter, for what this pressure gradient shall be considered. Pressure meter also is affected by stability, due to time and frequency time usage.

Density

Density of liquid at base conditions have to be known exactly to calculate correction factors CTL and CPL, due errors caused by an incorrect density measurement will have a considerable effect in CPL and CTL.

If density is obtained, for example using a densimeter, so all magnitudes that affect this instrument have to be considered.

Models for RHOb and F determination

Others magnitudes that are important to consider are the associated with mathematical model for determination of RHOb and F, which are determined by calculation procedures established in API MPMS. Chapter 11, section 2 part 1M, established compressibility factor for liquid hydrocarbons can be estimated form equation:

$$F = e^{\left(A + BT + \frac{C}{RHO15^2} + \frac{DT}{RHO15^2}\right)} \qquad [1]$$

Uncertainty associated to this mathematic model is 6.5% F, with a confidence level of 95%.

II. Determination of estimated values for inputs

For flow volume metering systems of liquid hydrocarbons, estimated values of inputs referring to number of pulses, temperature, pressure and density aren't obtained form repeated observations, simply values of magnitudes obtained from operation of systems are considered, it mean, field operational conditions. And, estimated value for MF is determined from measured flow and on basis information located in calibration report.

III. Uncertainty sources quantification

Uncertainty components are evaluated considering type B method, because none one of them are obtained form a series of repetitions; they are obtained form only one observation because it belongs to a dynamic metering system characterized by variations of pressure, temperature, density and, as result, flow volume or similarly change of properties of fluid being measured.

According described above, quantification of uncertainty source consists in determination of its distribution, PDF, depending available information. Once PDF is assigned, standard uncertainty can be determined, which is calculated basis on type of distribution selected and considering next criteria:

Available Information	Probability Density Function	Standard Uncertainty
– The quoted uncertainty is given as a multiple of a standard deviation – Coverage factor	Gaussian	$u \; x_i = \frac{U}{k}$
– It may be possible to estimate only the bounds (upper and lower limits) to state that the probability that the value of X_i lies within the interval a_- to a_+. – There may not be enough information available.	Rectangular	$u \; x_i = \frac{a_+ - a_-}{\sqrt{12}}$
– Values near the bounds are less likely than those near the midpoint.	Triangular	$u \; x_i = \frac{a}{\sqrt{6}}$
– Values near the bounds are less likely than those near the midpoint.	Trapezoidal	$u \; x_i = \frac{a \cdot \; 1+\beta}{\sqrt{6}}$

Table 1. Probability functions

IV. Consideration of correlations between uncertainty components

According defined characteristics of metering system and for a typical installation with multiple meters, some of the uncertainty components are considered correlated in next situations:

- When meters are calibrated using same reference meter

Frequently, for a metering system composed by multiple meter runs, calibration of metering instruments is developed using only a reference meter for each magnitude. In this way, correlation depends only by reference meter used for calibration.

- When only a meter (temperature, pressure, density or observed temperature) is used to determine magnitude and only this found value is used for calculation of corrected volume of all flow meters installed.

This situation generally happens because exist only one density meter and observed temperature for whole metering system, so calculation for base density and flow volume are made using same values for each meter run.

- When same equation is used for calculation associated with each meter.

Mathematical models used to estimate base density and compressibility factor are established in API Chapter 11 and are used in same way for flow volume calculation in each meter run.

If equations for calculation of flow volume indicate in API Chapter 11 are observed, it can be determined a correlation between CTL and CPL, due a third magnitude, RHO, affect both of them. Nevertheless it's recommended, in those situations where applicable, redefine mathematical model in order to eliminate correlation due method described in GUM for management of uncertainty components correlated is complex.

V. Calculation of measurement result

As was described above, net volume of metering system is determined adding individual volumes so:

$$V_N = \sum_{i=1}^{5} VI_i \times CCF_i$$

Where:

$$VI_i = \frac{N_i}{KF_i}$$

$$CCF_i = MF_i \times CTL_i \times CPL_i$$

VI. Standard uncertainty determination of measurement result

In order to estimate standard uncertainty of net volume, it's necessary to combine standard uncertainties of inputs estimations:

$$u_C\left(V_N\right) = \sqrt{\sum_{i=1}^{4}\left[c_i \cdot u\left(x_i\right)\right]^2 + 2\sum_{i=1}^{3}\sum_{j=i+1}^{4} c_i \cdot c_j \cdot u\left(x_i, x_j\right)}$$

Sensitivity coefficients C_i, are determined by means of partial derivative of V_N with regard to each one of influence magnitudes defined as:

$$c_i = \frac{\partial f}{\partial x_i}$$

Sometimes sensitivity coefficients can be difficult to obtain using algebraic methods, mainly when mathematical models are complex. In these cases, alternative methodologies which consider other techniques can be used, for example numerical analysis.

ISO 5168 propose a numerical technique for sensitivity coefficients determination, which quantify effect of a small change in input variable x_i, on result value y, keeping constant other variables. So, sensitivity coefficients are calculated according next expression:

$$c_i \approx \frac{\Delta y}{\Delta x_i}$$

Its recommended increasing value used Δx_i will be as small as possible, and not larger than uncertainty of parameter x_i. Process can initiate with a Δx_i value equal to uncertainty in x_i and reduce progressively until C_i value corresponds to a result between established tolerances.

In this way, to determine sensitivity coefficient for C_{varN}, first net volume is calculated, V_N using N value, and its recalculated using $N + \Delta N$, where ΔN is a small increased value in N. Result can be expressed as $V_N + \Delta V_N$, where ΔV_N is the incremented valued caused by ΔN.

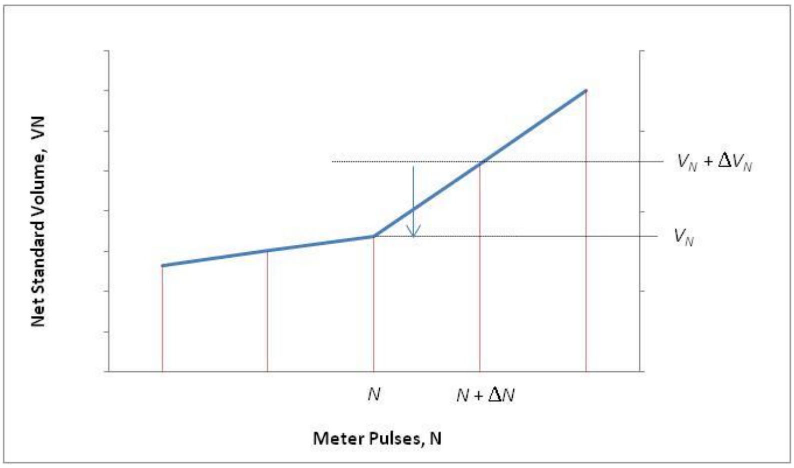

Figure 3. V_N Variation

Once standard uncertainties of uncertainty components, sensitivity coefficients and estimated covariance are obtained, it can be determined standard uncertainty of result, Net Volume, applying next:

$$u_C(V_N) = \sqrt{\sum_{i=1}^{4}\left[c_i \cdot u(x_i)\right]^2 + 2\sum_{i=1}^{3}\sum_{j=i+1}^{4} c_i \cdot c_j \cdot u(x_i, x_j)}$$

VII. Coverage factor definition

Standard uncertainty Uc obtained previously generally implies to content a true value with a probability *p* of 68% more or less, but usually a better probability is desired so a coverage factor *k* is used to expand this interval to an upper confidence level.

In order to obtain a rigorous estimation of expanded uncertainty of the flow volume meter system, degrees of freedom for each one of uncertainty components defined was obtained using:

$$v_i \approx \frac{1}{2}\left[\frac{\Delta u(x_i)}{u(x_i)}\right]^{-2}$$

Basis on available information, and finally obtain expanded uncertainty

$$U = u_c t_p(v_{eff})$$

Results

VIII. Measuring result report

The way result of a measurement process is expressed is V_N = V_N +/- *U* with corresponding units. Also its included relative expanded uncertainty and *k* factor used to obtain *U*.

Generally, number of significant digits used in uncertainty expression is one according literature. Besides, number of significant digits of flow volume has to be consistent with same number of uncertainty value.

c. Spreadsheet elaboration

As first stage in this paper, a spreadsheet was developed to register al required information for flow volume calculation and for associated uncertainty evaluation: models, equations, etc. This was developed in order to define required models and equations, apply GUM methodology, validate if its adequate use of this methodology for this specific application, define parameters to use in software and as previous support to develop software.

Preliminary spreadsheet to evaluate uncertainty measurement of metering systems for liquid hydrocarbons, was developed in excel, following recommendations established in GUM.

d. Validation of GUM methodology through Monte Carlo

For uncertainty evaluation its recommendable applies uncertainty propagation law (methodology used by GUM) as well as Monte Carlo method, and later to compare both results. If comparison is favorable, uncertainty propagation law can be used later to solve similar problems. Otherwise, Monte Carlo simulation can be applied.

As was mentioned previously, Monte Carlo method (MCM) permits combine using numerical simulation PDF of inputs defined to flow volume metering systems and obtain a PDF of result, it mean: volume.

Procedure considered during MCM applying for uncertainty evaluation (distribution propagation) conforms Supplement 1 of GUM and it's described next:

- Select number of Monte Carlo tests, M, to be made.
- For each defined input (influence magnitude) for flow volume metering system, generate M random numbers according PDF assigned and considering this criteria:

Available information	**PDF**	**Uncertainty Standard**
$R(a,b)$ Lower and upper limits a, b	Rectangular	$\xi = a + (b - a)r$
$T(a,b)$ Lower limit $a = a_1 + a_2$ Upper limit $b = b_1 + b_2$	Triangular	$\xi = a + \frac{b-a}{2}(r_1 + r_2)$
$Trap(a,b,\beta)$ Lower limit $a = a_1 + a_2$ Upper limit $b = b_1 + b_2$ $\beta = \lvert (b_1 - a_1) - (b_2 - a_2) \rvert / (b - a)$	Trapezoidal	$\xi = a + \frac{b-a}{2}\left[(1+\beta) r_1 + (1-\beta) r_2\right]$
Best estimate x Associated standard uncertainty u(x)	Gaussian	$\xi = x + u(x) \cdot z$

Table 2. Random number generation

- For each generated vector (group of each random data of each input), flow volume is obtained according mathematical model defined. By this way, M volume values are obtained.
- Organize M volume values in descendent order
- Estimate y and its standard deviation associated *u(y)*, it means, average and deviation of M volume values, respectively.
- Calculate coverage interval for a determinate coverage probability *p* (confidence level). One option to obtain this is using position measurement of position, percentile. In this way, variable values under a determined percentage can de obtained.

In order to compare both techniques, steps indicate in Supplement 1 of GUM were followed:

- Apply GUM methodology (uncertainty propagation law) and obtain $y +/- U_p$ in a coverage interval 100 *p*% for result value.
- Apply Monte Carlo simulation and obtain standard uncertainty *u(y)* associated to estimate value of result value and limits Y_{low} and Y_{high} of coverage interval 100*p*% for result value.

Finally, determine if coverage interval obtained using GUM methodology and MCM are between established tolerances, it mean, if absolute differences of limits of both coverage intervals aren't higher than established tolerance, so use of GUM methodology is valid for this application.

e. Definition of characteristics to include in software

Once spreadsheet for uncertainty evaluation is developed, not only characteristics that software have to comply are defined in order to evaluate uncertainty according GUM methodology, but also characteristics of a tool to obtain in a practical manner an uncertainty of a flow volume metering system for liquids hydrocarbons. By this way next was defined:

- As generally a metering system include several meter runs, it was decided the software can evaluate uncertainty of a system conformed by maximum four meter runs.
- When an equation is provided in calibration report to determine MF at different flows generally isn't indicate associated uncertainty of meter model. For this reason, software will have capability to obtain calibration curve and its associated uncertainty.
- According type of available information regards variability of influence magnitudes, a distribution function will be associated, but with option to select other type of PDF.
- Availability to input process data and uncertainties in different units according influence magnitude.
- As mathematical model considered for evaluation of volume uncertainty is defined basis on applicable standards, an option to recalculate volume at reference conditions (20 °C) and correction factors will be include in order to determine if an error exists in calculation.

- Graphs to show uncertainty components that have major contribution to total uncertainty of volume metering system are included.

f. Flowcharts for programming

Once characteristics to include were defined, flowcharts were developed about procedures for uncertainty evaluation in order to programming tasks were simple and understandable. Next figure shows main diagram and functionalities to include in software for uncertainty evaluation:

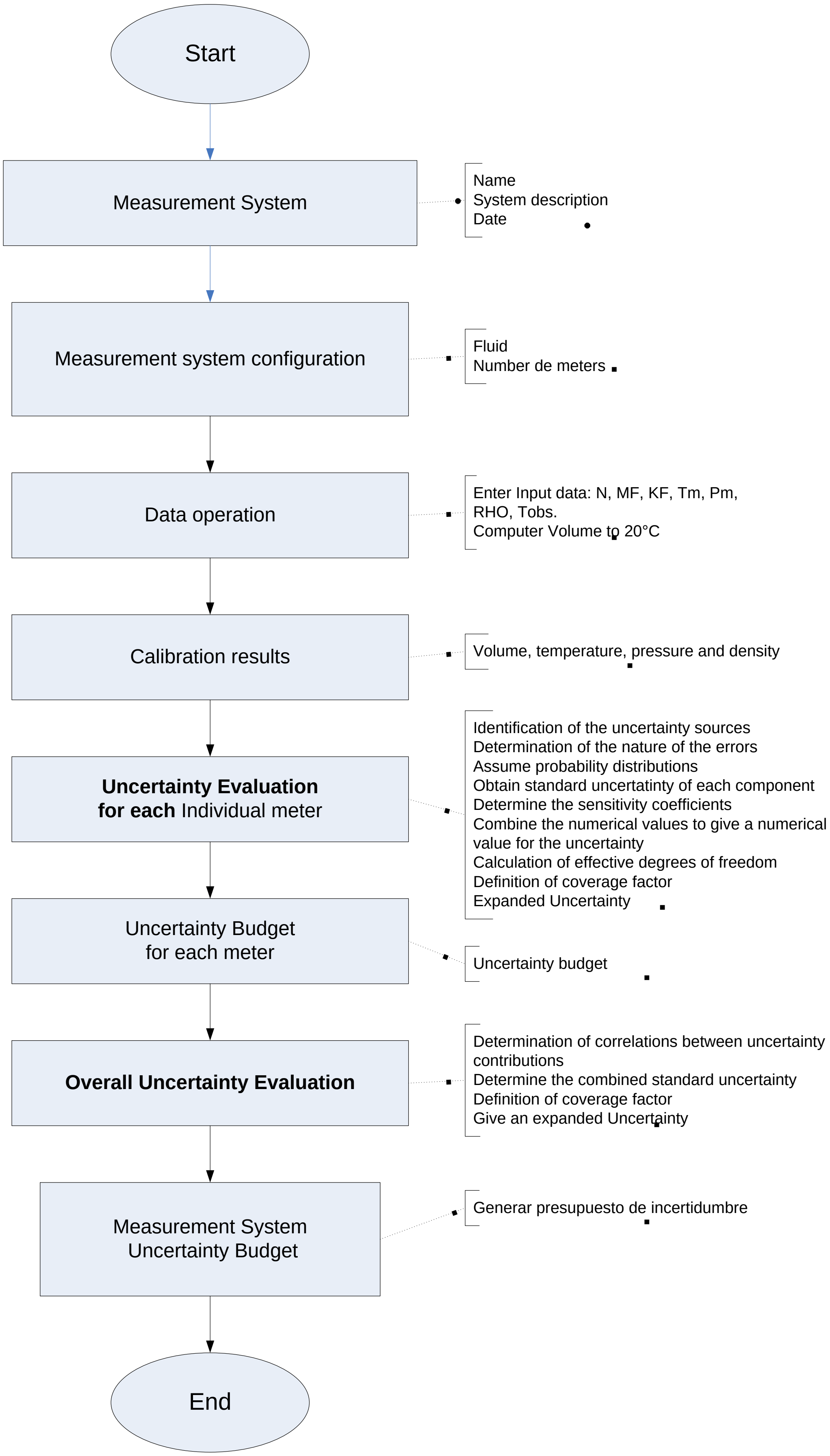

Figure 4. Software functionalities diagram

g. Software Development

Initial stage for software development was to select programming platform, which main consideration was programming language was simple, mainly due to number of mathematical model to programming. Visual Basic was selected due is a relatively easy to learn and use programming language, because of its graphical development features Visual Basic can create executables (EXE files), and also is used to develop Windows applications and to interface database systems

Also, it was decided to use a database due quantity of variables and parameters to handle. Option to store generated information regarding uncertainty evaluation to recover later if it's required for post analysis or similar.

Once platform was selected for software development, a task related with windows creation starts according design characteristics defined previously, following this to implement algorithms defined.

Final task of software development was its validation / verification. This was developed using spreadsheet as reference to software. The fact to validate spreadsheet calculation using Monte Carlo method, alternative methods to sensitivity coefficient determination, review of generated codes (functions, algorithms and parameters) and calculation validation of correction factor for liquid flow volume using proposed examples in different standards, guarantee reliability and quality of obtained results.

By this way if software generated results correspond to spreadsheet results for testing exercises, can be affirmed software developed is adequate for uncertainty evaluation of volume metering systems for liquid hydrocarbons.

Some screens of software are showed:

Figure 5. Input data screen and volume calculate at 20°C

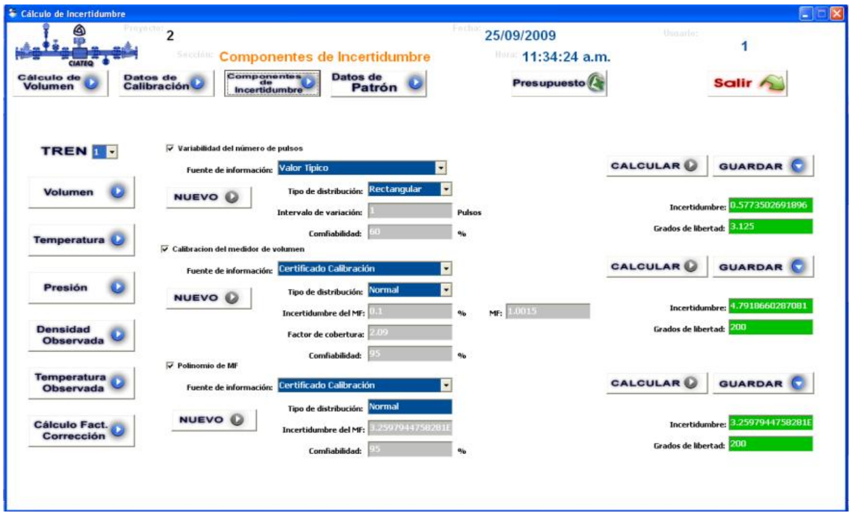

Figure 6. Uncertainty sources selecting and its associated distribution screen

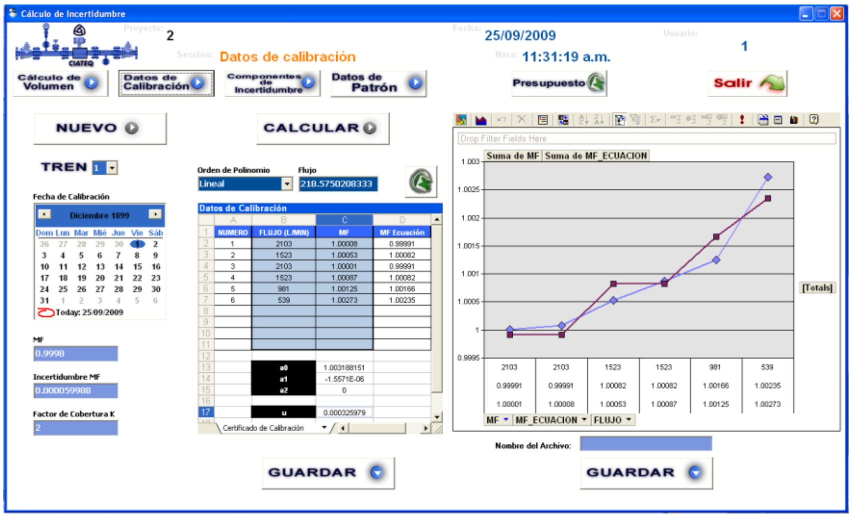

Figure 6. Calibration curve and its associated uncertainty screen

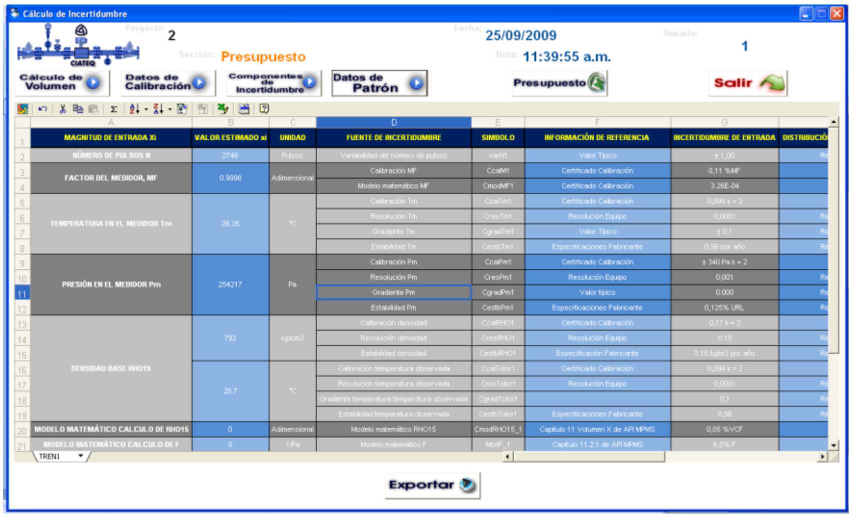

Figure 7. Uncertainty Budget associated to meter run 1 of the metering system

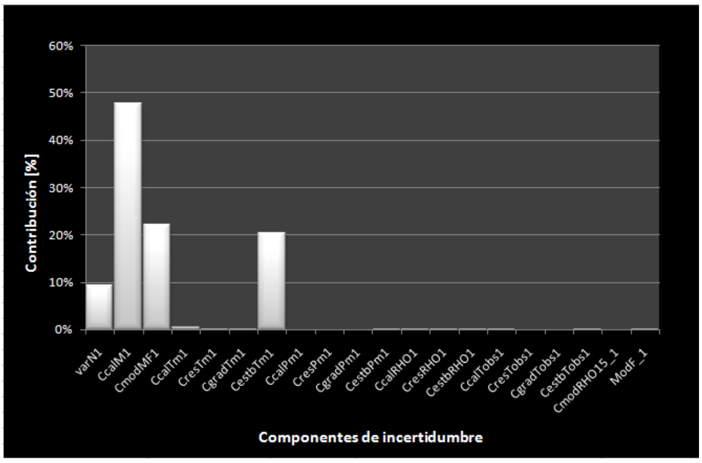

Figure 8. Components contribution graph for uncertainty determination

Conclusion

In Mexico, end users of flow liquid hydrocarbon metering systems aren't yet familiarize with measurement uncertainty concept and, mainly, with its importance to determine and know uncertainty of their measurements. Nevertheless, quality systems requirements and related standards will require offer better guarantee of their measurements results, therefore they will have to validate, assure traceability of their measurements to national and international standards and indicate associated uncertainty of each one.

There is a lot of information related with uncertainty evaluation, however its is presented in a complicated language which results that any person not familiarize with metrology language can't assimilate this important information being this data difficult to access to improve a measurement process. For the reason above mentioned importance of generation of knowledge and tools as described in this paper, which facilities metrology application in all aspects of our life and promote use of uncertainty when a measurement concept is declared, as a data that indicate quality of measurement reported.

This software will facilitate evaluation process of flow volume metering systems of liquid hydrocarbon due only require to input system operational data, choice from la list sources which contribute to uncertainty according characteristics of metering systems and finally to select and input available information related to variability of each component. Once this information is loaded, software can automatically determine uncertainty of metering system and report components which have more participation in measurement uncertainty. These results can be useful to visualize fulfillment of requirements and established tolerances for operation of metering system, and also as metrological control mechanism of measurements which permits minimize, in some cases, effect of a specific component in a total uncertainty of metering system.

In one hand, analysis made for uncertainty evaluation of flow volume metering systems which is base for this software development, guarantee reliability of results. In other hand, MCM application to validate GUM methodology for uncertainty evaluation in this specific case, permits guarantee reliability results obtained with this software and can be use to demonstrate quality of measurement result in a effective way.

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