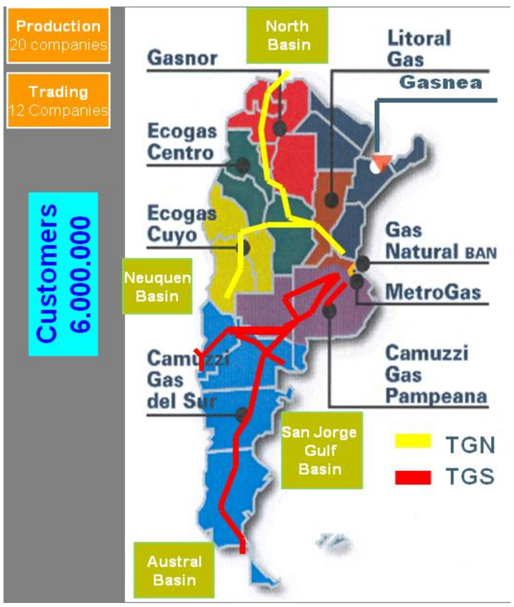
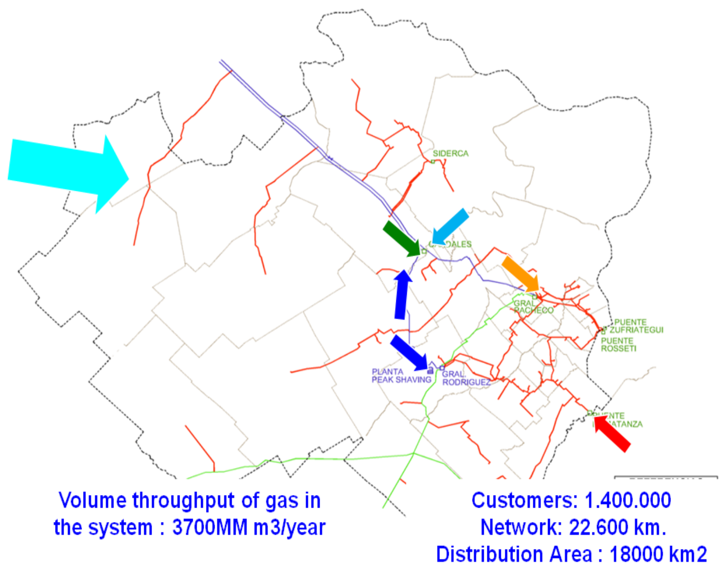
Meter Testing Methodology for diminishing & control of unaccounted for gas


Jorge Doumanian
Guillermo Lanzillotti
Gas Natural BAN S.A.


## Business Scenario

The study case was developed in Argentina, a mature natural gas market.




The business scenario is a distribution company located in the North West Buenos Aires area.

These are the main characteristics data of the distribution situation:

Volume throughput of gas in the system: 3700MM m3/year
Customers: 1.400.000
Network: 22.600 km.
Distribution Area: 15.000 km2 of the North West Buenos Aires area in Argentina

## What was really happening?

The different studies on unaccounted for gas (UFG), determined the necessity to develop a residential customers meters quality performance control program to establish their contribution to the UFG and enables to define policies for its reduction.

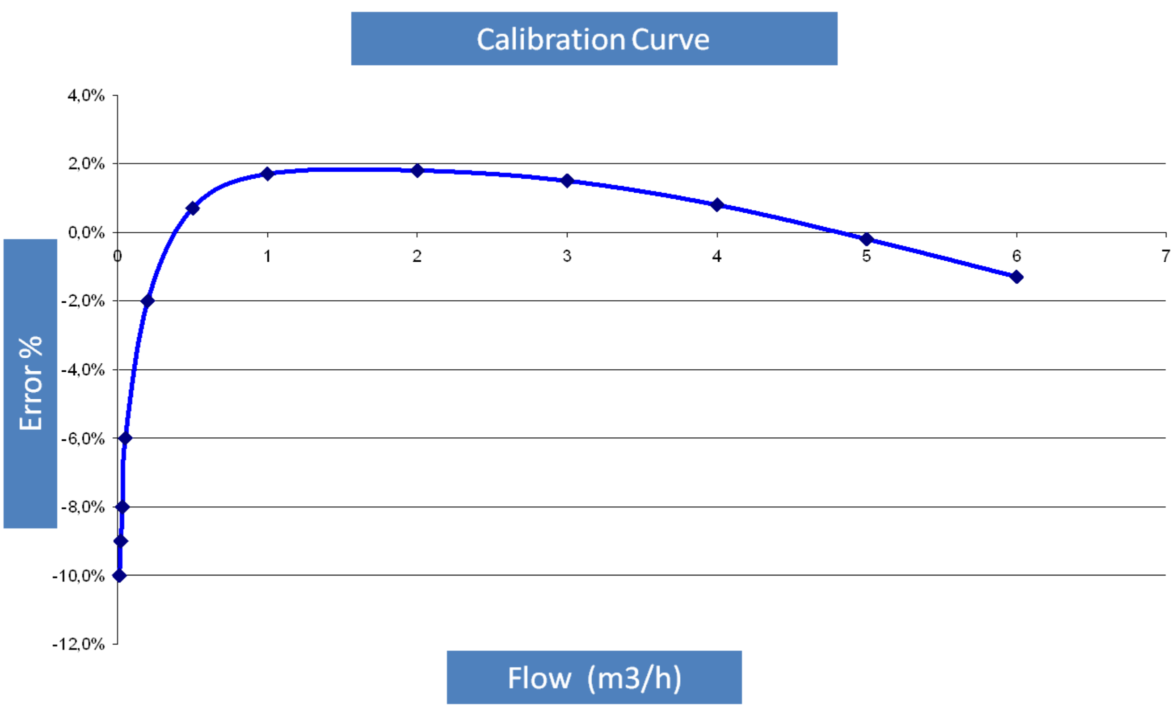
## What was the purpose of the project?

The purpose of the project was to develop a methodology to evaluate the meters, the measurements errors & the overall condition of the meters universe of 1.4MM customers, in order to control UFG, and also a tool for monitoring the status of household meters universe to establish their contribution to the UFG which enables to define policies for its reduction.

This paper does not pretend to generalize the results in different scenarios. It shows the successfully applied of the methodologies and tools used in this particular case.

It is important to express some concepts that help to understand the methodology. As shown below, the measurement error is a function of measured gas flow, so this UFG depends on two variables:

The installed meters calibration curve
The customers' consumption profile



## Key Findings

### How was the job organized?

First of all, an initial comprehensive study, which allowed determining the status of the meters universe, and their contribution to UFG. The scope covered up to gauges G4 (6 m3 / h) inclusive.

Subsequent studies, smaller in quantities, were done on the meters that were removed for different reasons from the network to update and go in deep.

Continuous & periodical evaluation of the meters universe:

a) Meters removed from the network, whatever its cause, must be subjected to metrological study (calibration).
b) In the case that the number of meters obtained with the procedure is not sufficient to constitute a representative sample that assesses it´s quality; the sample will be expanded by replacing installed meters trying to cause as much as possible the least inconvenience to customers

Meters samples composition & handling:

a) The sample is proportional to the composition of the installed meters universe, taking into account: Size, Model, Manufacturer, and Year of manufacture
b) The meters quantities to be calibrated were determined for each batch with an statistical methodology.
c) It is very important that the sample´s meters are handled and transported with due care to ensure they do not suffer any sudden shock or impact.

Operations:

1) Removal of packing and cleaning.
2) First inspection indicating those aspects that were significant: State seals, signs of rape, etc.
3) Frauds Unit participation, in order to inspect the sample and record those considerations about suspected tampering.

### What tools, technologies or methodologies were used & which are the resources involved in the project?

Taking in consideration the amount of residential customers (approximately 1,400,000) statistical tools were used.

To approach the knowledge of the measurement errors contribution to the UFG, a random and representative sample of customers was analyzed; the UFG of the sample was determined and then inferred the results to the meters population.
To implement this procedure, we must know the result of meters calibration and the consumption profile of each customer in the sample.

As the diaphragm meters do not provide flow values but volume values, it is necessary to install data loggers to integrate these volumes in short periods calculating in this way the flow rate.

The existing meters did not have pulse generators for the data loggers' installation, so they should be replaced with new meters. If this operation was done, we will lose the relationship between a customer's consumption and a meter calibration.
Because of this issue, the consumption profile was determined separately from the meters calibration.
To solve this problem, a simulation model was created to represent:
a) The measurement error of the meters in relationship with the flow.
b) The customers' consumption´s behavior across all days and hours of the calendar year

Meter Sample Calibration

The calibration for checking the meters performance is done in a room where temperature is stable, preferably with air conditioning.

The meters are located on the premises twenty-four hours prior to achieve a stable temperature.

The meters are calibrated on a bench meter in the usual home of the Laboratory.

A report is creating with at least the following fields for each meter:

• Serial Number • Year of purchase • Manufacturer • Type • Capacity • Date verification
• Failed to Q max (E3) • Failed to 0.2 Q max (E2) • Failed to Q min (E1) • Observations

The meters are intended to analyze UFG monitoring are calibrated at 10 points, according to the parameters already determined to find a calibration curve to allow running the simulation model and determine the measurement error.

It should be noted that the primary object of this study is to determine whether the meters meet the metrological requirements but how they contribute to UFG.

For each calibration flow the measurement error is calculated according to the following expression: (Q meter-Q bench) / Q bench * 100

This process is certified under ISO 17025 Standards

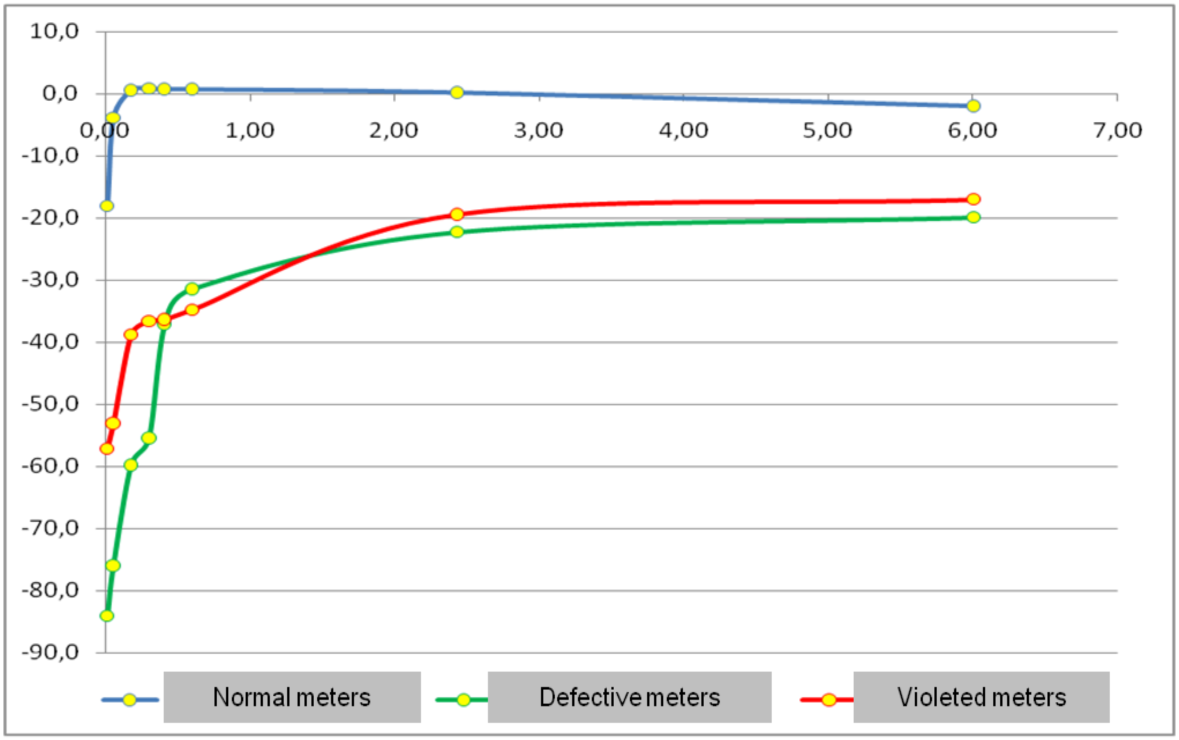
As a result of the meter´s samples and their analysis, the meters were classified in "Normal", "Defectives" and "Violated".

The definition of "Normal" is statistical. It refers to those that constitute the normal population regardless of whether the calibration is within the parameters specified by regulatory standards.

The "Defective" were those that had errors that differed from the normal population, but had not been tampered.

Those classified as "violated" were intentionally manipulated in order to alter the measurement and reduce the amounts to pay for the service.

1) Average values of the calibration curves according to the meters classification




The mean values of the calibration curves according to the classification of the meter are shown in the figure below.
Interestingly, is the similarity of the curves of the meters "violated" and "defective". This allowed both use similar technical treatment.

The model allowed the evaluation of the effect of measurement error on the violated and defective meters. It is also a tool for analysis and forecasting of the effects of any changes that may occur both in the customers' consumption, and in the meters universe.

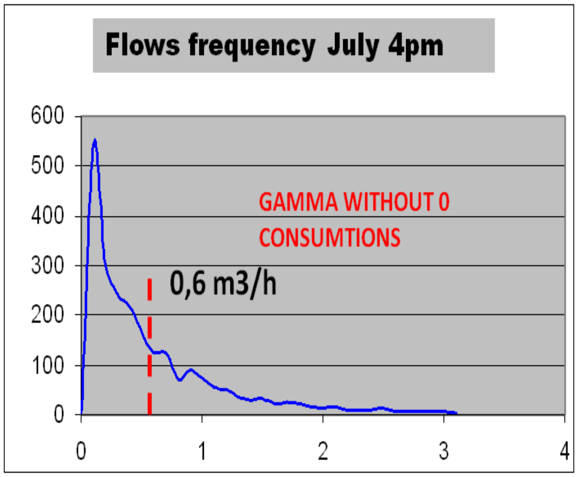
<u>Customers' consumption curves</u>

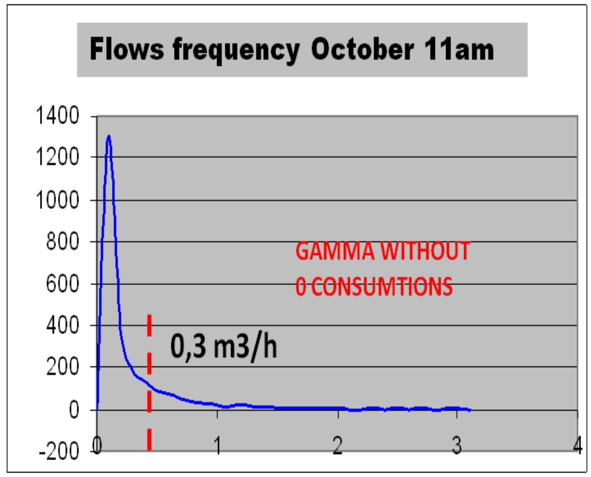
As it was said, flow data loggers were installed to determine the consumption values for a period of one calendar year.

The consumption distribution curves were not normal, fitting a Gamma distribution, defining one for each hour and day of the year. Zero consumptions were considered separately.

At the graphics can be seen, by way of example, the distributions of consumption in July at 4 pm (winter) and October at 11 am (spring)

It should highlight that the integration of data loggers was performed every hour, so there is certainly a flattening, result of averaging the one-hour period.

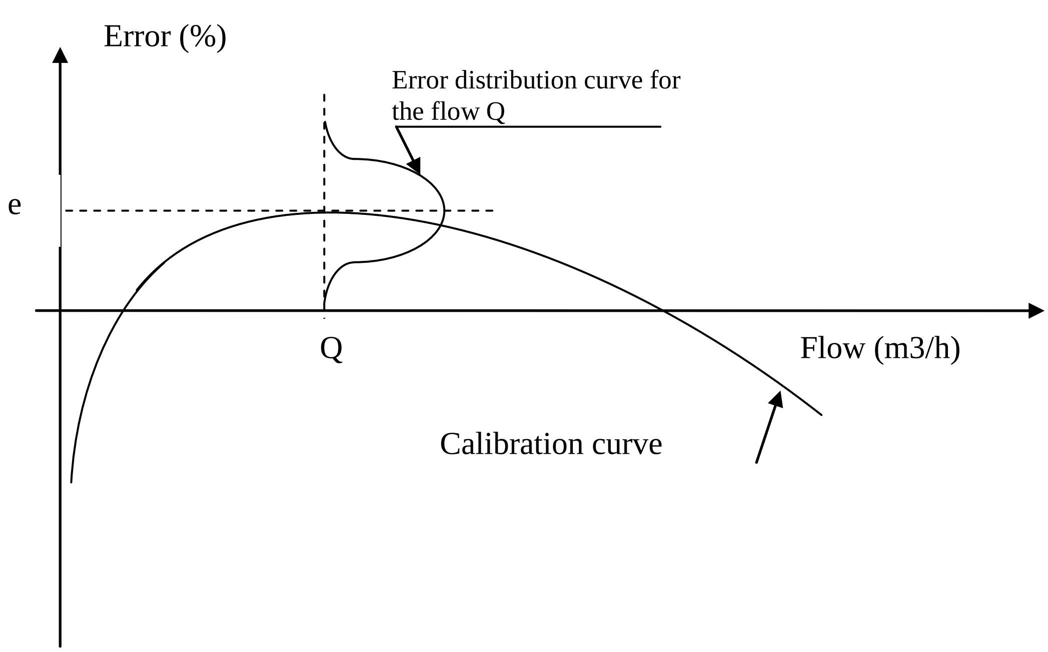



UFG Calculation Method

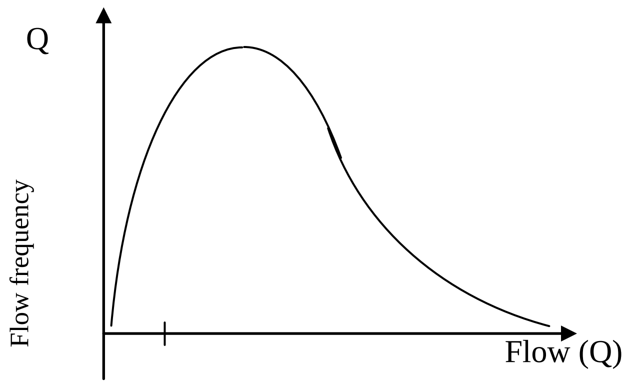
A graphical and simplified explanation of the methodology is presented below:

Knowing the meters calibration curves, an average dispersion curve point to point can be determined.
The following chart illustrates this curve, representing the meters universe. At each point "Q" there will be an average value of error "e" and a spread of values as detailed.

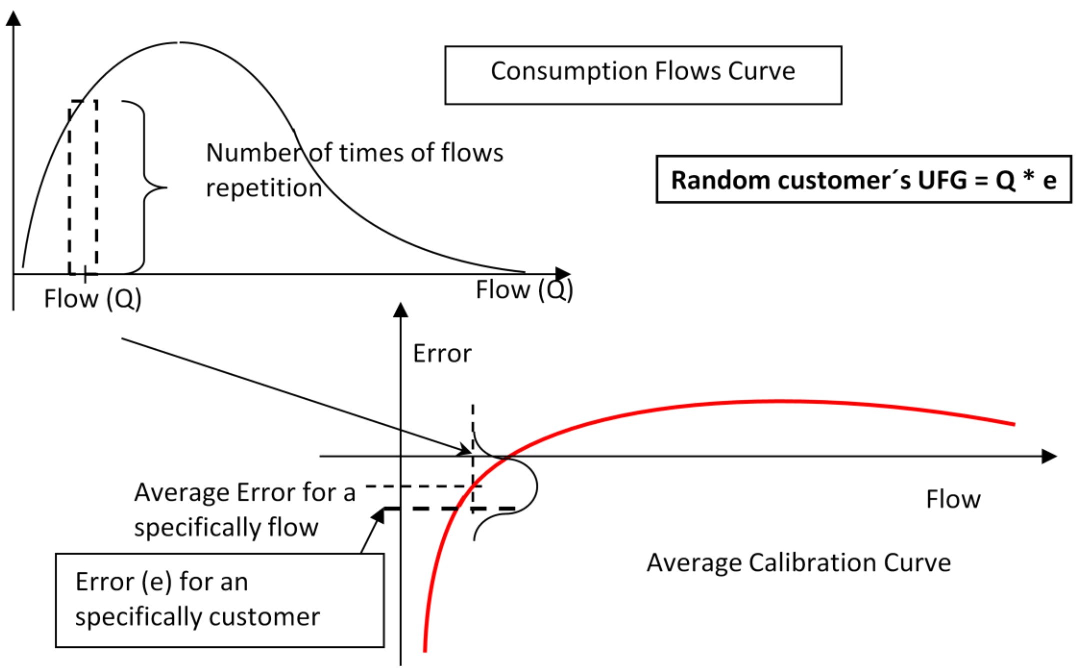


Consumption is represented by a curve of Gamma type distribution. Coefficients α and β are different for each hour of the year under review.

An imaginary random customer will have a meter with a calibration curve that will result from random values taken from the population curves of the meters universe.
This customer will also have a particular consumption for each hour of the year that will result from random values taken from the consumption distribution curves for each particular hour.




With this random flow selected from all the flows at that hour, and the randomly calibration curve from all the meters in the universe, a measurement error is determined as shown in the following scheme:



This is done randomly, with the help of a computer, a number of times, for instance 500 times and determined their average.
This UFG average is taken as the average for the whole population for that hour and day of the year.
The procedure is repeated for every hour of every day of the year, obtaining the annual UFG.

Selecting a specific average calibration curve may see the UFG corresponding to a particular classification of meters, for example, defective or violated can be determined.

What is the time frame?

12 months for the first results

Results

What results is the project helping to produce?

Selecting a determined average calibration curve we can find the UFG for a certain classification of meters, for example, defective or violated.

| Type | Universe % | ERROR | PARTICIPATION IN THE TOTAL ERROR |
|---|---|---|---|
| NORMALS | 86,0 % | 0,25 % | 0,22 % |
| DEFECTIVES | 1,8 % | - 32,8 % | - 0,59 % |
| VIOLATED | 12,2 % | - 30,5 % | - 3,72 % |
| TOTAL | | | - 4,09 % |

For the universe of analysis of this study case, this error represents at least 22 MM m3 /year of potential UFG, 19 MM/year for violated types & 3MM/year for defective meters

The errors listed in the table should be interpreted as the percentage in defect or excess that the meter measures, depending on the flow rates that have gone through it. This value is not a one calibration point, and shows the defects or excess on the meter measured during a year.

In this way a measurement of a group of meters can be analyzed, classifying it in some way, for example by gauges, brand or age.

What is the value of the results?

At least, 22 MMm3/year potential UFG under control.

## Conclusions

What lessons were learned from the project?

- ✓ It is possible to perform a sustainable program to assure the measurement quality

- ✓ (Use IT tools that are common in other industrial applications for solving a problem that at the very beginning is very far for the final solution)
- ✓ From the studies conducted in order to find the meters cluster responsible for the UFG, and in general, no associations were found with the age of the meters.
  It was determined a possibility of recording or no low flows (up to 180 / 100 l / h) by the meters. In the following table, each row is overturned with the results of the calibration values for each meter. Then the cells were stained according to the range of error according to the following criteria;

| |
|---|
| **e = -100 %** |
| **-100 % < e < -6 %** |
| **-6 % < e < 0 %** |
| **0 < e** |

The table shows that when a flow calibration error is -100%, for all low flows in that meter will also be the error of -100%.

The sample shows that 15% of the meters have a flow point with error equal to -100%. So, apparently earlier, 15% of the meters of the sample had an error equal to -100% in the flow of 10 l / h (about pilot flow).

What good practices were identified?

- ✓ Coordination between Laboratory people, IT & Field operations crew
- ✓ IT tools practical use
- ✓ Information analysis for quality measurements assurance

What are the main benefits?

- ✓ You can minimize costs and operation efforts finding with an intelligent tool the objectives you are looking for, with a high level of success

What are the critical issues?

- ✓ The field operations logistic, and the continuous maintenance and filling of the databases

How could the initiative be improved or maintained longer?

- ✓ Improved the efficiency with early detection of meters anomalies.
- ✓ Systemic reports emission showing potential measurement anomalies