IBP 1102_19

Gas Allocation System - Possible applications for a gas routing identification system on a pipeline network.

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Abstract

SAQGAS identifies the gas route in a pipeline system, that is, it defines the proportion of gas reaching each delivery point from each receipt point. The original motivation came from meeting tax requirements that establish different rates for each gas origin and destination. However, new purposes were found while implementing this software, such as: definition of gas quality at delivery points without chromatographs, flow meters or chromatography error identification by comparing measured and calculated data, energy calculation in the pipelines for energy balance purpose. The software determines intermediate flow rate along the pipeline system from the receiving and delivery flows. Knowing these flows allows to define the proportions of the mixtures in each point and along the pipelines. The present article describes the development of the mathematical model, the prerequisites to obtain the desired results, as well as other applications used today: gas flow monitoring along the pipeline system, calculation of intermediate flows for comparison with operational meters to detect measurement errors, calculation of the associated energy with the volume of gas delivered, calculation of stored energy in the pipelines and other possible applications.

Keywords: Gas. Allocation. Energy.

1. Introduction

The legislation that controls the circulation of products across Brazilian territory determines the payment of interstate and inter-municipal tax rates. The main tax is the ICMS (tax on operations related to the movement of goods and on services of inter-state, inter-municipal and communication services) and this rate also affects the modalities of pipeline transport. In order to comply with the law, it informs the origin and destination of the product to be transported, as there is a difference between the rates of States belonging to the Union. Thus, SAQGAS was developed.
However, new applicabilities were discovered during the elaboration of the system, they are:

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- Determination of volume and the energy of gas of each source stored in the network in an alternative way to the mass balance;
- Association of gross calorific value to the delivery points without chromatography;
- Calculation of the chemical composition of the gas of each delivery point without a chromatograph;
- Use of artificial intelligence to identify errors in gas flow measurement comparing measured and calculated data.

Thus, this work has the objective of discussing the principle of software operation, the creation of the mathematical model, the methodology of validation of the calculations and the critical analysis of the results obtained. S also interferon subjects covered on the s current and future applications and on the use of software as a tool to meet the demands for the new gas market scenario in Brazil and in line with the new regulatory and tax rules.

2. Working principle

SAQGAS is a software developed with the main purpose of allocating the gas delivered at each delivery point (PTE) belonging to the gas pipeline network, through the supply points (PTR) connected to this network. That is, for each volume of gas delivered in an installation, the program will indicate the proportion of gas coming from each supply point registered in the system.

Image 1 refers to the Gas Routing and Allocation Report generated by SAQGAS. In this report, the first column describes the delivery point that received all the volume described in each line that has its code (example: PE-SUZANO) and the fourth column indicates the possible supply points that can grant gas for such delivery point.

Starting from the example of delivery point "PE-SUZANO", we have the following scenario: 579 576 m³ are from the "PR-GUARARE" supply point, 190 172 m³ from the supply point "PE-GASTSJC" and 174 033 m³ from the "PE-GASTAUB" supply point.

PLANILHA DE ROTEAMENTO

MÊS DE REFERÊNCIA: JUNHO - 2018

CÓDIGO	PTE	GTA PTE	PTR	GTA PTR	Dia 1	Dia 2	Dia 3	Dia 4	Dia 5	Dia 6
PE-SUZANOE-RD-6711	PE-SUZANO	MALHAS SUDESTE	E-RD-6711	GASDUC III	0	0	0	0	0	0
PE-SUZANOPR-GUARARE	PE-SUZANO	MALHAS SUDESTE	PR-GUARARE	MALHAS SUDESTE	579.576	576.599	477.849	1.219.404	752.952	1.000.600
PE-SUZANOPR-REPLAN	PE-SUZANO	MALHAS SUDESTE	PR-REPLAN	MALHAS SUDESTE	0	0	0	0	0	0
PE-SUZANOPR-RPBC	PE-SUZANO	MALHAS SUDESTE	PR-RPBC	MALHAS SUDESTE	0	0	0	0	0	0
PE-SUZANOPR-REDUC-L	PE-SUZANO	MALHAS SUDESTE	PR-REDUC-L	MALHAS SUDESTE	0	0	0	0	0	0
PE-SUZANOPR-REDUC	PE-SUZANO	MALHAS SUDESTE	PR-REDUC	MALHAS SUDESTE	0	0	0	0	0	0
PE-SUZANOPR-GNLBGB	PE-SUZANO	MALHAS SUDESTE	PR-GNLBGB	MALHAS SUDESTE	0	0	0	0	0	0
PE-SUZANOPE-GASTSJC	PE-SUZANO	MALHAS SUDESTE	PE-GASTSJC	GASTAU	190.172	172.004	213.898	0	507.608	447.895
PE-SUZANOPE-GASTAUB	PE-SUZANO	MALHAS SUDESTE	PE-GASTAUB	GASTAU	174.033	163.882	174.236	150.713	366.389	364.844
PE-TAUBATEE-RD-6711	PE-TAUBATE	MALHAS SUDESTE	E-RD-6711	GASDUC III	0	0	0	0	0	0
PE-TAUBATEPR-GUARARE	PE-TAUBATE	MALHAS SUDESTE	PR-GUARARE	MALHAS SUDESTE	0	0	0	0	0	0
PE-TAUBATEPR-REPLAN	PE-TAUBATE	MALHAS SUDESTE	PR-REPLAN	MALHAS SUDESTE	0	0	3.513	0	0	0
PE-TAUBATEPR-RPBC	PE-TAUBATE	MALHAS SUDESTE	PR-RPBC	MALHAS SUDESTE	0	0	0	0	0	0
PE-TAUBATEPR-REDUC-L	PE-TAUBATE	MALHAS SUDESTE	PR-REDUC-L	MALHAS SUDESTE	0	0	0	0	0	0
PE-TAUBATEPR-REDUC	PE-TAUBATE	MALHAS SUDESTE	PR-REDUC	MALHAS SUDESTE	0	0	0	0	0	0
PE-TAUBATEPR-GNLBGB	PE-TAUBATE	MALHAS SUDESTE	PR-GNLBGB	MALHAS SUDESTE	0	0	0	0	0	0
PE-TAUBATEPE-GASTSJC	PE-TAUBATE	MALHAS SUDESTE	PE-GASTSJC	GASTAU	50.335	0	0	84.306	88.696	0
PE-TAUBATEPE-GASTAUB	PE-TAUBATE	MALHAS SUDESTE	PE-GASTAUB	GASTAU	0	48.353	55.029	0	0	94.213

Image 1 - Routing and Allocation Report

The principle of operation of the SAQGAS is divided into two main steps: (1) calculating the intermediate flows of the sections belonging to the pipeline network and (2) determining the origins of natural gas at each delivery point by monitoring the gas flow.

The software was designed to reproduce in a faithful way the pipeline network and its peculiarities. The following installations can be registered in the system: pipelines, delivery points, supply points, compression stations, valves, interconnection points between pipelines and measuring stations.

2.1 Calculation of the intermediate flows in the pipeline sections

The mathematical model used to calculate the internal flows of the pipeline network was based on a "node" system. After the network mapping, the locations, in each pipeline, where there is: valve, delivery point, supply point, compressor stations, measuring stations or at a point where there is a branch, allowing more than one possible path for the gas to flow, were properly marked as a node and identified by a numbering.
Next, the "sections" belonging to the pipeline network were mapped, that is, the segments formed by the union of two nodes. Image 2 below shows a simplified schematic of the network, where it is possible to identify nodes and sections.

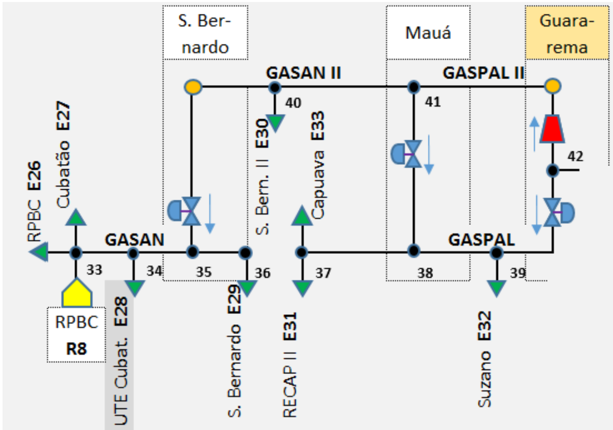


Image 2 - Simplified schematic of the pipeline network

2.1.1 Mathematical equations used to calculate the intermediate flows

The mathematical model used is based on a linear system of equations. The equations are divided into two categories: equations of nodes and equations of sections. Image 3 below illustrates a schematic that has 5 nodes, 4 sections (segments), 3 supply points and 2 deliveries points.

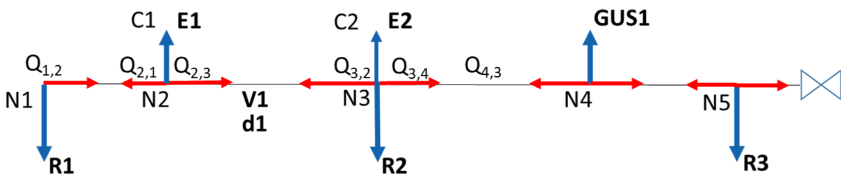


Image 1 - Schematic of the system of equations

SUBTITLE:
N: Node
R: Supply Flow (Volume received in the period considered)
E: Delivery Flow (Volume delivered in the period considered)
Q: Intermediate flow to be calculated
V: Volume contained in the segment between two nodes (linepack of the section)
C: Current (matrix containing vectors with values for the supply points)
d: Imbalance (variation of the linepack in the section)
GUS: Natural gas for system use.

Variables - Once daily volumes delivered to each delivery point and supply point are known, the unknowns are the gas stream between the nodes (horizontal arrows shown in Image 3). In the case of the example presented, there are 9 variables.
Sign Convention - was adopted for the convention of signals that all the output (indicated by the arrow) of a node will have a positive value and every value (indicated by the arrow) entering the node will have a negative algebraic signal.
Node Equation - The equation of each node is the sum of all the gas inputs and outputs in the node, equaling zero. Since the node does not expand or contract, the sum of the entire input volume and the entire output volume of the node will result in a zero value, which will always be true.
With this, we can consider that the equation of node N1 presented in the above example is:

$$R1 + Q1,2 = 0 \quad (1)$$

Where: Q1,2 refers to the exit gas flow from node 1 driving to node 2.
Given this methodology, according to the example, we have 5 node equations to solve the question.
Segment Equation - In order to obtain new equations for the system to be solvable, the segment equations were also used. One segment consists of a section of pipeline connecting two different nodes. Thus, in the example presented, we have the segment connecting nodes 1 and 2. Since we have the arrow Q1,2 (flow from node 1 to node 2) and arrow Q2,1 (flow from node 2 to node 1), we conclude that the sum of Q1,2 with Q2,1 must be equal to the imbalance (variable of linepack between two periods).
Considering the linepack variable equal to zero for the section connecting points 1 and 2, we have:

$$Q1,2 + Q2,1 = 0 \quad (2)$$

With this, in the given example, we obtain 4 more equations through this new methodology.

Given the above considerations, there are a total of 9 equations, thus composing a system with 9 variables. Through this model, it becomes possible to obtain the gas flow values between the nodes and their respective direction.
In numbers, the system has 227 registered nodes, 207 stretches that, interconnected, have 434 gas flows or internal flows to be calculated. That is, there are 434 unknowns to be discovered. The NTS network has 9 Supply Points and 47 Delivery Points. Therefore, 56 input data to be entered into the system.

2.2 Determination of gas origins for each delivery point by monitoring the gas flow

After calculating all the intermediate flow of the network, it becomes possible to determine the percentage of each source (supply point) which reached the edge of each segment, that is, reached the deliveries points. For this set of percentages by origin, the term gas stream. In the diagram shown in Image 4, the gas current will be represented as a matrix containing vectors with values for the supply points R1, R2 e R3 → [R1, R2, R3].
Considering calculated indicating the flow directions of the gas adjusted:

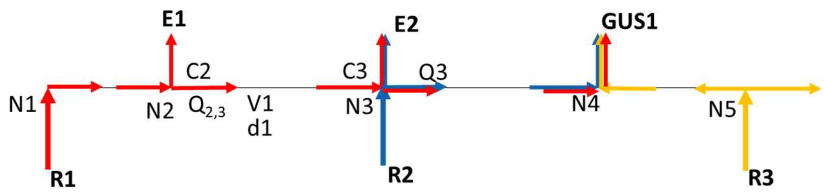


Image 2 - Schematic - calculation of gas current

Taking as an example the section between the nodes N2 and N3, it is known Q2,3 the value and the direction of gas flow, so calculate it is the transit time between the nodes, that is, the time for gas go through the segment N2-N3:

- Calculation of transit time from N2 to N3:

$$T = V1/Q2,3 \quad (3)$$

For example, if V1 = 1000m³ and the flow Q2,3 = 200m3/h, the time for the gas to travel through the N2-N3 segment at the operating pressure will be 5 hours. The determination of the gas stream [R1;R2;R3], flowing in each part of the system, in time (T), will occur as follows:

Image 3 - Schematic for the determination of the stream that reaches the end of the section.

That is, That is, a current C3 will be the same as C2 of 5 hours ago. Finally, it is enough to perform this operation for all segments before calculating the gas stream of each node. For the calculation of the stream of each node, the average weighted by the flows of the input currents in the node is used. In the example below, we have:

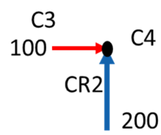


Image 4 - Schematic for calculating the gas stream of the system.

Therefore, the output stream of the node shown in Image 6 will be:

$$C4 = [10/30] * C3 + [20/30] * CR2 \quad (4)$$

2.3 Calculation of the Gross Calorific Value (PCS) of the Delivery Points:

The calorific value of a substance is the amount of heat produced during will combust, which can be expressed in two ways: Gross Calorific Value - quantity heat produced during the complete combustion of a unit volume or mass; Net Calorific Value - quantity heat produced during the complete combustion of a unit volume or mass without the occurrence of condensation of water vapor contained.

In terms of revenues, it accounts for energy delivered to each delivery point and not only the volume delivered daily. To inform this energy, a chemical analysis equipment called a chromatograph is used. This equipment indicates the percentage of the chemical components present in a gas mixture. Since each chemical has a standard gross calorific value, which is an additive property, it is possible to calculate the gross calorific value resulting from the gas

mixture. SAQGAS uses the information of gross calorific value determined by chromatographic analysis of supply points to calculate gross calorific value regarding gas mixture into each delivery point.
The calculation consists of using the gross calorific value data of each supply point, which are stored daily as vectors belonging to the [R1, R2, R3] matrix. Knowing the current that was delivered at a delivery point, such ratio is used in a weighted way to calculate the gross calorific value resulting from the mixture.
1º) Example of the matrix of the resulting current to the Point of Delivery:

$$[R1,R2,R3] = [0{,}1;0{,}3;0{,}6]$$

2º) Resultant gross calorific value (PCS):

$$[PCSR1; PCSR2 ;PCSR3]$$

$$PCS_{RESULTANTE} = [PCSR1 * 0{,}1] + [PCSR2 * 0{,}3] + [PCSR3 * 0{,}6] \quad (5)$$

Note that the PCS receiving point used in the final calculation takes into account the gaseous mixture flow time in the network, that is, the gas mixture input at the supply point R1 arrived at the delivery point five days after entering the network, the PCS R1 of five days ago is used in the weighted average.

2.4 Parameterization

The SAQGAS software was developed in a configurable way, that is, it allows the user to design any type of network arrangement, that is, to insert or withdraw delivery points, supply points, pressure points, measurement and compressors stations. It is also possible to create or discard new pipelines as well as points of interconnection between these facilities.
The system is prepared to block sections by closing valves, which makes it feasible to represent the peculiar operational changes of each month. It is also possible to enter the flow value of intermediate operating meters located at any point in the network. Thus, it is possible to use the previous flow counted by this meter for comparisons or for use n the calculation of the intermediate flows in branched passages, when necessary.
As new nodes and sections are registered in the system, the mathematical equations that make up the general linear system are created automatically. Similarly, the exclusion of these components eliminates the equations bound thereto, making it possible to build a set of consistent equations are registered with the network facilities.

3 Results and discussions

3.2 Validation calculations of intermediate flow

To validate the result of the intermediate flow calculated by SAQGAS we used 35 operational measuring points located at different strategic points of the network. The main purpose is to compare the measured flow value with the value calculated by the SAQGAS.

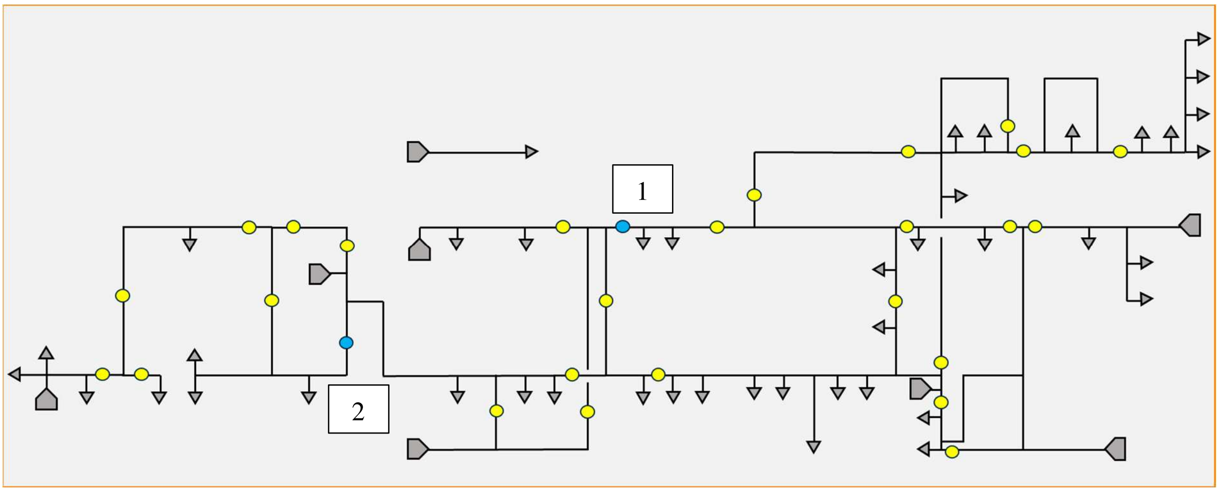
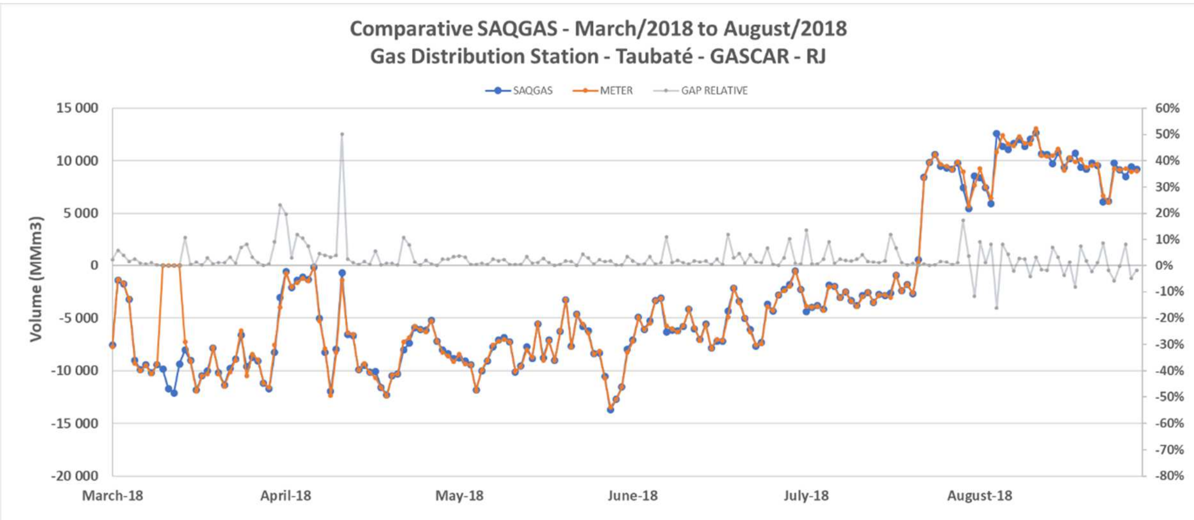


Image 5 - Positioning of the 35 operational flow meters in the NTS network.

Graph 1 refers to the operational meter located in the GASCAR pipeline, city of Taubaté, in a section that has two branches (image 7 - meter 1). The orange coloring indicates the curve computed by the operational flow meter during the period of 6 months, and the blue color indicates the flow curve calculated by the system for the same period. The gray curve indicates the error relative to the meter, that is, for negative results, the meter is showing a lower value than calculated.

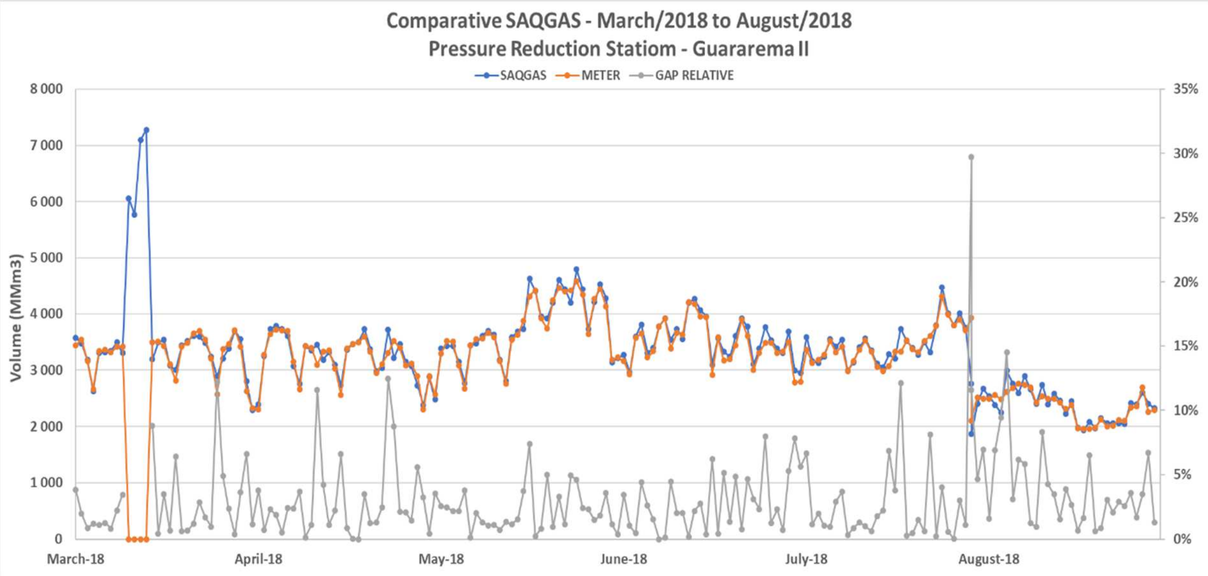


Graph 1 - Comparison of the measurements calculated and measured by the operational meter

The curves in blue and orange have the same trend throughout the period reported on the graph, which indicates the magnitude of the flow rate calculated by the accompanying SAQGAS the magnitude indicated by the operating meter. On the dates between March 10 and 13, there was a loss of signal between the historian who feeds the system, resulting in the lack of data from the operational meter. Therefore, the meter has zeroed values for this time. However, SAQGAS continued to calculate the expected flow values for this point, which explains the difference pointed out in Image 1 for this period.

During the period between March / 2018 and July / 2019, negative values indicate that the gas flow occurred Taubaté towards Rio de Janeiro. After stopping for intervention at the Caraguatatuba Gas Treatment Unit, which occurred in late July / 2018, the gas flow at this point of the network was inverted, completely changing the regular course of the network. As can be seen in the chart, the system also deduced the reversal, automatically reversing the flow of the

signal and keeping very close to calculated values of the measured values by the operating meter.
The gray curve, in Graph 1, has as its reference the secondary axis located in the right corner of the graph. The analysis indicates that most of the relative error values are within ±10%. The standard deviation of the error, in the period, is 5,58%.



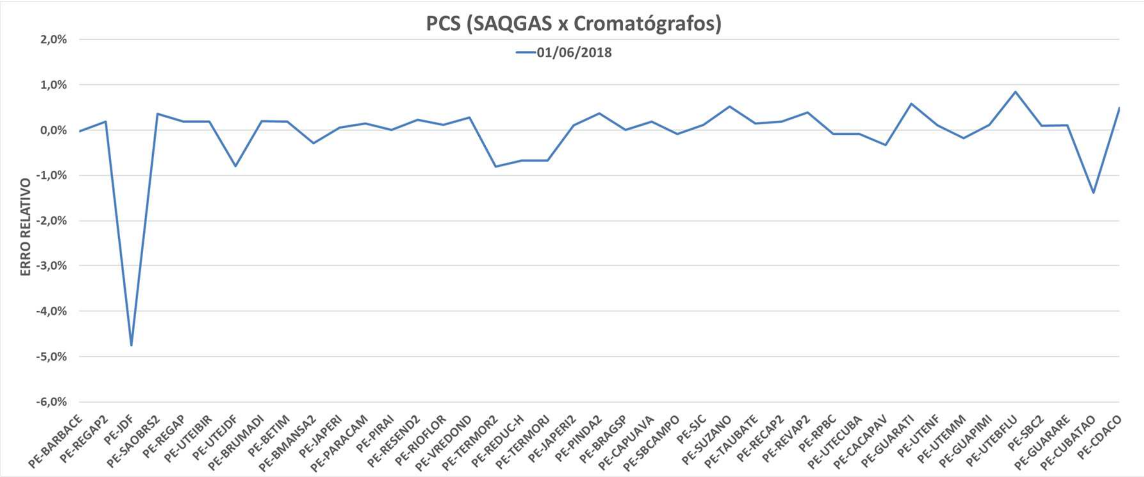
Graph 2 - Comparison of calculated measurements and are measured by operating a measuring

Graph 2 shows the results of the meter located in the Guararema Pressure Reduction Station, a point with a complex branching (as indicated in Image 7 - meter 2). Following the same line of analysis used for the Taubaté-GASCAR-RJ meter, it is possible to observe that the flow calculated by the system follows the same tendency of the flow obtained through the data of the operational meter during the six months analyzed.
In this case, there was no flow inversion during the analyzed period. However, the same error data acquisition occurred between the SAQGAS system and the information of the operational meter in the period of March 2018, and, in the same way as indicated for the analysis of the above meter, the SAQGAS calculated the flow rate that went through the section in question.
The gray curve, in graph 2, has as its reference the secondary axis located in the right corner of the graph. The analysis indicates that most of the relative error values are within ±10%. The standard deviation of the error, in the period, is 3,40%.

3.3 Validation of gross calorific value (PCS) calculations

The validation of PCS values calculated by SAQGAS system, for each point of delivery was made through the comparison between the calculation result and the energy you've got through the chromatograph analyzing the gas mixture is conveyed. For delivery points that do not have a chromatograph, the association mechanism (allowed by the ANP, through regulation for gas transportation) is used.
The methodology of gas association to a delivery point that does not have a chromatograph occurs through the use of the PCS value assigned to the nearest delivery point that has the chemical analysis equipment, always respecting the direction of the gas flow.
Graph 3 indicates the assessment referring to the day 06/01/2018, to delivery points mentioned in x-axis. The ordinate axis specifies the result of the relative error between the measurement and the calculation of the SAQGAS. It can be seen that the relative error variation is ± 1.5 for

most delivery points. However, Graph 3 indicates a result of -4.76% for the delivery point Juiz de Fora.



Graph 3 - error concerning the value of PCS calculated by the SAQGAS and obtained through a chromatograph

The delivery point Juiz de Fora does not have its own chromatograph, being thus, an association is realized to the point of delivery PE-UTE Juiz de Fora. Thus, it is possible to justify the high value of relative error, since the association does not take into account the transit time factor of the gas mixture.

Another relevant aspect for analysis is the measurement attributed to the point by local distribution companies (LDCs). If the reported PCS value is of different magnitude, the LDC may make a formal complaint to the shipper. For the day of the analysis in question, there was a formal complaint from the client, pointing out that the measure calculated by the SAQGAS may indicate greater precision than the association process.

4 Applications

4.1 Current Application

In light of the analysis of the result, SAQGAS is used to generate the Routing Report and Inventory Management, indicating the gas stream delivered at each delivery point.

Also, the program is used to carry out critical analyzes on the measurements of the intermediate flows for cases of investigation of possible measurement problems in interconnections located strategically in the mesh and between contracts.

4.2 Applications in development

Taking into account the versatility of the SAQGAS software, the possibility of parameterizing any type of installation in the system, the discretization in short sections of each pipeline belonging to the network, the gas and energy volume (PCS) information entered in the system and the satisfactory results pointed out in the topics of results and discussions, new uses are envisaged to aid in future processes and to optimize the measurements made.

4.2.1 Determination of the volume and energy of the gas from each source stored in the network as an alternative to the mass balance;

As a result of the changes foreseen for Brazilian tax legislation, new legal attributions are expected for the members of the gas sector in the country. The main known changes are:

- For the shipper: commercial routing, which will ease the transaction between the delivery and receiving locations of gas;
- For the transporter: inform the Brazilian Treasury of the movement and linepack of the pipeline network in units of MMBTU (energy), indicating the amount of energy by the source that remained in the pipelines.

The biggest challenge is to report linepack in energy. However, obtaining the volume of gas stored by source precedes this challenge. The most widely used method for determining the volume per stock source is the mass balance, where the daily flow measured values of the delivery and receiving points are used through the routing information and the inventory is calculated.

Image 6 - Schematic of a pipeline segment containing gas from three sources

$$Ef = EI + VR - VE \tag{6}$$

Onde:
Ef – Final linepack
EI – Inicial linepack
VR – Received volume
VE – Delivered volume

However, this methodology becomes imprecise when the volume moved is much higher than the volume stored. That is, if there is a measurement error in the volumes delivered or received, this error will be reflected in the calculation of the final stock. For the subsequent month, the final linepack will become the initial linepack, so the error is charged month-to-month throughout the asset's lifetime.

Using SAQGAS, there is no mass balance. The methodology presented in "2. Working principle" determines the linepack daily: accompanying the received gas flow through each supply point calculating the proportions arising from the mixtures occurring in each interconnection and branching of sections. Lastly, distributing the gas mixture in each section. Thus, there is close control of the linepack origin of each pipe segment.

In the case of volume, the total volumetric linepack (without regard to origins) is calculated with high precision through pressure data and the design of the pipeline. However, for energy, there is no equipment that determines the energy stored in a pipeline.

An alternative would be to use the methodology similar to the mass balance, nevertheless employing the energy data. However, this choice carries with it the error of the measuring equipment that checks the input and output data of the system. As the volume moved is much higher than the volume stored, the calculated linepack will be impacted by this error.

The volumes delivered and received will be converted into energy using the chromatograph information from the delivery and supply points. Stipulating the energy stored initially, it is possible to calculate the final energy, by origin, according to equation 6.

The alternative to avoiding propagating this error in the calculation of energy monthly is the use of SAQGAS. Since the system has stored data of gas stream (source matrix) and PCS (considering the transit time of the gas mixture) for all segments belonging to the gas pipelines of the network.

Thus, it is possible to calculate the energy stock for all segments of pipelines (as needed to section the pipelines) by source, without the need to adopt approximations to stipulate the daily resulting PCS to be used to convert the linepack into energy for a certain day.

4.2.2 Association of Gross Calorific Value (PCS) and Calculation of chemical composition to delivery points that do not have a chromatograph

Another possible application to SAQGAS is the determination of the chemical composition of the gas mixture delivered at the delivery points. The chemical composition is the set of chemical compounds that make up the gas mixture. The main ones are:

- Methane;
- Ethane;
- Propane;
- Carbon dioxide;
- Iso-butane;
- Iso-pentane;
- Nitrogen;
- Others.

Knowledge of the proportion of these compounds is essential for compliance with the legal compliance requirements of the gas as well as for determining the energy of the mixture since each chemical has a specific calorific value.
Using the chemical composition data collected from the chromatographs in all the receiving points of the network and following the transition time of the gas mixture, possible interactions with other blends derived from other receiving points can be calculated in proportion to the intermediate flow rates, the resulting chemical composition given in all the delivery points.

Image 7 - Schematic of the calculation of the chemical composition of the delivery points from the chromatographic data of the receiving points.

Image 9 shows a schematic of a pipeline segment having two supply points and a delivery point. By inserting the chemical composition information of the receiving points into the system, SAQGAS will apply the same logical order displayed in the operating principle to calculate and report the chemical composition report of all the delivery points registered in the system.
The use of this methodology implies two major benefits to the gas measurement process:
1º) Carry out the energy association and description of the chemical components for the delivery points that do not have a chromatograph;
2º) Comparison between the chemical composition presented by the chromatographs and the calculated product.

For the first case a form of calculation improvement, resulting in a better association is to use the measurements of the chromatographs neighboring the point of delivery that does not have this instrument. For example:

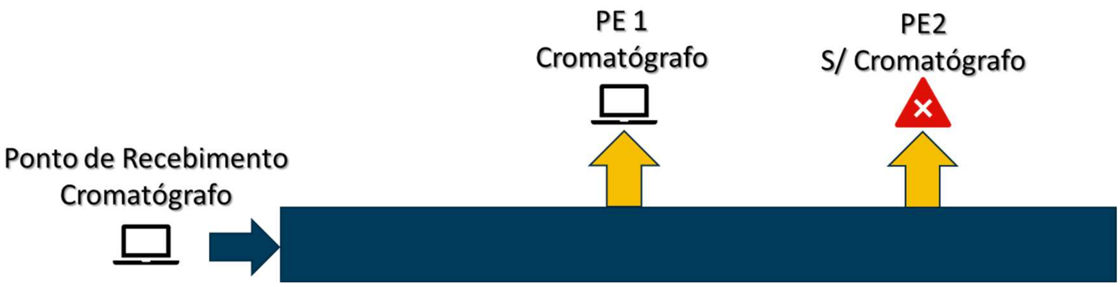


Image 8 - Improvement of the chemical composition calculation for delivery points without chromatographs

In Image10, delivery point 2 (PE2) has no chromatograph while delivery point 1 (PE1) has the instrument. As the PE1 is closer physically PE2, the chemical composition information calculated by the chromatograph is used to associate them to the PE2. The differential is the monitoring of the transit time and the storage of the information daily. Therefore, the associated information will respect the modifications of flow and operational movement of the network, minimizing errors from approximations.

The comparative utility reported in the second topic points to the anticipation of disputes over the quality of the chromatographic measurements. That is, if there is a significant variation between the value generated by the equipment and the calculated value, it is possible to check if there is any irregularity in the instrument before the billing period.

4.2.3 Use of artificial intelligence to identify errors in gas flow measurement comparing measured and calculated data.

The basis of artificial intelligence is the development of algorithms that have the ability to learn trends through interaction with large volumes of data. The gas measurement and quality area work with several operational parameters that have a wide correlation with each other and that instantly impact the measurement result. In this way, there is a demand for simultaneous analyzes that cannot be performed by humans. The close observation made by intelligent machines can indicate unexpected situations that would not be detected by other means. Thus, an application of AI is to monitor and perform predictive analyzes on the movement of gas in a pipeline network.

One way to use AI in SAQGAS is through monitoring the trend of measurement of all meters scattered in the NTS network, which may be custody or operational transfer meters. From the history of each meter, it will be possible to develop and train finding algorithms to look for differences between the reported and measuring the predisposition.

The main utilities are:

- Use the intermediate flows calculated by the SAQGAS for comparison with the operational meters in order to detect high deviations and use the measurements of the other meters to correct possible erroneous values;
- Use the new mass balance values to mitigate measurement errors in custody transfer meters and to predict possible claims for divergence between customer and carrier values.