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Paper 2:

INTRODUCING THE COMPACT PROVER IN BRAZIL BY COMPARISON TESTS WITH A CONVENTIONAL ONE

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Author:
Virgilio A. Rezende
Petrobras, Brazil

Organiser:
Norwegian Society of Chartered Engineers
Norwegian Society for Oil and Gas Measurement
Co-organiser:
National Engineering Laboratory, UK

NORTH SEA FLOW MEASUREMENT WORKSHOP 1995

INTRODUCING THE COMPACT PROVER IN BRAZIL BY COMPARISON TESTS WITH A CONVENTIONAL ONE

Virgílio A. Rezende
PETROBRÁS/Brazil

Summary

In December 1993, the PETROBRÁS Paulínia Refinery acquired a Compact Prover for calibrating LPG turbine meters, replacing an old existing conventional prover. The compact prover were installed in parallel with the conventional prover to conduct comparative performance tests during transfer of custody. These tests were performed in accordance with API Measurement Standards, from November 1994 to February 1995. The Meter Factor obtained from the two provers for the same reference turbine showed good approximation results. The compact prover was approved in tests by PETROBRÁS and it is being used by the Paulínia Refinery (REPLAN) for calibrating LPG turbine meter.

I - INTRODUCTION

PETROBRÁS is the governmental monopoly company that explores and refines petroleum in Brazil. It refines 1.4 million bbl/d of crude oil, billing around 20 billions US dollars per year. Brazil's largest refinery is Paulínia Refinery - REPLAN, located in the city of Paulínia - SP. REPLAN crude oil load is 300,000 bbl/d and main products are: gasoline, diesel and LPG.

Through PETROBRÁS/REPLAN, an average of 50,000 tons/month of Liquefied Petroleum Gas (LPG) are sold. The international price of this product fluctuates under US $ 200.00/ton. This inventory represents an annual billing on the order of US $ 120 million. Uncertainties or variations close to 1.0 % in the measurement of LPG sales from the refinery, represent to PETROBRÁS US $ 1.2 million that can be lost annually, depending on the direction of the error of the measuring instrument.

Instruments and equipment, that measure and record as faithfully as possible the inventory of products sold by the refinery, are grouped in the same area, forming the systems called by PETROBRÁS EMEDs (Portuguese abbreviation for "Measurement Station") which are composed of piping, filters deaerating vessels, flowmeters, as well as indicators, totalizers, and so on.

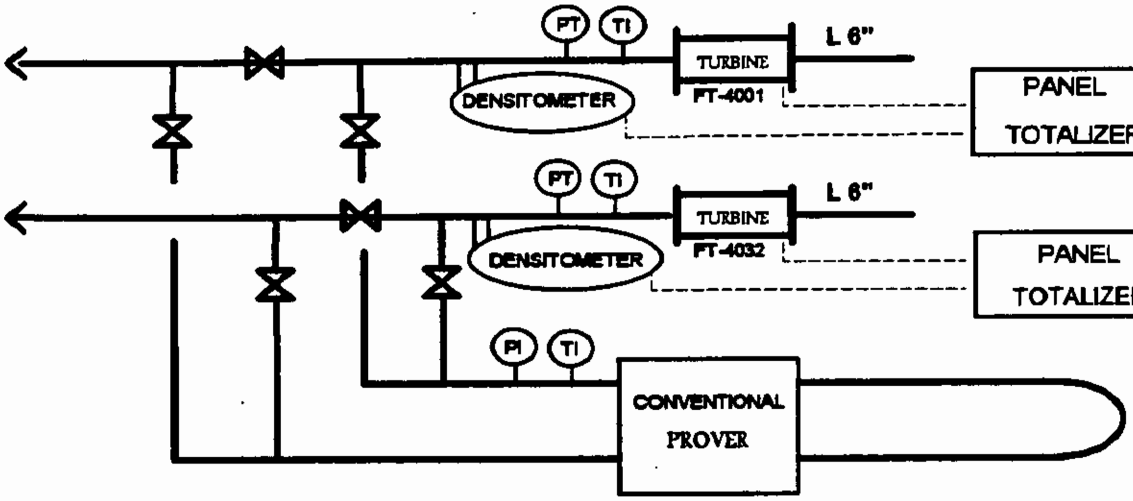
Among the equipment of the EMEDs, the flowmeters stand out as being the essential equipment and the provers as being that of the greatest hierarchical precision.

2 - OBJECTIVE

To evaluate the performance of the "Brooks Compact Prover", purchased to verify the Liquefied Petroleum Gas flowmeters of the Paulínia Refinery by the performance of comparative tests with an existing "Conventional Prover".

3 - THE PAULÍNIA REFINERY LPG MEASUREMENT STATION

Figure 1 illustrates in simplified manner, in the form of a flow chart, the interconnections of the main components: turbine-type flowmeters, densitometers, and prover of REPLAN Liquefied Petroleum Gas (LPG) Measurement Station.



GENERAL SCHEME OF LPG MEASUREMENT STATION

Figure 1

3.1 - Main meters of Paulínia Refinery Measurement Station

For quantification of the LPG to be sold, the product is pumped, passing first through a system of deaeration, filtration, and flow rectification before reaching the turbine and densitometer shown in Figure 1.

The Paulínia Refinery Measurement Station has two A. O. Smith Systems turbines[1], Model L6", with a basic "K" factor of 6000 pulses/m^3 (factory nominal K factor), represented in Figure 1 with the following designations: FT-4001 and FT-4002. The "K" factor of a turbine is the ratio between the pulses generated and the volume measured.

The densitometer used by the Paulínia Refinery in the LPG Measurement Station is of the Dynatrol brand. The density signal, after conversion of frequency to current, has the following correspondences: 20 mA is equivalent to 600 kg/m^3 and 4 mA is equivalent to 500 kg/m^3, which are the density limits of the LPG specified for sale.

Figure 2 below shows the scheme of the signals that are received from the turbine and from the densitometer by the totalizer. The Paulínia Refinery LPG Measurement Station uses a Model CMOS CDC-75 totalizer from Smith Meter[2] for each measurement line.

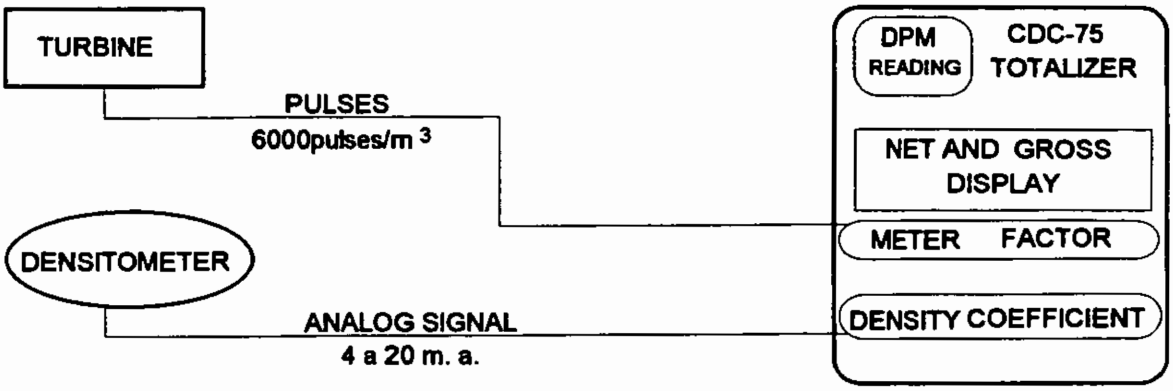


DIAGRAM OF SIGNALS TO THE TOTALIZER

Figure 2

3.2 - Totalization by weight of LPG

The CMOS CDC-75 totalizer located in the panel receives pulses corresponding to the volumetric flow rate sent by the turbine and analog current signal of 4 to 20 mA sent by densitometer. The signals are multiplied inside the totalizer to obtain the quantity transferred by weight in accordance with equations (1) to (3), shown below:

$$\text{NET MASS} = P \,.\, Mp \,.\, [\, 1 - Xd \,] \qquad (1)$$

$$Mp = (\, Dmax \,) \div (\, K \,) \qquad (2)$$

$$Xd = \frac{(Dm\acute{a}x - Dmin)}{Dm\acute{a}x \times 0.9} \times \frac{DPM}{100} \qquad (3)$$

The terms of equations (l), (2), and (3) have the following meanings:

NET MASS = totalized weight
Mp = meter pulse factor
Xd = DPM reading density scale
P = number of pulses coming from meter
K = meter factor: pulse/m^3
Dmax = maximum density
Dmin = minimum density
DPM = internal scale of density signal in CMOS CDC-75 with range of 0 to 90

The METER FACTOR seen in figure 2 means the Meter pulse factor (Mp) corrected by Meter Factor (MF), obtained by proving meter.

The display GROSS seen in Figure 2, indicates pulses comes from meter are totalized without the density correction [1 - Xd].

The DPM scale has the following correspondence with the analog density signal:

I = current signal
For the minimum density: Imin = 4 mA ⇒ DPM = 90
For the maximum density: Imax = 20 mA ⇒ DPM = 0

Xd has negative signal in equation (1) to do the density correction from gross to net weight, thus if operating density is equal maximum, doesn't have any correction and GROSS is equal NET weight, but if operating density is equal minimum then DPM=90 and the maximum correction is done.

The DENSITY COEFFICIENT, seen in Figure 2, must be entered into the totalizer in order to configure it according to the product to be measured. The density coefficient is obtained by the first part of equation (3) and it may be written as equation (4), below:

$$\text{density coefficient} = \frac{(\text{Dmax} - \text{Dmin})}{\text{Dmax} \times 0.9} \tag{4}$$

To quantify by weight the LPG sold by the Paulínia Refinery, the CDC-75 totalizer comes to have the following configuration:

Maximum and minimum densities of the Paulínia Refinery LPG:

Dmax = 0.6 t/m^3 (0.6 g/cm^3)
Dmin = 0.5 t/m^3 (0.5 g/cm^3)

Applying in equation (4):

$$\text{density coefficient} = (0.6 - 0.5) \div (0.6 \times 0.9) = 0.1852$$

Applying density coefficient in equation (3):

$$Xd = 0.1852 \times \frac{DPM}{100}$$

Applying turbine "K" factor in equation (2):

$$Mp = \frac{0.6 \ t/m^3}{6000 \ pulse/m^3} = 10^{-4} \ t/pulse$$

At this point is important to choose the meaning of quantities that will be totalized. PETROBRÁS/REPLAN chosen to totalize each 1 dt (1 decimal ton = 100 Kg) of LPG. Then changing Mp from "ton" to "dt", the equation (2) gives Mp = 10^{-3} dt/pulse. But to set the totalizer with Mp = 10^{-3} dt/pulse is impossible, because the CDC-75 gives only possibilities between 0.0000 and 1.9999 for Mp values.

To solve this problem, CDC-75 has the possibility of multiply Mp by 10, 10^2, 10^3 or 10^4 since that the same number will be used to divide pulses coming from meter, by setting totalizer pulse divisor.

In this case Mp = 10^{-3} dt/pulse must be multiplied for 10^3 to obtain Mp = 1 dt/pulse and pulses coming from meter must be divided by 10^3 to compensate.

Configured in this manner, the equation (1) becomes:

$$M = \frac{P}{(10^3)} \times Mp \times [\,1 - Xd\,] \qquad (1)$$

$$M = \frac{P}{(10^3)} \times \frac{1\ dt}{pulse} \times [\,1 - 0.1852 \quad \times \frac{DPM}{100}\,]$$

In accordance with the equation (1) as REPLAN configuration represented above, when 100,000 pulses are coming from the meter, with LPG density of 0.55 t/m^3 (DPM = 45), the display GROSS totalization will be:

GROSS = (100,000/10^3) dt
GROSS = 100 dt (10 ton)
Not corrected for the density.

The display NET will be corrected for density = 0.55, firstly finding Xd by equation (3):

$$Xd = 0.1852 \times (45 / 100) = 0.08334$$

and forward calculating NET MASS by equation (1):

NET MASS = [(100,000 pulses) / (10^3)] x (1 dt/pulse) x (1 - 0.08334)
NET MASS = 91.67 dt (9.167 ton)
For corrected density.

3.3 - The function of the prover

Flowmeters of the turbine type, when perfectly calibrated, operate with margins of error below 0.2%, according to data from the literature and manufacturers' catalogs[1]. Because of they presenting such a high precision of measurement, as well as their ruggedness and other favorable mechanical characteristics, turbines are considered the best meters currently available on the market for industrial applications within the limits of viscosity, temperature, and other physical properties of the fluids, which, depending on the value, may hinder their use. The API MPMS Chapter 5[3] provides orientations with limits of application of turbines.

Despite the advantages presented by turbines, if a Measurement Station, contemplated with turbines, does not have a prover for verification of the same, it will be quite difficult for the user to detect whether the turbines are measuring the flow rate correctly or if they are requiring correction of the "K" factor. It will also be difficult to perceive when a turbine will be requiring maintenance due to some subtle defect that could cause errors in the measurement. The prover is the instrument that manages to achieve monitoring of the performance of the turbine.

3.4 - Method of verification of meters

The Meter Factor, according to the API, is a number which multiplied by the indicated flow rate of a turbine taking its basic "K" factor into account, furnishes the actual flow rate, eliminating the intrinsic errors of the meter during a process of custody transfer.

The Paulínia Refinery uses tubular provers called "Pipe-Provers" by the API[4,5], the main function of which is to verify the flowmeters and determine the Meter Factor. Determination of the Meter Factor is accomplished by the prover by means of a field operation called "run".

The verification "run" of a turbine consists of making an alignment in series of the latter with the prover so that the same flow rate passes through the prover and the turbine at the same time. The calibrated volume of the prover is equipped with detectors that start and stop the electronic counting of the turbine pulses, during the proving, by means of the passage of a sphere, or piston , according to the type of prover, which is launched into the flow of the product within the prover pipe.

Conventional provers[4] normally use a polyurethane sphere and compact provers[5,6] normally have a metal piston integral with an "optical ruler".

The measured turbine volume, corresponding to the pulses that prover have been counted during the passage of the sphere, or of the optical ruler of the piston, through the detectors of the prover, when compared to the prover' calibrated volume, provides the calculation of the Meter Factor. To perform the cited calculation, the volumes must be corrected to the same reference condition of pressure and temperature.

According to API MPMS 12.2[7], the Meter Factor may be defined as being the ratio between the calibrated volume of the prover and the volume measured by the flowmeter during proving run.

Equation (5) below, whether referred to the same temperature and pressure conditions, expresses API definition.

$$MF = \frac{\text{prover volume}}{\text{volume measured by meter}} \tag{5}$$

The prover volume is calibrated by a test standardized by the API[4,5] called "water draw". The test procedure may also be found in the prover manufacturer's catalog[6].

The volume measured by turbine is taking by the ratio between number of pulses generated during the proving run and turbine's basic K factor, as showing in equation(6):

$$\text{volume measured by meter} = \frac{\text{number of pulses}}{\text{K factor}} \tag{6}$$

Adding into equation (6) the temperature and pressure corrections as contained in API MPMS 12.2[7], replacing the terms in equation (5) and rearranging them, the result is the expression of equation (7):

$$MF = \frac{(\text{prover volume}) \times (\text{K factor}) \times (CTSp) \times (CPSp) \times (CTLp) \times (CPLp)}{(\text{number of pulses}) \times (CTLm) \times (CPLm)} \tag{7}$$

The terms CTSp and CPSp of equation (7) are, respectively, correction factors of the steel volume of the prover for the actual temperature and pressure inside the prover that differ from the prover calibration conditions. The other terms of equation (7): CPLp, CTLp, CPLm, and CTLm, are, respectively, the correction factors of liquid pressure inside the prover, liquid temperature inside the prover, liquid pressure in the meter, and liquid temperature in the meter. Equations (8) to (13), extracted from API MPMS 12.2[7], provide the calculation of these terms.

$$CTSp = 1 + (Tp - Tr)\,\gamma \tag{8}$$

$$CPSp = 1 + Pp \times \frac{D}{E \times t} \tag{9}$$

$$CPLp = [\,1 - (Pp - Pe) \times F\,]^{-1} \tag{10}$$

$$CTLp = 1 - (Tp - Tr) \times \alpha \tag{11}$$

$$CPLm = [\,1 - (Pm - Pe) \times F\,]^{-1} \tag{12}$$

$$CTLm = 1 - (Tm - Tr) \times \alpha \tag{13}$$

in which:

Tp = actual temperature of liquid inside prover
Tr = reference temperature at which prover was calibrated
γ = coefficient of volumetric expansion of prover calibrated pipe material
D = Internal diameter of prover calibrated pipe section
Pp = actual internal pressure in prover
E = Modules of Elasticity of prover calibrated pipe material
t = wall thickness of prover calibrated pipe section
Pe = vapor pressure at actual, or at a conservative given, temperature. Reid Vapor Pressure may be used as the value of Pe.
F = compressibility factor of the liquid. Value found in API Tables chapter 11[8]
α = coefficient of volumetric expansion of liquid
Pm = actual liquid pressure inside meter at run timing
Tm = actual liquid temperature inside meter at run timing

The value of Meter Factor (MF) obtained by the above methods and equations, must be multiplied with the value of totalizer configured Meter pulses factor (Mp) and the result must be entered manually in the totalizer METER FACTOR place as seen in Figure 2 of Section 3.1. During the totalizer counting pulses operation, the entered value of MF will be multiplied by number of pulses coming from the meter, to get the correct volume as shown by equation (14) below, extracted from API MPMS 12.2[7].

$$(\text{ACTUAL VOLUME}) = (\text{INDICATED VOLUME}) \times (\text{MF}) \qquad (14)$$

In this manner, after a verification run on a Paulínia Refinery Measurement Station turbine, if an MF value of MF = 0.9955 is obtained by the prover and this number is entered in the totalizer, following the same example for the calculation of Mp shown in section 3.2, for every 100,000 pulses of the turbine with LPG density equal to 0.55 t/m3 (DPM=45), the display GROSS totalization now will be:

$\text{GROSS} = (100{,}000/10^3)\ \text{dt} \times (0.9955) = 99.55\ \text{dt}$
(9.955 ton instead of 10 ton in the example of section 3.2)

The NET MASS in this case will be corrected by actual density in the same way as seen in example of section 3.2 with equations (1) and (3):

From equation (3): $Xd = 0.1852 \times (45 / 100) = 0.08334$

From equation (1): $\text{NET MASS} = \text{GROSS} \times (1 - 0.08334) = 91.25\ \text{dt}$
(9.125 ton instead 9.167 ton in example of section 3.2)

Another way to interpret the meaning of the Meter Factor (MF) is to consider as the ration between the basic "K" factor of the meter and the actual "Net K" factor obtained by the proving. Equation (15) exemplifies this meaning.

$$\text{MF} = \frac{\text{nominal K factor}}{\text{Net K factor}} \qquad (15)$$

It should be noted that equations (15) and (7) have exactly the same meaning and calculation of the Meter Factor made by either of them leads to the same value of MF.

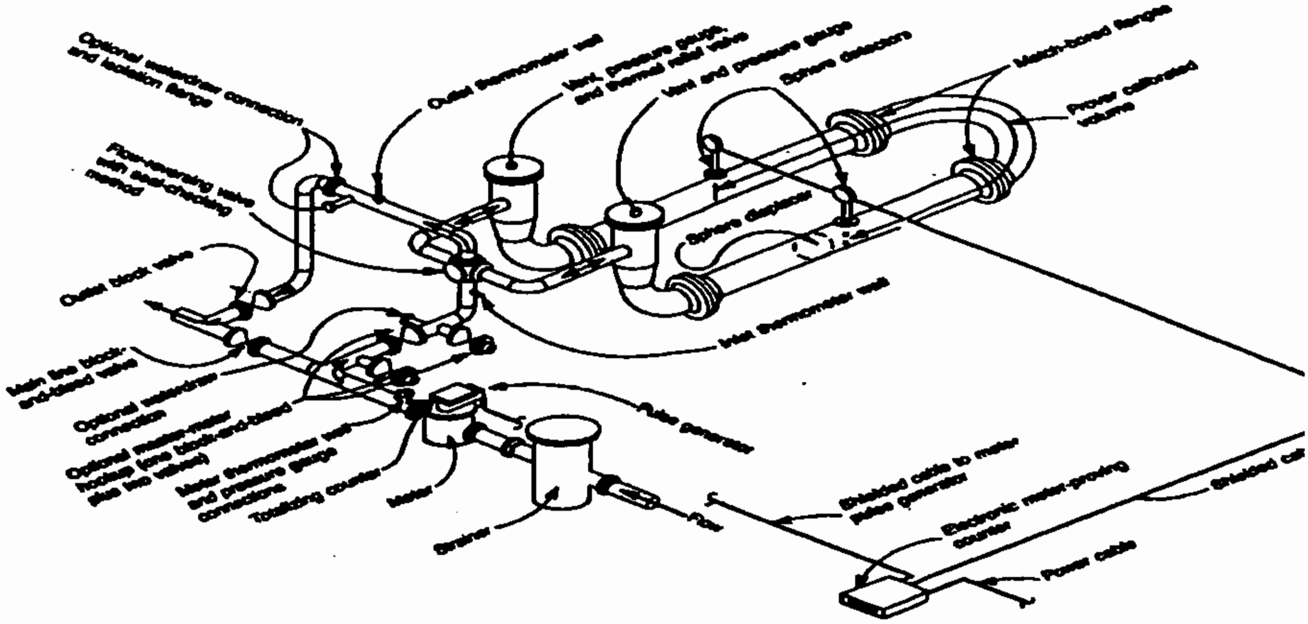
4 - CONVENTIONAL AND COMPACT PROVERS

All tubular provers for in-line connection, the calibrated volume of which permits counting of at least 10,000 pulses originating from the meter to be verified, are called "conventional provers" by the API[4]. The reason for the 10,000 pulses is so that the counting pulses error to obtain the Meter Factor must be at least ± 0.02% or better, in accordance with API.

A proving run with at least 10,000 integer pulses counted, if the first or the last one haven't been correctly detected, the error will be around: $(\pm 2) \div (10{,}000) = 0.02\%$.

Such provers are called conventional because of they had been the first in-line provers for piping systems to be standardized by the American institute .

Figure 3 extracted from API MPMS Chapter 4[4], provides an illustrative drawing of a conventional and bi-directional prover.



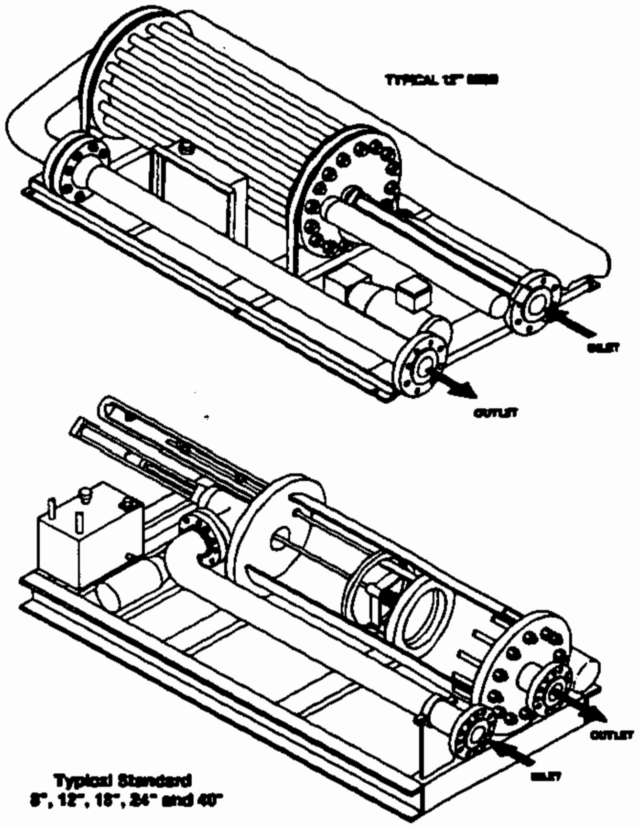
CONVENTIONAL PROVER

Figure 3

The provers called "compact" by the API[5] are those for which the calibrated volume does not permit the 10,000 pulses to be accumulated. In this type of prover, the calibrated volume is about ten times less than in the conventional. The precision of the verification and the error margin are assured by a process of counting and interpolation of pulses, called double chronometry, that is standardized by the API MPMS[6,9].

With the interpolation of pulses, the equation (7) of Section 3.4 ends up with the term "number of pulses" in the denominator, interpolated to approximately three places after the decimal point, whereas for conventional provers, in which whole pulses are counted directly, this term is an integer number.

Figure 7 shows Brooks compact prover similar to the one purchased by Paulínia Refinery.



BROOKS COMPACT PROVER

Figure 4

5 - PURCHASE AND INSTALLATION OF THE NEW PROVER

Besides the LPG Measurement Station, the Paulínia Refinery (REPLAN) has two more measurement stations, one for kerosene, gasoline, diesel and petrochemical naphtha, and another for fuel oil. For each group of these products, the exist a dedicated prover. These tree provers that have handled the REPLAN Measurement Stations for twenty years have the following tags:

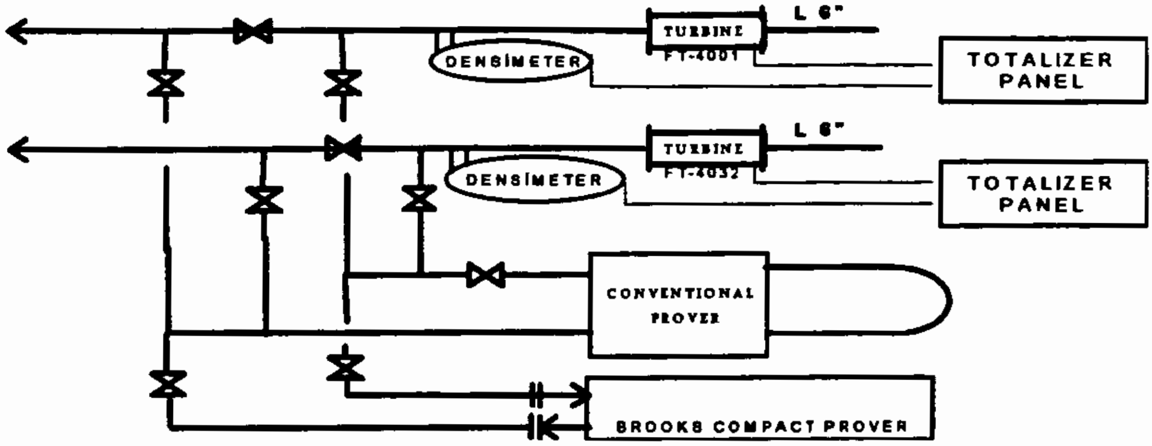
Prover 1 - handles the clear products (execpted LPG).
Prover 2 - handles the fuel oil.
Prover 3 - handles the LPG.
All these are of the conventional type.

In the end of 1993, the refinery purchased a new prover with the purpose of replacing the Prover 3 in its Liquid Petroleum Gas Measurement Station.

The reasons for the replacement were the constant problems presented in the hydraulic system of Prover 3, with consequent low operating availability and the aggravation of its being an old prover, already out of production. The new prover received the tag of Prover 4.

For the purchase of the new prover, a public bidding was held, in which tree companies with technical acceptance proposals participated. The successful bidder, by the criterion of lowest price, was the American company, Brooks, represented in Brazil by Hirsa, with the proposal of a compact prover.

Figure 5 shows the interconnection of the new prover in the LPG Measurement Station:



INTERCONNECTIONS WITH THE NEW PROVER

Figure 5

The prover furnished by Brooks is a model with volume of 120 liters, diameter of 18 inches, and operating range of 8 to 800 m^3/h. This was the fourth compact prover to be purchased in Brazil.

Among the first three ones, only COPENE's prover had a good operation run. The other two (one bought by PETROBRÁS and another bought by a multinational oil company), hadn't had good operation results. They had many different problems, they didn't obtain the prescribed repeatability, they obtained many different Meter Factors for the same flowmeter without a good reason, and other kind of problems. Error in the system's assembly or in the process conditions may be the sources of these problem.

Although COPENE have had good operation performance, they never publish any report from which Brazilians engineers can take good lecture reference in that country conditions. For Brazilians, compact prover for chemical and oil companies, was a failure experience, they almost guilt the compact prover technology, before REPLAN's tests.

6 - COMPARATIVE TESTS

In September 1994 a no-load startup was made on REPLAN's Prover 4 and the first experimental runs were made. At that time, some problems originating from the power supply installation were detected and corrected. Once the installation problems were corrected, the prover operated normally when the evaluation testing began in earnest.

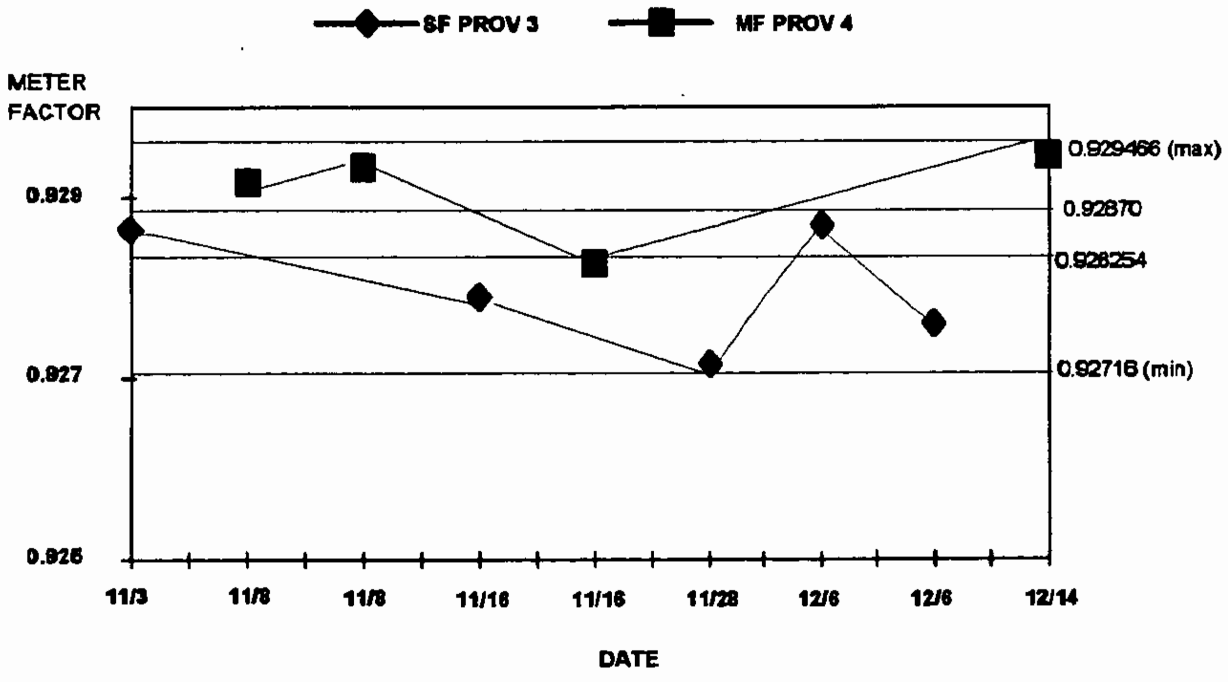
To verify the performance of Prover 4 in the field, operating during a process of transfer of custody transfer, the LPG turbine FT-4001, shown in Measurements Stations Figures 1 and 5, was selected as reference for comparisons to be made between the Meter Factors obtained for this turbine with Prover 3 (conventional), called FS in Brazil, and the Meter Factor obtained with Prover 4 (compact) called MF, to distinguish them in the graphs and tables below, containing the presentation of the comparative results.

The tests were performed taking care to verify and use, for the calculations of FS and MF, the same temperature and pressure references of calibration of the provers and the correction factors: CPLp, CTLp, CPSp, CTSp, CTLm, and CPLm from API MPMS 12.2[7]. Also observed for all runs was repeatability better than 0.05% like API recommends[5,10].

The first comparative sampling of the results of verification runs was obtained during the period between November 8, 1994 and December 15, 1994, in which four verifications of the FT-4001 Meter Factor, with the compact prover were made, and several runs with the conventional prover.

Among the verifications made with Prover 3 (conventional), the four that took place on dates closest to the runs made with the compact prover were taken so that the factors obtained between the two provers could be compared for the same turbine.

The results have been plotted on the graph in Figure 6.



COMPARISON OF FACTORS OBTAINED: PROVER 3 VS. PROVER 4

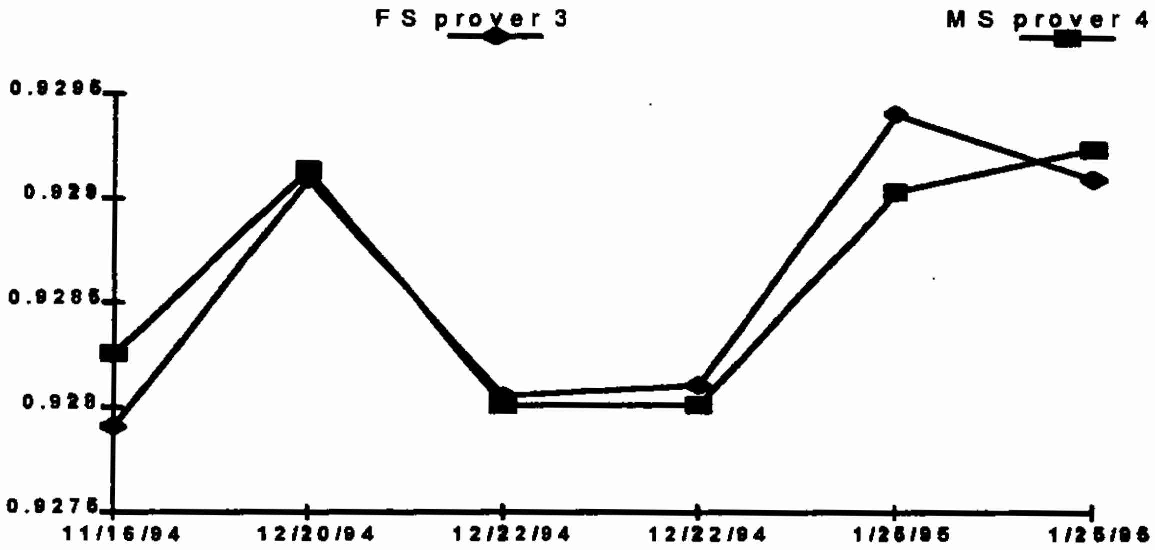
Figure 6

The sampled data are found in Table I.

Table I

DATE	FS PROVER 3	MF PROVER 4	flow rate m^3/h	temp. °C	pressure KPa
11/03/94	0.928645		154	30	0950
11/08/94		0.929153	233	29	1250
11/08/94		0.929342	253	30	1200
11/16/94	0.92791		345	31	1550
11/16/94		0.928254	272	34	1350
11/28/94	0.92716		254	24	1150
12/06/94	0.92870		309	32	1550
12/06/94	0.92760		318	31	1550
12/14/94		0.929466	270	37	1300

It is normal that Meter Factors present such variations through changes in the pumping conditions of the same product: flow rate, pressure, and temperature. Taking this fact into account, a second phase of testing was carried out, seeking to compare the factors obtained by the two provers with runs made for the same pumping. The results have been plotted on the graph in Figure 7.



COMPARISON MADE FOR THE SAME PUMPING CONDITIONS

Figure 7

The data from the runs represented in the graph of Figure 7 may be better visualized in Table II:

TABLE II

DATE	FS prover 3	MF prover 4	differences
11/16/94	0.92791	0.928254	-0.000344
12/20/94	0.929093	0.929135	-0.000042
12/22/94	0.92806	0.928014	0.000146
12/22/94	0.92811	0.928013	0.000097
01/25/95	0.929406	0.929033	0.000373
01/25/95	0.929095	0.929237	-0.000142

7 - ANALYSIS OF RESULTS

7.1 - Comments of first phase tests results

Analyzing the first phase of testing, the results of which are in Table I, taking as reference the minimum value of the factors obtained for each prover:

The variations in MF by Prover 4 were:
(0.929466 - 0.928254) / (0.928254) = 0.131%

The variations in FS by Prover 3 were:
(0.92870 - 0.92716) / (0.92716) = 0.166%

The average of the factors obtained by Prover 4:
MFaverage = 0.92905375

The average of the factors obtained by Prover 3:
FS average = 0.928003

Difference in averages of the two provers:
0.00105075 or 0.113227%

According to API MPMS 12.2[7], a good criterion for monitoring and control of the Meter Factor by means of a "flow chart" is to permit a maximum tolerance in variation on the order of 0.25%.

From the data of Table I and the graph of Figure 6, it is noted that this criterion has been met by both provers.

7.2 - Comments of the second phase of tests results

From the analysis of the second phase of testing, when the comparisons were made under similar pumping conditions and the results of which are found in Table II and in the graph of Figure 7, the following comments may be made:

In Table II, it is observed that the major difference between the factors obtained by the two provers in the same pumping took place in a run made on January 25, 1995, showed a variation between FS and MF of 0.0373%. This order of variation is possible of occurring even with the same prover, as may be observed with Prover 3, when the difference for the two runs on the 25th day (same pumping) was 0.0311%.

It is also noted that for the runs of the same pumping, the differences observed between the two provers are less than 0.05%. According to API MPMS 4.2 Appendix B[5], this is the range of repeatability that a conventional prover must achieve with the launchings of the sphere for pulse counting, or a compact prover with groups of piston launchings, for a proving run. The data show that the variation in factors obtained by the two provers, in the refinery facilities during the testing period, was within the range of variation allowed by the API[5] for a single prover, indicating that the performance of both was practically equal. The difference in averages was consider to be zero.

7.3 - Comments of the comparative results between the two phases tests

Comparative analysis of the two testing phases permits the following comments:

The results of the graph in Figure 7, when compared with those of Figure 6, show a greater approximation between the values obtained by the two provers. It confirms that the Meter Factor is affected significantly by variations in the pumping conditions like the flow rate, the temperature and pressure.

In the period covered by the graph in Figure 7, Prover 3 exhibited a variation of 0.161% while Prover 4 exhibited 0.132%. These figures are quite close to those observed in the period covered by the graph in Figure 6, when Prover 3 exhibited a variation of 0.166% and Prover 4 exhibited 0.131%. Its confirmed in these tests analysis that the compact prover exhibited variations less than the conventional, on the order of 0.13% versus 0.16% in the monitoring of the factor of FT-4001.

According to the catalog of the manufacturer of the turbine, variations of tip to 0.20% in its factor are normal. These above figures indicate that turbine FT-4001 is in perfect condition and that the factors obtained by both provers had a normal variation; below the 0.20% advised by the manufacturer.

8 - CONCLUSIONS

To perform the tests with both provers during the same pumping condition was a difficult task due to the maneuvers and operations required to make the alignments correctly and safely. Such procedures caused the time expended on the testing to be extensive, besides requiring the collaboration of the operators, who also had to be attentive to the other occurrences of the various systems that are operated from the same measurement station panel. Although collected data may appear to be few, they results presented here were considered sufficient to reach the following conclusions:

The factors obtained by both provers are in conformity with the API recommendations indicating that the Paulínia Refinery LPG Measurement Station is in good operating condition.

The performance of the compact prover during the testing carried out was quite good, having slightly surpassed the conventional prover in terms of repeatability and of less spread in the calculated factor: 0.13% vs. 0.16%.

The acquisition of pressure and temperature data directly from transmitter available in the new prover avoids probable readout errors and loss of time with the manual collection of information made for the old provers.

Calculation of the meter factor, with the compact prover, is done by the same computer that operates the equipment, whereas in the conventional prover it is done with calculators or on a PC computer with data entry in the form of keyboard entry, thus being more subject to errors and more delayed.

The new prover, besides being more rugged, supporting several simultaneous runs without problems, is faster, consuming for performing a run about 1/10 of the time spent by the conventional.

Despite its being a new equipment for operators, with more electronic components, there was no difficulty in assimilation by the operators and maintenance people in the training of the compact prover.

From the results of the testing, Prover 4 was considered suitable for entering into the normal operating regime, being available and reliable for correcting the factors of the Measurement Station turbines.

The Paulínia Refinery compact prover tests, was published in Brazil's meetings and technical magazines. After these PETROBRÁS/REPLAN tests, more than 10 compact provers have being purchased in the last two years. These evaluating tests, introduced the compact prover and double chronometry technologies in Brazil.

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LECTURER VITA

Name:	Virgílio Antônio Rezende
Education:	Mechanical Engineer Federal University of Uberlândia - Brazil
Professional experience:	10 years working at petroleum company (PETROBRÁS), as project coordinator engineer of process plants improvements and Revamps. Specialist in mechanical structure, pressure vessels and stress analyses. In the last three years, has work as instrumentation engineer specially in custody transfer measurement stations. Has several piping and vessels stress analyzes and flowmeters measurements papers published in Brazil.