Development of a Primary Standard Flow of liquids in Pipelines Closed

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SUMMARY

In Brazil, especially in Minas Gerais there is a lack of calibration of flow measurement systems, while other mechanical areas have a reasonable number of laboratories accredited to their respective measurands. To encourage change this scenario, this work presents the construction of a primary standard flow (PSF) of liquids in closed pipes.

According to the NBR ISO 4185 and other related supplementary rules, it defined the development of the standard reservoir fed by constant level satisfying the various requirements for accurate measurements of the standard in favor of the uncertainty and get 0.1% .

The primary standard of measurement mentioned above is in the final stages of construction. Then it will be subjected to reviews of metrological performance. It is expected to start calibrations within the various scientific papers developed by the Center for Hydraulic Research UFMG and the scientific community of Minas Gerais.

1. INTRODUCTION

The increasing depletion of natural resources (NR) in the entire world has been a concern to all nations. In Brazil, the country owns numerous NR, holds the greatest water potential of the planet, with the prevision in 2015 half the population will not have access to fresh water.

In this context, the constant advancement and technological improvement of measurement systems that were created centuries ago, helps to better use of water resources, as long as these are properly calibrated to perform an accurate measurement.

Calibration is an experimental process in which are correlated under the same experimental conditions, the measures of the measurement systems and standards in favor of fit and / or check out the SM to provide this standardized measures within the tolerances specified by the reference agencies.

Currently, the certified laboratories for calibration of volumetric flow meters and mass are concentrated in the southeastern region of Brazil, more specifically in Sao Paulo and Rio de Janeiro. The example of this is Table 1 Laboratorios RBC - Accredited INMETRO, endorsing the fact.

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[*] **Erro! Indicador não definido.**

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Table 1 Laboratories RBC - Certified Inmetro

Service: Flowmeter Water Wt (Labs Brazilian Calibration Network) Certified by INMETRO			
Range	**Uncertainty**	**Laboratory**	**City / State**
(>0,8 até 800) m^3/h	0,03%	Fluid Metrology Center	São Paulo-SP
(0,5 m^3/h até 25 m^3/h)	0,25%	ELUS Instrumentation	São Paulo-SP
(36 m^3/h até 300 m^3/h)	*0,3%	LC CONSTROLS METROLOGY	Belford Roxo-RJ
(360 m^3/h até 700 m^3/h)	0,11%	LABORATORY EMERSON	Sorocaba-SP
(0,03 m^3/h até 580 m^3/h)	0,38%	LABORATORY FLOW AND VOLUME AND MASS SPECIFIC	Santana do Parnaíba-SP
(1 m^3/h até 110 m^3/h)	0,20%	Golf Measurements	Nilópolis-RJ
(0,5 m^3/h até 2000 m^3/h)	0,50%	LABORATORY FLOW LEVEL - CONAULT EMBÚ	Embú-SP

With poor access in some regions of Brazil to calibration systems. Set up the planning and implementation of the Primary Standard Flow, which throughout development showed up, more and more assertive position with the sustainability needs of society today. Subsequently become supportive of scientific metrology, industrial metrology and possibly legal metrology.

The method selected for the device construction was the method of flow measurement in closed ducts, also known as gravimetric method, this is the measurement process of the mass of a volume of liquid collected in a weigh tank in a interval of time known. This makes the calibration of the device under test by the indirect method, which needs to have the error at least 10 times less than the system to be calibrated.

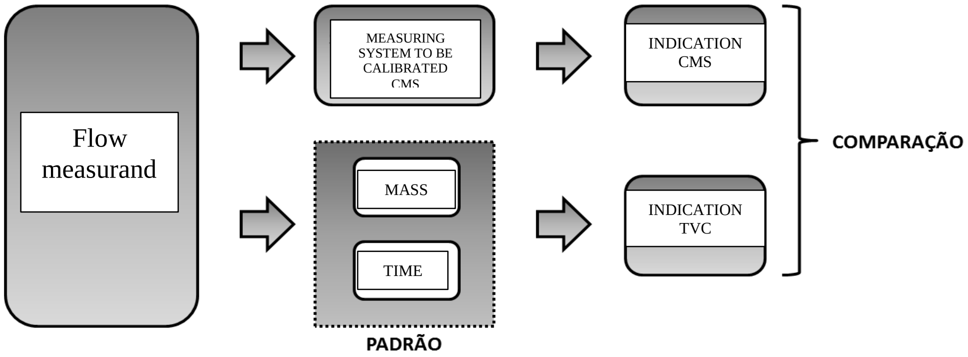


Figure 1 Indirect Calibration Method
Source: Gonçalves, 2008

The standard reference for design and auxiliary standards ISO 4006, ISO 5168 and OIML n ° 1, 2, 3, 20, 28 and 33, provided the intrinsic conditions and contour necessary for the measuring equipment conditions, procedure, the method of flow calculation and uncertainties associated with the measurement.

So that, static weighing was selected for construction of the device first. This principle is based:

1) Determine the initial mass of any residual liquid tank;

2) Diverts the flow into the tank weighing the divertor operation until it contains a sufficient amount of fluid to meet the desired accuracy. Simultaneously, the divertor triggers a stopwatch to measure the time of filling;

3) Determine the final mass of the tank plus the liquid collected. Is given in eq. (1):

$$q_m = \frac{m}{t} = \frac{m_l - m_0}{t} \times \frac{1 - \frac{\rho_a}{\rho_p}}{1 - \frac{\rho_a}{\rho}} \tag{1}$$

$q_m = \text{mass flow}$
$m = \text{mass variation}$
$t = time$
$m_l = \text{mass of liquid}$
$m_0 = \text{tank mass} + \text{specific mass of liquid}$
$\rho_p = \text{specific mass of liquid}$
$\rho_a = \text{specific mass of air}$
$\rho = \text{specific mass of standard}$

The eq. (1) can be approximated by eq. (2) and equation (3) due to the relative magnitudes of quantities.

$$q_m = \frac{m}{t} = \frac{m_l - m_0}{t} \times (1 + \varepsilon) \tag{2}$$

$$\varepsilon = \rho_a \left(\frac{1}{\rho} - \frac{1}{\rho_p} \right) \tag{3}$$

$\varepsilon =$ correction due to thrust

2. METHODOLOGY

The process of construction of the primary standard flow in closed ducts followed the dictates of ABNT NBR 4185 1SO and other supplementary standards, on which is required the fulfillment of several requirements in order to obtain the uncertainty of 0.1%.

The schematic diagram of selected typical installation suggests that the standard is the model:

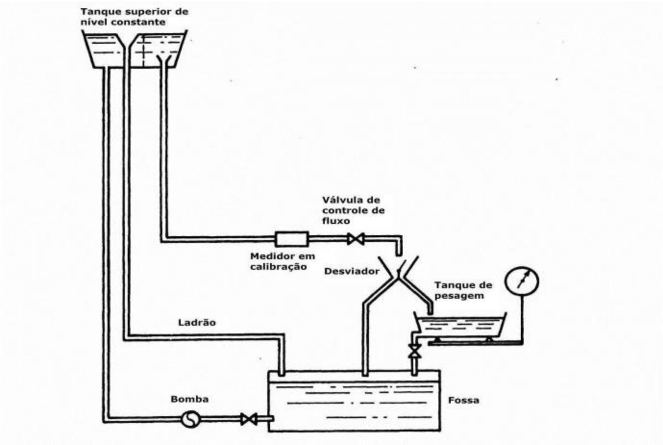


Figure 2 Diagram of a calibration installation for weighing (static method, feeding reservoir constant level)

Through the numerous instructions collected constituted the various projects and planning required for the implementation of PSF, which are: **Construction Planning of PSF, Project Structural Mechanic (Structures Auxiliary), Pneumatic and Eletrical design and Improvement of the Treatment Unit Signal – TUS.**

2.1. Construction Planning of PSF:

Planning for construction of Primary Standard Flow was effected through planning and strategy maps that optimize the process of implementation and show the development of the project.An example of this is creating spreadsheets in Excel software and also in Bitrix 24, as soon as these allow modifications and is easy to use.

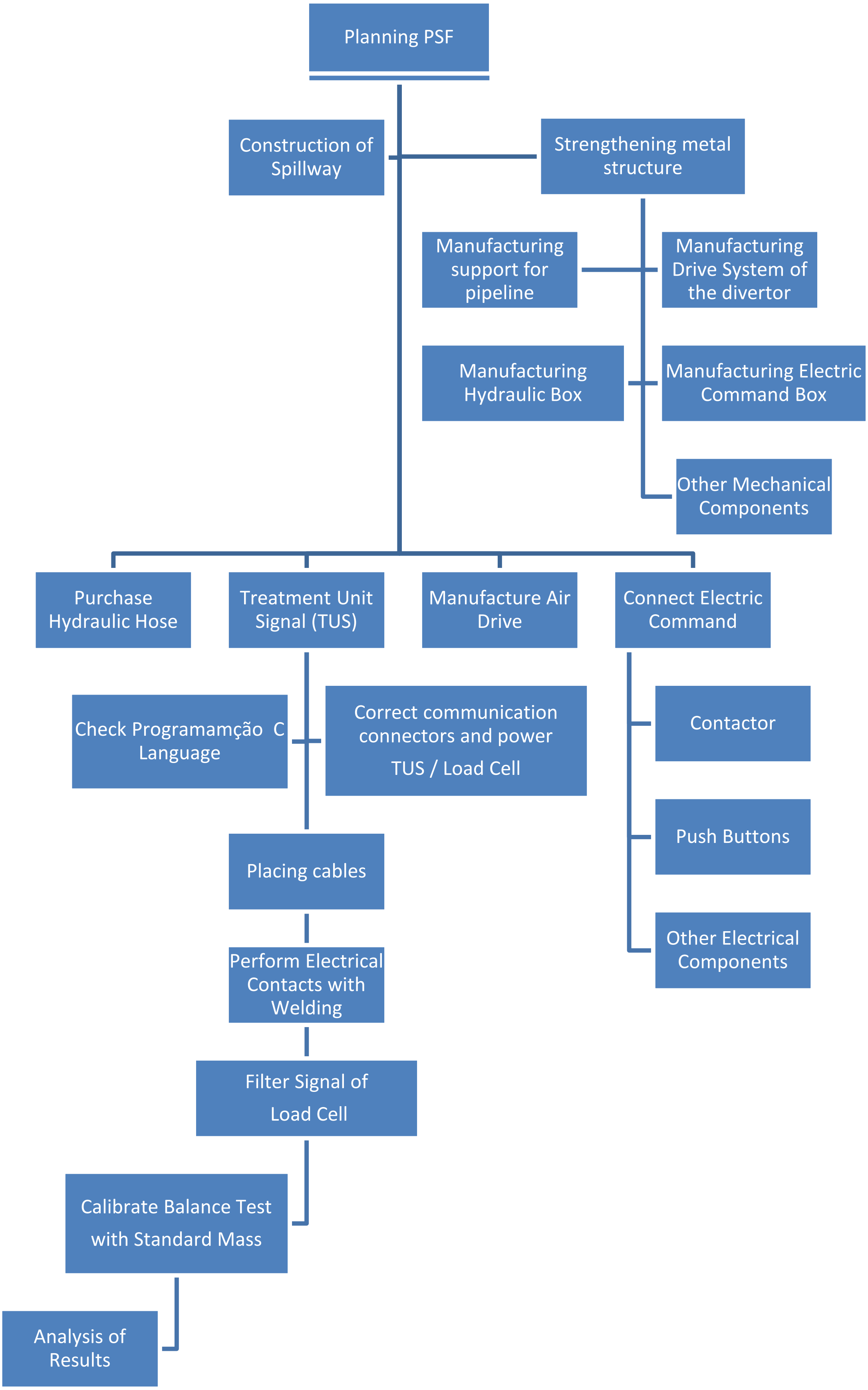


Figure 3 Flow Diagrama of PSF Development

2.2. Project Structural Mechanic (Structures Auxiliary):

The Development of auxiliary structures was in AUTOCAD 2007, so that the shear stress, tensile, bending and oxidation results in high quality and precision equipment.

Table 2 Table of Engineered Mechanical Equipment

Equipment
1. Divertor;
2. Structure;
3. Wall bracket (1 ° fixation the cylinder);
4. Stop cylinder;
5. Eyelet cylinder;
6. Wall bracket (2 ° fixation the cylinder);
7. Bracket nozzle;
8. Fixing flanges of the divertor;
9. Bushing;
10. Pneumatic control;
11. Electrical control;
12. Trigger lever divertor;
13. Coupling drive of the divertor;
14. Support pipe of Magnetic Flow Meter;
15. Tubing;
16. Load Cell.

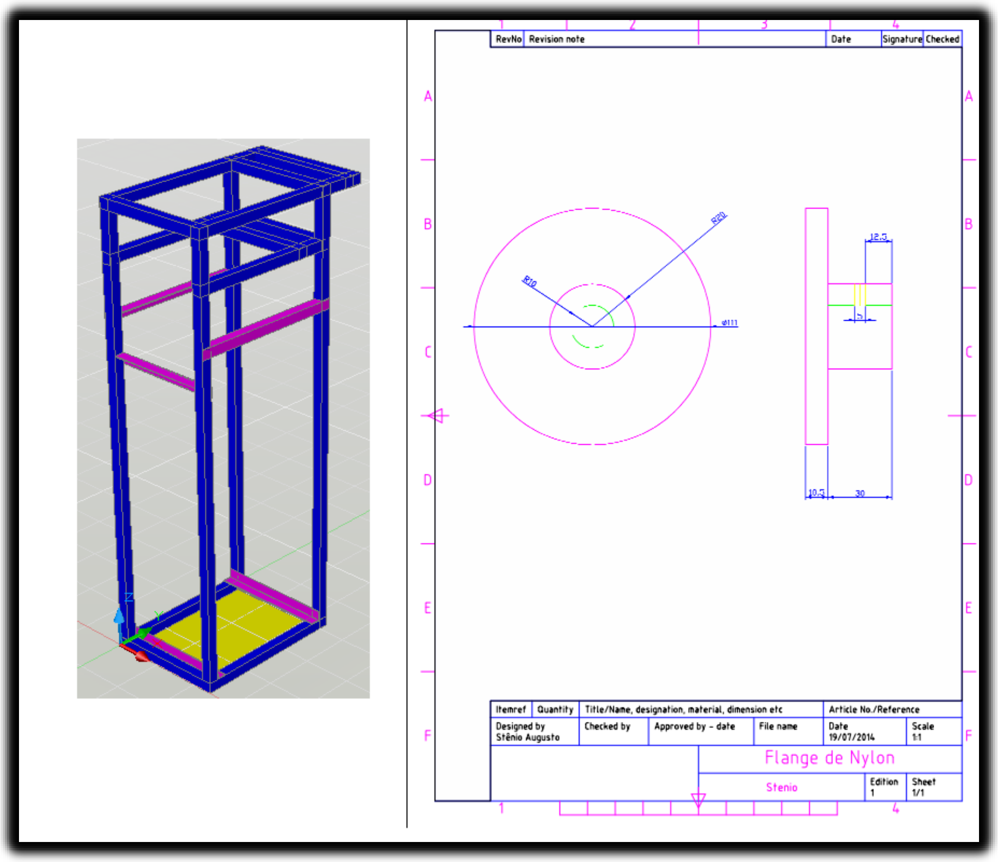


Figure 4 Mechanical Projects 3D Structure (left) and Proojeto Flange Nylon 2D (right)

Table 3 Specifications Load Cell Projected

SPECIFICATION LOAD CELL	
Description	Description
Nominal load	**Nominal load**
Maximum Load	**Maximum Load**
Maximum deformation	**Maximum deformation**
Gain Strain Gauge	**Gain Strain Gauge**
Sensitivity of Wheatstone Bridge	**Sensitivity of Wheatstone Bridge**
Excitement of the Wheatstone bridge	**Excitement of the Wheatstone bridge**
Range Output Signal	**Range Output Signal**
Coefficient Conversion	**Coefficient Conversion**

2.3. Pneumatic and Eletrical design:

The Electrical control of PSF is necessary for semi-automatic tilting system divertor. Below it is the list of major equipment:

Table 4 Table of Electrical Equipment (purchased)

Equipment
1. 1 Main switch;
2. 1 Green push button (NO);
3. 1 Red command button (NF);
4. 1 contactor 220V;
5. Source Rectifier 220/24 V 500 mA;
6. Red wire 1 m x 2,5 mm²;
7. Blue wire 1 m x 2,5 mm²;
8. Black wire 1 m x 2,5 mm²;
9. Fixation Command - flat bar 300 mm x 1/4pol;

The pneumatic drive project of the divertor was developed in FluidSIM-P (Version-Demo) FESTO software, in which it was tested and verified the functioning and efficiency of the designed circuit.

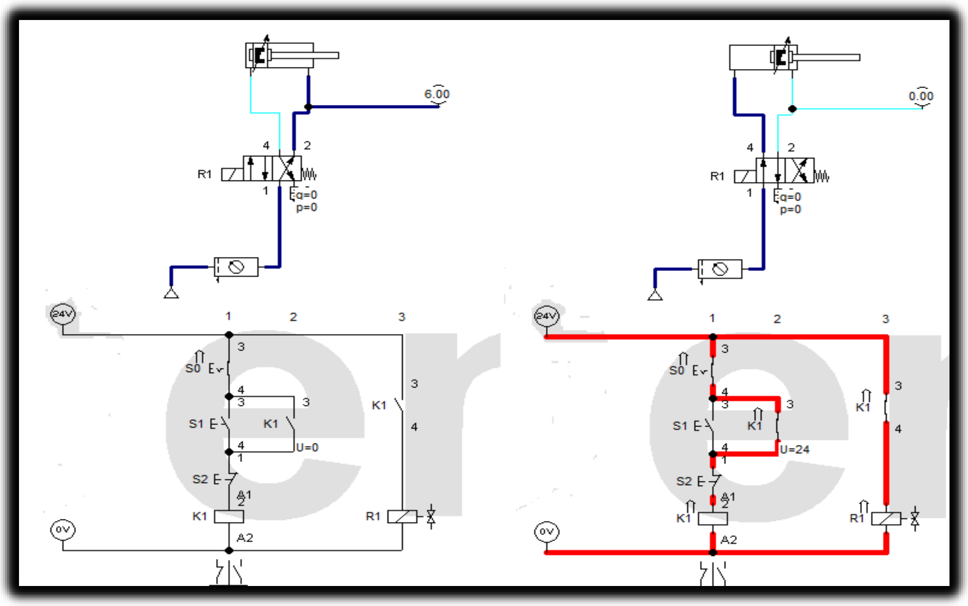


Figure 5 Project Pneumatic / Electrical

2.4. Improvement of the Treatment Unit Signal – TUS.

Refinements were performed together signal processing, the example is the increased tension in the power supply of 5 V to 12 volts, with subsequent voltage reduction, in favor of minimizing fluctuations in the system.

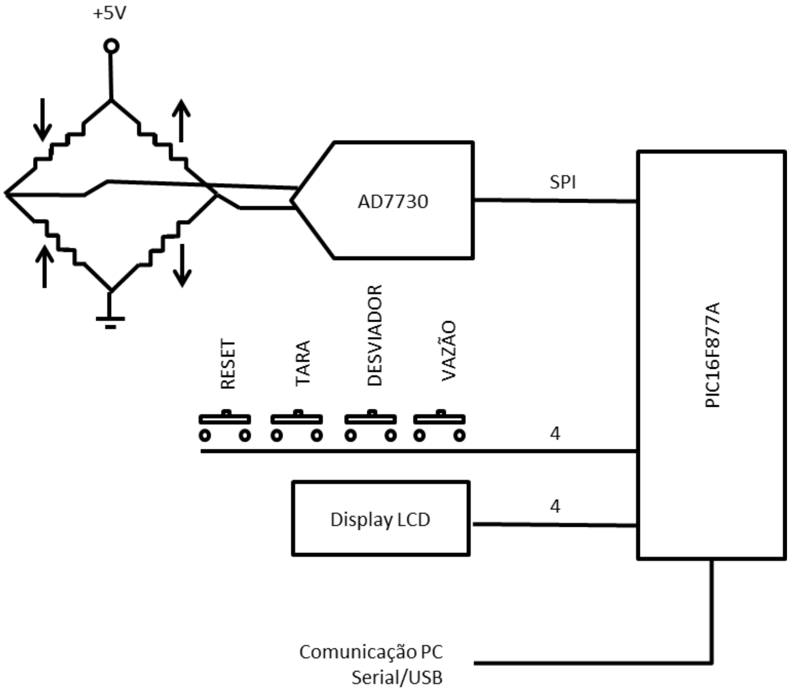


Figure 6 The block Diagram

3. CALIBRATION

Calibration was performed for the range of 0 to 44.100 kg. The calibration method adopted follows below:

For each block of standard mass was performed the following sequence:

- ✓ Reset;
- ✓ Tare the balance;
- ✓ Measuring the value of the standard mass or masses sequence;
- ✓ Collect the time of the experiment;
- ✓ Conduct the average of values collected.

The realization of this procedure provides independent measures. Thus it is possible to calculate the measurement result to a measurand invariant according to eq. (4) below:

$$RM = I + C \pm {}^{\mathrm{Re}}\!\big/\!_{\sqrt{n}} \qquad (4)$$

$RM =$ measuring result

$I =$ average indications of "n" repeated measurements

$C =$ correction of the measurement system

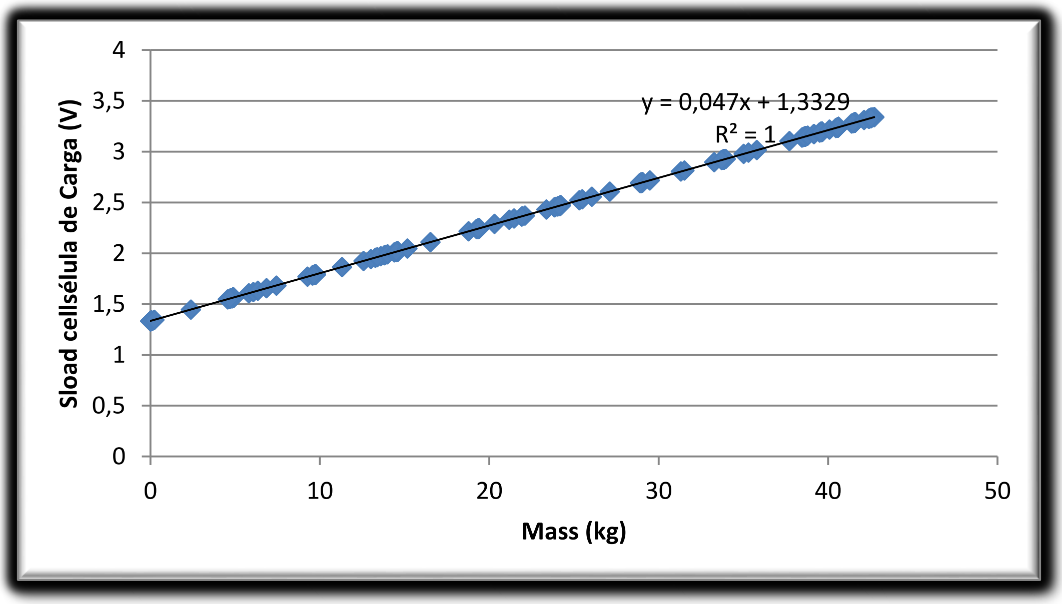
$\mathrm{Re} =$ repeatability of the measurement system

$n =$ number of measurements

4. RESULTS AND DISCUSSION

In the evaluation test of the load cell was tested standard weights 0 to 44.100 kg. The signal from the load cell was the first experiment and so that the data obtained are:

Graaphic 1 Signal Graphic of Load Cell with Mass Variation (0 to 44.100 kg)

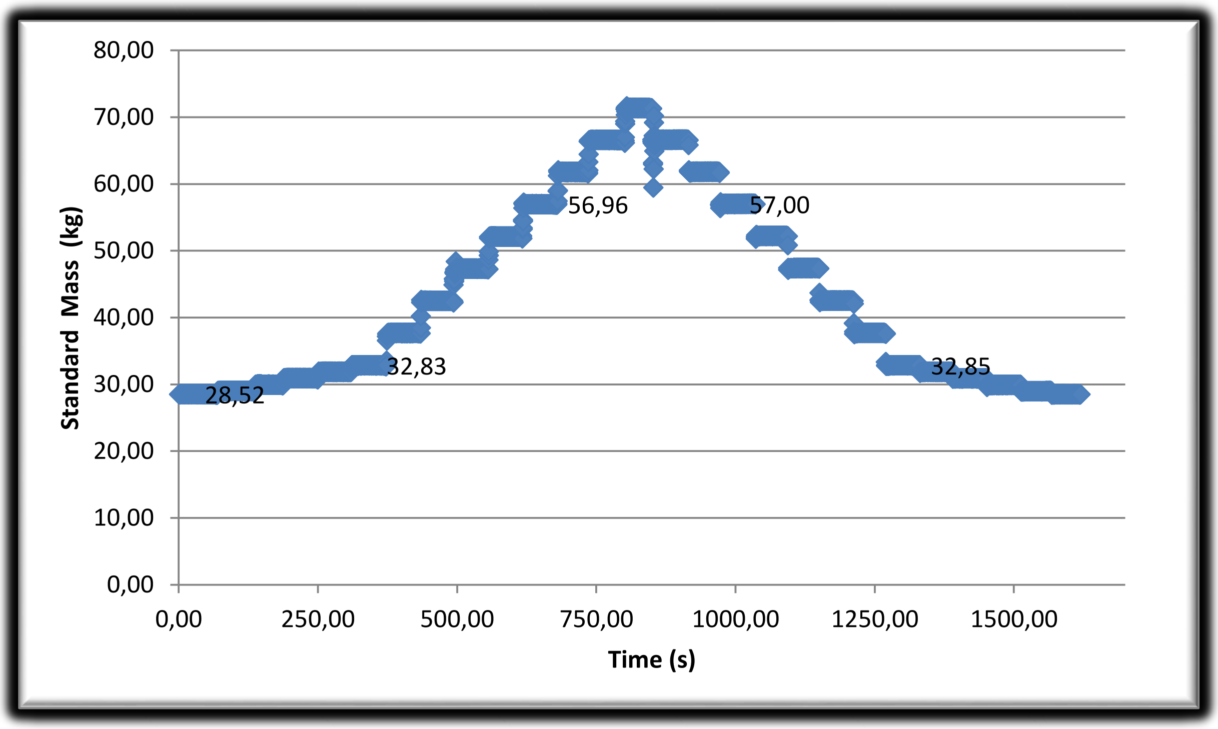


Initially there is a signal different of zero in the load cell due to the fastening components, and the central axis positioning of the tank cables and eletrical supply to the Wheatstone bridge. The reference value 0.047mV represents the coefficient for converting kg to mV, which was constructed and inserted into the C language program TUS, ie in every kg load cell signal to be incremented 0.047mV.

The coefficient of linear conversion was implemented in the Treatment Unit Signal thus realizing the overall conversion (without considering systematic effects) mV to kg.

The TUS developed was tested on the load cell idealized by the Centre for Water Resources and Hydraulic Research at UFMG, and in order to calibrate and operate in TUS / Load Cell blocks set standard weights were used. Data were collected through the Windows Hyperterminal program and saved in Excel. Data were processed in Excel. The program has a range of tools that were used to analyze the data collected.

Gaphic 2 Sequence of Measurement (0 to 44,100 and 44,100 to 0) kg

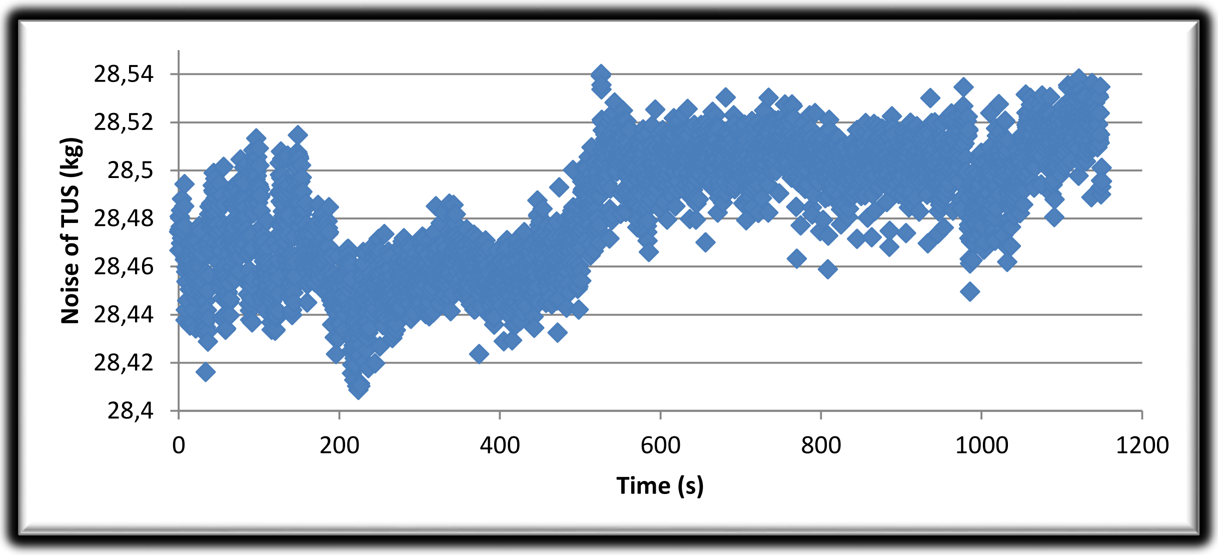


In the first 60s was incremented a mass of 100g, then notices a small change in the electrical signal received.

From 120s was incremented a mass of 1 kg in 60s to 60s approximately. 300s after the balance would have been added to 4.100 kg. From 300s masses of 5kg were added till 44.100 kg. After 850s the masses were removed one at a time with each interval of 60s.

In Graphic 3, without standard mass, presents a time 1200s reading without the variation of standard mass in a balance, so that there was an increase in the variation of signal after 500s. This was due to heating of electronic components and effects of external interference equipment.

Graphic 3 Without Standard Mass

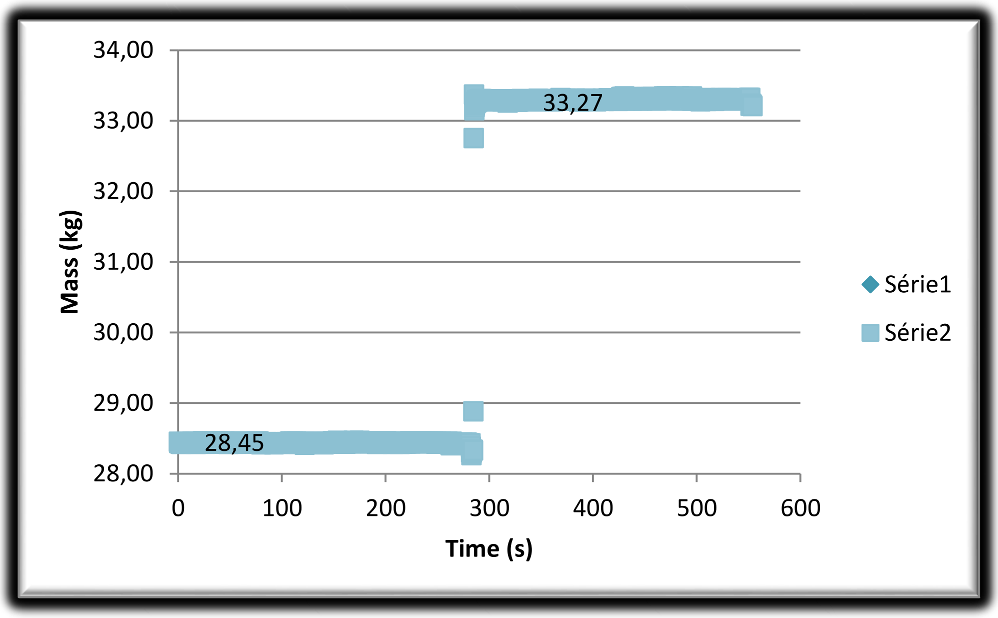


The analysis of section 3 of the graphic used to analyze the level of measurement noise. The difference is 0.12901 kg to a maximum point (28.539296) and minimum (28.410286).

The average deviation calculated equals 0.022804713 kg and the standard deviation is equal to 0.025772153 kg

Graphic 4, 5kg variation, presents a quick response from a variation of the standard mass and a low oscillation incremented value.

Graphic 4 Variation of 5kg



Due to find out a calibration points PSF and their results. It was built up several tables for points similar calibration point calibration 5kg, the following:

Table 5 Reference Data of Calibration Point of 5kg

Mensurement	Indication	Total Error	Random Error	Conventional Real Value
1	4,81	-0,19	0,00	5,00
2	4,82	-0,18	0,01	5,00
3	4,83	-0,17	0,01	5,00
4	4,80	-0,20	-0,01	5,00
5	4,80	-0,20	-0,01	5,00

Standard Deviation	Coeficient "t" Student	Repeatability 95%	square root of n
0,01	2,776	0,03	2,236067977

Average Indications	Tendency	Measurement Results
4,81	-0,19	5,00 ± 0,01

The treatment of other measuring points is given the same way as the calibration point and 5kg were synthesized as follows:

Table 6 Result of 10 Calibrations Points

Point	Conventional Real Value [kg]	Average Indications [Kg]	Tendency [kg]	Repeatability 95% [kg]
1	0,00	-0,02	-0,02	0,05
2	5,00	4,81	-0,19	0,03
3	10,00	9,63	-0,37	0,07
4	15,00	14,45	0,55	0,03
5	20,00	19,21	0,79	0,07
6	25,00	24,08	-0,92	0,11
7	30,00	28,78	-1,22	0,05
8	35,00	33,51	-1,49	0,19
9	40,00	38,20	-1,80	0,10
10	44,10	42,52	-1,58	0,03

It is observed that when analyzing the points obtained are high tendency values for the measurement points 7, 8, 9 and 10. Can be inferred that these values are probably due to the fact of using a linear curve fit ($y = 0{,}047 mV \cdot x + b$),obtained in the development of TUS.

The measurement uncertainty for the calibration points is between 30 kg and 190 kg. These values are compatible with the measuring range of the measurement system developed, but should be reduced by decreasing noise TUS.

Initially, it is established that the PSF can only measure mass above 190 kg in favor of obtaining the less uncertainty than 0.1%. Because the device is in the process of adjustments and enhancements.

5. CONCLUSÃO

The construction of the Primary Standard Flow - PSF showed satisfactory results regarding the operation of the equipment directing the implementation of improvements for better accuracy of the device. Consonant, obtaining the uncertainty less than 0.1%.

The large contribution of this work is a complete measuring system was developed from technologies ranging from construction techniques of mechanical elements (load cell) and the software. However, some devices were not obtained and developed without harming the device.

Thus, it is believed that the final suitability of the PSF, according to the standards of ISO 4185 and related standards, readily will solve the needs of CPH - UFMG and the scientific community of Minas Gerais, in addition to the significant gain in terms of know -how.

6. REFERÊNCIAS

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