AUTOMATION IN THE LABORATORIES OF DIMEL

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Summary: This work shows the automation of a calibration process using the program LabView®, looking for the improvement of the current procedure of calibration of the Onneken pressure standard.
Using the program helps to increase the productivity and efficiency of the laboratories of DIMEL, where some steps of the current process have been reduced or eliminated.

Key Words: Calibration, Sphygmomanometer, Legal Metrology.

1. INTRODUCTION

With the growing demand for high quality services and tests of and at reduced costs, the laboratories have reached a very important point of change: how to find solutions that can assure the costs reduction and the process reliability.

Actually the organizations are just living this context and they surely affirm that one of the paths that might help to significantly reduce costs and the accuracy of measurement of a instrument is the automation of the processes, by removing mistakes, wastes, reducing time of the calibration, issuing automatically reports or certificates and minimizing costs in general.

This work has as objective to discuss the automation of the calibration process of the Onneken pressure standard: possible sources of errors and uncertainties, automation levels among others.

2. SYMBOLOGY

I_p = uncertainty of Hüber standard;
ΔH_{ob} = hysteresis of Onneken standard;
ΔL_{ob} = resolution of Onneken standard;
R_{ob} = reproducibility of Onneken standard;
ΔT_{ob} = temperature on Onneken standard;
S_{ob} = sensibility of Onneken standard;
E_{ob} = error from the Onneken standard;
$\sigma^2_{Seq1c}, \sigma^2_{Seq1d}$: variance of the 1st sequence in the increasing pressure (c) and decreasing (d); and
$\sigma^2_{Seq2c}, \sigma^2_{Seq2d}$: variance of the 2nd sequence in the increasing pressure (c) and decreasing (d).

3. METHODOLOGY

3.1. Current procedure of calibration [11]

The reference standard can be a quantity with a well-known value or a measurement system with an accuracy much better than that one of the measurement system to be calibrated.

The current procedure is based on the indirect method, whose Hüber reference standard attends to the requirements of maximum permissible error and the measurement uncertainty. Figure 1 shows a calibration example represented by the indirect method.

The value of the pressure to be applied to the measurement system in each calibration point is adjusted in Onneken standard and read in the Hüber reference standard. The main advantage is that you do not need to evaluate the subdivisions of the scale of Onneken standard and, consequently, reduce or eliminate the contribution of the uncertainty from the operator. Table 1 shows the technical characteristics of both standards.

According to the reference [6], for class 0.1 manometers, it should be made the calibration in, at least, 10 calibration points in each scale.

Manufacturer	Onneken	Hüber Instrument
Model	OM 631.000 S	PRF 3220-2405
Range of indication	0 a 300mmHg	0 a 400mmHg^1
Scale division	0,2mmHg	0,01mmHg
Resolution	0,03% VFE^2	0,01% VFE

***Tab. 1** Characteristics of the standards.*

Fig. 1 Calibration example for the indirect method.

In the practice [10], it has been adopted 13 points of calibration from 0mmHg, with increments of 25mmHg. Two measurement cycles are realized, in each cycle is made a load sequence and, after 5 minutes, one of unload sequence, resulting in 52 points of calibration.

Taking into account those data already registered, a Certificate of Calibration is issued with the following parameters informed:

- Hysteresis;
- Systematic error maximum;
- Medium dispersion; and
- Uncertainty of measurement.

In the procedure previously described, the following difficulties or problems were observed:

- The time spent in the calibration, using only one operator can surely affect the results of some parameters;
- The initial registration of the data written down in paper, could generate some annotation mistakes;
- The typing of the data for emission of the certificate or the difficulty of recognition of the operator's calligraphy that realized the calibration, could generate some typing mistakes;
- The operator's experience in handling the Onneken standard determines the agility of the same;
- Using two operators can reduce the time of calibration, even it is expensive; and
- The physical construction of Onneken standard which it does not offer analogical output.

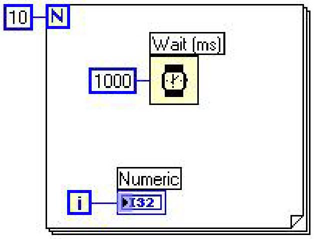
3.2. Automated procedure

This procedure tries to follow the current one, except that some difficulties have been reduced or eliminated by using technology of programs, increasing the productivity of the laboratory. It can be stated that the automation of the calibration of the Onneken pressure standard is partial, because due to its physical construction it still makes necessary the operator's presence.[1]

3.2.1. LabView® Program

The LabView® program of National Instruments [3, 4] is a programming language, oriented to graphic objects, devoted to the virtual instrumentation of laboratories, allowing the aid in projects, generating reports in Word® and Excel® formats, as well as the improvement, development and management of great and complex systems.[1]

The LabView® Platform is of easy visualization, through graphic resources; it possesses several built-in functions. Besides innovator, it substitutes the traditional environment conceived in lines code by icons (subroutines), interlinked for threads, in which each color represents the flow of several types of data (strings, integers, vectors, matrix etc.). In the Figure 2 a routine is presented in LabView® and one in the traditional environment.



Esta corresponde a forma tradicional:

```
for i = 0 to 9
   display i;
   pause 1 second;
end;
```

Fig. 2 *Comparison between both ambient*

The control panel of the program shows an interface for Windows®, being built easily with graphic tools previously developed as tables, graphs, indicators, controls, leds, etc. The Figure 3 exhibits the interfaces of data input of the two patterns.

Before starting the calibration it should be selected the configuration of Hüber standard by means of the controls exhibited in the front panel: time of integration; stability and transmission type. The

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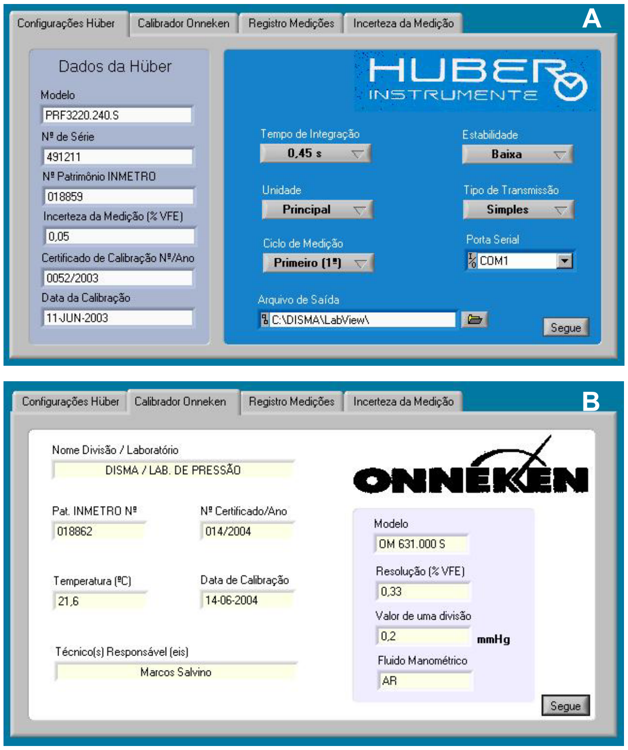
[1] This is a special range. The nominal range is from 0 to 1,250mmHg.

[2] VFE = Final Value of the Scale

other controls possess defined values or the program searches to adapt itself.

To execute the automation, the full duplex RS232 communication interface has been used with connectors DB25 or DB9. The program accomplishes an automatic search in the ports of communication COM1 and COM2, identifying in which of them the Hüber reference standard is actually connected.

In this automated procedure, some improvements have been observed such as the obtaining of a larger number of measurements for a certain calibration point, the automatic fulfillment of the worksheet that it can be visualized by the operator, the automatic generation of the calibration certificate, the exclusion of unstable data, the counting of time with sound warning, the calculation of the measurement uncertainty, besides the other parameters mentioned previously. In the Figure 4, it shows the interfaces of the worksheet and the data output.



Dados da Hüber

Modelo: PRF3220.240.S
Nº de Série: 491211
Nº Patrimônio INMETRO: 018859
Incerteza da Medição (% VFE): 0,05
Certificado de Calibração Nº/Ano: 0052/2003
Data da Calibração: 11-JUN-2003

Tempo de Integração: 0,45 s
Estabilidade: Baixa
Unidade: Principal
Tipo de Transmissão: Simples
Ciclo de Medição: Primeiro (1º)
Porta Serial: COM1
Arquivo de Saída: C:\DISMA\LabView\

Nome Divisão / Laboratório: DISMA / LAB. DE PRESSÃO
Pat. INMETRO Nº: 018862
Nº Certificado/Ano: 014/2004
Temperatura (ºC): 21,6
Data de Calibração: 14-06-2004
Técnico(s) Responsável (eis): Marcos Salvino

Modelo: OM 631.000 S
Resolução (% VFE): 0,33
Valor de uma divisão: 0,2 mmHg
Fluido Manométrico: AR

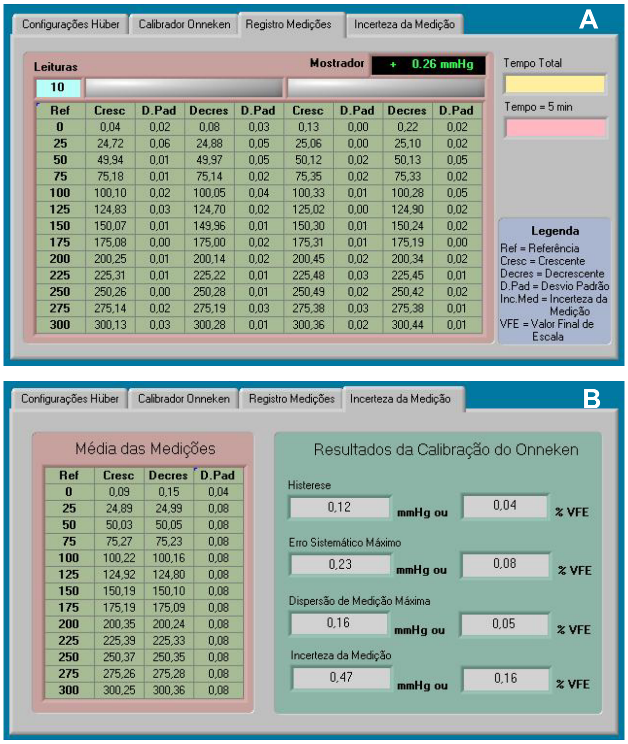
Fig. 3 Interfaces of data input of the Hüber and Onneken standards

One of the main structures elaborated in the program, shown in the Figure 5, is the routine of validation of data. This while loop structure happens so many times as they are necessary until obtaining the stop parameter that is the string correspondent's format, that represents a stable reading supplied by the Hüber reference standard. This string has a format in which the read quantity provided, followed by the unit mmHg. If during the data acquisition there is any instability in the pneumatic circuit, in a calibration point, the routine neglects the current datum.

3.2.2. Determination of the measurement uncertainty

The estimate of the measurement uncertainty of the Onneken pressure standard followed the methodology from the Guide for the Expression of the Uncertainty of Measurement [7]. The measurement uncertainty is the combination of the uncertainties of the type A and type B, what can be expressed by the mathematical relationship:

$$I_M = \sqrt{I_A^2 + I_B^2} \qquad (1)$$



Leituras: 10
Mostrador: + 0.26 mmHg
Tempo Total
Tempo = 5 min

Ref	Cresc	D.Pad	Decres	D.Pad	Cresc	D.Pad	Decres	D.Pad
0	0,04	0,02	0,08	0,03	0,13	0,00	0,22	0,02
25	24,72	0,06	24,88	0,05	25,06	0,00	25,10	0,02
50	49,94	0,01	49,97	0,05	50,12	0,02	50,13	0,05
75	75,18	0,01	75,14	0,02	75,35	0,02	75,33	0,02
100	100,10	0,02	100,05	0,04	100,33	0,01	100,28	0,05
125	124,83	0,03	124,70	0,02	125,02	0,00	124,90	0,02
150	150,07	0,01	149,96	0,01	150,30	0,01	150,24	0,02
175	175,08	0,00	175,00	0,02	175,31	0,01	175,19	0,00
200	200,25	0,01	200,14	0,02	200,45	0,02	200,34	0,02
225	225,31	0,01	225,22	0,01	225,48	0,03	225,45	0,01
250	250,26	0,00	250,28	0,01	250,49	0,02	250,42	0,02
275	275,14	0,02	275,19	0,03	275,38	0,03	275,38	0,01
300	300,13	0,03	300,28	0,01	300,36	0,02	300,44	0,01

Legenda
Ref = Referência
Cresc = Crescente
Decres = Decrescente
D.Pad = Desvio Padrão
Inc.Med = Incerteza da Medição
VFE = Valor Final de Escala

Média das Medições

Ref	Cresc	Decres	D.Pad
0	0,09	0,15	0,04
25	24,89	24,99	0,08
50	50,03	50,05	0,08
75	75,27	75,23	0,08
100	100,22	100,16	0,08
125	124,92	124,80	0,08
150	150,19	150,10	0,08
175	175,19	175,09	0,08
200	200,35	200,24	0,08
225	225,39	225,33	0,08
250	250,37	250,35	0,08
275	275,26	275,28	0,08
300	300,25	300,36	0,08

Resultados da Calibração do Onneken

Histerese: 0,12 mmHg ou 0,04 % VFE
Erro Sistemático Máximo: 0,23 mmHg ou 0,08 % VFE
Dispersão de Medição Máxima: 0,16 mmHg ou 0,05 % VFE
Incerteza da Medição: 0,47 mmHg ou 0,16 % VFE

Fig. 4 Interfaces of the worksheet and the data output

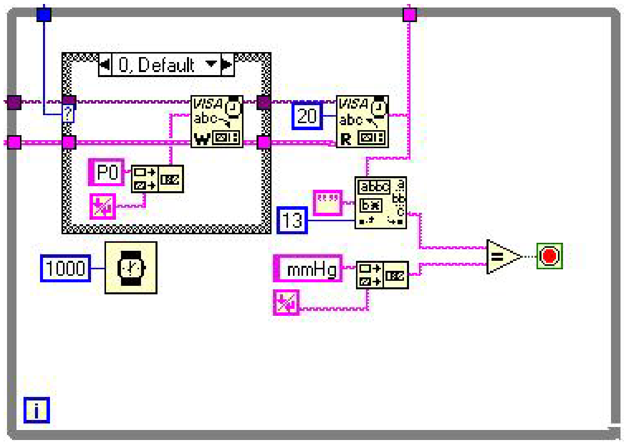


***Fig. 5** Routine of validation of data.*

The contribution of the uncertainty of the type A is determined by the standard deviation of the measurements and it is expressed as follows:

$$I_A = s_{mediciones} \qquad (2)$$

From the technical data supplied in the manuals and certificates of Onneken [8] and Hüber [9] standards, it has been identified the sources that contribute to the uncertainty of the type B, expressed by the following equation [5, 10, 11]:

$$I_B = I_p + \Delta H_{ob} + \Delta L_{ob} + R_{ob} + \Delta T_{ob} + S_{ob} + E_{ob} \qquad (3)$$

From the Equation (3) [5], it has been verified that the sources above can be neglected without causing significant change in the final result. Once identified, the Equation (3) could be rewritten in the following way:

$$I_B = I_p + E_{ob} \qquad (4)$$

The value of I_A^2 it is obtained considering the largest value of the column *D.Pad*, in the *Média das Medições*, shown in the Figure 4-B, it is determined as follows:

$$I_A^2 = \left(s_{Seq1c}^2 + s_{Seq1d}^2 + s_{Seq2c}^2 + s_{Seq2d}^2 \right) \qquad (5)$$

And it is intended that the measurement uncertainty, for the automated process, of the calibration of Onneken standard is given as:

$$I_M = \sqrt{\sigma_{Seq1c}^2 + \sigma_{Seq1d}^2 + \sigma_{Seq2c}^2 + \sigma_{Seq2d}^2 + I_B^2} \qquad (6)$$

4. RESULTS

The presentation of the obtained results can be seen in Figure 4 in both interfaces of data output. In both of them the measurement averages, the standard deviation are evaluated and the other parameters already mentioned.

It has also been verified that the time of the automated calibration process till the emission of the certificate experienced a significant reduction of the order from 40 to 50%. In this case, the time factor depends on the operator's experience in handling of Onneken standard.

Besides the reduction of the calibration time, one of the advantages is the decrease of mistakes in the emission of the certificate discussed previously or the operator's interference in the same.

5. CONCLUSIONS

Thus, it can be stated that the automation of the Onneken pressure standard could improve the productivity, the execution time and the quality of the services offered by the Laboratory of Pressure of the Management of Legal Metrology. The development of projects with automated systems has contributed to the operator's improvement.

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