XVIII IMEKO WORLD CONGRESS
Metrology for a Sustainable Development
September, 17 – 22, 2006, Rio de Janeiro, Brazil

IMPROVEMENTS ON A 10KN DEADWEIGHT MACHINE

Jorge Antônio da Paz Cruz [1], Luis Carlos Cabral de Freitas[1], Cláudio Afonso Koch[1],
Ademir Chagas[1], Adriana da Cunha[1] Rocha

[1] INMETRO, Rio de Janeiro, R.J., Brasil,
jacruz@inmetro.gov.br
lccabral@inmetro.gov.br
cakoch@inmetro.gov.br
achagas@inmetro.gov.br
acrocha@inmetro.gov.br

Abstract: The main purpose of this work is to present the modifications and improvements performed on the 10kN deadweight machine installed at the Force, Torque and Hardness Laboratory of the National Institute of Metrology, Standardization and Industrial Quality – INMETRO. This work is also an extension of a previous IMEKO paper [1] where this same machine has been characterized.

A series of modifications were implemented in the machine along the years. These modifications consisted mainly of switching the loading frame from two columns one to a set of three columns. Also, the installation of a mass leveling and centralization system was performed and an automatic supporting for its loading frame was installed . The data acquisition system , which was previously done manually by readings of the digital display of the machine is now done through a computer using a dedicated software. This software is able to control and manage the movement of the loads according the standards ASTM E 74.[2], NBR 6674 [3] and ISO 376 [4].

After these modifications, the measurement uncertainty was evaluated and compared to the previous value for that machine. It could be then observed a significant decrease on this value of about 90% from the previous value obtained.

The modifications in the machine also lead to a series of tests performed and the Best Measurement Capability (BMC) was then determined.

Keywords: deadweight machine, force, BMC.

1. INTRODUCTION:

The Force, Torque and Hardness Laboratory – LAFOR, has been engaged in the modification and improvement of its deadweight machine in order to optimize its measuring process and decreasing the related uncertainty of its data. The machine was designed and built by a Brazilian company, in association with the Instituto de Pesquisas Tecnológicas do Estado de São Paulo - IPT/SP, for calibration of force transducers.

After identifying some drawbacks on the performance of the 10kN machine, a series of modifications were implemented which consisted basically on switching the loading frame from two columns one to a set of three, installation of a mass leveling and centralization system and automatic supporting for its loading frame. Also, the data acquisition system is now done through a computer using a dedicated software.

The Brazilian Standard NBR 6674 [3], similar to the ISO 376 [4] is the one used for evaluating the machine's performance, through the comparison of experimental results (calibration of load cells formerly calibrated at the Physikalisch-Technische Bundesanstalt - PTB) with those obtained by calculation, taking into account all the quantities that could have an influence on the results.

The measurement uncertainty was evaluated according to the documents EA 10/04 "Uncertainty in Calibration Results in Force Measurements" [5], ISO Guide to the Expression of Uncertainty in Measurement [6].

After the new implementation on the machine, a series of testes were performed and the Best Measurement Capability (BMC) determined.

2. METHODS

2.1. The Structure of the machine

This machine was projected to calibrate low-capacity force measuring devices such as force transducers, load cells and proving rings. Tension and compression forces are generated through direct application of a deadweight, under the effect of local acceleration due to gravity and the air buoyancy, exerts a force directly transmitted to the instruments being calibrated.

The machine consists basically of a rigid structure with the following itens:

(A) 2 screw columns
(B) adjustable crossbeam
(C) loading frame
(D) compression plate
(E) tension rig
(F) small weights set
(G) small weights set

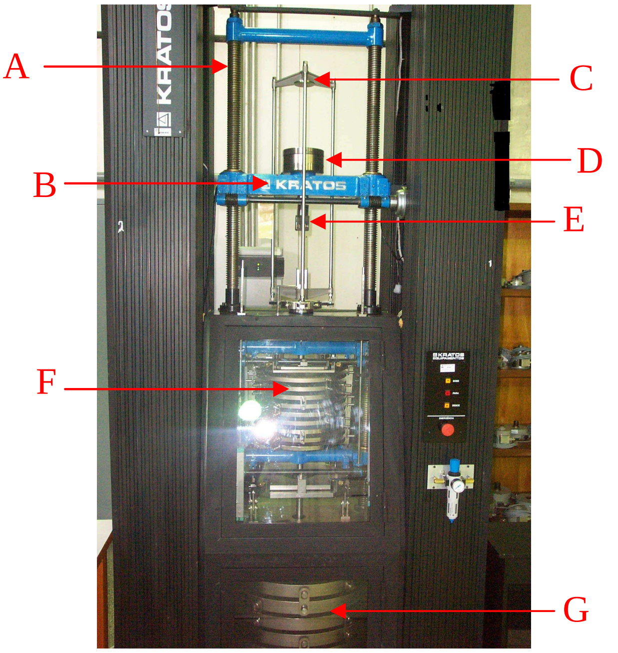

Figure 1 – Front view of the 10kN deadweight machine.

The scale pan has 1450 mm of lenght and generates a nominal force of 0,1 kN in compression and tension tests. The loading frame has a height of 720 mm and a width of 275 mm for compression tests which generates a nominal force of 0,1 kN. A set of 19 standard masses, that are used individually or in combination are able to generate forces up to 10 kN in the compression and tension mode.

2.2 *The Standard Weights*

The weights are manufactured in low carbon rolled steel (SAE 1010/1020), according to NBR 6674[3], and chemically covered with nickel for protection against corrosion. They are subdivided in two sets:

- 10 disks of 336 mm diameter and 15 mm thickness, each one generating a nominal force of 0,1 kN, and
- 9 disks of 610 mm of diameter and 45 mm thickness, each one generating a nominal force of 1,0 kN.

The mass values were determined in ± 10 parts per million for the set of 0,1 kN and ± 20 parts per million for the set of 1,0 kN, through the method of substitution by comparison of the unknown values of weights with national standards.

3. RESULTS AND DISCUSSION

Tests with two force standard machines, one from INMETRO and the other from PTB were performed using four force transducers (1kN, 2kN, 5kN, 10kN) and a DMP 40 digital display. The same transducers were then tested on the 10kN machine and the results were analyzed according the EA 10/04 document. The **Best Measurement Capability** (**BMC** or **W_{bmc}**) was then determined, using the following equation

$$\mathbf{W_{bmc} = k \, . \, (w^2_{refv} + w^2_{fcm})^{1/2}} \qquad (1)$$

Where,
k = coverage factor
$\mathbf{w_{refv}}$ = reference relative uncertainty
$\mathbf{w_{fcm}}$ = standard relative uncertainty

The following graph presents the results from the calculations for the BMC:

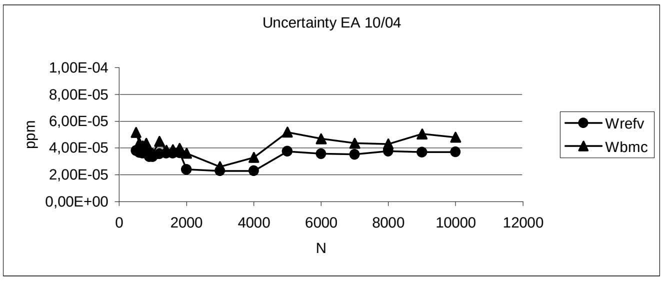

Figure 2 – Best Measurement Capability

Comparing the reference values with those obtained from the 10kN machine, one can notice that for smaller values of force, the uncertainties values are quite similar and somehow superimposed, as observed by the graph. Values higher than 2kN start to show a spreading between the uncertainty reference values and those obtained from the machine, although the curve profile and curve trend are very similar. This similarity indicates that, although the values for the uncertainty of the reference values are still lower than the ones acquired from the machine, those are still quite close to the ones from the reference.

When compared to previous uncertainty values, i.e., those obtained prior to the modifications on the machine, the improvement is huge. First calculated uncertainty was 670ppm, which is 90% higher than the one obtained after the modifications, which is 50ppm.

3. CONCLUSIONS

A significant improvement on the BMC was observed after the modifications were implemented. The previous value for the expanded uncertainty dropped from 670 ppm to 50 ppm showing how beneficial the modifications were.

REFERENCES

[1] Souza, M.R.A; Cruz, J. A. P.; Domingues, S. M. P.; Freitas, L.C.C. – Characterization of a Brazilian 10kN Deadweight Machine, annals of the Imeko World Conference, Madrid, Spain, 1996.

[2] American Society for Testing and Materials – ASTM E74 – 2002 – Standard Practice of Calibration of Force-Measuring Instruments for Verifying the Force Indication of Testing Machines.

[3] Associação Brasileira de Normas Técnicas - ABNT, 1999, M*ateriais Metálicos - Calibração de instrumentos de medir força utilizados na calibração de máquinas de ensaios uniaxiais* (Metallic Materials - Calibration of force proving instruments used for the verification of uniaxial testing machines) NBR 6674/99.

[4] International Organization for Standardization - ISO 376:2004 - Metallic materials -- Calibration of force-proving instruments used for the verification of uniaxial testing machines

[5] European Accreditation - EA 10/04 “Uncertainty in Calibration Results in Force Measurements”.

[6] International Organization for Standardization - ISO, 2003, *Guide to the Expression of Uncertainty in Measurement*, ISBN 92-67-10188-9,

***