

DEVELOPMENT OF THE CAPABILITY TO CALIBRATE LOAD CELLS IN TENSION AT THE LEVEL OF 2 MN USING THE PYRAMIDAL METHOD.

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Abstract: The purpose of this paper is to present the results of the development, at the Mechanical Metrology Laboratory – IPT, the capability to calibrate load cells until 2MN in tension using the pyramidal method. This type of assembly is normally applied for compression. The goal is to achieve an uncertainty of 0,05%.

Keywords: calibration, force, load cell.

1. INTRODUCTION

The demand of the industry for better accuracy at the level of 2MN and higher requires that the Calibration Laboratories improve their capacity to attend this demand. So the Mechanical Metrology Laboratory – IPT started to develop a procedure using a classical method of measuring forces higher than 2MN [2], in compression, using the pyramidal, but applied to tension.

2. PURPOSE

Using the experience of the Mechanical Metrology Laboratory – IPT in calibrating load cells for compression until 3MN in, shown in figure 1, the technical body decided to implement the capacity, in tension, at the level of 2MN.



Fig 1 Pyramidal system for compression

The main equipments were a Testing Machine (fig 2) Tinius Olsen with maximum load capacity of 2,25MN, used as force generator and three load cells of 1MN, manufactured by HBM, model C3H3, calibrated in INMETRO [1];[5] to guarantee traceability of the results at the proposed level of uncertainty of 0,05%. All rods and connections were manufactured in accordance with DIN EN 376-2005 e NBR 6674 -1999 [3-4]. With the system showed

in fig.3 there were made several runs to verify its consistency and repeatability.

To check the accuracy some points were made a cross checking of the load cell under test using a Dead Weight Machine MPM330 with 0,3MN as limit of load, certified by INMETRO, table 1 shows some preliminary results.

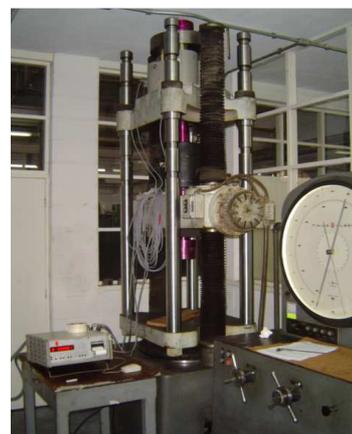


Fig 2 Force generator

3. METHODS

The method used was the pyramidal arrangement using three load cells as reference and one as measurand. In figure 3 is shown the method applied to a calibration in tension.



Fig 3 Pyramidal system for tension

The results for the preliminary test in compression for further comparison are shown in fig 4 and table 1.

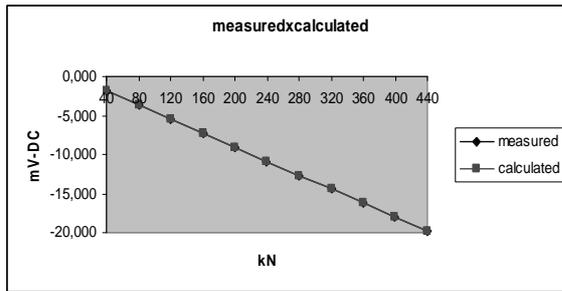


Fig 4 Result of the adjusted curve at the results

Table 1-Data for the compression test.

Load kN	Mean Value mV-DC	Uncertainty kN	k (~95%)
40	-1,806	0,03	2,1
80	-3,613	0,03	2,0
120	-5,420	0,04	2,0
160	-7,226	0,05	2,2
200	-9,033	0,09	2,0
240	-10,837	0,08	2,0
280	-12,643	0,09	2,0
320	-14,448	0,11	2,1
360	-16,252	0,11	2,0
400	-18,056	0,13	2,0
440	-19,864	0,18	2,4

Value in **bold** were obtained with the pyramidal arrangement, the remaining with the Dead Weight Machine (*DWM*)

4. RESULTS AND DISCUSSION

In the fig.5 and table 2 are shown the preliminary results of the new method for tension calibration, using for control the results from the calibration on the *DWM*.

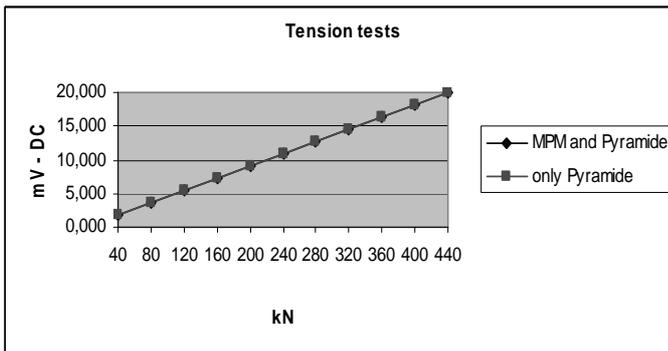


Fig. 5 Comparison DWM and Pyramidal arrangement in tension

The graphic shows a very good agreement or overlapping of the results obtained calibrating the load cell with the Dead Weight Machine (MPM 330) and using the Pyramidal assembly developed at the Mechanical Metrology Laboratory, at least for the preliminary made with relative low loads, but helped to go further, the process was under control.

Table 2. Comparison *DWM*xPyramid in tension

Load kN	MPM and Pyramidal	Uncertainty kN	k (95%)	Only Pyramidal
40	<i>1,808</i>	<i>0,03</i>	2,1	1,806
80	<i>3,616</i>	<i>0,04</i>	2,0	3,614
120	<i>5,424</i>	<i>0,04</i>	2,0	5,422
160	<i>7,234</i>	<i>0,05</i>	2,2	7,231
200	<i>9,043</i>	<i>0,06</i>	2,0	9,041
240	<i>10,852</i>	<i>0,08</i>	2,0	10,851
280	<i>12,663</i>	<i>0,09</i>	2,0	12,662
320	14,473	0,12	2,1	14,472
360	16,286	0,14	2,0	16,284
400	18,099	0,14	2,0	18,097
440	19,911	0,16	2,4	19,912

Datas in *italic* were obtained with the pyramidal assembly and in **bold** with the *DWM* (MPM330) in tension test. The fifth column gives the calibration results using only the pyramidal arrangement,

Shows that at the level of 440 kN the agreement is better than 0,002 mV/V or 0,02% at the point 200 kN or at 10% of the full load, what means the goal of 0,05% is close.

The results, showed above, encouraged the group to use the system for higher loads as tension until 2,25 MN. The tests were made in three steps: first step 100 to 300 kN was used the *DWM*; second step from 400 to 1000 kN was used a load cell HBM – C3H3 and the last step from 1200 to 2250 kN was used the pyramidal assembly Table 3a and 3b is an extract of the calibration report giving the results with new calibration system showed on figure 2.

Table 3a Measuring results (Report resume)

Loads (kN)	Mean values (mV/V)	Reproducibility (%)	Calculated values
100	<i>0,10209</i>	<i>0,052</i>	<i>0,10209</i>
200	<i>0,20407</i>	<i>0,128</i>	<i>0,20407</i>
300	<i>0,30616</i>	<i>0,116</i>	<i>0,30616</i>
400	0,40831	0,127	0,40833
600	0,61285	0,122	0,61287
800	0,81778	0,105	0,81768
1000	1,02266	0,135	1,02276
1200	1,22790	0,129	1,22812
1400	1,43373	0,103	1,43375
1600	1,63974	0,100	1,63966
1800	1,84600	0,100	1,84583
2000	2,05252	0,102	2,05228
2250	2,31047	0,144	2,31073

Table 3b Measuring results (Report resume – cont.)

Loads (kN)	Interpolation error (%)	Reversibility Error (%)	U (kN)	k
100	<i>0,054</i>	<i>0,084</i>	<i>0,1</i>	2,0
200	<i>0,004</i>	<i>0,120</i>	<i>0,3</i>	2,9
300	<i>-0,003</i>	<i>0,073</i>	<i>0,4</i>	2,9
400	-0,005	0,108	0,5	2,9
600	-0,003	0,060	0,7	2,9
800	0,012	-0,009	0,8	2,6
1000	-0,010	0,032	1,3	2,9
1200	-0,018	0,043	1,6	2,9
1400	-0,001	0,004	1,4	2,6
1600	0,005	0,018	1,5	2,5
1800	0,009	-0,007	1,7	2,5
2000	0,012	-0,003	2,0	2,5
2250	-0,011	-	3,6	3,0

5. CONCLUSION

The values in *italic* were obtained at the *DWM* (MPM330) dead weight machine, in **black** results using a 1MN reference load cell and in **bold** using the pyramidal arrangement. We can conclude that we have to make some improvements in the positioning of the cells by means of (may be) a better machining of the supports to improve the repeatability which a little bit higher than the goal 0,1% against 0,05%. But the overall results are very consistent and so for the moment we can assume that the method is reliable.

So with the results presented in this paper, which are very acceptable, we can say that the Mechanical Metrology Laboratory – IPT can use this development to offer calibration in tension up to 2,25 MN and compression un to 3,0 MN with acceptable precision as specified by the standards DIN EN 376-2005 e NBR 6674 -1999 [3-4].

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REFERENCES

- [1] ISO/IEC 17025:1999 – “General Requirements for the Competence of Testing and Calibration Laboratories”.
- [2] NBS SPECIAL PUBLICATION 300 volume 8 – “Precision Measurement and Calibration – Mechanics” 218-1 to 235-18
- [3] DIN EN ISO 376 - 2005 – “Calibration of force-proving instruments used for the verification of uniaxial testing machines”, 22p.
- [4] NBR – 1999 – “Materiais metálicos – Calibração de instrumentos de medição de força utilizados na calibração de máquinas de ensaios uniaxiais”, 16pag.
- [5] ILAC-G2:1994 – “Traceability of Measurements”, ILAC, 53p, 1996.