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INTERLABORATORY COMPARISONS PERFORMED IN TURKEY: FORCE CALIBRATION OF STATIC MATERIAL TESTING MACHINES

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Abstract:
An interlaboratory comparison, for the calibration of static uniaxial testing machines was organized in Turkey by TUBITAK UME Force Laboratory as the reference laboratory in 2009 to 2010. 14 different calibration laboratories located in Turkey which provide force calibration for static uniaxial material testing machines have been participated to this interlaboratory comparison. Each laboratory calibrated to force of the static uniaxial material testing machine by using EN ISO 7500-1 standard. In interlaboratory comparison, it was requested to measure 3 different ranges: 100 kN in compression mode, 1 kN in tension mode and 100 N in tension mode.

This study presents the main results obtained during the interlaboratory comparison. The values of measurements and the associated uncertainties were reported by each laboratory as a part of the calibration report. The degree of equivalence of each laboratory relative to comparison reference values and the figures of "En" values of the participants are presented.

Keywords: interlaboratory comparison, material testing machine, force calibration

1. INTRODUCTION

In Turkey, calibration laboratories should obey the rules of ISO 17025 for their recognition by the customer and increase the quality of their calibration and test services [1]. In order to give traceable service in testing and calibration area, National Accreditation System controls the laboratories in all countries. TURKAK is the responsible for the organization of accreditation system in Turkey.

One of the most important activities at European (EA, EURAMET) and national level (TUBITAK UME, TURKAK) is the organization of a series of interlaboratory comparisons, to verify the measurement capabilities of the calibration laboratories.

An interlaboratory comparison is organized by the TUBITAK UME to see the closeness and equivalency of the test results among the participating laboratories. Technical protocol were prepared and announced by TUBITAK UME. The static uniaxial material testing machine, is located in TUBITAK UME, was used as measuring device. All participant laboratories were performed the calibration using their own procedures accordance with EN ISO 7500-1 standard and own calibration equipments [2]. The calibration results were evaluated according to same procedures explained in related standards by the laboratories. The values of measurements and the associated uncertainties were calculated in accordance with international standards and procedures stated by each laboratory as a part of the calibration report [3-8].

In this paper, the main results obtained during the interlaboratory comparison are discussed; in particular an analysis was applied to evaluate the differences in the uncertainties by the different laboratories. The calculated "En" values of the calibration results for the participant laboratories are presented and shown in graphs [3-6].

2. TECHNICAL PROTOCOL

The calibration results using the comparison reference values obtained by the TUBITAK UME Force Laboratory, nominated as reference laboratory, were considered "reference values".

First of all, the technical protocol was prepared and it was sent to all participant laboratories. It includes the specifications of measuring device, time table for the calibration, calibration reports and calibration requirements [3]. Each laboratory calibrated to the static uniaxial material testing machine by using EN ISO 7500-1 standard. In interlaboratory comparison measurements, it was requested to measure 3 different ranges: 100 kN in compression mode, 1 kN in tension mode and 100 N in tension mode. The test machine of TUBITAK UME, used for measuring, is shown in Figure 1.

2.1. Participant Laboratories and Timetable

14 different calibration laboratories were participated to this interlaboratory comparison in Turkey. For interlaboratory comparison, 10 laboratories participated all ranges; 2 laboratories participated two ranges; 2 laboratories participated one range. Interlaboratory comparison was started on April 27.2009 and was completed on April

08.2010. All measurements were completed according to time schedule declared in technical protocol.

Fig. 1. Material Testing Machine of TUBITAK UME used in interlaboratory comparison measurements

3. RESULTS

After completing the calibrations by each laboratory, the calibration reports were sent to the pilot laboratory which is TUBITAK UME Force Laboratory. TUBITAK UME evaluated all calibration reports according to ISO 17043 standard [4]. In given figures and tables, each laboratory is represented with a letter as A, B,… and O. The letter "A" represents the calibration results of TUBITAK UME and it is taken as the reference (pilot) laboratory. The calibration results and uncertainties of the all laboratories are given in Figure 2,3,4. These figures are given accuracy and uncertainty in minimum and maximum force values. The maximum differences of measurement results are shown on figures, so these values selected.

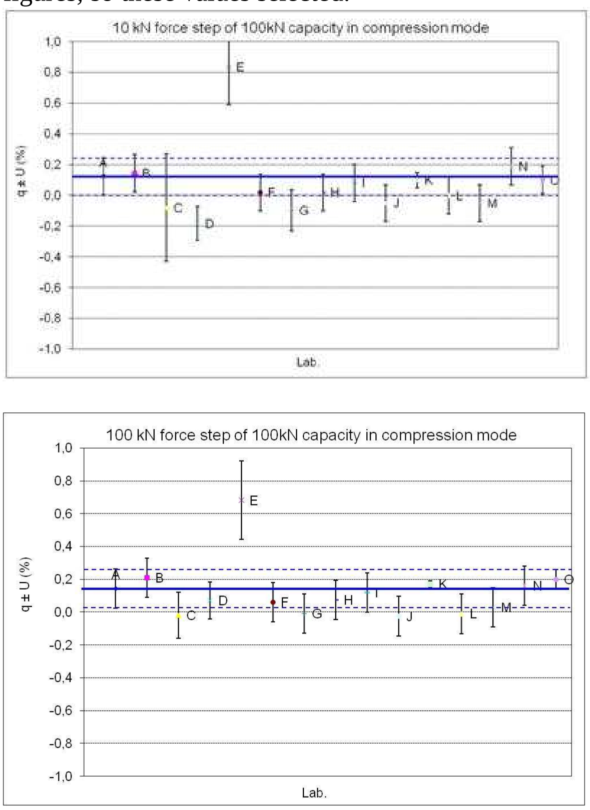

Fig. 2. Accuracy (q) and uncertainty (U) values of the participant laboratories for 100 kN capacity in compression mode

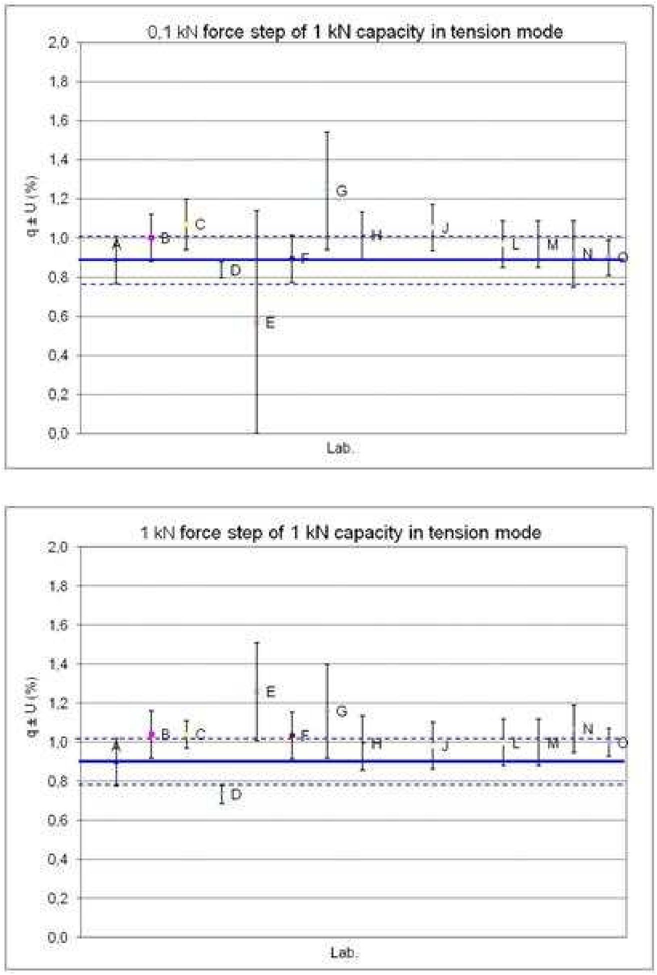

Fig. 3. Accuracy (q) and uncertainty (U) values of the participant laboratories for 1 kN capacity in tension mode

The results of all participant laboratories are examined in the calibration certificates. The distributions of maximum, minimum, mean values of repeatability (b), accuracy (q) and uncertainty (U) are given in Table 1.

All relative repeatability error values was seen to remain within 0,80 % error band.

When relative accuracy error values were examined, it was shown inside a band of 1,26 % of all error values. The amount of deviation in mean values were determined 0,09 % in 100 N tension mode, 0,10 % in 100 kN compression mode, and 1,00 % in 1 kN tension mode.

Uncertainty values have a maximum value in 0,57 %. The mean value of uncertainty in all measurement is 0,13 %.

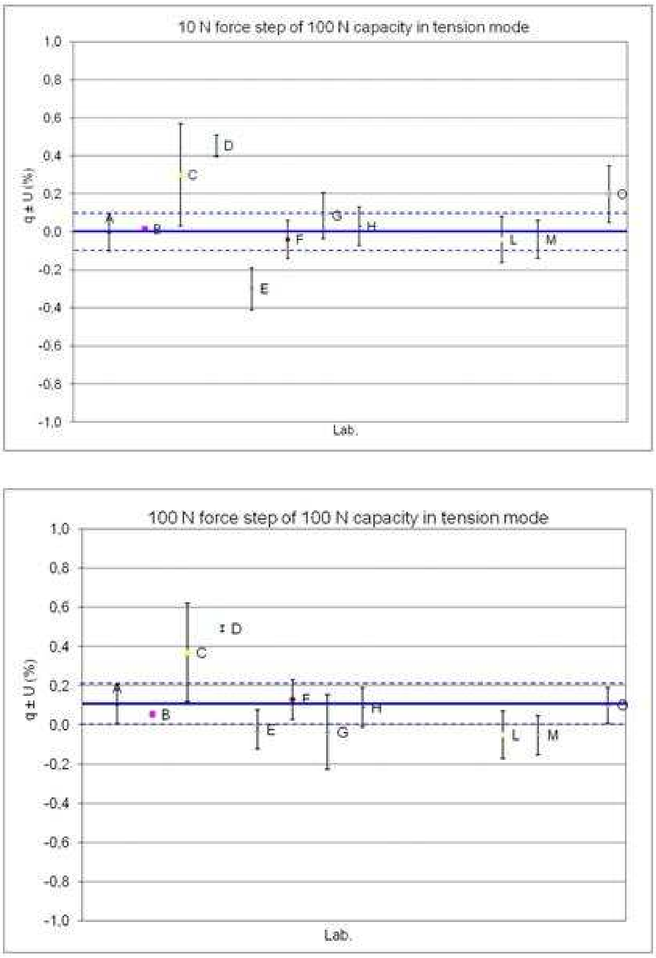

Fig. 4. Accuracy (q) and uncertainty (U) values of the participant laboratories for 100 N capacity in tension mode

Table 1. Distributions of the error values

Differences of the values	**% b**		
Calibration	Max.	Min.	Mean
100N Tension	0,30	0,00	0,06
1kN Tension	0,78	-0,11	0,05
100kN Compression	0,10	-0,04	0,02
Differences of the values	**% q**		
Calibration	Max.	Min.	Mean
100N Tension	0,49	-0,30	0,09
1kN Tension	1,26	0,57	1,00
100kN Compression	0,84	-0,18	0,10
Differences of the values	**% U**		
Calibration	Max.	Min.	Mean
100N Tension	0,34	0,01	0,11
1kN Tension	0,57	0,04	0,13
100kN Compression	0,35	0,02	0,12

The calibration results of the participating laboratories were evaluated in according to ISO 17043 standard [3,4]. "En" value is taken as assessment method of the evaluated results. "En" values are calculated using below equation:

$$E_n = \frac{x - X}{\sqrt{{U_{\text{lab}}}^2 + {U_{\text{ref}}}^2}}$$

Where,
U_{lab} is the expanded uncertainty of a participant's result;
U_{ref} is the expanded uncertainty of the reference laboratory's assigned value.

Criteria for performance evaluation should be established after taking into account whether the performance measure involves certain features. The features of "E_n" values for performance evaluation are the following.

$|E_n| \leq 1$ indicates "satisfactory" performance and generates no signal
$|E_n| > 1$ indicates "unsatisfactory" performance and generates an action signal.

100 kN, 1 kN and 100 N capacities in all force steps for the participated laboratories are given in Table 2, 3, 4 for the calculation of En numbers [5-7]. The calculated results in "E_n" values of greater than 1 in Table 2, 3, 4 are indicated by bold characters. The evaluations of the "E_n" values are also given in Table 5.

Table 2. Calculated "E_n" Values for 100 kN capacity in compression mode of all force steps

Force Steps (kN)	E_n - 100kN Compression / Lab. Codes													
	B	C	D	E	F	G	H	I	J	K	L	M	N	O
10	0,1	0,6	**1,9**	**2,6**	0,6	**1,3**	0,6	0,3	1,0	0,2	0,7	1,0	0,4	0,2
20	0,3	0,8	**1,4**	**2,3**	0,6	**1,1**	0,6	0,1	1,0	0,1	0,8	0,9	0,2	0,5
30	0,3	0,8	**1,1**	**2,1**	0,6	1,0	0,5	0,1	1,0	0,1	0,9	0,9		0,6
40	0,3	1,0	1,0	**2,1**	0,6	1,0	0,5	0,2	1,0	0,1	0,9	0,7	0,0	0,5
50	0,3	0,9	0,8	**2,0**	0,5	0,9	0,4	0,1	1,0	0,2	0,9	0,8		0,5
60	0,3	1,0	0,7	**2,7**	0,5	0,9	0,4	0,1	1,0	0,2	0,9	0,7	0,0	0,5
70	0,4	0,9	0,6	**2,0**	0,5	0,9	0,4	0,1	1,0	0,2	0,9	0,7		0,5
80	0,4	0,9	0,6	**1,9**	0,5	0,9	0,4	0,1	1,0	0,2	0,9	0,7	0,1	0,5
90	0,4	0,9	0,5	**2,0**	0,5	0,9	0,4	0,1	1,0	0,2	0,9	0,6		0,4
100	0,4	0,9	0,4	**2,0**	0,5	0,9	0,4	0,1	1,0	0,2	0,9	0,7	0,1	0,4

Table 3. Calculated "E_n" Values for 1 kN capacity in tension mode of all force steps

Force Steps (kN)	E_n - 1 kN Tension / Lab. Codes													
	B	C	D	E	F	G	H	I	J	K	L	M	N	O
0,1	0,7	1,0	0,4	0,5	0,0	**1,1**	0,7		1,0		1,0	0,5	0,2	0,1
0,2	0,7	0,5	**1,3**	0,4	0,2	**1,1**	0,8		0,8		1,0	0,5	1,0	0,8
0,3	0,7	0,5	**1,2**	0,1	0,4	1,0	0,8		0,7		0,7	0,5		0,8
0,4	0,7	0,8	1,0	1,0	0,6	0,7	0,8		0,7		0,7	0,5	0,9	0,7
0,5	0,7	0,9	**1,1**	1,0	0,7	0,9	0,7		0,6		0,8	0,5		0,7
0,6	0,8	0,9	**1,1**	0,8	0,7	1,0	0,8		0,6		0,8	0,6	1,0	0,7
0,7	0,8	0,9	**1,1**	0,9	0,8	1,0	0,8		0,5		0,8	0,5		0,7
0,8	0,8	1,0	**1,2**	**1,1**	0,8	1,0	0,7		0,5		0,8	0,6	1,0	0,7
0,9	0,8	1,0	**1,2**	**1,2**	0,8	1,0	0,7		0,4		0,8	0,5		0,7
1,0	0,8	1,0	**1,3**	**1,3**	0,8	1,0	0,5		0,5		0,8	0,6	1,0	0,7

Table 4. Calculated “E_n” Values for 100 N capacity in tension mode of all force steps

Force Steps (N)	E_n - 100 N Tension / Lab. Codes													
	B	C	D	E	F	G	H	I	J	K	L	M	N	O
10	0,1	1,0	**4,0**	**2,0**	0,3	0,5	0,2				0,0	0,3		**1,1**
20	0,2	1,0	**3,5**	**2,0**	0,2	0,0	0,0				0,0	0,4		0,6
30	0,3	0,7	**3,0**	**2,2**	0,3	0,0	0,2				0,3	0,6		0,4
40	0,2	0,6	**2,8**	**2,2**	0,4	0,6	0,0				0,4	0,8		0,2
50	0,5	0,8	**2,9**	**2,4**	0,1	0,9	0,2				0,5	0,9		0,0
60	0,4	0,8	**3,6**	0,6	0,2	0,9	0,2				0,5	1,0		0,0
70	0,5	0,9	**3,7**	0,7	0,4	0,9	0,2				0,7	1,0		0,0
80	0,7	1,0	**3,7**	0,8	0,4	0,8	0,2				0,7	**1,1**		0,0
90	0,6	1,0	**3,6**	0,9	0,2	0,8	0,3				0,7	**1,1**		0,1
100	0,5	1,0	**3,8**	0,9	0,2	0,7	0,1				0,6	**1,1**		0,0

Table 5. Evaluated “E_n” Values

En Values	Total Lab.	$\lvert E_n \rvert \leq 1$		$\lvert E_n \rvert > 1$	
		The number of Lab.	%	The number of Lab.	%
100 kN capacity compression mode	14	11	78,6	3	21,4
1 kN capacity tension mode	12	9	75,0	3	25,0
100 N capacity tension mode	10	7	70,0	3	30,0

14 calibration laboratories were participated in 100 kN capacity in tension mode. “E_n” values of 11 of them were obtained satisfactory. 12 laboratories were participated calibration of 1 kN capacity in tension mode and 9 of them were evaluated satisfactory according to “E_n” values. The 7 of calibration laboratories in 100 N capacities were obtained satisfactory, too. Laboratories according to intercomparison results provided to satisfactory 70 % in all ranges.

4. CONCLUSIONS

The main aims of the interlaboratory comparison were to demonstrate the stated measurement capability of the participant laboratories, and to check the adequate dissemination of force unit in Turkey. 14 different laboratories were participated to the interlaboratory comparison for the force calibration of static uniaxial testing machines. TUBITAK UME Force laboratory was organized to this proficiency testing in 2009-2010.

Generally, all the participating laboratories demonstrated the compatibility of the force measurements with the reference laboratory in the nominated range, having different determined measurement capabilities. However, there were three laboratories having unsatisfactory measurement results, probably due to the force transmitting equipments and calculation errors for calibration results.

The force calibration depends on the quality of the machine itself and from the force transmitting. The practical method to fix the force transducers for force transmitting is most important. In these cases the used force transducers have been fixed for reference calibration and for calibration of participants on different ways. This is possible according the EN ISO 7500-1 because it does not give any mandatory definitions for that. Especially, big “E_n” values depended on force transmitting equipment in small force capacities, 1 kN and 100 N ranges. There were calculation errors in other results.

As summary for future investigations, the force transmitting equipments should be defined in uniaxial testing machine. The participation laboratories should be given raw and calculated all values.

5. REFERENCES

[1] EN ISO 17025 General requirements for the competence of testing and calibration laboratories, 2005

[2] EN ISO 7500-1, “Metallic materials-Verification of static uniaxial testing machines. Part 1: Tension/compression testing machines- Verification and calibration of the force-measuring system”, 2005

[3] B. Aydemir, S. Fank, C. Vatan, Malzeme Test Makinası Kuvvet Kalibrasyonu Teknik Protokolü, UME-KV-10-01, TÜBİTAK UME, Gebze-KOCAELİ, 2009

[4] EN ISO/IEC 17043, Conformity assessment - General requirements for proficiency testing, 2010

[5] P704, TÜRKAK Yeterlilik Deneyleri ve Laboratuvarlararası Karşılaştırma Programları Prosedürü, Rev 3, 26.01.2006

[6] B. Aydemir, S. Fank, C. Vatan, Malzeme Test Makinası Kuvvet Kalibrasyonu Karşılaştırma Raporu, UME-KV-10-01, TÜBİTAK UME, Gebze-KOCAELİ, 2010

[7] B. Aydemir, S. Fank, C. Vatan, Malzeme Test Makinası Kuvvet Kalibrasyonu Karşılaştırma Raporu, UME-KV-10-02, TÜBİTAK UME, Gebze-KOCAELİ, 2010

[8] Aimo Pusa, Nordic Intercomparison of Calibration of the Material Testing Machines Report of the Force Calibration, Proceedings of the 17th International Conference on Force, Mass, Torque and Pressure Measurements, IMEKO TC3, 17-21 Sept. 2001, Istanbul, Turkey