

INTERLABORATORY COMPARISON IN CALIBRATION OF HARDNESS TESTING MACHINES IN TURKEY

C. Kuzu and E. Pelit

TÜBİTAK UME, Kocaeli, Turkey, cihan.kuzu@ume.tubitak.gov.tr
TÜBİTAK UME, Kocaeli, Turkey, ercan.pelit@ume.tubitak.gov.tr

Abstract: One of the best ways for assuring the quality of the calibration results for accredited/non-accredited laboratories is to participate in interlaboratory comparisons. For this reason TURKAK (Turkish Accreditation Agency) and TÜBİTAK UME (National Metrology Institute of Turkey) for first time had decided to organize an interlaboratory comparison which was piloted by UME Hardness Laboratory in the field of verification/calibration of hardness testing machines (HTM). Besides UME, 9 accredited laboratories participated in the comparison and E_n numbers for all ranges between pilot and each participating laboratory were evaluated. It was a good practice to see differences between laboratories' uncertainty declarations and applications. In this paper the comparison method and results are explained.

Keywords: Rockwell, Brinell, Vickers, interlaboratory comparison, hardness testing machine.

1. INTRODUCTION

An interlaboratory comparison was organized with a cooperation between UME and TURKAK to provide a manner to calibration laboratories for assuring their technical proficiency and calibration result's quality as a requirement of ISO 17025 item 5.9. A total of 10 accredited laboratories including the pilot participated in the comparison which was piloted by UME Hardness Laboratory. Two testing machines were supplied by UME and all participants were invited to realize their calibrations of these machines at UME.

In this organization it was planned to realize comparison of;

1. calibration of HTM force application system
2. calibration of HTM indentation measurement system
3. calibrations of HTM with hardness reference blocks

Every laboratory made its own measurements with its own reference devices/blocks and filled the measurement result's forms prepared by the pilot laboratory and declared their calculations and uncertainties by preparing a calibration certificate. The two hardness machines determined for comparison were a microvickers hardness machine and a Rockwell-Brinell-Vickers HTM. It was decided to make

force calibration in different ranges like HRB and HB 187,5 kgf scales and by the way force calibration was planned to cover 10 kgf, 100 kgf and 187,5 kgf. For comparison of indentation measurement system calibration, it was preferred to compare calibration of a microvickers machine in a commonly used range such as 0 mm – 0,5 mm. The third subject of the comparison was calibration of HTM by calibrated hardness reference blocks. The scales for which the HTM calibration compared were HV1 and HRC, the very commonly used scales in Turkey.

2. COMPARISON PROCEDURE

The comparison procedure was prepared in accordance with requirements of EN ISO 6508-2, EN ISO 6506-2 and EN ISO 6507-2 standards and availabilities of the calibration laboratories. Each participant laboratory visited UME and performed calibrations for about one day. The calibration procedure for comparison had been decided as explained in the following paragraphs.

2.1. Calibration of HTM Force Application Systems

As a part of direct calibration, force application systems of HTM are calibrated by reference force measuring devices with Class1 according to EN ISO 376. In the comparison it was decided to perform comparison of force calibration at different levels like 10 kgf, 100 kgf (HRB) and 187,5 kgf (HBW2,5/187,5).

First measurements were done by pilot laboratory (UME) and then each participating laboratory made its own measurements and pilot again at the end. Three force measurements were taken at each position of the indenter which makes a total of 9 measurements for 10 kgf - 100 kgf - 10 kgf for Rockwell-B and 9 measurements for 187,5 kgf Brinell testing cycles. All measurements and ambient conditions were recorded on to the data sheet prepared by pilot laboratory. For some scales force values of the HTM were set to force values different than the nominal values belonging to the scales to search awareness of some deviations in calibration results. Calculations of the results and uncertainties were made at participant laboratories places and the results were sent to the pilot laboratory within a couple of weeks. In the comparison reports, measured values of the forces, deviations from the nominal values and uncertainty of measurements were declared.

2.2. Calibration of HTM Indentation Measurement Systems

Second part of comparison was the calibration of indentation measurement systems of HTM. They were calibrated by reference line scales (stage micrometers). In the comparison it was decided to perform comparison of indentation measurement system calibration up to 0,5 mm by dividing it into 10 ranges. In this measurement also the pilot made its measurement at the beginning and at the end. Three series of measurement were taken by the participants and the measurement results were recorded onto the data sheet.

2.3. Calibration of HTM by Hardness Reference Blocks

An important procedure to check the performance of HTM as a whole is to calibrate them by certified hardness reference blocks, called indirect calibration. For comparison of this part HV1 and HRC were preferred. Three ranges for each scale were used. Hardness ranges for microvickers are;

- 211 HV1
- 524 HV1
- 824 HV1

for Rockwell-C are;

- 25 HRC
- 45 HRC
- 64 HRC

3. ANALYZING MEASUREMENT RESULTS

Pilot laboratory performed two measurements; one at the beginning and one after everybody completed measurements. Mean values of the pilot's two measurements were accepted as the reference value of the comparison and deviation of each laboratory from this value was evaluated in accordance with EN ISO/IEC 17043-2010: Conformity assessment - General requirements for proficiency testing[1]. Two parameters, deviation from the reference value (d) and E_n factor were calculated as given below in (1) and (2), respectively.

$$d = X_{LAB} - X_{UME} \quad (1)$$

$$E_n = \frac{X_{LAB} - X_{UME}}{\sqrt{U_{LAB}^2 + U_{UME}^2}} \quad (2)$$

Where,

X_{UME} is the measured value by UME

U_{UME} is the expanded uncertainty of UME

X_{LAB} is the measured value by each participant lab.

U_{LAB} is the expanded uncertainty of participant lab.

The obtained results with $E_n \leq 1$ are accepted as satisfactory while the ones with $E_n \geq 1$ are accepted as unsatisfactory. This way of assessment was applied to every value of force, each range of indentation and every hardness block

measurement. All measurement results were satisfactory except for one at HV1 in calibration by hardness reference blocks.

4. COMPARISON RESULTS

In the graphical representations the x_axis represents the pilot lab value and the deviations represent deviation of participants from the pilot. The pink lines show uncertainty of the pilot while the bars on each result is the uncertainty of the participant.

4.1. Calibration of HTM Force Application Systems

Calibration results of the participating laboratories were compared with the pilot laboratory and E_n number for each participant was calculated. Below E_n number and graphical views of the attained results are given.

Table 1. E_n Values Between Participants and Pilot for Force Measurements

E _n Values In Accordance With UME (Pilot)										
Scale	Force (N)	A	B	C	D	E	F	G	H	I
HRB	1. preload	0,1	0,0	0,2	0,2	0,7	0,0	0,1	0,4	0,0
	2. preload	0,1	0,5	0,6	0,1	0,9	0,5	0,1	0,0	0,7
	Total load	0,6	0,0	0,3	0,7	0,8	0,0	0,2	0,8	0,8
HBW 2,5/187,5	Total load	0,7	1,0	0,2	0,3	1,0	0,4	0,4		0,7

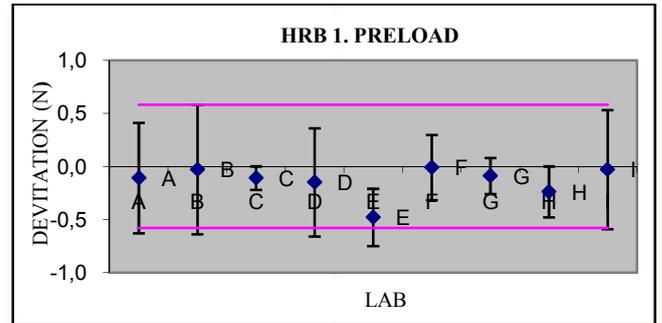


Fig. 1. Deviation of Participants from the Pilot for HRB Scale Preload

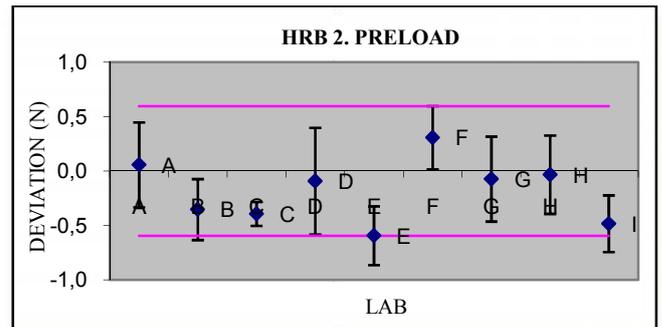


Fig. 2. Deviation of Participants from the Pilot for HRB Scale Preload

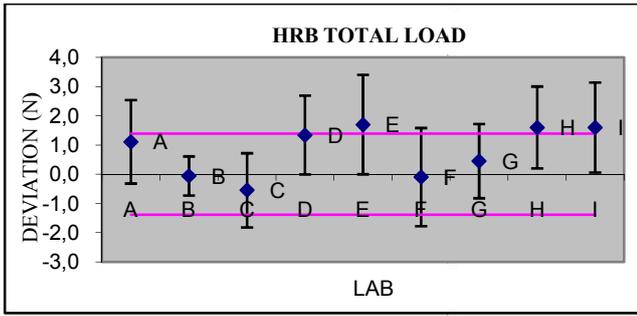


Fig. 3. Deviation of Participants from the Pilot for HRB Scale Total Load

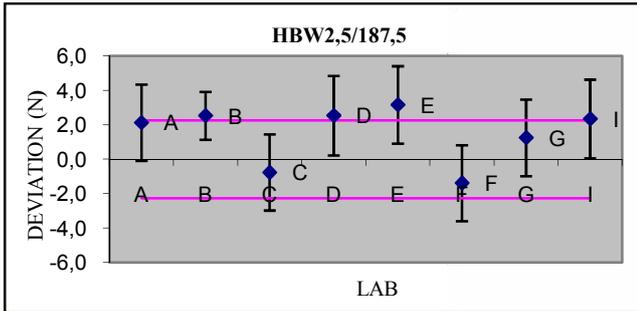


Fig. 4. Deviation of Participants from the Pilot for HB 187,5 kgf

4.2. Calibration of HTM Indentation Measurement System

An indentation measurement system with 10X objective lens was calibrated for 0,5 mm in 10 ranges. The same calculation manner as done in the force was applied. Below E_n number and graphical views of the declared results are given.

Table 2. E_n Values Between Participants and Pilot for Indentation Measurement System

E_n Values in Accordance with UME								
Range (μm)	A	B	C	D	E	F	G	I
50	0,3	0,1	0,0	0,0	0,0	0,3	0,0	0,0
100	0,3	0,3	0,6	0,1	0,3	0,1	0,2	0,3
150	0,0	0,1	0,5	0,4	0,4	0,0	0,2	0,0
200	0,6	0,4	0,5	0,7	0,6	0,5	0,2	0,2
250	0,0	0,2	0,0	0,6	0,6	0,5	0,1	0,2
300	0,1	0,1	0,2	0,1	0,5	0,7	0,1	0,1
350	0,6	0,0	0,0	1,0	0,2	0,4	0,1	0,2
400	0,0	0,4	0,0	0,0	0,3	0,0	0,1	0,2
450	0,2	0,3	0,0	0,0	0,4	0,0	0,0	0,0
500	0,0	0,3	0,0	0,0	0,0	0,0	0,0	0,3

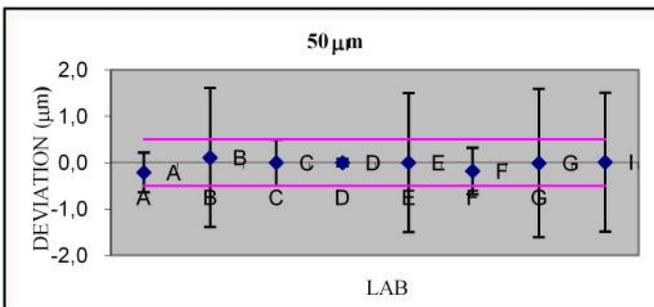


Fig. 5. Deviation of Participants from the Pilot for 50 μm nominal value

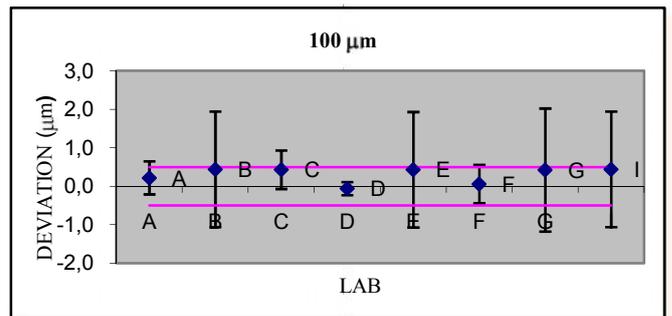


Fig. 6. Deviation of Participants from the Pilot for 100 μm nominal value

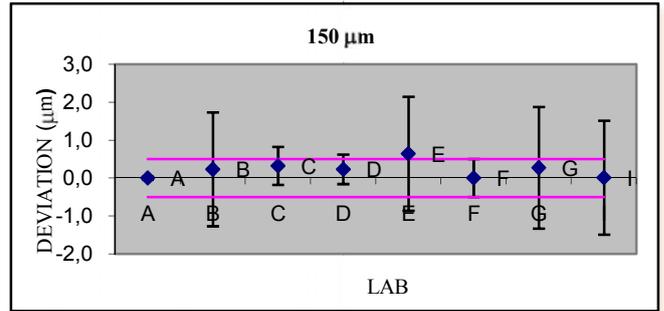


Fig. 7. Deviation of Participants from the Pilot for 150 μm nominal value

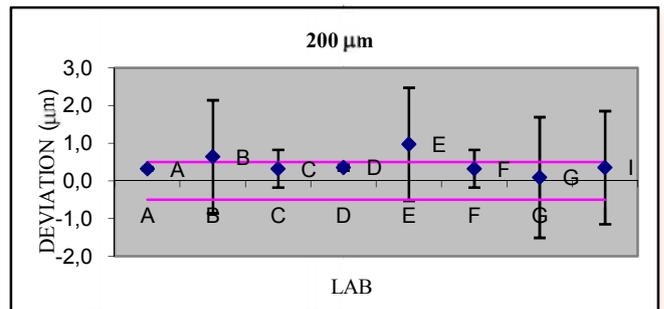


Fig. 8. Deviation of Participants from the Pilot for 200 μm nominal value

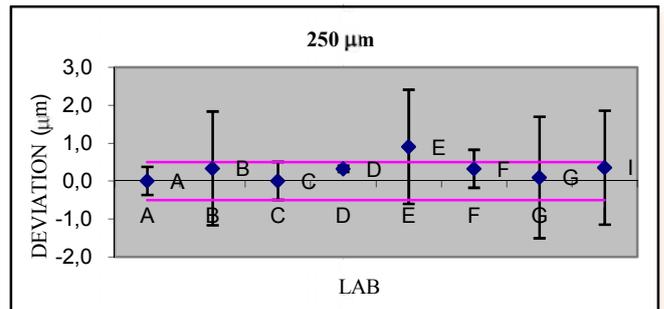


Fig. 9. Deviation of Participants from the Pilot for 250 μm nominal value

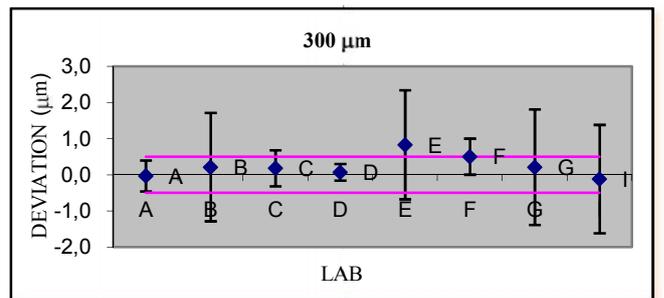


Fig. 10. Deviation of Participants from the Pilot for 300 μm nominal value

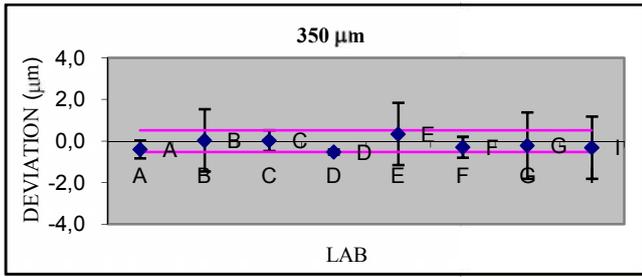


Fig. 11. Deviation of Participants from the Pilot for 350 µm nominal value

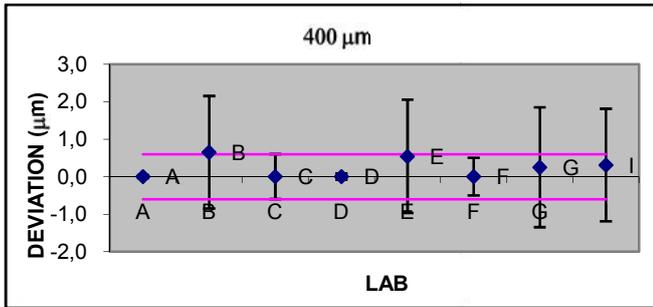


Fig. 12. Deviation of Participants from the Pilot for 400 µm nominal value

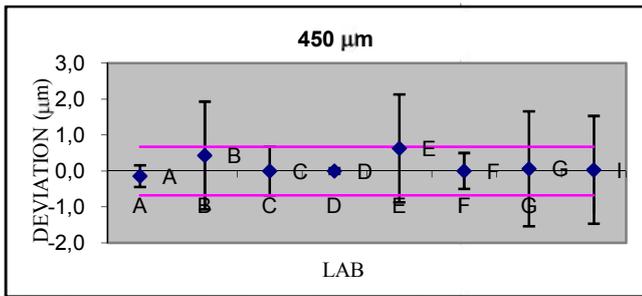


Fig. 13. Deviation of Participants from the Pilot for 450 µm nominal value

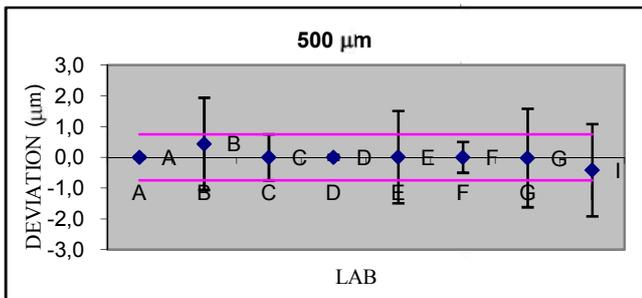


Fig. 14. Deviation of Participants from the Pilot for 500 µm nominal value

Table 3. E_n Values Between Participants and Pilot for Calibration with Hardness Reference Blocks

Scale	Hardness Value	E_n Values with respect to UME								
		A	B	C	D	E	F	G	H	I
HRC	25,04	0,8	0,7	0,8	0,6	0,7	0,5	0,4	0,8	0,6
	45,50	1,0	0,9	0,9	0,7	0,6	0,8	0,4	1,0	0,9
	64,36	1,0	0,9	1,0	0,6	0,6	0,3	0,3	1,0	0,8
HV1	210,50	0,5	0,5	0,1	0,1	0,2	0,1	0,7		1,3
	524,10	0,2	0,2	0,2	0,1	0,1	0,4	0,2		0,3
	823,50	0,1	0,0	0,1	0,3	0,0	0,5	0,2		

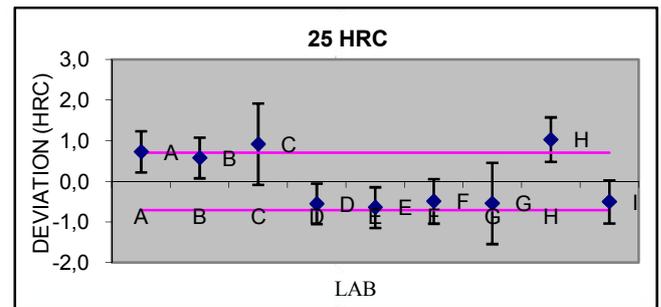


Fig. 15. Deviation of Participants from the Pilot for 25 HRC nominal value

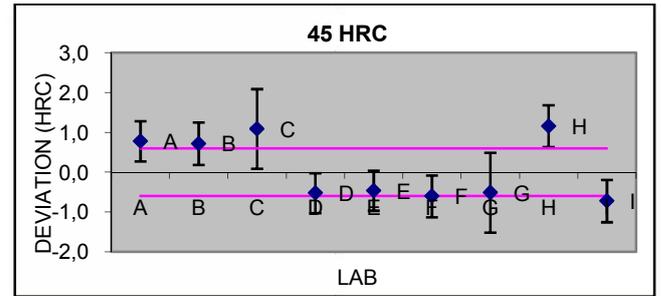


Fig. 15. Deviation of Participants from the Pilot for 45 HRC nominal value

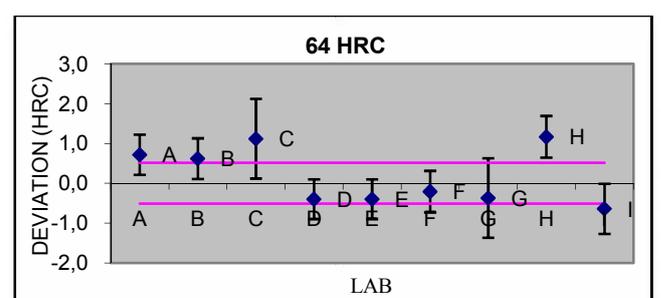


Fig. 16. Deviation of Participants from the Pilot for 64 HRC nominal value

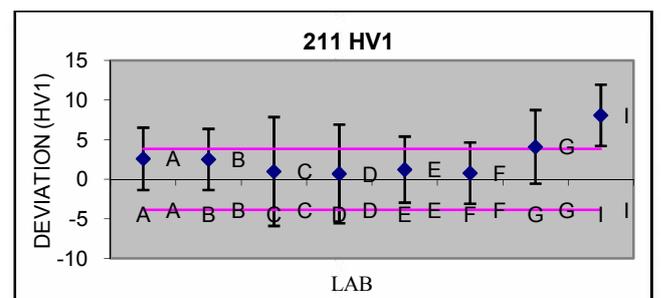


Fig. 17. Deviation of Participants from the Pilot for 211 HV1 nominal value

4.3. Calibration of HTM Hardness Reference Blocks

For comparison of indirect calibration of HTM's two very commonly used hardness scales were preferred: HRC and HV1. Three hardness blocks each from high, middle and low hardness ranges were selected. Five hardness measurements were performed on each block and deviation and uncertainty values declared by the participants. Below E_n number and graphical views of the declared results are given.

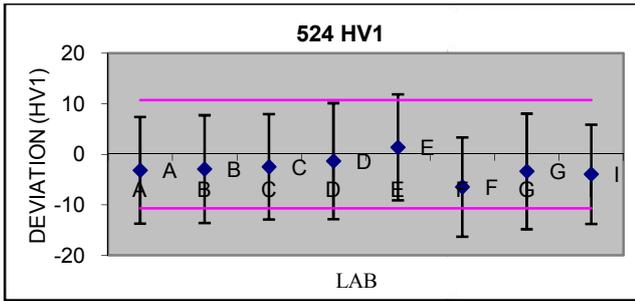


Fig. 18. Deviation of Participants from the Pilot for 524 HV1 nominal value

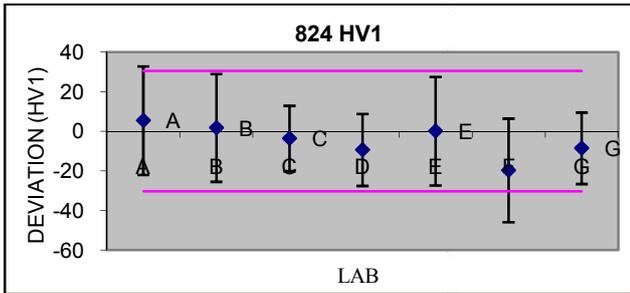


Fig. 19. Deviation of Participants from the Pilot for 824 HV1 nominal value

5. COCNLUSION

At the end of an in interlaboratory comparison organized for first time in Turkey by UME Hardness Laboratory, the following results are attained:

- 10 participant laboratory, including the pilot, took part in the comparison .
- In force, HRB and HBW 2,5/187,5 scales were calibrated. Indentation measurement system was calibrated for 0 mm – 0,5 mm. Calibration with hardness reference blocks were made in HV1 and HRC scales
- One participant could not make measurement in HV1 scale
- Calculated E_n was ≤ 1 for all except for one participant.
- It was a very good practice for accredited laboratories to compare and correct themselves for small errors.

6. REFERENCES

- [1] EN ISO/IEC 17043: 2010. Conformity assessment - General requirements for proficiency testing.
- [2] EN ISO 6508-1: 2005. Metallic Materials – Rockwell Hardness Test - Part1: Test Method (scales A, B, C, D, E, F, G, H, K, N, T).
- [3] EN ISO 6508-2: 2005. Metallic Materials - Rockwell Hardness Test - Part2: Verification and Calibration of Testing Machines (scales A, B, C, D, E, F, G, H, K, N, T).

[4] EN ISO 6506-1: 2005. Metallic Materials - Brinell Hardness Test - Part1: Test Method.

[5] EN ISO 6506-2: 2005. Metallic Materials - Brinell Hardness Test - Part2: Verification and Calibration of Testing Machines.

[6] EN ISO 6507-1: 2005. Metallic Materials - Vickers Hardness Test - Part1: Test Method.

[7] EN ISO6507-2: 2005. Metallic Materials - Vickers Hardness Test - Part2: Verification and Calibration of Testing Machines.

[8] EURAMET/cg-16/v.01:2007. Guidelines on the Estimation of Uncertainty in Hardness Measurements