

INTERLABORATORY COMPARISON ON CALIBRATION OF DUROMETERS OF TYPES "A" AND "D" IN TURKEY

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Abstract – Many accredited calibration laboratories in Turkey have extended their calibration scopes and begun to serve calibration of durometers as a result of clients' demand. Interlaboratory comparison is one of the best ways for assuring the quality of the calibration results and a proof of the dissemination of the SI units to industry for accredited calibration laboratories. 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 durometers type A and D, the very widely used rubber hardness measurement methods in Turkey. Besides UME, 6 accredited laboratories participated in the comparison and E_n numbers for all ranges and measured quantities between the pilot and each participating laboratory were evaluated. In this paper the comparison method and results are explained.

Keywords: Shore A, Shore D, interlaboratory, comparison, hardness, durometer.

1. INTRODUCTION

An interlaboratory comparison was organized with a co-operation between UME and TURKAK to provide a manner for accredited calibration laboratories for assuring their technical proficiency and calibration results' quality as a requirement of ISO 17025 item 5.9. A total of 7 calibration laboratories, including the pilot, participated in the comparison which was piloted by UME Hardness Laboratory with the support of UME Dimensional Laboratory. Two durometers were supplied by UME and all participants were requested to realize their calibrations in their own laboratories.

In this organization it was planned to realize comparison of;

1. calibration of indenter spring force
2. calibration of indenter and pressure foot geometry
 - a. indenter cone angle
 - b. indenter shaft diameter
 - c. pressure foot hole diameter
 - d. indentation depth

- e. indenter cone frustum top diameter (for Shore A)
- f. pressure foot diameter
- g. indenter tip radius (for Shore D)

After the pilot laboratory finished its first measurements, every laboratory made its own measurements with its own reference devices and filled the measurement results forms prepared by the pilot laboratory and declared their measurement results and uncertainties. At the end the pilot laboratory realized its second measurement and the measurements for type A and type D durometers were completed.

2. COMPARISON PROCEDURE

The comparison procedure was prepared in accordance with requirements of EN ISO 18898 [3] standard and availabilities of the calibration laboratories. As a result the following calibration procedure was decided for comparison.

2.1. Calibration of Durometer Spring Force

As a part of durometer calibration, durometer spring force is calibrated by reference force measuring devices such as load cells or laboratory balance. In the comparison it was decided to perform comparison of Shore A and Shore D which corresponds to 8050 mN and 44500 mN for 100 Shore unit, respectively. First measurements of force were done by the pilot laboratory (UME) and then each participating laboratory made its own measurements and the pilot again at the end. Three force measurements were made for each hardness value in increasing order from 10 Shore unit to 100 Shore unit at every 10 Shore unit which makes a total of 30 force measurements for 10 force steps, for Shore A and Shore D durometers. All measurements and ambient conditions were recorded onto the data sheet prepared by pilot laboratory. Calculations of the results and uncertainties were made at participant laboratories places and the results were sent to the pilot laboratory.

2.2. Calibration of Indenter and Pressure Foot Geometry

Second part of comparison was the calibration of indenter and pressure foot dimensional properties

measurements. At this part of the comparison UME Dimensional Laboratory took part in the comparison measurements and gave its support. In UME measurements a profile projector is used as a reference device for dimensional measurements. In the comparison each of indenter and indenter shaft diameter at three different heights, cone frustum top diameter, cone angle, pressure foot diameter, pressure foot hole diameter, indentation depth and indenter tip radius were decided to be measured 5 times and the calculations were made accordingly. In this measurement also the pilot made its measurement twice; at the beginning and at the end.

3. ANALYZING MEASUREMENT RESULTS

In analyzing the results first the reference value is calculated by taking the mean value of the Pilot Laboratory's two measurements 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 $E_n > 1$ are accepted as unsatisfactory. This way of assessment was applied to every value of force, each geometrical parameter of the indenter and pressure foot.

4. COMPARISON RESULTS

In the graphical representations, the x-axis represents the pilot lab value, accepted as 0, and the deviations represent deviation of participants from the pilot for each laboratory, A to F. The pink lines show uncertainty of the pilot laboratory and uncertainty of the participating laboratories are declared in the bar style for each deviation.

4.1. Calibration of Durometer Spring Force

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

Table 1. E_n Values Between Participants and the Pilot for Shore A Durometer Force Measurements

Shore Hardness Unit	H_A (Shore A)	Participating Lab. – Pilot Lab E_n Values					
		A	B	C	D	E	F
10		0,56	0,79	0,04	0,32	0,14	0,02
20		0,43	0,98	0,01	0,75	0,07	0,03
30		0,42	0,80	0,02	0,81	0,22	0,02
40		0,28	0,72	0,10	0,20	0,28	0,01
50		0,34	0,58	0,08	0,35	0,27	0,03
60		0,07	0,90	0,21	0,55	0,15	0,00
70		0,23	0,66	0,22	0,80	0,31	0,05
80		0,27	0,59	0,18	0,98	0,23	0,07
90		0,15	0,85	0,13	0,39	0,13	0,17
100		0,23	0,63	0,28	0,45	0,31	0,15

Table 2. E_n Values Between Participants and the Pilot for Shore D Durometer Force Measurements

Shore Hardness Unit	H_D (Shore D)	Participating Lab. – Pilot Lab E_n Values					
		A	B	C	D	E	F
10		0,36	0,68	0,06	0,03	0,11	0,02
20		0,14	0,73	0,03	0,66	0,08	0,09
30		0,10	0,87	0,01	0,50	0,05	0,00
40		0,31	0,86	0,01	0,24	0,24	0,03
50		0,06	0,93	0,06	0,17	0,29	0,05
60		0,07	0,98	0,10	0,05	0,38	0,03
70		0,15	0,97	0,02	0,53	0,55	0,04
80		0,02	0,96	0,14	0,86	0,69	0,02
90		0,03	0,95	0,22	0,52	0,79	0,06
100							

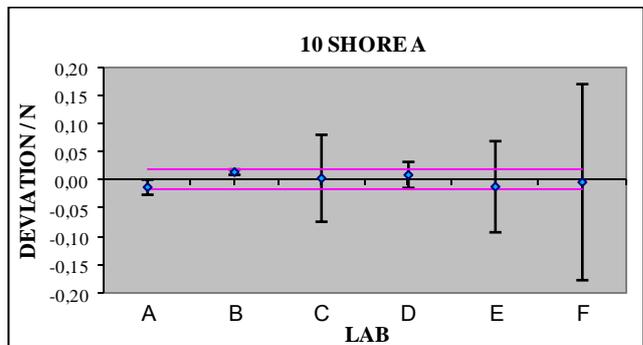


Fig. 1. Deviation of Participants from the Pilot for 10 Shore A

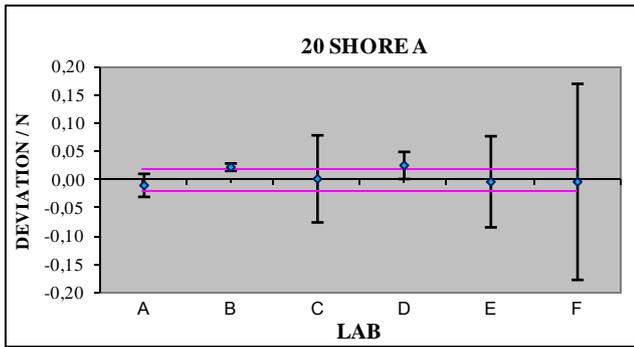


Fig. 2. Deviation of Participants from the Pilot for 20 Shore A

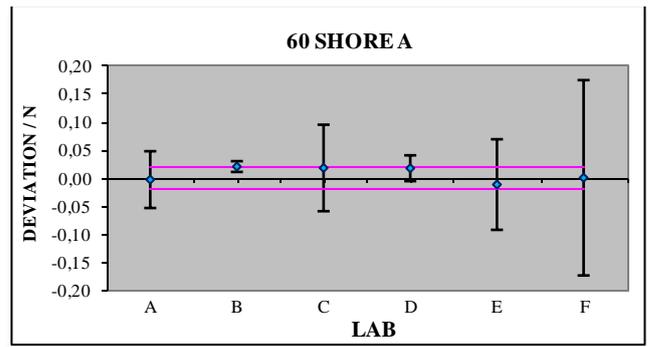


Fig. 6. Deviation of Participants from the Pilot for 60 Shore A

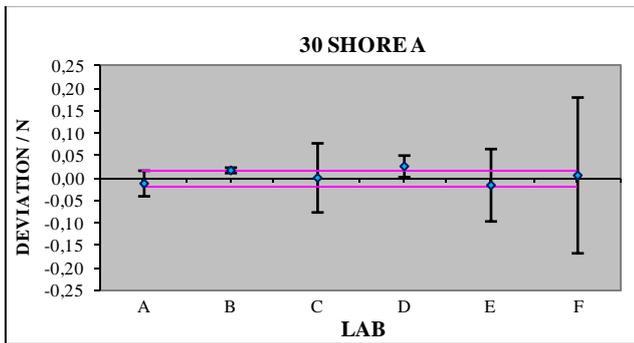


Fig. 3. Deviation of Participants from the Pilot for 30 Shore A

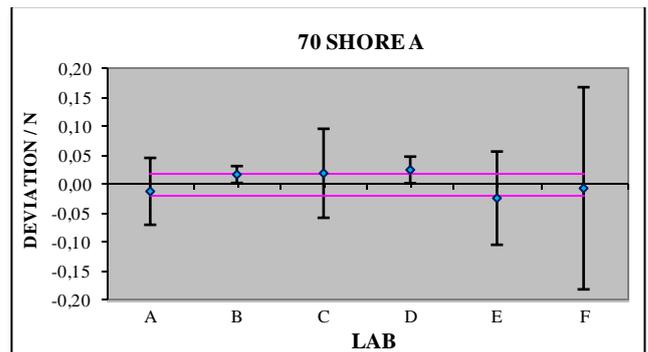


Fig. 7. Deviation of Participants from the Pilot for 70 Shore A

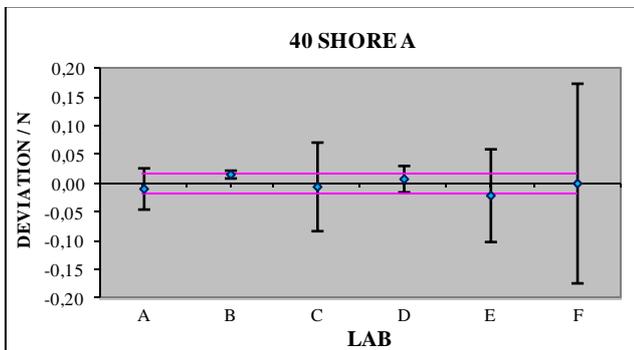


Fig. 4. Deviation of Participants from the Pilot for 40 Shore A

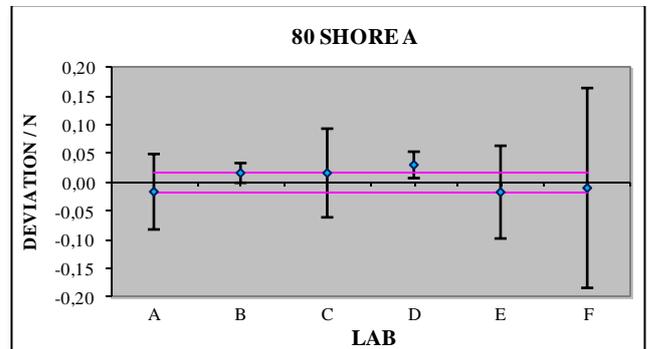


Fig. 8. Deviation of Participants from the Pilot for 80 Shore A

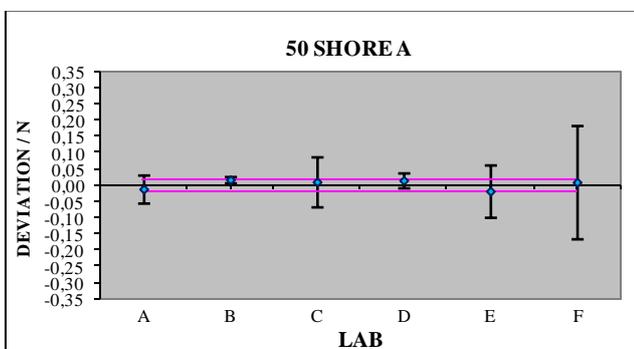


Fig. 5. Deviation of Participants from the Pilot for 50 Shore A

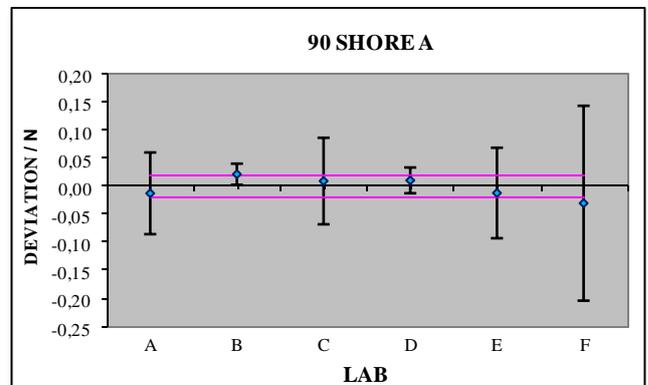


Fig. 9. Deviation of Participants from the Pilot for 90 Shore A

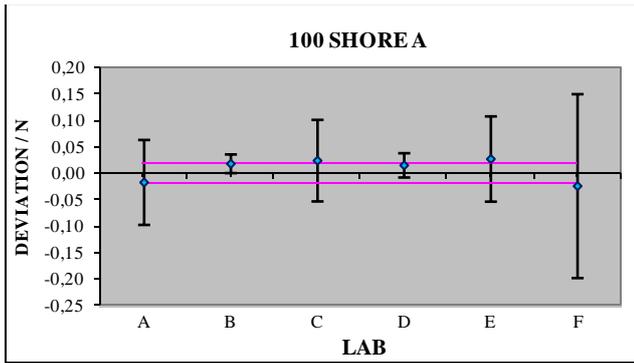


Fig. 10. Deviation of Participants from the Pilot for 100 Shore A

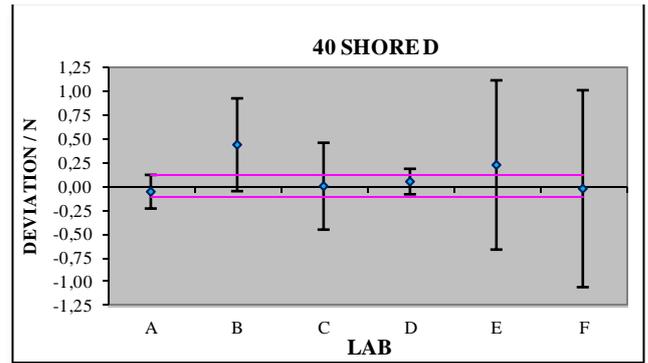


Fig. 14. Deviation of Participants from the Pilot for 40 Shore D

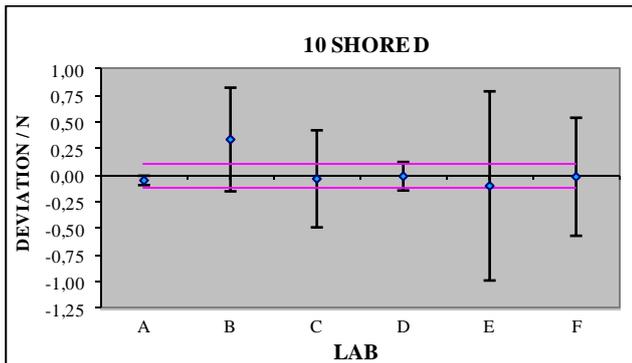


Fig. 11. Deviation of Participants from the Pilot for 10 Shore D

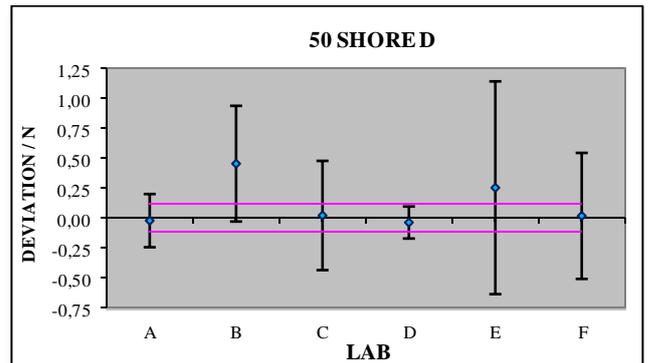


Fig. 15. Deviation of Participants from the Pilot for 50 Shore D

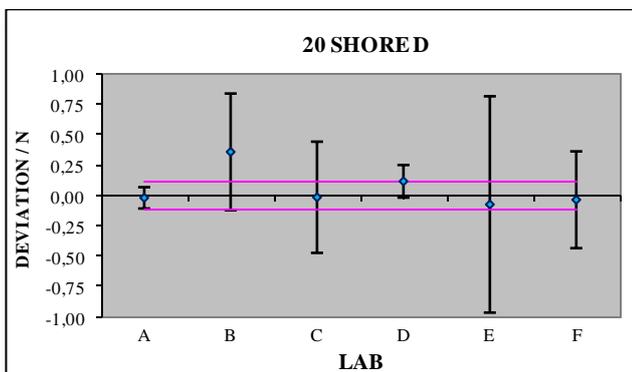


Fig. 12. Deviation of Participants from the Pilot for 20 Shore D

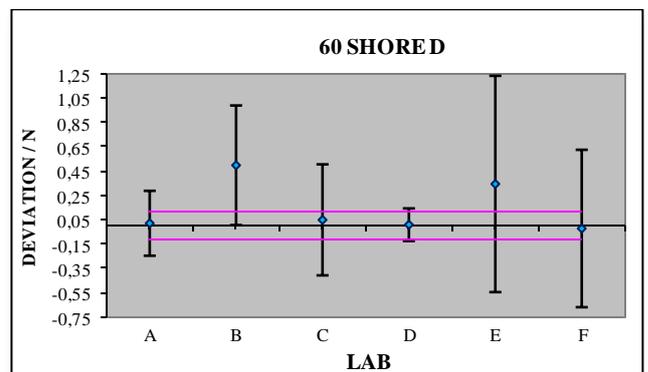


Fig. 16. Deviation of Participants from the Pilot for 60 Shore D

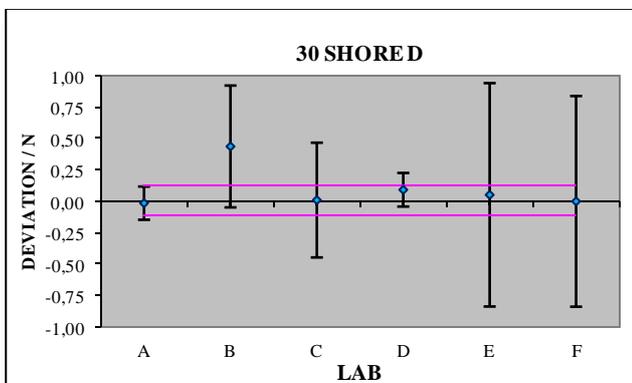


Fig. 13. Deviation of Participants from the Pilot for 30 Shore D

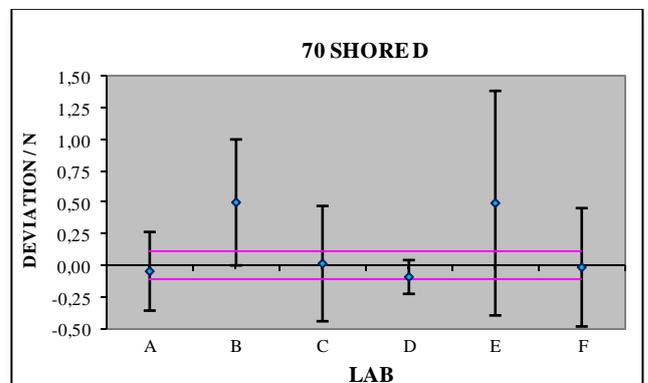


Fig. 17. Deviation of Participants from the Pilot for 70 Shore D

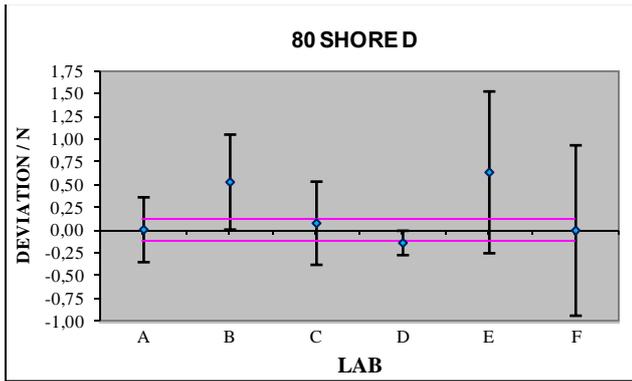


Fig. 18. Deviation of Participants from the Pilot for 80 Shore D

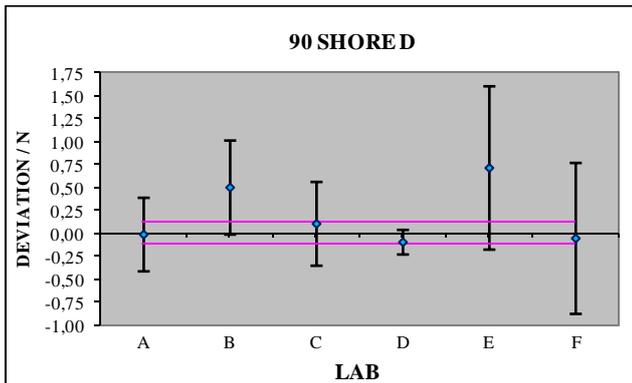


Fig. 19. Deviation of Participants from the Pilot for 90 Shore D

4.2. Calibration of Indenter and Pressure Foot Geometry

Calibration results of geometrical properties of the indenter and pressure foot in accordance with EN ISO 18898 [3] standard, E_n numbers and graphical views of the declared results are given.

Table 3. E_n Values Between Participants and the Pilot for Shore A Durometer Indenter and Pressure Foot Geometrical Measurements

Indenter and pressure foot dimensional measurements	Participating Lab. – Pilot Lab E_n Values					
	A	B	C	D	E	F
Cone angle	0,8	1,0	0,7	0,4	0,3	0,6
Indenter shaft diameter	0,7	0,6	0,4	0,2	0,1	0,9
Pressure foot hole diameter	0,1	0,9	0,9	0,1	0,9	0,6
Indentation depth	0,8	0,2	0,8	0,2	0,2	1,0
Cone frustum top diameter	0,1	0,4	0,2	0,4	0,0	0,3
Pressure foot diameter	1,6	0,7	0,1	0,3	0,6	0,3

Table 4. E_n Values Between Participants and the Pilot for Shore D Durometer Indenter and Pressure Foot Geometrical Measurements

Indenter and pressure foot dimensional measurements	Participating Lab. – Pilot Lab E_n Values					
	A	B	C	D	E	F
Cone angle	0,3	0,6	1,0	0,2	0,3	0,6
Indenter shaft diameter	0,1	0,1	0,4	0,2	0,1	3,0
Pressure foot hole diameter	0,9	0,1	0,0	0,4	1,0	0,4
Indentation depth	1,7	0,2	1,0	0,4	2,1	0,4
Indenter tip radius	0,1	0,1	0,1	0,5	0,1	0,5
Presser foot diameter	0,9	0,6	0,1	0,1	1,0	0,1

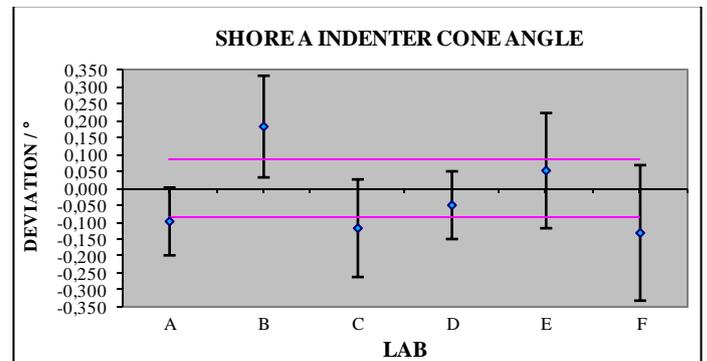


Fig. 20. Deviation of Participants from the Pilot for indenter cone angle

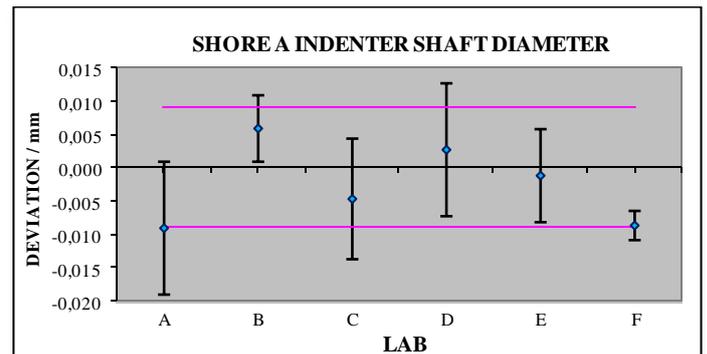


Fig. 21. Deviation of Participants from the Pilot for indenter shaft diameter

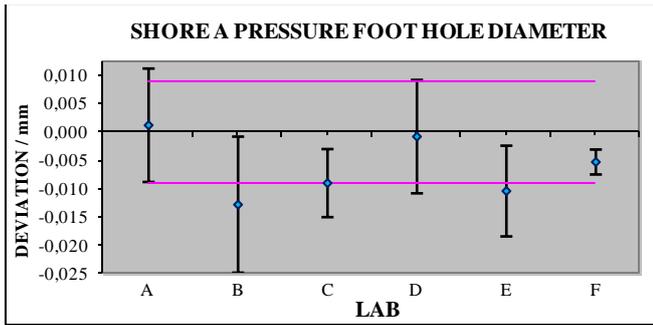


Fig. 22. Deviation of Participants from the Pilot for pressure foot hole diameter

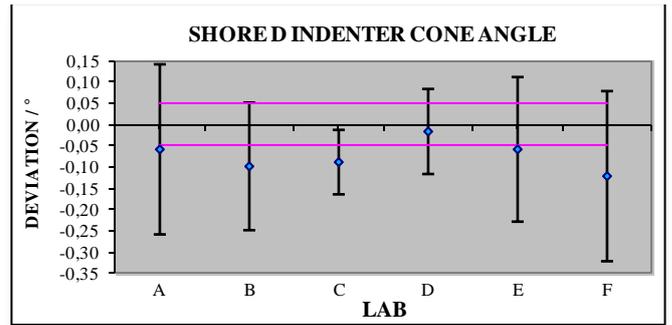


Fig. 26. Deviation of Participants from the Pilot for indenter cone angle

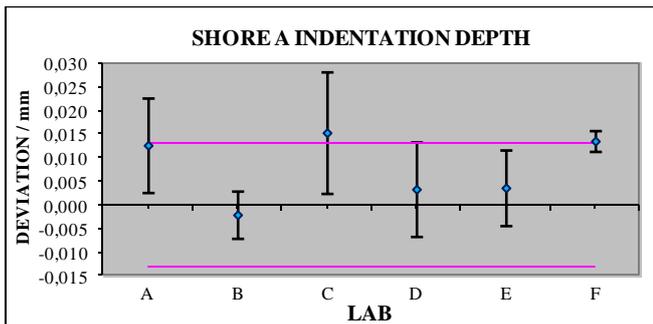


Fig. 23. Deviation of Participants from the Pilot for indentation depth

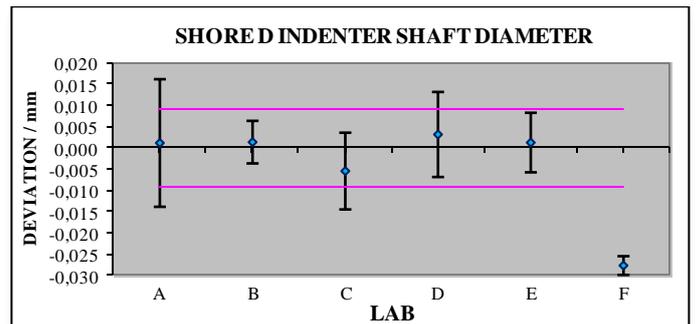


Fig. 27. Deviation of Participants from the Pilot for indenter shaft diameter

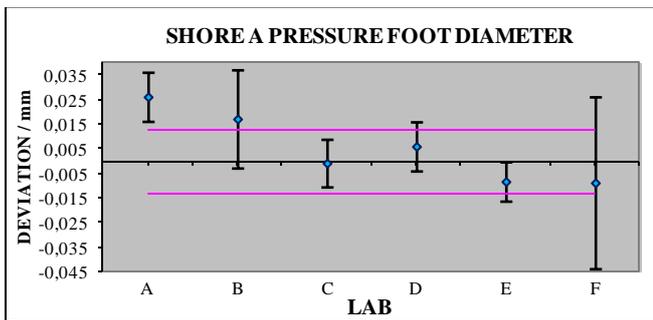


Fig. 24. Deviation of Participants from the Pilot for pressure foot diameter

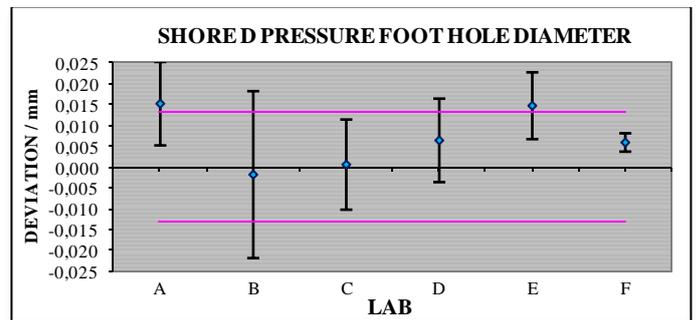


Fig. 28. Deviation of Participants from the Pilot for pressure foot hole diameter

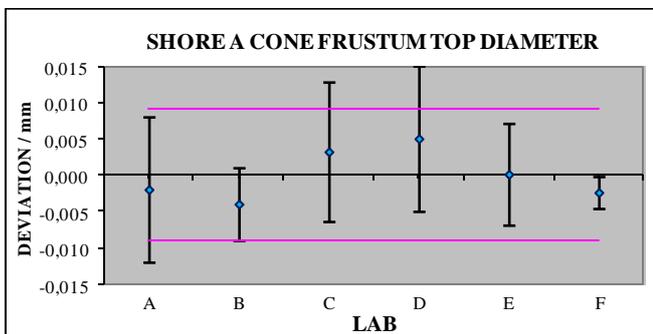


Fig. 25. Deviation of Participants from the Pilot for Cone frustum top diameter

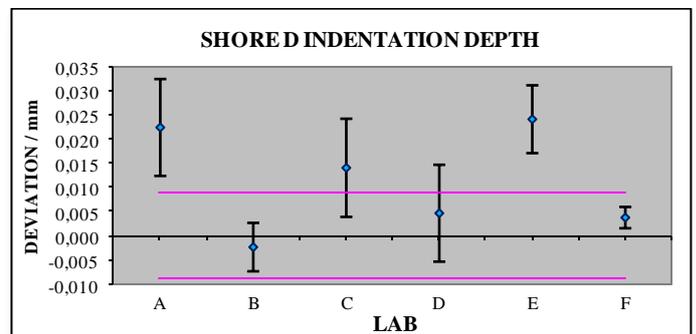


Fig. 29. Deviation of Participants from the Pilot for indentation depth

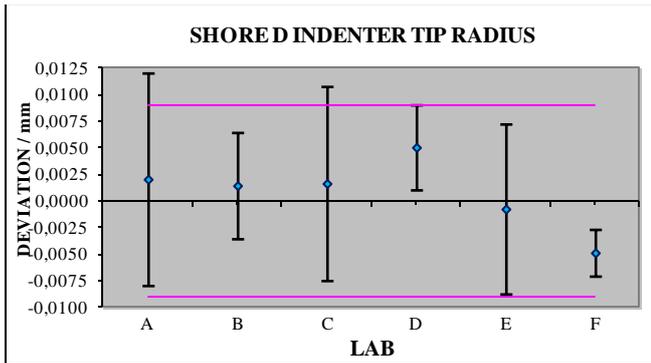


Fig. 30. Deviation of Participants from the Pilot for indenter tip radius

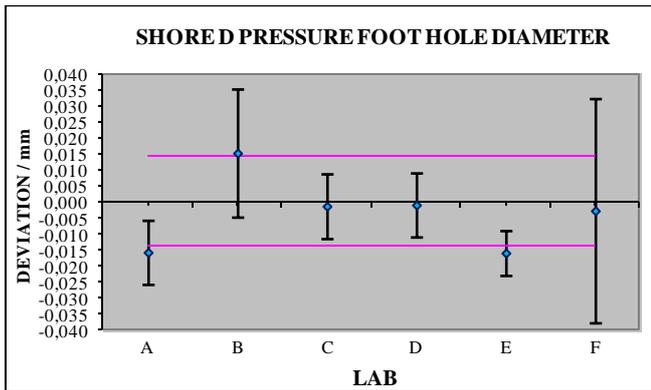


Fig. 31. Deviation of Participants from the Pilot for pressure foot hole diameter

5. COCNLUSION

There were a total of 7 participating laboratories interested in the interlaboratory comparison for calibration of durometers. At the end of the comparison organized for first time by UME Hardness Laboratory, the following results are attained:

- There were a consistency in force measurements
- The inconsistencies were about dimensional measurements
- Participant laboratories were not able to make measurements at 100 Shore D
- Calculated E_n was ≤ 1 for all except for 4 results
- 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] EURAMET/cg-16/v.01:2007. Guidelines on the Estimation of Uncertainty in Hardness Measurements
- [3] EN ISO 18898. Rubber – Verification and Calibration of Hardness Testers
- [4] EN ISO 868. Plastics and ebonite – Determination of indentation hardness by Means of a Durometer (Shore Hardness)