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THE EVALUATION of INTERLABORATORY COMPARISON IN HYDRAULIC PRESSURE REGION

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Abstract:
Inter laboratory studies serve several needs and aspects of the quality management of measuring measurements. Inter laboratory comparisons are important for the laboratories to assess their own measurement capability.
In this paper, results of the inter laboratory comparisons in pressure metrology at two measurement scopes are presented. The artefacts used for these inter laboratory measurement scopes are analogue and digital manometers in hydraulic pressure and 250 bar and 700 bar ranges. Also 12 different laboratories joined as participant and these laboratories made more than 12 measurements in two different measurement scopes.

Keywords: Pressure, inter laboratory comparison, manometer

1. INTRODUCTION

Measurement underpins a wide range of socio-economic activities, both domestic and international. The global market needs accurate and reliable measurements so that technical barriers to trade can be minimized. In all sectors, the need for reliable measurement results that can be compared across space and time has never been greater. Reliable measurements depend critically on competent staff, validated and tested methods, comprehensive quality systems, and traceability to appropriate measurement references. Recognition of these requirements is underscored by the increasing adoption of standards and measurement quality systems, such as laboratory accreditation against EN ISO/IEC 17025. [2],[3]

The inter laboratory comparisons are quite important tool for test and calibration laboratories to assuring the quality of test and calibration results. The laboratories allow the validation of measuring methods, assessing the proficiency of individual laboratories, estimating measurement uncertainty and certifying reference materials in a wide range of application fields. As per accreditation rules, it is mandatory for the testing and calibration laboratories to participate in such comparisons time to time. [1]

A survey was conducted through the calibration laboratories to determine the comparison scope. As a result of this survey, it was decided to arrange a multi-scope inter laboratory comparison in hydraulic pressure media covering two types of instruments and 250 bar and 750 bar ranges.

2. THE SCOPE OF MEASUREMENT OF INTER LABORATORY COMPARISON

Comparison scope covers two different pressure measurement ranges and two different type of instruments. These were analog and digital manometers in different pressure measuring ranges at 0-250 bar and 0- 700 bar in hydraulic media.

The instruments used as transfer standards in the comparison are shown in Figure 1 and Figure 2.

Figure 1. Digital manometer

Figure 2. Analog manometer

Participant laboratories usually used pressure calibrators for measurement except the calibrator calibration scope. For the calibrator calibration laboratories used pressure balances or the calibrators with high accuracies.
7 calibration laboratories participated in the analog manometer (250 bar range) comparison and 5 calibration laboratories participated in the digital manometer (700 bar range) comparison.

3. THE METHOD OF MEASUREMENTS

Since many participants and scopes were available for comparison, to prevent any complication that could be able to appeared due to the some drifts of instruments, star type inter laboratory comparison method was selected. TUBITAK UME (National Metrology Institute of Turkey) Pressure Laboratory was the pilot laboratory. Inter laboratory comparison was carried out according to the schedule specified in the technical protocol. In star type measurement, the pilot laboratory calibrated the transfer instrument first than it was sent to the participant and after participant had completed its calibration, the pilot laboratory made transfer calibration again. This means, before and after for every participant measurements, pilot laboratory measured the transfer standard once more. This method allowed us to determine the possible drifts between measurements if available.

4. THE EVALUATION OF MEASUREMENT RESULTS

The participant laboratories made their measurements according to the method which had already used to declare the uncertainty values for their own best measurement capability. Evaluations carried out based on comparison scopes one by one. E_n values and error values are calculated at every calibration point specified in the technical protocol for every comparison scope for each laboratory. [4], [6]
If the measurements performed by pilot laboratory before the laboratory are labelled as pilot_1 and after the laboratory as pilot_2, then the reference value is calculated as arithmetic mean of the these two measurements as follows;

$$Reference\_value = \frac{pilot\_1+pilot\_2}{2} \quad (1)$$

There were also some drift observed between the measurements due to obvious reasons. Difference between the results of pilot_2 and pilot_1 was named as “drift” value which is calculated as follows;

$$Drift\_value = pilot\_2-pilot\_1 \quad (2)$$

The impact of thus calculated drift value was taken into consideration while calculating results. Because of the drifts in measurements, participant laboratory error value was not put directly in to E_n formula. Instead of this, first of all, “laboratory corrected value” was calculated by means of subtracting half of the drift value from the laboratory error value. Since the laboratory measured the instrument in between the pilot_1 and pilot_2, half of the drift value was used when calculating the laboratory corrected value given in equation 3.

$$Lab.corrected\_value = lab.\_error\_value - \frac{drift}{2} \quad (3)$$

The normalized error E_n – values were calculated as shown in the equation 4.

$$En = \frac{reference\_value-labcorrected\_value}{\sqrt{U_{ref}^2+U_{lab}^2}} \quad (4)$$

Where U_{ref} refers to reference uncertainty value at coverage factor of k=2 and U_{lab} refers to the laboratory uncertainty value at coverage factor of k=2 level.

$$En = \frac{reference\_value-labcorrected\_value}{\sqrt{U_{ref}^2+U_{lab}^2+2*absolute(drift/\sqrt{3})}} \quad (5)$$

A laboratory result is regarded as equivalent with the reference value if the E_n – value is between -1 and +1.

5. THE RESULTS OF COMPARISON

Multi-scope inter laboratory comparison results were published in the final comparison report. [5]
Since there were many tables and graphs for error values versus pressure and E_n values versus pressure, here in this paper only E_n tables of laboratories and E_n values versus pressure graphs are given.

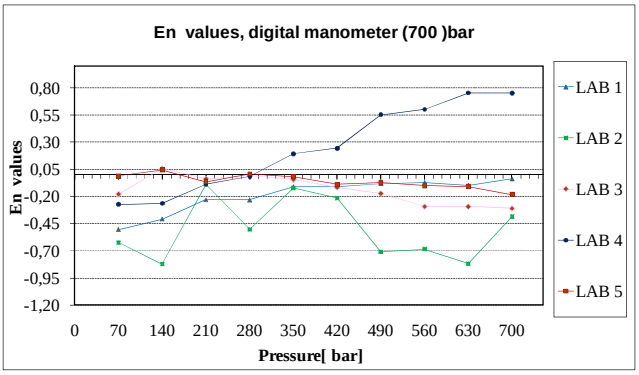

Figure 3. E_n values for digital manometer (700 bar)

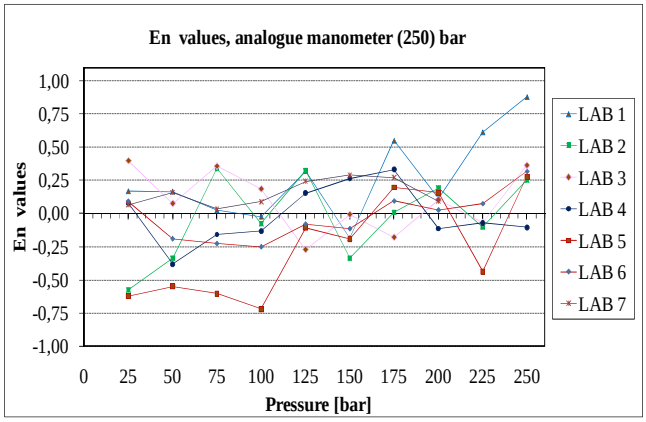

Figure 4. E_n values for analog manometer (250 bar)

Table 1. En values of the laboratories for the comparison scope digital manometer (700 bar)

E_n values, digital manometer (700) bar					
Nominal pressure (bar)	**Lab 1**	**Lab 2**	**Lab 3**	**Lab 4**	**Lab 5**
70	-0,50	-0,63	-0,18	-0,27	-0,01
140	-0,41	-0,82	0,06	-0,26	0,04
210	-0,23	-0,09	-0,04	-0,09	-0,06
280	-0,23	-0,50	-0,01	-0,02	0,01
350	-0,11	-0,12	-0,04	0,19	-0,02
420	-0,11	-0,21	-0,11	0,24	-0,09
490	-0,08	-0,71	-0,17	0,55	-0,07
560	-0,07	-0,68	-0,29	0,60	-0,10
630	-0,10	-0,82	-0,29	0,75	-0,11
700	-0,04	-0,39	-0,31	0,75	-0,18

Table 5. En values of the laboratories for the comparison scope analog manometer (250 bar)

E_n values, analogue manometer (250) bar							
Nominal pressure (bar)	**Lab 1**	**Lab 2**	**Lab 3**	**Lab 4**	**Lab 5**	**Lab 6**	**Lab 7**
25	0,17	-0,58	0,40	0,08	-0,62	0,09	0,07
50	0,17	-0,34	0,08	-0,38	-0,55	-0,19	0,16
75	0,02	0,34	0,36	-0,16	-0,60	-0,23	0,04
100	-0,03	-0,08	0,19	-0,13	-0,72	-0,25	0,09
125	0,32	0,32	-0,27	0,15	-0,11	-0,08	0,24
150	-0,19	-0,34	-0,01	0,27	-0,19	-0,11	0,29
175	0,55	0,01	-0,18	0,33	0,20	0,09	0,27
200	0,11	0,19	0,10	-0,11	0,16	0,03	0,09
225	0,61	-0,10	-0,07	-0,07	-0,44	0,07	-
250	0,88	0,25	0,36	-0,11	0,28	0,32	-

And also it could be given the graphics including error values versus laboratories at 250 bar and 700 bar for each instrument type.

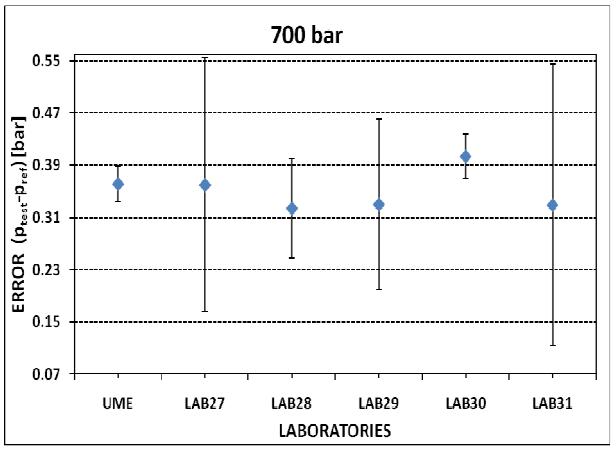

Figure 5. The error values of laboratories for 700 bar hydraulic pressure range.

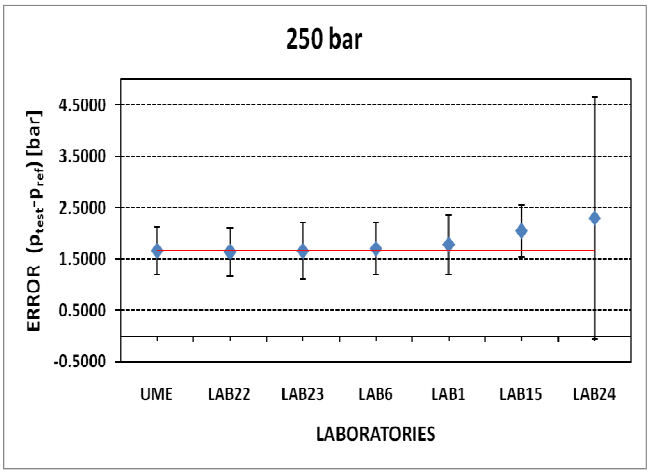

Figure 6. The error values of laboratories for 700 bar hydraulic pressure range.

6. CONCLUSION

A multi-scope inter laboratory comparison carried out to help and contribute assuring the quality of test and calibration results realized in the country by UME Pressure Laboratory.

Comparison organized for 2 different pressure areas which were analogue manometers up to ranges 250 bar pneumatic and digital manometer up to 700 bar hydraulic. The selected pressure ranges are common ranges for pressure calibrations although uncertainty requirements are generally not very high. 14 different calibration laboratories were participated in the comparison.

In the case of inspecting the accredited scopes of the participant laboratories, it is obviously seen that laboratories did not apply the comparison for all accredited quantities in their accreditation scope.

Since there were many participant laboratory made star type measurements in 2 different scopes, huge amount of measurement data produced during the comparison. So, it was very important point in terms of reliability of the

comparison results that picking up the measurement results from participant laboratories correctly.
Finally, this comparison is expected to create consciousness on pressure measurements in the country. We believe that it presented some opportunities to the participants to determine their necessities in terms of technical employee, trainings, and improve measurement methods and measurement capacity of the laboratory.

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