Final Report of

EURAMET 1197

SUPPLEMENTARY BILATERAL COMPARISON OF HYDRAULIC GAUGE PRESSURE STANDARDS UP TO 50 MPa

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Abstract

Inter laboratory comparisons are important for the laboratories to assess their own measurement capability. It is equally important for the accreditation bodies and assessors during the audit process of laboratory to judge whether the laboratory is doing well. As per accreditation rules, it is mandatory for the testing and calibration laboratories to participate in such comparisons time to time.

In this report, results of the bilateral inter laboratory comparison in pressure area in hydraulic media up to 50 MPa gauge are presented. The artefact used for the comparison is a digital pressure calibrator.

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1 Introduction

The inter laboratory comparisons are quite important tool for test and calibration laboratories to assuring the quality of test and calibration results.[1] It is useful to demonstrate the technical competence of test and calibration laboratories. A calibration laboratory establishes traceability of its own measurement standards and measuring instruments to the SI by means of an unbroken chain of calibrations or comparisons linking them to relevant primary standards of the SI units of measurement.[3] Test and calibration laboratories especially the accredited laboratories present their services to the customer according to a quality standard. Both types of laboratories are expected to participated in inter laboratory comparisons with multi participants to show and declare their service quality. According to the EN ISO/IEC 17025 international standard [3], it is a necessity for both accredited laboratories and the other laboratories to join into inter laboratory comparisons and to get acceptable results for each measurement quantity parameter for their declared calibration scope.

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2 Participants and their standards

UME

UME is the pilot laboratory in this comparison. The reference standard of UME used in this comparison was a DH Budenberg 5306 pressure balance equipped with a piston/cylinder assembly serial no 8254. The effective area of the piston/cylinder unit was determined with pressure measurements at UME in February 2011 (certificate G2BA-0018). The pressure measurements of UME are traceable to LNE.

The effective area of the piston/cylinder unit is nominally (19,61 ± 5,10E-04) mm^2. The distortion coefficient of piston/cylinder unit is (0,56E-06 ± 0,09E-06) MPa^{-1}.

The 100 kg weight set DH Budenberg serial no 3387 was used and it was calibrated at UME in December 2010 – January 2011 (certificate G2BA-0001).

BoM

The reference standard of BoM was a DH-Budenberg 580 pressure balance serial no 580/28477. The effective area of the piston/cylinder assembly type 580DX and serial no 830H is traceable to EIM (Hellenic Institute of Metrology, the latest certificate PRE-10-058_A, dated 09-13.09.2011).

The effective area of the piston/cylinder unit is nominally (80,65 ± 4,30E-04) mm^2. The distortion coefficient of piston/cylinder unit is (1,5E-06 ± 1,1E-06) MPa^{-1}.

3 Transfer standard

Transfer standard used was a digital pressure gauge Druck DPI 615 external sensor serial no 1736804. The transfer standard was made available by TÜBİTAK UME.

The nominal pressure range of the external sensor is from 0 bar to 500 bar in the gauge mode. The resolution was 0,01 bar.

4 Measurement instructions

The measurement instructions were given in the measurement protocol dated July 2011.

The nominal pressure points to be measured were 0 bar, 50bar, 100 bar, 150 bar, 200 bar, 250 bar, 300 bar, 350 bar, 400 bar, 450 bar and 500 bar.

A minimum stabilization time of 2 hours was specified with the mains power switch on and the pressure connection opened to the atmosphere.

The results in increasing and decreasing directions were treated separately to minimise hysteresis effects. For the same reason it was stated that the pressure on the transfer standard should not be set to zero between successive nominal pressures.

The results were to be presented as average deviations and measurement uncertainties with coverage factor k=2 at each nominal pressure.

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5 Measurements and the presentation of results

The measurements were carried out two times at UME and once at BoM according to the following schedule:

UME (1)	13.07.2011
BoM	14.10.2011
UME (2)	04.11.2011

BoM submitted its results in excel sheets by e-mail to the pilot laboratory.

The result set from the first measurement at UME(1) was used for the comparison. The other UME measurement which is UME(2) was used to calculate the drift value and to control the stability of the transfer standard. Drift value is calculated as in formula (1) and given in Table 1 for each calibration points.

$$X_{drift} = [UME\ (2) - UME\ (1)] \qquad (1)$$

6 Results and equivalence with the reference values

Reference values

The first measurement values of UME which is UME(1) including deviations from reference values and uncertainty values at each calibration point, were used as the reference values for the comparison. These results are given in Table 1.

Equivalence with the reference values

En value is calculated for each calibration point in the comparison based on formula (2). A laboratory result is regarded as equivalent with the reference value if the En value is between -1 and +1. [2]

$$En = \frac{X_i - X_{ref}}{\sqrt{U_{xi}^2 + U_{xref}^2 + U_{drift}^2}} \qquad (2)$$

Note: Uncertainties considered as expanded uncertainty values at k=2 confidence level in formula (2).

Participant laboratory's corrected deviation value is calculated as in formula (3);

$$X_i = X_p - (X_{drift} / 2) \qquad (3)$$

Drift uncertainty calculation is calculated as in formula (4);

$$u_{drift} = \frac{X_{drift}}{2\sqrt{3}} \qquad (4)$$

Where,

En	: Normalised error
X_i	: Participant laboratory corrected deviation value
X_{ref}	: Reference deviation value
U_{xi}	: Participant laboratory uncertainty value
U_{xref}	: Reference laboratory uncertainty value
U_{drift}	: Drift uncertainty value between the measurements of UME(1) and UME(2)
X_p	: Participant laboratory deviation value
X_{drift}	: Drift value between the measurements of UME(1) and UME(2)

Participant laboratory values

Participant laboratory uncertainties as well as the deviations from the reference values for each calibration point are shown in Table 1. The normalised error En values are also included in Table 1.

The reference deviation values and participant deviation values with uncertainties versus nominal pressures for both in increasing and decreasing directions are given in Figure 1 and Figure 2 respectively.

Also the drawn graph of En values versus pressure values for both in increasing and decreasing directions were given in Figure 3 and Figure 4 respectively.

Table 1. The Measurement Results

Nominal pressure P_{nom} (MPa)	Reference deviations X_{ref} (MPa)	Reference uncertainty *(k=2)* U_{xref} (MPa)	Drift X_{drift} (MPa)	Participant deviations X_p (MPa)	Corrected participant deviations X_i (MPa)	Participant uncertainty *(k=2)* U_{xi} (MPa)	Drift uncertainty *(k=2)* U_{drift} (MPa)	En
0,000	0,000	0,000	0,000	-0,001	-0,001	0,002	0,000	-
5,000	0,000	0,002	0,001	0,000	-0,001	0,002	0,001	0,19
10,000	0,002	0,001	0,001	0,001	0,000	0,003	0,001	0,56
15,000	0,004	0,001	0,001	0,004	0,003	0,004	0,001	0,18
20,000	0,007	0,002	0,001	0,006	0,005	0,005	0,001	0,28
25,000	0,011	0,002	0,001	0,011	0,010	0,006	0,001	0,22
30,000	0,014	0,002	0,001	0,014	0,012	0,007	0,001	0,24
35,000	0,019	0,002	0,000	0,016	0,016	0,009	0,000	0,35
40,000	0,023	0,002	0,001	0,020	0,019	0,010	0,001	0,44
45,000	0,027	0,002	0,001	0,026	0,025	0,011	0,001	0,19
50,000	0,030	0,002	0,002	0,027	0,026	0,012	0,001	0,35
50,000	0,030	0,002	0,002	0,027	0,026	0,012	0,001	0,34
45,000	0,027	0,002	0,001	0,023	0,022	0,011	0,000	0,44
40,000	0,022	0,002	0,001	0,021	0,020	0,010	0,001	0,17
35,000	0,018	0,002	0,001	0,016	0,015	0,009	0,001	0,32
30,000	0,014	0,002	0,001	0,013	0,012	0,007	0,001	0,23
25,000	0,010	0,002	0,001	0,009	0,008	0,006	0,001	0,32
20,000	0,006	0,002	0,001	0,007	0,006	0,005	0,001	0,05
15,000	0,003	0,001	0,001	0,004	0,003	0,004	0,001	0,02
10,000	0,001	0,001	0,001	0,002	0,001	0,003	0,001	0,07
5,000	-0,001	0,001	0,001	0,000	-0,001	0,002	0,001	0,16
0,000	0,000	0,000	0,000	-0,001	-0,001	0,002	0,000	-

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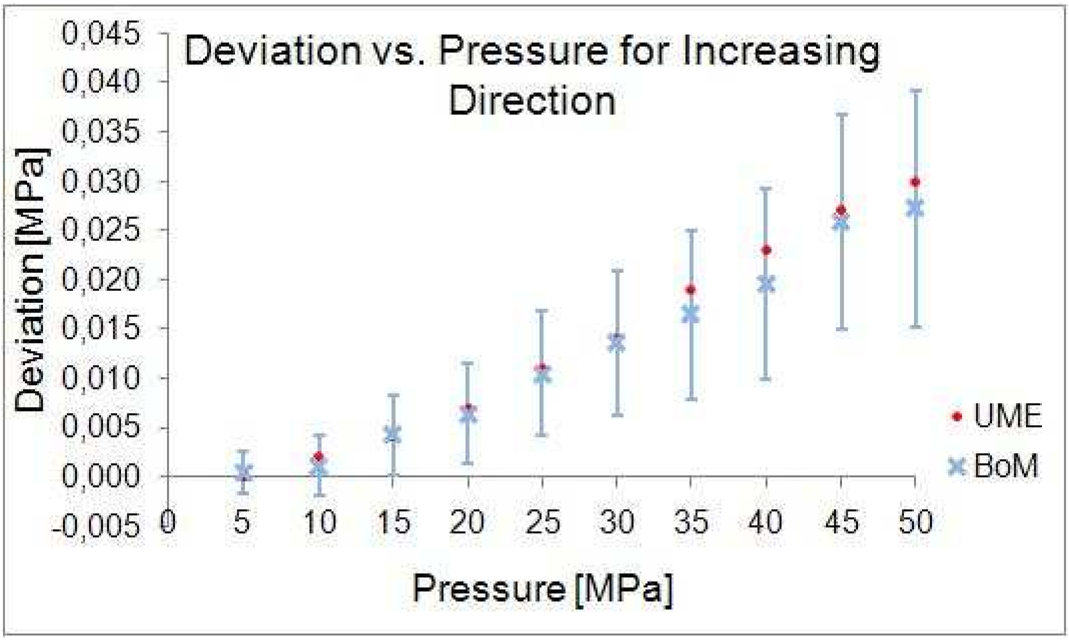

Figure 1. Deviations of reference and participant laboratories versus pressure for increasing direction

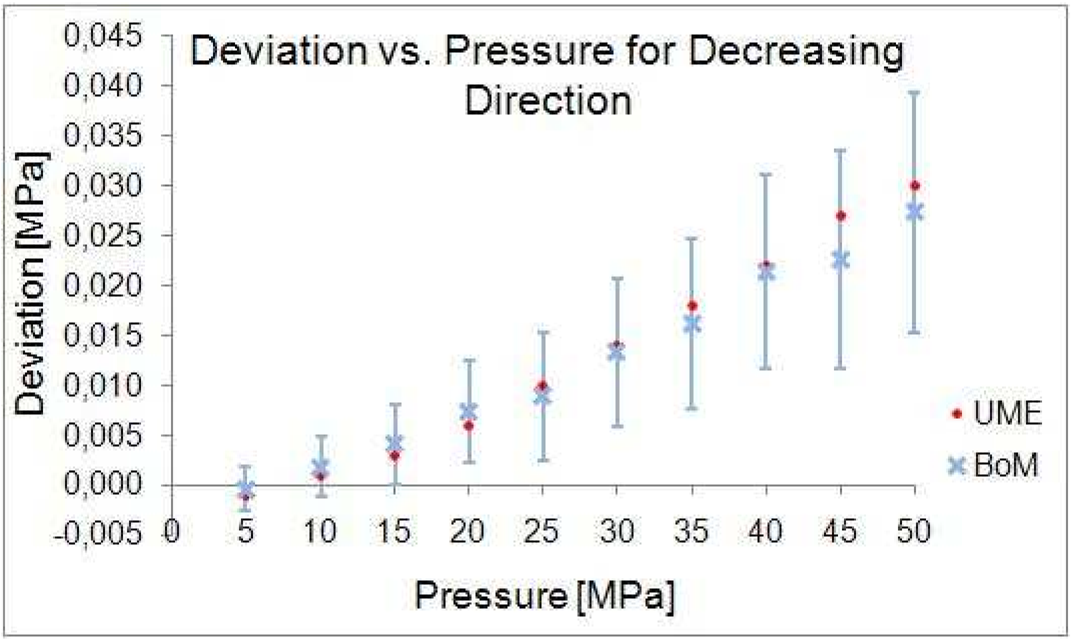

Figure 2. Deviations of reference and participant laboratories versus pressure for decreasing direction

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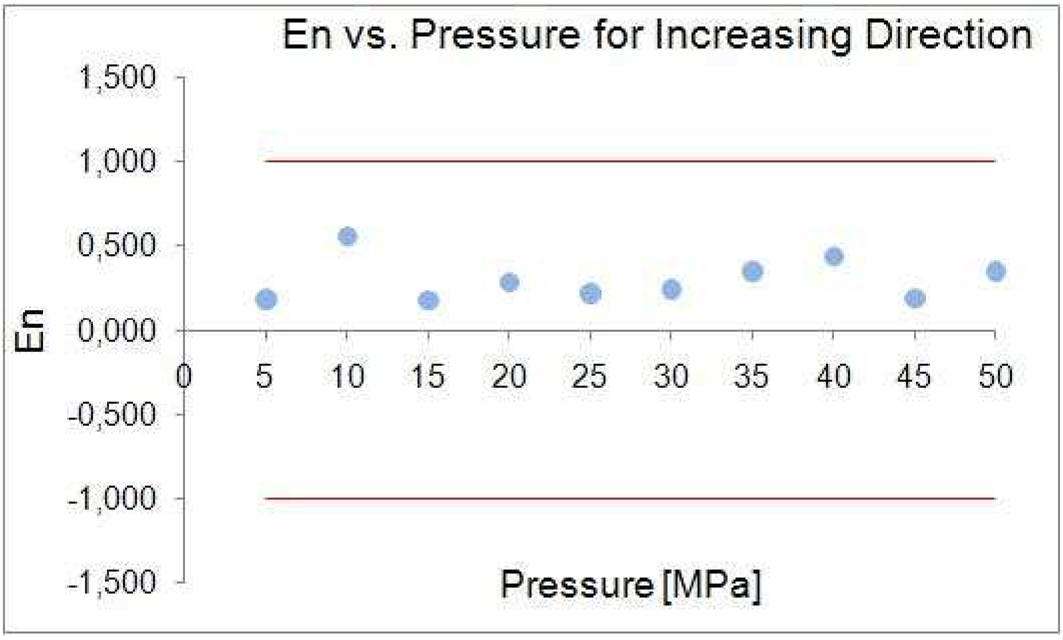

Figure 3. En values of participant laboratory versus pressure for increasing direction

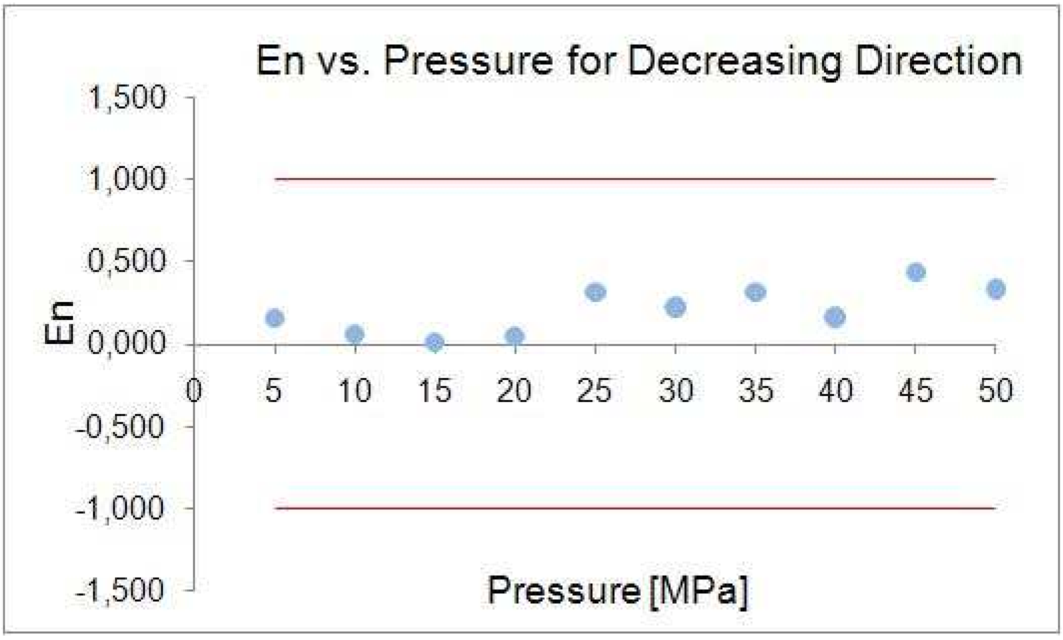

Figure 4. En values of participant laboratory versus pressure for decreasing direction

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7 Conclusions

Comparison confirms that UME's and BoM's results are paralel to each other. BoM deviations are not so different of those from UME. All En values are with in the accaptable limits. Since there is some drift about 0,01 bar for the transfer device, drift correction was applied on the BoM's results and also drift uncertainty taken into consideration while calculating the En values.

In order to minimise the drift effect due to transfer standard, pilot laboratory made two measurements before and after the participant laboratory. When the deviation and En graphs are analysed, no huge scattering were observed.

8 References

[1] UME–G2BA–TR– K002 Karşılaştırma Ölçümleri, Laboratuvarlararası Çok Kapsamlı Basınç Karşılaştırması Sonuç Raporu, UME 2011

[2] EURAMET Project 1131, Negative gauge pressure comparison, MIKES, 2009

[3] TS EN ISO/IEC/17025, Deney ve Kalibrasyon Laboratuvarlarının Yeterliliği İçin Genel Şartlar, TSE, Aralık 2005

[4] ISO/IEC Guide 43-1:1997, Proficiency testing by interlaboratory comparisons –

Part 1 : Development and operation of proficiency testing schemes

Part 2 : Selection and use of proficiency testing schemes by laboratory accreditation bodies

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