

Pressure Calibration Quality Assessment through Interlaboratories Comparison

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Abstract – Proficiency Testing (PT) and Inter-Laboratory Comparison (ILC) can provide many benefits to testing and calibration laboratories. The successful completion of a well-designed proficiency test can validate the measurement method, technical training, traceability of standards, and uncertainty budgets of the laboratory. Additionally, proficiency tests can provide a good indication about the quality of the reported results. The main goal of this intercomparison was the assessment of laboratories capabilities that perform calibrations within pressure field and a travelling measurement standard [1] was used.

Keywords – proficiency testing, interlaboratories comparison, elastic element pressure gauge.

I. INTRODUCTION

Participation in PT / ILC activities can gauge where a laboratory's measurements may stand in the community of similar laboratories. PT reports [2] can provide information on where a laboratory may need improvement. Problems with equipment, processes, or operator training can easily be identified through proficiency testing data. Proficiency testing essentially validates the work that is performed each day by comparison to others. Clients of laboratories will expect that results are correct and comparable. A comparison between different results or between results achieved and given specifications can only be done correctly if the measurement uncertainty of the results is taken into account [3].

At this interlaboratories comparison a number of 10 laboratories had participated, according to the scheme presented in fig. 1.

The scope of PT was the evaluation of laboratories in calibration of measuring instruments – elastic element pressure gauges/manometers.

II. TRAVELING MEASURING STANDARD

Type of proficiency testing scheme was quantitative sequential participation scheme, which had involved the

proficiency test item being circulated, as is presented schematically in fig. 1, circulated back, from time to time, to the proficiency testing provider for rechecking, to the next ones.

Proficiency test item was a elastic element pressure gauge, having the following characteristics:

- measuring range: (0...4) bar
- accuracy class : 1.6
- diameter: 160 mm
- pressure connexion : M 20 x 1.5
- gas:air

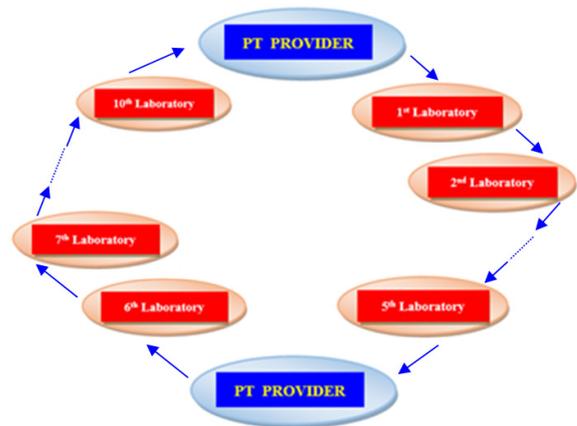


Fig. 1. Route of traveling measurement standard

III. RESULTS & DISCUSSION

The reference laboratory of provider performed the characterization of traveling measurement standard 4 times. The assigned values taken into account were the means of measurement values by the reference laboratory for each established point/value.

The relative measurement errors at each established point of pressure were calculated.

Two types of measurement uncertainty can be taken into account:

- Measurement uncertainty of the assigned value.
- Measurement uncertainty of the participant result.

The evaluation of acceptance criteria for each laboratory was made using the following formula

$$E_n = \frac{x - X}{\sqrt{U_x^2 + U_{ref}^2}} \quad (1)$$

where

- x - measurement result of i laboratory, for each measurement point;
- X - assigned value of PT object;
- U_x - expanded uncertainty of the participant's result x ;
- U_{ref} - expanded uncertainty of the assigned value X determined in a reference laboratory.
 - En Numbers [4] criteria:
 - $|En| \leq 1.0$; the score indicates "satisfactory" performance
 - $|En| > 1.0$; the score indicates "unsatisfactory" performance.

In table 1 are presented the measurement results of this interlaboratories comparison [5]: reported measurements, deviations, measurement uncertainties and E_n numbers.

2nd & 3rd figures show intrinsic errors curves, 4th & 5th figures show measurement bias, 8th & 9th figures show E_n numbers of 1st – 10th laboratories and 6th & 7th figures show intrinsic errors of 1st-5th laboratories at 1 bar & 2 bars.

In this interlaboratories comparison 7 from 10 participating laboratories obtained measurement results comparable with those of reference laboratory. Laboratories numbers 7 & 9 obtained measurement uncertainties smaller than reference laboratories, due to the fact that they didn't take into consideration the uncertainty of travelling standard item. Laboratory number 4 reported large measurement uncertainty. It made different other mistakes. Laboratories numbers 5 & 9 made reading mistakes of true value from calibration certificate. En Numbers took values from -1.21 to 0.99.

IV. CONCLUSIONS

The measurement results of this inter-laboratories comparison proved the participants capabilities, which ones of them meet the acceptance criteria of competence.

It is very important that measurement results, reported by testing laboratories, to be compared each with others, even if these measurement result are often obtained using different methods. In this respect, traceability of measurement results to reference values is a fundamental issue in competent laboratory operation [3].

Laboratories numbers 1, 2, 3, 7 & 10 reported values very close to those of reference laboratory.

Laboratories numbers 7, 8, 9 & 10 reported measurement uncertainties smaller than those of reference laboratory.

Laboratory number 4 didn't report measurement values and measurement uncertainties for „zero" point.

Laboratory number 4 reported measurement

uncertainties greater than maximum permissible errors of calibrated device, maximum permissible errors of device was ± 0.064 bar and reported measurement uncertainties were between 0.08 bar and 0.11 bar.

Laboratories numbers 5 & 9, obtained only three from five values of E_n numbers within the range [-1.00:1.00], the rest exceeded the limits.

Measurement uncertainties given by reference laboratory were from 0.021 bar to 0.023 bar, in comparison with

measurement uncertainties reported by participating laboratories, which were from 0.013 bar to 0.11 bar.

REFERENCES

- [1] *International Vocabulary of Metrology, Basic and General Concepts and Associated Terms VIM, 3rd edition*, JCGM 200:2008 (2008)
- [2] *ISO/IEC 17043:2010, Conformity assessment – General requirements for proficiency testing*, (2010)
- [3] Springer "Handbook of Metrology and Testing", Czichos & others, 2011
- [4] *Eurachem Guide, The fitness for purpose of analytical methods, 2nd edition*, (2014)
- [5] *ISO 13528:2005, Statistical Methods for Use in Proficiency Testing by Interlaboratory Comparisons*, (2005)

Table 1 - Measurement results: measurement pressure, deviation, uncertainty & E_n Number

Results [bar] & En Number	Reference pressure	Reference laboratory	Participating Laboratory's Number					Reference laboratory	Participating Laboratory's Number				
			1	2	3	4	5		6	7	8	9	10
Pressure	0.000	0,000	.000	0.000	0.00	-	0.00	0.000	0.00	0.00	0.00	0.000	0.00
Deviation			.000	0.000	0.00	-	0.00	0.000	0.00	0.00	0.00	0.000	0.00
Uncertainty		0.021	.025	0.022	0.02	-	0.03	0.021	0.03	0.015	0.02	0.013	0.02
E_n Number			0.00	0.00	0.00	-	0.00		0.00	0.00	0.00	0.00	0.00
Pressure	1.000	0.968	.965	0.977	0.97	1.05	0.95	0.973	0.96	0.97	0.97	0.955	0.98
Deviation			.003	0.009	0.002	0.082	-0.018		-0.013	-0.003	-0.003	-0.018	0.007
Uncertainty		0.023	.025	0.022	0.03	0.08	0.03	0.023	0.03	0.015	0.02	0.014	0.02
E_n Number			0.09	0.28	0.05	0.99	0.48		0.34	0.11	0.10	0.67	0.23
Pressure	2.000	1.964	.965	1.963	1.95	2.06	1.92	1.964	1.95	1.96	1.96	1.945	1.97
Deviation			.001	-0.001	-0.014	0.096	-0.044		-0.014	-0.004	-0.004	-0.019	0.006
Uncertainty		0.023	.025	0.022	0.03	0.11	0.03	0.023	0.03	0.015	0.02	0.014	0.02
E_n Number			0.03	0.03	0.37	0.85	1.16		0.37	0.15	0.13	0.71	0.20
Pressure	3.000	2.963	.965	2.964	2.97	3.06	2.93	2.970	2.95	2.97	2.96	2.940	2.96

Deviation			.002	0.001	0.007	0.097	-0.033		-0.020	0.000	-0.010	-0.030	-0.010
Uncertainty		0.023	.025	0.022	0.03	0.10	0.03	0.023	0.03	0.015	0.02	0.018	0.02
E _n Number			.06	0.03	0.19	0.95	0.87		0.53	0.00	0.33	1.03	0.35
Pressure	4.000	3.980	.980	3.989	3.98	4.05	3.94	3.980	3.96	3.99	3.96	3.950	3.97
Deviation			0.000	0.009	0.000	0.070	-0.040		-0.020	0.010	-0.020	-0.030	-0.010
Uncertainty		0.021	0.025	0.022	0.02	0.08	0.03	0.021	0.03	0.015	0.02	0.013	0.02
E _n Number			0.00	0.30	0.00	0.84	1.09		0.55	0.34	0.69	1.21	0.34

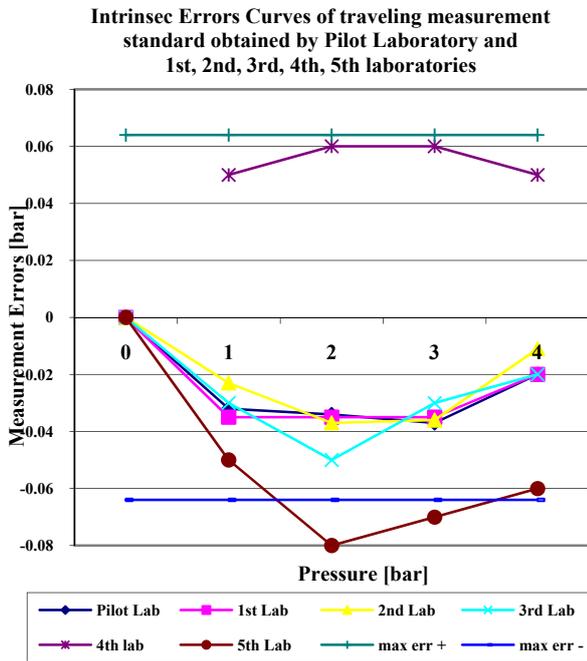


Fig. 2. Intrinsic Error Curves of 1st -5th laboratories

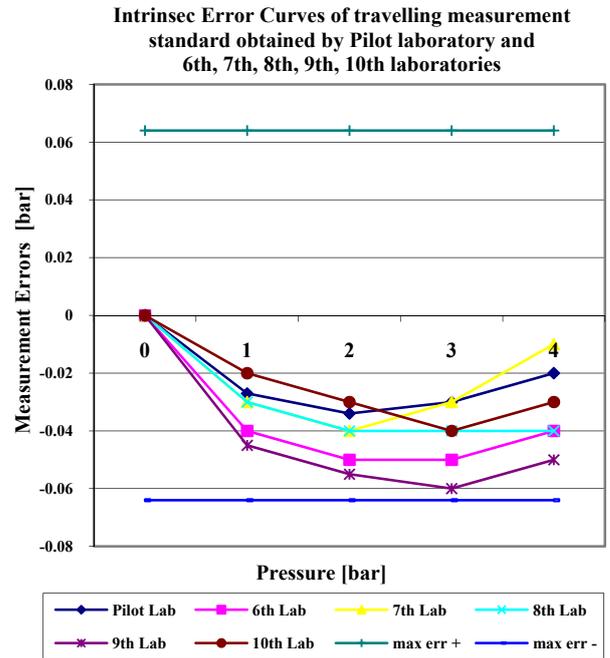


Fig. 3. Intrinsic Error Curves of 6th -10th laboratories

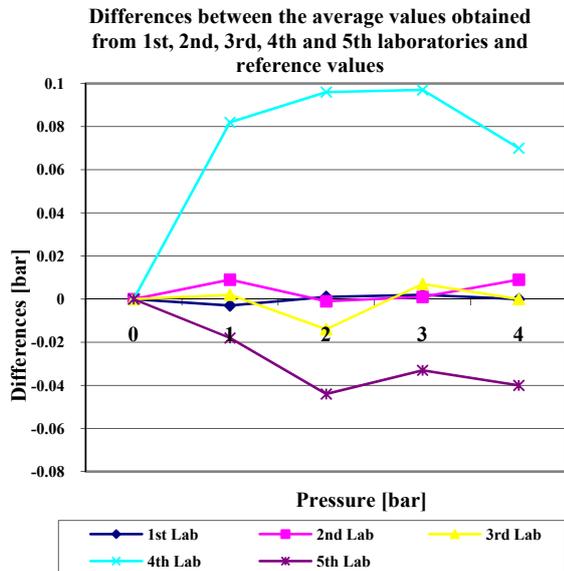


Fig.4. Measurement bias of 1st-5th laboratories

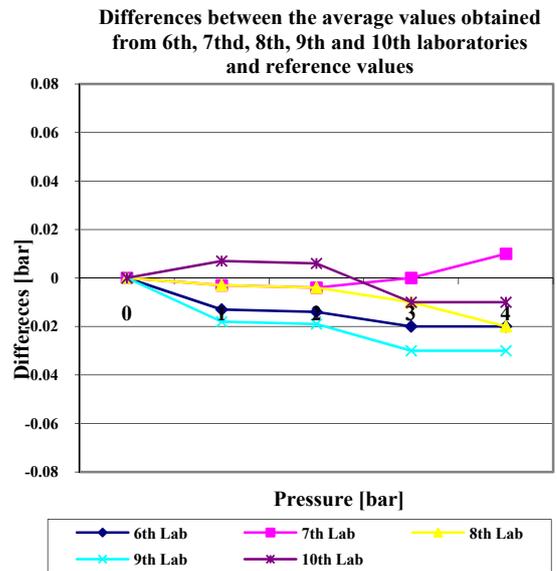


Fig.5. Measurement bias of 6th -10th laboratories

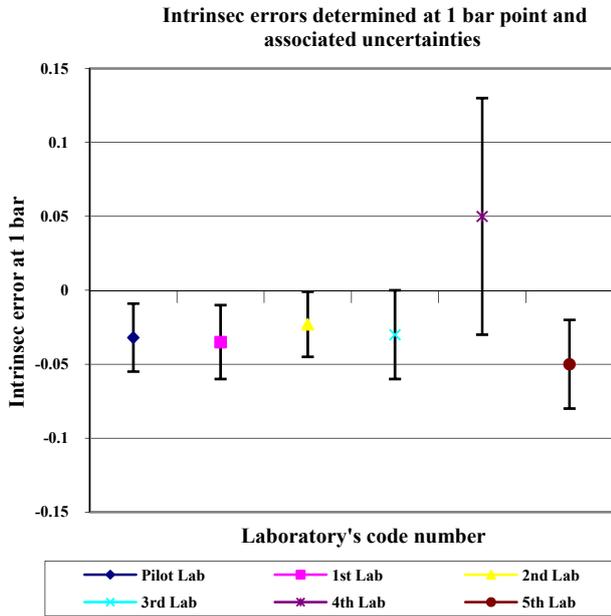


Fig.6. Intrinsic errors of 1st-5th laboratories at 1 bar

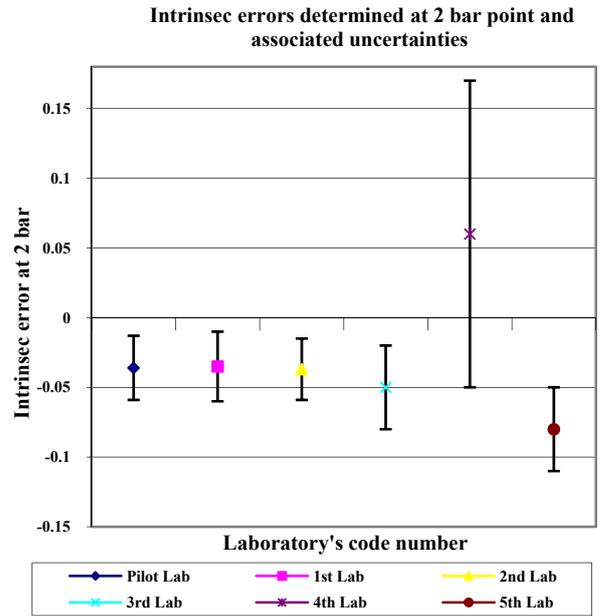


Fig.7. Intrinsic errors of 1st-5th laboratories at 2 bars

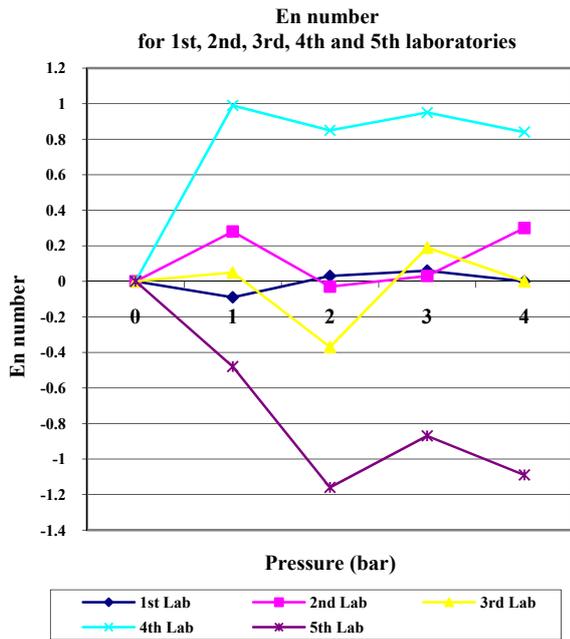


Fig.8. En numbers of 1st-5th laboratories

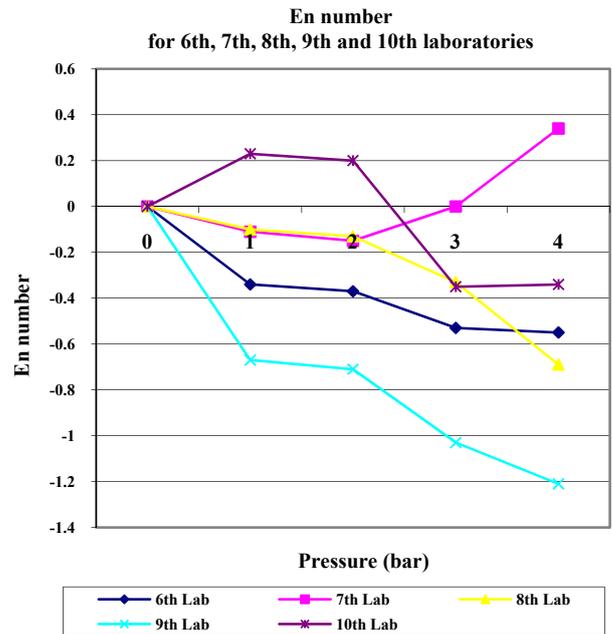


Fig.9. En numbers of 6th-10th laboratories