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INTERLABORATORY COMPARISONS IN ITALY TO VERIFY THE ACCREDITATION ON TORQUE WRENCH CALIBRATION

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Abstract – In 2008 one ILC, for the calibration of torque wrenches, was organised in Italy by COPA-SIT (Sistema Italiano di Taratura). In the present paper the main results obtained during the ILC are discussed, in particular the differences on the repeatability and accuracy given by the different laboratories are compared and evaluated.

Keywords: torque-wrenches, dissemination, comparison.

1. INTRODUCTION

The increasing demand, in Italy in particular, for calibration and certification activity for the accreditation of new calibration SIT Centres is due to a number of concomitant factors, namely:

- the exigency of compliance with the EN Standards in the fields of quality and production;
- the necessity for industrial concerns, to operate in accordance with ISO 17025-2005.
- the Italian law 273/91 establishing the National Calibration System (Sistema Nazionale di Taratura), which is constituted by the Primary Metrological Institutes (Istituto Nazionale di Ricerca Metrologica (INRiM) e l'Istituto Nazionale di Metrologia delle Radiazioni Ionizzanti) and by the ACCREDIA-SIT Centres (actually 177 in total, 23 for the force quantity as load cell, testing machines, impact pendulum and torque). The SIT Certificates number issued by the accredited Labs in the force field show an increasing of more than 350% in 10 years.

Measurement of a physical quantity requires the establishment of a metrological chain, the starting point of which is the primary standard of the quantity in question. This standard must be transferable to secondary standards and to work standards having the required metrological characteristics.

In 2008 one ILC, for the calibration of torque wrenches, was organised in Italy by COPA-SIT (Sistema Italiano di Taratura). In the present paper the main results obtained during the ILC are discussed.

2. GENERAL EVALUATION AND PROCEDURE

One of the difficulties for this kind of ILC is that the object of the comparison (the torque wrench) has not the status of a reference standard. For this reason the ILC, for the calibration of TW, are organised in Italy with the following purposes:

1. to give an experimental validation of the torque dissemination in Italy;
2. to evaluate the calibration competence of the different laboratories;
3. to give a contribution to solve the problem for the future international comparison for such kind of equipment.

At the experimental ILC participated 8 SIT Centres: AEP, ATLASCopco-BLM, CERMET, MG, OMECO, PRORE, STI, USAG.

In order to evaluate in the better way the calibration capability of each laboratory three torque wrenches were chosen of different capacity (from 20 Nm to 340 Nm), different type (1 and 2) and Class (A, B), respectively:

- Torque Wrench USAG (Indicating Torque Tools), Model: 823/180, capacity (36-180) Nm
- Pre-set Torque Wrench USAG Model: 810N340 Measurement Range: (60 ÷ 340);
- Pre-set Torque Wrench USAG Model: 810N100, Measurement Range: (20 ÷ 100) Nm;

The SIT Centres carried out the calibrations of the aforesaid transducers using torquemeter benches with different metrological characteristics :

- bench equipped with lever and dead weights up to 2 kNm (Figg. 2and 5)
- mass and lever bench equipped with comparative torquemeter (Fig. 4)
- hand system equipped with reference torquemeters (Figg. 6)
- automatic system equipped with reference torquemeters (Figg. 1 and 3)

3. REFERENCE VALUE OF THE TORQUE

At the ILC participated 8 Calibration Centres with 3 torque wrenches of different capacity and type. For this reason was decided to consider as “reference value” for each range of the 3 TW’s, the average value of the calibrations carried out by the different laboratories.

With this method, it is possible to reduce strongly the effects due to the individual characteristic of the TW’s. These effects can be further reduced by considering the average value of the results obtained by the different laboratories participating at the ILC.
The differences evaluated from these mean value results could be considered mainly, if not exclusively, due to the calibration capabilities (technical, operational) of each calibration centres with only a limited contribution of the accuracy errors of the different torque wrenches, but not for the stability.

4. EXPERIMENTAL RESULTS AND ANALYSIS

At each laboratory was asked to calibrate the TW by using their normal procedure (in general derived from ISO UNI EN 6789). Usually the tests were repeated several times at 20%, 60% and 100% of the rated capacity of each TW.. The values obtained by each lab’s are represented as “accuracy errors”. The accuracy error is evaluated by the average value, over the 5 to 10 measurements at each torque level. The relative accuracy errors are calculated as the differences of this individual average value and the “reference value” (as defined in Ch. 3), divided by the nominal torque.
Table.1 gives the measurement results declared in the Calibration Certificates by the different lab’s and the accuracy error, as determined on the same torque value for the Indicating Torque Tools, capacity (36-180) N m.
Table 2 shows: A) the average value given by the 8 participating laboratories for the Pre-set Torque Wrench, Measurement Range: (20 ÷ 100) N m); in the table (B) the total average and the original report given by FACON are also compared.
Table 3 shows: A) the average value for the Pre-set Torque Wrench (20 ÷ 100) N m); B) the measurement uncertainty declared in the Calibration Certificates by the different lab’s and the En, as determined at the different torque level.
Table 4 gives the comparison results on 2 TW types by using different calibration systems (Figg. 2, 4 and 6)
Table 5 shows: A) the accuracy erroc for the Pre-set Torque Wrench (20 ÷ 340) N m); B) the measurement uncertainty declared in the Calibration Certificates by the different lab’s and the En, as determined at the different torque level.
In the Tables the results obtained by applying two different procedures are also compared.

The results were evaluated using the Normalised Error En, according the EA guideline and SIT-Doc. 511:

$$En = \frac{\left| X_{LAB} - X_0 \right|}{\sqrt{U^2_{LAB} + U^2_0}} \qquad (1)$$

Where:
X_{LAB}= the calibration result given by the laboratory
X_0 = the reference value
U_{LAB}= the accredited uncertainty reported by the laboratory
U_0 = the uncertainty of the reference value.

Tables 6b and 7b give the measurement uncertainty declared in the Calibration Certificates by the different lab’s and the En, as determined on the same torque wrench.

The Normalised Error (En), evaluated from the calibration values (accuracy errors) obtained by the 8 laboratories on the 3 torque wrenches of different nominal capacities and different types, is in general less than 1: only 5 En values, over 80, are greater than 0,80.
These results underline the coherence of the resultats obtained in the intercomparison with the measurement uncertainty declared by the 8 calibration centres and the reference values

5. CONCLUSIONS

At the ILC participated 8 SIT Centres with three torque wrenches. For this reason was taken as “reference value”, for each range of the three TW’s, the average value of the calibrations carried out by the laboratories.
The results obtained by all the different laboratories are compatible among them as regards the repeatability, the accuracy (usually well inside +/-4 % as required by the ISO EN Standard) and the En number as well.
The Normalised Error (En), evaluated from the calibration values obtained by the 8 laboratories on the 3 torque wrenches, is in general less than 1: only 5 En values, over 80, are greater than 0,80.

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Table 1: Torque Wrench Indicating Torque Tools, capacity (36-180) Nm: Example of Intercomparison results

Nominal Torque [Nm]	a [Nm]	b [Nm]	c [Nm]	d [Nm]	e [Nm]	f [Nm]	g [Nm]	h [Nm]	i [Nm]	AVERAGE [Nm]
36	35,95	36,15	36,4	36,4	35,7	36,4	35,81	36,08	35,84	36,08
108	107,92	109,12	108,8	108,4	108	107,7	108,34	107,92	107,48	108,19
180	180,56	180,71	182	182	180,1	178,85	179,4	179,92	179,06	180,29

AVERAGE [Nm]	Differences of the single laboratory from the total average — Centres								
	a [%]	b [%]	c [%]	d [%]	e [%]	f [%]	g [%]	h [%]	i [%]
36,11	-0,36	0,19	0,88	0,88	-1,06	0,88	-0,75	0,00	-0,67
108,19	-0,25	0,86	0,57	0,20	-0,17	-0,45	0,14	-0,25	-0,65
180,29	0,15	0,23	0,95	0,95	-0,10	-0,80	-0,49	-0,20	-0,68

Table 2: Pre-set Torque Wrench, capacity (20 – 100) N m

A)

Nominal Torque [Nm]	a [Nm]	b [Nm]	c1 [Nm]	c2 (ISO) [Nm]	e [Nm]	f [Nm]	g1 [Nm]	g2 (ISO) [Nm]	h [Nm]	i [Nm]
20	20,17	20,15	20,13	20,12	19,83	20	19,95	19,95	19,88	20,13
60	58,6	58,9	58,43	58,3	57,74	58,1	58,64	58,64	58,25	58,92
100	98,18	97,51	96,73	96,3	96,37	96,5	97,04	97,04	96,95	98,13

B)

TOTAL AVERAGE [Nm]	FACOM Original Report
20,05	20,06
58,53	58,29
97,10	97,08

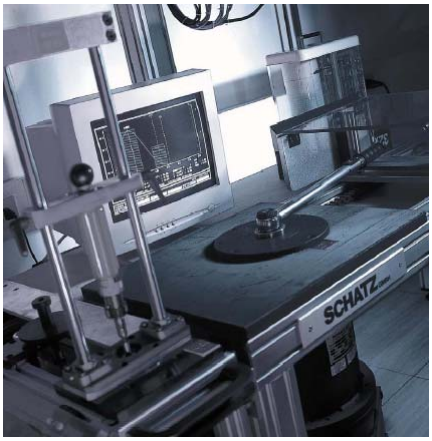

Fig.1: automatic system equipped with reference torquemeters

Fig. 2: bench equipped with lever and dead weights up to 2 kNm

Fig.3:automatic system equipped with reference torquemeters

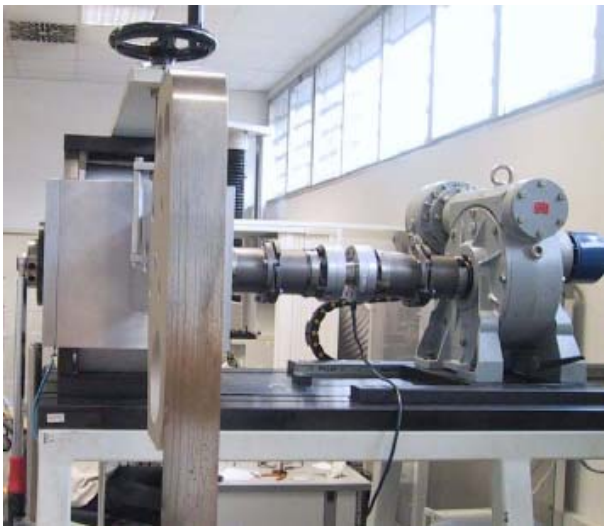

Fig. 4: mass and lever bench equipped with comparative torquemeter

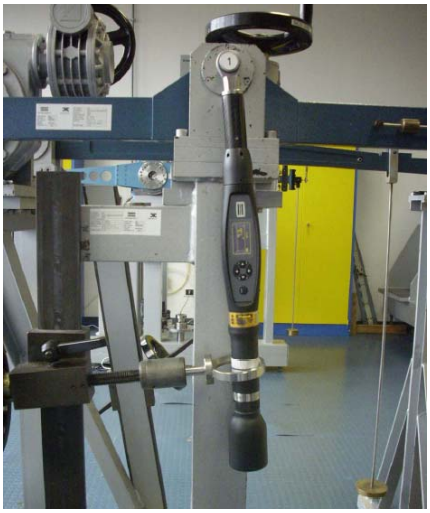

Fig.5: bench equipped with lever and dead weights up to 1 kN m

Fig.6: hand system equipped with reference torquemeters

Table 3: Pre-set Torque Wrench, capacity (20 – 100) N m

	a	b	c1	c2 (ISO)	e	f	g	h	i
	Differences of the single laboratory from he total average								
[N m]			A	[%]					
20	0,69	0,59	0,49	0,44	-1,00	-0,16	-0,41	-0,41	-0,74
60	0,25	0,77	-0,04	-0,26	-1,22	-0,60	0,32	0,32	-0,35
100	1,14	0,45	-0,35	-0,80	-0,73	-0,59	-0,04	-0,04	-0,13
			B	U (%)					
[Nm]	a	b	c1	c2 (ISO)	e	f	g	h	i
20	0,91	1,30	1,83	1,83	2,2	2,20	2,25	0,93	1,15
60	0,91	1,30	1,12	1,12	1,2	0,90	1,1	0,61	0,87
100	0,98	1,30	1,05	1,05	0,9	0,80	0,81	0,58	0,41
[Nm]				Ec					
20	0,54	0,32	0,19	0,17	0,33	0,05	0,13	0,31	0,46
60	0,20	0,42	0,02	0,16	0,73	0,47	0,21	0,37	0,28
100	0,82	0,24	0,24	0,54	0,56	0,52	0,03	0,04	0,23

Table 4: Comparison results by using different calibration systems.

100 Nm TW

APPLIED TORQUE N·m	BT2000 Ref. Transd. N·m	GM 2K Manual N·m
20	19,874	19,882
60	58,024	58,25
100	96,728	96,946

Deviation %
0,040
0,389
0,225

APPLIED TORQUE N·m	BT2000 Ref. Transd. N·m	BT2000 mass N·m	GMC2K Manual N·m
36	36,08	36,00	36,00
108	107,92	107,84	107,76
180	179,92	179,92	179,68

Deviation Mass-RT %	Deviation Mass-GMC %
0,222	0,000
0,074	-0,074
0,000	-0,133

Table 5: Pre-set Torque Wrench, capacity (60 – 340) N m

Nominal Torque [Nm]	TOTAL AVERAGE [Nm]	a	b	c1	c2	f	h	i
			Differences of the s gle laboratory from the total average					
					[%]			
68	66,33	0,65	-0,30	0 1	0,62	-0,95	-1,25	0,61
204	203,56	0,30	0,26	0 0	0,38	-0,42	-0,33	-0,59
340	337,10	0,46	0,60	0 4	0,01	-0,03	-0,70	-0,38

Nominal Torque [Nm]	TOTAL AVERAGE [Nm]	a	b	c1	c2	f	h	i
					U%			
68	66,33	0,87	1,6	1 8	1,16	1,61	1,32	0,76
204	203,56	0,42	1,4	1 5	1,17	0,61	0,81	0,34
340	337,10	0,28	1,2	1 6	1,19	0,64	0,78	0,25

Nominal Torque [Nm]	TOTAL AVERAGE [Nm]	a	b	c1	c2	f	h	i
					Ec			
68	66,33	0,53	0,13	0 2	0,38	0,42	0,67	0,57
204	203,56	0,51	0,13	0 4	0,23	0,49	0,29	1,22
340	337,10	1,16	0,35	0 3	0,01	0,03	0,64	1,07