The dissemination of the force unit in Italy: calibration of material testing machine intercomparison

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Abstract

One of the most important activities at European (EA) and National level of the National Accreditation Body (NAB) is the organisation of a series of interlaboratory comparisons (ILC), to verify the measurements capability of the calibration laboratories.
In 2001 one ILC, for the calibration of uniaxial testing machines, was organised in Italy by SIT-IMGC with the IMGC-CNR as reference laboratory. In the present paper the main results obtained during the ILC are discussed, in particular a regression analysis was applied to evaluate the differences on the repeatability and accuracy given by the different laboratories.

Introduction

The increasing demand, in Italy in particular, for calibration and certification work and for the accreditation of new calibration centres, is due to a number of concomitant factors, namely:
the need for industry to operate in accordance with EN 45000, ISO 9000 and ISO17025 as regards quality; the Italian law 273/91 establishing the National Calibration System, which comprises the Primary Metrological Institutes and the SIT centres) /1,2/.

IMGC provides for traceability to the standards of mechanical and thermal quantities all over the country, so as to allow high-quality measurements and tests to be made /3/.
At present the number of SIT centres is 135 in total, 22 for force quantity (load cell, testing machines, impact pendulum and torque).
One of the most important activities of the National Accreditation Body (NAB) is the organisation of a series of interlaboratory comparisons (ILC), at European (EA) and National level, to verify the measurements capability of the accredited laboratories /4/.

In 2001 one ILC, for the calibration of uniaxial testing machines, was organised in Italy by SIT-IMGC with the IMGC-CNR as reference laboratory. Three materials testing machines (MTM) were chosen of 1000kN, 5000kN and 100kN rated load, located at the Politecnico of Torino and at the IMGC-CNR.
In the present paper the main results obtained during the ILC are discussed, in particular a regression analysis was applied to evaluate the differences on the repeatability and accuracy given by the different calibration laboratories.

General Evaluation

The possibility of one intercomparison on material testing machines was given at the meeting of the EA Dimensional Metrology and EA Mass Metrology Expert Groups. A first comparison was financed by MIKES (Finland) and organised by RPO. The main results were presented at the IMEKO TC3 Conference in Istanbul /5/.

One of the difficulties in the technological field is represented by the big weight and large size of the equipments to calibrate, so it is difficult or impossible to circulate such equipments (e.g. materials testing machines or impact pendulum). In this case each participating calibration centre has to travel to the location were the equipment is located. A second difficulty is that the object of the comparison (the material testing machine) haven't the status of a reference standard.
In 2001 one ILC, for the calibration of uniaxial testing machines, was organised in Italy by SIT-IMGC with the IMGC-CNR as reference laboratory with the following purposes:

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

Material Testing Machines and Procedure

In order to evaluate in the better way the calibration capability of each laboratory three material testing machines (MTM) were chosen of different capability (1000kN, 5000kN and 100kN rated load) and different structure (two or three column), respectively:

- Type Instrom model 8562 - 100 kN in traction;
- Type PMC 500 kN – 5 MN in compression (three ranges);
- Type PMC 100 kN – 1000 kN in compression (three ranges: 200 kN, 500 kN and 1 MN).

At the experimental ILC participated 8 calibration centres, with a grand total of more than 50 first line standards. At each laboratory was asked to calibrate the MTMs by using their normal procedure (usually UNI EN 10002/2 or ISO 7500-1 and UNI 6686/1/2).

Each calibration centre was not able to carry out the calibration on all the ranges.

In Table I a summary is given of the intercomparison.

Tab I : General experimental program

Testing Machine	Load Range	Calibration Centres							Number of Transducers
		A	B	C	D	E	F	G	
Instron 8562	200 N - 10 kN	X	X	X	X	X	X		22
	20 kN - 200 kN	X		X	X	X	X	X	
PMC 100	100 kN - 500 kN	X		X	X	X	X	X	17
	100 kN - 1000 kN	X		X	X	X	X	X	
	50 kN - 500 kN	X	X	X		X			
PMC 500	100 kN - 1000 kN	X	X	X		X			14
	250 kN - 2500 kN	X			X	X	X	X	

Reference Value of the Force

At the ILC participated several Calibration Centres (8) with a big number of Reference Force Transducers (more than 50). For this reason was decided to consider as "reference value" for each ranges of the three uniaxial testing machines the average value of the calibrations carried out by the different laboratories.

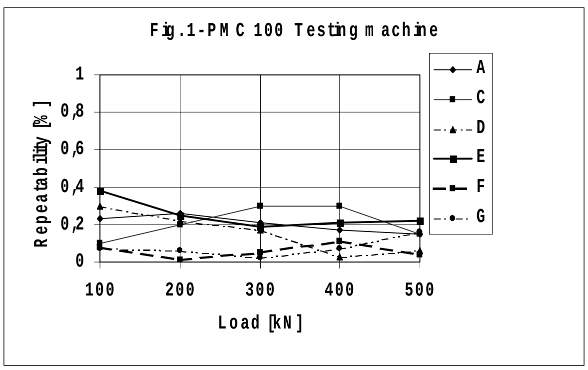
With this method, taking for each laboratory the mean value over the three angular positions, it is possible to reduce strongly the effects due the parasitic components . These effects can be further reduced by considering the average value of the results obtained by all the laboratories participating at the ILC.

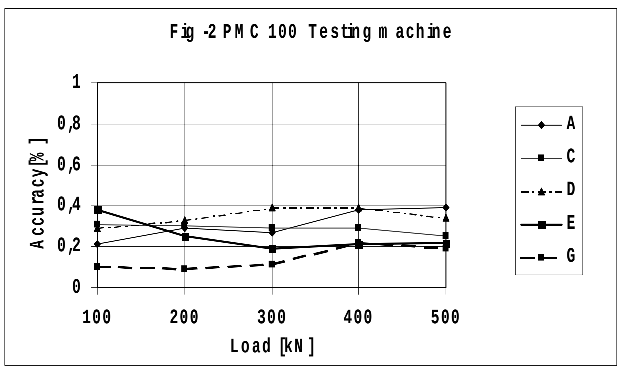
The differences against the polynomial regression evaluated from these mean value results could be considered mainly, if not exclusively, due to the calibration capabilities (technical, operational) of each calibration centres with only a limited contribution of the accuracy errors of the different material testing machines.

Experimental Results and Analysis

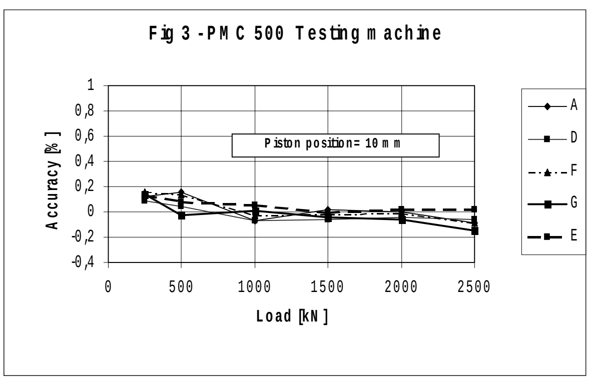
Fig. 1 shows the repeatability given by the participating laboratories (A; C; D; E; F; G) for the PMC-100 uniaxial testing machine (range 500 kN).

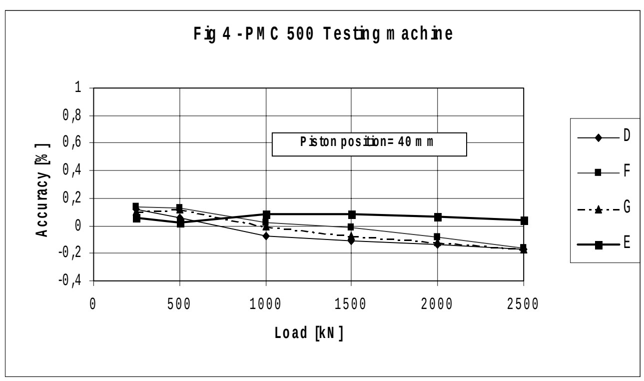
Fig. 2 gives the accuracy as determined on the same testing machine in compression.





In Table II the repeatability results for the PMC-500 and for two different piston positions (10 mm, 40 mm) are reported.



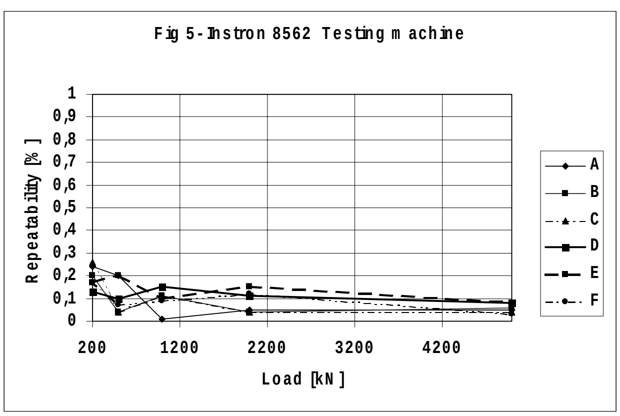


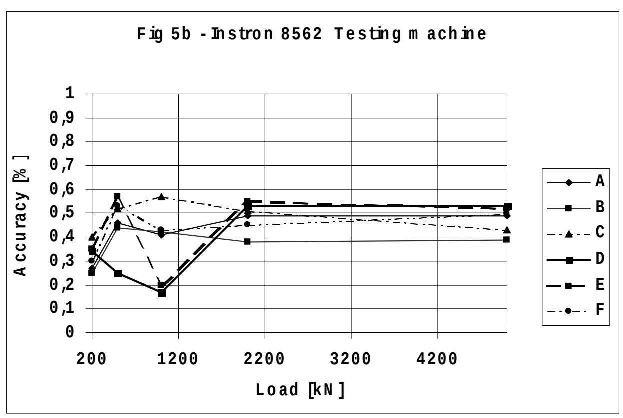
Tab. II: Repeatability on PMC testing machine at two different Piston positions

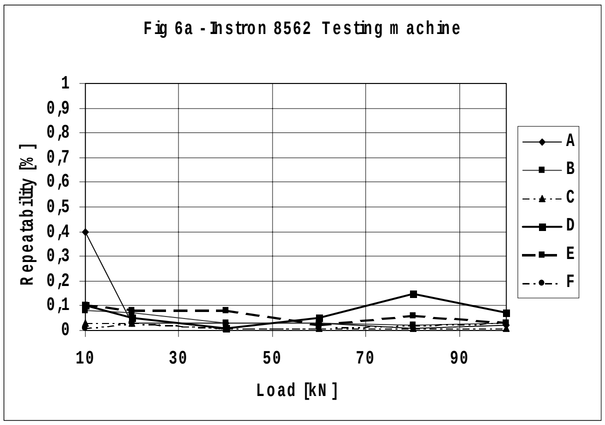
	PMC 500 n. 19933 Repeatability [%]				
Load kN	Laboratories				
	A	D	F	G	E
	Piston position 10 mm				
250	0,13	0,27	0,11	0,27	0,09
500	0,17	0,24	0,19	0,09	
1000	0,14	0,16	0,04	0,06	0,03
1500	0,19	0,23	0,03	0,05	0,02
2000	0,16	0,22	0,06	0,04	0,04
2500	0,21	0,21	0,06	0,02	0,01
	Piston position 40 mm				
250		0,16	0,14	0,16	0,18
500		0,19	0,06	0,17	0,19
1000		0,05	0,03	0,08	0,14
1500		0,19	0,03	0,02	0,11
2000		0,23	0,04	0,02	0,11
2500		0,18	0,04	0,05	0,05

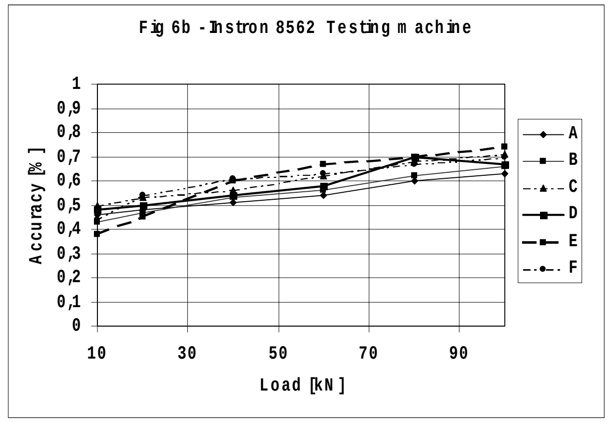
Figs. 3 and 4 give the accuracy results as determined by laboratories A, D, E, F and G on the PMC-500, range 2500 kN, for different piston positions (10mm, 40 mm). In fact, “for hydraulic machines, where the hydraulic pressure at the actuator is used to measure the test force, the influence of a difference in position of the piston shall be verified (ISO, point 6.4.7)”.

Fig. 5a,b and 6a,b give the calibration results in tension (repeatability and accuracy) for the Instrom testing machine from 200 N to 100 kN.









All the diagrams give the measurement results without reversibility because the reversibility, as outlined by other author /5/, depends more from testing machine than from the reference transducers.

The standard ISO 7000/1 gives in fact the possibility to carry out the calibration of static uniaxial testing machines with or without reversibility but, according point 6.4.8 of the ISO Standard, the relative reversibility error is only determined when required.

The results of the calibration of the uniaxial testing machine in tension show, as can be expected, the lowest deviation between the different laboratories. The parasitic components are lower and the force transmission conditions for the different labs are more uniform for the test in tension.

The results can be evaluated using the En number according the EA guideline:

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

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.

Conclusion

At the ILC participated eight calibration centres with 50 Reference Force Transducers. For this reason was taken as "reference value", for each ranges of the three uniaxial testing machines, the average value of the calibrations carried out by the laboratories.
The differences against the polynomial regression 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 material testing machines, but not for the stability.
The results given by all the different laboratories are in good agreement as regards repeatability, accuracy (usually inside +/-0,2 %) as well the classification (class 1 in compression and class 1 in tension).

References

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