TECHNICAL PROTOCOL
Bilateral Comparison of Deadweight Machines Between TÜBİTAK UME and SASO NMCC

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TÜBİTAK UME

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Contents

1. Introduction

It was planned to organise a bilateral comparison on force standard machines between SASO NMCC and TÜBİTAK UME, in the frame of the Project of Development and Realization Measurement and Calibration System for the National Measurement and Calibration Centre (NMCC) at Saudi Standards, Metrology and Quality Organization (SASO).

The bilateral comparison will be performed by measuring force values taken from force standard machines located in TÜBİTAK UME and SASO NMCC.

TÜBİTAK UME is acting as the pilot laboratory. The travelling standards will be provided by TÜBİTAK UME. TÜBİTAK UME will be responsible to monitoring standard performance during the circulation and the evaluation and reporting of the comparison results.

2. Travelling Standard

Transfer standards or travelling standards are given in Table 1. There are 3 force transducers as transfer standards.

Table 1. Details of the travelling standards and selected force steps

TÜBİTAK UME Transfer Force Transducer			
Capacity	**Manufacturer / Model**	**Serial Number**	**Selected force steps**
1 kN	HBM / Z30A-1000 N	182913015	0.4 kN, 0.6 kN, 0.8 kN, 1 kN
10 kN	HBM / Z30A-10 kN	193930010	4 kN, 6 kN, 8 kN, 10 kN
100 kN	HBM / Z4A-100 kN	191430052	40 kN, 60 kN, 80 kN, 100 kN

These force transducers belong to TÜBİTAK UME. The transfer standards will be supplied by TÜBİTAK UME. These standards were chosen for its high accuracy and stability in time (shown in Fig.1).

To minimize the uncertainty associated with the indicating instrument a high resolution, 1 ppm, indicators having good stability (HBM, type DMP 40) should be used in comparison. The indicators are self-calibrating. During an auto calibration cycle, the measuring voltage is replaced periodically by a zero signal and then by a highly-precise calibration voltage. A low frequency carrier frequency of 225 Hz is fed into the force transducers. In the DMP 40, the signal is amplified, demodulated, filtered and transformed into a digital value which is fed into a computer. For the DMP 40, the six-wire technique is used in the measuring line, i.e. the supply voltage is taken at the transducer and returned to the amplifier. The resolution of this indicating instrument used is 1 ppm and the relative accuracy of it is estimated to be 4 ppm [7].

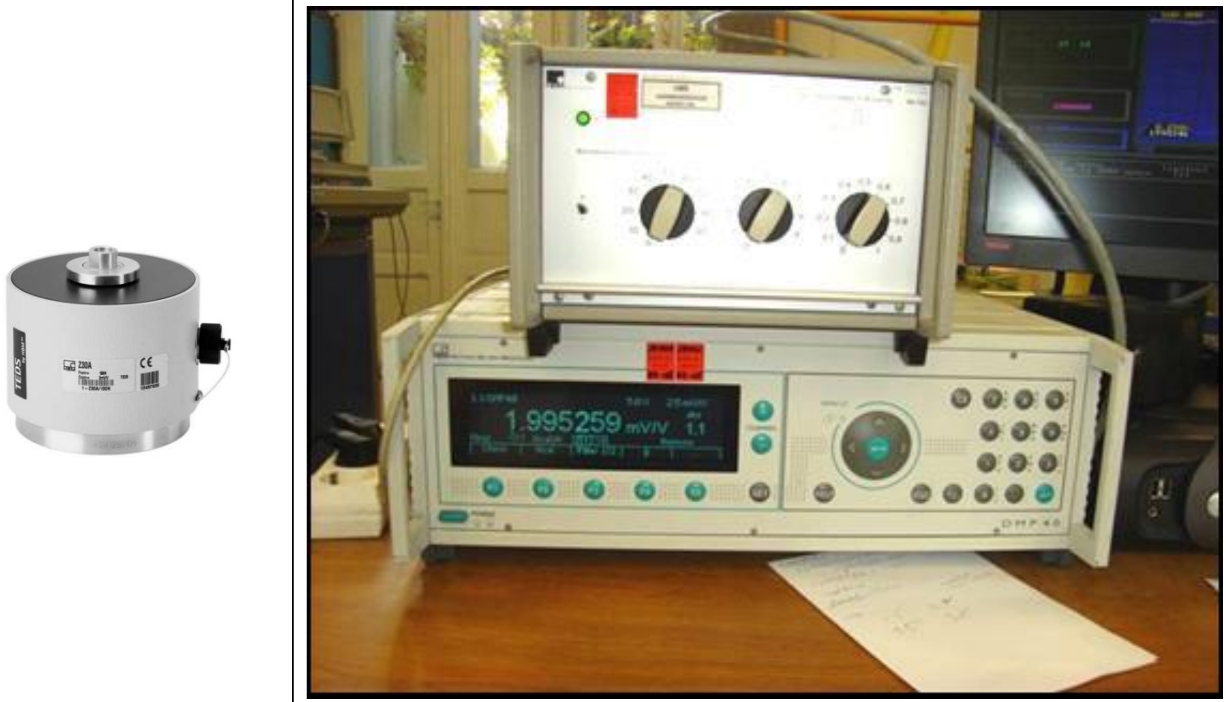

Figure 1. Picture of the force transducer and precision indicating instrument (DMP 40) and BN 100 calibrator of TÜBİTAK UME

DPM 40 is adjusted as absolute value (ABS), 0,.22 Hz Bessel filter, 5 V excitation voltage and ± 2.5 mV/V measuring range values during measurements.

At the same time, in order to check both DMP 40 indicating devices belong to TÜBİTAK UME (HBM, DMP 40 S6: SN: 964720034) and SASO NMCC (HBM, DMP 40), a BN 100 type HBM product calibrating device is used during comparison measurements (shown in Fig.1).

3. Participant Laboratories

The pilot institute for this comparison is TÜBİTAK UME (Turkey). The contact details of the coordinator are given below:

Table 2. Coordinator of Bilateral Comparison

Pilot Institute:	TÜBİTAK Ulusal Metroloji Enstitüsü (TÜBİTAK UME)
Coordinator :	Dr. Bülent AYDEMIR

The participating institutes and contact persons with their addresses are given in Table 3.

Table 3. Participants

Country	Institute	Acronym	Shipping Address	Contact Person
Turkey	TÜBİTAK Ulusal Metroloji Enstitüsü	TÜBİTAK UME	TÜBİTAK Ulusal Metroloji Enstitüsü (TÜBİTAK UME) TÜBİTAK Gebze Yerleşkesi Barış Mah. Dr. Zeki Acar Cad. No:1 41470 Gebze-Kocaeli, TURKEY	Dr. Bulent AYDEMIR bulent.aydemir@tubitak.gov.tr Tel: +90 262 679 50 00
Saudi Arabia	SASO The National Measurement and Calibration Center	SASO NMCC	Saudi Standards, Metrology and Quality Organization of The Kingdom of Saudi Arabia (SASO) Riyadh 11471, P.O. Box 3437 KINGDOM of SAUDI ARABIA	A.A. Binown a.binown@saso.org.sa Tel: +966 1 252 9734

4. Time Schedule

The time schedule for the comparison is given in the Table 4. The circulation of travelling standard is organized so that to monitor the performance of the travelling standard.

Table 4. Circulation Time Schedule

Acronym of Institute	Country	Time for measurement dates
TÜBİTAK UME	Turkey	January 2017
SASO NMCC	Saudi Arabia	February – March 2017
TÜBİTAK UME	Turkey	April 2017

5. Transport Case

The travelling standard is packed in a transport case of size (40 x 55 x 55) cm and a total weight of approximately 35 kg. The transport case can easily be opened for customs inspection.

6. Transportation of Travelling Standard

The comparison will be organised in a single loop of two laboratories in order to allow close monitoring of the behaviour of the standard. TÜBİTAK UME is responsible for the transportation of the travelling standard. TÜBİTAK UME will transport the package from TÜBİTAK UME to Saudi Arabia and back to TÜBİTAK UME by hand-carrying or with cargo. After arrival in the participant's laboratory, the standard should be allowed to stabilise in a temperature and possibly humidity controlled room for at least two days before use. Each institute will have two weeks available. This includes the measurements and the stabilisation of the standard.

6.1. Failure of Travelling Standard

In case of any damage or malfunction of the travelling standard, the comparison will be carried out after the travelling standard is repaired.

6.2. Financial aspects

Each participant laboratory is responsible for its own costs for the measurements as well as any damage that may occur within its country. The overall costs for the organization of the comparison are covered by the pilot laboratory. The pilot laboratory has no insurance for any loss or damage of the travelling standard.

7. Measurement Quantities and Points

The quantities to be measured and the measurement force points are given in Table 5. All transfer force transducers used in the range 40% to 100%.

Table 5. Measurement quantity and points

Quantity	Measurement Steps (kN)
Force	40 kN, 60 kN, 80 kN, 100 kN
	4 kN, 6 kN, 8 kN, 10 kN
	0.4 kN, 0.6 kN, 0.8 kN, 1 kN

8. Calculation of the Comparison Reference Value

The Comparison Reference Value (CRV) for each measurement point will be calculated using the results of the pilot laboratory.

9. Measurement Instructions

9.1. Before the Measurements

- ➢ It should be allowed to stabilize in a temperature and humidity controlled environment for at least 2 days before commencing measurements.

9.2. Environmental Conditions

- ➢ The ambient temperature and humidity must be measured. No corrections will be performed for temperature and humidity effects.
- ➢ Preferably, the measurements should be carried out at the ambient conditions given below;

  Temperature : (21 ± 1) °C

  Relative humidity : (45 ± 10) %rh

9.3. Method of measurement

The procedure for performing the comparison measurements is described two increase series on each position. The results of all transfer force transducers evaluated in the range 40% to 100%.

To minimize the effect of creep, for each force transducer included in the comparison, the time required achieving a stable response following loading and unloading was determined prior to start of the comparison. In most instances it was found that a 2 min. time delay between the initiation of the loading (or unloading) and the actual reading was adequate. In addition this, after force transducer is loaded or unloaded, some drifts due to mechanical, thermal and electrical affects occur in the output of the transducer.

Local heating due to electrical power dissipation may cause this by the strain-measuring bridge. Many measurements and experience show that this effect on force transducer output stabilizes within about 2 minute. For these reasons 2 minute time delay is selected as a time interval among each measurement.

Machine transducer interactions can significantly influence measurement accuracy. Normal imperfections in alignment of loading machines and force transducers can result in significant bending, shear and twist components of deformation in the force transducers. To minimize the errors due to these non-axial components of deformation, the response of each force transducer is obtained at five symmetrically distributed positions relative to the axis of the machine (0°, 90°, 180°, 270°, 360°). In order to get better results, prior to start measurement cycle, the force transducer should be loaded with maximum test load three times at the 0° position.

The measurements shall carry out at (21 ± 1) °C and relative humidity (45 ± 10) %rh, the usual laboratory conditions at TÜBİTAK UME and SASO NMCC. Due to equality of laboratory conditions, effect of temperature difference on uncertainty can be eliminated. Both the force transducers and indicator should keep in laboratories for at least 1 day prior to the initiation of measurements. Force steps selected for international comparison of the SASO NMCC and TÜBİTAK UME Force Standard Machines are shown in Table 1.

10. Measurement Uncertainty

The uncertainty of measurement must be calculated according to the JCGM 100 “Guide to the Expression of Uncertainty in Measurement” [1] for the coverage probability of approximately 95%. The uncertainties were estimated in respect of principles laid out in the Document “Expression of Uncertainty of the Measurement in Calibration”, published EA 4/02 [2]. The principal components of the uncertainty budget to be evaluated are in accordance with the document “Calibration Guide EURAMET/cg-04/v.02 (03/2011)-Uncertainty of Force Measurements” [4] or in accordance with equivalent consensus documents.

11. Reporting of Results

The results should be prepared and send to the pilot institute within 30 days after completing the measurements.

Results shall be reported to the pilot laboratory. The report must contain at least:

- Details of participating laboratory,
- The date of the measurements,
- A detailed description of the measurement method and system used,
- The measurement standards used in the comparison measurements,
- Software used in the comparison measurements,
- The environmental conditions during the measurements,
  - ambient temperature
  - relative humidity
- Results of measurement; the measurement results shall be provided according to the Annex A format.
- A statement of traceability,
- Model function of measurement with explanations of the symbols,
- Expanded measurement uncertainty, estimated for the coverage probability of approximately 95%.

12. Final Report of the Comparison

The pilot laboratory is responsible for the preparation of a comparison report.

The draft version of the comparison report will be issued within two months after receiving the participant report by the pilot laboratory. Draft report will be sent to the SASO NMCC for discussion and approval. This draft will be confidential between the participants.

The participant will have one week to send their comments on Draft Report. After approval, Draft Report will become the Final Report.

Comparison results will be evaluated according to the En value which is calculated Equation 1 stated at ISO/IEC 17043 “Conformity assessment — General requirements for proficiency testing” [3] Standard.

$$E_n = \frac{x_{lab} - x_{ref}}{\sqrt{U_{lab}^2 + U_{ref}^2}} \qquad (1)$$

x_{lab}: Participant laboratory measurement result

x_{ref}: Pilot laboratory measurement result

U_{lab}: Participant laboratory measurement uncertainty

U_{ref}: Pilot laboratory measurement uncertainty

The laboratory measurement results will be utilized according to the criteria of E_n value which is given below.

If $|E_n| \leq 1$ then it is successful

If $|E_n| > 1$ then it is unsuccessful

13. References

[1] Evaluation of measurement data - Guide to the Expression of Uncertainty in Measurement (GUM), JCGM 100, First edition, September 2008 (available on the BIPM website: http://www.bipm.org/utils/common/documents/jcgm/JCGM_100_2008_E.pdf)

[2] EA Publication EA-4/02, Expression of the Uncertainty of Measurement in Calibration

[3] ISO/IEC 17043 “Conformity assessment — General requirements for proficiency testing”, International Standardization Organization”, 2010

[4] Calibration Guide EURAMET/cg-04/v.02 (03/2011)-Uncertainty of Force Measurements

[5] Tegtmeier,F., Kumme,R., Seidel,M., Improvement of the realization of forces between 2 MN and 5 MN at PTB, XIX IMEKO World Congress, Fundamental and Applied Metrology, September 6-11, 2009, Lisbon, Portugal

[6] Dizdar, H., Aydemir, B., Vatan, C., Kuvvet Ölçümlerinde Belirsizlik, 2015, EURAMET cg-4, 2. Baskı (03/2011) çevirisi, Şubat 2015, TÜBİTAK UME

[7] Aydemir, B., Fank, S., Vatan, C., Interlaboratory comparisons performed in Turkey: Force calibration of static material testing, 2012, XX IMEKO World Congress, September 9-14, 2012, Busan, Republic of Korea, S.1-4

ANNEX A

PARTICIPANT REPORT

1. PARTICIPANT INFORMATION

Laboratory Name	SASO NMCC
Related Person Name	
Telephone No	
Fax No	
E-mail	
Address	Riyadh 11471, P.O. Box 3437 KINGDOM of SAUDI ARABIA

2. MEASUREMENT DATE

3. ENVIRONMENTAL CONDITION

Temperature : (21 ± 1) °C

Relative Humidity : (45 ± 10) %rh

4. REFERENCES USED IN MEASUREMENT

Instrument Name	Manufacturer	Type / Model	Serial No	Traceability

5. MEASUREMENT METHOD

6. MEASUREMENT RESULTS

Force	Deflection / (mV/V)					
	Orientation Degrees					Mean Value
kN	0°	90°	180°	270°	360°	