EXTERNAL

ADQCC –
EMIRATES METROLOGY INSTITUTE (EMI)

Establishing a Force and Torque Laboratory that meets the requirements of ISO 17025

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T&M 2015 Conference, 13 October 2015

Lord Charles Hotel, Somerset West, Cape Town, RSA

مجلس أبوظبي للجودة والمطابقة
ABU DHABI QUALITY AND CONFORMITY COUNCIL

EMI laboratories are located in the CERT Health Science Building

Facilities

Measurement Areas

- Mass*
- Volume*
- Liquid and Solid Density
- Dimensional* and Form
- Angle
- Temperature* and Humidity*
- Force* and Torque*
- Liquid and Gas Flow
- Time and Frequency*
- DC/LF Electrical*
- Pressure and Vacuum

* Covered by Initial Assessment

Check List for ISO 17025

● EMI has produced a 68 page document to be used as a check list for its own Internal Audits. This is based on the NIST document that is available:

http://www.nist.gov/pml/wmd/labmetrology/upload/ISOIEC17025Cklist-2009-compatibleWord2003-2.doc

● EMI chose the United Kingdom Accreditation Service – UKAS – as the accreditation body for assessment to ISO 17025 (Calibration). UKAS is a member of the International Laboratory Accreditation Cooperation (ILAC) and a signatory of the ILAC Mutual Recognition Arrangement (MRA)

Main UKAS Activities – Lead Assessor

- **Quality Manual** - Reviewed prior to visit
- **Organisation**

  Legal Status, Resources, Organisation Structure, Responsibility and Authority, Independence, Impartiality, Integrity and Confidentiality
- **Management System**

Control of documents	Complaints
Control of records	Control of non-conforming work
Review of requests, tenders and contracts	Corrective and preventive action process
Sub-contracting of calibrations	Internal Audit
Purchasing services and supplies	Management review
Service to the customer	Supervision and monitoring of staff

Main UKAS Activities – Technical Assessor

Technical Competence requirements included:

- Personnel
- Contract review implementation
- Reporting the results (proposed example certificates)
- Accommodation and environmental conditions
- Calibration Methods
- Uncertainty of measurement
- Control of data
- Equipment
- Measurement traceability arrangements
- Handling of calibration items
- Assuring the quality of calibration results

5 MN Force Standard Machine

- The Force Standard Machine (FSM) uses reference force transducers calibrated in an FSM of an NMI that has an appropriate CMC (PTB)
- Forces can be applied in compression and tension, both incrementally and decrementally, over the range 50 kN to 5000 kN
- The machine can be operated under manual control or computer control and store readings from a range of different indicators (DMP39, DMP40, etc.) on a data file
- The uncertainty of the applied force is provisionally 0.02 %

1000 N·m Torque Standard Machine

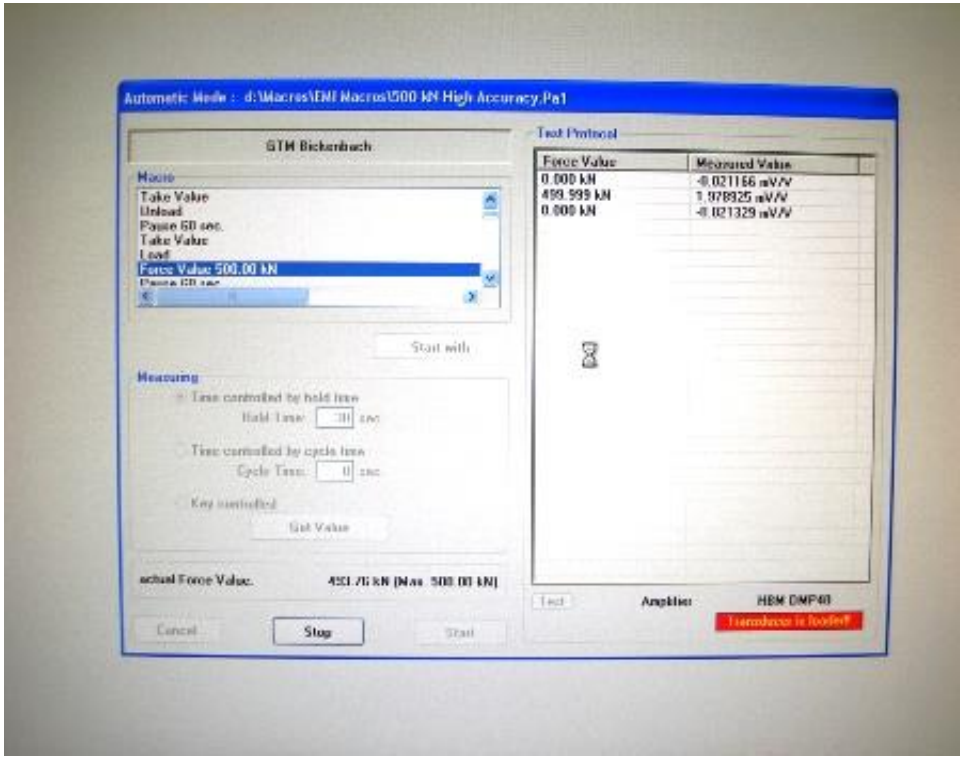
1000 N·m Torque Standard Machine

- Torques are applied by the manual application of weights to scalepans attached to a lever by strip hinges
- The lever itself is supported on a strip hinge arrangement
- All of the strip hinges have strain gauges bonded to both sides so that they are effectively bending moment transducers having a high sensitivity
- The lever is balanced by bringing the summed output of the strain gauge bridges to zero

1000 N·m Torque Standard Machine

- Torques can be applied in the clockwise and anticlockwise directions, both incrementally and decrementally, over the range 0.5 N·m to 1000 N·m
- The weights are applied and removed by hand and are located on the scalepans, and on each other, using a conical location
- The free movement of the scalepans and the beam itself is damped using an Eddy current damping arrangement
- The machine is operated using a computer with manual entry of data or with data entry through an inbuilt mV/V indicator
- Columns under both sides of the lever restrict its movement to avoid overloading the sensitive strain-gauged strip hinges
- The lever is brought to a position of balance using a manually-driven high-ratio gearbox
- The uncertainty is estimated as 0.01 % of applied torque, and is being re-evaluated at the lower values of torque

Control computer displays for Force and Torque Standard Machines



Force resolution is 0.001 kN; Torque resolution is 0.00001 N·m

5 MN Force Standard Machine - Procedures

- **ISO376h** for the calibration of Force Proving Devices with ten equal force steps, applied both incrementally and decrementally, and with a creep and creep recovery test at the end of the calibration. Positions of rotation are 0°, 120° and 240°
- **Repeatability Test** to determine the repeatability of the system at the forces used in the ISO376h procedure. A total of seven runs are made in the 0° position only
- **High Accuracy Test** for the evaluation of Force Transfer Standards used for the verification of Force Standard Machines. The test gives equal weighting to increasing and decreasing forces and uses positions of rotation of 0°, 90°, 180° and 270°. Forces are applied in steps of 10 %, 20 % by 20 % to 100 % of maximum force. The procedure includes a 30 min creep and creep recovery test and a test to measure the temperature coefficient of span over at least 2 °C

It is designed to provide traceability for the EMI 5 MN FSM

1000 N·m Torque Standard Machine - Procedures

- **EURAMET Guide cg-14** is used for the calibration of Static Torque Measuring Devices. Calibrations can also be made in accordance with **DIN 51309** and **BS 7882**
- **Inter Laboratory Comparison Test** is based on cg-14 for the ILC with Norbar Torque Tools, Banbury, UK. The intercomparison covers clockwise and anticlockwise torque, for increasing values only and includes supported and unsupported beams at Norbar
- **Hinge Moment Calibration** is undertaken using small weights applied to the lever in its free condition. Calibration is also undertaken at 1000 N·m using a 1000 N·m reference torque transducer
- **Sensitivity Test** is undertaken with the lever in its free condition and with a torque of 1000 N·m applied to determine the hysteresis in the strain-gauged strip hinges
- **Equality of Lever Length** is determined by the application of a series of equal forces to both scalepans, starting with zero force applied

Calibration Results Sheet

- The Calibration Results Sheet (CRS) is used to record information by hand during a calibration (Date, observer, ambient conditions and device temperature). The sheet can be used to record the results obtained during a calibration if necessary, but the calibration results are normally either recorded automatically by the computer, or are entered by hand using the computer keyboard
- It is important to use a CRS when using the 1000 N·m Torque Standard Machine, as it guides the operator through the procedure of applying the weights by hand and balancing the lever
- Data from the CRS is entered on the associated Excel Calibration Analysis Sheet that analyses all the information and produces the results in a form that can be transferred to the Calibration Certificate
- It is planned to use a second computer with the Force and Torque Standard Machines to avoid the need to use a CRS and to also record data from devices which cannot be interfaced with the software provided

Calibration Results Sheet for ISO 376

CALIBRATION RESULTS SHEET (ENVIRONMENTAL) FOR FORCE TRANSDUCER FOR ISO 376			
Date:		Metrologist:	

Work Order Number:			
Data file reference:			
Device capacity / kN:			
Calibration mode:		c or t	
Transducer model number:			
Transducer serial number:			
Indicator model number:		)	Check instruments are in calibration
Indicator serial number:		)	
Indicator resolution:		)	
Environment sensor model:		)	
Environment sensor serial:		)	
Device temperature model:		)	
Device temperature serial:		)	

Humidity / %rh			
Temperature / °C			
Pressure / hPa			
Device / °C			
	Tests X_1 X_2	Tests X_3 X'_4	Tests X_5 X'_6

Humidity / %rh	
Temperature / °C	
Pressure / hPa	
Device / °C	

Sheet checked by:		Name
		Signature
Transfer of Data to CAS checked by:		Name
		Signature

Calibration Analysis Sheet - Classification

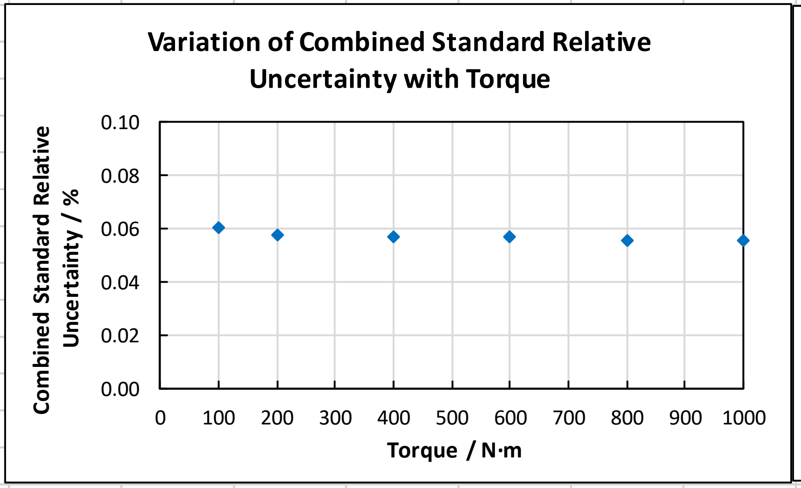
Limits for Classification / %											
Class	**0.05**	**0.1**	**0.2**	**0.5**	**1**	**2**	**5**				
b	0.05	0.10	0.20	0.50	1.00	2.00	5.00				
b'	0.025	0.05	0.10	0.25	0.50	1.00	2.50				
f_a	0.025	0.05	0.10	0.25	0.50	1.00	2.50				
f_0	0.0125	0.025	0.05	0.125	0.25	0.50	1.25				
h	0.063	0.125	0.25	0.63	1.25	2.50	6.25				
r	0.025	0.05	0.10	0.25	0.50	1.00	2.50			**Torque**	**Class**
										N·m	
1000	**0.2**							Min		1000	0.2
b	10	10	0.2	0.5	1	2	5	0.2		800	0.2
b'	0.05	0.1	0.2	0.5	1	2	5	0.05		600	0.2
f_a	0.05	0.1	0.2	0.5	1	2	5	0.05		400	0.2
f_0	0.05	0.1	0.2	0.5	1	2	5	0.05		200	0.2
h	0.05	0.1	0.2	0.5	1	2	5	0.05		100	0.2
r	0.05	0.1	0.2	0.5	1	2	5	0.05			
800	**0.2**							Min			
b	10	10	0.2	0.5	1	2	5	0.2			
b'	0.05	0.1	0.2	0.5	1	2	5	0.05		**NB**	A classification must extend down to at least 50 % of the range.
f_a	0.05	0.1	0.2	0.5	1	2	5	0.05			
f_0	0.05	0.1	0.2	0.5	1	2	5	0.05			Class 10 means that no classification is possible to EURAMET cg-14.
h	0.05	0.1	0.2	0.5	1	2	5	0.05			
r	0.05	0.1	0.2	0.5	1	2	5	0.05			

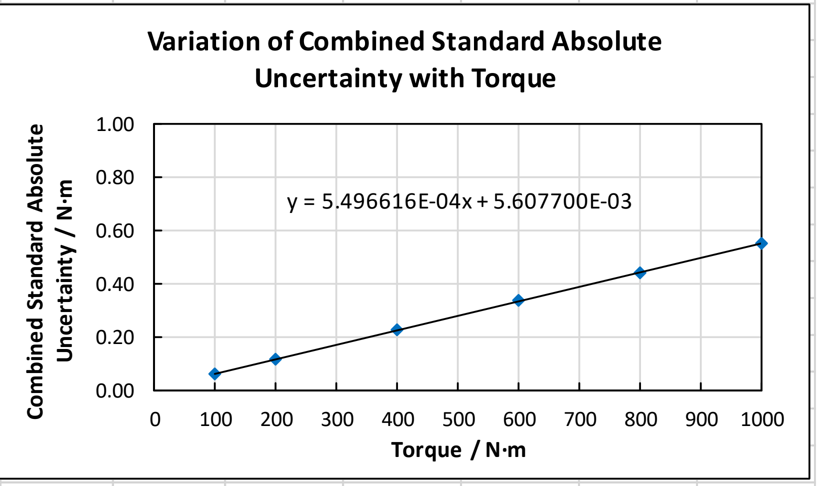
Calibration Analysis Sheet - Uncertainty

Applied Torque	Standard Relative Uncertainty					Combined Standard		Combined Expanded	
	Ref Torque	Reprod b	Repeat b'	Res r	Interp f_a	w_c	u_c	W_c	U_c
N·m	%	%	%	%	%	%	N·m	%	N·m
100	0.0100	0.0581	0.0106	0.0014	0.0047	0.0601	0.0601	0.1201	0.1201
200	0.0100	0.0562	0.0018	0.0007	0.0001	0.0571	0.1143	0.1143	0.2285
400	0.0100	0.0556	0.0000	0.0004	0.0004	0.0565	0.2259	0.1130	0.4518
600	0.0100	0.0556	0.0006	0.0002	0.0006	0.0565	0.3391	0.1130	0.6781
800	0.0100	0.0546	0.0004	0.0002	0.0006	0.0555	0.4441	0.1110	0.8881
1000	0.0100	0.0544	0.0028	0.0001	0.0002	0.0554	0.5542	0.1108	1.1085

NB

The uncertainty of the Ref Torque is the uncertainty at **k=1**





Storage of Data

Data is filed and stored on the EMI "Sharepoint" main server using the conventional method of using a series of folders:

- Manufacturer
  - Model number / capacity
    - Serial number
      - Date of test(s) (ISO format)

Under the Date of test(s) folder, the data file is stored with a file name:

Serial number-Date of test-Mode-Procedure/Macro-Comment eg:

58622-20150625-c-ISO376h

For force transducer 58622 calibrated on 25 June 2015 in compression to ISO 376 for increasing and decreasing forces. If a second calibration is made to the same procedure, on the same day, the letter A is added immediately after the ISO date

Storage of Data

For torque transducer 59737, calibrated at Norbar on 20 July 2015 in the anticlockwise direction to the procedure F005A (for the ILC with Norbar Torque Tools), the data file would be:

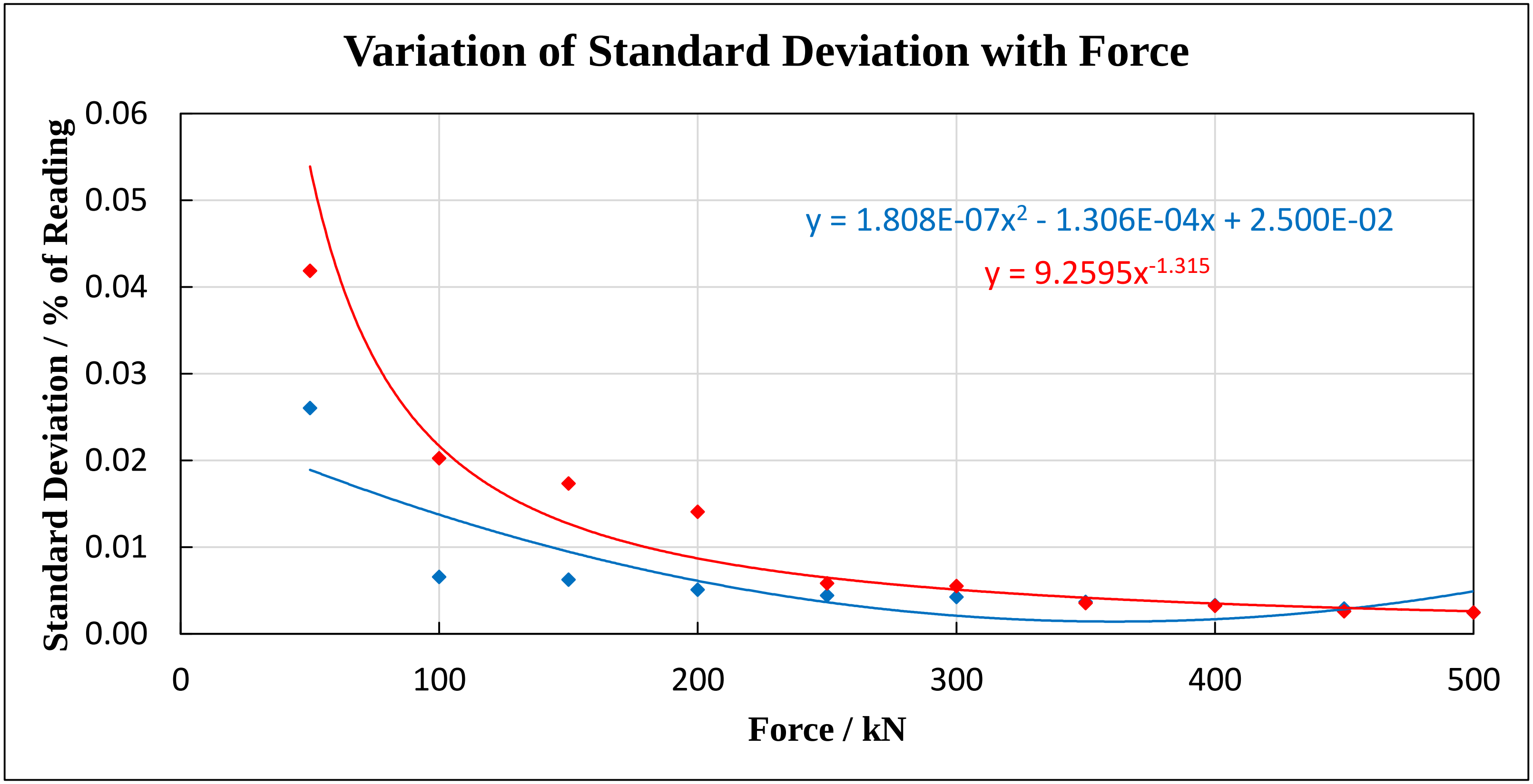
59737-20150720-acw-F005A-Norbar unsupported

As well as containing the data file, the Date of test(s) folder contains:

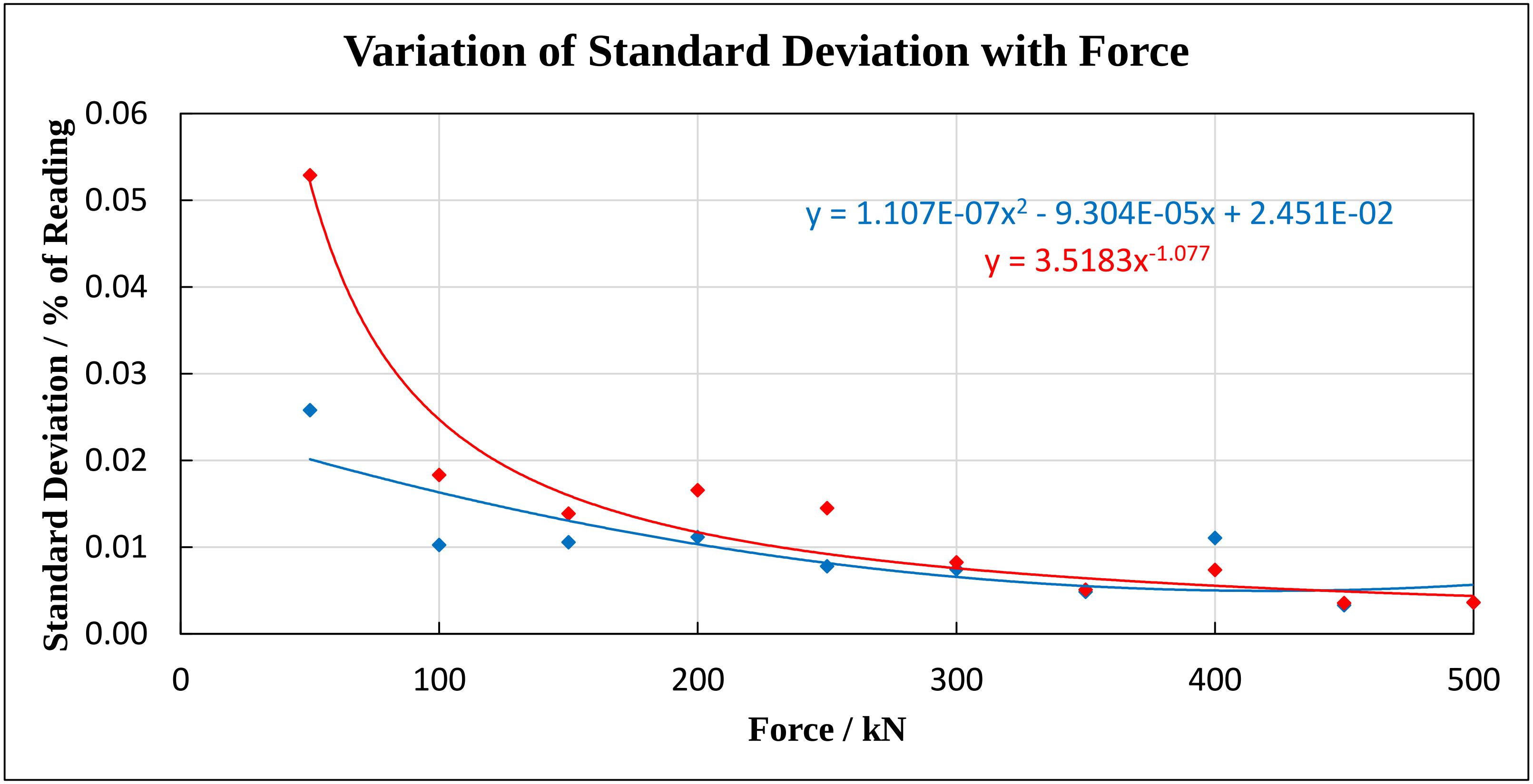
- Scanned copy of the appropriate Calibration Results Sheet
- The associated Excel Calibration Analysis Sheet that analyses the calibration results
- Calibration certificate in Word format
- Scanned copy of the signed and stamped calibration certificate

We are aiming for a “paperless” system in the future

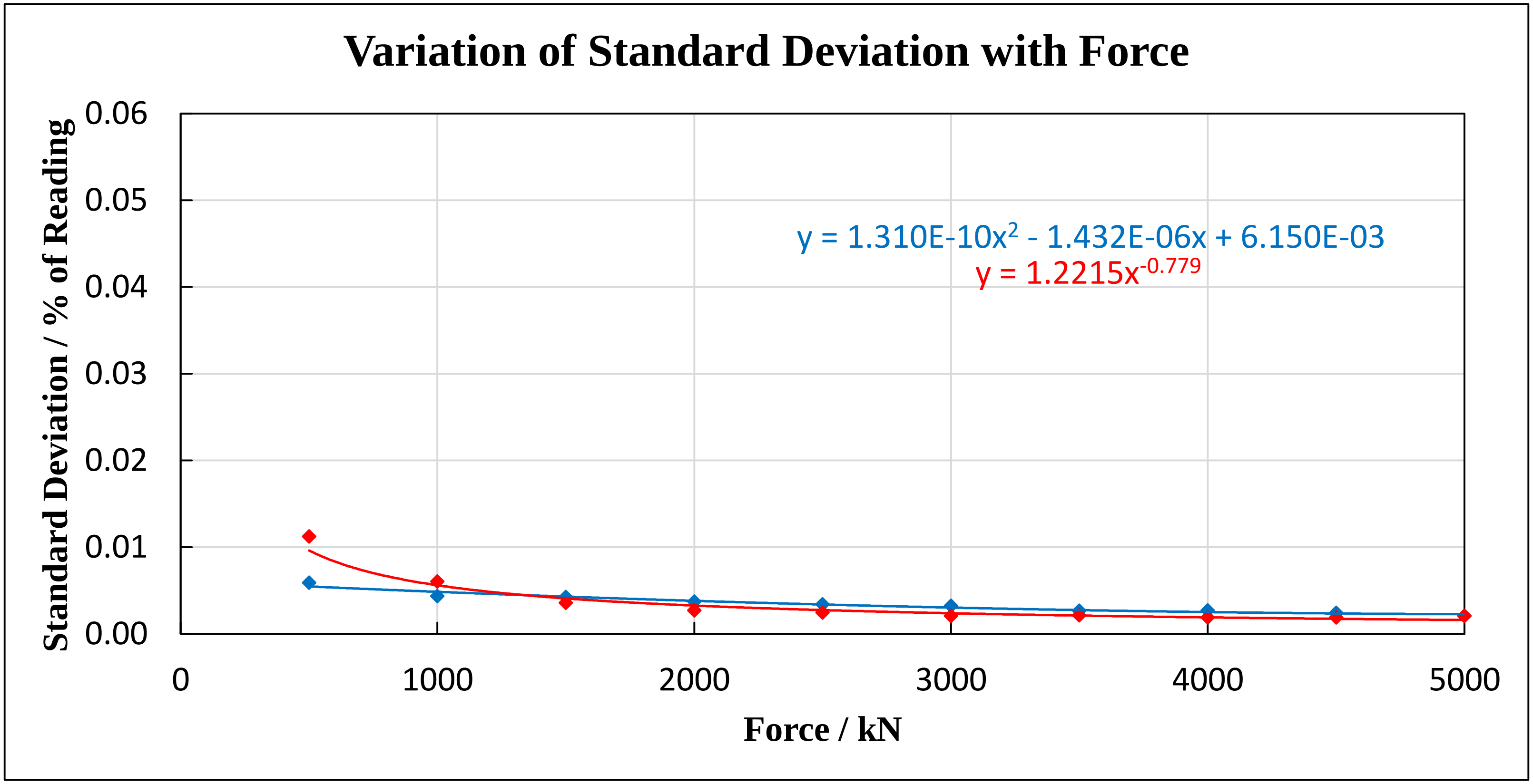
5 MN FSM Repeatability Tests 58622



5 MN FSM Repeatability Tests 61894

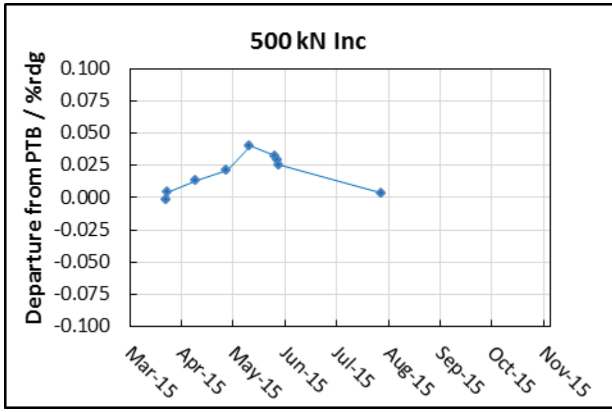


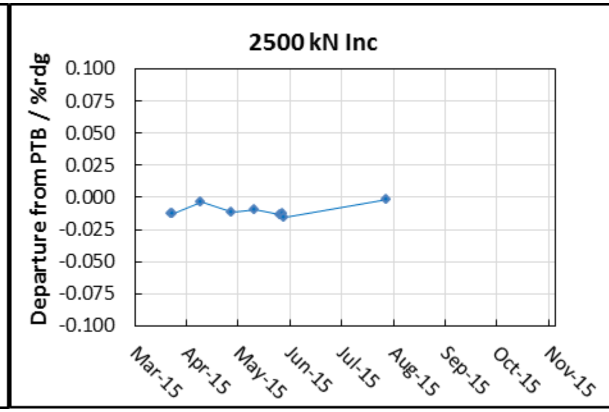
5 MN FSM Repeatability Tests 58671

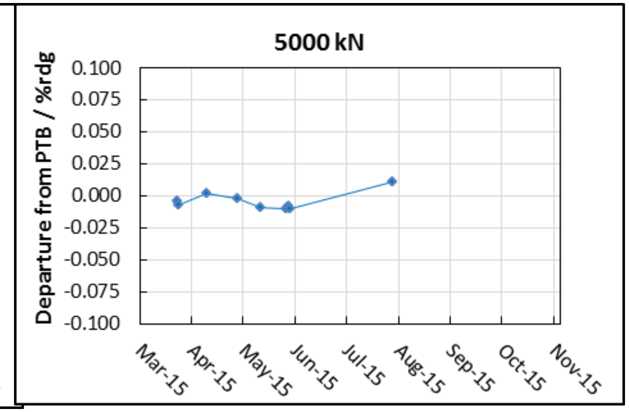


Calibrations to ISO 376

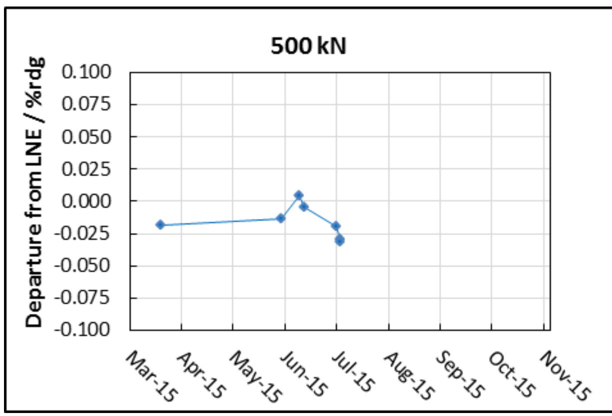
PTB

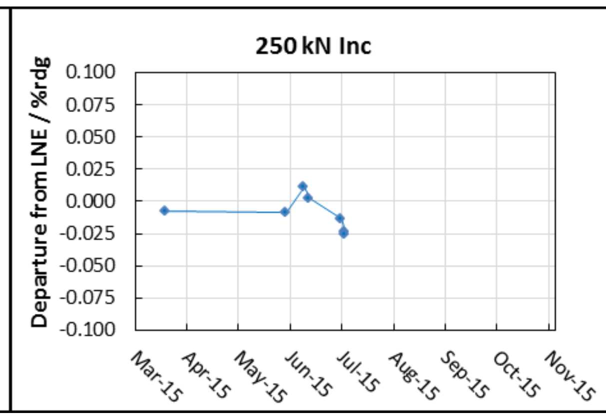


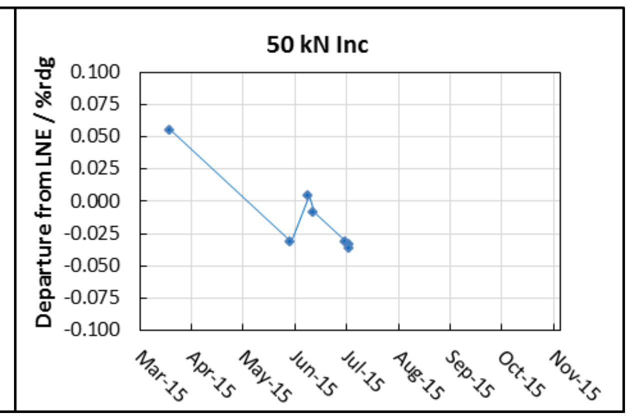




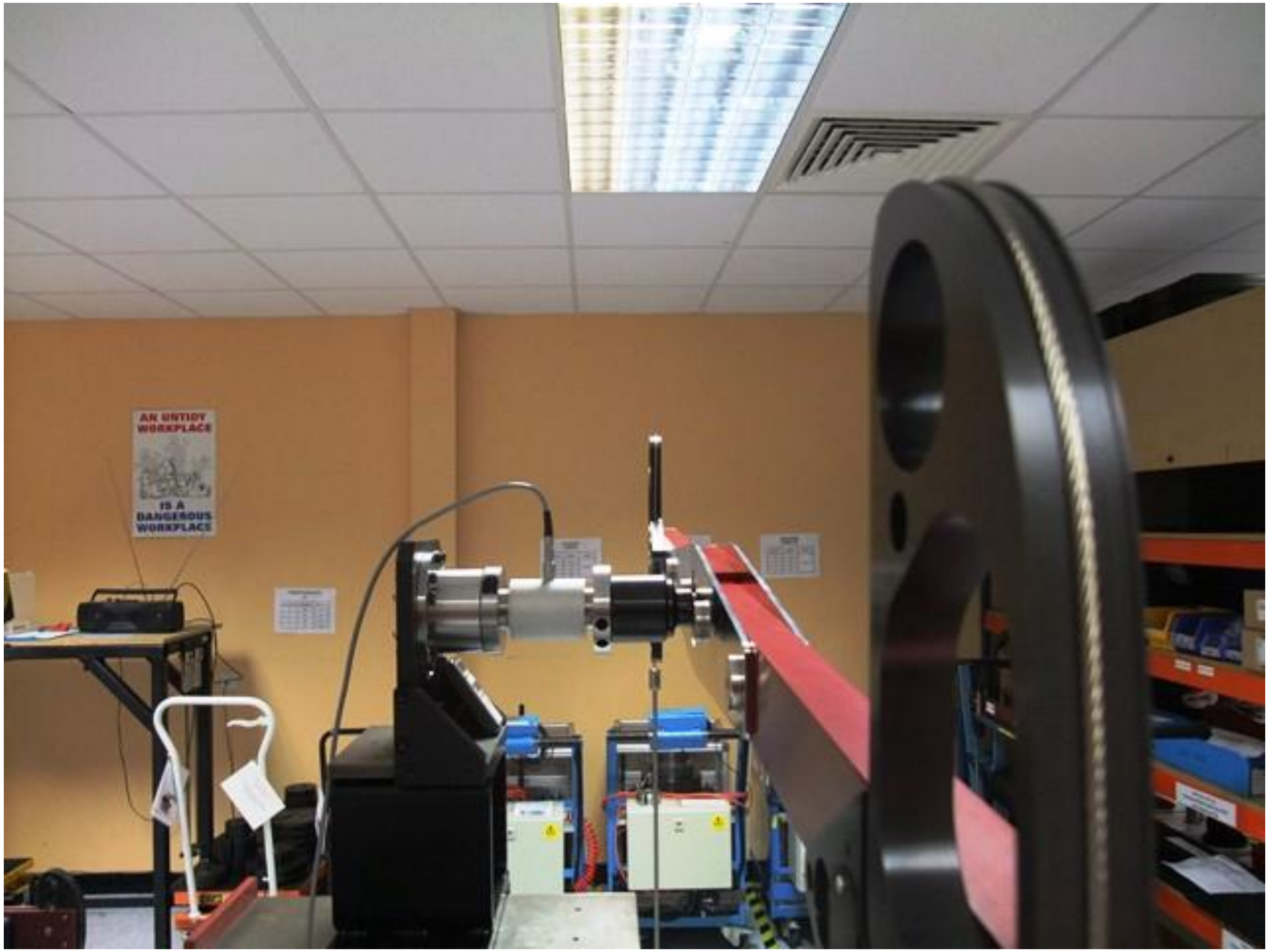
LNE



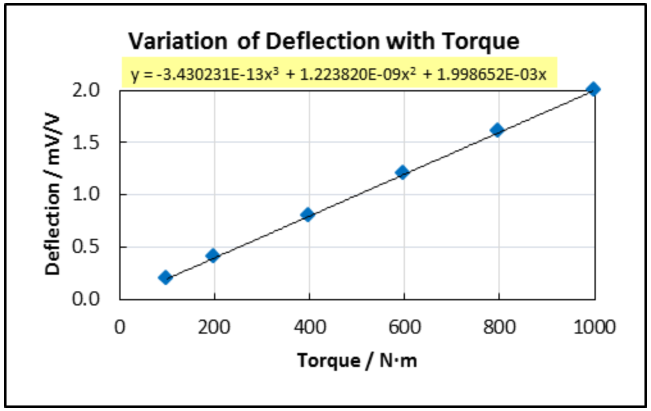


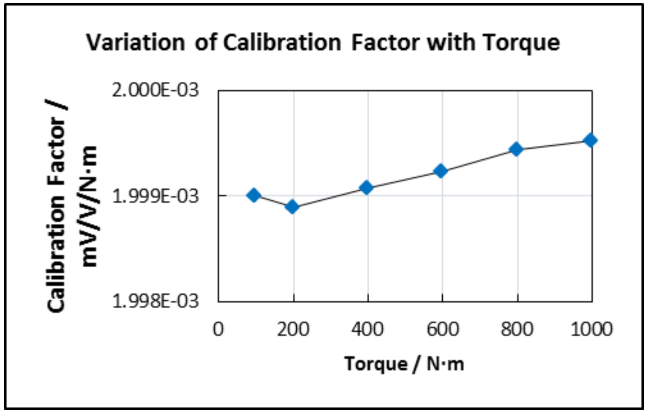


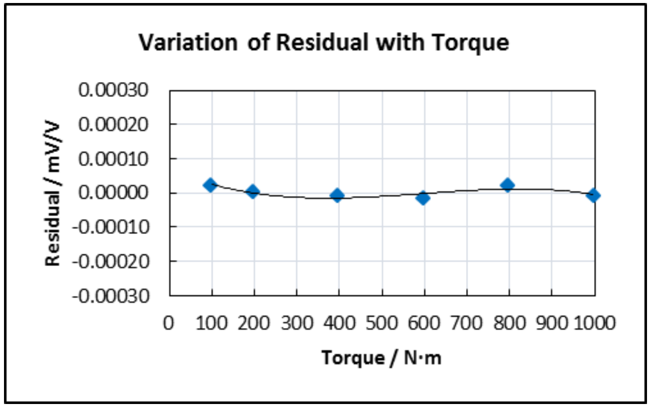
Intercomparison with Norbar

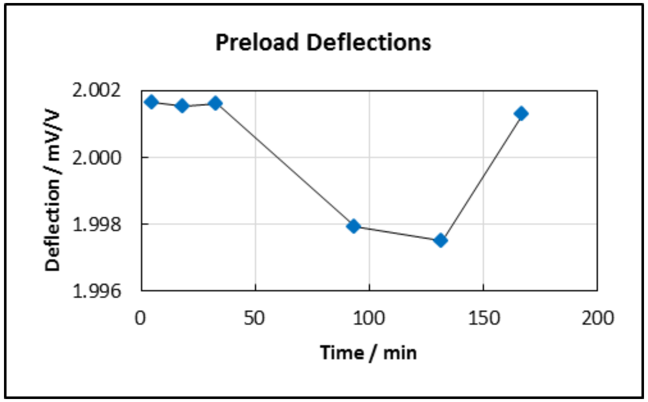


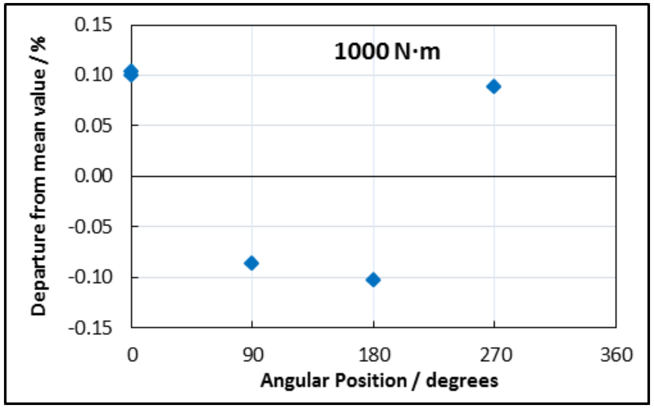
Characteristic Graphs for Torque Transducer



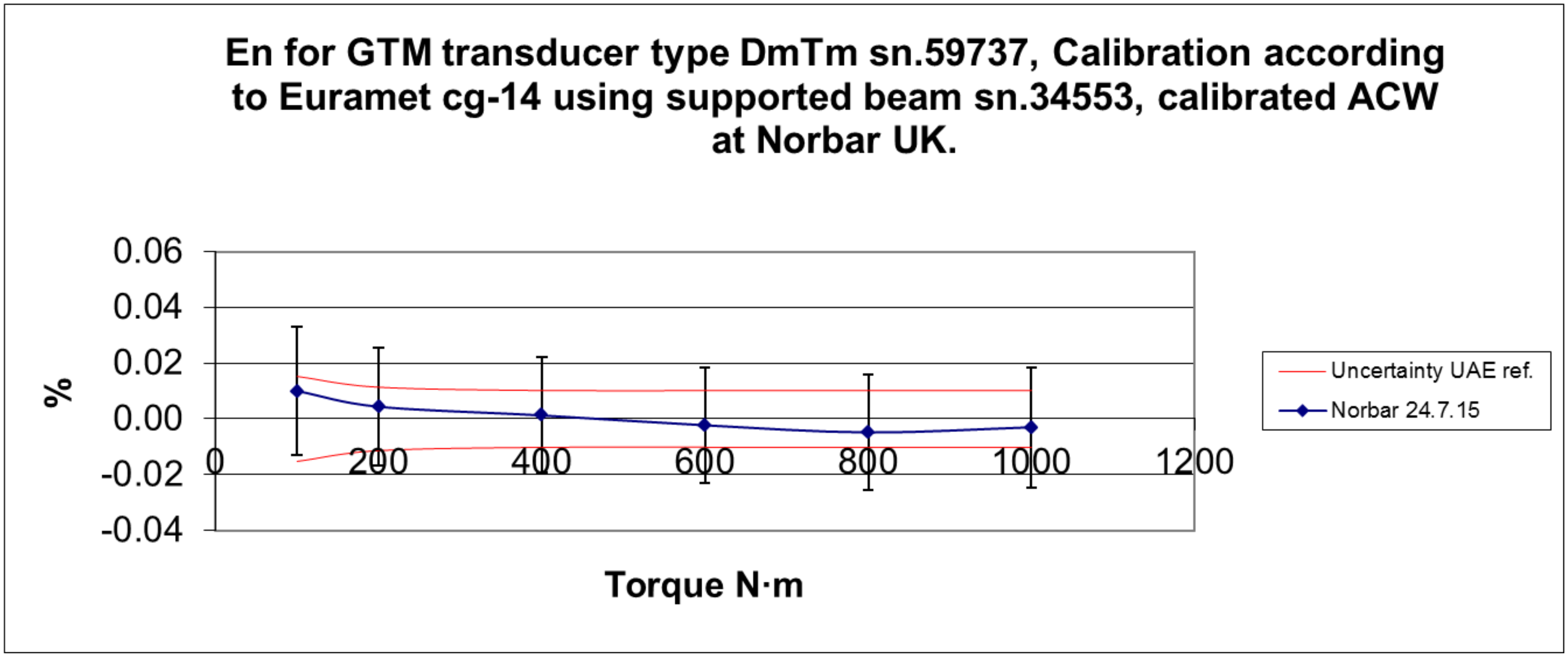








Results of Intercomparison with Norbar



Conclusions

- It is essential to establish the protocol for maintaining traceability in the long-term, using appropriate calibration procedures which can be undertaken in-house, or by an acceptable external calibration laboratory
- A regular monitoring program is needed for all the important elements of a Force or Torque Standard Machine
- Participation in Inter Laboratory Comparisons is also essential
- The routine calibration process should be automated as much as possible – Data collection, Data analysis and Certificate preparation
- Spreadsheets should give graphical information to assist in easily identifying anomalies, and must be validated carefully

Thank you