The effect on a torque measuring devices sensitivity when using an unsupported calibration beam.

Barry C. Pratt
Head of Laboratory
Norbar Torque Tools Ltd
Beaumont Road
Banbury
Oxfordshire
OX16 1XJ
United Kingdom

Phone: + 44 (0) 1295 270 333
E-mail: bpratt@norbar.com

Abstract – Unsupported calibration beams coupled directly to a transducer are used in industry for reasons of cost and simplicity. They can be used to calibrate transducers to the highest levels of classification, however they do induce bending effects [1] into the device and depending on the weight of the beam relative to the transducers capacity this can cause an increase in the transducers sensitivity for low relative torque values. Example sensitivity curves are given together with suggestions to minimise this effect. Comparison against the UK National torque standard is also given.

Introduction

Unsupported Calibration Beams are flexible and easy to use and in many instances replicate the way the torque measuring device is subsequently used. This makes them well suited for calibration of the many forms of torque measuring devices found in industry.

It is best practice to use a beam with a capacity that is commensurate with the transducer being calibrated and ideally the weight of the beam should be as light as possible. A calibration range of 10% - 100% of full scale is preferred as the transducers sensitivity (mV/V/N·m) can increase sharply below the 10% mark.
For example it is preferable to use a 0.5 metre radius beam with a capacity of 500 N·m to calibrate a 500 N·m transducer rather than a 1.0 metre radius beam with a capacity of 1500 N·m, even though the smaller beam requires twice the load to generate the same torque. This does not mean that a 1500 N·m beam cannot be used to calibrate a 500 N·m transducer but if a choice was available the smaller beam should be used.

The suitability of a particular beam is also relative to the stiffness of the transducer under calibration, and a device which has an output of 0.8 mV/V will be less susceptible to bending and sensitivity effects than one which has an output of 2.0 mV/V.
The characteristics of how a transducer behaves, what its output is and how its mounted are important factors to consider. It is best practice to calibrate the transducer in a symmetrical manner to minimise the influence from bending.
Sensitivity and bending effects should be considered as part of the uncertainty calculation and data from a double load test [2] can provide an insight into a transducers performance.
.

General

The distance between the beam and transducer should be kept to a minimum. Where possible it is always best to connect the beam directly to the transducer in order to minimise any slack in the coupling of the square drives, and the transducer itself should be held as rigidly as possible in the calibration fixture

Sensitivity

The sensitivity of a transducer is calculated by dividing the mean deflections by the applied torque to give a sensitivity at each applied torque in units of mV/V/N·m.

Two curves are given in figure 1 for a 50 N·m transducer calibrated with two unsupported calibration beams, one weighing 2.78 kg. and one weighing 1.87 kg.
The error bars represent the weight of the beam as an equivalent torque value. The lighter beam significantly reduces the increase in sensitivity at the lower torque values.

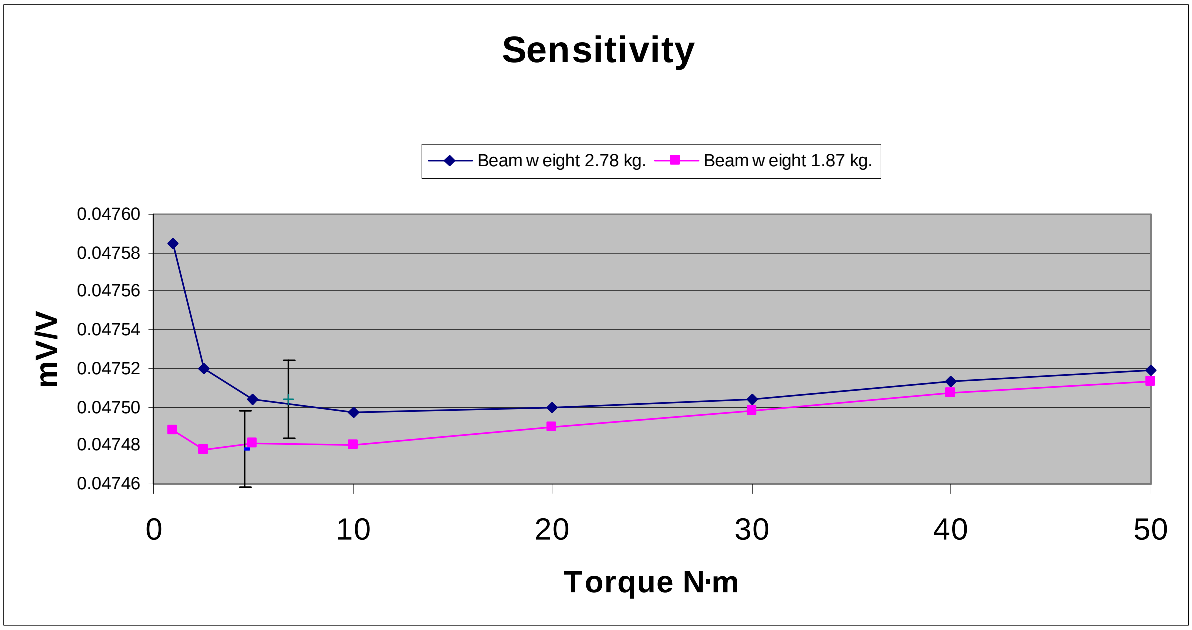

Figure 1. Sensitivity of a 50 N·m transducer calibrated with unsupported calibration beams.

Two curves are given in figure 2 for a 1 N·m transducer calibrated with two unsupported calibration beams, one weighing 0.46 kg. and one weighing 0.16 kg.
The error bars represent the weight of the beam as an equivalent torque value. The lighter beam significantly reduces the increase in sensitivity at the lower torque values.

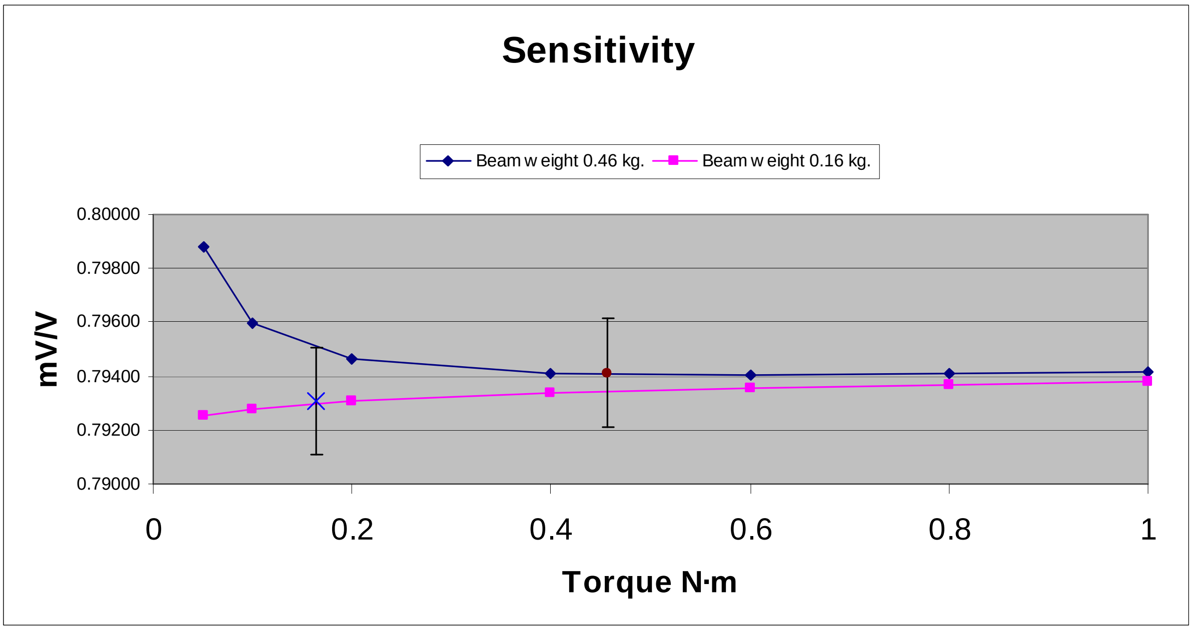

Figure 2. Sensitivity of a 1 N·m transducer calibrated with unsupported calibration beams.

Comparison against national standards

Providing an appropriate calibration beam is used results within 0.02% in comparison to national standards are achievable, even though there is a tendency for the sensitivity to increase at the lower torque values. Much depends on the transducer and best results are achieved from those that behave in a symmetrical manner.

Figure 3 shows the deviation of a 100 N·m unsupported beam calibration from reference values provided by the UK national torque standard machine [3] held at the National Physical Laboratory in London. The calibration beam had a capacity of 150 N·m and weighed 4.85 kg. (equivalent to 23.78N·m of applied torque). Its uncertainty of applied torque is ± 0.02%. The nominal output of the transducer was 2 mV/V.

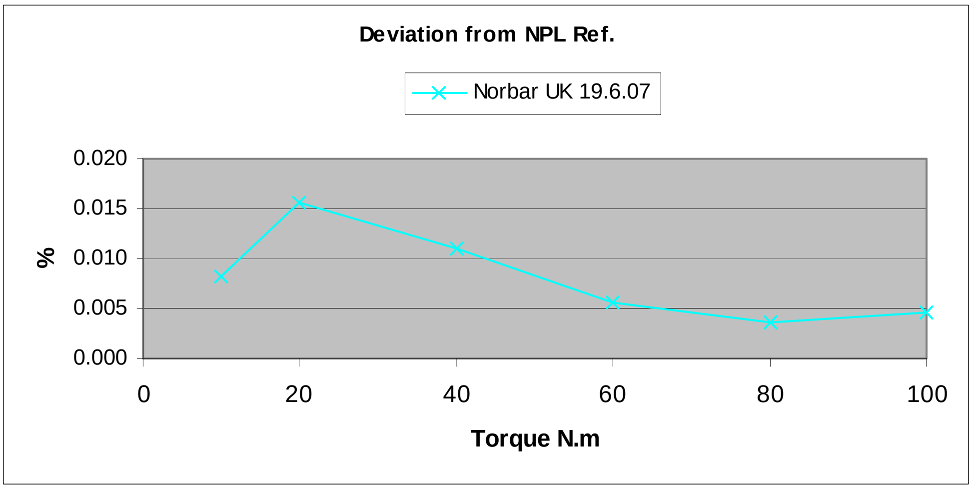

Figure 3. deviation of a 100 N·m transducer from the NPL reference value.

Table one gives the expanded uncertainty of the two calibrations and the En-ratio value, the uncertainties do not include any allowance for bending or sensitivity effects.

The En-ratio is a method for comparing the results of similar calibrations and provides a measure of their equivalence. When an En-ratio between two measurements is less than 1.0 the two measurements are deemed to be equivalent to each other. The En-ratio was calculated using the difference between similar mean values and the expanded uncertainty of the NPL and Norbars calibration. Ideally the EN-ratio should be 0.5 or less, the lower the value the better the agreement between the results.

Table1. Uncertainty and En-ratio for 100 N·m transducer

N·m	NPL Uncertainty %	NOR UK Uncertainty %	En-ratio
0	0	0	
10	0.06423	0.03719	0.111682
20	0.03777	0.04150	0.276527
40	0.01625	0.04301	0.237301
60	0.01219	0.04242	0.125762
80	0.01021	0.04339	0.080604
100	0.00834	0.04317	0.106599

Conclusion

When using unsupported calibration beams it is best practice to include an allowance for bending effects in the calibration uncertainty calculation. It is also important to check that the bending allowance encompasses any increase in the transducers sensitivity (m/V/V/N·m) for readings in the range 2% - 10% of full scale deflection. With bending and sensitivity effects taken into consideration it is possible to perform fit for purpose calibrations to high levels of accuracy over the transducers calibrated range.

References

[1] Pratt B, Robinson A, 2006 A comparison between supported and unsupported beams for use in static torque calibrations. *Proceedings of the* 18th Imeko World Congress, Rio de Janeiro.

[2] Robinson A, 2008 Guide to the calibration and testing of torque transducers. NPL. National measurement good practice guide No.107.

[3] Robinson A, 2007 The Design, Development and Commissioning of a 2 kN·m Torque Standard Machine. *CalLab, Jan – Mar*.