21 Tips on How to Install a Torque Sensor

The torque sensor is a critical component of accurate measurement and, by design, can act similar to a **mechanical fuse**. If it's installed improperly, the torque sensor can be damaged beyond repair - costing you time and money. To get the **best performance and longevity** out of your torque sensor, be sure to install it properly. In this paper, you'll learn **installation tips and tricks** in the following areas:

- Arrival - handling, moving, shipping
- Driveline design - critical speed, parasitic forces and design
- Mechanical installation - couplings, mounting and alignment
- Cabling - construction and noise immunity
- Electrical setup - shunt value, calibration data and onsite calibration.

Handle with care

Rotating torque sensors and reaction torque sensors are **very sensitive measuring devices,** and in turn, must be handled with care. **Low-capacity torque sensors** - those under 100 Newton Meters - in particular can be **overloaded** or wrecked very easily, so handle them gently. Just accidentally dropping the sensor can cause damage.

➢ **Tip 1:** Some of the heavier, larger-capacity torque sensors have threaded holes. To prevent rough handling, you can **attach eyebolts and straps to the holes** to lift and move the sensor more easily around your facility.

➢ **Tip 2:** If you need to ship your torque sensor, delicately pack the device in **protective packing material.**

Ensure peak performance with a thoughtful driveline design

The **design of your driveline** will impact the performance and longevity of your torque sensor and the accuracy of your readings.

Every driveline has a **critical speed** [in rotations per minute (RPM)] at which the shaft becomes unstable, resulting in torsional vibration. This vibration can be damaging to the torque sensor. To measure the torque accurately, **strain must be directed to an exact point** - generally the weakest point of the sensor structure. So the torque sensor is specifically designed to be one of the weaker parts of the driveline.

Critical speed is caused by a combination of four driveline factors:

- Length
- Stiffness
- Weight
- RPM

➢ **Tip 3:** To improve performance, keep your driveline **as short as possible, as stiff as possible and as light as possible.** This will help avoid any critical speeds and damage to the sensor.

Moreover, a long, complicated driveline has many mechanical parts, introducing opportunities for problems and errors. So the fewer the parts, the better.

In **image 1**, the torque sensor (in blue) is mounted close to the bearing block in the absorber, or dynamometer. Since it's mounted to the left of center, the bearing of the dynamometer is holding most of the weight, helping to move the critical speed away from the measuring range of the application or test.

➢ **Tip 4:** It's a good practice to put the torque sensor **as close to a bearing as possible** instead of in the center of the driveline.

Image 2 is a test output of a long drive shaft from a diesel engine on an engine dynamometer. The shaft reached critical speeds early in the test, causing a torsional vibration, which dramatically skewed the reading. If the torque sensor was not sized properly, this vibration or peak torque could have damaged the sensor. However, once the RPMs increased, the torsional vibration decreased, and the test continued without issue. So quickly passing through a critical speed, or avoiding one altogether, is important both for testing accuracy as well as protecting your torque sensor.

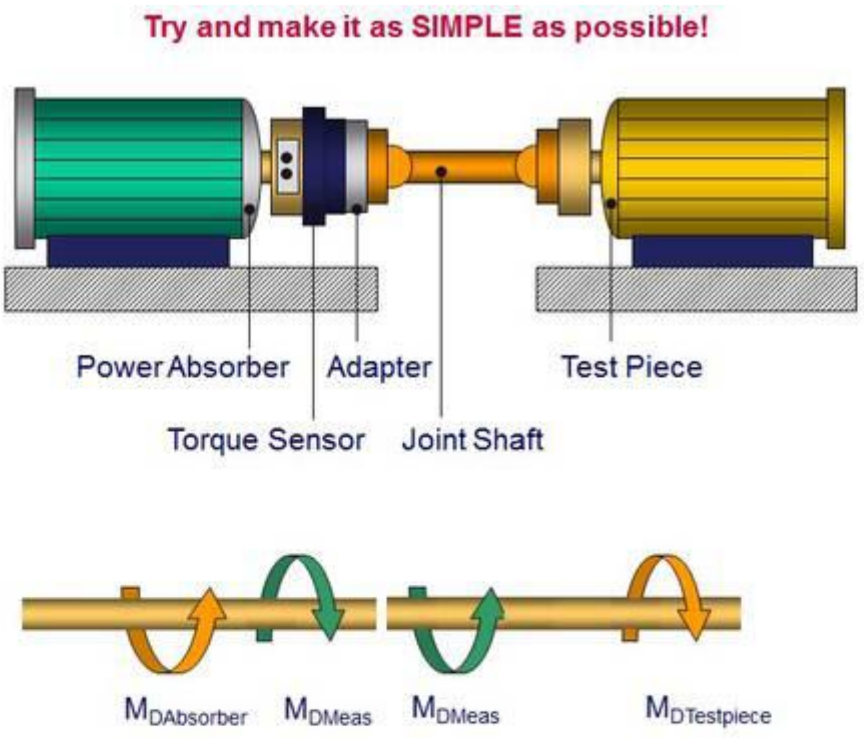


Image 1: A short, simple driveline

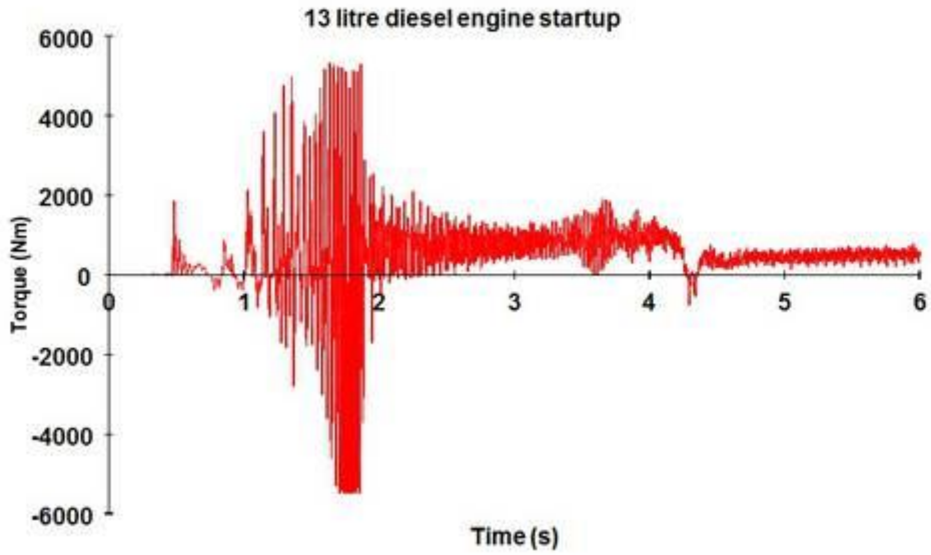


Image 2: The test output of a long drive shaft from a diesel engine on an engine dynamometer

Balancing the torque sensor

Another way to stay away from vibration is to **balance your torque sensor and driveline.**

➢ **Tip 5:** Check with the **manufacturer** to find out if your torque sensor was **balanced** at the factory.

Circular shaft-style torque sensors generally have one or two **keyways** on each end of the shaft. These keyways are a source of imbalance and backlash if the torque is alternating in the application. Make sure that **the keys fit in the keyways properly.** Then once installed, balance the entire driveline because the keys can create an imbalance.

A more modern flange-mount telemetry torque sensor application should have the **entire driveline balanced** once the rotors are installed.

Minimizing parasitic extraneous loading

Extraneous forces or off-axis loading can also cause torsional vibrations. The following are the most common off-axis loads:

- **Longitudinal** (thrust or tensile) limit force is the maximum permissible axial force
- **Lateral** (shear) limit force - which can be X or Y - is the maximum permissible radial force
- **Bending moment** - which is the weight times the distance away from the end of the torque sensor - is the maximum permissible bending force

The data sheet for most torque sensors includes a **parasitic load chart** with the lateral, longitude and bending moment limits for the sensor. While they're generally not catastrophic or damaging limits, staying under the parasitic load limits prevents an excessive amount of error in your torque reading.

➢ **Tip 6:** Reaching **100 percent of the cumulative parasitic load limit** places about **a 0.3 percent full-scale error** on a torque sensor output. For example, if all three limits are 33.3 percent of the maximum value on the data sheet, this adds up to 100 percent and will cause a 0.3 percent of full-scale torque error.

Understand proper mechanical installation

The more rigid the driveline, the greater its ability to pass along torque information. So in some applications, a torsionally rigid coupling is an advantage. However, in applications where measuring peak torque is not required, a less rigid coupling can be used. This will dampen the torque spikes and allow the sizing of the torque sensor to be closer to the average torque.

Mounting the torque sensor

There are two ways to install a torque sensor: **foot-mounted or floating.**

Foot-mounted torque sensors

A foot-mounted torque sensor can have a square "foot" that is used for mounting to a pedestal. As a result, the torque sensor does not float in the driveline. (See image 3)

Foot-mounted torque sensors have bearings. So you need to account for both angular and parallel misalignments, requiring a full coupling (or dual-flex coupling) on both sides of the sensor.

➢ **Tip 7:** Use a foot mount to reduce the length of the unsupported shaft and to change the critical speed. Note that when using a foot mount, proper alignment is critical.

However, in image 4, the torque sensor on the left is foot mounted from the front with a pulley on one side. The floating pulley does not require a coupling. So in this mounting application, only one dual-flex coupling is required.

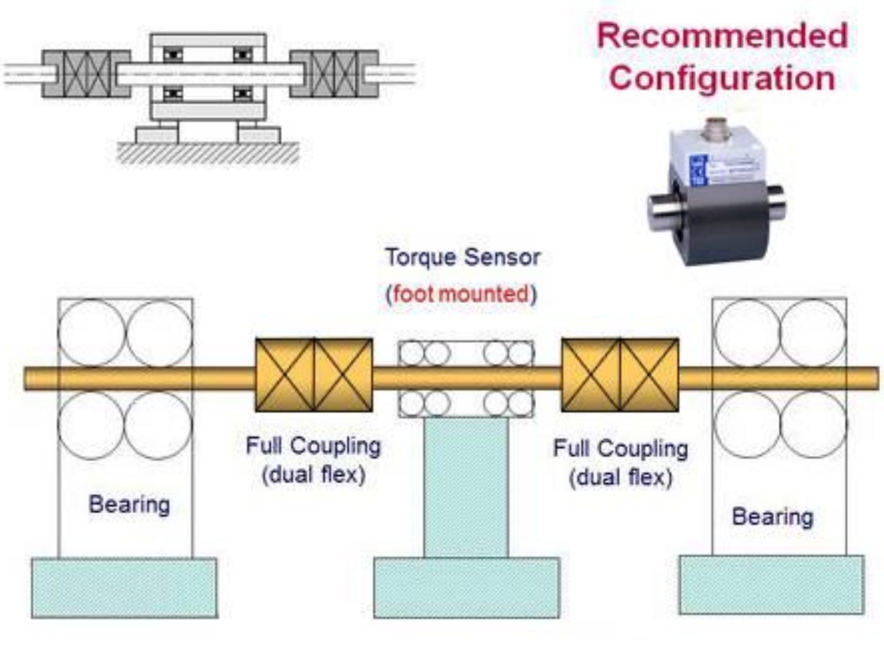


Image 3: A foot-mounted slip-ring (rotary transformer) torque sensor

Image 4: A foot-mounted sensor with two dual-flex couplings and a foot-mounted pulley sensor with one dual-flex

Floating torque sensors

A floating torque sensor can be **bearingless** and floats in the driveline (see **Image 5**). When using a floating torque sensor, it’s possible to put the torque **sensor in between two half couplings**, as opposed to one dual-flex coupling. Only **parallel misalignment** needs to be accommodated for as angular misalignment is helped by the floating sensor.

However, using two half couplings is not a recommended practice: When the torque sensor is in the middle of the driveline and in between two flexible couplings, the weight of the torque sensor can sag and start to “jump rope” when rotating. This can cause a catastrophic situation under the wrong conditions.

➢ **Tip 8:** Mount the torque sensor **close to a bearing block, and place both dual-flex couplings on one side of the torque sensor** - generally on the load side of the sensor.

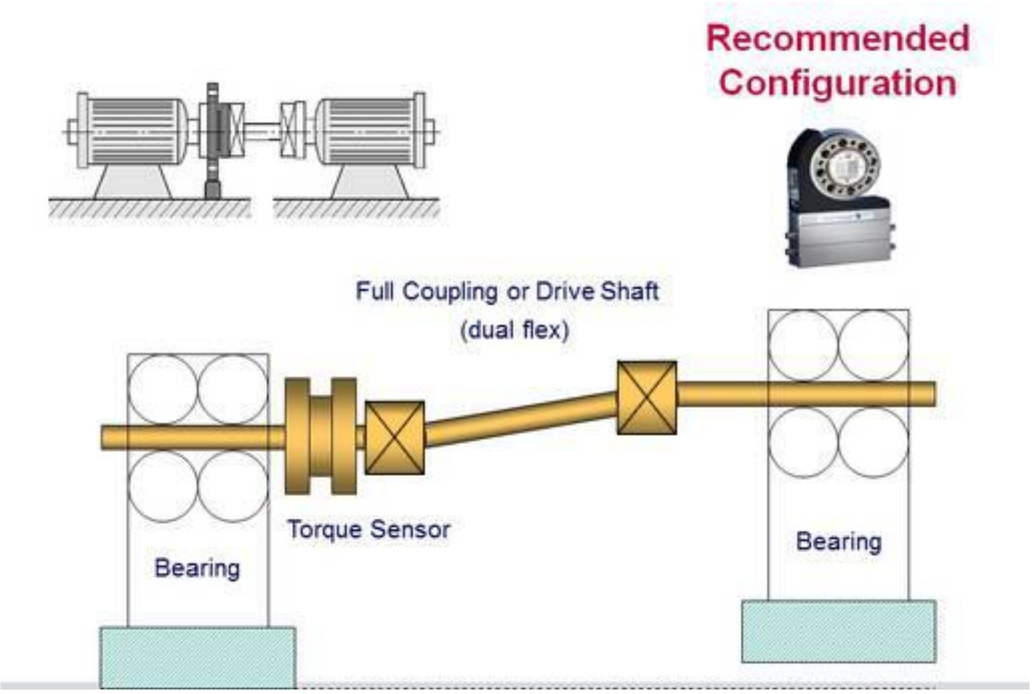


Image 5: A floating telemetry-style torque sensor

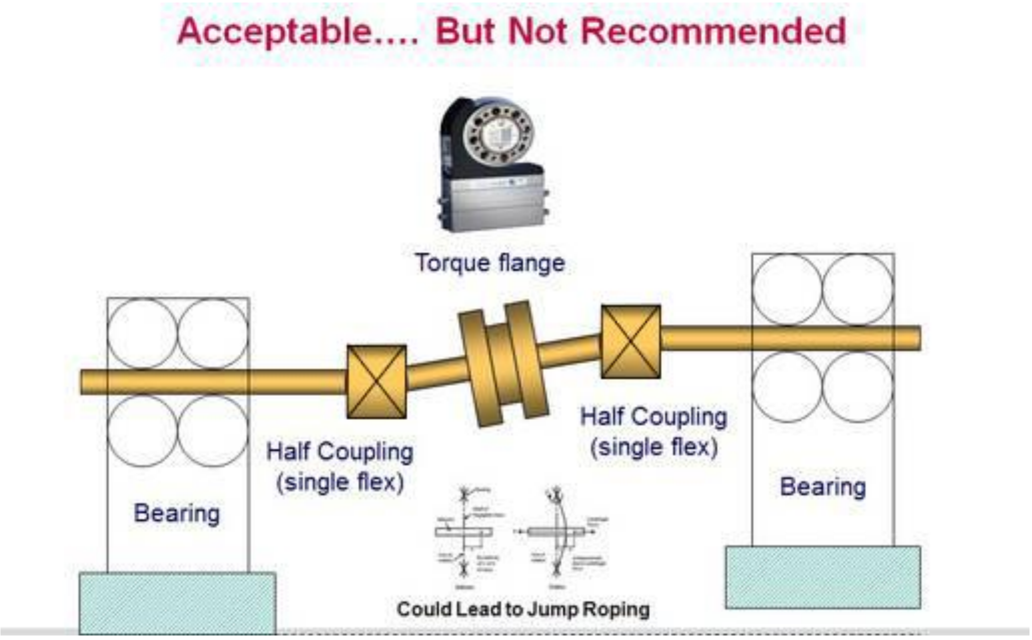


Image 6: A torque flange floating between two half couplings

Installing integral coupling assemblies (i.e. bolt on couplings)

Some torque sensor manufacturers offer **integral coupling assemblies**.

➢ **Tip 9:** The recommended way to configure an integral coupling assembly is by having the **two flex packs on the load side of the torque sensor**. The drive side is rigidly mounted.

Using one flex pack on either side of the torque sensor is acceptable but not recommended: It could cause the torque sensor to sag between the two flex members and cause a critical speed problem.

Mounting and aligning your stator and rotor

When mounting the rotors, it's important to use the proper **bolts**. Inside your torque sensor manual, you'll likely find a **chart** indicating what bolts to use and how to tighten them.

➢ **Tip 10:** Use **grade-eight bolts** or better. Tighten the bolts based on the capacity of the torque sensor. You can use the chart in **Image 7**.

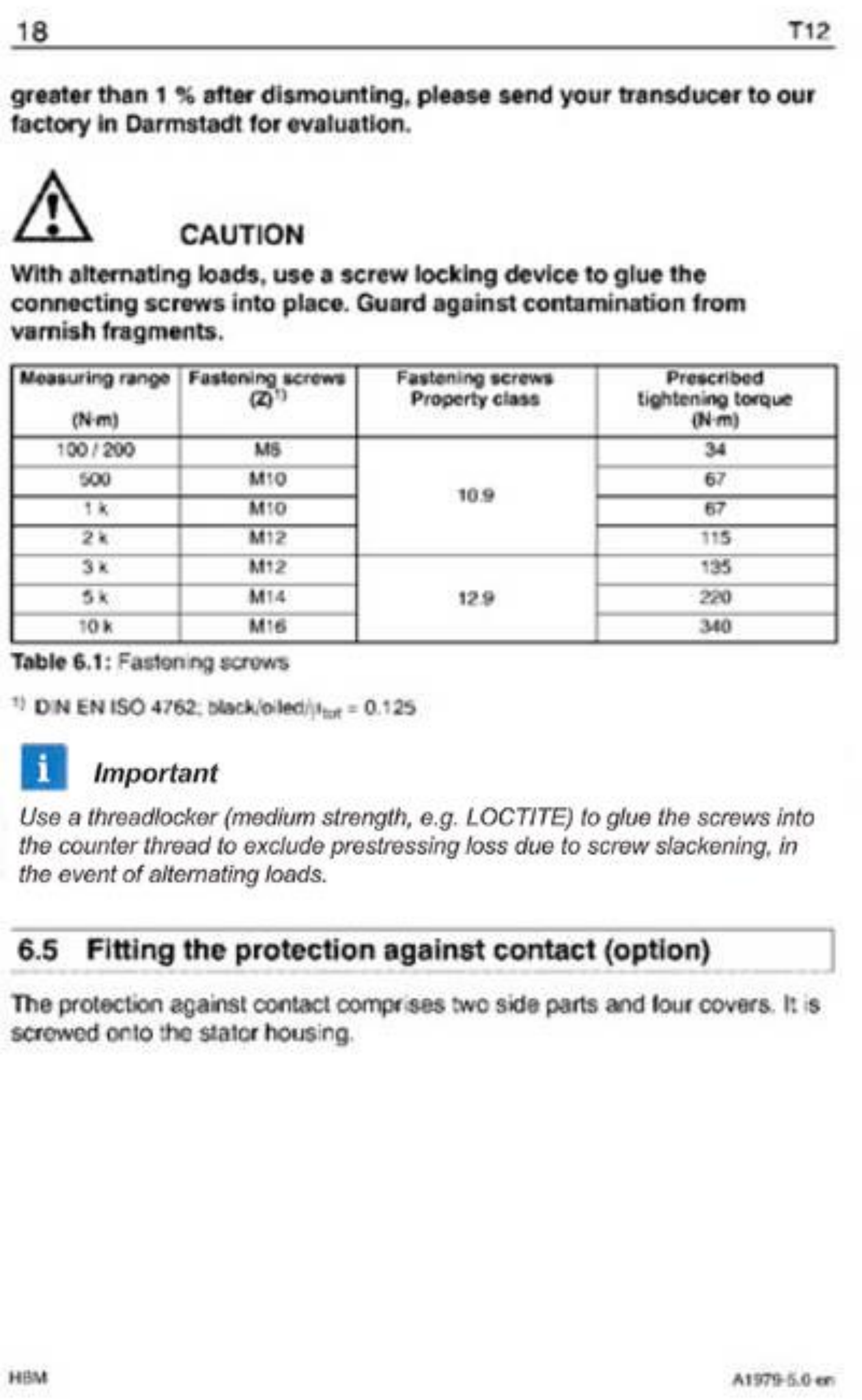
When making adaptor flanges, it's important to note that they should be **hardened to a Rockwell (RW) hardness that's near the hardness of the torque sensor**. Most torque sensors are made to RW 38-42, and so the adaptor flanges should be hardened to a similar level.

There **are proper clearances** that must be maintained when mounting the stator and the rotor. The distance between the stator and the rotor, or the air gap, is typically four millimeters total - or about **2 millimeters** on each side from the center.

➢ **Tip 11:** If you're **hard mounting the rotor into the driveline** and not using couplings, use the chart in **Image 8** to align the male and female pilots. However, very precise alignment is required, so **couplings are recommended**.

Refer to **your torque sensor manual** to align the stator to the rotor. Most stators have a light indicating proper alignment. In most cases, a green light verifies communication between the rotor and stator, and a red light indicates improper alignment and no communication.

➢ **Tip 12: The stator can be mounted or orientated in any manner around the torque sensor's rotor**, such as upside down. This is helpful when space is a concern. With most telemetry torque sensor systems, the orientation of the stator to the rotor is not important in terms of the operation.



18 T12

greater than 1 % after dismounting, please send your transducer to our factory in Darmstadt for evaluation.

CAUTION

With alternating loads, use a screw locking device to glue the connecting screws into place. Guard against contamination from varnish fragments.

Measuring range (N·m)	Fastening screws (Z)[1]	Fastening screws Property class	Prescribed tightening torque (N·m)
100 / 200	M8	10.9	34
500	M10		67
1 k	M10		67
2 k	M12		115
3 k	M12	12.9	135
5 k	M14		220
10 k	M16		340

Table 6.1: Fastening screws

[1] DIN EN ISO 4762; black/oiled/μ_{tot} = 0.125

Important

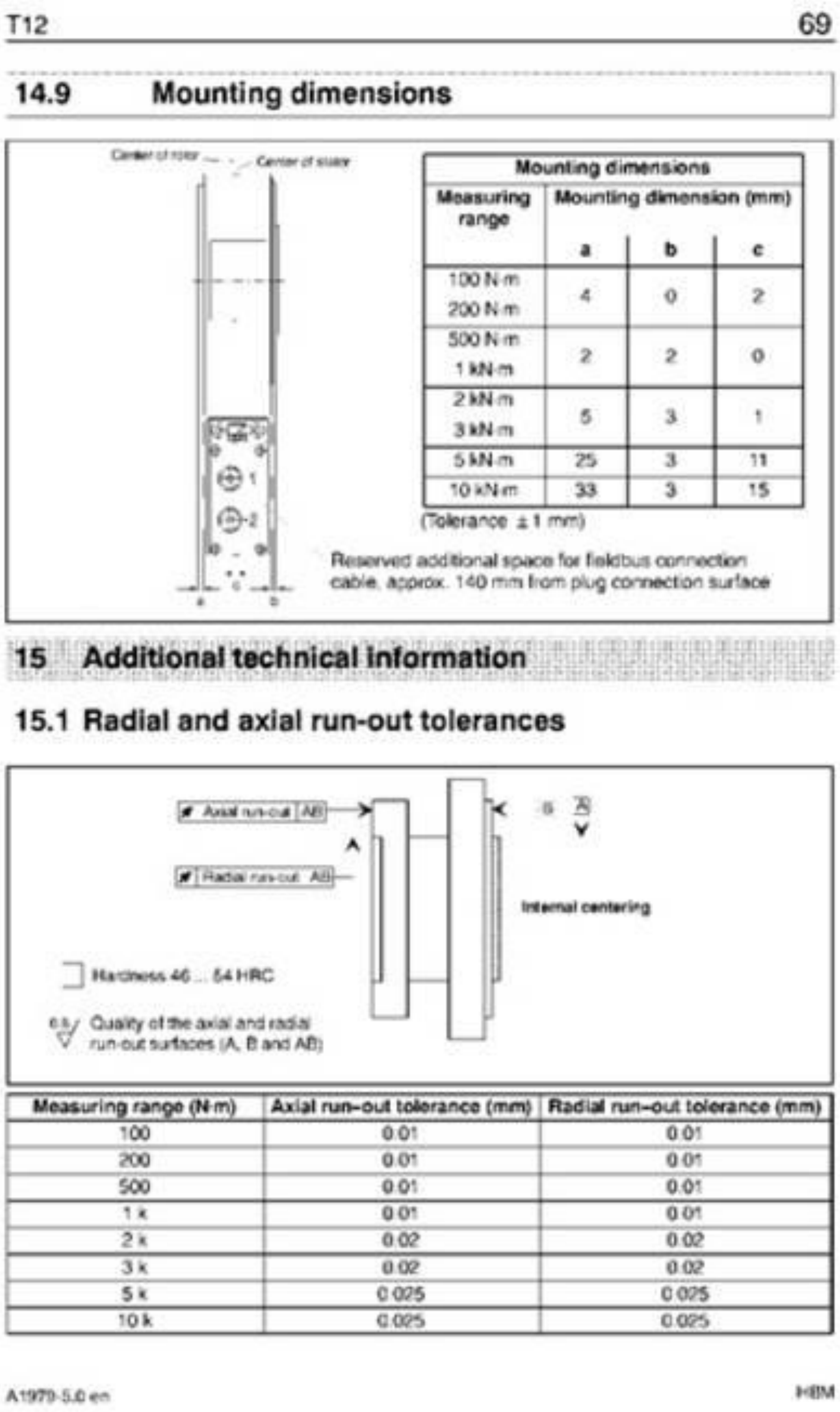
Use a threadlocker (medium strength, e.g. LOCTITE) to glue the screws into the counter thread to exclude prestressing loss due to screw slackening, in the event of alternating loads.

6.5 Fitting the protection against contact (option)

The protection against contact comprises two side parts and four covers. It is screwed onto the stator housing.

HBM A1979-5.0 en

Image 7: Rotor mounting bolts torque chart



14.9 Mounting dimensions

Mounting dimensions			
Measuring range	Mounting dimension (mm)		
	a	b	c
100 N·m 200 N·m	4	0	2
500 N·m 1 kN·m	2	2	0
2 kN·m 3 kN·m	5	3	1
5 kN·m	25	3	11
10 kN·m	33	3	15

(Tolerance ± 1 mm)

Reserved additional space for fieldbus connection cable, approx. 140 mm from plug connection surface

15 Additional technical information

15.1 Radial and axial run-out tolerances

Measuring range (N·m)	Axial run–out tolerance (mm)	Radial run–out tolerance (mm)
100	0.01	0.01
200	0.01	0.01
500	0.01	0.01
1 k	0.01	0.01
2 k	0.02	0.02
3 k	0.02	0.02
5 k	0.025	0.025
10 k	0.025	0.025

Image 8: Rotor pilots chart

Allowing proper metal clearance around the sensor

Some **older telemetry systems** are affected by **nearby metal objects** - such as adaptor plates or shrouding - which can act as secondary antennas, drawing the induced power away or affecting the **data communication between the rotor and stator**. Your **manual** should include a chart on the proper clearances around the system antennas in order for the torque sensor to work properly.

More-modern telemetry systems - such as digital telemetry systems - may not have this problem, but it's a good idea to contact the **manufacturer** of the torque sensor to confirm that nearby metal objects will not be a problem.

Make cabling in the right way

Here are **tips on making cables:**

➢ **Tip 13:** Be sure the **cable jacket** is resistant to all corrosive fluids in the test cell.

➢ **Tip 14:** The **conductors of the cables** should have low-resistance and low-capacitance levels to help improve the accuracy of the data.

➢ **Tip 15:** Adhere to **color codes**, which are generally located in the sensor manuals, to take guesswork out of making cables.

➢ **Tip 16:** Make sure that when you're soldering or crimping wires into connectors that there are **no broken connections**.

➢ **Tip 17:** A vibrating or bending cable can break the conductors due to **fatigue**, so ensure that the strain relief is attached properly when completing the cable.

➢ **Tip 18:** In terms of electrical-mechanical interference, **avoid ground loops** by properly shielding the cabling, and **keep data lines away from high voltage lines**, such as 220VAC or 440VAC, to reduce electrical noise or interference.

Shunt calibration, calibration data, and spanning electrical set-up

Older torque sensors, such as rotary transformers or slip-ring-style torque sensors, have a **strain gauge output** - typically millivolt per volt. With this output, you need a **strain gauge amplifier** to power and condition the signal, which is then turned into a usable high-level output. **Telemetry torque sensors** are typically **self-amplified** and do not require any type of strain gauge conditioning. They can come with a variety of high-level output types: typically a +/-10vdc or a frequency output.

Your calibration data includes a **shunt cal value**, which performs a number of functions. The shunt cal value is derived from a resistor in parallel with one leg of the wheatstone bridge. When a switch is closed, it shunts the resistive value across that leg. Typically, you'll get somewhere between 50 percent and 80 percent of full-scale output as the shunt value.

➢ **Tip 19:** If you have a self-amplified torque sensor, the **shunt cal value** can also check the **functionality** of the amplifier.

The shunt value can also check for **output changes**. It's derived during the calibration process from the full-scale output of the torque sensor. So if there's a change in the torque sensor's full-scale output, it will be seen by a change in the shunt cal value.

Depending upon the accuracy of the shunt network, a shunt cal value can help with **accurately spanning your instrumentation to the output of the torque sensor** (i.e. 5vdc

= 100Nm). Another way of spanning your instrumentation and torque sensor would be using full-scale output value from the calibration data sheet. Each torque sensor should come with a **“Test Protocol”**. This should include linearity and hysteresis, shunt value, and the output at specific torque levels.

➢ **Tip 20:** Instead of using the shunt value to span your instrumentation, you can use the **full-scale output of the torque sensor**, which you can find on your calibration data sheet.

If you choose not to use the full-scale output or the shunt value, you can **span your instrumentation** by performing a **dead-weight calibration with a lever arm and calibrated weights**. However, this can difficult to do as it forces you to break the driveline, lock down the shaft and add a calibration arm. The correct number of calibrated weights are needed along with a person to hang the weights, which has the potential to cause injury. The hanging of weights can also bend the arm and put a parasitic load on the torque sensor, causing errors in reading. Plus, the arm, weights and instrumentation generally need to be calibrated once a year.

➢ **Tip 21:** Use a **reaction torque sensor and hydraulics** in place of the lever arm and the calibrated weights. It’s an easier way to perform a calibration versus using a lever arm and weights.

For more information on torque sensors and to learn the proper ways to measure torque in your test environment, download HBM's torque reference book on the HBM website.

About the Author

Mark Minda is the business development manager for HBM’s torque products. He has more than 20 years of experience in the repair, calibration and day-to-day use of torque sensors. Mark has been with HBM for seven and a half years.

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