Lessons From the Field — Lesson 1: A Torqued Bolt Isn't Necessarily a Tight Bolt

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Out in the field, I sometimes hear, "Those bolts are tight. I torqued 'em up."

One of the biggest field bolting issues is still the confusion on torque being thought of as **tight,** whether for installation or inspection. As you may have heard before, **torque is not tight.** Well, why is it then that everybody's torquing bolts if tension is the goal? The confusion comes from the nuts — the nuts must be torqued, spun along the threads of a bolt for bolt tension to be induced.

Pop quiz: What's torque? What's tension? Well, come on now. You've been using the word "torque" like you know what it means. It's not easy is it? Now try telling a bolt installer with 20 years experience that torque isn't tight. They look at you with that distant gaze, nodding their heads "yes" all the wile in disbelief.

Maybe this will clear things up.

Torque is the amount of energy it takes to spin the nut up along the threads of a bolt. Force x Distance that is, put a 200-pound ironworker on the end of a two-foot spud and you have 400 foot-lbs. of torque.

Tension is the stretch or elongation in a bolt that provides the clamping force in a joint. A325 and A490 bolts are actually made to stretch a few hairs. This **Stretch** is a good thing. It's what clamps the steel plies together.

When a bolt is inserted into the steel, the underside of the bolt head bears against the steel; it can't travel any further because the steel is in the way. Then the nut is put on the threaded end and run up the threads to the steel until it can't go any further either. So, as the nut is turned (torqued) along the threads beyond this point, the steel gets pinched together between each end of the bolt assembly causing the bolt to stretch: **E-L-O-N-G-A-T-I-O-N.**

So what is the downside of measuring torque to get tension? There are lots of things that upset the torque-to-tension relationship in the field. Field circumstances that can cause torque make-up issues are changed in lubrication or deterioration caused by exposure to dirt, heat, moisture, open kegs, tarps used to cover kegs, bolts left in the steelwork too long (see figures 1 and 2). Also, changes to the air wrench, including the operator, compressor and hoses. Using a predetermined torque value was such a problem for achieving bolt tension in the field bolt that the Research Council on Structural Connections (RCSC) banned torque tables over 50 years ago. See Sec. 8.2.2.

Figure 1: An open keg of galvanized nuts without any visible dye lubricant with rusty threads. This will definitely increase the turning resistance making the bolt assemblies more difficult to tension.

Figure 2: Kegs left unprotected in the weather will increase the torque needed as well. Did you notice the water in the keg?

Figure 3: The rust increases the turning force (torque) needed by causing more friction or resistance between the threads.

Even before you make it to the field, brand new bolts can have a +/-40% variation in the torque to achieve the same amount of tension. What that means is, after you do the required testing in a Skidmore on 1-1/8" A325 bolts and figure it takes a 1,000 ft-lbs. of torque to get to the minimum required tension of 56,000 pounds, the next bolt could take 1,400 ft-lbs. of torque to hit 56,000 pounds of tension. The downside: You've set your air wrench to deliver 1,000 ft-lbs. and you'll only achieve 40,000 pounds of tension; well below the required 56,000 pounds.

Look at torque this way — while cruising on a flat stretch of road, you can go 55 mph in a car and get 25 mpg, but once that road goes uphill, to maintain that same 55 mph, you'll only get 15 mpg. It just takes more effort.

Installing dry rusty bolts is just like driving your car straight uphill. While your ultimate goal of cruising 55 mph hasn't changed, the amount of energy needed to get there has changed dramatically. The steeper the hill, the harder your car will have to work. The dryer and rustier the bolt the more energy it takes to properly tension the bolt (see Figure 3). On construction sites, the workers often go at it as if all the roads in the world are flat. They forget to consider all the hills

	Greasy Bolt	Dry Bolt	Rusty Bolt
Torque in ft-lbs.	300	500	800
Tension	39,000	39,000	25k before torsional failure

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(dry and rusty bolts) en route that will affect the amount of energy consumed (torque) to maintain 55 mph (bolt tension).

Consider this for a moment — a good greasy 7/8" A325 bolt might take as little as 325 ft-lbs. (energy consumed) to reach the minimum required tension of 39,000 pounds (ultimate goal), but as soon as the bolt starts to dry out, you're going to need more energy to get up that hill. Instead of 325 ft-lbs. you might need as much as 500 ft-lbs. to get to the same bolt tension of 39,000 pounds. Once the same bolt is left out in the steel work or in an open keg for a week, or worse, two weeks, it could take 700 ft-lbs. to reach 39,000 pounds of tension — if the bolt doesn't break!

Figure 4: How to identify a torsional failure; conical shape and a spiraling to the grain of the bolt.

Another concern using torque for measuring bolt tightness is that you might believe that the broken bolt (see Figure 4) has been tightened TOO much. In the field, they would say the bolt was "over-tightened." They believe the bolt has seen too much load and has broken due to that load.

What they don't realize is that the bolt has been over-torqued not over-tightened (see Figure 2). Remember bolt tightness is actually measured in TENSION (stretch), not TORQUE (twist). This 7/8" A325 bolt has experienced only 25,000 pounds of tension before it broke in torsion (twist) while someone applied 800 ft-lbs. of torque. Not because the bolt was over-tightened, but because there was enough resistance between the threads so the nut couldn't run up the threads any further and the twisting force was more than the bolt could handle.

What was that middle part again? Torque is not actually a measurement of bolt tightness. Torque is only the amount of energy is takes to spin (think twisting force) the nut along the threads of a bolt. Torque must be applied to tension a bolt. Bolt torque is usually greater affected by lube, thread condition and exposure to weather.

Tension is what we're actually after here. This is how bolt tightness is measured. Tension is the actual load caused by stretching the bolt that clamps the joint together.

It's going to take a while to get used to saying "tension" instead of "torque" when you talk about bolting — but just give it some time.