About the Author/WAYNE WALLACE

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Bolts Should Stretch and Occasionally Fracture, Never Strip

Our company manufactures Direct Tension Indicating washers, also called DTIs, or Load Indicating washers, which are used to impart a known tension or preload in structural bolts. We are, therefore, in the business of bolting tension quality assurance.

A customer called one day and said, “...When we tighten the bolts, and compress your load-indicating washers, sometimes the threads of the bolt begin to strip...What’s wrong?”

Whoops. Tilt. As you might imagine, this gets our attention, because stripping should NEVER happen. Bolts have been designed to fracture in tension before stripping, if they are made correctly.

First, a very quick primer on how bolt assemblies should respond to being tightened.

Fig. 1 shows, for an A325 heavy hex structural bolt/nut assembly, the normalized load (read “bolt tension/proof load”) vs. degrees of nut rotation for bolt assemblies tightened with DTIs (A) and without (B). Note the “X” at the ends of all the curves, designating fracture of the bolt. Fracture is separation of the bolt in the shank, usually accompanied by a loud bang. You’ll know it when you hear it.

Heavy hex structural bolts are design so that they must develop at first the minimum level of preload (read “MIN INST TENSION” on Fig. 1), usually at or near the minimum specified “proof” load. While the nut rotation continues the bolts begin to stretch a little in the first few threads, the bolt tension peaks, and then the load in the bolt begins to fall off prior to ultimate fracture (the “X’s” in Fig. 1). During this process, the nut has to hang on to the bolt threads without failing. Heavy hex structural nuts are deeper than...
regular nuts so they engage more thread length, and they’re beefier so as not to spread or widen when highly stressed or heated up by the tightening process. The thread form of the bolt, when engaged by the deeper nut, must never strip prior to the bolt stretching and fracturing as in the schematic curves of Fig. 1. And DTI’s are made so that a bolt tension of about 1.30 times minimum specified proof load completely flattens them.

Fig. 1 shows that the “stiffness” of the bolt/nut/DTI combination is shallower than the same assembly without a DTI. In other words, the addition of a DTI “softens” the bolt response to the nut being turned the same amount. This is good because the bolt, which has a DTI on it, “sees” or senses less of the external force applied to it. Note that even though an installer might flatten the DTI or even go a long way past the point where the DTI was dead flat, the bolt/nut assembly should still fail in tension or combined torsion and tension, not by stripping.

Note that nowhere is there any mention of thread stripping, either of the bolt threads or within the nut. That’s why, when our customer called us and implied that it must be the DTI that was causing the bolts to strip, we immediately moved to correct that thought.

We asked the customer to quickly send some of the bolts (See Fig. 2 and 3). Fig 2 shows the stripping of the bolts has occurred prior to bolt fracture and in the case of one of them (the left hand one), it has been stripped even before any stretching of the bolt shank. In Fig. 2 the right hand bolt is unused, and all four nuts appear to be in good condition, with the required blue wax lubricant in evidence. Fig. 3 shows a close-up of two of the bolt threads, one stretched and necked a little in the first few threads, which is okay, and the other not visibly necked. In all cases, the nut had been engaged with two or three threads projecting, which sounds about right.

From the shape of the deformed threads in Fig. 3, where the nut had been engaged, it appears that stripping was indeed the failure mode. The tops of the bolt threads have been tunicated either fully or partially by the action of the nut trying to “pull” over the bolt threads.

Why does this happen?

1. The nut thread is too large. Perhaps the nuts in this case have been over-tapped too much to allow for galvanizing.

2. The bolt thread is too small.

3. The lubricant is too efficient.

4. The bolt has been improperly heat treated and the surface left deeply decarburized, and therefore with little strength.

5. A combination of all the above.

6. Inadvertent incompatible hardware, such as a 7/8” Imperial nut on a Metric M22 bolt.

At the time this article was written, the customer had still not determined the answer as to why the bolts were stripping. ☞