About the Author/JOHN A. HERR

John Herr is Director of Quality Assurance at Applied Bolting Technology in Rockingham, Vermont. A ten-yar veteran at Applied, John is an ASQ certified inspector, and organizes Applied's ISO Guide 17025 Lab Certification program. John leads the team that tests millions of Direct Tension Indicating Washers annually, and is qualified to do Rotational Capacity testing of bolts. He can be reached at Applied Bolting Technology, phone 800-552-1999.

Tests Show Squirter™ DTIs Are Amazingly Accurate

Blind Testing of Squirter Direct Tension Indicating Washers

Direct Tension Indicating Washers (DTIs) are specially deigned fasteners used in high strength bolt assemblies to assure that required tension (preload) of the bolt is achieved during installation. Standard DTIs accomplish their function through the compression of a radial array of protrusions (bumps) concentrically located between the inner and outer diameters of the washer. Required tension is determined by inspection of the gaps between the bumps with .015 in. or .005 in. thick feeler gauges to identify the number of entries and refusals into those gaps.

In 1996, we at Applied Bolting developed the Squirter™ Self-Indicating DTI. This modification of the standard DTI added stamped channels to the undersides (depressions) of the bumps from the outer diameter of the washer. These depressions were then filled with an orange colored silicone rubber compound and allowed to cure. (See Fig. 1) The resulting product, when installed in a high strength bolt assembly, will extrude an identifiable amount of silicone (squirt) when the bumps are compressed and the required tension for the bolt is achieved.

Figure 1

In the course of demonstrating our new invention, a question was raised as to how accurate and repeatable squirt event is in determining bolt assembly tension, and even further:

Could the squirt event replace the feeler gauge as the best indicator of required tension?

After 5 million Squirters in the field, and thousands of in-process and development tests performed here in our lab, we say definitely, "Yes!"

The following is a formal study into this question that we did a couple of years ago, and is typical of the bolt tension accuracy that results when bolt tightening is stopped when the squirt event is just right.

Test Method

To best investigate the reliability of squirt as an indicator of required tension, we conducted a battery of tests based on the methods outlined in our product installation guides. These involved:

1. Naming a target compression load for the bolt assembly.
2. Identifying the visual volume of extruded material (squirt) that corresponded with the desired compression load (calibrating the squirt).
3. Attempting to achieve the desired compression load by using only the observed squirt as a guide (blind testing).

We used the following equipment for our tests:

- Skidmore-Wilhelm Model HT-4000 Torque Tension Tester
- 7/8 - 9 x 4-1/2" A490 Plain Finish Bolts
- DH Nuts
- F436 Plain Finish Flat Washers
- 7/8" A325 Squirter DTIs MG Coated — Production Lot #H64

Note: Plain finish A490 bolts were used to allow multiple tests using the same hardware without compromising the integrity of the assembly.

Test assemblies were installed in the Skidmore Tester using DTI Installation Method #2 in which the F436 washer is between the Squirter DTI and the nut. Assemblies were lubricated after each test to prevent seizing.

Three target compression values were designated for the testing battery:

- 40 kips
- 44 kips
- 50 kips

Reprinted from Distributor's Link Magazine, Spring 2003

Twenty-five tests were performed for each target value.

The testing battery was performed by two persons: a test operator and a test observer.

Calibrating the Squirt

For each target value, five preliminary or calibration tests of Squirter DTI assemblies were performed: The test operator installed the assembly, tightened the nut until the target value was reached on the tester dial indicator so that it could not be read by the test operator. The test operator then proceeded to install and tighten a Squirter DTI assembly until what he considered to be the proper amount of squirt was achieved. (See Fig. 2) The operator then turned away from the machine while the test observer uncovered the dial and recorded the compression value. This method was performed 25 times for each target value.

Figure 2

Test Results (all values in kips)

Target Value	Actual Mean (25 Tests)	Standard Deviation
40	39.7	2.98
44	42	3.3
50	50	3.36

Conclusion — Forget the Feeler Gauge

The numbers show that Squirter DTIs are capable of visibly indicating required tension loads in bolt assemblies with admirable reliability. That a solely mechanical/visual device can do this so well and at such little cost is amazing!

With this kind of predictability, is it necessary to use a feeler gauge to check the assembly for gap that would indicate required load? We think not:

1. The Squirt tells you that the bolt has been tightened. In many cases in the field, inspection by feeler gauge is used just to see if the bolts have had a wrench put to them. Just a glance at an assembly with a Squirter DTI in it will tell you its status.

2. The Squirt is more accurate than the feeler gauge in indicating required bolt tension. Too often with feeler gauges it's "Did it go all the way in?" "Is it two entries?" "Is it two-and-a-half?" "My feeler gauge is bent!" "Maybe we need to tighten the assembly a little more?" "Oops, dropped the *&^(S#@!" After you have calibrated your squirt to the load you want, you know what tight looks like, and when you know what tight looks like, you don't need a feeler gauge to tell you.

And Now: Phase II — Squirter-Twister Bolts

With the introduction of our new Squirter-Twist Bolts (see Fig. 3), the advantages and accuracy of the Squirter DTI can be realized single-handed. The Squirter-Twist Bolt allows the user to tighten bolt assemblies with a TC wrench, so bolting is now a one-hand, one-man job.

Figure 3

Because the spline does not shear on the Squirter-Twist Bolt, it can be snugged and tightened without worry over premature breakoff. A recent test series in our testing lab came up with the following results:

Ten assemblies consisting of galvanized M20 Grade 8.8 Squirter-Twist Bolts, M20 Grade 8.8 Squirter DTIs, F436 washers and A563M nuts were tested for squirt in a Skidmore-Wilhelm Model #HT-4000 Torque and Tension Tester using a Tone S-60EZA Shear Wrench to install the assemblies. The assemblies were snugged to 22-24 kips and then tightened to final squirt.

Test #	Sung Tension	Final Squirt Tension
1	24	42
2	24	43
3	24	44
4	24	44
5	24	43
6	23	44
7	22	45
8	22	42
9	23	42
10	22	43

The Squirter-Twist Bolts were able to withstand the startup torque generated from the snug condition to final squirt tension without spline shearing. All tensioning was performed by one operator alone without need of restraining the bolt head. All assemblies were easily disassembled using regular wrenches and sockets.

So there you have it: a load indicating washer that shows you what a properly tensioned bolt looks like and a bolt assembly that goes together with one-handed ease. Squirters and Squirt-Twist Bolts: Can it get any better than that?