# SQUIRTER™ DTI’s MAKE SCR/HRSG BOLTING EASY

Wayne Wallace -- M. Eng.,
President - Applied Bolting Technology Products, Vermont USA

Dr. Peter J. Carrato -- PhD., PE, SE
Fellow - Bechtel Corporation, Frederick MD USA

## ABSTRACT
Field installation and inspection of structural bolts in SCR’s and HRSG’s consume thousands of man-hours. Bolts are installed by various qualities of labor: ironworkers, boilermakers, pipefitters, millwrights, laborers, or non-union workers, especially in offshore locations. Project schedules require rapid assembly of steelwork so that the mechanical systems can be located and made operational in the least possible time. Tightening specifications for bolts used in these applications change frequently, and field personnel often have difficulty keeping abreast of the changes. Direct Tension Indicating (DTI) washers have made bolt tightening in these applications more or less foolproof for twenty or more years, but their installation and inspection has been labor-intensive. With the development of the DTI “Squirter Washer”, bolts can be tightened and inspected in about one-half the time previously devoted to this operation. Duke/Fluor Daniel, Bechtel, Babcock & Wilcox, The Industrial Company, and other contractors are now using Squirter DTI’s and sharing the savings with their client power project owners.

## INTRODUCTION
The decade of the 1990’s saw the introduction of two terms: “HRSG” -- Heat Recovery Steam Generator, and “SCR” -- Selective Catalytic Reduction. These terms refer to equipment constructed at power plants to improve their power-generating efficiency or to reduce NOx emissions. Prototype SCR’s and HRSG’s were built around the country and elsewhere in the world, sometimes linked to the Department of Energy’s “Clean Coal” demonstration projects such as at JEA Northside in Florida.

## JEA NORTHSIDE PROJECT
SCR’s and HRSG’s have something in common: they both need supporting steelwork with lots and lots of bolts. And the bolts must be tightened (read “tensioned”) correctly. Although it varies by type of project, field installation and inspection of bolts consumes from twenty to thirty percent of all the field labor man-hours on the project. This labor costs the project owner from US$40.00 to US$80.00 per
man-hour, so the task of minimizing the overall bolting labor becomes an important one. For instance, installing 12 bolts per $60.00 man-hour will result in an installation cost of $5.00 per bolt, and inspection typically adds another $1.00. So on a job where there is 100,000 bolts, you’re looking at $600,000 to get them installed, or more.

When the bolting installation labor pool includes laborers, ironworkers, pipefitters, boilermakers, millwrights, and other trades, more or less skilled, and when they sometimes don’t even speak the same language, the cost per bolt and the task of minimizing bolting man-hours becomes more difficult. When the bolting inspection personnel are sometimes the least skilled workers on the jobsite, the task becomes more difficult again.

Pressure to avoid late completion penalty clauses also imposes an imperative to get the bolting job done in the least possible time to keep bolting off the critical path. When bolting falls behind, additional labor is often concentrated on it to accomplish in, say, two weeks, what normally would have taken four weeks. So bolting effort is often hurried, with all the confusion, overtime, errors, and other problems that entails.

State-of-the-art in bolting installation and inspection specifications change frequently, and from jobsite to jobsite, making it difficult for workers to know conclusively that what they are told to do is really correct. Failing certainty, and failing adequate jobsite training, bolting workers revert to old “wives tale” methods that they have learned. Often as not, these methods prove to be incorrect or out-of-date. How many times have you heard that there surely is a certain “torque” necessary to get a bolt installed correctly? But, bolt installation torque tables, at least for structural steel in North America, were abandoned in 1954, because installing bolts by torque-controlled methods, under real field conditions, is known to produce highly variable results.

BOLTING METHODS

Here are the current North American structural bolting specifications, in a nutshell:

The Research Council on Structural Connections (RCSC, See Footnote 1) states that high strength bolts must be installed by one of four methods:

1. Calibrated wrench – Calibrate the torque installation value to be used by bolt production lot, every day, by field testing them in a Skidmore-Wilhelm bolt tension calibrator. Snug the plies, then apply the “calibrated” torque to every bolt. Very laborious, rarely used in construction, and highly variable bolt tension results can be expected due to the inherent variability of torque aggravated by construction conditions.

2. Turn-of-Nut – Snug the plies, scribe a line across the nut and bolt shank, then rotate the nut a prescribed amount of rotation which varies with bolt length and diameter. With good snugging and diligent workers and supervision, this method can produce good results. Shortcuts in this method can result in very poor results, and after it’s done it’s impossible to determine if it was done correctly.

3. Twist-Off (“TC”) Bolts – A special bolt is provided with a splined extension on the shank, and a special wrench grips the splined end and simultaneously turns the nut until the splined end shears off at a neck that has been manufactured into the bolt shank. Favored by many erectors because splined end shears off at a torque, regardless of correct bolt tension. Recent RCSC provisions now make it imperative to check these bolts in a Skidmore bolt tension calibrator to see that the actual tension that is developed in these bolts at break-off is above minimum. This laborious
checking procedure must use sample bolts that have been exposed to the same conditions as the bolts that are about to be tightened in the steelwork.

4. Direct Tension Indicators (DTI’s) -- DTI’s are the only bolting method completely independent of the torque resistance of the bolt set. There are two types:

(a) Standard DTI’s -- Steel washers with raised bumps on one side which are engineered to compress ONLY at a minimum bolt tension, regardless of torque. These are inspected by means of attempting to insert a feeler gage into the DTI bump space to be sure that the bumps are sufficiently compressed. If they are, the bolt MUST have been tensioned correctly, regardless of torque.

(b) Squirter DTI’s – Exactly the same steel washers as above, but which have had bright orange silicone deposited into them so that the action of compressing the bumps ejects the (then cured) silicone radially outward through little grooves, showing the bolt installer and inspector that the bumps have been sufficiently compressed. Feelers are only used to calibrate the squirt event or to occasionally check bump compression as the work progresses. Squirter DTI washers are visually obvious to the bolt installers and inspectors, as can be seen here.

BOLTING PROBLEMS

All the above bolting methods, if correctly done and checked, will result in properly tensioned bolts. However, in reality, besides the difficulty in enforcing a certain bolting method, there are a myriad of other problems in getting bolting done correctly on construction sites.

Here are the leading problems that conspire to cause poorly constructed steelwork and inefficient and costly field operations:

(a) Inadequate information on site specifying which method is to be used to tighten the bolts.
(b) Inadequate understanding that it’s bolt tension that is needed, not torque, and the difference between the two.

(c) Inadequate attention paid to “snugging” (that is, getting the plies firmly together) before starting any tightening procedure.

(d) Poor bolt storage conditions which allow deterioration of the bolt/nut friction factor, leading to higher-than-necessary torque resistance, tool wear, breaking bolts, and puzzled inspectors.

(e) Misleading torque wrench tightening or inspection.

(f) Galvanized hardware that doesn’t seem to work very well, is not manufactured correctly, or is improperly and incorrectly handled in the field.

(g) Improper rusting and then improper relubrication of twist-off bolts in the field which can lead to hidden thread stripping failures.

(h) Incorrect placement of the DTI on bolts.
BOLTING WITH SQUIRTER DTI'S

Squirter DTI's were developed in an attempt to compensate for these situations, and therefore to make field bolting as foolproof as possible. Here’s the tightening method when squirters are used:

(a) Snug the joint by partially tightening all the bolts in the connection, partially compressing the DTI bumps, but making sure no or very little silicone is showing at this point.

(b) On the second pass, drive all the bolts until the silicone shows more or less all around the squirter DTI. “Drive them ‘til they squirt!” becomes the method.
HOW WELL DO SQUIRTER DTI’S WORK?

In a series of blind tests at the University of Idaho, students tightened bolts to the point where the “squirt event”, that is, the volume and appearance of silicone alone, told them to stop tightening. Here’s the results they found:

EXCELLENT BOLT TENSION DISTRIBUTION DETERMINED BY THE “SQUIRT EVENT”

SAVINGS FROM USING SQUIRTER DTI’S

When squirters are used, the cost savings can be 25% of the bolting installation and inspection time, which, in the example above, amounts to $1.50 per bolt. Out of this savings comes the cost of the squirter DTI, around $0.50, leaving something like $1.00 per bolt net savings for the owner of the project. But more than just the real dollar savings, when squirters are used, it’s just plain simple. “Snug – No squirt. Then just make it squirt on the final pass.” If the inspector can walk by within a couple of days, the silicone is usually still visible, making his or her job the simplest of all.

PROJECTS

Squirters have been used on nine HRSG and SCR projects in the US, for Carolina Power & Light, PG&E, Duke Power, Reliant Energy, Southern Company, Louisville Gas & Electric, AES, and others. The following photos are typical of some of the connections and steelwork.
STEELWORK CAN GET RELATIVELY HEAVY

THE SQUIRT SHOWS THAT THESE CONNECTIONS HAVE BEEN TIGHTENED
SUMMARY

Squirter DTI’s are being used to minimize the labor involved in tightening bolts on SCR’s, HRSG’s, and other bolt-intensive steelwork associated with power plants. Although squirter DTI’s are a new development, they are being adopted for use by the millions in projects within the USA and offshore. Project managers report the time savings in installation and inspection outweigh the extra initial cost.

REFERENCES


ii Ibid, page 49,50