

About the Author/BARNABY MYHRUM

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A Simple Quality Assurance System for Wind Turbine Towers

My colleague, Wayne Wallace, has written prolifically in this publication about the finer points of structural bolting, most recently concerning Wind Turbine Tower flanges. As we at Applied Bolting gear up to supply our Squirters™ to this market, we are making the rounds attending trade shows and demonstrating the use of Squirters™ in the field. We frequently hear the same question about our unique product: "Are multiple squirts possible?" The question typically comes from the owner-operators and the erectors who assemble the towers, so we listen carefully.

What we hear is that they would love to have a better, quicker and cheaper way to assemble and maintain their towers. Wind turbine OEMs typically specify bolt torque when the towers are assembled, and periodic inspection procedures involve torque as well. We know that what they really want is tension, and we offer Squirters™ as the means to guarantee the proper bolt tension. But the issue of re-tensioning is a new question for us. In North American structural applications, once the bolt is properly tensioned (in a well designed joint) the Research Council on Structural Connections says your job is done. Nonetheless, we decided to investigate the second squirt capability.*

*Applied Bolting's Second squirt capability is Patent Pending.



At Windpower2009 in Chicago, Germanisher Lloyd delivered Applied Bolting certificate 76368 indicating that our M36, M42 and M48 Squirters™ guarantee target tension +/- 10%. We spent over a year preparing for and conducting the experiments in our ISO/IEC 17025 laboratory to achieve this level of accreditation. This summer we went back to the laboratory to investigate the second squirt capability of our M42 10.9 Sqrter™.

Laboratory Tests

Initially, we used the same laboratory equipment GL used to certify M42 10.9. The minimum preload for M42 10.9 is 710 kN, and the proof load is 930kN. The purpose of the Sqrter™ DTI is to ensure that minimum preload is achieved. Therefore, the target tension for the test was 778 kN, 10% higher than the minimum preload. The mean tension achieved in the GL tests was 791 kN, well above the minimum preload and well below the proof load.

We lab tested a handful of Squirters™ from the same lot that GL tested. After running them up to target tension, we relaxed the tension, wiped off the original squirt and carefully retensioned to see if a second squirt appeared. We discovered that second squirt was not only feasible, it was pretty reliable. In round numbers, the second squirt appeared at tensions roughly 50 kN above the original squirt.

Flange Tests

Encouraged by our findings, we did a more thorough investigation. Under the guidance an outside consultant, our engineering intern Bryan Carignan ultrasonically instrumented 20 EN14399-3 bolt assemblies. In a temperature controlled environment, we installed them in actual flange sections. Each bolt was tensioned using squirt appearance alone. The bolt elongation and calculated tension was recorded, along with the torque indicated by our Tone Tower Master electric wrench.

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The first squirt results are shown in figure 1, along with a photograph of a typical first squirt. The average tension achieved using only the squirt appearance was 761kN with a standard deviation of 20kN. All values were above the minimum preload of 710kN and well below the 930kN proof load. Notice that the tension varies less than 10% while the torque varies more than 20%. While this degree of variation is allowed by specification, one can quickly understand why erectors experience problems in the field when just using torque to tighten flange bolts. More on this later.

After cleaning off the original squirt and letting the flange assembly relax for a day, we retorqued the nut until the second squirt appeared. The results are shown in figure 2, along with a photograph of a typical second squirt. The second squirt is not as voluminous as the first, but it is distinct. The average tension achieved at second squirt was 810 kN with a standard deviation of 40kN. This value is 49kN above the first squirt tension, consistent with what we observed in the laboratory. There is more variation in

the data, yet the tensions are still well below the proof loads. In three cases, our wrench didn't have enough torque to achieve the second squirt, so the sample size is slightly smaller (17 vs 20).

Conclusions


There are a number of important conclusions from this study. First of all, Squirters™ will allow OEMs and erectors using M42 10.9 bolts to achieve initial target tensions +/-10% in tower flange bolts as certified by Germanischer Lloyd. What's more, the second squirt capability is a viable method for achieving a slightly higher tension when retensioning is required at a later date. Given the variation in the bolts' frictional characteristics (k factors) allowed by specification, this could provide a simple structural quality assurance system for wind turbine OEMs and erectors. 

Figure 1: M42 10.9 Torque vs. Tension: First Squirt

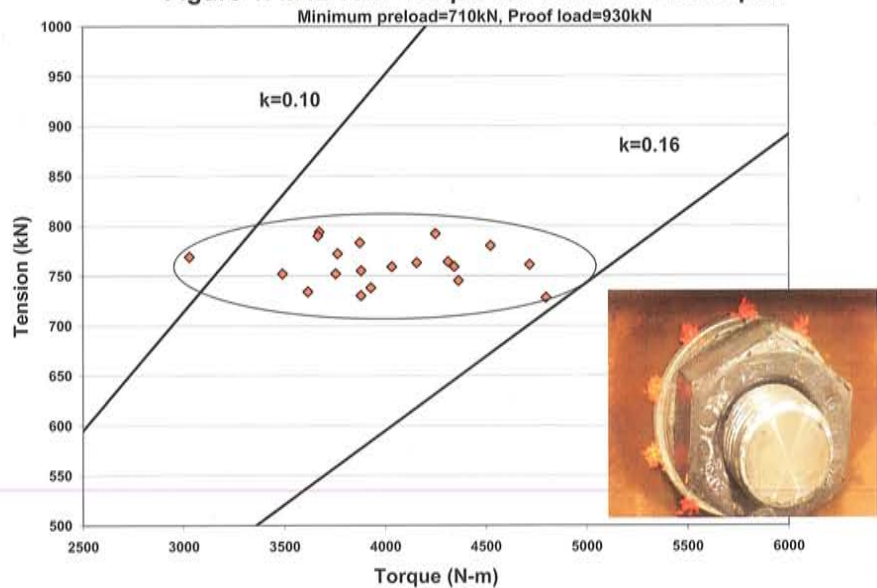


Figure 2: M42 10.9 Torque vs. Tension: Second Squirt

