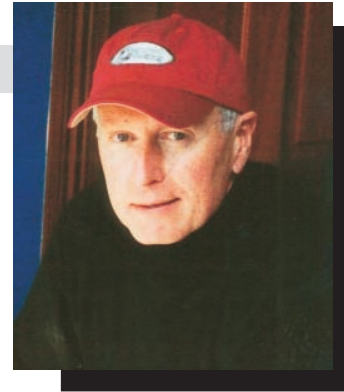


About the Author/WAYNE WALLACE

Wayne Wallace is the president of Applied Bolting Technology Products. The company provides bolting consulting services and manufactures direct tension indicating washers from its base in Rockingham, Vermont. Wallace is a member of the Research Council on Structural Connections, owner of several patents, and author of numerous papers on the practical aspects of quality assurance in structural bolting. He can be reached by phone at 800-552-1999, by fax at 802-460-3104, or e-mail at wwllace@sover.net.



Applied Bolting & Germanischer Lloyd Work Together For Wind Turbine Tower Flange Bolt Squirter® DTIs

Two thousand-eight saw 7500 MW of wind energy capacity added in North America. This was 4,500 wind turbines of various sizes, consisting of 13,500 tower sections, and 2.25 million bolts used in the tower flange splices. Furthermore, between now and 2011, it is forecast that 1/5th of the world's wind power capacity will be installed in the USA. By 2011 the number of tower flange splice bolts required annually will likely reach 5 million. And the typical size is M42 diameter by 330 mm long – a substantial bolt indeed.

In a recent visit to Cardinal Fastener in Cleveland, even the new American President seemed to recognize the importance of having good bolts for these splices (Figure 1).

But just obtaining large diameter metric high strength bolts in North America isn't the entire story. Getting them correctly installed in the wind tower splices, that is, to the correct tension, or preload, is the other part of the story. That's where Applied Bolting's newly designed Squirter® DTIs will come in handy in filling out the Quality Management (QM) system that all the wind turbine manufacturers must design and maintain.

Applied Bolting, knows that correct tensioning of the wind turbine tower flange splice bolts is critical to any third party QM system. We also know of the difficulties currently being experienced in the bolt tensioning operation as the towers are erected. These observations prompted us a few years ago to design a set of large diameter Squirter DTIs which could be used on the M36, M42, and M48 property class 10.9 bolts typically used in the tower flange splices. Prototype parts, manufactured and tested by Applied Bolting, confirmed that Squirter DTIs could allow more accurate and faster tightening of the flange bolts, and demonstrations of

the product to several prominent wind turbine manufacturers verified their interest.

However, since these Squirter DTI products are outside the size and compression load range of conventional DTI specifications we decided that an outside certification agency such as Germanischer Lloyd (GL) of Hamburg, Germany should certify their performance.

In 2007, Applied Bolting contacted GL with the intention of obtaining their input and advice on certification of our Squirter DTIs. Up to M36 grade 10.9, the strength/bump compression properties are controlled by ASTM F959M. But the wind industry uses mostly

splice bolts of diameter M42 and M48, so no recognized world standard existed against which GL could audit our M42 and M48 Squirter products. We did, however, know the strength properties and design preload for the M42 and M48 grade 10.9 bolts that were typically used for tower splices (see Figure 2), so we wrote a performance specification for the Squirter DTIs against which GL could perform an audit.

Why submit parts to an outside auditor like GL? Germanischer Lloyd is the leading third party certification body

in the wind-energy sector, offering project and type certifications in the field of renewable-energy equipment for manufacturers, banks and insurers of wind turbines and components, and they've been doing it for 30 years.

The rapid growth of the wind energy industry and the growing size of wind farms force financing banks, insurance companies, and jurisdictional authorities to require reliability and safety assessments of these projects. Assessments are carried out by means of



Figure 1: President Obama at Cardinal Fastener

WIND TURBINE, from page 40

certifying components, turbines, and the wind farms in total, by a third party. The certification process emphasizes reliability, safety, strength and fatigue in an attempt to guarantee safe operation.

Before third party manufacturing surveillance may begin, certain Quality Management (QM) requirements has to be met by each manufacturer or component supplier. As a rule, the QM system should be certified to comply with ISO 9001, otherwise the third party certification body has to take part in devising and approving an applicable QM system. The extent of the surveillance during production depends on the level that the QM system demands. In general, actions and approvals such as inspection and testing of materials and components, scrutiny of QM records (test certificates, reports), surveillance of production, inspection of the corrosion protection and of the electrical power system will take place.

European designers of wind turbines specify that certain torque values be used to tighten the flange splice bolts, but in North America this is not allowed by the Research Council on Structural Connections. Under RCSC regulations, since the tower itself is clearly a

structure, the bolts **MUST** be preloaded by one of only three allowable methods – none of which involves a torque value specified by a remote manufacturer. The RCSC points out that using a prescribed torque value to tighten bolts is too inaccurate.

Does it matter? You bet. Tower flanges **MUST** be brought together and the bolts used **MUST** be preloaded carefully in order to resist the external loading. Wind turbines have suffered many highly visible failures of entire machines and of components, including failures caused by incorrectly tightened bolts. All the turbine manufacturers are very interested in getting their bolts installed, that is, preloaded, correctly, but until now they only had torque to use.

The minimum bolt preload as designed by the wind turbine tower makers is as follows:

- M36 Three load levels 458 kN, 510 kN, and 572 kN
- M42 One load level 710 kN
- M48 One load level 930 kN

Applied Bolting designed Sqrter DTIs to suit these preloads. For example, the M42 product we designed

please turn to page 170

Figure 2: Bolt Properties

Bolt dia.	Property Class	Stress Area mm ²	Nominal Ultimate Stress N/mm ² Note 1	Actual Ultimate Stress N/mm ² Note 1	Actual Tensile Strength N	.2% Offset Yield Stress N/mm ² Note 1	.2% Offset Yield Strength N
M36	8.8	817	800	830	678,110	660	539,220
M36	10.9	817	1000	1040	849,680	940	767,980
M42	10.9	1121	1000	1040	1,165,840	940	1,053,740
M48	10.9	1473	1000	1040	1,531,920	940	1,384,620

Note 1: From ISO 898.1 (M36) or DAST Richtlinie 021 (M42, M48)

Figure 3: Preload Accuracy

Diameter, Grade of Assembly	Minimum Preload Needed kN	Yield Strength of Bolt kN	Minimum Ultimate Strength of Bolt kN	Using Sqrter DTI		Using Torque Values			
				Target Preload kN	Achievable Preload Min/Max 97.7% Confidence kN	Torque Min Nm	Preload kN	Torque Max Nm	Preload kN
M36 8.8	458	539	678	507	495-526	1700	315	3200	592
M36 M 10.9	510	768	849	550	556-604	1900	352	3500	650
M36 10.9	572	768	849	632	598-638	2100	390	4000	740
M42 10.9	710	1054	1166	780	753-821	3200	510	6000	950
M48 10.9	930	1384	1532	1024	983-1042	4500	625	8000	1110

WIND TURBINE, from page 168

to show a reproducible squirt at preloads between 750 and 820 kN. The mean expected would be half way between these two limits, around 775 kN, safely above the minimum of 710 kN, but not too high. Furthermore Applied claimed that this preload would be achieved in BLIND tests, that is, after Squirter calibration, only using the squirt feature as the determinant of correct preload – that is, no feeler gage. Also, GL required that we demonstrate to them that Squirters can control preload accuracy to a 97.7% confidence level.

Figure 3 shows the Preload Accuracy of Squirters vs. the existing "Torque Control" procedure. As an example, for the M42 Property Class 10.9 bolt, using a Squirter DTI, the preload can be controlled to between 753 and 821 kN, whereas using the torquing procedure, preloads as low as 510 kN and as high as 950 kN can be expected. These values

are to be compared to the 710 kN (minimum) needed, and not too much more than 800 or 850 kN to avoid "overtensioning" and "shake-down" problems during the re-tightening of the bolts that is done after some months of service.

Figure 4 shows the Squirter DTI compression test setup and what the calibrated squirt appearance looks like at the intended preload. The field installers doing the bolting will continue to use the torque values given them by the turbine tower manufacturers, but at the same time they will aim to get the squirt appearance shown. If they do not, or if the squirt appearance occurs before the torque value is fully applied, they can modify their procedure accordingly: a little less torque, a little more torque. Once Squirter DTIs are part of the QM plan, a superior bolting result will be obtained, every time. ⚙

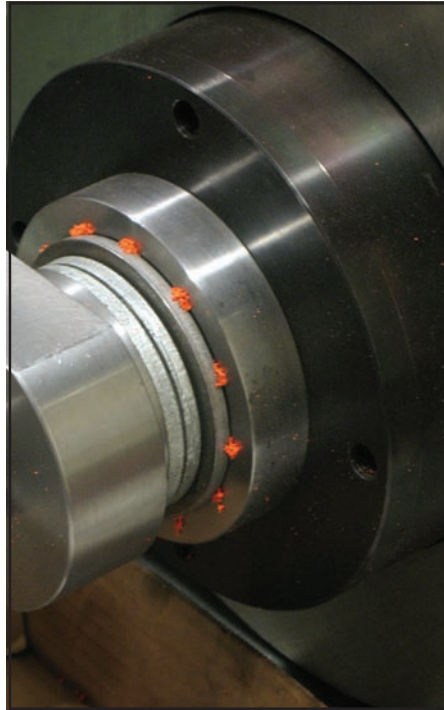


Figure 4