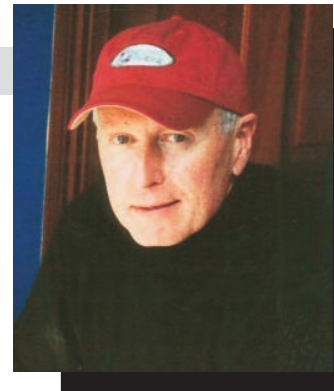


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# RC Tests, Nut Factors, and the Europeans

I have never really understood the concept “rotational capacity” of bolts. After bolts are installed (that is, tensioned correctly) is failure caused by some mysterious extra rotation? Does the external loading of the bolt somehow “rotate” it a little more, and then, presto! It breaks? And does this mysterious external rotational force only apply to galvanized A325 bolts, but not to black A325 bolts, to A490 bolts, to A194 B7 studs, or to SAE J429 cap screws? I don’t think so.

### ASTM Rotational Capacity Tests

ASTM A325 states that the final supplier of the galvanized ASTM A325 bolt set, including bolt, nut, and flat washer, must provide evidence that three of these assemblies have been tightened to double the turn-of-nut “turn-from-snug” angle in a solid joint without breaking. And AASHTO (they’re the bridge people) calls for a similar test of galvanized bolt sets with a few more conditions on maximum nut factor (read ‘lubrication’) and minimum preload (read ‘tension’) achieved in the test. (*A325 RC test — Reference: ASTM A325 Specification, Published under the jurisdiction of the ASTM F16 Committee on Fasteners, section 6.3 and clause 10.*)

The ASTM RC test, as it is called, is intended to test the lubrication and thread fit of the high strength assembly – the “nut factor”:

$$\text{Nut Factor: } k = \frac{\text{Torque Resistance}}{\text{preload} \times \text{diameter}}$$

Without adequate lubrication on the nut or bolt thread the torque resistance will defeat the preloading effort before the intended preload of 70% minimum ultimate tensile strength (UTS) is achieved. And, someone has decided, in the case of AASHTO, that this limit on “nut factor” is 0.25. Without adequate control on nut overlapping, which is of course necessary on galvanized bolt assemblies, the thread fit might be so loose that the nut just slips off the thread at preload levels far below minimum. If overlapping is missed or undersized the bolt will break in torsion below a preload of 70% min UTS, guaranteed.

So it’s not really a test for the bolt’s “capacity” to withstand additional “rotation” in service that underlies the so-called “rotational capacity” test. It’s really intended to be a last minute sort of “point-of-purchase” check on the integrity of the bolt/nut set, because the components are usually made by different manufacturers. But, it’s only two or three bolt sets from each assembly lot, so it’s a pretty small sample.

And even though the bolt installation might be with DTIs, which actually measure the bolt preload, an RC test is still demanded for the galvanized bolts. Puzzling. When the bolts successfully compress a DTI it really means that ALL the bolts have been tested to 70% - 80% of minimum UTS. Not just a sample of two or three. So, why bother with an RC test when DTIs are going to be used?

Are there any other tests that do the same thing as the RC test? Yes. In North America, one such test is called the RCSC “Pre-Installation Test.”

### RCSC Pre-Installation Tests

The RCSC, called the “Council,” is the Research Council on Structural Connections. Their website is [www.boltcouncil.org](http://www.boltcouncil.org). This is a non-profit volunteer organization of about 75 individuals (structure designers, university professors, manufacturers, etc.) who have some interest and knowledge of structural steel bolting. Meetings are open to the public, but official membership and voting status is by invitation only. The Council publishes the “Specification for Structural Joints using A325 and A490 Bolts,” which theoretically is called into law for every steel structure in North America, defines design parameters and installation requirements, and is the basis for the AISC, CISC, AREA, and ASCE specifications. (*RCSC Pre-Installation Test — Reference: Research Council on Structural Connections, “Specification for Structural Joints using ASTM A325 or A490 Bolts” 2004 edition, section 7.*)

The “Specification”, as it is called, states that, on every project site, a test be done in which three bolts from each lot are to be inserted into a bolt tension

calibrator (read Skidmore) and tightened by whatever method is going to be employed on the site. The bolt preload read by the Skidmore must be at least the minimum tension (and that comes from the RCSC Specification too) plus 5% for good measure.

Why is the RCSC “pre-installation test” needed? In the opinion of the Council, it is imperative to see (a) if the bolt assembly will take that preload, and (b) that the workers and equipment can actually produce the desired result.

But again, if DTI’s are used, why bother to do a test of (only three) bolt assemblies, when by compressing the DTI’s it will be shown that 100% of the bolts have achieved correct preload. Indeed, the Council is now balloting a provision that, if passed, will allow certain “calibrated” lots of DTI’s to be used instead of Skidmores in the test.

And now the Europeans have imported our Rotational Capacity thinking and immortalized it in their REALLY complicated ISO/EN 14399 Part 2 “Suitability test for preloading.”

### EN 14399-2 Suitability Tests

EN 14399 (High-strength Structural Bolting Assemblies for Preloading) is to Europe what ASTM A490M and ANSI is to North America, except that it is mostly just for Property Class 10/10.9 bolts. It covers bolts up to M36 only. EN 14399 is an important specification for North America to know about because if we intend to participate in the European market this is the definitive finished product specification. There are eight sections approved, with the 9th (DTI’s) about to be approved. It is ONLY metric, of course. Have you noticed? That’s the system of the world. (ISO/EN 14399 CEN — Reference: European Standard EN 14399, “High Strength Bolting Assemblies for Preloading,” section 2 - “Suitability Test for Preloading,” published by the European Committee for Standardization, Brussels, 2005.

Part 3 (called “System HR”) mimics the BS4395 higher strength type of bolt and nut, with long threads and deep nuts, that are intended to fail by fracture of the bolt shank. In Eurospeak, this is confirmed subtly in the Scope section where it says “...to obtain ductility predominately by plastic elongation of the bolt...” These are like our A490 bolts and 563 nuts.

Part 4 (called “System HV”) mimics the DIN 6914/15 bolt assembly, with short threads, shallow nuts, that are intended to fail by thread stripping. In Eurospeak, this is confirmed subtly in the Scope sec-

tion where it says “...to obtain ductility predominantly by plastic deformation of the engaged threads...”

Both EN14399 Parts 3 and 4 are preceded by Part 2, “Suitability Test for Preloading,” in which it is expected that a sample of bolts from an assembly lot be tension tested in a solid joint (note – solid, not a hydraulic cell such as a Skidmore) for nut factor, maximum preload achieved, and for rotational angular capacity to certain defined limits.

The graph which illustrates the angles and loads to be measured can be seen in EN 14399. But the angular values are actually found in the European equivalent of our RCSC Specification, called ENV 1090 “Execution of Steel Structures.” The latter specification also defines the “k class” of the assembly: either K2 for torque control tightening, K1 for a combined method (really a bedding torque plus part turn), and K0 for the DTI method. These K factors are just that - k factors, or nut factors. (Reference: *European Standard prEN 1090-2, “Execution of Steel Structures, Part 2: Technical Requirements... Stage 34,” published by the European Committee for Standardization, Brussels, 2005 (draft).*



*Who Cares About K Factor Here, and the Europeans Agree*

K1 for a combined torque-plus-turn method, and is similar to the DIN 18800 pt 7 specification. I’ve heard this called “14399 Suitability Test Moderately Heavy”. It reflects the German perspective on bolting, with shallow nuts, large nut lots, a torque/tension test with bolts from one heat but different lengths, and bolts probably only tensioned in their design to 70% of YIELD.

K2 applies to a pure torque control method. It derives from the French system, with torque/tension tests on every batch of bolt/nut assemblies, and the K2 factors are used to determine tightening torques. I hear second hand that some discretion and knowledge is needed in the field to use the K2 factor. This is “14399 Suitability Test Really Heavy”. Maybe you’ve noticed that the French mostly use concrete anyway, and now you know why. Stated kindly, their bolting procedures are involved.

K0 applies to tightening with EN 14399-9 DTI’s, and of the three makes the most sense to me because you simply don’t need to measure torque and tension. You don’t need a K anything. This means they think the nut factor is irrelevant, and to me that makes complete sense. Just squash the bumps, and if you succeed, who cares what the k factor was. This is what I’d call “14399 Suitability Test Light”. ◻