

About the Author/WAYNE WALLACE

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Specification Conformance and Product Usability

They're Not Always the Same Thing in Structural Bolting

If ever a product suffered from specification overload, it the lowly ASTM A325 or A490 structural bolt. These are the bolts used in buildings, bridges, towers, industrial structures, and the like. More and more they are also used in cranes and other machinery because many distributors stock them. There are a wide variety of specifications involved with their supply and installation, because the **bolt** specifications are different from the **nut** specifications, and they're both different again from the **washer** specifications. If that wasn't bad enough, the **application** specifications are different again. Distributors must know that these bolts are governed by all these different specifications - called *product*, and usability specifications. Product specifications govern the manufacture of the product, and usability specifications govern the functionality of the assembly.

Distributors should know that all of the components of the assembly can be manufactured correctly, to specification, but the assembly still might not function correctly or might not be considered an allowable assembly according to the usability specification.

Let's take a quick look at some of the two types of specifications, where conflicts arise, and where some caution should be exercised.

Product Specifications

ASTM A325, A490

These are the workhorse specifications for bolts used in structural connections, lower strength and higher strength respectively, and only come in heavy hex (ANSI B18.2.1) form and only to 1 1/2" diameter. Possibly more than 100 million of these bolts are manufactured in the US yearly. Note that there is no such thing as an A325 or A490 nut. Just the bolt. Head, shank, male threaded end, that's all. They virtually always come with UNC thread. The A325 specification allows for hot dip or mechanically galvanization, but the A490 specification is silent on coatings. Applications should only be considered at "normal atmospheric temperatures". Samples of the production lots for both grades must pass representative physical strength tests, and for A325 bolts, a "rotational capacity" test of nut lubricant must be done prior to shipping.

Manufacturing must include "lot control", and lot sizes can vary widely from a few hundred (for very large diameter, long bolts) to one hundred thousand or more (for the standard 3/4" by 2" for instance). Distributors normally hold large quantities of these types of bolts in inventory. Believe it or not, a Type Iii (weathering) A490 bolt is allowed, and one manufacturer says they have made some, but I've never seen one.

Caution: The ASTM A325 rotational capacity test applies only to galvanized bolts, and its criteria has been different from the state DOT specified "ROCAP" test often encountered in purchase documents. There is no ASTM rotational capacity test specified for A490 bolts although some end users are considering making one.

ASTM A354, A449

These are older and more general specifications for both headed bolts and for studs having threads on both ends, two strength grades for A354 and one strength grade for A449, to 4" diameter, coarse or fine thread, and are normally used at atmospheric temperatures, although occasional excursions to what is called "elevated temperatures" is allowed for A354 (In my mind "elevated temperatures" mean any temperature outside the normal human range). In the heavy hex form, these could be considered structural bolts, but are rarely encountered. Manufacturing "lot control" in the sense that is meant in A325 or A490 above is not usually anticipated. Perhaps a few million of these are made annually in the US, and they are not normally seen in the structural industry. Distributors do not normally stock them, substituting A325 and A490 in the smaller diameters where possible. These bolts are occasionally seen in movable bridges with turned shanks for use in interference-fit holes.

ASTM A193

These are alloy steel bolts and nuts, and are rarely seen in structures. Some grades are intended for high temperature service, and so are used in piping flange bolts, studs etc. Some structural distributors stock a few grade B7 products.

CONFORMANCE,

TC Bolts

There is STILL no product specification for the manufacture of "TC", or "twist-off", or "tension control" bolts. These are the special-geometry bolts made with a button or hex head, and which have an extended splined end on the shank for connection to an electric double chuck wrench. The TC bolt specification has been drafted and is in the approval stage at ASTM subcommittee F16.02, but still has not been published. Meanwhile the manufacturers use the A325 and A490 product specifications and do the best they can from there. These are made, tested, and sold as assemblies, which is good, and they do not use A563 grade C nuts. Alteration of the assembly by means of relubrication at installation is prohibited. They have size and grade and coating limitations which are different from regular hex head bolts, because some TC bolt manufacturers are reluctant to make galvanized TC bolts, and some are reluctant to make any A490 grade TC bolts.

Caution: Occasionally engineers specify or allow the use of TC bolts with DTI's for installation tension control. On TC bolts with diameters 1" and larger having a large button head form, it's inadvisable to use a DTI under the large button head since access to the DTI gap is restricted by the "overhang" of the head, if you will. In this instance, suggest that your customer put the DTI on the nut end under a flat hardened F436 washer, and the DTI will register correctly.

Caution: Do not allow these bolts to be relubricated by anyone other than the manufacturer. If the PO calls for spray cans of WD40 with the TC bolts, watch out.

Caution: Ask the purchaser if a Research Council (see RCSC below) field installation test is going to be done. If it is, make sure the TC bolts will break off above 1.05 times the minimum allowable tension.

ASTM A563, A194

These are the workhorse nut specifications for use with the above bolts and studs. Several grades of A563 nuts are allowed for use with A325 and A490 bolts, with the (usually) non-heat treated grade C prohibited with A490 bolts, and to be avoided if at all possible in favor of grades D (usually heat-treated) or DH (always heat-treated) even with A325 bolts. A194 grade 2H nuts are excellent for use with both bolt grades, but grade 2H nuts may be downgraded to disallow galvanizing of them to go with galvanized A325 bolts as A563 says. The specification prohibits galvanized A563 grade C nuts also.

Caution; Grade C nuts are acceptable for many appli-

cations, but don't sell them to any customer who has the least likelihood of supplying them to a bridge project - chances are they won't be happy with them and they may be prohibited. Sell them some hardened nuts for a few pennies more.



Bolts and nuts can be made correctly, but they have to be installed correctly.

Caution: Beware the purchase order which calls for A325 and A490 bolts of the same diameter. Look closely to see if they are asking for two different nut grades. They could easily get mixed up and might have to be removed from the site - not your problem exactly, but you'll have a big telephone bill getting it all straightened out.

ASTMF959, F436

These are the load indicating and fiat washers to be used with the above bolts and nuts. Note that these washers don't have the same ID. F436 inner diameters are larger than those of F959 for the same size bolts. Puzzling, that. Of course, F959 "Direct Tension Indicating Washers" are not really washers at all, but mechanical load cells used to gage the tension induced in the bolt as it is installed. Their hardnesses, although not specified, are usually well below that of flat F436 washers (about Rc 30 or less Vs Re 38 or more) and therefore their use to replace a flat F436 washer is controversial. F959 DTI's are only allowed to be coated with mechanically deposited zinc, whereas F436 washers can be either hot dip or mechanically galvanized.

With standard hex head (non-TC) bolts, F436 washers can be used on either end, but are usually put on the nut end however so the nut can be rotated against the hardened F436 surface instead of against the soft steel plates being connected.

Caution: If F436 washers are to be used on "top" of DTI's, as they would be if the DTI is placed under the nut as ASTM F959 allows¹, the large ID of the F436 flat washer can be incompatible with the DTI, resulting in a "sooner-than-expected" DTI compression at a specific bolt preload. Ask the purchaser on what end of the DTI's are to be installed, and inquire of the DTI manufacturer as to whether this incompatibility will occur. If so, special ID F436 washers are available.

Caution: If your PO includes DTI's, and if there's a state DOT involved, advise the manufacturer of the DTI's. It may mean that slightly different strength DTI's must be supplied (see state DOT's below) because some states test the incoming DTI's in a special non-standard manner, eg Tennessee.