

Ballot Item 5: (S07-011)

(a) **1.3 Referenced Standards and Specifications****American Society for Testing and Materials**

{Add to the existing list}

ASTM F1136-04 Standard Specification for Zinc/Aluminum Corrosion Protective Coatings for Fasteners

{Add to the existing list}

**IFI: Industrial Fastener Institute**IFI 144 Test Evaluation Procedures for Coating Qualification Intended for Use on High-Strength Structural Bolts

## (b) {Modify Table 2.1 as shown}

**Table 2.1 Acceptable ASTM A563 Nut Grade and Finish and ASTM F436 Washer Type and Finish**

ASTM Desig.	Bolt Type	Bolt Finish <sup>a</sup>	ASTM A563 nut grade and finish <sup>a</sup>	ASTM F436 washer type and finish <sup>a,d</sup>
A325	1	Plain (uncoated)	C, C3, D, DH <sup>c</sup> and DH3; plain	1; plain
		Galvanized	DH <sup>c</sup> ; galvanized And lubricated	1; galvanized
		<u>Zn/Al Inorganic, per ASTM F1136 Grade 3</u>	<u>DH; Zn/Al Inorganic, per ASTM F1136 Grade 5</u>	<u>1; Zn/Al Inorganic, per ASTM F1136 Grade 3</u>
F1852	1	Plain	C3 and DH3; plain	3; plain
		Plain (uncoated)	C, C3, DH <sup>c</sup> and DH3; plain	1; plain <sup>b</sup>
		Mechanically Galvanized	DH <sup>c</sup> ; mechanically galvanized and lubricated	1; mechanically galvanized <sup>b</sup>
		<u>Zn/Al Inorganic, per ASTM F1136 Grade 3</u>	<u>DH <sup>c</sup>; Zn/Al Inorganic, per ASTM F1136 Grade 5</u>	<u>1; Zn/Al Inorganic, per ASTM F1136 Grade 3 <sup>b</sup></u>
A490	1	Plain	C3 and DH3; plain	3; plain <sup>b</sup>
		Plain	DH <sup>c</sup> and DH3; plain	1; plain
		<u>Zn/Al Inorganic, per ASTM F1136 Grade 3</u>	<u>DH; Zn/Al Inorganic, per ASTM F1136 Grade 5</u>	<u>1; Zn/Al Inorganic, per ASTM F1136 Grade 3</u>
	3	Plain	DH3; plain	3; plain

<sup>a</sup> Applicable only if washer is required in Section 6.<sup>b</sup> Required in all cases under nut per Section 6.<sup>c</sup> The substitution of ASTM A194 Grade 2H nuts in place of ASTM A563 grade DH nuts is permitted.<sup>d</sup> "Galvanized" as used in this table refers to hot-dip galvanizing in accordance with ASTM A513 or mechanical galvanizing in accordance with ASTM B695.<sup>e</sup> "Zn/Al Inorganic" as used in this table refers to application of Zn/Al Corrosion Protective Coating in accordance with ASTM F1136 and which have met all the requirements of IFI-144.

F2329

## Ballot Item 5: (S07-011) continued:

- (c) 2.3.3 Reuse: ASTM A490 bolts and galvanized or Zn/Al Inorganic coated ASTM A325 bolts shall not be reused. When approved by the *Engineer of Record*, black ASTM A325 bolts are permitted to be reused. Touching up or re-tightening bolts that may have been loosened by the installation of adjacent bolts shall not be considered to be a reuse.

**Commentary:**

ASTM A325 and ASTM A490 currently provide for two types (according to metallurgical classification) of *high-strength bolts*, supplied in diameters from 1/2 in. to 1 1/2 in. inclusive. Type 1 covers medium carbon steel for ASTM A325 bolts and alloy steel for ASTM A490 bolts. Type 3 covers *high-strength bolts* that have improved atmospheric corrosion resistance and weathering characteristics. (Reference to Type 2 ASTM A325 and Type 2 A490 bolts, which appeared in previous editions of this Specification, has been removed following the removal of similar reference within the ASTM A325 and A490 Specifications). When the bolt type is not specified, either Type 1 or Type 3 may be supplied at the option of the *manufacturer*. Note that ASTM F1852 twist-off-type tension-control bolt assemblies may be manufactured with a button head or hexagonal head; other requirements for these *fastener assemblies* are found in Section 2.7.

Regular heavy-hex structural bolts and twist-off-type tension-control bolt assemblies are required by ASTM Specifications to be distinctively marked. Certain markings are mandatory. In addition to the mandatory markings, the *manufacturer* may apply additional distinguishing markings. The mandatory and sample optional markings are illustrated in Figure C-2.1.

*{Figure C-2.1 is unchanged and not reproduced here.}*

ASTM Specifications permit the galvanizing of ASTM A325 bolts but not ASTM A490 bolts. Similarly, the application of zinc to ASTM A490 bolts by metallizing or mechanical coating is not permitted because the effect of mechanical galvanizing on embrittlement and delayed cracking of ASTM A490 bolts has not been fully investigated to date.

An extensive investigation conducted in accordance with IFI-144 was completed in 2006 and presented to the ASTM F16 Committee on Fasteners (F16 Research Report RR: F16-1001). The investigation demonstrated that Zn/Al Inorganic Coating, when applied per ASTM F1136 Grade 3 to ASTM A490 bolts, does not cause delayed cracking by internal hydrogen embrittlement, nor does it accelerate environmental hydrogen embrittlement by cathodic hydrogen absorption. It was determined that this is an acceptable finish to be used on type 1 ASTM A490, A325, F1852, and F2280 bolts.

Prior to embedding bolts coated with Zn/Al Inorganic Coating in concrete, testing should be conducted to ensure there is no negative impact (to the bolt or the concrete) caused by the reaction of the intended concrete mix and the aluminum in the coating.

Galvanized *high-strength bolts* and nuts must be considered as a manufactured *fastener assembly*. Insofar as the hot-dip galvanized bolt and nut assembly is concerned, four principal factors must be considered so that the provisions of this Specification are understood and properly applied. These are:



## Ballot Item 5: (S07-011) continued:

- (1) The effect of the hot-dip galvanizing process on the mechanical properties of high-strength steels;
- (2) The effect of over-tapping for hot-dip galvanized coatings on the nut stripping strength;
- (3) The effect of galvanizing and lubrication on the torque required for pretensioning; and,
- (4) Shipping requirements.

Birkemoe and Herrschaft (1970) showed that, in the as-galvanized condition, galvanizing increases the friction between the bolt and nut threads as well as the variability of the torque-induced pretension. A lower required torque and more consistent results are obtained if the nuts are lubricated. Thus, it is required in ASTM A325 that a galvanized bolt and lubricated galvanized nut be assembled in a steel *joint* with a galvanized washer and tested by the *supplier* prior to shipment. This testing must show that the galvanized or Zn/Al Inorganic coated nut with the lubricant provided may be rotated from the snug-tight condition well in excess of the rotation required for pretensioned installation without stripping. This requirement applies to both hot-dip galvanized, and mechanically galvanized, and Zn/Al Inorganic coated fasteners. The above requirements clearly indicate that:

- (1) Galvanized and Zn/Al Inorganic coated high-strength bolts and nuts must be treated as a fastener assembly;
- (2) The supplier must supply nuts that have been lubricated and tested with the supplied high-strength bolts;
- (3) Nuts and high-strength bolts must be shipped together in the same shipping container; and,
- (4) The purchase of galvanized high-strength bolts and galvanized nuts from separate suppliers is not in accordance with the intent of the ASTM Specifications because the control of over-tapping, the testing and application of lubricant and the supplier responsibility for the performance of the assembly would clearly not have been provided as required.

Because some of the lubricants used to meet the requirements of ASTM Specifications are water soluble, it is advisable that galvanized *high-strength bolts* and nuts be shipped and stored in plastic bags or in sealed wood or metal containers. Containers of fasteners with hot-wax-type lubricants should not be subjected to heat that would cause depletion or change in the properties of the lubricant.

Both the hot-dip galvanizing process (ASTM A153) and the mechanical galvanizing process (ASTM B695) are recognized in ASTM A325. The effects of the two processes upon the performance characteristics and requirements for proper installation are distinctly different. Therefore, distinction between the two must be noted in the comments that follow. In accordance with ASTM A325, all threaded components of the *fastener assembly* must be galvanized by the same process and the *supplier's* option is limited to one process per item with no mixed processes in a *lot*. Mixing *high-strength bolts* that are galvanized by one process with nuts that are galvanized by the other may result in an unworkable assembly.

F2329

## Ballot Item 5: (S07-011) continued:

Steels in the 200 ksi and higher tensile-strength range are subject to embrittlement if hydrogen is permitted to remain in the steel and the steel is subjected to high tensile stress. The minimum tensile strength of ASTM A325 bolts is 105 ksi or 120 ksi, depending upon the diameter, and maximum hardness limits result in production tensile strengths well below the critical range. The maximum tensile strength for ASTM A490 bolts was set at 170 ksi to provide a little more than a ten-percent margin below 200 ksi. However, because *manufacturers* must target their production slightly higher than the required minimum, ASTM A490 bolts close to the critical range of tensile strength must be anticipated. For black *high-strength bolts*, this is not a cause for concern. However, if the bolt is hot-dip galvanized, delayed brittle fracture in service is a concern because of the possibility of the introduction of hydrogen during the pickling operation of the hot-dip galvanizing process and the subsequent "sealing-in" of the hydrogen by the zinc coating. There also exists the possibility of cathodic hydrogen absorption arising from the corrosion process in certain aggressive environments.

ASTM A325 and A490 bolts are manufactured to dimensions as specified in ANSI/ASME B18.2.6. The basic dimensions, as defined in Figure C-2.2, are shown in Table C-2.1.

*{Table C-2.1 and Figure C-2.2 are unchanged and not reproduced here.}*

The principal geometric features of heavy-hex structural bolts that distinguish them from bolts for general application are the size of the head and the unthreaded body length. The head of the heavy-hex structural bolt is specified to be the same size as a heavy-hex nut of the same nominal diameter so that the ironworker may use the same wrench or socket either on the bolt head and/or on the nut. With the specific exception of fully threaded ASTM A325T bolts as discussed below, heavy-hex structural bolts have shorter threaded lengths than bolts for general applications. By making the body length of the bolt the control dimension, it has been possible to exclude the thread from all shear planes when desirable, except for the case of thin outside parts adjacent to the nut.

The shorter threaded lengths provided with heavy-hex structural bolts tend to minimize the threaded portion of the bolt within the *grip*. Accordingly, care must also be exercised to provide adequate threaded length between the nut and the bolt head to enable appropriate installation without jamming the nut on the thread run-out.

Depending upon the increments of supplied bolt lengths, the full thread may extend into the *grip* for an assembly without washers by as much as 3/8 in. for 1/2, 5/8, 3/4, 7/8, 1-1/4, and 1-1/2 in. diameter *high-strength bolts* and as much as 1/2 in. for 1, 1-1/8, and 1-3/8 in. diameter *high-strength bolts*. When the thickness of the ply closest to the nut is less than the 3/8 in. or 1/2 in. dimensions given above, it may still be possible to exclude the threads from the shear plane, when required, depending upon the specific combination of bolt length, *grip* and number of washers used under the nut (Carter, 1996). If necessary, the next increment of bolt length can be specified with ASTM F436 washers in sufficient number to both exclude the threads from the shear plane and ensure that the assembly can be installed with adequate threads included in the *grip* for proper installation.

At maximum accumulation of tolerances from all components in the *fastener*

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