

# COOLING TECHNOLOGY INSTITUTE

## CTI Fastener Material Guidelines



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This guideline document summarizes the best current state of knowledge regarding the specific subject. This document represents a consensus of those individual members who have reviewed this document, its scope and provisions. It is intended to aid all users or potential users of cooling towers.

Approved by the CTI Executive Board.



This document has been revised and approved as part of CTI's Five Year Review Cycle. This document is again subject to review in 2022.

Approved by the  
CTI Executive Board

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CTI-Guideline  
ESG-144 (17)

# CTI Fastener Material Guidelines

## 1.0 SCOPE

**1.1** To set forth guidelines for selecting fasteners used in the cooling tower industry.

**1.2** To identify and specify materials typically used in cooling tower fasteners. List and define what physical and chemical properties are to be recommended in cooling.

## 2.0 DEFINITIONS

### 2.1 Alloy Steel

An alloy steel is a steel containing elements other than carbon and iron which have been added to obtain definite mechanical properties, such as higher strength at elevated temperatures, toughness, etc.

### 2.2 Annealed

A fastener is considered in the annealed state when it has been heated and quenched to make it soft. Once complete, it is free from internal stresses/hardness caused by cold working or previous heat treatment, therefore the strength is reduced.

### 2.3 Carbon Steel

Carbon steel is steel which does not contain any substantial amounts of alloying materials other than carbon.

### 2.4 Cap Screws

Defined by ANSI B18.2.1 Table 4 and accompanying notes. Manufactured to closer dimensional tolerances than hex bolts. Requires a flat machined bearing surface under the fastener head. Nominal body diameter is maximum (tolerance to smaller than nominal values). Typically specified for applications requiring tighter fastener dimensional control than provided by hex bolts.

### 2.5 Commercially Available

Fasteners manufactured to Industrial Fastener Institute (IFI) standards from common materials are generally readily available within reasonable lead times.

### 2.6 Critical Pitting Temperature

The critical pitting temperature is the lowest temperature at which the growth of stable pits is possible. This is typically tested using ASTM G150 and/or ASTM G48.

### 2.6 Fastener Specification or Standard

A specification or standard that defines the materials and properties of a finished fastener as opposed to the raw material used to make the fastener. For example, ASTM Standard F593, a Fastener Standard specifically for bolting, would be defined by this paragraph.

### 2.7 Full Body

Full body means the unthreaded shank diameter of the bolt or cap screw is generally within the dimensional limits (tolerance) of the major diameter of the threads. Full body fasteners are generally have cut treads, but they can also have rolled threads too. Full body is standard when specifying a cap screw, but is **not** standard for machine bolts.

### 2.8 Graded Fastener

Any fastener with a grade identification marking indicating that the fastener's base material, strength properties, or performance capabilities conform to a specific product standard or specification of a consensus standards organization; i.e. (B8 on a head of a stainless steel means the part is a 304-stainless steel and meets the requirements of ASTM Standard A193 or ASTM Standard A320. Six radial lines on the head of a steel bolt means the bolt meets the requirements of SAE Standard J429 Grade 8).

### 2.9 Heading

Heading is a type of forming process that can be done via hot or cold processing. Hot heading is above the recrystallization temperature and has no length limitations. Cold heading is below the recrystallization temperature and is limited to the stroke of the header. Most bolts 10" and under are manufactured by the cold heading process. For bolts over 10" in length the hot heading process is most common.

### 2.10 Hex Bolts

Defined by ANSI B18.2.1 Table 2 and accompanying notes. Allows wider dimensional tolerances than cap screws. Body diameter may be slightly larger than nominal diameter. Flat machined bearing surface under bolt head is not required. Typically specified for general structural bolting requirements.

### 2.11 Material Specification or Standard

A specification or standard that defines the materials used in the manufacture of various products, one of which may be fasteners. ASTM A276 is a material standard used to make various items, including fasteners, and would be defined by this by this paragraph. Fasteners manufactured from materials, identified by material standards, start with qualified base materials and are subsequently hot or cold formed into the finished fastener shape. Fasteners supplied to material standard requirements are not subject to physical properties testing in their finished form. The actual physical properties of the fastener may vary somewhat from the original properties of the base material. When material standards are specified for fasteners, the finished fasteners may not be rejected even if the physical properties are different from

the base material properties.

## **2.12 Pitting Resistance Equivalent Number (PREN)**

Pitting resistance equivalent number is a theoretical way of comparing pitting corrosion resistance of various types of stainless steels. This doesn't apply to any non-ferrous (non-iron) metals and only compares pitting resistance, not general corrosion or other forms of corrosion (e.g. MIC, erosion corrosion, etc.) This number should only be used as a comparative means between the different types of stainless steel, and not as a prediction of whether a grade will be suitable for a given application, where pitting corrosion may be a hazard. These numbers are generated by using an equation that incorporates weight percent of chromium, nitrogen & molybdenum. Some iterations of this equation contain tungsten too.

## **2.13 Plastic Deformation**

Plastic deformation is a type of shape change to a material that is irreversible due to an outside force acting on the material. For plastic deformation to have occurred first elastic (reversible) deformation should have occurred.

## **2.14 Precipitation Hardening**

Precipitation hardening or age hardening is a process used to greatly increase the strength and hardness of a material. This is done by the addition of a secondary uniformly distributed substance at an elevated temperature. This step is called solution treating, which is then followed by quenching and aging.

## **2.15 Recrystallization Temperature**

Recrystallization temperature is the lowest temperature at which a metallic grain structure is converted into a strain-free grain structure. This typically happens around four tenths of the melting point.

## **2.16 Reduced Body**

Reduced body means the unthreaded shank diameter of the bolt may range from the pitch diameter rolled thread blank size up to the minimum major diameter of the threads which is common on longer machine bolts. Reduced body bolts should still meet the strength requirements of the purchase specification as applicable.

## **2.17 Stainless Steel**

Stainless steel is a corrosion resistant type of alloy steel which contains a minimum of 12% chromium.

**2.17.1 Martensitic Stainless Steel** – Martensitic grades are straight chromium steels containing no nickel. They are magnetic and can be hardened by heat treatments. These are typically used where strength, hardness and wear resistance are required. These grades (as a group) typically have the lowest corrosion resistance.

**2.17.2 Ferritic Stainless Steel** – Ferritic grades

were developed to resist corrosion and oxidation, while being highly resistant to stress corrosion cracking. These steels are magnetic, but cannot be hardened or strengthened using heat treatments. They can be cold worked and softened by annealing. As a group, these are more corrosion resistance than martensitic grades, but are generally inferior to austenitic grades. These grades generally contain straight chromium and no nickel.

**2.17.3 Austenitic Stainless Steel** – Austenitic grades contain both nickel and chromium, a few premium grades contain molybdenum (e.g. 316). These steels are used when high corrosion resistance is necessary. These steels are not magnetic; nor can they be hardened or strengthened by heat treatments. However, these grades can be hardened significantly by cold working and softened by annealing. These grades are susceptible to stress corrosion cracking.

**2.17.4 Duplex Stainless Steel** – Duplex grades are a blend of austenitic and ferritic grades. In general, these grades exhibit higher strength and corrosion resistance than either austenitic or ferritic steels. These grades “inherited”, from the ferritic side, an excellent resistance to SCC. These steels are magnetic.

## **2.18 Strain Hardening (Work Hardening)**

Strain hardening is the increase in hardness, and hence strength, resulting from plastic deformation at a temperature below the recrystallization temperature.

## **2.19 Stress Corrosion Cracking (SCC)**

Stress corrosion cracking is a type corrosion where a crack propagates through a component and causes sudden failure of a normally ductile metal. The metal needs to be subjected to a corrosive environment and a tensile stress, elevated temperatures increase the occurrence of SCC.

## **2.20 Threads**

External threaded fasteners may be supplied with either cut or rolled thread unless the process is specified. Internal threaded fasteners will be tapped (cut thread).

*Note: When rolled threads are required, the purchaser should specify whether a full body is required. Reduced shank diameters may be supplied on machine bolts if full body is not specified. Full bodies are always required on cap screws. Cap screws may be substituted for machine bolts but machine bolts may not be substituted for cap screws without purchaser approval.*

## **2.21 Thread Class**

Threads will be supplied to ANSI/ASME B1.1 Standards unless otherwise specified; I.E. Class 2A on bolts and cap screws and 3A on socket headed product.

## **2.22 Un-Graded Fastener**

Any fastener without a grade identification marking. The fastener may or may not have an alloy identification

marking indicating the base material. A fastener not manufactured or tested to a fastener specification or standard.

### 3.0 SELECTION CRITERIA

**3.1** Corrosion resistance and strength are the primary selection criteria for cooling tower fasteners. Tables I through IV list standard fastener material grades, conditions and the corresponding strength levels.

3.1.1 In applications where corrosion resistance is the primary consideration table II lists various stainless steels and table III lists non-ferrous materials. Austenitic stainless steels, which include group 1 and 2 alloys from table II, are readily available in the cold worked condition, cold headed with rolled threads. Diameters 3/4" and larger may be hot headed but should have rolled threads to attain the required mechanical properties.

Standard cold worked sizes include:

| Diameter | Length       | Diameter | Length   |
|----------|--------------|----------|----------|
| 1/4      | thru 6"      | 3/4      | thru 10" |
| 5/16     | thru 6"      | 7/8      | thru 10" |
| 3/8      | thru 7"      | 1        | thru 10" |
| 7/16     | thru 5"      | 1 1/8    | thru 10" |
| 1/2      | thru 10 1/2" | 1 1/4    | thru 10" |
| 5/8      | thru 10"     |          |          |

(Note: Where appropriate and specified, metric size equivalents apply to these guidelines)

Fasteners made from austenitic stainless steel that are too long to cold work are readily available in the hot formed condition, hot headed with cut threads. The mechanical properties of these fasteners would be the same as the annealed group 1 and 2 alloys.

Strain hardened alloys, annealed alloys, 410 heat treated alloy, and 630 precipitation hardening alloy for the most part should be made to order.

Non-ferrous fasteners, including, Nickel alloys 400, 405, 500, Copper alloys 651 and 655 are stocked in somewhat limited range of sizes when compared with stainless or steel fasteners, but most standard fasteners sizes can be supplied within a relatively short time.

3.1.2 2205 is a duplex stainless steel containing about 40-50% ferrite in the annealed condition. 2205 has been a practical solution to chloride SCC problems experienced with 304/304/L or 316/316L stainless. The high chromium, molybdenum and nitrogen contents provide corrosion resistance superior to 316/316L and 317L in most environments. 2205 is not suggested for operating temperatures up to 600° F.

The design strength of 2205 is significantly higher than 316/316L, often permitting lighter wall

construction. 2205 has good notch impact toughness down to temperatures -40°F.

3.1.3 When corrosion is not the primary concern or when strength becomes the overriding factor table I lists different grades of hardened steel fastener materials. Also listed are non-hardened fastener materials for less critical applications.

3.1.4 Tables V through VII identify the specifications pertaining to washers and rivets. These specifications pertain only to material and dimensional data.

**3.2** Fastener may be identified by product description, detailed drawing, material, material specification or product specification if required by the fastener application.

i.e.: 1/2-13 X 6" hex head cap screw, 304 per ASTM F593, cond cw per dwg. 12345, Revision 2

**3.3** Choosing the correct grade of material based on the chloride content of the process water is an important consideration. Pitting and crevice corrosion requires the presence of chlorides and, for a given chloride level, the more highly alloyed stainless steels are more resistant. In general, the higher the chromium, molybdenum and nitrogen contents of the steel, the better the corrosion resistance. While there are other factors that influence corrosion rate in waters, chloride content is a major factor for selection of an appropriate grade and is easily measurable. As crevice corrosion tends to occur at lower chloride levels and temperatures than pitting, it is normally the parameter used to guide selection. (as referenced by the Nickel Institute's Guidelines for Alloy Selection for Waters and Waste Water Service)

### 4.0 QUALITY AND SPECIFICATIONS OF MATERIALS

**4.1** When specified, all non-graded fasteners (material only) may be supplied with either full lot traceability and/or the chemical certifications documenting compliance with the chemical requirements of the material specification.

**4.2** To assure conformance on all graded fasteners the supplier is to maintain full lot traceability as well as maintaining chemical and physical certifications on file.

**4.3** All graded products should be marked as required by the applicable product specification and Public Law 101-592.

**4.4** Fasteners will typically be supplied, as specified, to current revisions of the specification. Fasteners may be supplied to previous specification revisions upon agreement of purchaser and supplier with certification of the previous specification.

### 5.0 SPECIAL APPLICATION CONSIDERATIONS

**5.1** NACE MR-01-XX Trim <National Association of Corrosion Engineers.>

5.1.1 When NACE trim is a specification



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