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Standard Terminology for F16 Mechanical Fasteners[1]

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1. Scope

1.1 This terminology standard provides a compilation of definitions for terminology used for mechanical fasteners.

1.2 Terms in this terminology are organized alphabetically. In Appendix X1 they are listed under fastener characteristic.

1.3 Additional definitions are shown in ANSI/ASME B18.12; IFI Glossary of Terms, IFI-139 and IFI-140; and SAE J412.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

A 563 Specification for Carbons and Alloy Steel Nuts

E 456 Terminology Relating to Quality and Statistics

2.2 *ANSI/ASME Standard:*[3]

B18.12 Glossary of Terms for Mechanical Fasteners

2.3 *IFI Standards:*[4]

Glossary of Terms Relating to Aerospace Fasteners

IFI-139 Quality Assurance Requirements for Fastener Testing Laboratories

IFI-140 Carbon and Alloy Steel Wire, Rods, and Bars for Mechanical Fasteners

2.4 *SAE Standard:*[5]

SAE J412 General Characteristics and Heat Treatments of Steels

3. Mechanical Fastener Definitions

acceptance number—numerical value representing the maximum number of permissible non-conformances within a sample submitted for testing and acceptance of the population.

age hardened—precipitation of constituents within certain alloy metals to increase mechanical properties.

alloy group—materials grouped by their chemical designation and considered to be functionally or chemically similar for general purpose use.

alloy steel—steel is considered to be alloy when the maximum range given for manganese exceeds 1.65 % or a definite minimum quantity for any of the following elements is specified or required within the limits of the recognized field of constructional alloy steels: chromium, molybdenum, nickel, or any other alloying element added to obtain a desired alloying effect.

alter—to change fastener properties such as hardness, tensile strength, surface finish, length, or other characteristics of the fastener through such processes as heat treatment, plating, and machining.

alteration distributor—distributor of fasteners who alters a fastener prior to sale and assumes the full responsibilities of the alteration and its affected mechanical and performance characteristics.

anchor bolt—steel rod or bar, one end of which is intended to be cast in concrete while the opposite end is threaded and projects from the concrete for anchoring other material to the concrete. The end cast in concrete may be either straight or provided with an anchor, such as a bent hook, forged head, or a tapped or welded attachment to resist forces imposed on the anchor bolt as required.

annealing—general term applied to a variety of thermal treatments applied to fasteners for the purpose of softening or homogenizing material properties. The specific types of annealing are:

full annealing—heating steel above the upper critical transformation temperature, holding it there long enough to fully transform

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[4] Available from Industrial Fasteners Institute, 1717 E. 9th Street, Suite 1105, Cleveland, OH 44114.

[5] Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, http://www.sae.org.

the steel to austenite, and then cooling it at a controlled rate, in a furnace, to below a specified temperature. A full anneal refines grain structure and provides a relatively soft, ductile material that is free of internal stresses.

intercritical annealing/isothermal annealing —heating a steel above the lower critical transformation temperature, but below the upper-critical transformation temperature, to dissolve all the iron carbides, but not transform all the ferrite to austenite. Cooling slowly from this temperature, through the lower critical temperature, produces a structure of ferrite and pearlite that is free of internal stresses. In *intercritical annealing*, the steel continues to cool slowly in the furnace, similarly to full annealing. In *isothermal annealing*, cooling is stopped just below the lower critical, assuring complete transformation to ferrite and coarse pearlite, and eliminating the potential for bainite formation. The coarse pearlite structure greatly improves machinability of medium carbon steels.

normalizing—variation of full annealing in which steel is heated above the upper critical temperature and is then air cooled in air, rather than in a furnace. Normalizing relieves the internal stresses caused by previous working, and while it produces sufficient softness and ductility for many purposes, it leaves the steel harder and with a higher tensile strength than full annealing. To remove cooling stresses, normalizing if often followed by tempering.

process annealing—sometimes called subcritical annealing or stress relieving, performed at temperatures just below the lower critical temperature. Process annealing neither refines grains nor redissolves cementite, but does improve the ductility and decreases residual stress in work-hardened steel.

solution annealing—heating an austenitic stainless steel to a temperature that puts the carbides into solution. The steel is held at this temperature long enough to achieve grain growth. It is then quenched in a medium for fast cooling, which prevents most of the carbides from reprecipitating. The process achieves optimum creep strength.

spheroidize annealing—type of subcritical annealing used to soften steel and improve machinability. Heat treating fine pearlite for a long time just below the lower critical temperature of the steel, followed by a very slow cooling, produces a spheroidal or globular form of the pearlite.

stabilization annealing—heating an austenitic stainless steel used in severe aqueous corrosion environments by first solution annealing and then reheating to about 1600°F, and holding at that temperature. The treatment causes grain boundary precipitation of carbides, but also the hold time permits the chromium remaining in the austenite solution to redistribute within the grains, restoring corrosion resistance, even adjacent to the grain boundaries.

applicable standards—those having the capability of being applied in some fashion to the host standard.

arbitration hardness location— prescribed location on the fastener, such as at mid-radius, using 90° intervals taken through the cross section, one diameter from the threaded end for bolts and screws.

assembly lot—assembly lot may consist of a combination of different products. As long as the products that make up the assembly are in accordance with *lot*, the quantity of assemblies determine the sample size. Example: ten assemblies consisting of a bolt, nut, and a washer would have a lot size of ten if the bolts, nuts, and washers meet the criteria of *lot*. However, if any of the components in the assembly are not in accordance with *lot* then the ten assemblies will have to be separated into lots that meet all the requirements of *lot*.

austenitic stainless alloys—steel alloys that contain a minimum of 15 % chromium and from a residual to 20 % nickel. Some alloys may contain as much as 18 % manganese. The metal is predominantly face centered cubic in structure and hardenable only by cold working. Essentially nonmagnetic in its wire form, it may become slightly magnetic from cold working. Austenitic stainless steels can be grouped into three categories: 300 series alloy, Cr-Ni-Mn alloys, and Cr-Ni-Mo-Ti.

average coating thickness—determined as either the value obtained by analytical methods or the mean value of a specified number of local thickness measurements that are evenly distributed over the significant surface.

baking duration—time measured from when the plated product reaches a specified temperature in the baking furnace or oven until it is removed.

bar—solid rolled or forged section that is long in relationship to its cross-sectional dimensions with a relatively constant cross-section throughout its length. Carbon and alloy steel bars are produced from hot rolled or cast billets, or from blooms rolled single strand into coils.

barrel-plating process—fastener-coating process which employs a containment vessel called a barrel that is designed to move a given batch of fasteners together through each of the process steps, allowing ready ingress and egress of processing solutions and rinses. As the barrel moves through the process steps, it is rotated or oscillated, causing the fasteners to cascade over one another, and in the electrocleaning and electroplating steps, and electric current is applied.

batch average thickness—calculated average thickness of a coating if it were uniformly distributed on the surfaces of the items.

bend test—various tests in which a fastener is bent through its axis or on a round mandrel to determine the toughness and ductility of the fastener.

bendable bolts—bolts furnished with an altered section at some location at which the bolt will bend.

bilateral specifications—specifications that have both an upper and a lower value.

bolt—headed and externally threaded fastener designed to be assembled with a nut.

bolt load - elongation behavior— when tensile loaded, a bolt will elongate elastically until stressed beyond its proportional limit where it will behave plastically.

bolt-nut-washer assembly—a combination of bolt, nut, and washer components from singular lots that have been assembled,

lubricated as necessary, tested as required, and prepared for shipment to a customer creating a unique set and certifiable lot.

break loose torque—torque applied in a removal direction necessary to start the fastener in motion from its fully preloaded installed position.

breakaway torque—torque necessary to start a fastener in motion after the axial load of the mating components has been reduced to zero.

burst—open break in the metal during forging located on the flats or corners of bolt and screw heads, or at the periphery of a flanged or circular headed bolt or screw, or on the flats or corners of the nut.

carbide precipitation "sensitization"—condition which affects some austenitic stainless steels which have been subjected to temperatures in the critical range, typically 800° to 1400°F. Complex chromium carbides precipitate and reside primarily at the grain boundaries, causing deterioration of its corrosion resistance by depleting its adjacent areas of chromium.

carbon boron steel—carbon steel in which boron has been intentionally added at a minimum of 0.0005 % and a maximum of 0.003 % in order to obtain an expected hardenability.

carbon steel—steel for which no minimum content is specified or required for chromium, molybdenum, nickel, or any other element added to obtain a desired alloying effect; or steel for which maximum content specified for manganese does not exceed 1.65 %. When specified, boron may be added to killed carbon steel with a maximum allowable of 0.003 %.

case hardening—a process which intentionally produces a surface hardness for a steel fastener that is harder than its core.

certificate of compliance—document or electronic record, signed by an authorized party, affirming that the supplier of the fastener or related service, or both, has met the requirements of the relevant specifications, contract, or regulation.

certificate of conformance—document or electronic record affirming that the fastener has met the requirements of the relevant specifications, contract, or regulation.

certification—procedure and action by a duly authorized body of determining, verifying, and attesting in writing to the qualifications of personnel, processes, procedures, or items in accordance with applicable requirements.

certified quality assurance system—system so designated officially by a recognized accrediting body as having met all of the criteria within a national or an international third party quality system standard.

chemical anchors—chemical materials that provide anchorage between a bolt or bar and a drilled hole.

check analysis—see *product analysis*.

clamp load—sometimes called preload or initial load. It is a tension on a bolt or screw, which results in equal and opposite forces which exist at the interface between two members generated through the cumulative effect of tightening one or more fasteners.

cold forged—formed by hammering or pressing with the material at or near ambient temperature.

cold forming—process of forming material below the recrystallization temperature by forcing or pressing metal into various dies.

cold heading quality material— material that has dimensional, chemical, and residual limits such that it will successfully form a given fastener geometry when machine-applied pressure produces a metal flow that results in the desired geometry. Additionally, subsequent treatment as necessary to achieve given mechanical properties results in a fastener with freedom from internal or external imperfections that would impair its intended use.

cold heading wire—wire produced by specially controlled manufacturing practices to provide satisfactory quality for heading, forging, and roll threading.

commingling—mixing of fasteners from different lots that are of the same grade and size in the same container.

common cause—common cause variation affects all the individual values of the process output being studied. In control chart analysis, it appears as part of the random process variation.

compressible-washer-type direct tension indicator—direct tension indicator having the capability of indicating the achievement of a required minimum bolt tension by the degree of its plastic deformation.

compression load—load which tends to compress or shorten the member. The value for compressive strength may depend upon the degree of distortion.

cone proof load—inch series— a calculated value derived from the formula

$$CPL = (1 - 0.30D) \times f \times A_s \quad (1)$$

where:

CPL = cone proof load (lbs),
D = nominal diameter of nut (in.),
f = specified proof stress of nut (psi), and
A_s = tensile stress area of nut (in.^{2}).

To meet the requirements of the cone proof load test, the nut shall support its specified cone proof load without stripping or rupture.

cone proof load—metric series—a calculated value derived from the formula

$$CPL = (1 - 0.012D)f \times A_s \times 0.001 \quad (2)$$

where:

CPL = cone proof load (kN),

D = nominal diameter of nut (mm),
f = specified proof stress of nut (MPa), and
A_s = tensile stress area of nut (mm^2).

To meet the requirements of the cone proof load test, the nut shall support its specified cone proof load without stripping or rupture.

cone proof load test—test performed using a conical washer and threaded mandrel to determine the influence of surface discontinuities (that is, forging cracks or seams) on the load-carrying capability of hardened steel nuts. The test includes a simultaneous dilation and stripping action of the nut.

conical washer—washer that has a crown height that flattens under load and is partially recovered following load removal.

consensus standard—widely available standard developed by ASTM, ASME, SAE, ISO, or any other standards-setting organization which has under its structure those parties which include users, producers, and other interested persons.

control limit—limits on a control chart which are used as criteria for signaling the need for action, or for judging whether a set of data does or does not indicate a state of statistical control. **E 456**

control plan—written description of a system for controlling fasteners and the processes used in their manufacture. Three distinct phases are used in a control plan, including prototype, pre-launch, and production.

corrosion resistance—ability of a fastener to resist corrosion under specified conditions.

crack—crystalline fracture passing through or along the grain boundaries which is normally caused by overstressing the metal during manufacturing, such as forging, forming, or heat treating.

cut thread—produced by removing material from the surface with a form cutting tool.

decarburization—loss of carbon from the surface layer of the fastener, normally associated with heat treatment.

gross decarburization—a complete decarburization characterized by a sufficient carbon loss to show only clearly defined ferrite grains.

partial decarburization—a loss of carbon sufficient to cause a lighter shade of tempered martensite than of the immediately adjacent base metal, but as being of insufficient carbon loss to show clearly defined ferrite grains.

defect—departure of a quality characteristic from its intended level or state (or the sum of departures of different quality characteristics) that occurs with a severity sufficient to cause a fastener not to satisfy intended normal, or reasonably foreseeable, usage requirements. The term *defect* is appropriate for use when a quality characteristic is evaluated in terms of its usage.

deoxidation—process of reducing the oxygen content from steel during the process of steel making, either by adding strong oxide forming elements, such as silicon or aluminum, or by the process of vacuum degassing to such a level that no oxidation of carbon or other elements takes place during solidification of steel.

destructive test—test to determine the properties of a material or the behavior of an item which results in the destruction of the sample or item.

detection process—past-oriented strategy of quality control that attempts to identify the nonconforming product after it has been produced, and then to separate it from the conforming product.

detection system—system which relies on final inspection as the primary means of controlling the quality of finished fasteners.

distributor—person or organization who purchases fasteners for the purpose of reselling them. A distributor may or may not alter the fasteners prior to resale. (Significant alterations and insignificant alterations are defined separately.)

drill-drive test—test in which a self-drilling screw is driven into and through a test plate, under specified test conditions, to determine drilling and thread forming performance characteristics of the screw.

drive test—test in which a tapping screw is driven into a test plate hole to determine thread forming or thread cutting performance characteristics.

drive torque—the maximum torque to install a screw prior to contact of the head of the fastener with the surface of the test plate.

ductility of externally threaded fasteners—ability of a fastener to deform before it fractures. Machined test specimens made from a fastener allow the measurement of elongation and reduction of area which are criteria used to evaluate the specimen. However, since yielding and fracture normally occur in the screw threads, these are impractical for the actual fastener. Hardness and the wedge tensile test are ductility indicators for the actual fastener. The lower the ratio of its specified minimum yield strength to its specified minimum tensile strength, the greater the fastener ductility.

dud—incomplete, mutilated, or foreign part.

effective case depth—perpendicular distance from the surface of a hardened case to the furthest point where a specified level of hardness is maintained.

elongation—increase in length of the gage length expressed as a percentage of the original gage length.

endurance limit—maximum stress below which a bolt or screw can presumably endure an infinite number of stress cycles.

end user—party that installs the mechanical fastener during assembly of a component or product.

environmental hydrogen embrittlement—can be "corrosion-assisted hydrogen embrittlement" caused by the liberation of hydrogen during the corrosion process, which is absorbed as atomic hydrogen, resulting in embrittlement under certain conditions of material strength and applied external stress. The end result is brittle failure. The hydrogen may also be absorbed from other external chemical sources.

extensometer—device for sensing the elongation of fastener material while it is subjected to tensile stress, for the purpose of

measuring linear deformation under controlled test conditions.

eye bolt—bolt having a head which is a closed or open ring which as a threaded shank and has a defined breaking strength, proof load, and tensile strength.

fastener—see *mechanical fastener* .

fastener electroplating—electro-deposition by electrolysis of an adherent metallic coating upon a fastener serving as an electrode. This coating may function as protective, decorative, or in a defined engineering function such as wearability or abrasive resistance.

fastener manufacturer—organization or firm that procures a raw material, fabricates it into a mechanical fastener, and processes it to have certain mechanical properties.

fastener quality—conformance of a fastener to its specification for dimensions, mechanical properties, performance requirements, and other requirements of a specification.

fastener specification—precise statement of a set of requirements to be satisfied by a fastener, its material, or its processing. It also indicates the procedure used to determine whether the requirements given are satisfied.

fastener standard—document which details the attributes of a finished fastener and includes such characteristics as geometry, material or chemistry, heat treatment, finish, lot size, and packaging.

fastener tensile stress area— assumed cross sectional area of a threaded fastener through the thread, which is used when computing the load a fastener can support in tension.

fastener testing—determination or verification that the fastener meets its specification requirements.

fatigue limit—see *endurance limit*.

fatigue strength—maximum stress on an externally threaded fastener which can be tolerated for a specified number of repeated cycles prior to failure.

fold—doubling over of metal which occurs during forging at or near the intersection of diameter changes which are found on the shoulders, heads, or shanks of bolts and screws, or on nuts at the intersection of diameter changes on the top face or on the bottom face.

forging cracks—occur during fastener manufacturing at the cutoff or forging operations and are located on the top of the head or on the raised periphery of indented head bolts and screws.

forming—primary operation in the fastener industry which includes heading, upsetting, extruding and forging.

fracture—the separation of a fastener or test specimen into two or more separate pieces in service or during testing.

brittle fracture—a separation accompanied by little or no macroscopic or microscopic plastic deformation. The fracture typically has a bright granular appearance with little or no necking apparent.

ductile fracture—a separation accompanied by tearing with appreciable gross plastic deformation.

full size specimen—tension test specimen consisting of a completed fastener for testing in the ready to use condition without altering the configuration.

grade identification symbols— inch series standardized symbols denoting the combination of the fastener's base material, its strength properties, its performance capabilities, and the engineering standard against which it was produced.

hardness—measure of a material's ability to resist abrasion or indentation, or both.

head-to-shank integrity—assurance that a headed fastener under load is able to meet its mechanical and performance requirements without failure at the junction of the head to shank.

heat analysis—chemical analysis of a given heat by the producer which determines the percentages of its elements.

heat control—the control by a manufacturer at any step in the processing of a fastener, which allows identification of the heat of material from which it is manufactured.

heat resistance—extent to which a material retains useful properties as measured during exposure of the material to a specified temperature and environment for a specified time.

hexavalent chromium—corrosion inhibitor often used in passivation and conversion coatings. It consists of chromium in the +6 (hexavalent) oxidation state.

high strength bolts—term which is used commercially to denote ASTM A 325 or A 490 bolts which are primarily used in construction applications.

high temperature bolts—bolts that are specifically manufactured of high temperature alloys to sustain tensile loads at temperatures between 500°F and 1800°F, depending upon the alloy and processing during manufacture.

high temperature fastener alloys— those alloys that will maintain their anticipated strength and characteristics within the high temperature range.

high temperature for mechanical fasteners — this term is generally understood to refer to a temperature range of approximately 500°F (260°C) to 1800°F (982°C).

hot dip galvanizing—immersion of fasteners in a bath of molten zinc for a controlled time period to obtain specified coating weight or thickness.

hot forged—formed by hammering or pressing of metal at a temperature which allows recrystallization to occur simultaneously with deformation, and avoids strain hardening.

hot forming—heat is applied to wire or rod to enhance metal flow into dies using machine applied pressures as opposed to metal removal by cutting for forming purposes.

hydrogen embrittlement, internal— see *internal hydrogen embrittlement*.

hydrogen embrittlement relief— process applied to fasteners which reduces or eliminates embrittlement caused by the absorption of hydrogen during processing. Normally, this is described as a baking operation.

impact strength—often referred to as impact energy; it is the amount of energy required to fracture a fastener, usually measured by either an Izod or Charpy test.

inch threaded Class 2A coating thickness—a coating thickness which does not exceed ⅛ of the allowance for Class 2A threads to avoid interference.

indentation hardness—resistance of a material to indentation. This is the usual type of hardness test in which a pointed or rounded indenter is pressed into a surface under a substantially static load.

in-process control—system that provides a method to detect the variation of product characteristic(s) during manufacturing and processing and initiates corrective action to maintain the product characteristic(s) within its specified limits.

in-process sampling inspection— random sample of product drawn from prescribed points of the processing stream (usually characteristic sensitive) and performing specific inspections and tests to determine conformance of the product at that point of the processing stream.

inspection—process of measuring, examining, testing, gaging, or using other procedures to ascertain the quality or state of, detect errors or defects in, or otherwise appraise materials, products, services, systems, or environments to a preestablished standard.

inspection plan—set of instructions defining product characteristics, specifications, or frequency of inspection, or a combination thereof, for product at a specified operation.

inspection test—fastener or its selected characteristics tested in process or after manufacture to determine conformance of the fastener or its selected characteristics to the manufacturing specifications.

inspection torque—torque necessary to maintain tightening motion in a fastener at its fully preloaded installed tension.

internal hydrogen embrittlement— embrittlement caused by residual hydrogen from fastener processing, such as cleaning, pickling, phosphating, or electroplating.

ladle analysis—see *heat analysis*.

liquid medium—liquid used to quench a steel fastener to achieve desired mechanical properties. The selection of the medium must be compatible with the basic material and geometry to avoid quench cracks.

local thickness—mean of the thickness measurements of which a specified number is made within a reference area.

locking ability—characteristic intentionally manufactured or added to a fastener to resist loosening.

lot—quantity of product of one part number that has been processed essentially under the same conditions from the same heat treatment lot and produced from one mill heat of material and submitted for inspection at one time.

lot sampling inspection—random sample drawn from a lot and performing specified inspections and tests to determine the acceptability of the lot.

low carbon martensite—as-quenched phase of low carbon steels, particularly to which Boron has been intentionally added to increase the hardenability of the material, and some stainless steels.

machine process capability study— study conducted to provide a level of confidence in the ability of a machine/process to meet engineering specification requirements.

machined specimen—test specimen machined from a full-size fastener to specific dimensions to standardize test results; often specified when a full-size fastener cannot be reasonably or practically tested.

macro-etch test—immersion of a prepared fastener specimen into a hot acid or aggressive media followed by examination of the etched surface. The examination is done with the unaided eye or at magnification not exceeding 10×.

macrograph—photographic reproduction of any object that has not been magnified more than ten times.

macroscopic—visible either with the naked eye or under low magnification (as great as about ten diameters).

macrostructure—structure of metal as revealed by macroscopic examination.

magnetic permeability—degree which a material becomes magnetically attractive.

manufacturer—see *fastener manufacturer* .

martensitic alloys—iron-chromium alloys with 12% to 17% chromium and sufficient carbon to permit strengthening by conventional heat treatment.

material lap—longitudinal surface discontinuity extending into rod, bar, or wire, caused by doubling over of metal during hot rolling.

material review—evaluation by a team of fastener experts to determine the fasteners's fitness for general use, fitness for intended use, or fitness for specified use.

material specification—proprietary or consensus standards document which defines the material, acceptable chemical limits, and other requirements used in fastener manufacturing.

material test report—written document or electronic record, signed by an authorized party, attesting that the raw material is in accordance with specified requirements, including the actual results of all required chemical analyses, tests, and examinations.