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A Guide for the Development of ASME B18 Standards for Mechanical Fasteners

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A GUIDE FOR THE DEVELOPMENT OF ASME B18 STANDARDS FOR MECHANICAL FASTENERS

1. Introductory Notes

1.1 Scope

This guide covers the elements for the complete development of B18 standards. It should be understood that only those elements applicable to the development of any given standard should be adopted. Clearly, not all may be reasonably applied to any given standard. The discussion of these elements is presented in the order they would normally appear in a given B18 standard and a template is included in Appendix A.

1.2 Comparison to ISO Standards

Where ISO standards exist, a detailed comparison to the ASME metric standard, including each geometric characteristic, material, range of size, and performance is suggested to facilitate specification by respective users. The detail of comparison should be included in an appendix while this paragraph in the standard identifies the ISO standards for comparative purposes and refers to the appendix for a detailed summary by applicable characteristic. A good example of this comparison may be found in Appendix IV of ASME B18.2.3.1M. Also, an example taken from B18.2.3.4M is included in Appendix B of this standard for illustrative purposes.

1.3 Dimensions

A statement indicating that: "unless otherwise specified, all dimensions are in inches" or that "all dimensions, unless otherwise specified, are in metric (mm)" should be included. It is recommended

that standards be written only in inch or only in metric (mm) and that dual dimensions be avoided. This is intended to provide a basis for possible global acceptance of purely metric documents. All dimensions shall apply before coating and this statement should be included to prevent confusion regarding any dimensional changes that may occur as a result of coating.

1.4 Options

This paragraph is intended to offer flexibility to the application of the standard. For example, where special materials, coatings, lubrication, or packaging may be needed by the purchaser, this provision should be included in the standard and specified by the purchaser on the purchase order.

1.5 Terminology

This paragraph is intended to reduce the verbiage in each standard and to focus on a single document, namely, ASME B18.12, to provide for consistency in definitions that may have formerly appeared in multiple standards with slight variations. Where terms are not defined in ASME B18.12, they are included and defined in this paragraph.

1.5.1 Terminology Referenced

For definitions of terminology not specifically defined in this standard, refer to ASME B18.12.

1.6 Referenced Standards

This paragraph is intended to identify all standards that are specified or referred to in a given stan-

dard by name, number, and publisher. It should also state that the latest edition of the listed standard is to be used, unless a specific date of issue is included in the list. Specific dates shall not be listed, unless a technical engineering reason has been established necessitating the citing of a specific issue.

1.6.1 Example of Referenced Standards

Standards that are called out should be listed by issuing source. The most current issue of the referenced standard is applicable, unless otherwise specified by the purchaser. Below is an example:

Example:

Referenced Standards

Unless otherwise specified, the standards referenced shall be the most recent at the time of order placement.

ASME B1.1, Unified Inch Screw Threads (UN and UNR Thread Form)

ASME B18.12, Glossary of Terms for Mechanical Fasteners

ASME B18.18.1, Inspection and Quality Assurance for General Purpose Fasteners

ASME B18.18.2, Inspection and Quality Assurance for High-Volume Machine Assembly Fasteners

ASME B18.24, Part Identifying Number (PIN) Code System for B18 Fastener Products

Publisher: The American Society of Mechanical Engineers (ASME International), Three Park Avenue, New York, NY 10016-5990; Order Department: 22 Law Drive, Box 2300, Fairfield, NJ 07007-2300

ASTM B21, Specification for Naval Brass, Rod, Bar, and Shapes

ASTM F1137, Specification for Phosphate/Oil and Phosphate/Organic Corrosion Protective Coatings for Fasteners

ASTM F1941, Specification for Electrodeposited Coatings on Threaded Fasteners [Unified Inch Screw Threads (UN/UNR)]

Publisher: American Society for Testing and Materials (ASTM), 100 Barr Harbor Drive, West Conshohocken, PA 19428

1.7 Related Standards

This may list standards and their sources that are not referred to in the given document but may cover similar or related products or tests. For example, a spring pin standard may list related standards for other pins such as clevis, cotter, or dowel pins. These would be listed in a similar way as shown in paragraph 1.6.1.

1.8 Part Identifying Number

This is a standard "boiler plate" paragraph to refer the specification user to ASME B18.24 and a recommended procedure to establish a part identification number (PIN) applicable to all B18 product standards, typically, paragraph 1.8:

For a Part Identifying Number, refer to ASME B18.24.

2. General Data

This paragraph provides for specification of geometry, materials and heat treatment, dimensional conformance, quality assurance, workmanship, gaging and acceptance procedures, marking requirements, and packaging. A review of the template included in Appendix A of this guide will help to identify, for a given product, which of the features should necessarily be included.

2.1 Heads

The intention of this paragraph is to describe and identify the head configuration and its dimensions and tolerances. A drawing is usually present and the dimensions are identified by letters which are included with a word description in tables together with stated dimensions and tolerances. These should be specific so that wrench or driver fit is assured. In those products such as pins or studs, which have no head configuration, this paragraph should not be applied. A list of seventeen head characteristics which may be included as appropriate in subparagraphs are listed in Appendix A. The following is an example of typical head characteristics:

Example:

2.1.1 Top of Head. *Top of head shall be full form and chamfered or rounded with the diameter of chamfer circle or start of rounding being equal to the maximum width across flats within a tolerance of minus 15%.*

2.1.2 Width Across Flats. *The width across flats of heads shall be the distance, measured perpendicular to the axis of product, overall between two opposite sides of the head.*

2.1.3 Head Taper. *Maximum width across flats shall not be exceeded. No transverse section through the head between 25% and 75% of actual head height, as measured from the bearing surface, shall be less than the minimum width across flats.*

2.1.4 Head Height. *The head height shall be that overall distance measured*

parallel to the axis of the product from the top of the head to the bearing surface and shall include the thickness of the washer face. Raised grade and manufacturer's identification are excluded from head height.

2.1.5 True Position of Head. *The axis of the head shall be located at true position with respect to the axis of the body (determined over a distance under the head equal to one diameter) within a tolerance zone having a diameter equivalent to 6% of the maximum width across flats at maximum material condition.*

2.2 Product Length

This paragraph would normally define the overall product length and tolerances, which are standard, and a procedure for measurement. Additionally, such lengths as the thread length (2.5), grip gaging length, body length, and transition thread length (2.6) are often included as subparagraphs to assist in selection and application.

Example:

The length of the screw shall be measured parallel to the axis of the screw from the plane of the bearing surface under the head to the plane of the flat of the point.

2.3 Threads

Most threads are specified by reference to ASME B1.1 or ASME B1.13M including a given pitch and a class of fit. Methods relating to acceptability are identified as a given system in ASME B1.3, and a separate paragraph (2.4) would be used to specify the thread acceptance system. The following is a typical paragraph for thread specification:

Example:

Threads shall be cut or rolled in accordance with ASME B1.1, Unified Coarse, Class 2A.

2.4 Thread Acceptance Gaging

Typically, this paragraph would specify thread dimensional acceptability in accordance with Gaging System 21 as specified in ASME B1.3 or ASME B1.3M for metric product. However, the user may have specified certain thread characteristics which will require a different acceptance procedure and this paragraph will usually state System 21, unless otherwise specified.

Example:

Unless otherwise specified by the purchaser, gaging for screw thread dimensional acceptability shall be in accordance with Gaging System 21 as specified in ASME B1.3M.

2.5 Thread Length

Thread length is controlled on many bolts by the so-called grip gaging length maximum. This paragraph will specify this, if applicable, and subparagraphs will specify the method or procedure for measurement. Certain small products, such as machine screws, may specify the thread length in terms of its approach to the bearing surface of the head by the number of thread pitches.

Example:

2.5.1 Machine Screws. *Machine screws shall have thread lengths conforming to the following: On screws threaded full length, the distance to first full form thread shall be measured, parallel to the axis of screw, from*

the bearing surface of the head to the face of a nonchamfered or noncounterbored standard 3A GO thread ring gage assembled by hand as far as the thread will permit.

(a) Sizes No. 5 and Smaller. *Screws of nominal lengths equal to three diameters and shorter shall have full form threads extending to within one pitch (thread) of the bearing surface of the head, or closer, if practicable. Nominal lengths greater than three diameters, up to and including 1-1/8 in., shall have full form threads extending to within two pitches (threads) of the bearing surface of the head, or closer, if practicable. Screws of longer nominal lengths shall, unless otherwise specified, have a minimum length of full form thread of 1 in.*

(b) Sizes No. 6 and Larger. *Screws of nominal lengths equal to three diameters and shorter shall have full form threads extending to within one pitch (thread) of the bearing surface of the head, or closer, if practicable. Nominal lengths greater than three diameters, up to and including 2 in., shall have full form threads extending to within two pitches (threads) of the bearing surface of the head, or closer, if practicable. Screws of longer nominal lengths shall, unless otherwise specified, have a minimum length of full form thread of 1.50 in.*

2.5.2 Body Length

Body length is the distance, as measured parallel to the axis of the fastener, from the underside of the head to the last scratch of thread or top of the extrusion angle.

2.5.3 Grip Gaging Length

This is the distance as measured parallel to the axis of the fastener from the underside of the

head bearing surface to the face of a noncounter-bored or noncountersunk standard Go thread ring gage which has been assembled by hand as far as the thread will permit.

2.6 Transition Thread Length

A dimension commonly expressed as a reference dimension which accounts for the length of incomplete threads, extrusion angle for rolled threads, and the tolerances on the grip length. It is recommended that both a rolled and cut thread representation be present for each threaded product as may be applicable. Often, the transition thread length may be expressed as the number of pitches for a given thread.

2.7 Point

All screws have a point to facilitate starting or to apply pressure (compression). Such points are called out as flat, oval, cup, cone, or half dog. In other cases, points are described as chamfered or rounded from a given diameter below the minor thread diameter, and having a length which is a multiple of the thread pitch. The length of the point measured to the first full formed thread at the major diameter may be specified in the dimensional table for a given screw. Rivets and pins may have sheared ends or may be crowned or chamfered as specified in the applicable product standard. Point features not defined in a given product standard are at the discretion of the manufacturer.

2.8 Body Diameter

This is generally the unthreaded portion of a shank whose diameter is the maximum or minimum limit or the basic size with plus and minus tolerances applied. It is often used to "account" for any swell, fin, or die seam under the head from manufacture.

2.8.1 Reduced Diameter Body

These have a body diameter not less than the minimum pitch diameter, and not exceeding the specified minimum full size diameter body.

2.9 True Position of Tapped Hole

The axis of a tapped hole in the nut is located at true position with respect to the axis of the nut body within a tolerance zone having a diameter equal to a given percentage of the the maximum width across flats.

2.10 Nut Thickness

The nut thickness is the overall distance measured parallel to the axis of the nut, from the top of the nut to the bearing surface. This includes the thickness of the washer face where provided. Raised markings are not included in nut thickness.

2.11 Prongs

Cotter pins have a preferred point extended prong having a square or hammered lock design unless otherwise specified.

2.12 Taper

Taper pins provide for a taper on the diameter based on a unit of length and for a given tolerance.

2.13 Straightness

A rail gage or a sleeve gage is used to assure shank straightness or camber limitations included within respective product standards. At maximum material condition, maximum camber per unit length is generally specified for given product lengths.

2.14 Finishes

Dimensions for products and dimensional characteristics are usually specified for plain finish. If a coating is specified, it should be in accordance with a class or condition specified in an applicable standard such as an ASTM standard.

2.15 Workmanship

A clause which assures that a product will be visually free of irregularities that would impact its fit, form, or function.

2.16 Designation

This provides a standard method for call out in communications.

Example:

Product name, ASME dimensional standard, diameter-pitch, length, mechanical or performance standard, finish type and thickness including applicable standard.

Examples:

Heavy hex nut, ASME B18.2.6, Unified 1/2-13, ASTM A563 Grade C, Plain Finish

Hex cap screw, ASME B18.2.1, Unified 3/8-16 x 4, ASTM A354 Grade BD, type Fe/Zn-5A, ASTM F1941

Metric hex cap screws, ASME B18.2.3.1M, M16 x 2 x 100, ASTM F568M Class 10.9, Plain Finish

Metric hex nuts Style 2, ASME B18.2.4.2M, M10 x 1.5, ASTM A563M Class 9, Plain Finish

2.17 Grade or Property Class Symbol

These marks are mandated by the applicable material and performance specification such as those found in ASTM or SAE. Inch series products are generally related to Grades 2, 5, and 8; while metric series products are related to property classes ranging from 4.6 to 12.9. A typical callout is as follows:

Example:

Each bolt shall be marked in accordance with the requirements of ASTM A449.

2.18 Manufacturer's or Source Symbol

These marks are mandated by the standards that specify material, mechanical, and performance requirements. For fasteners subject to the Fastener Quality Act requirements, the marks used are to be fully traceable and registered by the manufacturer with the U.S. Patent and Trademark Office. This registration is required by the Fastener Quality Act.

2.19 Inspection and Quality Assurance

ASME has seven quality assurance documents (ASME B18.18.1 thru B18.18.7) for mechanical fasteners. ASTM has a document (ASTM F1470) to determine sample sizes for mechanical properties using detection or prevention techniques. The standard should be called out in this paragraph, which is the most basic for the given product, with the option for alternative specification left to the purchaser.

Example:

Unless otherwise specified, products shall be furnished in accordance with ASME B18.18.2.

2.20 Designated Dimensional Conformance

This paragraph is intended to designate the characteristics and inspection level established by the technical committee. These are characteristics that have significant impact on the fit, form, and function of the product, should they be found to be non-conforming.

2.20.1 Dimensional Conformance Example

Socket button head cap screws shall have the following designated characteristics inspected to ASME B18.18.2 to the inspection levels shown:

<u>Characteristic</u>	<u>Inspection Level</u>
Threads	C
Head Diameter	C
Socket Size (gaged)	C
Length	C
Fillet Transition Diameter	C

2.21 Materials and Heat Treatment

Requirements are usually found in the appropriate ASTM, IFI, or SAE standard.

2.21.1 Steel. Carbon and alloy steel requirements are defined in such standards as ASTM A307 - *Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength*, ASTM A449 - *Quench and Tempered Steel Bolts and Studs*, and ASTM A563 - *Carbon and Alloy Steel Nuts*, ASTM A563M - *Carbon and Alloy Steel Metric Nuts*, and ASTM F568M - *Carbon and Alloy Steel Externally Threaded Fasteners*.

2.21.2 Corrosion Resistant. A term used to describe a characteristic of the basic material or coating found in or on a fastener. Such standards as ASTM F593 - *Stainless Steel Bolts, Hex Cap Screws and Studs* and ASTM F594 - *Stainless*

Steel Nuts, ASTM F738M - *Stainless Steel Metric Bolts, Screws and Studs*, and ASTM F836M - *Stainless Steel Metric Nuts* define basic material and processing requirements.

2.21.3 Nonferrous. Includes materials such as brass, titanium, copper, nickel, or aluminum which, with various alloys, are defined in such standards as ASTM F468 - *Nonferrous Bolts, Hex Cap Screws, and Studs for General Use* or ASTM F468M - *Nonferrous Bolts, Hex Cap Screws, and Studs for General Use (Metric)*.

2.21.4 Total Case Depth. Is a distance measured perpendicularly from the surface of a hardened case to a point where differences in chemical or physical properties of the case and core can no longer be distinguished. SAE J423, ASTM F2328, ASTM F2328M, or SAE J121M specify a method to accurately measure the case depth.

2.21.5 Surface Hardness. The method to measure surface hardness involves the use of an indenter. For routine checks, a Knoop or pyramid indenter may be used. The referee method involves one of these indenters and a given load. See paragraph 3.4 *Surface Hardness after Tempering* of SAE J933.

2.21.6 Core Hardness. This requires cutting a transverse section through the thread of a bolt, screw, or stud at a distance one diameter from the point or end of the product. Four readings at 90 degree increments are averaged to establish a value. ASTM F606, ASTM F606M, and SAE J1237 describe a procedure for this measurement.

2.21.7 Microstructure. This examination involves a microscopic look at the metal structure of a polished and etched specimen using magnifications in excess of 10x. Such structures are pictured in the appendix of SAE J78, *Self-Drilling Tapping Screws*.

3. Performance Requirements and Tests

A given B18 standard may specify mechanical or performance characteristics for a product. Additionally, the standard may specify a test procedure to establish that a given fastener meets the applicable mechanical or performance requirements. A listing of the mechanical and performance characteristics generally included in some B18 standards is shown in Appendix A.

3.1 Tensile Strength

This is a requirement, usually stated as a minimum, to which a product is processed to meet. Often, for carbon and alloy steel product, it is broadly referred to as property class or strength grade. The exceptions to this rule are found in ASTM A307 and ASTM A490. Both specify a maximum tensile strength in addition to the specified minimum.

3.2 Proof Load

Is usually stated to be an absolute value that a product must meet without dimensional change or thread deformation. It is this value that is used with a factor of safety for design purposes.

3.3 Ductility Test

A test that is used to assure the integrity of the head to shank junction. It is usually done by

applying a load to the head of a screw or bolt by reaching a specified angle between the plane of the head bearing surface and the shank without head separation.

3.4 Drive Test

Used to establish that the threads of a screw will, without deformation of its threads, form mating threads in a specified test plate at given rotational speeds.

3.5 Torsional Test

In a specified test device, a screw is suitably torqued to failure. The failure torque should meet a given minimum requirement based on thread form.

3.6 Hardness

Values may be required at the core, surface, or at the total case depth depending upon the specification requirement. These may be related to tensile strength in screws that are too short to adequately tensile test.

3.7 Hydrogen Embrittlement

Products with high hardness and electroplated fasteners often require testing for this failure mode. This paragraph should specify applicable tests and steps to be followed in processing to reduce potential failure.

APPENDIX A STANDARDS TEMPLATE

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NONMANDATORY APPENDIX B COMPARISON WITH ISO STANDARDS

(This Appendix is not an integral part of ASME B18.2.3.4M-2001 and is included for information purposes only.)

This Appendix describes the technical differences between ASME B18.2.3.4M-2001 and ISO 4162: 1990, its draft revision, ISO/DIS 4162.2: 1998, and related ISO standards.

A1 PRODUCT NAMES *BOLT* AND *SCREW*

Of the products named *hex flange screw* per ASME B18.2.3.4M, those that are threaded full length would be named *hexagon screw with flange* per ISO 1891, but those that are not threaded full length are named *hexagon flange bolt* per ISO 4162: 1990, and *hexagon bolt with flange* per ISO 1891 and ISO/DIS 4162.2: 1998.

A2 HEAD HEIGHT AND WRENCHING HEIGHT

ASME B18.2.3.4M Table 5 specifies maximum head heights for M6, M12, and M16, and minimum wrenching height for M16, in agreement with ISO/DIS 4162.2: 1998, which are increased from those specified in ISO 4162: 1990.

A3 MAXIMUM WIDTH ACROSS CORNERS

ASME B18.2.3.4M, Table 5 maximum width across corners is not specified in ISO 4162. Instead, ISO/DIS 4759-1: May 1998 would control the shape of the hexagon by zero positional tolerance at maximum material condition, which is not specified in ASME B18.2.3.4M.

A4 GAGING OF HEX FLANGE HEAD

ISO/DIS 4162.2 would specify a gage C for gaging flange thickness, which is not included in ASME B18.2.3.4M.

A5 POSITION OF HEAD

ASME B18.2.3.4M, para. 11 and Table 2 specify positional tolerance at maximum material condition, as in ISO/DIS 4759-1: May 1998, instead of regardless of feature size, as in ISO 4759/I-1978. ISO/DIS 4759-1: May 1998 also specifies position of the flange diameter with respect to the shank, which is not specified in ASME B18.2.3.4M.

A6 BEARING SURFACE

ASME B18.2.3.4M, para. 13 and Table 5 specify bearing surface concavity of 0.75 ± 0.50 deg, as in ISO/DIS 4162.2: 1998, which is a draft revision. ISO 4162: 1990 specifies 0 to 1 degrees 30 minimum (0.75 ± 0.75 degrees). ISO/DIS 4759-1: May 1998 specifies straightness of radial lines on the bearing surface, which is not specified in ASME B18.2.3.4M. ASME B18.2.3.4M, Table 2 values for circular runout of the bearing circle are greater than those in ISO 4759/I-1978 or ISO/DIS 4759-1: May 1998.

A7 FILLETS

ASME B18.2.3.4M, Table 3 minimum fillet transition diameters and shorter maximum fillet lengths for screws threaded full length are not specified in ISO 4162. For Type U fillet, the radius of the fillet extension, r_4 reference in ISO 4162, is not specified in ASME B18.2.3.4M.

A8 BODY DIAMETER FOR SCREWS THREADED FULL LENGTH

ASME B18.2.3.4M, Tables 3 and 4 minimum diameters of unthreaded shank for screws threaded full length are not specified in ISO 4162.

A9 REDUCED DIAMETER BODY

ASME B18.2.3.4M, Table 6 maximum and minimum diameters of reduced body differ from ISO 4162 " d_2 is approximately equal to the pitch diameter (rolling diameter)." The limits specified in ASME B18.2.3.4M Table 6 were proposed to ISO/TC2/WG2 in May 1995, but ISO/TC2/WG2 was not willing to specify limits for the rolling diameter.

A10 POINT

ASME B18.2.3.4M, para. 17 and Table 5 optional rounded point is not in ISO 4162, but Table 8 agrees with ISO 4753.

A11 STRAIGHTNESS

ASME B18.2.3.4M specifies straightness at maximum material condition, as in ISO/DIS 4759-1: May 1998, instead of regardless of feature size, as in ISO 4759/I-1978. The formula in ASME B18.2.3.4M results in straightness tolerance zone diameters that are smaller for lengths 12 mm and shorter, and larger for lengths 16 mm and longer, than those in ISO 4759/I-1978 or ISO/DIS 4759-1: May 1998.

**A12 GRIP LENGTH FOR SCREWS
THREADED FULL LENGTH**

ASME B18.2.3.4M, Table 10 maximum unthreaded lengths under the head of screws shorter than 2D differ from ISO 3508.

A13 TRANSITION THREADS

ASME B18.2.3.4M, para. 20.4 specification on root contour of transition threads is not in ISO 4162.

A14 POSITION OF BODY-TO-THREAD

Coaxiality or position of the body with respect to the thread, specified in ISO 4759/I or ISO/DIS 4759-1, is not specified in ASME B18.2.3.4M.

A15 MARKING

ASME B18.2.3.4M, para. 22 allows markings on the top of the flange but not on the side of the head, as alternatives to markings on the top of the head, while ISO 898-1 allows markings on the side of the head but not on the top of the flange. ASME B18.2.3.4M, para. 22 dimensions of head markings are not specified in ISO 4162 or ISO 898-1.

A16 INSPECTION AND QUALITY ASSURANCE

ASME B18.2.3.4M, paras. 25 and 26 inspection and quality assurance provisions differ from those in ISO 4162.