Designation: A 490M – 93
METRIC

AMERICAN SOCIETY FOR TESTING AND MATERIALS
100 Barr Harbor Dr., West Conshohocken, PA 19428
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Standard Specification for High-Strength Steel Bolts, Classes 10.9 and 10.9.3, for Structural Steel Joints [Metric][1]

This standard is issued under the fixed designation A 490M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 This specification covers the chemical and mechanical requirements of quenched and tempered steel bolts, in nominal thread diameters M16 to M36, inch. These bolts are intended for use in structural joints that are comparable to those made under the Specification for Structural Joints Using ASTM A 325 or A 490 Bolts[2] issued by the Research Council on Structural Connections of the Engineering Foundation. The various types of bolts covered by this specification are:

1.1.1 *Type 1*—Bolts made of alloy steel, supplied in nominal thread diameters M16 to M36, inclusive.

1.1.2 *Type 2*—Bolts made from what is generally described as low-carbon martensite steel, supplied in nominal thread diameters M16 to M24 inclusive.

1.1.3 *Type 3*—Bolts in nominal thread diameters M16 to M36 , inclusive, having atmospheric corrosion resistance and weathering characteristics comparable to that of the steels covered in Specifications A 588/A 588M, A 242/A 242M, and A 709/A 709M. The atmospheric corrosion resistance of these steels is substantially better than that of carbon steel with or without copper addition. See 6.3. When properly exposed to the atmosphere, these steels can be used bare (uncoated) for many applications.

1.2 Unless otherwise specified, all nuts used on these bolts shall conform to the requirements of Specification A 563M, shall be heavy hex, and shall be of the class and surface finish for each type of bolt as follows:

Bolt Type and Finish	Nut Class and Finish
1 and 2, plain (noncoated)	10S, 1053, plain
3, plain	10S3, plain

1.3 Unless otherwise specified, all washers used on these bolts shall conform to the requirements of Specification F 436M and shall be of a surface finish for each type of bolt as follows:

Bolt Type and Finish	Washer Finish
1 and 2, plain (uncoated)	plain (uncoated)
3, plain	weathering steel, plain

1.4 This specification provides that heavy hex structural bolts and heavy hex nuts shall be furnished unless other dimensional requirements are stipulated in the purchase inquiry and order.

NOTE 1—For quenched and tempered steel bolts, studs, and other externally threaded fasteners with nominal thread diameters larger than M36, but with similar mechanical properties, refer to class 10.9 of Specification F 568.

NOTE 2—This specification is the metric companion of Specification A 490.

2. Referenced Documents

2.1 *ASTM Standards:*

A 242/A242M Specification for High-Strength Low-Alloy Structural Steel[3]

A 563M Specification for Carbon and Alloy Steel Nuts [Metric][4]

A 588/A588M Specification for High-Strength Low-Alloy Structural Steel with 50 ksi [345 MPa] Minimum Yield Point to 4 in. [100 mm] Thick[3]

A 709/A709M Specification for Structural Steel for Bridges[3]

D 3951 Practice for Commercial Packaging[5]

E 138 Method for Wet Magnetic Particle Inspection[6]

E 709 Guide for Magnetic Particle Examination[7]

F 436M Specification for Hardened Steel Washers [Metric][8]

F 568 Specification for Carbon and Alloy Steel Externally Threaded Metric Fasteners[8]

F 606 Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners,

[1] This specification is under the jurisdiction of ASTM Committee F-16 on Fasteners and is the direct responsibility of Subcommittee F16.02 on Steel Bolts, Nuts, Rivets, and Washers.

Current edition approved Feb. 15, 1993. Published April 1993. Originally published as A 490M – 82. Last previous edition A 490M – 92a.

[2] Published by the American Institute of Steel Construction, 400 N. Michigan Ave., Chicago, IL 60611.

[3] *Annual Book of ASTM Standards*, Vol 01.04.

[4] *Annual Book of ASTM Standards*, Vols 01.01 and 15.08.

[5] *Annual Book of ASTM Standards*, Vol 15.09.

[6] Discontinued; see 1980 *Annual Book of ASTM Standards*, Part II.

[7] *Annual Book of ASTM Standards*, Vol 03.03.

[8] *Annual Book of ASTM Standards*, Vol 15.08.

Washers, and Rivets[8]
F 788/F788M Specification for Surface Discontinuities of Bolts, Screws, and Studs, Inch and Metric Series[8]
G 101 Guide for Estimating the Atmospheric Corrosion Resistance of Low-Alloy Steels[9]
2.2 *ANSI Standards:*[10]
B1.13M Metric Screw Threads
B18.2.3.7M Metric Heavy Hex Structural Bolts
2.3 *Military Standard:*[11]
MIL-STD-105 Sampling Procedure and Tables for Inspection by Attributes

3. Terminology

3.1 *Definitions:*

3.1.1 Surface discontinuities as covered by this specification are defined as follows:

3.1.2 *acceptable quality level (AQL)*—as defined in MIL-STD-105, the maximum percent defective that, for purposes of sampling inspection, can be considered satisfactory as the process average.

3.1.3 *burst*—a break located at the periphery of the bolt head.

3.1.4 *crack*—a clean crystalline break passing through the grain boundary without inclusion of foreign elements.

3.1.5 *process average*—as defined in MIL-STD-105, the average percent defective of product at the time of original inspection. Original inspection is that first inspection of a particular quantity of product which is being reinspected after rejection and reconditioning.

3.1.6 *seam or lap*—a noncrystalline break through the metal which is inherent in the raw material.

4. Ordering Information

4.1 Orders for products under this specification shall include the following:

4.1.1 Quantity (number of pieces of bolts and accessories),

4.1.2 Name of products, including accessories such as nuts and washers when desired,

4.1.3 Dimensions, including nominal bolt diameter, thread pitch, and length. For bolts of dimensional requirements other than heavy hex structural bolts (see section 1.4) it is normally necessary to specify grip length,

4.1.4 Type of bolt (that is, Type 1, 2, or 3).

4.1.4.1 When the bolt type is not specified Type 1, 2 or 3 bolts may be supplied by the manufacturer.

4.1.4.2 When atmospheric corrosion resistance and weathering characteristics are required, Type 3 bolts should be specified by the purchaser.

4.1.5 ASTM designation and date of issue,

4.1.6 Whether proof load tests are required,

4.1.7 Specify if test reports are required, and

4.1.8 Any special requirements.

NOTE 3—Two examples of ordering descriptions follow: (*1*) 1000 pieces, heavy hex structural bolts, each with two hardened washers, ASTM F 436M, and one heavy hex nut, ASTM A 563M class 10S, M24 × 3 × 100, ASTM A 490M dated_____. (*2*) 1000 pieces, heavy hex structural bolts, no nuts or washers, M20 × 2.5 × 60, Type 1, ASTM A 490M dated_____.

5. Materials and Manufacture

5.1 Steel for bolts, and the heading, threading, and heat treatment of bolts shall be in accordance with requirements specified for classes 10.9 and 10.9.3 bolts in Specification F 568.

6. Chemical Composition

6.1 Type 1 bolts shall conform to the chemical composition requirements specified for alloy steel class 10.9 bolts in Specification F 568. The steel shall contain sufficient alloying elements to qualify it as an alloy steel.

NOTE 4—Steel is considered to be alloy, by the American Iron and Steel Institute, when the maximum of the range given for the content of alloying elements exceeds one or more of the following limits: manganese, 1.65 %; silicon, 0.60 %; copper, 0.60 %; or in which a definite range or a definite minimum quantity of any of the following elements is specified or required within the limits of the recognized field of constructional alloy steels: aluminum, chromium up to 3.99 %, cobalt, columbium, molybdenum, nickel, titanium, tungsten, vanadium, zirconium, or any other alloying elements added to obtain a desired alloying effect.

6.2 Type 2 bolts shall conform to the chemical composition requirements specified for low carbon martensite steel class 10.9 bolts in Specification F 568.

6.3 Type 3 bolts shall conform to the chemical composition requirements specified for class 10.9.3 bolts in Specification F 568. See Guide G 101 for methods of estimating the atmospheric corrosion resistance of low alloy steels.

6.4 Product analyses may be made by the purchaser from finished material representing each lot of bolts. The chemical composition thus determined shall conform to the requirements given in Tables 1 or 2 of Specification F 568, as applicable.

7. Mechanical Requirements

7.1 Bolts shall meet the mechanical requirements specified for classes 10.9 and 10.9.3 bolts in Specification F 568. In addition, bolts shall not have a tensile strength greater than 1200 MPa.

NOTE 5—For information purposes only, the mechanical properties of bolts are given in Appendix X1.

7.2 For bolts on which hardness and tension tests are performed, acceptance based on tensile requirements shall take precedence in case of controversy over low or high hardness readings.

8. Dimensions

8.1 Unless otherwise specified, bolts shall conform to the dimensions for heavy hex structural bolts specified in ANSI B 18.2.3.7M.

8.2 Threads shall be the metric coarse thread series as specified in ANSI B 1.13M, and shall have class 6g tolerances.

9. Workmanship

9.1 Surface discontinuity limits shall be in accordance with Specification F 788/F 788M.

[9] *Annual Book of ASTM Standards*, Vol 03.02.

[10] Available from American National Standards Institute, 11 West 42nd St., 13th Floor, New York, NY 10036.

[11] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

10. Quality Assurance of Mechanical Requirements

10.1 The manufacturer shall make sample inspections of every lot of bolts to ensure that properties of bolts are in conformance with the requirements of this specification. All bolts shall be inspected tested prior to shipment in accordance with one of the two quality assurance procedures described in 10.3 and 10.4, respectively. The manufacturer shall have the option of which procedure will be followed when furnishing bolts to any single purchase order.

10.2 The purpose of a lot inspection testing program is to ensure that each lot conforms to the requirements of this specification. For such a plan to be fully effective, it is essential that following delivery the purchaser continue to maintain the identification and integrity of each lot until the product is installed in its service application.

10.3 *Production Lot Method*:

10.3.1 All bolts shall be processed in accordance with a lot-identification-control quality assurance plan. The manufacturer shall identify and maintain the integrity of each production lot of bolts from raw-material selection through all processing operations and treatments to final packing and shipment. Each lot shall be assigned its own lot-identification number, each lot shall be tested, and the inspection test reports for each lot shall be retained.

10.3.2 A production lot, for purposes of assigning an identification number and from which test samples shall be selected, shall consist of all bolts processed essentially together through all operations to the shipping container that are of the same nominal diameter, the same nominal length, and produced from the same mill heat of steel.

10.3.3 The manufacturer shall make tests for tensile strength (wedge test) and hardness of each lot of bolts. Alternatively, in accordance with 7.1, tests may be tensile strength, yield strength, reduction of area, elongation, and hardness.

10.3.4 From each production lot, the minimum number of tests of each required property shall be as follows:

Number of Pieces in Production Lot	Number of Specimens
800 and less	1
801 to 8 000	2
8 001 to 35 000	3
35 001 to 150 000	8
150 001 and over	13

10.3.5 If any test specimen shows defective machining, it may be discarded and another specimen substituted.

10.3.6 Bolts shall be packed in shipping containers as soon as practicable following final processing. Shipping containers shall be marked with the lot identification number.

10.3.7 A copy of the inspection test report for each production lot from which bolts are supplied to fill the requirements of a shipment shall be furnished to the purchaser when specified in the order. Individual heats of steel need not be identified on the test report.

10.4 *Shipping Lot Method*:

10.4.1 In-process inspection during all manufacturing operations and treatments and storage of manufactured bolts shall be in accordance with the practices of the individual manufacturer.

10.4.2 Before packing bolts for shipment, the manufacturer shall make tests of sample bolts taken at random from each shipping lot. A shipping lot, for purposes of selecting test samples, is defined as that quantity of bolts of the same nominal diameter and same nominal length necessary to fill the requirements of a single purchase order.

10.4.3 The manufacturer shall make tests for tensile strength (wedge test), and hardness of each lot of bolts, including proof load tests when specified on the order. Alternatively, in accordance with 7.1 tests may be tensile strength, yield strength, reduction of area, elongation, and hardness.

10.4.4 From each shipping lot, the minimum number of tests of each required property shall be as follows:

Number of Pieces in Shipping Lot	Number of Specimens
150 and less	1
151 to 280	2
281 to 500	3
501 to 1 200	5
1 201 to 3 200	8
3 201 to 10 000	13
10 001 and over	20

10.4.5 If any test specimen shows defective machining, it may be discarded and another specimen substituted.

10.4.6 A copy of the inspection test report for each shipping lot shall be furnished to the purchaser when specified in the order. Individual heats of steel are not identified in the finished product.

11. Test Methods

11.1 Tests shall be conducted in accordance with Test Methods F 606.

12. Magnetic Particle and Visual Inspection for Surface Discontinuities

12.1 Bolts shall be examined by magnetic particle inspection for longitudinal discontinuities and transverse cracks, and shall conform to an AQL of 0.25 when inspected in accordance with the sampling plan described in 12.4. Eddy-current inspection may be substituted, at the option of the manufacturer, for the 100 % magnetic particle inspection specified in 12.4.1 and 12.4.2, provided that the bolts, after eddy current inspection, are subsequently randomly sampled according to Table 1 and subjected to the magnetic particle inspection and acceptance requirements as described above. In the case of dispute, the magnetic particle test shall govern.

12.2 Bolts shall be examined visually for bursts and shall meet an AQL of 2.5 when inspected in accordance with the sampling plan described in 12.5.

12.3 A lot, for purposes of selecting a sample for magnetic particle or visual inspection, shall consist of all bolts of one type, having the same nominal diameter and length offered for inspection at one time. No lot shall contain more than 10 000 pieces.

12.4 *Longitudinal Discontinuities and Transverse Cracks*:

12.4.1 From each lot of bolts a representative sample shall be picked at random and magnetic particle inspected for

TABLE 1 Sample Sizes and Acceptance Numbers for Inspection of Longitudinal Discontinuities, Transverse Cracks, and Bursts

Lot Size	0.25 AQL			2.5 AQL		
	Sample Size[A,B]	Acceptance Number	Rejection Number	Sample Size[A,B]	Acceptance Number[B]	Rejection Number
1 to 150	50	0	1	5	0	1
151 to 500	50	0	1	20	1	2
501 to 1 200	50	0	1	32	2	3
1 201 to 3 200	50	0	1	50	3	4
3 201 to 10 000	50	0	1	80	5	6

[A]Sample sizes, acceptance numbers, and rejection numbers are extracted from "Single Sampling Plan for Normal Inspection" Table IIA.MIL-STD-105.
[B]Inspect all bolts in the lot if lot size is less than sample size.

longitudinal discontinuities and transverse cracks in accordance with Guide E 709. (See Note 5). The sample size shall be as specified for an AQL of 0.25 in Table 1. If any defectives are found during inspection by the manufacturer all bolts in the lot shall be magnetic particle inspected and all defectives shall be removed and destroyed. If any defectives are found during inspection by the purchaser the lot shall be subject to rejection.

NOTE 6—Magnetic particle inspection may be conducted in accordance with Method E 138. For referee purposes Guide E 709 shall be used.

12.4.2 Any bolt with a longitudinal discontinuity (located parallel to the axis of the bolt in the threads, body, fillet, or underside of head), with a depth normal to the surface greater than 0.03 *D*, where *D* is the nominal bolt diameter in millimetres, shall be considered defective. In addition, any bolt with a transverse crack (located perpendicular to the axis of the bolt in the threads, body, fillet, or underside of head), shall be considered defective.

NOTE 7—Magnetic particle indications of themselves shall not be cause for rejection. If in the opinion of the inspector the indications may be cause for rejection, a representative sample shall be taken from those bolts showing indications and shall be further examined by microscopical examination to determine whether the indicated discontinuities are in accordance with the specific limits.

12.5 *Bursts*:

12.5.1 From each lot of bolts a representative sample shall be picked at random and visually inspected for bursts. The sample size shall be as specified for an AQL of 2.5 in Table 1. If the number of defectives found during inspection by the manufacturer is greater than the acceptance number given in Table 1 for the sample size, all bolts in the lot shall be visually inspected and all defectives shall be removed and destroyed. If the number of defectives found during inspection by the purchaser is greater than the acceptance number given in Table 1 for the sample size, the lot shall be subject to rejection.

12.5.2 Any bolt with a burst in the flat of the head which extends into the top crown surface (chamfer circle) or the under-head bearing surface shall be considered defective. In addition, bursts occurring at the intersection of two wrenching flats shall not reduce the width across corners below the specified minimum.

13. Inspection

13.1 If the inspection described in 13.2 is required by the purchaser, it shall be specified in the inquiry and contract or order.

13.2 The inspector representing the purchaser shall have free entry to all parts of the manufacturer's works that concern the manufacture of the material ordered. The manufacturer shall afford the inspector all reasonable facilities, to satisfy him that the material is being furnished in accordance with this specification. All tests and inspections required by the specification that are requested by the purchaser's representative shall be made before shipment, and shall be conducted as not to interfere unnecessarily with the operation of the works.

14. Certification

14.1 When specified on the order the manufacturer shall furnish the test reports described in 10.3.7 or 10.4.6, depending on whether the bolts are furnished by the production lot or shipping lot method.

15. Responsibility

15.1 The party responsible for the fastener shall be the organization that supplies the fastener to the purchaser and certifies that the fastener was manufactured, sampled, tested and inspected in accordance with this specification and meets all of its requirements.

16. Product Marking

16.1 Bolt heads shall be marked A 490M, and shall also be marked to identify the manufacturer or private label distributor, as appropriate.

16.2 In addition to the markings required in 16.1, Type 1 bolts shall be marked 10S; Type 2 bolts shall be marked 10S with this marking underlined; and Type 3 bolts shall be marked 10S3.

16.3 At the manufacturer's option, Type 3 bolts may have additional distinguishing marks to indicate the bolt is atmospheric corrosion resistant and of a weathering type.

16.4 All markings shall be located on the top of the bolt head with the base of the property class numerals positioned toward the closest periphery of the head. Markings may be either raised or depressed at the option of the manufacturer.

16.5 Type and manufacturer's or private label distributor's identification shall be separate and distinct. The two identifications shall preferably be in different locations and, when on the same level, shall be separated by at least two spaces.

17. Packaging and Package Marking

17.1 *Packaging*:

17.1.1 Unless otherwise specified, packaging shall be in accordance with Practice D 3951.

17.1.2 When special packaging requirements are required, they shall be defined at the time of the inquiry and order.

17.2 *Package Marking*:

17.2.1 Each shipping unit shall include or be plainly marked with the following information:

17.2.1.1 ASTM designation and type,

17.2.1.2 Size,

17.2.1.3 Name and brand or trademark of the manufacturer,

17.2.1.4 Number of pieces,

17.2.1.5 Lot number,

17.2.1.6 Purchase order number, and

17.2.1.7 Country of origin.

18. Keywords

18.1 alloy steel; bolts; metric; steel; structural; weathering steel

APPENDIX

(Nonmandatory Information)

X1. MECHANICAL PROPERTIES OF FULL-SIZE BOLTS

X1.1 See mechanical properties fo full-size bolts in Table X1.1.

TABLE X1.1 Mechanical Properties of Full-Size Bolts

Nominal Bolt Diameter and Thread Pitch	Stress Area, mm^2	Proof Load, kN		Tensile Strength, kN		Product Hardness				Surface Hardness
		Length Measurement Method	Yield Strength Method	Min	Max	HRC (Rockwell C)		HV (Vickers)		HR 30N (Rockwell 30N)
						Min	Max	Min	Max	Max
M16 × 2	157	130	148	163	188	. . .	. . .	. . .	. . .	. . .
M20 × 2.5	245	203	230	255	294	. . .	. . .	. . .	. . .	. . .
M22 × 2.5	303	251	285	315	364	. . .	. . .	. . .	. . .	. . .
M24 × 3	353	293	332	367	424	33	39	327	382	59
M27 × 3	459	381	431	477	551	. . .	. . .	. . .	. . .	. . .
M30 × 3.5	561	466	527	583	673	. . .	. . .	. . .	. . .	. . .
M36 × 4	817	678	768	850	980	. . .	. . .	. . .	. . .	. . .