Designation: A 490M – 04

METRIC

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.

1. Scope*

1.1 This specification covers two types of quenched and tempered alloy steel, metric heavy hex structural bolts having a tensile strength of 1040 to 1210 MPa.

1.2 These bolts are intended for use in structural connections comparable to those covered under the requirements of the Specification for Structural Joints Using ASTM A 325 and A 490 bolts, approved by the Research Council on Structural Connections; endorsed by the American Institute of Steel Construction and by the Industrial Fastener Institute.[2]

1.3 The bolts are furnished in nominal bolt diameters M12 to M36, inclusive. They are designated by type denoting chemical composition as follows:

Type	Description
Type 1	Medium carbon alloy steel
Type 2	Withdrawn in 2002
Type 3	Weathering steel

1.4 This specification is applicable to metric heavy hex structural bolts and alternate designs as established by the Research Council in its publication, Specification for Structural Joints Using ASTM A 325 and A 490 bolts.

1.5 For inch-pound bolts, see Specification A 490.

1.6 The following safety hazards caveat pertains only to the Test Methods portion, Section 13, of this specification: *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:* [3]

A 325 Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength

A 490 Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength

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

A 751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products

D 3951 Practice for Commercial Packaging

E 384 Test Method for Microindentation Hardness of Materials

E 709 Guide for Magnetic Particle Examination

E 1444 Practice for Magnetic Particle Inspection

F 436M Specification for Hardened Steel Washers [Metric]

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

F 606M Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, and Rivets [Metric]

F 788/F 788M Specification for Surface Discontinuities of Bolts, Screws, and Studs, Inch and Metric Series

F 959M Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners [Metric]

F 1470 Guide for Fastener Sampling for Specified Mechanical Properties and Performance Inspection

F 1789 Terminology for F16 Mechanical Fasteners

G 101 Guide for Estimating the Atmospheric Corrosion Resistance of Low-Alloy Steels

2.2 *ASME Standards:*[4]

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

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[2] Available from American Institute of Steel Construction (AISC), One E. Wacker Dr., Suite 3100, Chicago, IL 60601-2001.

[3] For referenced ASTM standards, visit the ASTM webbiest, 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 webbiest.

[4] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990.

***A Summary of Changes section appears at the end of this standard.**

TABLE 1 Chemical Requirements for Type 1 Bolts

Element	Heat Analysis, %	Product Analysis, %
Carbon		
For sizes through M30	0.30–0.48	0.28–0.50
For size M36	0.35–0.53	0.33–0.55
Phosphorus, max	0.040	0.045
Sulfur, max	0.040	0.045
Alloying Elements	→ See 6.1 ←	

TABLE 2 Chemical Requirements for Type 3 Bolts

Element	Heat Analysis, %	Product Analysis, %
Carbon		
Sizes M20 and smaller	0.20–0.53	0.19–0.55
Sizes larger than M20.	0.30–0.53	0.28–0.55
Manganese, min	0.40	0.37
Phosphorus, max	0.035	0.040
Sulfur, max	0.040	0.045
Copper	0.20–0.60	0.17–0.63
Chromium, min	0.45	0.42
Nickel, min	0.20	0.17
or		
Molybdenum, min	0.15	0.14

B1.13M Metric Screw Threads
B18.2.3.7M Metric Heavy Hex Structural Bolts
B18.24.1 Part Identifying Number (PIN) Code System

2.3 *ISO Standards:*[4]
7412 Hexagon Bolts for High Strength Structural Bolting With Large Width Across Flats (Short Thread Length)–Product Grade C–Property Classes 8.8 and 10.9

2.4 *SAE Standards*[5]*:*
J121 Decarburization in Hardened and Tempered Threaded Fasteners

3. Terminology

3.1 Terms used in this specification are defined in Terminology F 1789, unless otherwise defined herein.

4. Ordering Information

4.1 Orders for bolts under this specification shall include the following (see Note 1):

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

4.1.2 Size, including nominal bolt diameter, thread pitch, and bolt length;

4.1.3 Name of product: metric heavy hex structural bolts;

4.1.4 Type of bolt (Type 1 or 3). When type is not specified, either Type 1 or Type 3 shall be furnished at the supplier's option;

4.1.5 ASTM designation and year of issue;

4.1.6 Other components such as nuts, washers, and washer-type direct tension indicators, if required;

4.1.7 Certification, if required (see Section 16); and

4.1.8 Special requirements, if required.

4.1.9 For establishment of a part identifying system, see ASME B18.24.1.

NOTE 1—A typical ordering description follows: 1000 pieces M24 × 3 × 100 mm long, heavy hex structural bolt, Type 1, *ASTM A 490 M– 03;* each with two hardened washers, ASTM F 436M, Type 1; and one heavy hex nut, ASTM A 563M, Grade DH.

4.2 *Recommended Nuts*

4.2.1 Nuts conforming to the requirements of Specification A 563M are the recommended nuts for use with Specification A 490M heavy hex structural bolts. The nuts shall be of the class and have a surface finish for each type of bolt as follows.

Bolt Type and Finish	Nut Class and Finish
1, plain (uncoated)	A 563M—10S, 10S3, plain (uncoated)
3, weathering steel	A 563M—10S3, weathering steel

4.3 *Recommended Washers*

4.3.1 Washers conforming to Specification F 436M are the recommended washers for use with Specification F 490M heavy hex structural bolts. The washers shall have a surface finish for each type of bolt as follows.

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

4.4 *Other Accessories*

4.4.1 When compressible washer type tension indicators are specified to be used with these bolts, they shall conform to Specification F 959M, Type 10.9.

5. Materials and Manufacture

5.1 *Heat Treatment*—Type 1 and Type 3 bolts shall be heat treated by quenching in oil from the austenitic temperature and then tempered by reheating to a temperature of not less than 425°C.

5.2 *Threading*—The threads shall be cut or rolled.

5.3 *Protective Coatings*—The bolts shall not be coated[6] by hot-dip zinc coating, mechanical deposition, or electroplating with zinc or other metallic coatings.

6. Chemical Composition

6.1 Type 1 bolts shall be alloy steel conforming to the chemical composition requirements in Table 1. The steel shall contain sufficient alloying elements to qualify it as an alloy steel (see Note 2).

NOTE 2—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 3 bolts shall be weathering steel conforming to the chemical composition requirements in Table 2. See Guide G 101 for methods of estimating the atmospheric corrosion resistance of low alloy steel.

[5] Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001.

[6] For more detail see the H. E. Townsend Report "Effects of Zinc Coatings on Stress Corrosion Cracking and Hydrogen Embrittlement of Low Alloy Steel," published in Metallurgical Transactions, Vol. 6, April 1975.

6.3 Product analyses made on finished bolts representing each lot shall conform to the product analysis requirements specified in Table 1 or Table 2, as applicable.

6.4 Applications of heats of steel to which bismuth, selenium, tellurium, or lead has been intentionally added shall not be permitted for bolts. Compliance with this requirement shall be based on a statement on the steel certificate indicating that these elements were not intentionally added.

6.5 Chemical analyses shall be performed in accordance with Test Methods, Practices, and Terminology A 751.

7. Mechanical Properties

7.1 *Hardness*—The bolts shall conform to the hardness specified in Table 3.

7.2 *Tensile Properties*:

7.2.1 Except as permitted in 7.2.2 for long bolts and 7.2.3 for short bolts, nominal bolt diameters M24 and smaller having a length of 2¼ *D* and longer, and nominal bolt diameters larger than M24 having a length of 3*D* and longer shall be wedge tested full size and shall conform to the minimum wedge tensile load, and proof load or alternative proof load specified in Table 4. The load achieved during proof load testing shall be equal to or greater than the specified proof load.

7.2.2 When the length of the bolt makes full-size testing impractical, machined specimens shall be tested and shall conform to the requirements specified in Table 5. When bolts are tested by both full-size and machined specimen methods, the full-size test shall take precedence.

7.2.3 Nominal bolt diameters M24 and smaller having a length shorter than 2¼ *D* down to 2*D* inclusive, which cannot be wedge tensile tested shall be axially tension tested full size and shall conform to the minimum tensile load and proof load or alternate proof load specified in Table 4. Nominal bolt diameters M24 and smaller having a length shorter than 2*D* which cannot be axially tensile tested shall be qualified on the basis of hardness.

7.2.4 For bolts on which both hardness and tension tests are performed, acceptance based on tensile requirements shall take precedence in the event of low hardness readings.

8. Carburization/Decarburization

8.1 *Definition*—This test is intended to evaluate the presence or absence of carburization and decarburization as determined by the difference in microhardness near the surface and core.

8.2 *Requirements*:

8.2.1 *Carburization*—The bolts shall show no evidence of a carburized surface when evaluated in accordance with the hardness methods established in SAE J121.

8.2.2 *Decarburization*—Hardness value differences shall not exceed the requirements set forth for decarburization in SAE J121 for Class 2/3H materials.

8.3 *Procedure*—Testing for carburization/decarburization shall be performed in accordance with the microhardness (referee) methods established in SAE J121.

9. Dimensions

9.1 *Head and Body*:

9.1.1 The bolts shall conform to the dimensions for heavy hex structural bolts specified in ASME B18.2.3.7M for nominal bolt diameter M16 to M36 inclusive and ISO 7412 for size M12.

9.2 *Threads*:

9.2.1 Threads shall Metric Coarse Thread Series as specified in ASME B1.13M, and shall have Grade 6g tolerance.

9.2.2 The thread length shall not be changed from that specified for heavy hex structural bolts in ASME B18.2.3.7M and ISO 7412 in 9.1.1. Bolts requiring thread lengths other than those required by this specification shall be ordered under Specification F 568M, Class 10.9 and 10.9.3.

10. Workmanship

10.1 The allowable limits, inspection, and evaluation of the surface discontinuities, quench cracks, forging cracks, head bursts, shear bursts, seams, folds, thread laps, voids, tool marks, nicks, and gouges shall be in accordance with Specification F 788/F 788M (see Note 3).

NOTE 3—Specifications F 788/F 788M and F 1470 do not guarantee 100 % freedom from head bursts. Sampling is designed to provide a 95 % confidence level of freedom from head bursts in any test lot. Head bursts, within the limits of Specification F 788/F 788M, are unsightly but do not affect mechanical properties or functional requirements of the bolt.

11. Magnetic Particle Inspection for Longitudinal Discontinuities and Transverse Cracks

11.1 *Requirements*:

11.1.1 Each sample representative of the lot shall be magnetic particle inspected for longitudinal discontinuities and transverse cracks.

11.1.2 The lot, as represented by the sample, shall be free from nonconforming bolts, as defined in 11.3, when inspected in accordance with 11.2-11.2.4.

TABLE 3 Hardness Requirements for Bolt Sizes M12 to M36 Inclusive

Nominal Bolt Diameter, mm	Length[A]	Brinell		Rockwell C	
		min	max	min	max
M12 to M24, inclusive	Less than 2*D*	311	352	33	39
	2*D* and longer	. . .	352	. . .	39
Over M24 to M36, inclusive	Less than 3*D*	311	352	33	39
	3*D* and longer	. . .	352	. . .	39

[A] Heavy hex structural bolts M24 and smaller and shorter than 2*D* are subject only to minimum and maximum hardness. Heavy hex structural bolts larger than M24 to M36 inclusive and shorter than 3*D* are subject only to minimum and maximum hardness.

TABLE 4 Tensile Load Requirements for Full-Size Bolts

Nominal Bolt Diameter and Thread Pitch, mm	Stress Area,[A] mm²	Tensile Load,[B] kN		Proof Load,[B] kN	Alternative Proof Load,[B] kN
		min	max	Length Measurement Method	Yield Strength Method
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
M12 × 1.75	84.3	87.7	103	70	79.2
M16 × 2	157	163	190	130	148
M20 × 2.5	245	255	296	203	230
M22 × 2.5	303	315	366	251	285
M24 × 3	353	367	427	293	332
M27 × 3	459	477	555	381	431
M30 × 3.5	561	583	679	466	527
M36 × 4	817	850	989	678	768

[A] The stress area is calculated as follows:

$$A_s = 0.7854\ [D - (0.9382P)^2$$

where:
A_s = stress area, mm²
D = nominal bolt size, mm, and
n = thread pitch, mm.

[B] Loads tabulated and loads to be used for tests of full-size bolts larger than 36 mm in diameter are based on the following:

Nominal Bolt Diameter, mm	Column 3	Column 4	Column 5	Column 6
M12 to M36 inclusive	1040 MPa	1210 MPa	830 MPa	940 MPa

TABLE 5 Tensile Strength Requirements for Specimens Machined from Bolts

Nominal Bolt Diameter, mm	Tensile Strength, MPa		Yield Strength (0.2 % offset), min, MPa	Elongation in 50 mm, min, %	Reduction of Area, min, %
	min	max			
M12 to M36, inclusive	1040	1210	940	14	40

11.2 *Inspection Procedure*:

11.2.1 The inspection sample shall be selected at random from each lot in accordance with Table 6 and examined for longitudinal discontinuities and transverse cracks.

11.2.2 Magnetic particle inspection shall be conducted in accordance with Guide E 709 or Practice E 1444. Guide E 709 shall be used for referee purposes. If any nonconforming bolt is found during the manufacturer's examination of the lot selected in 11.2.1, the lot shall be 100 % magnetic particle inspected, and all nonconforming bolts shall be removed and scrapped or destroyed.

TABLE 6 Sample Sizes with Acceptance and Rejection Numbers for Inspection of Rejectable Longitudinal Discontinuities and Transverse Cracks

Lot Size	Sample Size[A]	Acceptance Number[A]	Rejection Number
2 to 50	all	0	1
51 to 500	50	0	1
501 to 1200	80	0	1
1201 to 3200	125	0	1
3201 to 10 000	200	0	1

[A] Inspect all bolts in the lot if lot size is less than sample size.

11.2.3 Eddy current or liquid penetrant inspection shall be an acceptable substitute for the 100 % magnetic particle inspection when nonconforming bolts are found and 100 % inspection is required. On completion of the eddy current or liquid penetrant inspection, a random sample selected from each lot in accordance with Table 6 shall be reexamined by the magnetic particle method. In case of controversy, the magnetic particle test shall take precedence.

11.2.4 Magnetic particle indications of themselves shall not be cause for rejection. If in the opinion of the quality assurance representative the indications may be cause for rejection, a sample taken in accordance with Table 6 shall be examined by microscopic examination or removal by surface grinding to determine if the indicated discontinuities are within the specified limits.

11.3 *Definitions*:

11.3.1 *Nonconforming Bolts*—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 0.03D, where D is the nominal diameter in millimetres, shall be considered nonconforming. 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) detectable by magnetic particle inspection when examined as specified in 11.2.4, shall be considered nonconforming.

12. Number of Tests and Retests

12.1 *Testing Responsibility*:

12.1.1 Each lot shall be tested by the manufacturer prior to shipment in accordance with the lot identification control quality assurance plan in 12.2-12.5.

12.1.2 When bolts are furnished by a source other than the manufacturer, the Responsible Party as defined in 18.1 shall be responsible for assuring all tests have been performed and the bolts comply with the requirements of this specification.

12.2 *Purpose of Lot Inspection*—The purpose of a lot inspection program shall be to ensure that each lot as represented by the samples tested conforms to the requirements of this specification. For such a plan to be fully effective, it is essential that secondary processors, distributors, and purchasers maintain the identification and integrity of each lot until the product is installed.

12.3 *Lot Method*—All bolts shall be processed in accordance with a lot identification-control quality assurance plan. The manufacturer, secondary processors, and distributors shall identify and maintain the integrity of each 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.

12.4 *Lot Definition*:

12.4.1 *Standard Lot*—A lot shall be a quantity of uniquely identified heavy hex structural bolts of the same nominal bolt diameter and length produced consecutively at the initial operation from a single mill heat of material and processed at one time, by the same process, in the same manner, so that statistical sampling is valid. The identity of the lot and lot integrity shall be maintained throughout all subsequent operations and packaging.

12.5 *Number of Tests*:

12.5.1 The minimum number of tests from each lot for the tests specified below shall be as follows:

Tests	Number of Tests in Accordance with
Hardness, tensile strength, proof load	Guide F 1470
Surface discontinuities	Specification F 788/F 788M
Magnetic particle inspection	Table 6
Dimensions and thread fit	ASME B18.2.3.7M and ASME B1.13M

12.5.2 For carburization and decarburization tests, not less than one sample unit per manufactured lot shall be tested for microhardness.

13. Test Methods

13.1 *Tensile, Proof Load, and Hardness*:

13.1.1 Tensile, proof load, and hardness tests shall be conducted in accordance with Test Methods F 606M.

13.1.2 Tensile strength shall be determined using the Wedge or Axial Tension Testing Method of Full Size Product Method or the Machined Test Specimens Method, depending on size and length as specified in 7.2.1-7.2.4. Fracture on full-size tests shall be in the body or threads of the bolt without a fracture at the junction of the head and body.

13.1.3 Proof load shall be determined using Method 1, Length Measurement, or Method 2, Yield Strength, at the option of the manufacturer.

13.2 *Carburization/Decarburization*—Tests shall be conducted in accordance with SAE J121 Hardness Method.

13.3 *Microhardness*—Tests shall be conducted in accordance with Test Method E 384.

13.4 *Magnetic Particle*—Inspection shall be conducted in accordance with Section 11.

14. Inspection

14.1 If the inspection described in 14.2 is required by the purchaser, it shall be specified in the inquiry and contract or order.

14.2 The purchaser's representative shall have free entry to all parts of manufacturer's works or supplier's place of business that concern the manufacture of the material ordered. The manufacturer or supplier shall afford the purchaser's representative 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 manufacturer's works or supplier's place of business.

15. Rejection and Rehearing

15.1 Disposition of nonconforming bolts shall be in accordance with the section titled "Disposition of Nonconforming Lots" in Guide F 1470

16. Certification

16.1 When specified on the purchase order, the manufacturer or supplier, whichever is the responsible party as defined in Section 17, shall furnish the purchaser a test report that includes the following:

16.1.1 Heat analysis, heat number, and a statement certifying that heats having bismuth, selenium, tellurium, or lead intentionally added were not used to produce the bolts;

16.1.2 Results of hardness, tensile, and proof load tests;

16.1.3 Results of magnetic particle inspection for longitudinal discontinuities and transverse cracks;

16.1.4 Results of tests and inspections for surface discontinuities including visual inspection for head bursts;

16.1.5 Results of carburization and decarburization tests;

16.1.6 Statement of compliance with dimensional and thread fit requirements;

16.1.7 Lot number and purchase order number;

16.1.8 Complete mailing address of responsible party; and

16.1.9 Title and signature of the individual assigned certification responsibility by the company officers.

16.2 Failure to include all the required information on the test report shall be cause for rejection.

17. Responsibility

17.1 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.

18. Product Marking

18.1 *Manufacturer's Identification*—All Type 1 and Type 3 bolts shall be marked by the manufacturer with a unique identifier to identify the manufacturer or private label distributor, as appropriate.

18.2 *Grade Identification*:

18.2.1 Type 1 bolts shall be marked "A 490M."

18.2.2 Type 3 bolts shall be marked "A 490M" underlined. The use of additional distinguishing marks to indicate the bolts are weathering steel shall be at the manufacturer's option.

18.3 *Marking Location and Methods*—All marking shall be located on the top of the bolt head and shall be either raised or depressed at the manufacturer's option.

18.4 *Acceptance Criteria*—Bolts that are not marked in accordance with these provisions shall be considered nonconforming and subject to rejection.

18.5 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.

19. Packaging and Package Marking

19.1 *Packaging*:

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

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

19.2 *Package Marking*:

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

19.2.1.1 ASTM designation and type,

19.2.1.2 Size, including nominal bolt diameter, thread pitch, and bolt length,

19.2.1.3 Name and brand or trademark of the manufacturer,

19.2.1.4 Number of pieces,

19.2.1.5 Lot number,

19.2.1.6 Purchase order number, and

19.2.1.7 Country of origin.

20. Keywords

20.1 alloy steel; bolts; metric; SI; steel; structural; weathering steel

SUMMARY OF CHANGES

Committee F16 has identified the location of selected changes to this standard since the last issue, A 490M–03, that impact the use of this standard. (Approved Jan. 1, 2004.)

(*1*) Revised Section 9.1 to include a note recognizing that Specification F 788/F 788M nor Specification F 1470 guarantee 100 % freedom from head burst.

Committee F16 has identified the location of selected changes to this standard since the last issue, A 490M–00, that may impact the use of this standard. (Approved May 10, 2003.)

(*1*) Overall revision to make the specification self standing without reliance on Specification F 568M, and in general align with Specification A 490 (except metric).