



Designation: **F 541 – 9700**

## Standard Specification for Alloy Steel Eyebolts<sup>1</sup>

This standard is issued under the fixed designation F 541; 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 ( $\epsilon$ ) 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 forged, quenched and tempered, alloy steel threaded eyebolts with improved toughness properties and intended primarily for low temperature applications. The eyebolts are chemically and metallurgically constituted to produce a low transition temperature to minimize brittle failure. Maximum thread size is 2.500 in. (63.50 mm).

1.2 The eyebolts are furnished in two types, as follows:

1.2.1 *Type 1*—Straight Shank Eyebolt.

1.2.2 *Type 2*—Shoulder Eyebolt.

1.3 The values stated in inch-pound units are to be regarded as the standard. The values in parentheses are for information only.

### 2. Referenced Documents

2.1 *ASTM Standards:*

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products<sup>2</sup>

<sup>1</sup> 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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\*A Summary of Changes section appears at the end of this standard.

- A 574 Specification for Alloy Steel Socket-Head Cap Screws<sup>3</sup>
- A 751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products<sup>2</sup>
- D 3951 Practice for Commercial Packaging<sup>4</sup>
- E 10 Test Method for Brinell Hardness of Metallic Materials<sup>5</sup>
- E 18 Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials<sup>5</sup>
- E 112 Test Methods for Determining the Average Grain Size<sup>5</sup>
- E 340 Test Method for Macroetching Metals and Alloys<sup>5</sup>
- E 709 Guide for Magnetic Particle Examination<sup>6</sup>
- F 606 Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, and Rivets<sup>3</sup>
- F 1470 Guide for Fastener Sampling for Specified Mechanical Properties and Performance Inspection<sup>3</sup>
- 2.2 *ANSI/ASME Standards:*
  - B1.1 Unified Screw Threads<sup>7</sup>
  - B18.15 Forged Eyebolts<sup>7</sup>
  - B18.24.1 Part Identifying Number (PIN) Code System<sup>8</sup>

### 3. Ordering Information

- 3.1 Orders for eyebolts under this specification shall include the following information to adequately describe the part:
  - 3.1.1 ASTM specification number and date of issue,
  - 3.1.2 Name of part (alloy steel eyebolts),
  - 3.1.3 Regular or shoulder pattern (8.1),
  - 3.1.4 Size (nominal diameter and threads),
  - 3.1.5 Number of pieces,
  - 3.1.6 Certification or test reports (if required) (13.1),
  - 3.1.7 Additional requirements (if required), and
  - 3.1.8 Supplementary requirements (if required).
  - 3.1.9 For establishment of a part identifying system, see ASME B18.24.1.

### 4. Materials and Manufacture

- 4.1 *Melting Process*—The steel shall be made to a fine-grain practice using a melting process yielding a product conforming to the requirements of this specification.
- 4.2 *Forging*—Eyebolts shall be forged without welds.
- 4.3 *Heat Treatment*—The eyebolts shall be quenched and tempered in accordance with proper practice to yield a product conforming to the requirements of this specification.
- 4.4 *Machining*—The eyebolt shall be machined prior to or after heat treatment at the manufacturer’s option.

### 5. Chemical Composition

- 5.1 *Limits*—The eyebolts shall be manufactured from steels having a heat analysis conforming to the requirements in Table 1.

<sup>2</sup> Annual Book of ASTM Standards, Vol 01.03.

<sup>3</sup> Annual Book of ASTM Standards, Vol 01.08.

<sup>4</sup> Annual Book of ASTM Standards, Vol 15.09.

<sup>5</sup> Annual Book of ASTM Standards, Vol 03.01.

<sup>6</sup> Annual Book of ASTM Standards, Vol 03.03.

<sup>7</sup> Available from American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036.

<sup>8</sup> Available from American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016–5990.

**TABLE 1 Chemical Requirements, %**

	Heat Analysis	Permissible Variation on Product Analysis, Over or Under
Carbon, max	0.33	0.02 over
Manganese	0.30 to 1.10	0.04
Phosphorus, max	0.025	0.005 over
Sulfur, max	0.025	0.005 over
Silicon	0.15 to 0.35	0.02
Chromium, max <sup>A</sup>	0.90	0.05 over
Molybdenum <sup>A</sup>	0.10 to 0.60	0.02
Nickel <sup>A</sup>	0.40 to 3.75	0.03

<sup>A</sup> The composition shall contain at least two of the elements shown.

5.2 *Product Analysis:*

5.2.1 The purchaser reserves the right to conduct product analyses on the finished eyebolts or request the manufacturer to conduct product analyses tests. The composition thus determined shall conform to the requirements specified in Table 1 subject to the product analysis tolerances.

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

**6. Metallurgical Requirements**

6.1 *Grain Size:*

6.1.1 *Requirements*—The finished eyebolts shall have an apparent heat-treated grain size of Test Methods E 112 No. 5 or finer.

6.1.2 *Specimen*—Grain size shall be rated on specimens taken from the eyebolt after final heat treatment.

6.1.3 *Test Method*—Grain size on the finished eyebolt shall be determined in accordance with Test Methods E 112.

6.2 *Macroetch Test:*

6.2.1 *Requirement*—When ground and etched, the cross section of the eyebolt shall be free of injurious surface seams, internal cracks, pipe, segregation, and other imperfections detrimental to the intended application.

6.2.2 *Specimen*—Macroetch test specimens shall consist of the full transverse cross section of a finished eyebolt shank.

6.2.3 *Test Method*—Macroetch tests shall be performed in accordance with Test Method E 340.

6.3 *Decarburization:*

6.3.1 *Requirement*—The depth of decarburization (total + partial), as measured on the eyebolts after heat treatment, shall not exceed the requirements in Table 2.

6.3.2 *Specimen*—The test specimens shall consist of the unmachined surface of the heat-treated eyebolts in an area where threads would normally be machined.

6.3.3 *Test Method*—The depth of decarburization shall be determined by metallographic etching. The edge of the specimen shall be suitably prepared to preserve the original surface and the sample shall then be polished for metallographic examination. The section shall be etched in 4 % nital and the samples examined under a microscope at 100× using an eyepiece graduated in 0.001-in. (0.025-mm) increments. The measured depth of any light etched band shall be taken as the decarburization depth.

6.3.4 When the metallographic etch method of 6.3.3 for decarburization renders results that are inconclusive, then the microhardness traverse method of Specification A 574 shall be employed. The depth of decarburization shall be denoted by that radial depth where the hardness decrease is more than the equivalent of 3 points HRA, when compared to the average microhardness of undecarburized locations beyond this site. The average microhardness of undecarburized locations of the eyebolt shall be determined for depths not exceeding 25 % of its shank diameter.

**7. Mechanical Properties**

7.1 *Hardness:*

7.1.1 *Requirements*—The eyebolts shall have a Brinell Hardness of 197 to 248 (equivalent Rockwell B93 to 101). Hardness tests are subject to confirmation by tensile tests.

7.1.1.1 In case of controversy, acceptance based on tensile requirements shall take precedence over low readings of hardness tests.

7.1.2 *Specimens*—For routine inspection, hardness tests shall be made on a properly prepared surface of the finished eyebolt. For referee purposes tests shall be made on a transverse section through the threads one diameter from the end.

7.1.3 *Test Method*—Hardness tests shall be made in accordance with Test Methods E 10 or E 18, as applicable.

7.2 *Tensile Strength:*

7.2.1 *Requirement*—Test specimens machined from finished eyebolts shall conform to the tensile properties specified in Table 3.

7.2.2 *Specimens*—Eyebolts for tensile tests shall be selected from the eyebolts subjected to the hardness test to represent the high and low end of the hardness test results. The specimens shall be machined from the finished eyebolts whenever possible. When the eyebolts are too small to remove machined specimens, they shall be taken from test coupons from the same heat of steel, subjected to the same reduction, and heat treated with the eyebolts represented.

7.2.3 *Test Methods*—Tension tests shall be made in accordance with Test Methods F 606.

7.3 *Breaking Strength:*

**TABLE 2 Decarburization Limits**

Nominal Size, In.	Depth of Decarburization, Total + Partial, max	
	in.	mm
0.250 to 0.375	0.030	0.762
0.4375 to 0.625	0.040	1.02
0.750 to 1.000	0.050	1.27
1.125 to 1.500	0.060	1.52
1.750 to 2.500	0.070	1.78

**TABLE 3 Tensile Requirements**

Tensile strength, min, psi (MPa)	95 000 (660)
Yield strength, min (0.2 % offset), psi (MPa)	70 000 to 100 000 (485 to 690)
Elongation in 2 in. (50 mm), min, %	22
Reduction of area, min, %	55
Brinell hardness <sup>A</sup>	197 to 248
Rockwell B hardness <sup>A</sup>	93 to 101

<sup>A</sup> Hardness tests are subject to confirmation by tension tests.

7.3.1 *Requirements*—The eyebolt shall conform to the breaking strength specified in Table 4.

7.3.2 *Specimens*—Eyebolts for breaking strength tests shall be selected from the eyebolts subjected to the hardness test to represent the high and low end of the hardness test results. The eyebolts shall be tested full size.

7.3.3 *Test Methods*—The breaking strength shall be determined by exerting an in-line pull upon the eyebolt which has had its threaded shank screwed into a block and secured in one jaw of the testing machine. The eye shall be loaded by a round section no greater than 50 % of eye diameter and secured in the other jaw of the testing machine.

7.4 *Proof of Load:*

7.4.1 *Requirements*—The eyebolts, when tested in accordance with Section 10, shall withstand the proof load specified in Table 4.

7.4.2 *Specimens*—Eyebolts for proof load tests shall be selected in accordance with 7.3.2 and may be the same specimens used for the breaking strength tests.

7.4.3 *Test Methods*—The proof load shall be defined as the load that can be applied without causing permanent deformation exceeding 1.5 % when measured between punch marks located across the diameter of the eye and 90 ° to the direction of the pull. The fixture for testing shall be as specified in 7.3.3.

7.5 *Impact:*

7.5.1 *Requirements:*

7.5.1.1 Eyebolts sufficiently large to remove full-size impact specimens shall have a Charpy V-notch impact strength of 35 ft-lbf (47.5 J) average minimum when tested at –40°C (–40°F). The impact value shall be taken as the average of three specimens tested with not more than one value below 35 ft-lbf but in no case below 23 ft-lbf (31.0 J).

7.5.1.2 Subsize Charpy V-notch specimens shall be obtained from eyebolts with section sizes not suitable for full size standard specimens. Impact strength shall be reported for information only. However, the fracture surface shall show a fine-grain fibrous structure characteristic of a shear fracture.

7.5.2 *Test Specimens*—Eyebolts for impact tests shall be selected from the eyebolts subjected to the hardness test to represent the high and low end of the hardness test results. Test specimens shall conform to the standard 10 by 10-mm Charpy V-notch Type A specimen shown in Test Methods A 370. Eyebolts too small for standard impact test specimens shall be tested using the largest possible subsize square specimen with the standard 45 ° V-notch adjusted in depth to be proportional to the standard specimen.

7.5.3 *Test Method*—Impact tests shall be made in accordance with Test Methods A 370 at –40°C (–40°F).

**TABLE 4 Breaking Strength and Proof Load**

Nominal Size and Number of Threads	Tension Stress Area, in. <sup>2</sup>	Breaking Strength, min		Proof Load, min	
		lb	Mg	lb	Mg
0.250—20	0.0318	3 020	1.37	1 220	0.55
0.3125—18	0.0524	5 000	2.27	2 000	0.91
0.375—16	0.0775	7 400	3.35	2 960	1.34
0.4375—14	0.1063	10 100	4.60	4 040	1.84
0.500—13	0.1419	13 500	6.1	5 400	2.44
0.625—11	0.226	21 500	9.8	8 600	3.92
0.750—10	0.334	32 000	14.5	12 800	5.8
0.875—9	0.462	44 000	20.0	17 600	8.0
1.000—8	0.606	58 000	26.5	23 200	10.6
1.125—7	0.763	72 000	32.5	28 800	13.0
1.250—7	0.969	92 000	42.0	36 800	16.8
1.500—6	1.405	133 000	60.0	53 200	24.0
1.750—5	1.90	180 000	82	72 000	32.8
2.000—4.5	2.50	238 000	108	95 200	43.2
2.500—4	4.00	380 000	172	152 000	68.8

7.6 *Bend:*

7.6.1 *Requirements*—Type 1 straight-shank eyebolts 1/2 in. diameter and smaller, when tested in accordance with Section 10, shall withstand bending through 45 ° at room temperature without visible ruptures in the threaded or unthreaded portions when examined at 10× magnification.

7.6.2 *Specimens*—Eyebolts for bend tests shall be selected from the eyebolts subjected to the hardness test to represent the high and low end of the hardness test results. The eyebolts shall be tested full size.

7.6.3 *Test Method*—The eyebolts shall be screwed into a steel block a minimum of one diameter to ensure bending primarily in the threaded section. Bending shall be accomplished by pressure or blows.

**8. Dimensions and Permissible Variations**

8.1 *Dimensions*—The dimensions of the eyebolts shall conform to the requirements specified in the latest issue of ANSI B18.15, Type 1 Regular Pattern, or Type 2 Shoulder Pattern, as specified by the purchaser.

8.2 *Threads*—The eyebolts shall be threaded. Threads shall conform to the Unified Coarse Thread Series as specified in ANSI B1.1, and shall have Class 2A tolerances.

**9. Workmanship, Finish, and Appearance**

9.1 The eyebolts shall be descaled.

9.2 The eyebolts shall be of uniform quality consistent with good manufacturing and inspection practices. They shall be free of fins, cracks, seams, laps, nicks, pipe, segregation, rough surfaces, and other injurious internal or surface imperfections which, due to their nature, degree, or extent, would make the eyebolts unsuitable for the intended use.

9.3 Threads shall be undamaged upon the receipt of eyebolts by the purchaser.

**10. Number of Tests**

10.1 *General Requirements:*

10.1.1 The manufacturer shall make sample inspections of every lot of eyebolts to ensure that the properties of the eyebolts are in conformance with the requirements of this specification. All eyebolts shall be inspection tested prior to shipment in accordance with one of the two procedures described in 10.2 and 10.3. Unless otherwise specified by the purchaser, the manufacturer shall have the option of which procedure will be followed when furnishing eyebolts to any single purchase order.

10.1.2 The purpose of a lot inspection testing program is to ensure that each lot conforms to the requirements of the specification and that delivered eyebolts are free of known defects. 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 released for use.

10.2 *Production Lot Method:*

10.2.1 All eyebolts shall be processed in accordance with a production lot quality assurance plan. A production lot from which test samples shall be selected shall consist of all eyebolts of the same size, from the same heat, same part number, heat treated in a continuous run and tempered at one time. The minimum number of tests shall be in accordance with 10.2.2 through 10.2.8.

10.2.2 *Grain Size*—One grain size test shall be made from each production lot.

10.2.3 *Macroetch and Decarburization*— The number of tests shall be in accordance with the manufacturer’s standard quality control practices. The eyebolts shall be produced by manufacturing practices and subjected to mill tests and inspection procedures to ensure compliance with the specified requirements. Disposition of eyebolts and the lots they represent, when tested by the purchaser that fail to meet the specified requirements, shall be in accordance with Guide F 1470 (Disposition of Nonconforming Lots, Purchasers Options).

10.2.4 *Hardness*—The number of hardness tests from each production lot shall be in accordance with Table 5.

10.2.5 *Tensile Strength*—Two tension tests, one representing the high and the low end of the hardness tests, shall be made to represent each production lot.

**TABLE 5 Number of Hardness Tests**

NOTE 1—Excerpt from MIL-STD-105<sup>A</sup>, Inspection Level II.

Number of Pieces in Lot	Number of Hardness Tests	Number of Pieces in Lot	Number of Hardness Tests
2 to 8	2	501 to 1 200	80
9 to 15	3	1 201 to 3 200	125
16 to 25	5	3 201 to 10 000	200
26 to 50	8	10 001 to 35 000	315
51 to 90	13	35 001 to 150 000	500
91 to 150	20	150 001 to 500 000	800
151 to 280	32	500 000 and over	1 250
281 to 500	50		

<sup>A</sup> This table from this military standard is available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

10.2.6 *Breaking Strength and Proof Load*— Four breaking strength and four proof load tests, two each representing the high and two the low end of the hardness tests, shall be made to represent each production lot.

10.2.7 *Impact*—Two impact tests, one representing the high and one the low end of the hardness tests, shall be made to represent each production lot.

10.2.8 *Bend*—Two bend tests, one representing the high and one the low end of the hardness tests, shall be made to represent each production lot.

10.3 *Shipping Lot Method:*

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

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

10.3.3 The manufacturer shall make tests for grain size, hardness, tensile strength, breaking strength, proof load, impact, and bend tests. Tests for macroetch and decarburization shall be in accordance with 10.2.3.

10.3.4 The number of hardness tests from each shipping lot shall be in accordance with Table 5. The number of grain size, tensile strength, breaking strength, proof load, impact, and bend tests shall be in accordance with Table 6 and shall be selected to represent the high and low end of the hardness tests.

**11. Retesting**

11.1 If the results of the hardness, tensile strength, breaking strength, impact, or proof load tests do not conform to the requirements specified, the lot, at the option of the manufacturer, shall be reheat treated, and the lot retested using twice the number of samples required for the original lot, in which case all additional tests shall meet the requirements of the specification.

11.2 If the impact test average equals or exceeds 35 ft·lbf (47.5 J) and more than one impact value is below 35 ft·lbf but not below 23 ft·lbf (31.0 J), the lot, at the option of the manufacturer, shall be reheat treated and retested in accordance with the original requirements, in which case all specimens tested shall have a value equal to or exceeding 35 ft·lbf.

11.3 If any test specimen shows defective machining, it shall be discarded and another specimen substituted.

**12. Inspection**

12.1 The manufacturer shall afford the purchaser’s representative all reasonable facilities necessary to satisfy him that the eyebolts are being produced and furnished in accordance with this specification. Mill inspection by the purchaser’s representative shall not interfere unnecessarily with the manufacturer’s operations. All tests and inspections shall be made at the place of manufacture, unless otherwise agreed to.

**13. Certification**

13.1 When requested by the purchaser, the manufacturer shall furnish one of the following as specified by the purchaser: ( 1) certification that the eyebolts were manufactured, tested, and the test results conform to this specification, or (2) a test report showing the results of the tests made to determine compliance with this specification. The report shall include the purchase order number and a lot identification number correlating the test results with the lot represented.

**14. Responsibility**

14.1 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.

**15. Product Marking**

15.1 Each eyebolt shall have the symbol “A” (denoting alloy steel) and the manufacturer’s name or identification mark forged in raised characters on the surface of the eyebolt.

**16. Packaging and Package Marking**

16.1 *Packaging:*

**TABLE 6 Number of Tests for Shipping Lot Testing**

Number of Pieces in Shipping Lot	Number of Specimens
280 and less	2
281 to 500	4
501 to 1 200	6
1 201 to 3 200	8
3 201 to 10 000	14
10 001 and over	20

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

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

16.2 *Package Marking:*

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

16.2.1.1 ASTM designation and type,

16.2.1.2 Size,

16.2.1.3 Name and brand or trademark of the manufacturer,

16.2.1.4 Number of pieces,

16.2.1.5 Purchase order number, and

16.2.1.6 Country of origin.

## 17. Keywords

17.1 alloy steel; eyebolts; steel

## SUPPLEMENTARY REQUIREMENTS

One or more of the following supplementary requirements shall apply only when specified by the purchaser in the inquiry, contract, and order. Details of these supplementary requirements shall be agreed upon by the manufacturer and the purchaser.

### S1. Magnetic Particle Inspection

S1.1 When magnetic particle inspection is specified, the eyebolts shall be inspected in accordance with Guide E 709 and shall show no indications of transverse defects (cracks). Other acceptance standards shall be as agreed upon between the purchaser and the manufacturer.

## SUMMARY OF CHANGES

This section identifies the location of selected changes to this specification that have been incorporated since the ~~last~~ -97 issue. For the convenience of the user, Committee F-16 has highlighted those changes that may impact the use of this specification. This section may also include descriptions of the changes or reasons for the changes, or both.

~~(1) Revised the following sections to change nonmandatory wording to mandatory. Sections changed: 4.4, 5.2.1, 6.3.3, 6.3.4, 7.1.2, 7.2.2, 7.4.1, 10.2.3, 11.1, 11.2, and 11.3.~~

~~(2) In 7.6.1, added missing "1½ in. diameter and smaller".~~

~~(3) In Section 12, changed "purchaser's quality assurance representative" to "purchaser's representative".~~

~~(4) Added Keywords, Section 17. Added 3.1.9, providing for optional use of ASME B18.24.1, Part Identifying Number (PIN) Code System.~~

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