IEEE Std C135.1-1999
(Revision of ANSI C135.1-1979)

IEEE Standard for Zinc-Coated Steel Bolts and Nuts for Overhead Line Construction

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**Transmission and Distribution Committee
of the
IEEE Power Engineering Society**

Approved 16 September 1999

IEEE-SA Standards Board

Abstract: The requirements for inch-based carriage bolts, machine bolts, double-arming bolts, and double-end bolts and nuts, commonly used in overhead line construction and where the applied load is primarily a tensile load, are covered.
Keywords: Double-arming bolts, double-end bolts, double-end nuts, inch-based carriage bolts, machine bolts.

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Introduction

(This introduction is not part of IEEE Std C135.1-1999, IEEE Standard for Zinc-Coated Steel Bolts and Nuts for Overhead Line Construction.)

This standard supersedes ANSI C135.1-1979, American National Standard for Galvanized Steel Bolts and Nuts for Overhead Line Construction.

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IEEE Standard for Zinc-Coated Steel Bolts and Nuts for Overhead Line Construction

1. Overview

1.1 Scope

This standard covers the requirements for inch-based carriage bolts, machine bolts, double-arming bolts, and double-end bolts and nuts commonly used in overhead line construction and where the applied load is primarily a tensile load. Where shear loads are of importance, reference should be made to ASTM A394-93.[1] Metric bolts and nuts are not covered by this standard.

1.2 Purpose

Bolts and nuts conforming to this standard shall, in all respects, meet the basic dimensional and performance requirements hereinafter stated. The text and specifications or standards references supplement each other and shall be considered as parts of this standard.

2. References

This standard shall be used in conjunction with the following publications:

ANSI B18.2.1-92, American National Standard for Square and Hex Bolts and Screws.

ANSI/ASME B18.5-90, American National Standard for Round Head Bolts.[2]

ANSI/ASME B18.2.2-93, American National Standard for Square and Hex Nuts.

ANSI/ASME B1.1-89, American National Standard for Unified Screw Threads.

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[1]Information on references can be found in Clause 2.

[2]ANSI publications are available from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA (http://www.ansi.org/). ASME publications are available from the American Society of Mechanical Engineers, 3 Park Avenue, New York, NY 10016-5990, USA (http://www.asme.org/).

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ASTM A153/A153M-95, Standard Specification for Zinc Coating on Iron and Steel Hardware.[3]

ASTM A394-93, Standard Specification for Steel Transmission Tower Bolts, Zinc-Coated and Bare.

3. Material

3.1 Bolts

All bolts shall be made from one of the following materials:

a) Hot-headed bolts, double-arming bolts, and double-end bolts shall be made from hot-rolled steel that has been produced by the open-hearth, basic-oxygen, or electric-furnace process and which is of a grade and quality suitable to meet the requirements of this standard.

b) Cold-headed carriage bolts and machine bolts shall be made from steel cold-heading wire, produced by the open-hearth, basic-oxygen, or electric-furnace process, and which is of a grade and quality suitable to meet the requirements of this standard, and shall be reheated if necessary to meet requirements.

3.2 Nuts

Nuts for bolts made from steel, in accordance with item a) and item b) in 3.1, shall be made from hot-rolled steel that has been produced by the open-hearth, basic-oxygen, or electric-furnace process, and which is of a grade and quality suitable to meet the requirements of this standard.

4. Dimensions

4.1 Bolt length

The length of semicone-pointed bolts shall be measured from the underside of the head to the last thread at the end of the bolt. The length of all other bolts shall be measured from the underside of the head to the end of the bolt. The points of double-arming and double-end bolts shall not be included in the length.

4.2 Machine bolt heads

All machine bolt heads shall be regular square or hexagonal, and shall be in accordance with ANSI B18.2.1-92. The dimensions of machine bolt heads before zinc coating shall be as given in Table 1 and Table 2.

4.3 Carriage bolt heads

All carriage bolt heads shall be in accordance with ANSI/ASME B18.5-90. The dimensions before zinc coating shall be as given in Table 3.

4.4 Nuts

All nuts shall be square or hexagonal in accordance with ANSI/ASME B18.2.2-93. The dimensions prior to zinc coating are given in Table 4 and Table 5.

[3]ASTM publications are available from the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA (http://www.astm.org/).

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4.5 Semicone points

Machine bolts and double-arming bolts that are 1/2 in, 5/8 in, and 3/4 in in diameter, 8 in and longer, shall have semicone points with the nominal dimensions shown in Table 6. The thread end of bolts not requiring semicone points shall be chamfered or rounded.

NOTE—1 in = 25.4 mm

Table 1—Dimensions of square-head bolts (in inches)

Nominal bolt size	Width across flats			Width across corners		Height			Maximum radius of fillet
	Basic	Max.	Min.	Max.	Min.	Basic	Max.	Min.	
3/8	9/16	0.562	0.544	0.795	0.747	1/4	0.268	0.232	0.031
1/2	3/4	0.750	0.725	1.061	0.995	21/64	0.348	0.308	0.031
5/8	15/16	0.938	0.906	1.326	1.244	27/64	0.444	0.400	0.062
3/4	1 1/8	1.125	1.088	1.591	1.494	1/2	0.524	0.476	0.062
7/8	1 5/16	1.312	1.269	1.856	1.742	19/32	0.620	0.568	0.062
1	1 1/2	1.500	1.450	2.121	1.991	21/32	0.684	0.628	0.093
1 1/4	1 7/8	1.875	1.812	2.652	2.489	27/32	0.876	0.812	0.093

NOTES

1—The top of the head shall be flat and chamfered. The diameter of the chamfer circle shall be equal to the maximum width across flats, within a tolerance of –15%.

2—The maximum width across flats applies at all points. No transverse section through the head between 25% and 75% of head height, as measured from the bearing surface, shall be less than the minimum width across flats.

3—The bearing surface shall be at right angles to the axis of the body within a tolerance of 3° for sizes 1 in and smaller, and 2° for sizes larger than 1 in.

4—The axis of the head shall be concentric with the axis of the body (determined by one diameter length of the body under the head) within a tolerance equal to 3% (6% FIR) of maximum width across flats.

5—Any swell, fin under the head, or die seam on the body shall not exceed the basic bolt diameter by the following:
0.030 in for sizes up to 1/2 in, inclusive
0.050 in for sizes 5/8 in and 3/4 in
0.060 in for sizes 7/8 in to 1 1/4 in, inclusive

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Table 2—Dimensions of hex-head bolts (in inches)

Nominal bolt size	Width across flats			Width across corners		Height			Maximum radius of fillet
	Basic	Max.	Min.	Max.	Min.	Basic	Max.	Min.	
3/8	9/16	0.562	0.544	0.650	0.620	1/4	0.268	0.226	0.031
1/2	3/4	0.750	0.725	0.866	0.826	11/32	0.364	0.302	0.031
5/8	15/16	0.938	0.906	1.083	1.033	27/64	0.444	0.378	0.062
3/4	1 1/8	1.125	1.088	1.299	1.240	1/2	0.524	0.455	0.062
7/8	1 5/16	1.312	1.269	1.516	1.447	37/64	0.604	0.531	0.062
1	1 1/2	1.500	1.450	1.732	1.653	43/64	0.700	0.591	0.093
1 1/4	1 7/8	1.875	1.812	2.165	2.066	27/32	0.876	0.749	0.093

NOTES

1—The top of the head shall be flat and chamfered. The diameter of the chamfer circle shall be equal to the maximum width across flats, within a tolerance of –15%.

2—The maximum width across flats applies at all points. No transverse section through the head between 25% and 75% of head height, as measured from the bearing surface, shall be less than the minimum width across flats.

3—The bearing surface shall be at right angles to the axis of the body within a tolerance of 3° for sizes 1 in and smaller, and 2° for sizes larger than 1 in.

4—The axis of the head shall be concentric with the axis of the body (determined by one diameter length of the body under the head) within a tolerance equal to 3% (6% FIR) of maximum width across flats.

5—Any swell, fin under the head, or die seam on the body shall not exceed the basic bolt diameter by the following:
0.030 in for sizes up to 1/2 in, inclusive
0.050 in for sizes 5/8 in and 3/4 in
0.060 in for sizes 7/8 in to 1 1/4 in, inclusive

Table 3—Dimensions of carriage bolt heads (in inches)

Nominal bolt size	Diameter of head			Height of head			Depth of square		Width of square	
	Basic	Max.	Min.	Basic	Max.	Min.	Max.	Min.	Max.	Min.
3/8	13/16	0.844	0.782	3/16	0.208	0.188	0.219	0.188	0.388	0.368
1/2	1 1/16	1.094	1.032	1/4	0.270	0.250	0.281	0.250	0.515	0.492
5/8	1 5/16	1.344	1.219	5/16	0.344	0.313	0.344	0.313	0.642	0.616
3/4	1 9/16	1.594	1.469	3/8	0.406	0.375	0.406	0.375	0.768	0.741
7/8	1 13/16	1.844	1.719	7/16	0.469	0.438	0.469	0.438	0.895	0.865
1	2 1/16	2.094	1.969	1/2	0.531	0.500	0.531	0.500	1.022	0.990

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Table 4—Dimensions of square nuts (in inches)

Nominal bolt size	Width across flats			Width across corners		Thickness		
	Basic	Max.	Min.	Max.	Min.	Basic	Max.	Min.
3/8	5/8	0.625	0.606	0.884	0.832	21/64	0.346	0.310
1/2	13/16	0.812	0.788	1.149	1.082	7/16	0.458	0.418
5/8	1	1.000	0.969	1.414	1.330	35/64	0.569	0.525
3/4	1 1/8	1.125	1.088	1.591	1.494	21/32	0.680	0.632
7/8	1 5/16	1.312	1.269	1.856	1.742	49/64	0.792	0.740
1	1 1/2	1.500	1.450	2.121	1.991	7/8	0.903	0.847
1 1/4	1 7/8	1.875	1.812	2.652	2.489	1 3/32	1.126	1.062

NOTES

1—The maximum width across flats applies at all points. No transverse section through the nut between 25% and 75% of the nut thickness, as measured from the bearing face, shall be less than the minimum width across flats.

2—The tops of nuts shall be flat and chamfered or washer crowned. The diameter of the chamfer circle shall be equal to the maximum width across flats within a tolerance of –15%.

3—The bearing surface shall be at right angles to the axis of the threaded hole within a tolerance of 3° for size 1 in nuts or smaller, and 2° for nuts larger than 1 in.

4—The axis of the tapped hole shall be concentric with the axis of the nut body within a tolerance equal to 5% (10% FIR) of the maximum width across flats.

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Table 5—Dimensions of hex nuts (in inches)

Nominal bolt size	Width across flats			Width across corners		Thickness		
	Basic	Max.	Min.	Max.	Min.	Basic	Max.	Min.
3/8	9/16	0.562	0.551	0.650	0.628	21/64	0.337	0.320
1/2	3/4	0.750	0.736	0.866	0.840	7/16	0.448	0.427
5/8	15/16	0.938	0.922	1.083	1.051	35/64	0.559	0.535
3/4	1 1/8	1.125	1.088	1.299	1.240	41/64	0.665	0.617
7/8	1 5/16	1.312	1.269	1.516	1.447	3/4	0.776	0.724
1	1 1/2	1.500	1.450	1.732	1.653	55/64	0.887	0.831
1 1/4	1 7/8	1.875	1.812	2.165	2.066	1 1/16	1.094	1.030

NOTES

1—The maximum width across flats applies at all points. No transverse section through the nut between 25% and 75% of the nut thickness, as measured from the bearing face, shall be less than the minimum width across flats.

2—Nuts, in sizes up to and including 5/8 in, shall be double-chamfered. Larger-sized nuts shall be double chamfered or have washer-faced bearing surface and chamfered top. The diameter of the chamfer circle on double-chamfered nuts and the diameter of the washer face shall be equal to the maximum width across flats within a tolerance of –5%. The tops of washer-faced nuts shall be flat and the diameter of the chamfer circle shall be equal to the maximum width across flats within a tolerance of –15%. The length of the chamfer at hex corners shall be from 5% to 15% of the basic thread diameter. The surface of the chamfer may be slightly convex or rounded.

3—Where a rounding or lack of fill at the junction of hex corners with the chamfer exists, the minimum width across corners shall be reached and maintained beyond a distance equal to 17.5% of the basic thread diameter from the chamfer faces.

4—The bearing surface shall be flat and at right angles to the axis of the threaded hole within a tolerance of 2° for size 5/8 in nuts or smaller, and 1° for nuts larger than 5/8 in.

5—Tapped holes shall be countersunk on the bearing face or faces. The maximum countersink diameter shall be the thread basic (nominal) major diameter plus 0.025 in for size 3/8 in nuts or smaller, and 1.06 times the basic major diameter for nuts larger than 3/8 in.

6—The axis of the tapped hole shall be concentric with the axis of the nut body within a tolerance equal to 3% (6% FIR) of the maximum width across flats.

Table 6—Dimensions of semicone points (in inches)

Bolt size	Approximate length of point beyond last thread	Approximate included angle of point
1/2	3/16	60°
5/8	1/4	60°
3/4	3/8	60°

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5. Threads

5.1 Kind of thread

Bolt threads shall be machine rolled or cut.

5.2 Dimensions and class of external thread for bolts

The threaded portion of all bolts shall, before zinc coating, be in accordance with Class 2 of ANSI/ASME B1.1-89 and Table 7.

Table 7—Dimensions of unified screw threads (in inches)

Nominal bolt size	Bolt threads		Major diameter[a]			Pitch diameter[b]		Minor[c] diameter
	Number per inch	Stress area (sq in)	Max.	Min.	Min.[d]	Max.	Min.	Nominal
3/8	16	0.077	0.374	0.364	0.359	0.333	0.329	0.297
1/2	13	0.142	0.499	0.488	0.482	0.449	0.443	0.404
5/8	11	0.226	0.623	0.611	0.605	0.564	0.559	0.512
3/4	10	0.334	0.748	0.735	0.729	0.683	0.677	0.625
7/8	9	0.462	0.873	0.859	0.852	0.801	0.795	0.737
1	8	0.606	0.998	0.983	0.975	0.917	0.910	0.845
1 1/4	7	0.969	1.248	1.231	1.223	1.155	1.148	1.072

[a]On a straight thread, the major diameter is the diameter of the coaxial cylinder, that would bound the crests of an external thread or the roots of an internal thread.
[b]On a straight thread, the pitch diameter is the diameter of the coaxial cylinder, the surface of which would pass through the thread profiles at such points as to make the width of the groove equal to one-half the basic pitch. On a perfect thread, this occurs at the point where the widths of the thread and groove are equal.
[c]On a straight thread, the minor diameter is the diameter of the coaxial cylinder, which would bound the roots of an external thread or the crests of an internal thread.
[d]For unfinished hot-rolled material.

5.3 Threads of zinc-coated bolts

The external threaded portion of all bolts shall, after zinc coating, be in a condition such that nuts, tapped in accordance with Table 8, will fit the zinc-coated bolt so that the nut can be run the entire length of the thread without the use of tools.

5.4 Dimensions for nuts and tapped parts

After zinc coating, all nuts and internally threaded parts shall be tapped oversize in accordance with the dimensions given in Table 8.

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Table 8—Dimensions for nuts and tapped parts (in inches)

Nominal bolt size	Number of threads per inch	Internal threads					Nominal tap size OD
		Pitch diameter		Minor diameter		Major diameter	
		Min.	Max.	Min.	Max.	Min.	
3/8	16	0.351	0.357	0.324	0.338	0.392	0.392-16
1/4	13	0.468	0.475	0.435	0.452	0.518	0.518-13
5/8	11	0.586	0.593	0.547	0.566	0.645	0.645-11
3/4	10	0.705	0.713	0.622	0.683	0.770	0.770-10
7/8	9	0.825	0.833	0.777	0.800	0.897	0.897-9
1	8	0.943	0.952	0.889	0.914	1.024	1.024-8
1 1/4	7	1.181	1.191	1.119	1.147	1.274	1.274-7

5.5 Length of threads

Unless otherwise stated, all bolts shall have thread lengths as given in Table 9.

Table 9—Thread length of bolts (in inches)[a]

Kind of bolt	Size	Bolt lengths	Minimum thread length excluding points
Carriage	3/8	3 up to less than 8	1 3/4
Carriage	1/2, 5/8, 3/4, 7/8, 1	4 up to less than 8	3
Machine	3/8, 1/2, 5/8, 3/4, 7/8, 1	4 up to less than 8	3
Machine	1/2, 5/8, 3/4, 7/8, 1, 1 1/4	8 up to less than 12	4
Machine	1/2, 5/8, 3/4, 7/8, 1, 1 1/4	12 and over	6
Double-arm	1/2, 5/8, 3/4	All lengths	Full thread
Double-end	7/8, 1	All lengths	3 at each end

[a]Bolts shorter or smaller, or both, than those listed shall have minimum thread lengths in accordance with ANSI B18.2.1-92.

6. Strength

6.1 Tensile strength

Bolts with nuts assembled shall meet the minimum tensile requirements listed in Table 10.

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Table 10—Tensile strength of bolts (in pounds)

Size and kind of bolt	Minimum tensile strength	
	Kilonewtons (kN)	Pounds-force (lbf)
3/8 in carriage or machine bolt	18.9	4250
1/2 in carriage, machine, or double-arming bolt	34.7	7800
5/8 in machine or double-arming bolt	55.2	12 400
3/4 in machine or double-arming bolt	81.6	18 350
7/8 in machine or double-end bolt	113	25 400
1 in machine or double-end bolt	149	33 500
1 1/4 in machine or double-end bolt	237	53 300

Failure shall occur in the shank or threaded section and not at the junction of the head and shank, and threads shall not strip below minimum specified tensile strength.

6.2 Cold bend test

The non-threaded portion of bolts shall be capable of being bent while at room temperature at any point through an angle of 180°, about a diameter equal to the diameter of the bolt without cracking the steel on the outside of the bent portion. In the case of completely threaded bolts, the threads shall be removed and the 180° bend shall be about a diameter equal to the reduced diameter of the bolt.

7. Sizes

Bolt sizes and lengths shall be as given in Table 11.

Table 11—Sizes and lengths of bolts (in inches)

Kind of bolt	Sizes	Lengths
Carriage	3/8, 1/2	4, 4 1/2, 5, 6
Machine	3/8	4 1/2, 5, 6
Machine	1/2	4 1/2, 5, 6, 8, 10, 12
Machine	5/8	6, 8, 10, 12, 14, 16, 18, 20
Machine	3/4, 7/8, 1, 1 1/4	8, 10, 12, 14, 16, 18
Double-arm	5/8, 3/4, 7/8, 1, 1 1/4	12, 14, 16, 18, 20, 22, 24
Double-end	7/8, 1, 1 1/4	12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36

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Unless otherwise specified, each machine bolt and carriage bolt shall be furnished with one nut assembled thereon, each double-arming bolt shall be furnished with four nuts assembled thereon, and each double-end bolt shall be furnished with two nuts assembled thereon.

8. Corrosion protection

All bolts and nuts shall be zinc coated. The coating shall be applied by

a) The hot-dip process in accordance with ASTM A153/A153M-95, or
b) Another method producing a zinc coating that meets the requirements of ASTM A153/A153M-95 for adhesion, purity, and thickness applicable to the class of material being coated.

9. Finish

Bolts shall be free from burrs, seams, laps, and irregular surfaces that affect serviceability.

10. Marking of bolts

All bolt heads shall bear the manufacturer's symbol or identification mark.

11. Marking of shipping packages

Each package of bolts shall be marked with the vendor's name and catalog number.

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