TOWER BOLTS

METRIC HEX TRANSMISSION TOWER BOLTS

IFI 541 1982

IFI NOTE:

IFI-541 is a new standard which is currently being considered for use as the basis for an American National standard by ASME Standards Committee B18. When an ANSI standard for metric hex transmission tower bolts is published, IFI will withdraw IFI-541 and support the ANSI standard.

GENERAL DATA

1. Scope.

1.1 This standard covers the complete general and dimensional data for metric hex transmission tower bolts. These bolts are suitable for use in the construction of transmission towers, substations and similar structures.

1.2 Guidance to assist designers in the selection and use of hex transmission tower bolts is given in a Commentary.

2. Comparison With ISO Standards

2.1 There are no ISO standards for hex transmission tower bolts. An effort was made to develop such standards but, because of irreconcilable differences between national practices, the ISO project was abandoned in March, 1980.

2.2 Letter symbols designating dimensional characteristics are in accord with those used in ISO standards, except capitals have been used for data processing convenience instead of lower case letters used in ISO standards.

3. Dimensions.

3.1 All dimensions in this standard are in millimeters, unless stated otherwise.

3.2 Symbols specifying geometric characteristics are in accord with American National Standard, Dimensioning and Tolerancing, ANSI Y14.5-1973.

4. Surface Condition. Bolts need not be finished on any surface except the threads.

5. Top of Head. The top of head shall be full form and chamfered or rounded. The diameter of the chamfer circle or the start of rounding shall be equal to the maximum width across flats within a tolerance of minus 15 percent.

6. Head Height. The head height is the distance, as measured parallel to the axis of the bolt, from the top of the head to the under head bearing surface.

7. Wrenching Height. The wrenching height is the distance, measured at a corner of the hex, from the plane of the bearing surface to the last plane of full formed hex, i.e., the plane closest to the top of head at which the width across corners of the hex is within its specified limits.

8. Corner Fill. The rounding due to lack of fill at the six corners of the head shall be reasonably uniform.

9. True Position of Head. The axis of the hex head shall be located at true position with respect to the axis of the bolt (determined over a distance under the head equal to one bolt diameter) within a tolerance zone of diameter equal to 6 percent of the specified maximum width across flats.

10. Bearing Surface. The bearing surface shall be reasonably flat, and, at the manufacturer's option, may be washer-faced. A die seam across the bearing face shall be permissible. Bearing surface shall be perpendicular to the axis of the body within a tolerance of 3 deg. Angularity measurement shall be taken at a location to avoid interference from a die seam.

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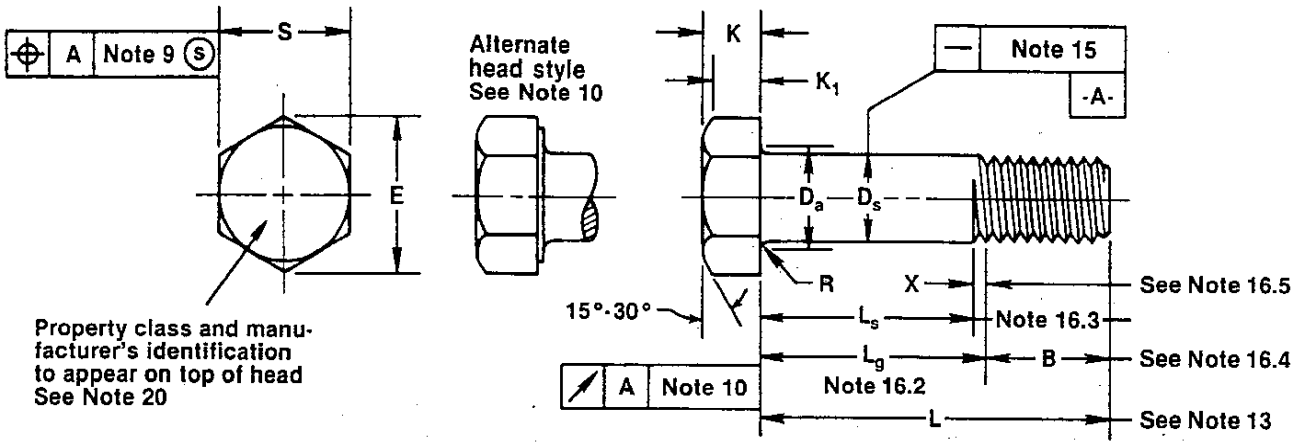

Table 1 Dimensions of Hex Transmission Tower Bolts

D	D_s		S		E		K		K_1	D_a	R	B (Ref)	X (Ref)
Nom Bolt Dia and Thread Pitch	Body Diameter		Width Across Flats		Width Across Corners		Head Height		Wrenching Height	Fillet Transition Dia	Radius of Fillet	Thread Length	Transition Thread Length
	Max	Min	Max	Min	Max	Min	Max	Min	Min	Max	Min	Basic	Max
M16 × 2	16.70	15.30	24.00	23.16	27.71	26.17	10.75	9.68	7.0	17.7	0.6	27.5	6.0
M20 × 2.5	20.84	19.16	30.00	29.16	34.64	32.95	13.40	12.12	8.8	22.4	0.8	32.0	7.5
M24 × 3	24.84	23.16	36.00	35.00	41.57	39.55	15.90	14.56	10.5	26.4	0.8	36.0	9.0
See Notes	11				7,8		6		7	12		16.4	16.5

11. Bolt Diameter.

11.1 Bolts shall be furnished with full diameter body within the limits specified in Table 1.

11.2 There may be a reasonable swell, fin, or die seam on the body adjacent to the underside of head not to exceed the nominal bolt diameter by 1.25 mm for M16 bolts, and 1.50 mm for M20 and M24 bolts.

12. Fillet. The fillet at junction of head and shank shall be a smooth concave curve within an envelope of R minimum and a radius tangent to the shank and to the underside of the head at a point equal to one-half of Da maximum from the axis of the bolt.

13. Length. The length of the bolt shall be measured parallel to the axis of the bolt from the underside of head to the extreme end of the shank. Length tolerance shall be plus and minus 2.0 mm. Recommended lengths of bolts for connecting various grips are given in Tables X.1 and X.2 in the Commentary.

14. Point. Bolts need not be pointed.

15. Straightness. Shanks of bolts shall be straight within a maximum camber of 0.006 mm/mm of bolt length. The referee gage and gaging procedure for checking bolt straightness is given in Appendix I of ANSI B18.2.3.5, page C—32.

16. Thread Length.

16.1 The length of thread on bolts shall be controlled by the maximum grip gaging length (Lg) and the minimum body length (Ls) as set forth in 16.2 thru 16.5.

16.2 Grip gaging length, Lg max, is the distance measured parallel to the axis of the bolt, from the under head bearing surface to

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Table 2 Maximum Grip Gaging Length and Minimum Body Lengths for Hex Transmission Tower Bolts

Nom Bolt Dia and Thread Pitch	M16 × 2		M20 × 2.5		M24 × 3	
L Nom Length	Lg Max	Ls Min	Lg Max	Ls Min	Lg Max	Ls Min
30	9.0	3.0	—	—	—	—
35	9.0	3.0	10.5	3.0	—	—
40	12.5	6.5	10.5	3.0	12	3
45	17.5	11.5	13	5.5	12	3
50	22.5	16.5	18	10.5	14	5
55	27.5	21.5	23	15.5	19	10
60	32.5	26.5	28	20.5	24	15
65	37.5	31.5	33	25.5	29	20
70	42.5	36.5	38	30.5	34	25
75	47.5	41.5	43	35.5	39	30
80	52.5	46.5	48	40.5	44	35
85	57.5	51.5	53	45.5	49	40
90	62.5	56.5	58	50.5	54	45
95	67.5	61.5	63	55.5	59	50
100	72.5	66.5	68	60.5	64	55

NOTES:

1. Lg is grip gaging length; Ls is body length.
2. For bolts with longer lengths, Lg and Ls values shall be computed from formulas given in Note 16 of General Data.

the face of a non-counterbored or non-countersunk standard GO thread ring gage assembled by hand as far as the thread will permit. For standard diameter-length combinations of bolts the values for Lg max are specified in Table 2. For diameter-length combinations not listed in Table 2, the maximum grip gaging length, as calculated and rounded to one decimal place, shall be equal to the nominal bolt length, L, minus the basic thread length, B, as specified in Table 1 (Lg max = L − B). (Note: On shorter bolt lengths Lg is controlled by the requirement that there be a shoulder under the head. See 16.3) Lg max shall be used as a criterion for inspection.

16.3 Body length, Ls min, is the distance, measured parallel to the axis of the bolt, from the under head bearing surface to the last scratch of thread or the top of the extrusion angle, whichever is closest to the head. For standard diameter-length combinations of bolts the values of Ls min are given in Table 2.

For diameter-length combinations not listed in Table 2, the minimum body length, as calculated and rounded to one decimal place, is equal to the maximum grip gaging length (as computed) minus the maximum transition thread length as given in Table 1 (Ls min = Lg max − X max) except that for no bolt shall Ls be less than 3 mm. This assures a shoulder under the head. Ls min shall be used as a criterion for inspection.

16.4 Basic thread length B, as specified in Table 1, is a reference dimension intended for calculation purposes only, and is the distance, measured parallel to the axis of the bolt, from the extreme end of the bolt to the last complete (full form) thread.

16.5 Transition thread length, X max, as specified in Table 1, is a reference dimension intended for calculation purposes only. It includes the length of incomplete threads and tolerances on grip gaging length and body length. The transition from full thread to in-

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complete thread shall be smooth and uniform. The major diameter of the incomplete threads shall not exceed the actual major diameter of the complete (full form) threads.

17. Threads.

17.1 Threads shall be metric coarse thread series conforming to dimensions for general purpose external threads given in ANSI B1.13M, page A—8, unless otherwise specified by the purchaser. The class 6g tolerance shall apply to plain finish (non-galvanized) bolts, and to galvanized bolts before galvanizing.

17.2 After galvanizing the maximum limits of pitch diameter and major diameter may exceed 6g limits by 0.42 mm for M16 × 2 threads, 0.53 mm for M20 × 2.5 threads, and 0.64 mm for M24 × 3 threads.

17.3 Unless otherwise specified by the purchaser, gaging for screw thread dimensional acceptability shall be in accordance with Gaging System 21 as specified in ANSI B1.3M, page A—35.

18. Material and Mechanical Properties. Unless otherwise specified, steel bolts shall conform to the requirements specified in ASTM A394M, (refer to Commentary).

19. Finish. ASTM A394M class 8.8.3 bolts shall be furnished plain (non-galvanized). A394M classes 4.6 and 8.8 bolts shall be hot dip galvanized or mechanically galvanized as specified by the purchaser.

20. Identification Symbols. Bolts shall be marked with the property class symbol and with the manufacturer's identification symbol. Minimum height of property class symbols shall be 4.0 mm. Markings shall be located on the top of the head and may be raised or recessed unless otherwise ordered by the purchaser. When raised, markings shall project not less than 0.3 mm above the surface of the head, and total head height (head plus markings) shall not exceed the specified maximum head height plus 0.4 mm.

21. Options. Options, where specified, shall be at the discretion of the manufacturer unless otherwise agreed upon by the manufacturer and the purchaser.

22. Terminology. For definitions of terms relating to fasteners or component features thereof used in this standard, refer to American National Standard, Glossary of Terms for Mechanical Fasteners, ANSI B18.12, page J—5.

23. Workmanship. Bolts shall not contain an excess of surface imperfections which might affect their serviceability, such as burrs, seams, laps, loose scale and other irregularities.

24. Clearance Holes. The recommended sizes of clearance holes in material to be assembled using hex transmission tower bolts are the normal series given in IFI-527, page J—21.

25. Designation. Bolts shall be designated by the following data, preferably in the sequence shown: product name, nominal diameter and thread pitch, nominal length, steel property class, and protective coating, if required.

Examples:

Hex transmission tower bolt,
M20 × 2.5 × 80, class 4.6,
hot dip galvanized.

Hex transmission tower bolt,
M16 × 2 × 60, class 8.8.3

26. Inspection and Quality Assurance. Unless otherwise specified by the purchaser in the original inquiry and purchase order, acceptability shall be based on conformance with the requirements specified in ANSI B18.18.1M, page J—23.

27. Reference Standards. Titles and source of availability of all documents referenced in this standard are given on page J—48.

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COMMENTARY

The information covered in this commentary is provided to assist designers in the selection and use of metric hex transmission tower bolts.

A) Bolt/Nut Combinations.

ASTM A394M covers the material and mechanical requirements of metric hex transmission tower bolts. At the time of the printing of this book A394M was still under development by ASTM Committee F-16. Consequently, references to A394M in this Commentary are in anticipation of its contents.

It is expected that A394M will recognize 3 types of metric hex transmission tower bolts as follows:

Type 1 — low carbon steel non-heat treated bolts, with mechanical properties in conformance with property class 4.6 of ASTM F568, page B—1. Type 1 bolts are galvanized. The recommended nuts for use with Type 1 bolts are Style 1 metric hex nuts (ANSI B18.2.4.1, page D—1) with properties in conformance with ASTM A563M (page B—10) property class 5 nuts tapped oversize for galvanizing.

Type 2 — medium carbon or low carbon martensite steel, quenched and tempered bolts with mechanical properties in conformance

Table X.1 Grip Ranges[1] for Property Class 4.6 Galvanized Bolts With Property Class 5 Galvanized Nuts

Nom Bolt Length	Nom Bolt Dia and Thread Pitch					
	M16 x 2		M20 x 2.5		M24 x 3	
	Min	Max	Min	Max	Min	Max
30	10.3	11.0	—	—	—	—
35	10.3	16.0	12.2	12.3	—	—
40	13.8	21.0	12.2	17.3	—	—
45	18.8	26.0	14.7	22.3	14.0	18.6
50	23.8	31.0	19.7	27.3	16.0	23.6
55	28.8	36.0	24.7	32.3	21.0	28.6
60	33.8	41.0	29.7	37.3	26.0	33.6
65	38.8	46.0	34.7	42.3	31.0	38.6
70	43.8	51.0	39.7	47.3	36.0	43.6
75	48.8	56.0	44.7	52.3	41.0	48.6
80	53.8	61.0	49.7	57.3	46.0	53.6
85	58.8	66.0	54.7	62.3	51.0	58.6
90	63.8	71.0	59.7	67.3	56.0	63.6
95	68.8	76.0	64.7	72.3	61.0	68.6
100	73.8	81.0	69.7	77.3	66.0	73.6

NOTES:

1. Grip is the total thickness of material to be connected, including washers, if used.
2. The tabulated values are applicable to other types of tower bolts in combination with a hex Style 1 nut.

Table X.2 Grip Ranges[1] for Property Class 8.8 Galvanized Bolts With Property Class 12 Galvanized Nuts and for Property Class 8.8.3 Bolts With Property Class 8S3 Nuts

Nom Bolt Length	Nom Bolt Dia and Thread Pitch					
	M16 x 2		M20 x 2.5		M24 x 3	
	Min	Max	Min	Max	Min	Max
30	—	—	—	—	—	—
35	10.3	13.7	—	—	—	—
40	13.8	18.7	12.2	14.6	—	—
45	18.8	23.7	14.7	19.6	14.0	15.9
50	23.8	28.7	19.7	24.6	16.0	20.9
55	28.8	33.7	24.7	29.6	21.0	25.9
60	33.8	38.7	29.7	34.6	26.0	30.9
65	38.8	43.7	34.7	39.6	31.0	35.9
70	43.8	48.7	39.7	44.6	36.0	40.9
75	48.8	53.7	44.7	49.6	41.0	45.9
80	53.8	58.7	49.7	54.6	46.0	50.9
85	58.8	63.7	54.7	59.6	51.0	55.9
90	63.8	68.7	59.7	64.6	56.0	60.9
95	68.8	73.7	64.7	69.6	61.0	65.9
100	73.8	78.7	69.7	74.6	66.0	70.9

NOTES:

1. Grip is the total thickness of material to be connected, including washers, if used.
2. The tabulated values are applicable to other types of tower bolts in combination with hex Style 2 nuts or with heavy hex nuts.

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with property class 8.8 of ASTM F568. Type 2 bolts are galvanized. The recommended nuts for use with Type 2 bolts are Style 2 metric hex nuts (ANSI B18.2.4.2, page D—5) with properties in conformance with ASTM A563M class 12 nuts tapped oversize for galvanizing. Acceptable alternate nuts are heavy hex nuts (ANSI B18.2.4.6, page D—22) with properties in conformance with ASTM A563M class 10S nuts tapped oversize for galvanizing. Style 2 nuts have the same widths across flats as the bolts, heavy hex nuts have larger widths across flats and are also slightly thicker than Style 2 nuts.

Type 3 — "weathering" grade steel, quenched and tempered bolts with mechanical properties in conformance with property class 8.8.3 of ASTM F568. Type 3 bolts are furnished plain. The recommended nuts for use with Type 3 bolts are heavy hex nuts (ANSI B18.2.4.6) with properties in conformance with ASTM A563M class 8S3 nuts. If nuts of the same width across flats as the bolts are required, then nuts made of "weathering" grade steel to the dimensions of Style 2 metric hex nuts (ANSI B18.2.4.2) non-heat treated or Style 1 metric hex nuts (ANSI B18.2.4.1) heat treated are both satisfactory substitutes.

B) Bolt Length/Grip Range.

Metric hex transmission tower bolts have special thread lengths which are shorter than standard. The reason is to assure to the degree possible that shear planes in joints will occur through the unthreaded body of the bolt. Thread lengths are designed to accommodate a specified grip range, with grip defined as the total thickness of material, including washers, to be joined by the bolt. It is important when computing the grip of any joint to add the *minimum* thickness of washers when washers are used. (See page E—6 for an explanation.)

Grip ranges for hex transmission tower bolts are computed similarly to those for high strength structural bolts. A detailed analysis of how the maximum and minimum grip is computed for any bolt is given on page E—6.

Tables X.1 and X.2 present the recommended grip ranges for hex transmission tower bolts. Table X.1 grip ranges are applicable when Style 1 hex nuts are used with the bolt, and Table X.2 grip ranges are applicable when Style 2 hex nuts or heavy hex nuts are used.

In all situations, including the highly remote possibility of the most unfavorable stack-up of tolerances on bolt length, nut thickness and washer thickness occurring in the same joint, neither of the two following conditions are violated:

a) no less than one full thread pitch for nut tightening purposes, and

b) no protrusion of the nut face beyond the end of the bolt.