



National Standard of the People's Republic of China

GB/T 3098.22—2009

Mechanical properties of fasteners
made of the fine grain non-heat
treatment steel—Bolts, screws and
studs

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Foreword

SAC/TC 85 is in charge of this English translation. In case of any doubt about the contents of English translation, the Chinese original shall be considered authoritative.

The GB/T 3098 *Mechanical properties of fasteners* consists of the following standards:

- a) GB/T 3098.1—2000 *Mechanical properties of fasteners—Bolts, screws and studs*;
- b) GB/T 3098.2—2000 *Mechanical properties of fasteners—Nuts—Coarse thread*;
- c) GB/T 3098.3—2000 *Mechanical properties of fasteners—Set screws*;
- d) GB/T 3098.4—2000 *Mechanical properties of fasteners—Nuts—Fine pitch thread*;
- e) GB/T 3098.5—2000 *Mechanical properties of fasteners—Tapping screws*;
- f) GB/T 3098.6—2000 *Mechanical properties of fasteners—Bolts, screws and studs made of stainless-steel*;
- g) GB/T 3098.7—2000 *Mechanical properties of fasteners—Thread rolling screws*;
- h) GB/T 3098.8—1992 *Mechanical properties of fasteners—Parts for bolted connections for use at temperatures from $-200\text{ }^{\circ}\text{C}$ $\sim$ $+700\text{ }^{\circ}\text{C}$* ;
- i) GB/T 3098.9—2002 *Mechanical properties of fasteners—Prevailing torque type steel nuts*;
- j) GB/T 3098.10—1993 *Mechanical properties of fasteners—Bolts, screws, studs and nuts made of non-ferrous metals*;
- k) GB/T 3098.11—2002 *Mechanical properties of fasteners—Drilling screws with tapping screw thread*;
- l) GB/T 3098.12—1996 *Mechanical properties of fasteners—Cone proof load test on nuts*;
- m) GB/T 3098.13—1996 *Mechanical properties of fasteners—Torsional test and minimum torques for bolts and screws with nominal diameters from 1 mm to 10 mm*;
- n) GB/T 3098.14—2000 *Mechanical properties of fasteners—Widening test on nuts*;

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- o) GB/T 3098.15—2000 *Mechanical properties of fasteners—Nuts made of stainless-steel*;
- p) GB/T 3098.16—2000 *Mechanical properties of fasteners—Setscrews made of stainless-steel*;
- q) GB/T 3098.17—1996 *Mechanical properties of fasteners—Preloading test for the detection of hydrogen embrittlement—Parallel bearing surface method*;
- r) GB/T 3098.18—2004 *Mechanical properties of fasteners—Blind rivets testing*;
- s) GB/T 3098.19—2004 *Mechanical properties of fasteners—Blind rivets with break pull mandrel*;
- t) GB/T 3098.20—2004 *Mechanical properties of fasteners—Wing nuts with specified proof torque*;
- u) GB/T 3098.21—2008 *Mechanical properties of fasteners—Tapping screws of stainless-steel*;
- v) GB/T 3098.22—2009 *Mechanical properties of fasteners made of the fine grain non-heat treatment steel—Bolts, screws and studs*.

This part is the part 22 of GB/T 3098.

Attention is drawn to the possibility that some of the elements of this standard may be the subject of patent rights. The issuing body of this document shall not be held responsible for identifying any or all such patent rights.

Annex A of this part is normative, Annex B is informative.

This part was proposed by China Machinery Industry Federation.

This part was prepared by SAC/TC 85 National Technical Committee on Fasteners of Standardization Administration of China.

National Technical Committee 85 on Fasteners of Standardization Administration of China is responsible for the interpretation.

Mechanical properties of fasteners made of the fine grain non-heat treatment steel—Bolts, screws and studs

1 Scope

This part of GB/T 3098 specifies mechanical properties of bolts, screws, and studs (hereinafter referred to as fasteners) made of the fine grain non-heat treatment steel when tested at an ambient temperature range of 10 °C to 35 °C.

Fasteners that conformed to technical requirements in this part at this ambient temperature may not retain the specified mechanical and physical properties at elevated or lower temperatures.

This part of GB/T 3098 is applicable to fasteners:

- made of fine-grain non-heat treatment steel produced by thermal-mechanical rolling process;
- having regular screw thread in accordance with GB/T 192
- with coarse pitch thread M6 to M16, and fine pitch thread M8 × 1 to M16 × 1.5;
- with diameter/pitch combinations in accordance with GB/T 193;
- having thread tolerances in accordance with GB/T 197 or GB/T 22029.

This part is not applicable to set screws and similar threaded fasteners not under tensile stresses (see GB/T 3098.3).

This part does not specify requirements for such properties as:

- weldability;
- corrosion resistance;
- shear stress resistance;
- fatigue resistance.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of GB/T 3098. For dated references, subsequent amendments (excluding corrections), or revisions, of any of these publications do not apply to this part of GB/T 3098. However, parties to agreements based on this part of GB/T 3098 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies.

GB/T 192, *General purpose metric screw threads—Basic profile* (GB/T 192—2003, ISO 68-1:1998, ISO general purpose screw threads—Basic profile—Part 1: Metric screw threads, MOD)

GB/T 193, *General purpose metric screw threads—General plan* (GB/T 193—2003, ISO 261: 1998, ISO general purpose metric screw threads—General plan, MOD)

GB/T 196, *General purpose metric screw threads—Basic dimensions* (GB/T 196—2003, ISO 724: 1993, ISO general purpose metric screw threads—Basic dimensions, MOD)

GB/T 197, *General purpose metric screw threads—Tolerances* (GB/T 197—2003, ISO 965-1: 1998, ISO general purpose metric screw threads—Tolerances—Part 1: Principles and basic data, MOD)

GB/T 222, *Permissible tolerances for chemical composition of steel products*

GB/T 223(all parts), *Iron, steel and alloy*

GB/T 224, *Determination of depth of decarburization of steels* (GB/T 224—2008, ISO 3887:2003, MOD)

GB/T 226, *Etch test for macrostructure and defect of steels* (GB/T 226—1991, neq ISO 4969: 1980)

GB/T 228, *Metallic materials—Tensile test at ambient temperature* (GB/T 228—2002, eqv ISO 6892: 1998)

GB/T 229, *Metallic materials—Charpy pendulum impact test method* (GB/T 229—2007, ISO 148-1: 2006, Metallic materials—Charpy pendulum impact test method—Part 1: Test method, MOD)

GB/T 230.1, *Metallic materials—Rockwell hardness test—Part 1: Test method (scales A, B, C, D, E, F, G, H, K, N, T)* (GB/T 230.1—2009, ISO 6508-1: 2005, MOD)

GB/T 231.1, *Metallic materials—Brinell hardness test—Part 1: Test method* (GB/T 231.1—2009, ISO 6506-1: 2005, MOD)

GB/T 1979, *Standard diagrams for macrostructure and defect of structural steels*

GB/T 2101, *General requirement of acceptance, packaging, marking, and certification for section steel*

GB/T 2975, *Steel and steel products—Location and preparation of test pieces for mechanical testing* (GB/T 2975—1998, eqv ISO 377:1997)

GB/T 3098.1, *Mechanical properties of fasteners—Bolts, screws and studs* (GB/T 3098.1—2000, idt ISO 898-1:1999)

GB/T 3098.3, *Mechanical properties of fasteners—Set screws* (GB/T 3098.3—2000, idt ISO 898-5:1998)

GB/T 3098.13, *Mechanical properties of fasteners—Torsional test and minimum torques for bolts and screws with nominal diameters from 1 mm to 10 mm* (GB/T 3098.13—1996, idt ISO 898-7:1992)

GB/T 4336, *Standard test method for spark discharge atomic emission—Spectrometric analysis of carbon and low-alloy steel (routine method)*

GB/T 4340.1, *Metallic materials—Vickers hardness test—Part 1: Test method* (GB/T 4340.1—2009, ISO 6507-1:2005, MOD)

GB/T 5267.1, *Fasteners—Electroplated coatings* (GB/T 5267.1—2002, ISO 4042:1999, IDT)

GB/T 5267.2, *Fasteners—Non-electrolytically applied zinc flake coatings* (GB/T 5267.2—2002, ISO 10683:2000, IDT)

GB/T 5267.3, *Fasteners—Hot dip galvanized coatings* (GB/T 5267.3—2008, ISO 10684:2004, IDT)

GB/T 5276, *Fasteners—Bolts, screws, studs and nuts—Symbols and descriptions of dimensions* (GB/T 5276—1985, eqv ISO 225:1983)

GB/T 5277, *Fasteners—Clearance holes for bolts and screws* (GB/T 5277—1985, eqv ISO 273:1979)

GB/T 5779.1, *Fasteners—Surface discontinuities—Bolts, screws and studs for general requirements* (GB/T 5779.1—2000, idt ISO 6157-1:1988)

GB/T 5779.3, *Fasteners—Surface discontinuities—Bolts, screws and studs for special requirements* (GB/T 5779.3—2000, idt ISO 6157-3:1988)

GB/T 6394, *Metal—Methods for estimating the average grain size* (GB/T 6394—2002, ASTM E 112:

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1996, MOD)

GB/T 6478, *Steels for cold heading and cold extruding* (GB/T 6478—2001, neq ISO 4954:1993)

GB/T 9145, *General purpose metric screw threads—Limits of sizes for the screw threads of medium quality and preferable plan* (GB/T 9145—2003, ISO 965-2:1998, *ISO general purpose metric screw threads—Tolerances—Part 2: Limits of sizes for general purpose external and internal screw threads—Medium quality, MOD*)

GB/T 10561, *Steel—Determination of content of nonmetallic inclusions—Micrographic method using standards diagrams* (GB/T 10561—2005, ISO 4967:1998, IDT)

GB/T 14981, *Dimension, shape, mass and tolerance for hot-rolled wire rod* (GB/T 14981—2009, ISO 16124: 2004, MOD)

GB/T 16825.1—2002, *Verification of static uniaxial testing machines—Part 1: Tension/compression testing machines—Verification and calibration of the force-measuring system* (ISO 7500-1: 2004, *Metallic materials —Verification of static uniaxial testing machines—Part 1: Tension/compression testing machines—Verification and calibration of the force-measuring system, IDT*)

GB/T 22029, *Hot-dip galvanized screw threads—On external screw threads there is the clearance for accommodating the hot-dip galvanized coat* (ISO 965-4:1998, *ISO general purpose metric screw threads—Tolerances—Part 4: Limits of sizes for hot-dip galvanized external screw threads to mate with internal screw threads tapped with tolerance position H or G after galvanizing, MOD*)

GB/T 20066, *Steel and iron—Sampling and preparation of samples for the determination of chemical composition* (GB/T 20066—2006, ISO 14284:1996, MOD)

YB/T 5293, *Metallic materials—Forging test*

3 Terms and definitions

For the purposes of this part, the following terms and definitions apply.

3.1

finished fastener

fastener for which all manufacturing steps have been completed, with or without any surface coating and with full or reduced loadability, and which has not been machined into a test piece

3.2

machined test piece

test piece machined from a fastener to evaluate material properties

3.3

full-size fastener

finished fastener with a shank diameter of $d_s \approx d_2$ or $d_s > d_2$, or screw threaded to the head, or fully threaded stud

3.4

fastener with waisted shank

finished fastener with a shank diameter of $d_s < d_2$

3.5

fine-grain

grain size can be indicated by the average area or average diameter of grains, grain size number is used to indicate grain size in industrial production. Standard grain size is divided into 8 levels, 1 to 3 is coarse grain (with diameter of 250 to 125 μm), 4 to 6 is medium grain (with diameter of 88 to 44 μm), 7 to 8 is fine grain (with diameter of 31 to 22 μm)

The materials specified in this part are ferrite + pearlite or bainite steel, with the average ferrite grain size less than or equal to 8 μm .

3.6

thermal-mechanical rolling

controlled rolling, refers to control the temperature of the metal in the rolling process to obtain some valuable characteristics which cannot be obtained in ordinary rolling, such as refined grain structure, good plasticity and toughness, and high strength, etc.

4 Symbols and units

For the purposes of this part, the symbols and units given in GB/T 5276, GB/T 197 and GB/T 228 and the following apply.

A Percentage elongation after fracture (of machined test piece), %

A_f Elongation after fracture for full-size fastener

$A_{s\text{ nom}}$ Nominal stress area in thread, mm^2

b Thread length, mm

b_m Thread length of stud (screw in metal) end, mm

d Nominal thread diameter, mm

d_0 Diameter of machined test piece, mm

d_1 Basic minor diameter of external thread, mm

d_2 Basic pitch diameter of external thread, mm

d_3 Minor diameter of external thread, mm

d_a Transition diameter (internal diameter of the bearing face), mm

d_h Hole diameter of wedge or block, mm

d_s Diameter of unthreaded shank, mm

$F_{m\text{ min}}$ Minimum ultimate tensile load, N

F_p Proof load, N

k Height of the head, mm

K_v Impact strength, J

l Nominal length, mm

l_0 Total length of fastener before loading, mm

l_1 Total length of fastener after first unloading, mm

l_2 Total length of fastener after second unloading, mm

l_s Length of unthreaded shank, mm

l_t Overall length of stud, mm

l_{th} Free threaded length of fastener in testing device, mm

- L_c Length of straight portion (of machined test piece), mm
- L_0 Original gauge length (of machined test piece), mm
- L_t Total length of machined test piece, mm
- L_u Final gauge length (of machined test piece), mm
- ΔL_p Plastic elongation, mm
- M_B Breaking torque, Nm
- P Pitch of thread, mm
- r Fillet radius, mm
- R_m Tensile strength, MPa
- $R_{p0.2}$ Stress at 0.2% non-proportional elongation for machined test piece, MPa
- s Width across flats, mm
- S_0 Cross-sectional area of machined test piece before tensile test, mm²
- S_p Stress under proof load, MPa
- S_u Cross-sectional area of machined test piece after fracture, mm²
- Z Percentage reduction of area after fracture for machined test piece, %
- α Wedge angle for tensile test under wedge loading, (°)
- β Angle of the solid block for head soundness test, (°)

5 Designation system for property classes

The symbol for property classes of bolts, screws, and studs consists of two numbers, separated by a dot:

—the number to the left of the dot consists of one or two digits and indicates 1/100 of the nominal tensile strength ($R_{m,nom}$), in MPa (see Table 3, 7.1);

—the number to the right of the dot indicates 10 times the ratio between the nominal stress at 0.2% non-proportional elongation ($R_{p0.2, \text{nom}}$) (see Table 3, 7.2) and the nominal tensile strength ($R_{m, \text{nom}}$), as specified in Table 1 (yield strength ratio).

Table 1—Ratio of nominal stress at 0.2% non-proportional elongation and nominal tensile strength

Number to the right of dot	.8	.9
$R_{p0.2, \text{nom}} / R_{m, \text{nom}}$	0.8	0.9

EXAMPLE 1 A fastener of nominal tensile strength $R_{m, \text{nom}} = 800$ MPa and with a yield strength ratio of 0.8 has the property class designation "8.8". A fastener with the same material properties but with reduced loadability is designated by "08.8" (see 10.4).

For fasteners made of the fine grain steel, the letter "F" shall be added after the number to the right of the symbol dot for property classes.

NOTE In the upcoming revision of GB/T 3098.22—2009, the designation system for property classes will be modified according to the tensile strength to distinguish it from the way it is designated in GB/T 3098.1.

EXAMPLE 2 A fastener made of the fine grain non-heat treatment steel with nominal tensile strength $R_{m, \text{nom}} = 800$ MPa and a yield strength ratio of 0.8 is designated by "8.8F".

The multiplication of the nominal tensile strength and the yield strength ratio gives the nominal stress at 0.2% non-proportional elongation, in MPa.

For fasteners made of the fine grain non-heat treatment steel, the symbol for property classes shall be as specified in 10.3. For fasteners with reduced loadability, specific marking symbols are specified in 10.4.

6 Materials

6.1 Material technical requirements

Material grades, chemical composition, ferrite grain size and mechanical properties shall be as specified in Annex A (specification annex).

6.2 Suitable fasteners

The applicable fastener products, dimensions and property classes made of fine grain non-heat treatment steel wire shall be as specified in Table 2.

Table 2—Suitable fastener products, dimensions and property classes

Material grade	Nominal thread diameter mm	Property class	Applicable product
MFT8	5-16	8.8F, 08.8F	bolts, screws and studs
MFT9	5-16	9.8F, 09.8F	
MFT10	5-16	10.9F, 010.9F	studs

6.3 Recommended processes

In order to ensure the properties of cold forming bolts, screws and studs, stabilization treatment shall be conducted. Recommended guideline of processing fasteners using fine-grain non-heat treatment steel hot-rolled wire rod is seen in Annex B.

7 Mechanical and physical properties

The properties of fastener products tested at ambient temperature range of 10 °C to 35 °C (–20 °C for impact strength), and in accordance with the methods specified in Chapter 9, shall meet the requirements specified in Table 3.

Chapter 8 sets forth the applicability of test methods for fasteners of different types and dimensions.

NOTE Even if the steel properties of the fasteners meet all relevant requirements specified in Tables 2 and 3, some types of fasteners have reduced loadability due to dimensional reasons (see 8.2 and 9.3).

Table 3—Mechanical and physical properties of fasteners

No.	Mechanical or physical property		Property class		
			8.8F	9.8F	10.9F
1	Tensile strength, R_m , MPa	nom ^a	800	900	1 000
		min	800	900	1 040
2	Stress at 0.2% non-proportional elongation, $R_{p0.2}$, in MPa	nom ^a	640	720	900
		min	640	720	940
3	Stress under proof load, S_p^b , in MPa	nom	580	650	830
	Proof strength ratio $S_{p,nom}/R_{p0.2,min}$		0.91	0.90	0.88
4	Percentage elongation after fracture for machined test piece, A , %	min	12	10	9
5	Percentage reduction of area after fracture for machined test piece, Z , %	min	52	48	48

Table 3 (Continued)

No.	Mechanical or physical property		Property class		
			8.8F	9.8F	10.9F
6	Head soundness		No fracture		
7	Vickers hardness, HV $F \geq 98 \text{ N}$	min	250	290	320
		max	320	360	380
8	Brinell hardness, HBW $F = 30 D^2$	min	238	276	304
		max	304	342	361
9	Rockwell hardness, HRC	min	22	28	32
		max	32	37	39
10	Breaking torque, M_B , in Nm	min	GB/T 3098.13		
11	Impact strength, $K_v^{c,d}$, in J	min	27		
12	Surface integrity		GB/T 5779.1 ^e		

^a Nominal values are specified only for the purpose of the designation system for property classes. See Chapter 5.

^b Proof loads are specified in Tables 5 and 7.

^c Values are determined at a test temperature of $-20\text{ }^{\circ}\text{C}$.

^d Applies to $d = 16\text{ mm}$.

^e Instead of GB/T 5779.1, GB/T 5779.3 may apply by agreement between the manufacturer and the purchaser.

Tables 4 to 7 specify minimum ultimate tensile load and proof load.

Table 4—Minimum ultimate tensile loads—coarse pitch thread

Thread ^a <i>d</i>	Nominal stress area $A_{s\,nom}^b$ mm ²	Property class		
		8.8F	9.8F	10.9F
		Minimum ultimate tensile load, $F_{m,\min}(A_{s,\min} \times R_{m\min})/\text{N}$		
M5	14.2	11 350	12 800	14 800
M6	20.1	16 100	18 100	20 900
M7	28.9	23 100	26 000	30 100
M8	36.6	29 200 ^c	32 900	38 100 ^c
M10	58	46 400 ^c	52 200	60 300 ^c
M12	84.3	67 400	75 900	87 700
M14	115	92 000	104 000	120 000
M16	157	125 000	141 000	163 000

^a Where no thread pitch is indicated in a thread designation, coarse pitch is specified.

^b To calculate $A_{s\,nom}$, see 9.1.6.1.

^c For fasteners with thread tolerance 6az subject to hot dip galvanizing, the values can be reduced in accordance with GB/T 5267.3, Annex A.

Table 5—Proof load—coarse pitch thread

Thread ^a d	Nominal stress area $A_{s\,nom}^b$ mm ²	Property class		
		8.8F	9.8F	10.9F
		Proof load, $F_P (A_{s\,nom} \times S_P) / N$		
M5	14.2	8 230	9 230	11 800
M6	20.1	11 600	13 100	16 700
M7	28.9	16 800	18 800	24 000
M8	36.6	21 200 ^c	23 800	30 400 ^c
M10	58	33 700 ^c	37 700	48 100 ^c
M12	84.3	48 900	54 800	70 000
M14	115	66 700	74 800	95 500
M16	157	91 000	102 000	130 000

^a Where no thread pitch is indicated in a thread designation, coarse pitch is specified.

^b To calculate $A_{s\,nom}$, see 9.1.6.1.

^c For fasteners with thread tolerance 6az subject to hot dip galvanizing, the values can be reduced in accordance with GB/T 5267.3, Annex A.

Table 6—Minimum ultimate tensile loads—fine pitch thread

Thread $d \times P$	Nominal stress area $A_{s\,nom}^a$ mm ²	Property class		
		8.8F	9.8F	10.9F
		Minimum ultimate tensile load, $F_{m\,min} (A_{s\,nom} \times R_{m\,min}) / N$		
M8 × 1	39.2	31 360	35 300	40 800
M10 × 1	64.5	51 600	58 100	67 100
M10 × 1.25	61.2	49 000	55 100	63 600
M12 × 1.25	92.1	73 700	82 900	95 800
M12 × 1.5	88.1	70 500	79 300	91 600
M14 × 1.5	125	100 000	112 000	130 000
M16 × 1.5	167	134 000	150 000	174 000

^a To calculate $A_{s\,nom}$, see 9.1.6.1.

Table 7—Proof load—fine pitch thread

Thread $d \times P$	Nominal stress area $A_{s\,nom}^a$ mm ²	Property class		
		8.8F	9.8F	10.9F
		Proof load, $F_P (A_{s\,nom} \times S_P) / N$		
M8 × 1	39.2	22 700	25 500	32 500

Table 7 (Continued)

Thread $d \times P$	Nominal stress area $A_{s\text{ nom}}^a$ mm^2	Property class		
		8.8F	9.8F	10.9F
		Proof load, $F_p(A_{s\text{ nom}} \times S_p)/\text{N}$		
M10 $\times$ 1	64.5	37 400	41 900	53 500
M10 $\times$ 1.25	61.2	35 500	39 800	50 800
M12 $\times$ 1.25	92.1	53 400	59 900	76 400
M12 $\times$ 1.5	88.1	51 100	57 300	73 100
M14 $\times$ 1.5	125	72 500	81 200	104 000
M16 $\times$ 1.5	167	96 900	109 000	139 000
^a To calculate $A_{s\text{ nom}}$, see 9.1.6.1.				

8 Applicability of test methods

8.1 General

Two main groups of test series are established for testing the mechanical and physical properties of fasteners specified in Table 3, FF and MP. Whereas group FF is used for testing finished fasteners, group MP is used for testing material properties of the fasteners. The two groups are divided into test series FF1, FF2, FF3 and FF4, and MP1 and MP2, respectively, for different types of fasteners. However, not all mechanical and physical properties specified in Table 3 can be tested on all types or sizes of fasteners due primarily to dimensional and/or loadability reasons.

8.2 Loadability of fasteners

8.2.1 Fasteners with full loadability

A fastener with full loadability is a finished fastener, standardized or non-standardized, which, when tensile tested in accordance with the test series FF1, FF2 or MP2:

a) breaks

—in the free threaded length for fasteners with $d_s > d_2$;

—in the free threaded length or in the unthreaded shank for fasteners with $d_s \approx d_2$;

b) the minimum ultimate tensile load, $F_{m\text{ min}}$, shall be in accordance with Tables 4 or 6.

8.2.2 Fasteners with reduced loadability

A fastener with reduced loadability is a finished fastener, standardized or non-standardized, with material properties in accordance with property classes as specified in this part of GB/T 3098 which, due to its geometry, does not fulfil the test requirements for loadability when tested in accordance with test series FF1, FF2 or MP2.

A fastener with reduced loadability does not normally break in the free threaded length when tensile tested in accordance with test series FF3 or FF4.

Basically, there are two geometrical reasons for reduced loadability of fasteners compared with the ultimate tensile load of the thread:

- a) a head design which applies to bolts and screws with low head with or without external driving feature, or with low round or cylindrical head with internal driving feature or countersunk head with internal driving feature. Test series FF3 applies to these fasteners, see Table 10.
- b) a shank design which applies to fasteners which are especially designed for applications where the loadability in accordance with this part of GB/T 3098 is not required or even not desired, e.g. screws with waisted shank. Test series FF4 applies to these fasteners (This part of GB/T 3098 does not apply to these products).

8.3 Manufacturer's control

The manufacturers may apply suitable methods of his choice, such as in-process control or inspection, to ensure their fasteners conform to all the requirements specified in Table 3.

In case of dispute, the test methods in accordance with Chapter 9 shall apply.

8.4 Supplier's control

The suppliers may control the fasteners they provide using the test methods of their choice, provided that all the requirements specified in Tables 3 is met.

In case of dispute, the test methods in accordance with Chapter 9 shall apply.

8.5 Purchaser's control

The purchasers may control the quality of delivered fasteners by the test methods given in Chapter 9 using tests selected from the relevant test series given in 8.6.

8.6 Feasible tests for groups of fasteners and machined test pieces

8.6.1 General

The applicability of test series FF1 to FF3 and MP1 to MP2, using the test methods described in Chapter 9, is specified in Tables 8 to 12.

Test series FF1 to FF3 in accordance with Tables 8 to 10 are provided for testing of finished fasteners:

—FF1: tests for the determination of the properties of finished bolts and screws with full head strength and full or reduced shank (full loadability), $d_s > d_2$ or $d_s \approx d_2$, see Table 8;

—FF2: tests for the determination of the properties of finished studs with full or reduced shank (full loadability), $d_s > d_2$ or $d_s \approx d_2$, see Table 9;

—FF3: tests for the determination of the properties of finished bolts and screws with $d_s > d_2$ or $d_s \approx d_2$ and reduced loadability due to:

- a) low head with or without external driving feature,
- b) low round or low cylindrical head with internal driving feature, or
- c) countersunk head with internal driving feature,

see Table 10;

Test series MP1 and MP2 in accordance with Tables 11 and 12 are provided for testing the material properties of the fastener and/or for process development. Test series FF1 to FF3 may also be used for that purpose.

—MP1: these are tests for the determination of the material properties of the fastener and/or for process development using machined test pieces. See Table 11.

—MP2: these are tests for the determination of material properties of full-size fasteners with full loadability and/or for process development, $d_s > d_2$ or $d_s \approx d_2$. See Table 12.

8.6.2 Applicable test methods

The applicability of the test methods to the fasteners is given in Tables 8 to 12, and implications of the content in rectangles are as following:



Feasible: the test can be carried out in accordance with Chapter 9 and, in case of dispute, the test shall be carried out in accordance with Chapter 9.



Feasible, but carried out only when explicitly specified: The test can be carried out in accordance with Chapter 9 as an alternative test for a given property (e.g.: torsional test when tensile test is possible), or as a particular test if required in a product standard or by the purchaser at the time of the order (e.g. impact test).



NFNot feasible: the test cannot be carried out either because of the form and/or dimension of the fastener (e.g. length too short to test, no head), or because it applies only to a particular category of fasteners (e.g. test for quenched and tempered fasteners).

8.6.3 Delivery of test results

When, for a specific order, the purchaser requires a report including test results, they shall be established using the test methods specified in Chapter 9 and selected from Tables 8 to 12. Any specific test specified by the purchaser shall be agreed upon at the time of order.

Table 8—Test series FF1—Finished bolts and screws with full loadability

Property (see Table 3)		Test method		Property classes	
				8.8F, 9.8F, 10.9F	
				$d < 5 \text{ mm}$ or $l < 2.5 d$ or $b < 2 d$	$d \geq 5 \text{ mm}$ and $l \geq 2.5 d$ and $b \geq 2 d$
1	Minimum tensile strength, $R_{m, \min}$	Tensile test under wedge loading	9.1	NF	^a
		Tensile test	9.2	NF	^a
3	Nominal stress under proof load, $S_{P, \text{nom}}$	Proof load test	9.4	NF	
6	Head soundness	Head soundness test $d \leq 10 \text{ mm}$	$1.5 d \leq l < 3d$	9.6	
			$l \geq 3d$		
7 or 8 or 9	Hardness	Hardness test	9.7		
10	Minimum breaking torque, $M_{B, \min}$	Torsional test $1.6 \text{ mm} \leq d \leq 10 \text{ mm}$ $b \geq 1 d + 2 P$	9.8		^b
12	Surface integrity	Surface discontinuity inspection	9.10		
^a For fasteners with $d \geq 5 \text{ mm}$, $l \geq 2 d$ and $b < 2 d$, see 9.1.5 and 9.2.5. ^b May be used instead of tensile test; however, in case of dispute the tensile test applies.					

Table 9—Test series FF2—Finished studs with full loadability

Property (see Table 3)		Test method		Property classes	
				8.8F, 9.8F, 10.9F	
				$d < 5 \text{ mm}$ or $l < 3 d$ or $b < 2 d$	$d \geq 5 \text{ mm}$ and $l \geq 3 d$ and $b \geq 2 d$
1	Minimum tensile strength, $R_{m, \min}$	Tensile test	9.2	NF	^a
3	Nominal stress under proof load, $S_{P, \min}$	Proof load test	9.4	NF	
7 or 8 or 9	Hardness	Hardness test	9.7		
12	Surface integrity	Surface discontinuity inspection	9.10		
^a If fracture occurs in the threaded length of the stud (metal) end, b_m , minimum hardness applies instead of $R_{m, \min}$. Alternatively, the tensile strength R_m using machined test pieces in accordance with 9.5 may be determined.					

Table 10—Test series FF3—Finished bolts and screws with reduced loadability

Property (see Table 3)		Test method		Property classes	
				8.8F, 9.8F, 10.9F	
				$d < 5 \text{ mm}$ or $l < 2.5 d$ or $b < 2 d$	$d \geq 5 \text{ mm}$ and $l \geq 2.5 d$ and $b \geq 2 d$
1	Minimum ultimate tensile load	Tensile test for screws which do not break in the free threaded length due to head design	9.2	NF	^a
7 or 8 or 9	Hardness	Hardness test	9.7		
12	Surface integrity	Surface discontinuity inspection	9.10		
^a See relevant product standard for minimum ultimate tensile load.					

Table 11—Test series MP1—Material properties determined on machined test pieces

Property (see Table 3)		Test method		Property classes
				8.8F, 9.8F, 10.9F
				$5 \leq d \leq 16$ mm and $d_0 \geq 3$ mm and $b \geq d$ and $l \geq d + 26$ mm
				a, b, c
1	Minimum tensile strength, $R_{m, \min}$	Tensile test for machined test pieces	9.2	
2	Minimum stress at 0.2% non-proportional elongation, $R_{p0.2, \min}$			
4	Minimum elongation after fracture, $A_{\min}$			
5	Minimum reduction of area after fracture, $Z_{\min}$			
7 or 8 or 9	Hardness	Hardness test	9.7	
11	Minimum impact strength $K_{v, \min}$	Impact test $d = 16$ mm and l^d or $l_t \geq 55$ mm	9.9	
12	Surface integrity ^e	Surface discontinuity inspection	9.10	
^a To determine the minimum total length for studs, add 1 d to the length formula. ^b For bolts and screws $l \geq d + 20$ mm to determine $Z_{\min}$. ^c For studs and full threaded studs $l_t \geq 2d + 20$ mm to determine $Z_{\min}$. ^d The solid part of the head may be included. ^e To be evaluated before machining.				

Table 12—Test series MP2—Material properties determined on finished fasteners with full loadability

Property (see Table 3)		Test method		Property classes
				8.8F, 9.8F, 10.9F
				$d \geq 5$ mm and $l \geq 2.7d^a$ and $b \geq 2.2d$
1	Minimum tensile strength, $R_{m, \min}$	Tensile test for finished fasteners	9.2	b
3	Stress under proof load S_p	Proof load test for finished fasteners	9.4	b
7 or 8 or 9	Hardness	Hardness test	9.7	
12	Surface integrity	Surface discontinuity inspection	9.10	
^a For studs: $l_t \geq 3.2d$. ^b $l \geq 2.5d$ and $b \geq 2d$.				

9 Test methods

9.1 Tensile test under wedge loading of finished bolts and screws (excluding studs)

9.1.1 General

The purpose of this tensile test is to determine simultaneously:

- the tensile strength on finished bolts and screws, R_m ;
- the integrity of the transition section between the head and the unthreaded shank or the thread.

9.1.2 Applicability

This test applies to bolts and screws with or without flange having the following specifications:

- flat bearing surface or serrated surfaces;
- head stronger than the threaded section;
- head stronger than any unthreaded shank;
- diameter of any unthreaded shank, $d_s \geq d_2$ or $d_s \approx d_2$;
- nominal length, $l \geq 2.5d$;
- thread length, $b \geq 2d$;
- $5 \text{ mm} \leq d \leq 16 \text{ mm}$;
- all property classes.

9.1.3 Apparatus

The tensile testing machine shall be in accordance with GB/T 16825.1. Self-aligning grips shall not be used.

9.1.4 Testing device

The grips, the wedge and the adaptors shall be in accordance with the following:

- hardness of 45 HRC min;

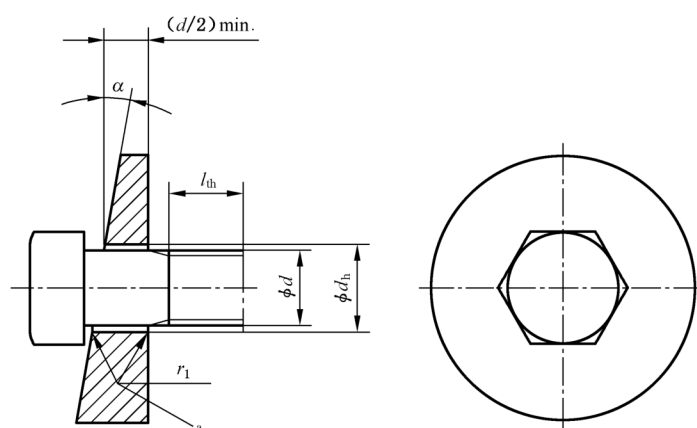
—thread tolerance class of the internally threaded adaptor in accordance with Table 13;

—hole diameter, d_h , in accordance with Table 14;

—wedge in accordance with Figure 1 and Tables 14 and 15.

Table 13—Thread tolerance classes of internally threaded adaptors

Finish of fastener	Thread tolerance class	
	Thread tolerance class of fastener before any surface coating	Thread tolerance class of internally threaded adaptor
As processed	6h or 6g	6H
Electroplating to GB/T 5267.1	6g or 6e or 6f	6H
Zinc flake coating to GB/T 5267.2	6g or 6e or 6f	6H
Hot dip galvanizing to GB/T 5267.3 in order to mate with nuts tapped to thread tolerance classes:		
—6H	6az	6H
—6AZ	6g or 6h	6AZ
—6AX	6g or 6h	6AX



^a Radius or chamfer of 45°.

Figure 1—Wedge loading of finished bolts and screws

Table 14—Hole diameters and radius for the wedge

In mm

Nominal thread diameter d	$d_h^{a,b}$		r_1^c
	min	max	
5	5.5	5.68	0.7
6	6.6	6.82	0.7

Table 14 (Continued)

In mm

Nominal thread diameter d	$d_h^{a,b}$		r_1^c
	min	max	
7	7.6	7.82	0.8
8	9	9.22	0.8
10	11	11.27	0.8
12	13.5	13.77	0.8
14	15.5	15.77	1.3
16	17.5	17.77	1.3
^a Medium series in accordance with GB/T 5277. ^b For square neck bolts, the hole shall be adapted to accommodate the square neck. ^c For product grade C, a radius r_1 should be used in accordance with the following formula: $r_1 = r_{\max} + 0.2$ where: $r_{\max} = (d_{a\max} - d_{s\min})/2$.			

Table 15—Wedge angle, α , for tensile test under wedge loading

Nominal thread diameter d	Property classes for	
	bolts and screws with unthreaded shank length $l_s \geq 2d$	screws threaded to the head and bolts and screws with unthreaded shank length $l_s < 2d$
	8.8F, 9.8F, 10.9F	
$5 \leq d \leq 16$	$10^\circ \pm 30'$	$6^\circ \pm 30'$

For finished bolts and screws with head-bearing diameters above $1.7d$ that fail the wedge tensile test, the head may be machined to $1.7d$ and re-tested on the wedge angle specified in Table 15.

Moreover, for finished bolts and screws with head-bearing diameters above $1.9d$, the 10° wedge angle may be reduced to 6° .

9.1.5 Test procedure

Specimens shall be bolts or screws qualified after inspection, such as size inspection.

Place the wedge specified in 9.1.4 under the head of the bolt or screw as shown in Figure 1. The free threaded length, l_{th} , subjected to the load shall be a minimum of $1d$.

The tensile test under wedge loading shall be carried out in accordance with GB/T 228. The speed of testing, as determined with a free-running cross-head, shall not exceed 25 mm/min.

The tensile test shall be continued until fracture occurs.

Measure the ultimate tensile load, F_m .

9.1.6 Test results

9.1.6.1 Determination of tensile strength, R_m

9.1.6.1.1 Method

The calculation of the tensile strength, R_m , is based on the nominal stress area, $A_{s,nom}$, and the ultimate tensile load, F_m , measured during the test:

$$R_m = F_m / A_{s,nom}$$

with:

$$A_{s,nom} = (\pi/4) \times [(d_2 + d_3)/2]^2$$

where

d_2 is the basic pitch diameter of external thread in accordance with GB/T 196;

d_3 is the minor diameter of external thread;

$$d_3 = d_1 - H/6$$

d_1 is the basic minor diameter of external thread in accordance with GB/T 196;

H is the height of the fundamental triangle of the thread in accordance with GB/T 192.

Values of the nominal stress area, $A_{s,nom}$, are given in Tables 4 and 6.

9.1.6.1.2 Requirements

For bolts and screws with $d_s > d_2$ and screws threaded to the head, the fracture shall occur in the free threaded length.

For fasteners with $d_s \approx d_2$, the fracture shall occur in the free threaded length or in the unthreaded shank.

R_m shall meet the requirements specified in Table 3. The minimum ultimate tensile load, $F_{m,min}$, specified in Tables 4 and 6 shall be met.

9.1.6.2 Determination of integrity of transition section between head and unthreaded shank/thread

The fracture shall not occur in the head.

For bolts and screws with unthreaded shank, the fracture shall not occur in the transition section between the head and the shank.

For screws threaded to the head, the fracture that causes failure may extend or spread into the transition section between the head and the thread, or into the head, before separation, provided it originates in the free threaded length.

9.2 Tensile test for finished fasteners for determination of tensile strength

9.2.1 General

The purpose of this tensile test is to determine the tensile strength on finished fasteners, R_m .

9.2.2 Applicability

This test applies to bolts, screws and studs having the following specifications:

- bolts and screws with head stronger than the threaded shank;
- bolts and screws with head stronger than any unthreaded shank;
- diameter of any unthreaded shank of $d_s > d_2$ or $d_s \approx d_2$;
- bolts and screws with nominal length $l \geq 2.5d$;
- thread length $b \geq 2d$;
- studs with total length $l_t \geq 3d$;
- $5 \text{ mm} \leq d \leq 16 \text{ mm}$;
- all property classes.

9.2.3 Apparatus

The tensile testing machine shall be in accordance with GB/T 16825.1. Side thrust on the fastener shall be avoided, e.g. by self-aligning grips.

9.2.4 Testing device

The grips and the adaptors shall be as follows:

—hardness, 45 HRC min;

—hole diameter, d_h , in accordance with Table 14;

—thread tolerance class of the internally threaded adaptor(s) in accordance with Table 13.

9.2.5 Test procedure

Specimens shall be bolts or screws qualified after inspection, such as size inspection.

Mount the bolts and screws to be tested into adaptors as shown in Figures 2a) and 2b); mount the studs to be tested into two threaded adaptors as shown in Figures 2c) and 2d). The length of thread engagement shall be at least $1d$.

The free threaded length, l_{th} , subjected to the load shall be minimum $1d$.

The tensile test shall be carried out in accordance with GB/T 228. The speed of testing, as determined with a free-running cross-head, shall not exceed 25 mm/min.

The tensile test shall be continued until fracture occurs.

Measure the ultimate tensile load, F_m .

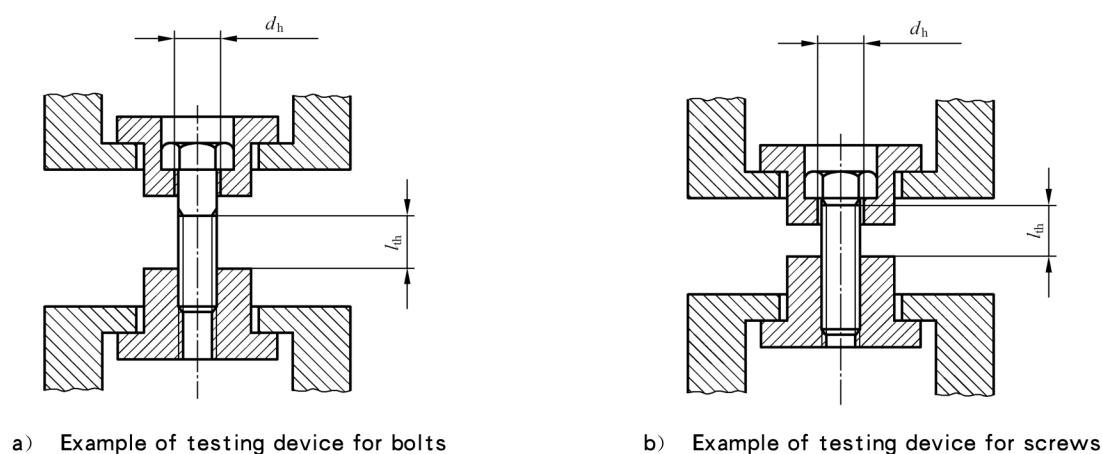


Figure 2—Examples of testing devices

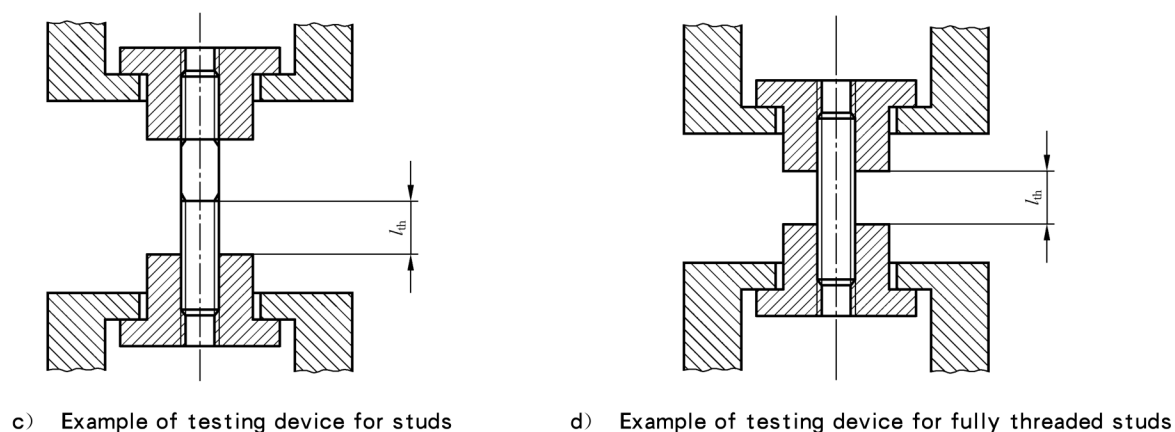


Figure 2 (Continued)

9.2.6 Test results

9.2.6.1 Method

For calculation, see 9.1.6.1.

9.2.6.2 Requirements

For fasteners with $d_s > d_2$, the fracture shall occur in the free threaded length.

For fasteners with $d_s \approx d_2$, the fracture shall occur in the free threaded length or in the unthreaded shank.

For screws threaded to the head, the fracture which causes failure may extend or spread into the transition section between the head and the thread or into the head before separation, provided that it originates in the free threaded length.

R_m shall meet the requirements specified in Table 3. The minimum ultimate tensile load, $F_{m,min}$, specified in Tables 4 and 6 shall be met.

9.3 Tensile test for bolts and screws with reduced head strength

9.3.1 General

The purpose of this tensile test is to determine the tensile load for bolts and screws not expected to break in the free threaded length and with head strength lower than the threaded section (see 8.2).

9.3.2 Applicability

This test applies to bolts and screws having the following specifications:

- diameter of any unthreaded shank $d_s > d_2$ or $d_s \approx d_2$;
- nominal length $l \geq 2.5d$;
- thread length $b \geq 2d$;
- $5 \text{ mm} \leq d \leq 16 \text{ mm}$;
- all property classes.

9.3.3 Apparatus

The tensile testing machine shall be in accordance with GB/T 16825.1. Side thrust on the fastener shall be avoided, e.g. by self-aligning grips.

9.3.4 Testing device

The grips and the adaptors shall be as follows:

- hardness, 45 HRC min;
- hole diameter, d_h , in accordance with Table 14;
- thread tolerance class of the internally threaded adaptor(s) in accordance with Table 13.

9.3.5 Test procedure

Specimens shall be bolts or screws qualified after inspection, such as size inspection.

Mount the fastener to be tested into an adaptor as shown in Figures 2a) and b);

The free threaded length, l_{th} , subjected to the load shall be minimum $1d$.

The tensile test shall be carried out in accordance with GB/T 228. The speed of testing, as determined with a free-running cross-head, shall not exceed 25 mm/min.

The tensile test shall be continued until fracture occurs.

Measure the ultimate tensile load, F_m .

9.3.6 Test results—Requirement

The ultimate tensile load, F_m , shall be equal to or above the minimum ultimate tensile load as specified in the relevant product standard.

9.4 Proof load test for finished fasteners

9.4.1 General

The proof load test consists of two main steps of operations, as follows:

- application of a specified tensile proof load (see Figure 3), and
- measurement of permanent elongation, if any, caused by the proof load.

9.4.2 Applicability

This test applies to bolts, screws and studs having the following specifications:

- bolts and screws with head stronger than the threaded shank;
- bolts and screws with head stronger than any unthreaded shank;
- diameter of unthreaded shank $d_s > d_2$ or $d_s \approx d_2$;
- bolts and screws with nominal length $l \geq 2.5d$;
- thread length $b \geq 2d$;
- studs with total length $l_t \geq 3d$;
- $5 \text{ mm} \leq d \leq 16 \text{ mm}$;
- all property classes.

9.4.3 Apparatus

The tensile testing machine shall be in accordance with GB/T 16825.1. Side thrust on the fastener shall be avoided, e.g. by self-aligning grips.

9.4.4 Testing device

The grips and the adaptors shall be as follows:

—hardness, 45 HRC min;

—hole diameter, d_h , in accordance with Table 14;

—thread tolerance class of the internally threaded adaptor(s) in accordance with Table 13.

9.4.5 Test procedure

The fastener as received shall be suitably prepared at each end, e.g. as shown in Figure 3. For length measurements, place the fastener in a bench-mounted measuring instrument fitted with spherical anvils or any other suitable method. Gloves or tongs shall be used to minimize measurement error caused by influence of temperature. Measure the total length of the fastener before loading, l_0 .

Mount the fastener to be tested into adaptors as shown in Figure 3. For studs, use two threaded adaptors. The length of thread engagement shall be at least $1d$. The free threaded length, l_{th} , subjected to the load shall be $1d$.

NOTE To obtain $l_{th} = 1d$ in a practical way, the following procedure is proposed:

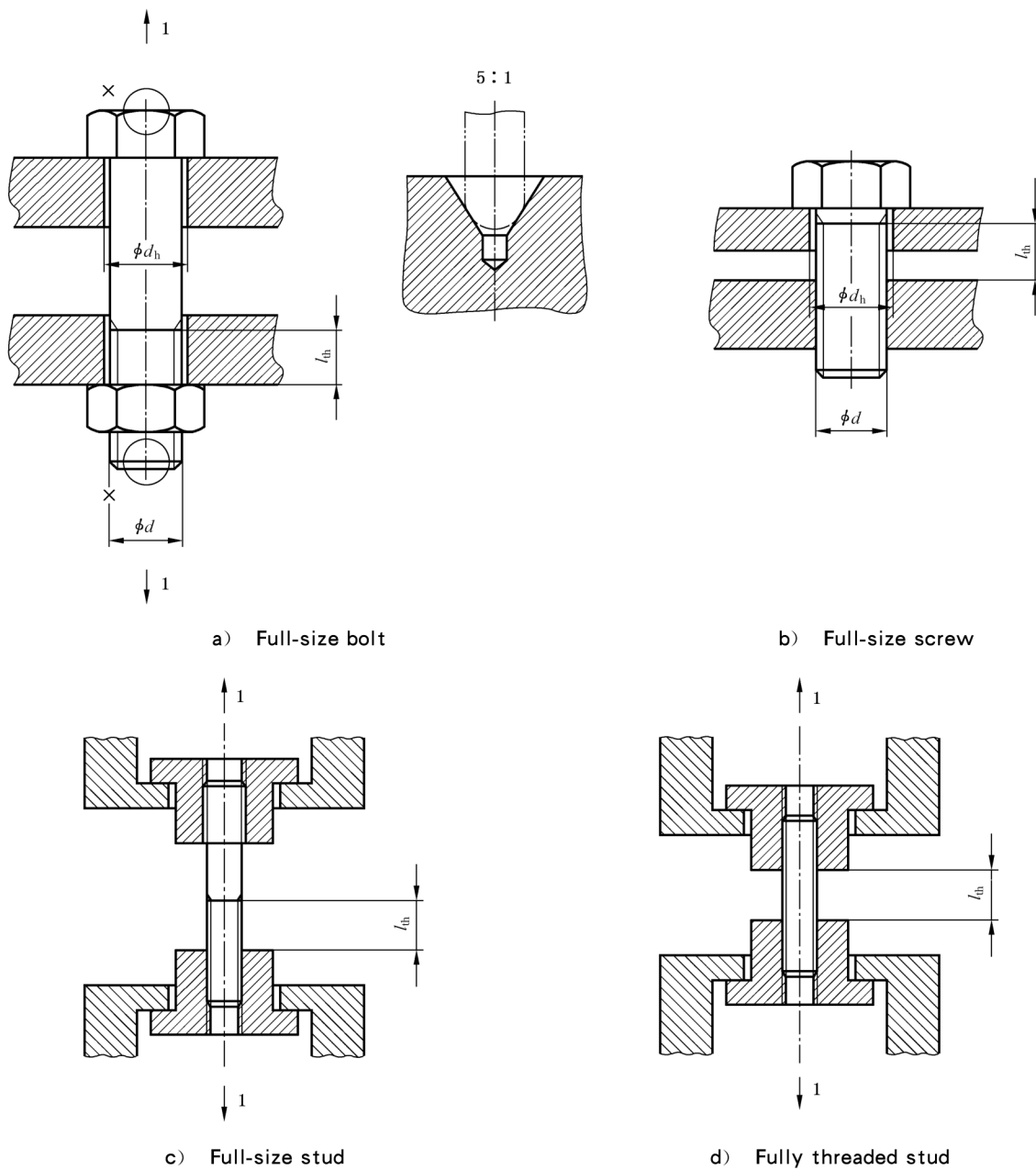
—screw on the threaded adaptor up to the thread run-out;

—unscrew the adaptor by the required number of turns corresponding to $l_{th} = 1d$.

The proof load, as specified in Tables 5 and 7, shall be applied axially to the fastener.

The speed of testing, as determined with a free-running cross-head, shall not exceed 3 mm/min. The full proof load shall be held for 15 s.

After unloading, measure the total length of the fastener, l_1 .



Key

1 load

EXAMPLE “sphere to cone” contact between the measuring points and the centre-drilled conical holes in the ends of the fastener is shown in detail. Any other suitable method may be used.

Figure 3—Example for set-up for application of proof load to finished fasteners

9.4.6 Test results—Requirement

The total length of the fastener after unloading, l_1 , shall be the same as before loading, l_0 , within a tolerance of $\pm 12.5 \mu\text{m}$ allowed for uncertainty of measurement.

Some variables, such as straightness, thread alignment and uncertainty of measurement, can result in apparent elongation of the fastener when the proof load is initially applied. In such cases, the fastener shall be retested in accordance with 9.4.5 using a 3% greater load than the proof load specified in Tables 5 and 7, and shall be considered satisfactory if the length after the second unloading, l_2 , is the same as before this loading, l_1 , within a tolerance of $\pm 12.5 \mu\text{m}$ allowed for uncertainty of measurement.

9.5 Tensile test for machined test pieces

9.5.1 General

The purpose of this tensile test is to determine

- the tensile strength, R_m ,
- the lower yield strength, R_{eL} , or stress at 0.2% non-proportional elongation, $R_{p0.2}$,
- the percentage elongation after fracture, A , and
- the percentage reduction of area after fracture, Z .

9.5.2 Applicability

This test applies to fasteners having the following specifications:

- a) machined test pieces made from bolts and screws:

- $5 \text{ mm} \leq d \leq 16 \text{ mm}$;
- thread length $b \geq 1d$;
- nominal length $l \geq 6d_0 + 2r + d$ (as indicated in Figure 4) to determine A ;
- nominal length $l \geq 4d_0 + 2r + d$ (as indicated in Figure 4) to determine Z ;

NOTE Machined test pieces can be made from fasteners which, due to their geometry, have reduced loadability, and from fasteners provided that the head is stronger than the cross-sectional area, S_0 , of the test piece, and from fasteners with unthreaded shank diameter $d_s < d_2$ (see 8.2).

b) machined test pieces made from studs:

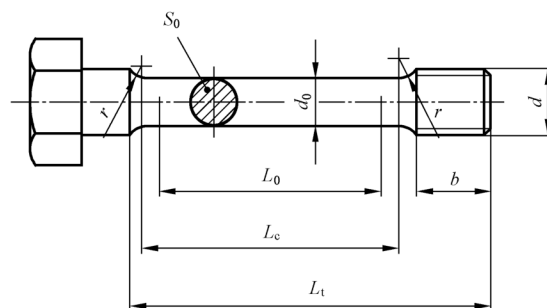
— $5\text{ mm} \leq d \leq 16\text{ mm}$;

—thread length of the stud (metal) end $b m \geq 1 d$;

—total length $l_t \geq 6 d_0 + 2 r + 2 d$ (as indicated in Figure 4) to determine A;

—total length $l_t \geq 46 d_0 + 2 r + 2 d$ (as indicated in Figure 4) to determine Z;

—all property classes.



Key

d nominal thread diameter;

d_0 diameter of machined test piece ($d_0 < d_{3\text{ min}}$ but, whenever possible, $d_0 \geq 3\text{ mm}$);

b thread length ($b \geq d$);

L_0 original gauge length of machined test piece:

for determination of elongation: $L_0 = 5 d_0$ or $(5.65 \sqrt{S_0})$;

for determination of reduction of area: $L_0 \geq 3 d_0$;

L_c length of straight portion of machined test piece ($L_0 + d_0$);

l_t total length of machined test piece ($L_c + 2 r + b$);

L_u final gauge length of machined test piece (see GB/T 228);

S_0 cross-sectional area of machined test piece before tensile test;

S_u cross-sectional area of machined test piece after fracture;

r fillet radius ($r \geq 4\text{ mm}$).

Figure 4—Machined test piece for tensile test

9.5.3 Apparatus

The tensile testing machine shall be in accordance with GB/T 16825.1. Side thrust on the fastener shall be avoided, e.g. by self-aligning grips.

9.5.4 Testing device

The grips and the adaptors shall be as follows:

—hardness, 45 HRC min;

—hole diameter, d_h , in accordance with Table 14;

—thread tolerance class of the internally threaded adaptor(s) in accordance with Table 13.

9.5.5 Machined test pieces

The test piece shall be machined from the fastener as received. The test piece shown in Figure 4 shall be used for the tensile test.

The diameter of the machined test piece shall be $d_0 < d_{3\text{ min}}$, but whenever possible $d_0 \geq 3$ mm.

For test pieces made from studs, both ends shall have a thread length of minimum $1d$.

9.5.6 Test procedure

The tensile test shall be carried out in accordance with GB/T 228. The speed of testing, as determined with a free-running cross-head, shall not exceed 10 mm/min up to the load at the stress at 0.2% non-proportional elongation, $R_{P0.2}$, and not exceed 25 mm/min for other tests.

The tensile test shall be continued until fracture occurs.

9.5.7 Test results

9.5.7.1 Method

The following properties shall be determined in accordance with GB/T 228:

a) tensile strength, R_m

$$R_m = F_m / S_0$$

b) stress at 0.2 % non-proportional elongation, $R_{p0.2}$;

- c) percentage elongation after fracture, providing that L_0 is at least $5d_0$:

$$A = (L_u - L_0) / L_0 \times 100\%$$

- d) percentage reduction of area after fracture, providing that L_0 is at least $3d_0$:

$$Z = (S_0 - S_u) / S_0 \times 100\%$$

9.5.7.2 Requirements

The following shall be in accordance with Table 3:

—the minimum tensile strength, R_m ;

—stress at 0.2% non-proportional elongation, $R_{P0.2}$;

—percentage elongation after fracture, A , or percentage reduction of area after fracture, Z ;

—if predicted, or nominal length, l , or overall length of finished fastener, l_t , is too short to determine the percentage elongation after fracture, A , the percentage reduction of area after fracture, Z , of machined test pieces may be determined.

9.6 Head soundness test

9.6.1 General

The purpose of the head soundness test is to check the integrity of the transition section between the head and the unthreaded shank or the thread by striking the head of the fastener on a solid block to a given angle.

NOTE This test is generally used when the tensile test under wedge loading cannot be carried out due to the too-short length of the fastener.

9.6.2 Applicability

This test applies to bolts and screws having the following specifications:

—head stronger than the threaded shank;

—nominal length $l \geq 1.5d$;

— $d \leq 10$ mm;

—all property classes.

9.6.3 Testing device

The solid block as illustrated in Figure 5 shall be as follows:

—hardness of 45 HRC min;

—hole diameter, d_h , and radius, r_1 , in accordance with Table 14;

—thickness of $2d$ minimum;

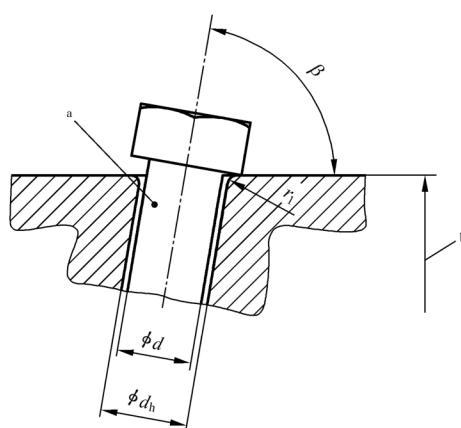
—angle β in accordance with Table 16.

9.6.4 Test procedure

Specimens shall be bolts or screws qualified after inspection, such as size inspection.

The head soundness test shall be carried out using a device as illustrated in Figure 5.

The block shall be firmly fixed. A hammer shall be used to strike the head of the bolt or screw by several blows so that the head bends to an angle of $90^\circ - \beta$. Values of angle β are specified in Table 16.



^a $l \geq 1.5d$.

^b minimum thickness of solid block: $2d$.

Figure 5—Testing device for head soundness test

Table 16—Angle of solid block, β , for head soundness test

Property class	8.8F, 9.8F
β	80°

The inspection should be carried out at 8-10 times.

9.6.5 Test result — Requirement

No sign of cracking at the transition section between the head and the unthreaded shank shall be found.

For screws threaded up to the head, this requirement is fulfilled even if a crack appears in the first thread, provided that the head does not fracture off.

9.7 Hardness test

9.7.1 General

The purpose of the hardness test is

—for all fasteners which cannot be tensile tested—to determine the hardness of the fastener;

—for fasteners which can be tensile tested (see 9.1, 9.2, 9.4 and 9.6): to determine the hardness of the fastener in order to check that the maximum hardness is not exceeded.

NOTE There may not be a direct relationship between hardness and tensile strength. Maximum hardness values are specified for reasons other than theoretical maximum strength consideration (e.g. to avoid embrittlement).

Hardness may be determined on a transverse section taken $1d$ back from the end of the thread, in the area between the axis and the half-radius position.

In case of dispute in acceptance, Vickers hardness test shall be the referee test.

9.7.2 Applicability

This test applies to fasteners having the following specifications:

—all sizes;

—all property classes.

9.7.3 Test methods

Hardness may be determined using the Vickers, Brinell or Rockwell hardness test.

a) Vickers hardness test

The Vickers hardness test shall be carried out in accordance with GB/T 4340.1.

b) Brinell hardness test

The Brinell hardness test shall be carried out in accordance with GB/T 231.1.

c) Rockwell hardness test

The Rockwell hardness test shall be carried out in accordance with GB/T 230.1.

9.7.4 Test procedure

9.7.4.1 Specimens shall be fasteners qualified after inspection, such as size inspection.

9.7.4.2 Hardness determined on a transverse section through the threaded portion

A transverse section shall be taken $1d$ back from the end of the thread, and the surface shall be suitably prepared.

Take hardness readings in the area between the axis and the half-radius position.

9.7.4.3 Hardness determined on a surface

The hardness shall be determined on flat surfaces of the head, on the end of the fastener or the unthreaded shank after removal of any plating or other coating and after suitable preparation of the test specimen.

This method may be used for routine inspection.

9.7.4.4 Test load for hardness determination

Carry out the Vickers hardness test with a minimum load of 98N.

Carry out the Brinell hardness test with a load equal to $30D^2$ expressed in newtons.

9.7.5 Requirements

For fasteners which cannot be tensile tested and bolts and screws with short thread length, the hardness shall be within the hardness range specified in Table 3.

For fasteners which can be tensile tested and machined test pieces, the hardness shall not exceed the values for maximum hardness in accordance with Table 3.

9.8 Torsional test

9.8.1 General

The purpose of the torsional test is to determine the breaking torque, M_B , for bolts and screws that cannot be tensile tested.

9.8.2 Applicability

This test applies to fasteners having the following specifications:

—bolts and screws with head stronger than the threaded section;

—diameter of unthreaded shank $d_s \geq d_2$ or $d_s \approx d_2$;

—thread length $b \geq 1d + 2P$;

— $5 \text{ mm} \leq d \leq 10 \text{ mm}$;

—all property classes.

9.8.3 Apparatus and testing device

See GB/T 3098.13.

9.8.4 Test procedure

Specimens shall be fasteners qualified after inspection, such as size inspection.

Clamp the bolt or screw into the test device in accordance with GB/T 3098.13 over a thread length of minimum $1d$. The free threaded length, l_{th} , shall be at least $2P$ at the head to thread run-out or at the unthreaded shank to thread run-out. Apply the torque in a continuously increasing manner.

9.8.5 Test results

9.8.5.1 Method

See GB/T 3098.13.

9.8.5.2 Requirements

See GB/T 3098.13.

In case of dispute the following applies:

—for bolts and screws that cannot be tensile tested, the hardness test in conformity with 9.7 shall be the referee test;

—for bolts and screws able to be tensile tested, the tensile test shall be the referee test.

9.9 Impact test for machined test pieces

9.9.1 General

The purpose of the impact test is to check the toughness of the material of the fastener under impact load at a specified low temperature.

9.9.2 Applicability

This test applies to fasteners having the following specifications:

—machined test pieces made from bolts, screws, and studs;

— $d = 16$ mm;

—total length of bolts and screws (including solid part of the head) ≥ 55 mm;

—studs with total length $l_t \geq 55$ mm;

—all property classes.

9.9.3 Apparatus and testing device

See GB/T 229.

9.9.4 Machined test piece

The test piece shall be machined from the fastener qualified after inspection, such as size inspection.

The machined test piece shall be in accordance with GB/T 229 (Charpy V-notch test). It shall be taken lengthwise, located as close to the surface of the fastener as possible, and located in the threaded portion as far as possible. The non-notched side of the test piece shall be located near the surface of the fastener.

9.9.5 Test procedure

The machined test piece shall be maintained at a stabilized temperature of $-20\text{ }^{\circ}\text{C}$. The impact test shall be carried out in accordance with GB/T 229.

9.9.6 Requirements

When tested at a temperature of $-20\text{ }^{\circ}\text{C}$, the impact strength shall be in accordance with Table 3.

NOTE Other test temperatures and impact strength values may be specified in appropriate product standards or agreed between the manufacturer and the purchaser.

9.10 Surface discontinuity inspection

Surface discontinuities of the fasteners shall be controlled in an interval acceptable. For fasteners of property classes 8.8F to 10.9F, a surface discontinuity inspection shall be carried out in accordance with GB/T 5779.1. By agreement between the manufacturer and the purchaser, GB/T 5779.3 may apply.

In the case of test series MP1, the surface discontinuity inspection shall apply before machining.

10 Marking

10.1 General

The designation system described in Chapter 5 and the provisions for marking in accordance with 10.3 or 10.4 shall be used only if all relevant requirements of this part of GB/T 3098 are met.

Unless otherwise specified in the product standard, the height of embossed markings on the top of the head shall not be included in the head height dimensions.

10.2 Manufacturer's identification mark

A manufacturer's identification mark shall be included during the manufacturing process on all fasteners marked with a property class symbol. Manufacturer's identification marking is also recommended on fasteners not marked with a property class symbol.

A distributor who distributes fasteners that are marked with his own identification mark shall be considered to be the manufacturer.

10.3 Marking and designation of fasteners with full loadability

10.3.1 General

Fasteners with full loadability manufactured to the requirements of this part shall be marked in accordance with 10.3.2 to 10.3.4.

Alternative or optional permitted marking as stated in 10.3.2 to 10.3.4 are left to the choice of the manufacturer.

10.3.2 Marking symbols for property classes

Marking symbols are specified in Table 17.

Table 17—Marking symbols for fasteners with full loadability

Property class	8.8F	9.8F	10.9F
Marking symbol ^a	8.8F	9.8F	10.9F
^a The dot “.” in the marking symbol may be omitted.			

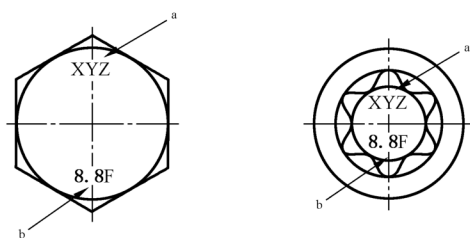
10.3.3 Identification

10.3.3.1 Hexagon and hexalobular head bolts and screws

Hexagon and hexalobular head bolts and screws (including fasteners with flange) shall be marked with the manufacturer's identification mark and with the marking symbol of the property class specified in Table 17.

The marking is required for fasteners of all property classes and of all dimensions.

The marking shall be made preferably on the top of the head by indenting or embossing, or on the side of the head by indenting (see Figure 6). In the case of bolts or screws with flange, marking shall be on the flange when the manufacturing process does not allow marking on the top of the head.



^a Manufacturer's identification mark.

^b Property class.

Figure 6—Examples of marking on hexagon and hexalobular head bolts and screws

10.3.3.2 Hexagon and hexalobular socket head cap screws

Hexagon and hexalobular socket head cap screws shall be marked with the manufacturer's identification mark and with the marking symbol of the property class specified in Table 17.

The marking is required for fasteners of all property classes and of all dimensions.

The marking shall be made preferably on the side of the head by indenting, or on the top of the head by indenting or embossing (see Figure 7).

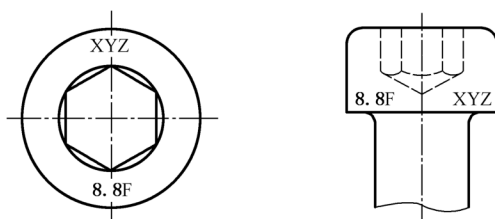


Figure 7—Examples of marking on hexagon socket head cap screws

10.3.3.3 Cup head square neck bolts

Cup head square neck bolts shall be marked with the manufacturer's identification mark and with the marking symbol of the property class specified in Table 17.

The marking is required for fasteners of all property classes and of all dimensions.

The marking shall be made on the head by indenting or embossing (see Figure 8).

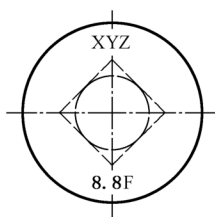


Figure 8—Example of marking cup head square neck bolts (“F” shall be added in this figure)

10.3.3.4 Studs

Studs shall be marked with the manufacturer’s identification mark and with the marking symbol of the property class specified in Table 17.

The marking is required for fasteners of all property classes and of all dimensions.

The marking shall be on the unthreaded part of the stud. If this is not possible, marking of the property class shall be on the nut end, and the manufacturer’s identification mark may be omitted (see Figure 9).

For studs with interference fit, the marking of property class shall be on the nut end, and the manufacturer’s identification mark may be omitted.

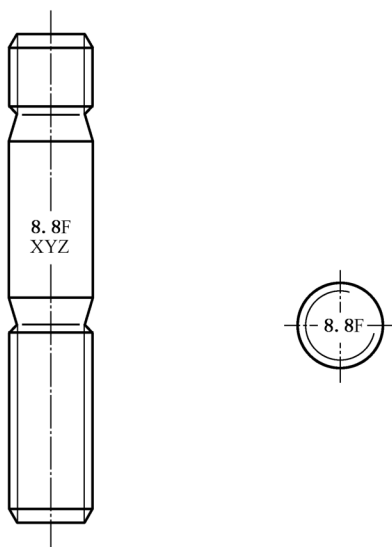


Figure 9—Example of marking of studs

10.3.4 Marking of bolts and screws with left-hand thread

Bolts and screws with left-hand thread and of all dimensions shall be marked with the symbol speci-

fied in Figure 10, either on the top of the head or on the point.

Alternative marking for left-hand thread as shown in Figure 11 may be used for hexagon bolts and screws.

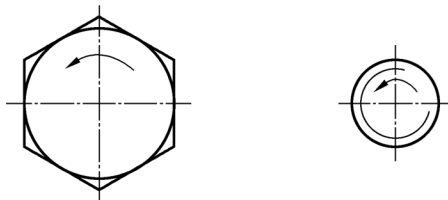
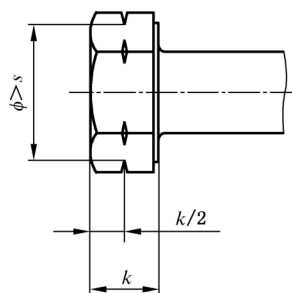


Figure 10—Marking of bolts and screws with left-hand thread



Key

s width across flats;

k height of the head.

Figure 11—Alternative marking of bolts and screws with left-hand thread

10.4 Marking and designation of fasteners with reduced loadability

10.4.1 General

Fasteners with reduced loadability manufactured in accordance with this part shall be marked in accordance with 10.3.3 and 10.3.4, except that the marking symbol for property class shall be preceded by the digit “0” in accordance with Table 18.

When reduced loadability applies to fasteners in accordance with a product standard, the marking symbols in accordance with Table 18 shall apply to all sizes specified in the product standard, even if some sizes would fulfil all requirements for full loadability. The reduced minimum tension load shall be given in the product standard.

10.4.2 Marking symbols for fasteners with reduced loadability

Marking symbols for fasteners with reduced loadability shall be in accordance with Table 18.

Table 18—Marking symbols for fasteners with reduced loadability

Property class	8.8F	9.8F	10.9F
Marking symbol ^a	8.8F	9.8F	10.9F
^a The dot “.” in the marking symbol may be omitted.			

10.5 Marking of packages

All packages for all types of fasteners of all sizes shall be marked (e.g. through labelling). The marking shall include the manufacturer's and/or distributor's identification and the marking symbol for property class in accordance with Table 17 or Table 18.

Annex A
(normative)

Technical requirements for fine grain non-heat treatment steel

A.1 Scope

This technical requirement specifies dimension, shape, mass and tolerance, technical requirement, test method, inspection rule, packaging, marking and certification of fine grain non-heat treatment steel hot-rolled wire rods.

A.2 Ordering Information

Orders for hot-rolled wire rods under this technical requirement shall include the following information in order contract:

- a) name of product;
- b) material grade;
- c) number of standard;
- d) dimension;
- e) mass and/or quantity;
- f) items or indicators agreed between the manufacturer and the purchaser and indicated in contract (if not indicated, at the manufacturer's option);
- g) special requirements requested by the purchaser.

A.3 Dimension, shape, mass and tolerance

Dimension, shape, mass and tolerance of hot-rolled wire rods shall be as specified in GB/T 14981.

Tolerance and out-of-roundness of wire rods can also be agreed between the manufacturer and the purchaser, when required by the purchaser.

A.4 Technical requirements

A.4.1 The grades and chemical composition

A.4.1.1 The grades and chemical composition (heat analysis) shall be as specified in Table A.1.

Table A.1—The grades and heat analysis chemical composition (%)

Grade	C	Si	Mn	P	S	V	Nb	Others
MFT8	0.16—0.26	≤0.30	1.20—1.60	≤0.025	≤0.015	may be added	be added	may be added
MFT9	0.18—0.26	≤0.30	1.25—1.60	≤0.025	≤0.015	may be added	be added	may be added
MFT10	0.10—0.28	≤0.60	1.30—2.20	≤0.025	≤0.015	may be added	may be added	may be added

A.4.1.2 When chemical analysis is made sampling from billet or wire rod, permissible tolerances for chemical composition shall be in accordance with GB/T 222.

A.4.2 Method of smelting

Wire rods steel shall be smelted with oxygen converter or with electric furnace and secondary refining.

A.4.3 Condition of delivery

Wire rods shall be supplied in the "as-rolled" condition.

A.4.4 Grain size

The ferrite grain size shall be estimated in accordance with GB/T 6394, and shall not be coarser than grade 11.

A.4.5 Mechanical properties

The mechanical properties shall be in accordance with Table A.2.

Table A.2—Mechanical properties

Grade	R_m , MPa	A, %	Z, %
MFT8	≥620	≥20	≥52
MFT9	≥680	≥18	≥48
MFT10	≥800	≥16	≥48

A.4.6 Cold forging

A.4.6.1 1/2 cold forging test must be carried out for every batch number of fine grain non-heat treatment steel wire rods. Cold forging test shall be carried out in accordance with the following requirements.

$$X = h_1/h = 1/2$$

where

h is the height of sample before cold forging (2 times of diameter of wire rods);

h_1 is the height of sample after cold forging.

A.4.6.2 The side of sample after cold forging test shall be checked to observe whether there is a breach that can be distinguished by naked eye. If breach does not appear, or even if a breach appears, there is no naked-eye visible original crack in the inner surface of breach, then the cold forging test is judged to be qualified. If naked-eye visible original crack in the inner surface of breach appears, the cold forging test is judged to be unqualified.

A.4.6.3 In accordance with the purchaser's request, agreed between the manufacturer and the purchaser, the contract shall be indicated that, cold forging can be tested in accordance with $X = h_1/h = 1/3, 1/4$, and samples after cold forging shall meet the requirements in A.4.6.2.

A.4.7 Decarburized zone

Decarburized zone shall be inspected for fine grain non-heat treatment steel hot-rolled wire rods, in accordance with relevant specifications in GB/T 6478.

A.4.8 Non-metallic inclusions

In accordance with the purchaser's request, agreed between the manufacturer and the purchaser, the contract shall be indicated that, non-metallic inclusion inspection can be carried out and the qualified level shall be determined between the manufacturer and the purchaser.

A.4.9 Surface quality

The surface of wire rod shall be free of cracks, scabs, folds and inclusions. If there are, the defects above must be cleared.

Individual small scratches, indentations, pitting, and small hairlines, with size no more than half of the dimension tolerance, are allowed.

A.5 Test methods

The test item, sampling method and test method shall be in accordance with Table A.3.

Table A.3—Specifications and reference standards

Test item	Sample size	Sampling method	Test method
Chemical composition (cast analysis)	1 sample per furnace	GB/T 20066	GB/T 223 GB/T 4336
Tensile	3 samples per batch	GB/T 2975	GB/T 228
Cold forging	One sample shall be taken from every 3 coils. When coil number is less than 10 in a batch, sample shall be taken from every coil.	After cutting off the defective portion and no-cooling portion at the head and tail, one test piece shall be taken from any end of any coil, and only one sample can be taken in one coil. Order of sample taking: in accordance with the order of rolling, the first coil of every three coils is referred as the sampling coil (including the first coil of the last coils less than 3).	YB/T 5293
Non-metallic inclusion	2 samples per batch	Different coil	GB/T 10561
Grain size	1 sample per batch	Any coil	GB/T 6394
Decarburized zone	2 samples per batch	Different coil	GB/T 224
Surface quality	Every coil	/	Visual inspection
Dimension	Every coil	/	Micrometer Vernier caliper

A.6 Inspection rules

A.6.1 Inspection and acceptance

Inspection and acceptance of wire rods shall be carried out by the quality and technical supervision department of the supplier.

A.6.2 Wire rod shall be inspected and accepted by batch, which is composed of the same heat num-

ber, material grade, and dimension.

A.6.3 Retest and criterion

For test item of cold forging, the retest and criterion of wire rods: If cold forging test, which is in accordance with A.4.6, is qualified, then the whole batch is determined to be qualified. When there is one sample is unqualified in cold forging, double samples shall be taken in adjacent coil for retest. If retest is qualified, then that batch is determined to be qualified. If retest is unqualified, one sample shall be taken from every coil for cold forging test. The qualified coil number can be determined as qualified.

For other test items, the retest and determination rule of wire rods shall be in accordance with relevant specifications in GB/T 6478.

A.7 Packaging, marking and certification

Packaging, marking and certification shall meet the specification in GB/T 2101.

Annex B
(informative)

**Guideline of material for processing fasteners using fine-grain non-heat
treatment steel hot-rolled wire rods**

B.1 This guideline provides a technique for processing high strength fasteners using fine-grain non-heat treatment cold heading steel hot-rolled wire rods.

B.2 Process program: Choose MFT8, MFT9, MFT10 non-heat treatment cold heading steel wire rods, after pickling, phosphating and sealing smut, draw with a reduction of area of 18% to 35% (optimal range: 25% to 30%, because deformation resistance is minimum when cold heading bolts, and loss of die is small). After that, cold head fasteners and roll thread. Finally, stabilization treatment and surface treatment shall be conducted to obtain 8.8F, 9.8 F, 10.9 F fastener products comply with standard requirements.

B.3 Stabilizing treatment: To improve proof load property, stabilizing treatment shall be carried out for bolts, screws, and studs after cold processing, and may be carried out together with surface treatment. Stabilization treatment may be heated to the temperature 200 °C to 510 °C and hold 0.5 h to 2.0 h. The recommended stabilizing treatment is 400 °C × 0.5 h.
