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GB/T 1591-2018

GB/T 1591-2008

High strength low alloy structural steels

低合金高强度结构钢

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Foreword

This Standard was drafted in accordance with the rules given in GB/T 1.1-2009.

This Standard replaces GB/T 1591-2008 “High strength low alloy structural steel”. As compared with GB/T 1591-2008, the main technical changes except editorial changes are as follows:

- DEFINE that the chemical composition of this Standard is also applicable to steel billets (see clause 1; clause 1 of the 2008 version);
- MODIFY the definitions of the terms “thermomechanical processed” and “normalizing rolling”, ADD the terms and definitions of “as-rolled” and “normalized” (see clause 3; clause 3 of the 2008 version);
- MODIFY the method of designation representation (see clause 4; clause 4 of the 2008 version);
- ADD the order content (see clause 5);
- DEFINE the size, shape, weight and tolerance requirements (see clause 6; clause 5 of the 2008 version);
- USE the Q355 steel-grade to replace the Q345 steel-grade and related requirements (see clause 7, 9.2; clause 6, 8.1 of 2008 version);
- SPECIFY the chemical composition of each designation in accordance with different delivery status, MODIFY the content of refined grain elements (see clause 7.1; clause 6.1 of 2008 version);
- Depending on the delivery status, SPECIFY the mechanical properties of each designation, and MODIFY the lower yield strength to the upper yield strength, INCREASE the index by 10 MPa ~ 15 MPa accordingly (see clause 7.4.1, 7.4.2; clause 6.4.1, 6.4.2 of 2008 version);
- DETAIL the steel surface quality requirements (see clause 7.5; clause 6.5 of 2008 version);
- MODIFY the test method and inspection rules, DEFINE the sampling location of the impact test (see clause 8, clause 9; clause 7, clause 8 of the 2008 version);
- ADD a designation comparison table between this Standard and foreign standards (see Appendix A).

This Standard was proposed by the China Iron and Steel Association.

This Standard shall be under the jurisdiction of the National Steel Standardization Technical Committee (SAC/TC 183).

Drafting organizations of this Standard: Angang Co., Ltd., Metallurgical Industry Information Standards Institute, Shougang Corporation, Hegang Co., Ltd. Tangshan Branch, Xiwang Special Steel Co., Ltd., Shandong Iron and Steel Co., Ltd. Laiwu Branch, Yingkou CRRC Structural Steel New Materials Co., Ltd., CITIC Metal Co., Ltd.

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This Standard replaces the standards previously issued as follows:

- GB 1591-1979, GB 1591-1988, GB/T 1591-1994, GB/T 1591-2008.

High strength low alloy structural steels

1 Scope

This Standard specifies the designation representation method, ordering content, size, shape, weight, technical requirements, test methods, inspection rules, packaging, marking, and quality certificate of high strength low alloy structural steel.

This Standard is applicable to high strength low alloy structural steel plates, steel strips, steel sections, steel bars, etc. for general structural and engineering purposes. Its chemical composition is also applicable to steel billets.

2 Normative references

The following documents are essential to the application of this document. For the dated documents, only the versions with the dates indicated are applicable to this document; for the undated documents, only the latest version (including all the amendments) are applicable to this Standard.

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

GB/T 223.3 Methods for chemical analysis of steels and alloys - Determination of phosphorus content by diantipyryl methane phosphomolybdate gravimetric method

GB/T 223.9 Iron steel and alloy - Determination of aluminum content - Chrome azurol S photometric method

GB/T 223.11 Iron, steel and alloy - Determination of chromium content - Visual titration or potentiometric titration method

GB/T 223.14 Methods for chemical analysis of iron, steel and alloy - The N-Benzoyl-N-Phenylhydroxylamine extraction photometric method for the determination of vanadium content

GB/T 223.17 Methods for chemical analysis of steels and alloys – Diantipyryl methane photometric method for the determination of titanium content

GB/T 223.18 Methods for chemical analysis of iron, steel and alloy - The sodium thiosulfate separation iodometric method for the determination of copper content

GB/T 223.23 Iron, steel and alloy - Determination of nickel content - The dimethylglyoxime spectrophotometric method

GB/T 223.26 Iron, steel and alloy - Determination of molybdenum content - The thiocyanate spectrophotometric method

GB/T 223.37 Methods for chemical analysis of iron, steel and alloy - The indophenol blue photometric method for the determination of nitrogen content after distillation separation

GB/T 223.40 Iron, steel and alloy - Determination of niobium content by the sulphochlorophenol S spectrophotometric method

GB/T 223.60 Methods for chemical analysis of iron, steel and alloy - The perchloric acid dehydration gravimetric method for the determination of silicon content

GB/T 223.63 Methods for chemical analysis of steels and alloys - The sodium periodate spectrophotometric method for the determination of manganese content

GB/T 223.68 Methods for chemical analysis of iron, steel and alloy - The potassium iodate titration method after combustion in the pipe furnace for the determination of sulfur content

GB/T 223.69 Iron, steel and alloy - Determination of carbon contents - Gas-volumetric method after combustion in the pipe furnace

GB/T 223.76 Methods for chemical analysis of iron, steel and alloy - The flame atomic absorption spectrometric method for the determination of vanadium content

GB/T 223.78 Methods for chemical analysis of iron, steel and alloy - Curcumin spectrophotometric method for the determination of boron content

GB/T 223.79 Iron and steel - Determination of multi-element contents - X-ray fluorescence spectrometry (Routine method)

GB/T 223.84 Steel and iron - Determination of titanium content - Diantipyrylmethane spectrophotometric method

GB/T 228.1 Metallic materials - Tensile testing - Part 1: Method of test at room temperature

GB/T 229 Metallic materials - Charpy pendulum impact test method

GB/T 232 Metallic materials - Bend test

GB/T 247 General rule of package mark and certification for steel plates (sheets) and strips

GB/T 702 Hot-rolled round and square steel bars - Dimension, shape, weight and tolerance

GB/T 706 Hot-rolled section steel

GB/T 709 Dimension, shape, weight and tolerances for hot-rolled sheets and strip

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

GB/T 2975-2018 Steel and steel products - Location and preparation of samples and test pieces for mechanical testing

GB/T 4336 Carbon and low-alloy steel - Determination of multi-element contents - Spark discharge atomic emission spectrometric method (Routine method)

GB/T 5313 Steel plates with through-thickness characteristics

GB/T 8170 Rules of rounding off for numerical values & expression and judgement of limiting values

GB/T 11263 Hot-rolled H and cut T section steel

GB/T 14977 General requirement for surface condition of hot-rolled steel plates

GB/T 17505 Steel and steel products General technical delivery requirements

GB/T 20066 Steel and iron - Sampling and preparation of samples for the determination of chemical composition

GB/T 20123 Steel and iron - Determination of total carbon and sulfur content Infrared absorption method after combustion in an induction furnace (routine method)

GB/T 20124 Steel and iron - Determination of nitrogen content - Thermal conductimetric method after fusion in a current of inert gas

GB/T 20125 Low-alloy steel - Determination of multi-element contents - Inductively coupled plasma atomic emission spectrometric method

GB/T 28300 Surface quality classes for hot-rolled bars and rods technical delivery conditions

YB/T 4427 General requirements for surface condition of hot-rolled sections

3 Terms and definitions

The following terms and definitions apply to this document.

3.1

As-rolled; AR or WAR

The status of steel which is not subject to any special rolling and/or heat treatment. [Translator's note: As "hot-rolled" and "as-rolled" are identical in Chinese, therefore, this Translation might not be able to identify the nuances between "hot-rolled" and "as-rolled"]

3.2

Normalized

N

The heat treatment process of steel by heating it to a suitable temperature above the temperature of the phase transition point, then cooling it in air to a temperature below a certain phase transition point.

3.3

Normalizing rolling

+N

The rolling process – the final deformation is performed in the rolling process within a certain temperature range, LET the steel to reach an as-rolled status, so as to facilitate that, even-though after normalizing, it still can reach the specified mechanical property values.

Note: For normalizing rolling, it is also referred to as "controlled rolling" in some publications.

3.4

Thermomechanical processed

M

The rolling process of which the final deformation of the steel is performed in a certain temperature range, thereby ensuring that the steel obtains such properties that cannot be obtained by only-heat treatment.

Note 1: Thermoforming that may reduce the steel strength value or steel post-weld heat treatment at temperatures above 580 °C may not be suitable. In accordance with the relevant technical specifications, flame straightening is allowed.

Note 2: Thermomechanical processing may include a process of increasing the cooling rate in a tempered or non-tempered state, the tempering includes self-tempering but not includes direct quenching and quenching & tempering.

Note 3: Also known as TMCP (thermomechanical controlled process), also referred to as “controlled rolling” in some publications.

4 Designation representation

4.1 The steel designation consists of four parts: the initial Pinyin Q of the yield strength “Qu”, the specified minimum upper yield strength value, the delivery status code, and the quality-grade symbol (B, C, D, E, F).

Note 1: When the delivery status is as-rolled, the delivery status code AR or WAR can be omitted; when the delivery status is normalized or normalizing rolling, the delivery status code is indicated by N.

Note 2: Q + The specified minimum upper yield strength value + delivery status code, abbreviated as “steel-grade”.

Example: Q355ND, where:

Q - The initials of the Chinese Pinyin “Qu” of the yield strength of steel;

355 - The minimum value of the specified upper yield strength, in megapascal (MPa);

N - The delivery status is normalizing or normalizing rolling;

D - The quality-grade is D.

4.2 When the purchaser requires the steel plate to have thickness-direction performance, a symbol representing the thickness direction (Z-direction) performance level, such as Q355NDZ25, is added after the above-mentioned specified designation.

5 Ordering content

5.1 Contracts or orders placed under this Standard shall include the following:

- a) This Standard number;

- b) Product type;
- c) Steel designation (steel-grade + quality-grade);
- d) Size, shape and tolerance (see clause 6);
- e) Delivery weight (or quantity);
- f) Selection contents of all requirements (see clause 5.2).

5.2 After consultation between the supplier and the buyer, and indicated in the contract, the following contents can be selected as the ordering content of this Standard. If the purchaser does not specify when providing the inquiry and ordering, the product is supplied as specified in 5.1.

- a) Carbon equivalent or weld crack sensitivity index (Pcm) (see 7.1.3, Table 6);
- b) Added alloying elements and their contents (see 7.1.6, Table 1, Table 3, Table 5);
- c) The lower chemical composition limit when supplying commodity steel billet (see 7.1.8);
- d) Finished-product analysis (see 7.1.9);
- e) Smelting methods (see 7.2);
- f) Impact-test's temperature and impact-test's sampling direction (see Table 11);
- g) Bending test (see 7.4.3);
- h) Properties of the steel in the thickness direction (see 7.1.7, 7.4.1.4 and 9.2.3);
- i) Surface quality (see 7.5.1.5, 7.5.2.4, 7.5.3.2, 7.5.4.2);
- j) Non-destructive testing (see 7.6);
- k) Sampling position of the impact specimen (see 8.3).

6 Size, shape, weight

6.1 The size, shape, weight and allowable deviation of hot-rolled steel bars [Translator's note: "hot-rolled" and "as-rolled" are identical in Chinese] shall comply with the provisions of GB/T 702, the specific groups shall be indicated in the contract.

6.2 The size, shape, weight and allowable deviation of hot-rolled steel sections shall comply with the provisions of GB/T 706, the specific group shall be specified in the contract.

6.3 The size, shape, weight and allowable deviation of hot-rolled steel sheets and strips shall comply with the provisions of GB/T 709, the specific accuracy categories shall be indicated in the contract.

6.4 The size, shape, weight and allowable deviation of hot-rolled H-section steel and split T-section steel shall comply with the provisions of GB/T 11263.

6.5 Steels of other sizes, shapes and allowable deviations may be supplied upon agreement between the supplier and the purchaser.

7 Technical requirements

7.1 Steel designations and chemical composition

7.1.1 The designation and chemical composition of the hot-rolled steel (melting analysis) shall comply with the requirements of Table 1, the carbon equivalent value shall comply with the requirements of Table 2.

7.1.2 The designation and chemical composition of the normalized and normalized rolled steel (melting analysis) shall comply with the requirements of Table 3, the carbon equivalent value shall comply with the requirements of Table 4.

7.1.3 The designation and chemical composition of the thermomechanical processed steel (melting analysis) shall comply with the requirements of Table 5, the carbon equivalent value shall comply with the provisions of Table 6. When the carbon content of the thermomechanical processed steel is not greater than 0.12%, it should use the weld crack sensitivity index (Pcm) instead of the carbon equivalent to evaluate the weldability of the steel. The Pcm value shall meet the requirements of Table 6. After consultation between the supplier and the buyer, it may specify using the carbon equivalent or weld crack sensitivity index to evaluate the weldability of the steel; when it is not specified, the supplier may choose either one.

7.1.4 Carbon equivalent (CEV) is calculated from the smelting analysis component in accordance with formula (1). The weld crack sensitivity index (Pcm) is calculated from the smelting analysis component in accordance with formula (2):

$$CEV(\%) = C + Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15 \dots\dots\dots(1)$$

$$Pcm(\%) = C + Si/30 + Mn/20 + Cu/20 + Ni/60 + Cr/20 + Mo/15 + V/10 + 5B \dots\dots\dots(2)$$

7.1.5 If the content of nitrogen in steel is guaranteed by the supplier, it can be exempted from analysis.

7.1.6 In order to improve the performance of the steel, the alloy elements other than those specified in Table 1, Table 3 and Table 5 may be added to the steel by agreement between the supplier and the buyer, the alloying elements and their contents shall be indicated in the quality certificate.

7.1.7 When the purchaser requires guaranteeing thickness direction performance steel plate, the sulfur content shall meet the requirements of GB/T 5313.

7.1.8 When supplying steel billets, in order to ensure that the mechanical properties of the steel meet the requirements of this Standard, the lower limit of the chemical composition of each element may be determined by both parties through negotiation.

7.1.9 When the purchaser requires performing the chemical composition analysis of the finished-product, the finished-product analysis shall be carried out, the chemical composition tolerance shall comply with the provisions of GB/T 222.

7.1.10 See Appendix A for the domestic and foreign designation comparison.

Table 1 -- Designations and chemical compositions of hot-rolled steels

Designation		Chemical composition (mass fraction) %															
Steel-grade	Quality-grade	C ^a		Si	Mn	P ^c	S ^c	Nb ^d	V ^e	Ti ^e	Cr	Ni	Cu	Mo	N ^f	B	
		Nominal thickness or diameter below/mm		Not greater than													
		≤40 ^b	>40														
		Not greater than															
Q355	B	0.24		0.55	1.60	0.035	0.035	—	—	—	0.30	0.30	0.40	—	0.012	—	
	C	0.20	0.22			0.030	0.030								—		
	D	0.20	0.22			0.025	0.025										
Q390	B	0.20		0.55	1.70	0.035	0.035	0.05	0.13	0.05	0.30	0.50	0.40	0.10	0.015	—	
	C					0.030	0.030										
	D					0.025	0.025										
Q420 ^g	B	0.20		0.55	1.70	0.035	0.035	0.05	0.13	0.05	0.30	0.80	0.40	0.20	0.015	—	
	C					0.030	0.030										
Q460 ^g	C	0.20		0.55	1.80	0.030	0.030	0.05	0.13	0.05	0.30	0.80	0.40	0.20	0.015	0.004	

^a For the steel sections of nominal thickness greater than 100 mm, the carbon content can be determined by the supplier and purchaser through negotiation.

^b For the steel of nominal thickness greater than 30 mm, the carbon content is not greater than 0.22%.

^c For the steel sections and steel bars, the upper limit of phosphorus and sulphur and content may be increased by 0.005%.

^d For Q390 and Q420, it can be as high as 0.07%; for Q460, it can be as high as 0.11%.

^e It can be as high as 0.20%.

^f If the acid soluble aluminium Als content in the steel is not less than 0.015% or if the total aluminium Alt content is not less than 0.020%, or other nitrogen-fixing alloy element is added, the content of nitrogen element is not limited, but the nitrogen-fixing element shall be indicated in the quality certificate.

^g It is only applicable to the steel sections and steel bars.

Table 2 -- Carbon equivalent of steels delivered in hot-rolling status (melting analysis)

Designation		Carbon equivalent CEV (mass fraction) / % Not greater than				
Steel-grade	Quality-grade	Nominal thickness or diameter /mm				
		≤ 30	$> 30 \sim 63$	$> 63 \sim 150$	$> 150 \sim 250$	$> 250 \sim 400$
Q355 ^a	B	0.45	0.47	0.47	0.49 ^b	—
	C					—
	D					0.49 ^c
Q390	B	0.45	0.47	0.48	—	—
	C					
	D					
Q420 ^d	B	0.45	0.47	0.48	0.49 ^b	—
	C					
Q460 ^d	C	0.47	0.49	0.49	—	—
^a When it is needed to control the silicon content (such as hot-dipped galvanized layer), the contents of other elements such as carbon or manganese are increased to reach the tensile strength requirements, the increase of the maximum carbon equivalent value in the Table shall comply with the following requirements: For Si $\leq 0.030\%$, the carbon equivalent may be increased by 0.02%; For Si $\leq 0.25\%$, the carbon equivalent may be increased by 0.01%. ^b For the steel sections and steel bars, the maximum carbon equivalent may be 0.54%. ^c It is only applicable to steel sections and steel bars.						

Table 3 -- Designations and chemical compositions of normalizing and normalizing rolling steel

Designation		Chemical composition (mass fraction)													
Steel-grade	Quality-grade	C	Si	Mn	P ^a	S ^a	Nb	V	Ti ^c	Cr	Ni	Cu	Mo	N	Als ^d
		Not greater than			Not greater than					Not greater than					
Q355N	B	0.20	0.50	0.90～ 1.65	0.035	0.035	0.005～ 0.05	0.01～ 0.12	0.006～ 0.05	0.30	0.50	0.40	0.10	0.015	0.015
	C				0.030	0.030									
	D				0.030	0.025									
	E	0.18			0.025	0.020									
	F	0.16			0.020	0.010									
Q390N	B	0.20	0.50	0.90～ 1.70	0.035	0.035	0.01～ 0.05	0.01～ 0.20	0.006～ 0.05	0.30	0.50	0.40	0.10	0.015	0.015
	C				0.030	0.030									
	D				0.030	0.025									
	E				0.025	0.020									
Q420N	B	0.20	0.60	1.00～ 1.70	0.035	0.035	0.01～ 0.05	0.01～ 0.20	0.006～ 0.05	0.30	0.80	0.40	0.10	0.015	0.015
	C				0.030	0.030									
	D				0.030	0.025									
	E				0.025	0.020									
Q460N ^b	C	0.20	0.60	1.00～ 1.70	0.030	0.030	0.01～ 0.05	0.01～ 0.20	0.006～ 0.05	0.30	0.80	0.40	0.10	0.015	0.015
	D				0.030	0.025									
	E				0.025	0.020									
The steel shall contain at least one of aluminium, niobium, vanadium, titanium or other refined grain elements, when it is added separately or in combination, it shall guarantee that the content of at least one alloy element is not less than the lower limit of the content as specified in the Table.															
^a For the steel sections and steel bars, the upper limit value of phosphorous and sulphur content may be increased by 0.005%.															
^b V + Nb + Ti ≤ 0.22%, Mo + Cr ≤ 0.30%.															
^c It can be as high as 0.20%.															
^d It can be replaced by total aluminium, at this time the minimum content of total aluminium is 0.020%. When niobium, vanadium, titanium or other refined grain elements are added to the steel and the content is not less than the lower limit of the content as specified in the Table, the lower limit value of the aluminium content is not limited.															

Table 4 -- Carbon equivalent of steels delivered in normalizing and normalizing rolling status (melting analysis)

Designation		Carbon equivalent CEV (mass fraction) / % Not greater than			
Steel-grade	Quality-grade	Nominal thickness or diameter /mm			
		≤63	>63~100	>100~250	>250~400
Q355N	B、C、D、E、F	0.43	0.45	0.45	As agreed
Q390N	B、C、D、E	0.46	0.48	0.49	As agreed
Q420N	B、C、D、E	0.48	0.50	0.52	As agreed
Q460N	C、D、E	0.53	0.54	0.55	As agreed

Table 5 -- Designations and chemical compositions of thermomechanical processed steel

Designation		Chemical composition (mass fraction)														
Steel-grade	Quality-grade	C	Si	Mn	P ^a	S ^a	Nb	V	Ti ^b	Cr	Ni	Cu	Mo	N	B	Als ^c
		Not greater than														
Q355M	B	0.14 ^d	0.50	1.60	0.035	0.035	0.01~0.05	0.01~0.10	0.006~0.05	0.30	0.50	0.40	0.10	0.015	—	0.015
	C				0.030	0.030										
	D				0.030	0.025										
	E				0.025	0.020										
	F				0.020	0.010										
Q390M	B	0.15 ^d	0.50	1.70	0.035	0.035	0.01~0.05	0.01~0.12	0.006~0.05	0.30	0.50	0.40	0.10	0.015	—	0.015
	C				0.030	0.030										
	D				0.030	0.025										
	E				0.025	0.020										

Table 5 (continued)

Designation		Chemical composition (mass fraction)														
Steel-grade	Quality-grade	C	Si	Mn	P ^a	S ^a	Nb	V	Ti ^b	Cr	Ni	Cu	Mo	N	B	Als ^c
		Not greater than														
Q420M	B	0.16 ^d	0.50	1.70	0.035	0.035	0.01~ 0.05	0.01~ 0.12	0.006~ 0.05	0.30	0.80	0.40	0.20	0.015	—	0.015
	C				0.030	0.030										
	D				0.030	0.025										
	E				0.025	0.020										
Q460M	C	0.16 ^d	0.60	1.70	0.030	0.030	0.01~ 0.05	0.01~ 0.12	0.006~ 0.05	0.30	0.80	0.40	0.20	0.015	—	0.015
	D				0.030	0.025										
	E				0.025	0.020										
Q500M	C	0.18	0.60	1.80	0.030	0.030	0.01~ 0.11	0.01~ 0.12	0.006~ 0.05	0.60	0.80	0.55	0.20	0.015	0.004	0.015
	D				0.030	0.025										
	E				0.025	0.020										
Q550M	C	0.18	0.60	2.00	0.030	0.030	0.01~ 0.11	0.01~ 0.12	0.006~ 0.05	0.80	0.80	0.80	0.30	0.015	0.004	0.015
	D				0.030	0.025										
	E				0.025	0.020										
Q620M	C	0.18	0.60	2.60	0.030	0.030	0.01~ 0.11	0.01~ 0.12	0.006~ 0.05	1.00	0.80	0.80	0.30	0.015	0.004	0.015
	D				0.030	0.025										
	E				0.025	0.020										
Q690M	C	0.18	0.60	2.00	0.030	0.030	0.01~ 0.11	0.01~ 0.12	0.006~ 0.05	1.00	0.80	0.80	0.30	0.015	0.004	0.015
	D				0.030	0.025										
	E				0.025	0.020										
The steel shall contain at least one of aluminium, niobium, vanadium, titanium or other refined grain elements, when it is added separately or in combination, it shall guarantee that the content of at least one alloy element is not less than the lower limit of the content as specified in the Table.																
^a For the steel sections and steel bars, the upper limit value of phosphorous and sulphur content may be increased by 0.005%. ^b It can be as high as 0.20%. ^c It can be replaced by total aluminium Alt, at this time the minimum content of total aluminium is 0.020%. When niobium, vanadium, titanium or other refined grain elements are added to the steel and the content is not less than the lower limit of the content as specified in the Table, the lower limit value of the aluminium content is not limited. ^d For steel sections and steel bars, the maximum carbon content of Q355M, Q390M, Q420M, and Q460M can be increased by 0.02%.																

Table 6 -- Carbon equivalent and weld crack sensitivity index of steel delivered at thermomechanical processed or thermomechanical processed + tempering status (based on melting analysis)

Designation		Carbon equivalent CEV (mass fraction) / % Not more than					Weld crack sensitivity index Pcm (mass fraction) / % Not greater than
Steel- grade	Quality- grade	Nominal thickness or diameter /mm					
		≤16	>16～ 40	>40～ 63	>63～ 120	>120～ 150 ^a	
Q355M	B、C、D、E、F	0.39	0.39	0.40	0.45	0.45	0.20
Q390M	B、C、D、E	0.41	0.43	0.44	0.46	0.46	0.20
Q420M	B、C、D、E	0.43	0.45	0.46	0.47	0.47	0.20
Q460M	C、D、E	0.45	0.46	0.47	0.48	0.48	0.22
Q500M	C、D、E	0.47	0.47	0.47	0.48	0.48	0.25
Q550M	C、D、E	0.47	0.47	0.47	0.48	0.48	0.25
Q620M	C、D、E	0.48	0.48	0.48	0.49	0.49	0.25
Q690M	C、D、E	0.49	0.49	0.49	0.49	0.49	0.25
^a It is not applicable to steel bars.							

7.2 Smelting method

The steel is smelted by a converter or an electric furnace, and if necessary, it can be refined outside the furnace. Unless the purchaser has special requirements and is indicated in the contract, the smelting method is generally selected by the supplier.

7.3 Delivery status

The steel is delivered in as-rolled, normalizing, normalizing rolling or thermomechanical processed (TMCP) status.

Note: The normalizing state includes a normalizing plus tempering status, the thermomechanical processed (TMCP) status includes thermomechanical processed (TMCP) plus tempering status.

7.4 Mechanical properties and process properties

7.4.1 Stretching

7.4.1.1 The tensile properties of hot-rolled steel shall comply with the requirements of Tables 7 and 8.

7.4.1.2 The tensile properties of normalizing and normalizing rolling steel shall comply with the requirements of Table 9.

7.4.1.3 The tensile properties of thermomechanical processed (TMCP) steels

shall comply with the requirements of Table 10.

7.4.1.4 In accordance with the requirements of the purchaser and as stated in the contract, when the thickness direction performance of the steel plate is required, the reduction ratio of the section in the thickness direction of the steel shall be in accordance with GB/T 5313.

7.4.1.5 For steel plates and strips with a nominal width of not less than 600 mm, transverse test specimens shall be taken for tensile tests; longitudinal specimens shall be taken for tensile tests of other steels.

7.4.2 Charpy (V-notch) impact

7.4.2.1 The test temperature and shock absorption energy of the Charpy (V-notch) impact test of steel shall comply with the requirements of Table 11.

7.4.2.2 Steels with a nominal thickness of not less than 6 mm or a nominal diameter of not less than 12 mm shall be subject to an impact test. The size of the impact specimen shall be standard specimen of 10 mm × 10 mm × 55 mm; when the steel is insufficient for the preparation of the standard specimen, it shall use the small-sized specimen of 10 mm × 7.5 mm × 55 mm or 10 mm × 5 mm × 55 mm, the shock absorption energy shall be not less than 75% or 50% of the value specified in Table 11, respectively, the larger-sized specimens shall be preferred.

Note: For steel sections, the thickness refers to the thickness of the prepared specimen as specified in GB/T 2975.

Table 7 -- Tensile properties of hot-rolled steel

Designation		Upper yield strength R _{eH} ^a / MPa Not less than								Tensile strength R _m /MPa				
Steel-grade	Quality-grade	Nominal thickness or diameter /mm												
		≤16	>16~ 40	>40~ 63	>63~ 80	>80~ 100	>100~ 150	>150~ 200	>200~ 250	>250~ 400	≤100	>100~ 150	>150~ 250	>250~ 400
Q355	B、C	355	345	335	325	315	295	285	275	—	470~ 630	450~ 600	450~ 600	—
	D									265 ^b				450~ 600 ^b
Q390	B、C、D	390	380	360	340	340	320	—	—	—	490~ 650	470~ 620	—	—
Q420 ^c	B、C	420	410	390	370	370	350	—	—	—	520~ 680	500~ 650	—	—
Q460 ^c	C	460	450	430	410	410	390	—	—	—	550~ 720	530~ 700	—	—
^a When the yield is not apparent, it may use the specified plastic extension strength R_{p0.2} to replace the upper yield strength. ^b It is only applicable to the steel plate of quality-grade D. ^c It is only applicable to steel sections and steel bars.														

Table 8 -- Elongation of hot-rolled steel

Designation		Elongation after fracture A/% Not less than						
Steel-grade	Quality-grade	Nominal thickness or diameter /mm						
		Specimen direction	≤ 40	$>40 \sim 63$	$>63 \sim 100$	$>100 \sim 150$	$>150 \sim 250$	$>250 \sim 400$
Q355	B,C,D	Longitudinal	22	21	20	18	17	17 ^a
		Transverse	20	19	18	18	17	17 ^a
Q390	B,C,D	Longitudinal	21	20	20	19	—	—
		Transverse	20	19	19	18	—	—
Q420 ^b	B,C	Longitudinal	20	19	19	19	—	—
Q460 ^b	C	Longitudinal	18	17	17	17	—	—
^a It is only applicable to the steel plate of quality-grade D. ^b It is only applicable to steel sections and steel bars.								

Table 9 -- Tensile properties of hot-rolled and normalizing rolling steels

Designation		Upper yield strength R _{eH} ^a / MPa Not less than								Tensile strength R _m /MPa			Elongation after fracture A/% Not less than					
Steel- grade	Quality- grade	Nominal thickness or diameter /mm																
		≤16	>16~ 40	>40~ 63	>63~ 80	>80~ 100	>100~ 150	>150~ 200	>200~ 250	≤100	>100~ 200	>200~ 250	≤16	>16~ 40	>40~ 63	>63~ 80	>80~ 200	>200~ 250
Q355N	B、C、D、E、F	355	345	335	325	315	295	285	275	470~ 630	450~ 600	450~ 600	22	22	22	21	21	21
Q390N	B、C、D、E	390	380	360	340	340	320	310	300	490~ 650	470~ 620	470~ 620	20	20	20	19	19	19
Q420N	B、C、D、E	420	400	390	370	360	340	330	320	520~ 680	500~ 650	500~ 650	19	19	19	18	18	18
Q460N	C、D、E	460	440	430	410	400	380	370	370	540~ 720	530~ 710	510~ 690	17	17	17	17	17	16
Note: Normalizing status includes normalizing plus tempering status.																		
^a When the yield is not apparent, it may use the specified plastic extension strength R _{p0.2} to replace the upper yield strength R _{eH} .																		

Table 10 -- Tensile properties of thermomechanical processed (TMCP) steels

Designation		Upper yield strength R _{eH} ^a / MPa Not less than						Tensile strength R _m /MPa					Elongation after fracture A/% Not less than
Steel- grade	Quality- grade	Nominal thickness or diameter /mm											
		≤16	>16～ 40	>40～ 63	>63～ 80	>80～ 100	>100～ 120 ^c	≤40	>40～ 63	>63～ 80	>80～ 100	>100～ 120 ^b	
Q355M	B、C、D、E、F	355	345	335	325	325	320	470～ 630	450～ 610	440～ 600	440～ 600	430～ 590	22
Q390M	B、C、D、E	390	380	360	340	340	335	490～ 650	480～ 640	470～ 630	460～ 620	450～ 610	20
Q420M	B、C、D、E	420	400	390	380	370	365	520～ 680	500～ 660	480～ 640	470～ 630	460～ 620	19
Q460M	C、D、E	460	440	430	410	400	385	540～ 720	530～ 710	510～ 690	500～ 680	490～ 660	17
Q500M	C、D、E	500	490	480	460	450	—	610～ 770	600～ 760	590～ 750	540～ 730	—	17
Q550M	C、D、E	550	540	530	510	500	—	670～ 830	620～ 810	600～ 790	590～ 780	—	16
Q620M	C、D、E	620	610	600	580	—	—	710～ 880	690～ 880	670～ 860	—	—	15
Q690M	C、D、E	690	680	670	650	—	—	770～ 940	750～ 920	730～ 900	—	—	14
Note: Thermomechanical processed (TMCP) status includes thermomechanical processed (TMCP) plus tempering status.													
^a When the yield is not apparent, it may use the specified plastic extension strength R _{p0.2} to replace the upper yield strength R _{eH} . ^b For the steel sections and steel bars, the thickness or diameter is not more than 150 mm.													

Table 11 -- Temperature and shock absorption energy of Charpy (V-notch) impact test

Designation		Minimum value of shock absorption energy at the following test temperature KV ₂ /J									
Steel-grade	Quality-grade	20 °C		0 °C		-20 °C		-40 °C		-60 °C	
		Longitudinal	Transverse	Longitudinal	Transverse	Longitudinal	Transverse	Longitudinal	Transverse	Longitudinal	Transverse
Q355, Q390, Q420	B	34	27	—	—	—	—	—	—	—	—
Q355, Q390, Q420, Q460	C	—	—	34	27	—	—	—	—	—	—
Q355, Q390	D	—	—	—	—	34 ^a	27 ^a	—	—	—	—
Q355N, Q390N, Q420N	B	34	27	—	—	—	—	—	—	—	—
Q355N, Q390N, Q420N, Q460N	C	—	—	34	27	—	—	—	—	—	—
	D	55	31	47	27	40 ^b	20	—	—	—	—
	E	63	40	55	34	47	27	31 ^c	20 ^c	—	—
Q355N	F	63	40	55	34	47	27	31	20	27	16
Q355M, Q390M, Q420M	B	34	27	—	—	—	—	—	—	—	—
Q355M, Q390M, Q420M, Q460M	C	—	—	34	27	—	—	—	—	—	—
	D	55	31	47	27	40 ^b	20	—	—	—	—
	E	63	40	55	34	47	27	31 ^c	20 ^c	—	—
Q355M	F	63	40	55	34	47	27	31	20	27	16
Q500M, Q550M, Q620M, Q690M	C	—	—	55	34	—	—	—	—	—	—
	D	—	—	—	—	47 ^b	27	—	—	—	—
	E	—	—	—	—	—	—	31 ^c	20 ^c	—	—
When the purchaser does not specify the test temperature, the normalizing, normalizing rolling, and thermomechanical processed grade C, D, E, F steel is respectively subject to 0 °C, -20 °C, -40 °C and -60 °C impact. Take longitudinal specimen for impact test. It may also take transverse specimen as negotiated between the supplier and the purchaser.											
^a It is only applicable to the Q355 steel plate of thickness more than 250 mm. ^b If specified by the purchaser, when the grade D steel can be subject to -30 °C impact test, the impact absorption energy is not less than 27 J longitudinally. ^c If specified by the purchaser, when the grade D steel can be subject to -50 °C impact test, the impact absorption energy is not less than 27 J longitudinally and not less than 16 J transversely.											

7.4.3 Bending

7.4.3.1 In accordance with the requirements of the purchaser, the steel may be subject to a bending test, the indicators shall comply with the requirements of Table 12.

7.4.3.2 If the supplier can guarantee the bending test is qualified, it may not be tested.

Table 12 -- Bending test

Specimen direction	180° bending test	
	D - Bending press head diameter; a - Specimen thickness or diameter	
	Nominal thickness or diameter / mm	
	≤ 16	> 16 ~ 100
For the steel plate and strip of the nominal width not less than 600 mm, take transverse specimen for tensile test; take longitudinal specimen for the tensile test of other steels.	D = 2a	D = 3a

7.5 Surface quality requirements

7.5.1 Steel plate

7.5.1.1 There shall be no harmful defects such as blisters, crusting, cracks, folding, inclusions and inclusive iron oxide scale on the surface of the steel plate. The steel sheet shall not have visually visible delamination.

7.5.1.2 The surface of the steel plate is allowed to have a thin layer of iron oxide scale, rust and inconspicuous roughness, texture, pitting, scratches and other partial defects caused by the intrusion of the scale and the roll, but the depth shall not be greater than half the tolerance of the steel plate thickness and shall ensure the minimum thickness allowed for the steel plate.

7.5.1.3 The surface defects of the steel plate are allowed to be removed by grinding or other methods. The cleaning place shall be smooth and free from sharp edges, the cleaning depth shall not be greater than the negative deviation of the thickness of the steel plate, and it shall ensure the minimum thickness allowed by the steel plate.

7.5.1.4 If there are defects on the surface of the steel plate that cannot be cleaned in accordance with 7.5.1.3, as negotiated between the supplier and the purchaser, they can be repaired by welding and shall comply with the following requirements:

- a) Use appropriate welding methods;
- b) Before the welding, use the method of leveling or grinding or other appropriate method to completely remove the harmful defects from the steel plate, the depth of the removed part is within 20% of the nominal thickness of the steel plate. The total grinding area of one side shall be within 2% of the area of the steel plate;
- c) There must be no undercut or overlap on the edge of the welded part of the steel plate, and the stack height shall be 1.5 mm or more above the rolling surface, then the stacking height shall be removed by leveling or grinding method, etc.;

d) Heat treatment shall be carried out again after welding repair of heat treated steel plate.

7.5.1.5 After consultation between the supplier and the purchaser, the surface quality of the steel plate may also meet the requirements of GB/T 14977.

7.5.2 Steel strip and its cut steel plate

7.5.2.1 The surface of the steel strip shall be free of defects such as crusting, cracks, folding, inclusions, blisters and iron oxide indentation which are harmful to use. The steel strip shall not have visible delamination.

7.5.2.2 The surface of the steel strip is allowed to have a thin layer of iron oxide scale, rust and slight pitting, scratches and other partial defects. The depth or height shall not exceed half of the thickness tolerance of the steel strip, and it shall ensure the allowable minimum thickness of the steel strip.

7.5.2.3 The steel is allowed to be delivered with partial defects, but the defective portion shall not exceed 6% of the total length of each steel strip.

7.5.2.4 After consultation between the supplier and the purchaser, the surface quality of the steel strip may also meet the requirements of GB/T 14977.

7.5.3 Steel sections

7.5.3.1 The surface quality of steel sections shall comply with the provisions of relevant standards.

7.5.3.2 The surface quality of the steel sections may also follow the provisions of YB/T 4427 after consultation between the supplier and the purchaser.

7.5.4 Steel bars

7.5.4.1 The surface quality of steel bars should comply with the provisions of relevant standards.

7.5.4.2 After consultation between the supplier and the purchaser, the surface quality of the steel bar can be as specified in GB/T 28300.

7.6 Non-destructive testing

After consultation between the supplier and the purchaser, the internal quality of the steel may be inspected by non-destructive testing. The testing criteria and requirements shall be as specified in the contract.

8 Test methods

8.1 The inspection items and test methods for each inspection of steel shall

comply with the requirements of Table 13.

8.2 The chemical composition test of steel is generally carried out in accordance with GB/T 4336, GB/T 20123, GB/T 20124, GB/T 20125 or general chemical analysis methods. During arbitration, it is carried out in accordance with GB/T 223.3, GB/T 223.9, GB/T 223.11, GB/T 223.14, GB/T 223.17, GB/T 223.18, GB/T 223.23, GB/T 223.26, GB/T 223.37, GB/T 223.40, GB/T 223.60, GB/T 223.63, GB/T 223.68, GB/T 223.69, GB/T 223.76, GB/T 223.78, GB/T 223.84 and GB/T 20125.

8.3 When the purchaser has no special requirement, the sampling position of the impact test shall be as follows:

- a) For steel sections, it shall be in accordance with the provisions of Figure A.3 of GB/T 2975-2018;
- b) For round steel, when the nominal diameter $d \leq 25$ mm, $25 \text{ mm} < d \leq 50$ mm and $d > 50$ mm, it shall be respectively in accordance with the provisions of a), b), d) of Figure A.5 of GB/T 2975-2018;
- c) For square steel, when the side length is not greater than 50 mm, it shall be in accordance with the provisions of a) of Figure A.9 of GB/T 2975-2018; when the side length is greater than 50 mm, it shall be in accordance with the provisions of b) in Figure A.9 of GB/T 2975-2018;
- d) For steel plates, when the nominal thickness is not greater than 40 mm, it shall be in accordance with the provisions of a) in Figure A.11 of GB/T 2975-2018; when the nominal thickness is greater than 40 mm, it shall be in accordance with b) of Figure A.11 of GB/T 2975-2018.

9 Inspection rules

9.1 Inspection and acceptance

The inspection and acceptance of steel materials shall be carried out by the technical supervision department of the supplier.

9.2 Batching rules

9.2.1 Steel shall be accepted in batches. Each batch shall be composed of steel of the same designation, the same furnace-number, the same specification and the same delivery status. The weight of each batch shall not be greater than 60 t, however, two rolling coils of steel strip and continuous rolling sheet of volume-weight greater than 30 t may form a batch; for the steel sections smelted by converter with a volume greater than 200 t, the weight per batch shall be not greater than 80 t. Through negotiation between the supplier and the purchaser,

2 batches can be tested per furnace.

9.2.2 Q355B-grade steel allows the formation of mixed batch by the steels of the same designation, the same smelting and pouring method, the same specification, the same production process system, the same delivery status or the same heat treatment system, different furnace-number. However, each batch shall not be more than 6 furnace-numbers, and the difference in carbon content between the furnace-numbers is not greater than 0.02%, the difference in Mn content is not greater than 0.15%.

9.2.3 For steels requiring thickness direction mechanical properties test, the batching rules shall comply with the provisions of GB/T 5313.

9.3 Sampling quantity

The sampling locations and sampling quantities of each batch of steel are as shown in Table 13.

Table 13 -- Steel inspection items, sampling quantities, sampling methods and test methods

No.	Inspection item	Sampling quantity	Sampling location and method	Test method
1	Chemical composition	1 / furnace	GB/T 20066	See 8.2
2	Tensile test	1 / batch	One end of steel, GB/T 2975-2018	GB/T 228.1
3	Bending test	1 / batch	One end of steel, GB/T 2975-2018	GB/T 232
4	Impact test	3 / batch	One end of steel, see 8.3	GB/T 229
5	Thickness direction performance test	3 / batch	GB/T 5313	GB/T 5313
6	Non-destructive testing	One by one	-	As negotiated
7	Size, shape	One by one	-	Gauge of corresponding accuracy
8	Surface quality	One by one	-	Visual inspection and measurement

9.4 Re-inspection and decision rules

The re-inspection and decision of steel shall comply with the provisions of GB/T 17505.

9.5 Numerical rounding off

The numerical decision adopts the rounding off value comparison method, the numerical rounding off is performed in accordance with the provisions of GB/T 8170.

10 Packaging, marking and quality certificate

If there is no special requirement, the packaging, marking and quality certificate of steel shall comply with the provisions of GB/T 247 or GB/T 2101.

Appendix A

(Informative)

Domestic and international standards' designation comparison

The domestic and international standards' designation comparison is as shown in Table A.1.

Table A.1 -- Domestic and international standards' designation comparison

This Standard	GB/T 1591—2008	ISO 630-2: 2011	ISO 630-3: 2012	EN 10025-2: 2004	EN 10025-3: 2004	EN 10025-4: 2004
Q355B(AR)	Q345B (as-rolled)	S355B	—	S355JR	—	—
Q355C(AR)	Q345C (as-rolled)	S355C	—	S355J0	—	—
Q355D(AR)	Q345D (as-rolled)	S355D	—	S355J2	—	—
Q355NB	Q345B (normalized/normalizing rolling)	—	—	—	—	—
Q355NC	Q345C (normalized/normalizing rolling)	—	—	—	—	—
Q355ND	Q345D (normalized/normalizing rolling)	—	S355ND	—	S355N	—
Q355NE	Q345E (normalized/normalizing rolling)	—	S355NE	—	S355NL	—
Q355NF	—	—	—	—	—	—
Q355MB	Q345B(TMCP)	—	—	—	—	—
Q355MC	Q345C(TMCP)	—	—	—	—	—
Q355MD	Q345D(TMCP)	—	S355MD	—	—	S355M
Q355ME	Q345E(TMCP)	—	S355ME	—	—	S355ML
Q355MF	—	—	—	—	—	—
Q390B(AR)	Q390B (as-rolled)	—	—	—	—	—
Q390C(AR)	Q390C (as-rolled)	—	—	—	—	—
Q390D(AR)	Q390D (as-rolled)	—	—	—	—	—
Q390NB	Q390B (normalized/normalizing rolling)	—	—	—	—	—
Q390NC	Q390C (normalized/normalizing rolling)	—	—	—	—	—
Q390ND	Q390D (normalized/normalizing rolling)	—	—	—	—	—
Q390NE	Q390E (normalized/normalizing rolling)	—	—	—	—	—
Q390MB	Q390B(TMCP)	—	—	—	—	—
Q390MC	Q390C(TMCP)	—	—	—	—	—
Q390MD	Q390D(TMCP)	—	—	—	—	—
Q390ME	Q390E(TMCP)	—	—	—	—	—
Q420B(AR)	Q420B (as-rolled)	—	—	—	—	—
Q420C(AR)	Q420C (as-rolled)	—	—	—	—	—
Q420NB	Q420B (normalized/normalizing rolling)	—	—	—	—	—
Q420NC	Q420C (normalized/normalizing rolling)	—	—	—	—	—

Table A.1 (continued)

This Standard	GB/T 1591—2008	ISO 630-2: 2011	ISO 630-3: 2012	EN 10025-2: 2004	EN 10025-3: 2004	EN 10025-4: 2004
Q420ND	Q420D (normalized/normalizing rolling)	—	S420ND	—	S420N	—
Q420NE	Q420E (normalized/normalizing rolling)	—	S420NE	—	S420NL	—
Q420MB	Q420B(TMCP)	—	—	—	—	—
Q420MC	Q420C(TMCP)	—	—	—	—	—
Q420MD	Q420D(TMCP)	—	S420MD	—	—	S420M
Q420ME	Q420E(TMCP)	—	S420ME	—	—	S420ML
Q460C(AR)	Q460C (as-rolled)	S450C	—	S450J0	—	—
Q460NC	Q460C (normalized/normalizing rolling)	—	—	—	—	—
Q460ND	Q460D (normalized/normalizing rolling)	—	S460ND	—	S460N	—
Q460NE	Q460E (normalized/normalizing rolling)	—	S460NE	—	S460NL	—
Q460MC	Q460C(TMCP)	—	—	—	—	—
Q460MD	Q460D(TMCP)	—	S460MD	—	—	S460M
Q460ME	Q460E(TMCP)	—	S460ME	—	—	S460ML
Q500MC	Q500C(TMCP)	—	—	—	—	—
Q500MD	Q500D(TMCP)	—	—	—	—	—
Q500ME	Q500E(TMCP)	—	—	—	—	—
Q550MC	Q550C(TMCP)	—	—	—	—	—
Q550MD	Q550D(TMCP)	—	—	—	—	—
Q550ME	Q550E(TMCP)	—	—	—	—	—
Q620MC	Q620C(TMCP)	—	—	—	—	—
Q620MD	Q620D(TMCP)	—	—	—	—	—
Q620ME	Q620E(TMCP)	—	—	—	—	—
Q690MC	Q690C(TMCP)	—	—	—	—	—
Q690MD	Q690D(TMCP)	—	—	—	—	—
Q690ME	Q690E(TMCP)	—	—	—	—	—

_____ **END** _____