JIS G4051 Carbon steel for Machine Structural Use

1. Scope

This Japanese Industrial Standard specifies the carbon steels for machine structural use manufactured by hot forming, such as hot rolling or hot forging, ordinarily to be used after further process of forging, cutting and heat treatment, hereinafter referred to as the "steel" JIS G 3201 and Jis G 3251 are excluded from the above.

2. Classification and Symbols

The steel shall be classified into 23 classes and the respective symbols shall be as given in Table 1. The 3 classes of S09CK, S15CK and S20CK, however, are used for case-hardening purposes.

3. Method of Manufacture

3.1 The steel shall be manufactured from killed steel ingot.

3.2 The steel shall be rolled or forged from steel ingot with forging ratio of not less than 4 S. When the forging ratio of the billet for forging or rolling is less than 4S, a prior agreement between the purchaser and the manufacturer shall be made.

3.3 Unless otherwise specified, the steel shall be as rolled or forged.

4.Chemical Composition

The chemical composition of the steel shall be determined by the ladle analysis and the value shall be as given in Table1.

Table 1. Symbol of Class and Chemical Composition

Symbol of class	Chemical composition %				
	C	Si	Mn	P	S
S10C	0.08 to 0.13	0.15 to 0.35	0.30 to 0.60	0.030 max.	0.035 max.
S12C	0.10 to 0.15	0.15 to 0.35	0.30 to 0.60	0.030 max.	0.035 max.
S15C	0.13 to 0.18	0.15 to 0.35	0.30 to 0.60	0.030 max.	0.035 max.
S17C	0.15 to 0.20	0.15 to 0.35	0.30 to 0.60	0.030 max.	0.035 max.
S20C	0.18 to 0.23	0.15 to 0.35	0.30 to 0.60	0.030 max.	0.035 max.
S22C	0.20 to 0.25	0.15 to 0.35	0.30 to 0.60	0.030 max.	0.035 max.
S25C	0.22 to 0.28	0.15 to 0.35	0.30 to 0.60	0.030 max.	0.035 max.
S28C	0.25 to 0.31	0.15 to 0.35	0.30 to 0.90	0.030 max.	0.035 max.
S30C	0.27 to 0.33	0.15 to 0.35	0.30 to 0.90	0.030 max.	0.035 max.
S33C	0.30 to 0.36	0.15 to 0.35	0.30 to 0.90	0.030 max.	0.035 max.
S35C	0.32 to 0.38	0.15 to 0.35	0.30 to 0.90	0.030 max.	0.035 max.

S38C	0.35 to 0.41	0.15 to 0.35	0.30 to 0.90	0.030 max.	0.035 max.
S40C	0.37 to 0.43	0.15 to 0.35	0.30 to 0.90	0.030 max.	0.035 max.
S43C	0.40 to 0.46	0.15 to 0.35	0.30 to 0.90	0.030 max.	0.035 max.
S45C	0.42 to 0.48	0.15 to 0.35	0.30 to 0.90	0.030 max.	0.035 max.
S48C	0.45 to 0.51	0.15 to 0.35	0.30 to 0.90	0.030 max.	0.035 max.
S50C	0.47 to 0.53	0.15 to 0.35	0.30 to 0.90	0.030 max.	0.035 max.
S53C	0.50 to 0.56	0.15 to 0.35	0.30 to 0.90	0.030 max.	0.035 max.
S55C	0.52 to 0.58	0.15 to 0.35	0.30 to 0.90	0.030 max.	0.035 max.
S58C	0.55 to 0.61	0.15 to 0.35	0.30 to 0.90	0.030 max.	0.035 max.
S09C	0.07 to 0.12	0.15 to 0.35	0.30 to 0.60	0.025 max.	0.025 max.
S15C	0.13 to 0.18	0.15 to 0.35	0.30 to 0.60	0.025 max.	0.025 max.
S20C	0.18 to 0.23	0.15 to 0.35	0.30 to 0.60	0.025 max.	0.025 max.

Remarks

1. As impurities, Cu, Ni, Cr and Ni + Cr for Classes S 09 CK, S 15 CK, S 20 CK shall not exceed respectively 0.25%, 0.20 % and 0.30 %, and Cu, Ni, Cr and Ni + Cr for throughout other classes shall not exceed respectively 0.30 %, 0.20 %, 0.20 and 0.35%.

2. When the product analysis on steel is requested by the purchaser, the tolerance for the product analysis shall conform to Table 2 specified in JIS G 0321.

5. Appearance and Shape, Dimensions and Its Tolerance

5.1 Hot Rolled Steel Bar and Wire Rod

5.1.1 Appearance

The hot rolled steel bar and the wire rod shall be well finished and free from harmful defects to use in appearance.

However, the steel bar which is supplied in coil may include some abnormal portions.

5.1.2 Reference of Flaw Dressing

Reference of flaw dressing of the hot rolled steel bar shall be as follows:

(1) Steel Bar for General Forging

The flaw dressing of the steel bar for general forging shall be made smoothly and to the depth not exceeding 4% of nominal size (5 mm max.) below nominal size, and the total width not exceeding 1/4 of the circumferential length of the same section. If the dressed portion is within the dimensional tolerance, however, it shall not be considered as the flaw of the portion dressed.

The permissible amount of remaining flaw shall be as agree upon between the purchaser and the manufacturer.

(2) Round Bar for Direct Cutting

The permissible depth of flaw on the round bar for direct cutting shall conform to the value given in Table 2 deducted from the nominal size.

Table 2. Permissible Depth of Flaw of Round Bar for Direct Cutting (Hot Rolled Steel Bar)

Diameter mm	Permissible depth of flaw
Under 16	Not exceeding 4 % of nominal size with the maximum of 0.5 mm
16 to 50 excl.	Not exceeding 3% of nominal size with the maximum of 1.0 mm
50 to 100 excl.	Not exceeding 2% of nominal size with the maximum of 1.5 mm
100 and over	Not exceeding 1.5 % of nominal size with the maximum of 3.0 mm

(3) Steel Bar for Cold Drawing

The flaw dressing of the steel bar for cold drawing shall be made smoothly and the permissible limit in repair shall conform to the value given in Table 3 deducted from the permissible minimum size.

The permissible amount of remaining flaw shall be as agreed upon between the purchaser and the manufacturer.

5.1.3 Standard Dimension

The standard dimensions of the hot rolled steel bar (round, square, hexagonal) and wire rod shall conform to Table 4.

5.1.4 Shape and Dimensional Tolerance

The shape and dimensional tolerances of the hot rolled steel bar and wire rod shall conform to (1), (2) and (3) with the exception of hot rolled steel bar and wire rod subjected to hear treatment.

Table 3. Permissible Limit in Repair of Steel Bar for cold Drawing (Hot Rolled Steel Bar)

Diameter or width across flats mm	Permissible limit in repair
Under 16	0.15 mm
16 to 50 excl.	Not exceeding 1 % of nominal size with the maximum of 0.35 mm
50 to 100 excl.	Not exceeding 0.7 % of nominal size with the maximum of 0.50 mm
100 to 130 incl.	Not exceeding 0.5 % of nominal size

Table 4. Standard Dimensions of Hot Rolled Steel Bar and Wire Rod

Round bar (dia.)					Square bar (width across flats)			Hexagonal bar (width across flats)		Wire rod (dia.)		
(10)	22	42	85	160	40	95	200	(12)	41	5.5	(15)	30
11	(24)	44	90	(170)	45	100		13	46	6	16	32
(12)	25	46	95	180	50	(105)		14	50	7	(17)	
13	(26)	48	100	(190)	55	110		17	55	8	(18)	
(14)	28	50	(105)	200	60	(115)		19	60	9	19	
(15)	30	55	110		65	120		22	63	9.5	(20)	
16	32	60	(115)		70	130		24	67	(10)	22	
(17)	34	65	120		75	140		27	71	11	(24)	

(18)	36	70	130		80	150		30	(75)	(12)	25	
19	38	75	140		85	160		32	(77)	13	(26)	
(20)	40	80	150		90	180		36	(81)	(14)	28	

Remark: It is desirable to avoid using figures in parentheses.

(1) The shape and dimensional tolerances of the hot rolled round bar and the square bar shall conform to Table

Table 5. Shape and Dimensional Tolerances of Hot Rolled Round Bar and Square Bar

Item	Shape and dimensional tolerance	
Tolerances on diameter or width across flats	【 1.5% with the minimum value of 0.4mm	
Deviation of diameter or deviation	Not exceeding 70% of range of tolerance on diameter or width across flats	
Tolerances on length	For length not exceeding 7 m	+ 40mm 0
	For length not exceeding 7 m	Add 5 mm to plus side tolerance for every increase of 1 m or its fraction
Radius on corners (R)	10 to 20% of width across flats, as a rule	
Twist	To be practically straight	
Bend	Not exceeding 3 mm for every 1 m and not exceeding 3 mm x length (m)/1 m for total length	

(2) The shape and the dimensional tolerances on the hot rolled hexagonal bar shall conform to Table 6.

Table 6. Shape and Dimensional Tolerances on Hot Rolled Hexagonal Bar

Item	Width across flats			Tolerance on width across flats	Deviation of width across flats
Tolerances and deviation on width across flats mm	(12)		13	【0.7	1.0 max.
	14		17		
	19	22	24	【0.8	1.1 max.
	27	30			
	32	36	41	【1.0	1.4 max.
	46	50			
	55	60	63	【1.2	1.7 max.
	67	71	(75)		
	(77)	(81)			
Tolerance on length	For length not exceeding 7 m	+ 40 mm 0			
	For length not exceeding 7 m	Add 5 mm to plus side tolerance for every increase of 1 m or its fraction			
Twist	To be practically straight				
Bend	Not exceeding 3 mm for every 1 m and not exceeding 3 mm x length (m)/1m for total length				

Remark :It is desirable to avoid using figures in parentheses.

(3) The dimensional tolerances on the hot rolled with rod shall conform to Table 7.

Table 7. Dimensional Tolerances on Hot Rolled Wire Rod

Diameter	Tolerances on dia.	Deviation
Under 16	【 0.4	0.5 max.
16 and over	【 0.5	0.6 max.

5. 2 Hot Rolled Plate, Sheet and Strip

5.2.1 Appearance

The appearance of the hot rolled steel plate, sheet and strip shall conform to 7. specified in JIS G 3193.

5.2.2 Reference of Flaw Dressing

The reference of flaw ressing of the jpt rolled steel plate and sheet shall conform to 7. specified in JIS G 3193. However, the application of repairing by welding and the permissible amount of remaining flaws shall be as agreed upon between the purchaser and the manufacturer.

5.2.3 Standard Dimension

The standard dimension of the hot rolled steel plate, sheet and strip shall be as given in (1) and (2).

(1) The standard thickness of the hot rolled steel plate, sheet and strip shall conform to 4.1 specified in JIS G 3193.

(2) The standard width and length of the hot rolled steel plate, sheet and strip shall conform to 4.2 and 4.3 specified in JIS G 3193.

5.2.4 Shape and Dimensional Tolerances

The shape and dimensional tolerances of the hot rolled steel plate, sheet and strip shall be as given in (1) and (2).

(1) The shape and dimensional tolerances of the hot rolled steel plate, sheet and strip shall conform to 5. specified in JIS G 3193. In this case, the tolerances on thickness apply to those under 160 mm.

However, in the case of 160 mm and over, it shall be agreed upon between the purchaser and the manufacturer.

(2) The permissible maximum values for flatness of the hot rolled steel plate and sheet shall be as given in (a) to (c).

(a) The steel plate and sheet (S 10 C to S 25 C)of the thickness under 160 n shall conform to 5.5 specified in JIS G 3193.

(b) The steel plate and sheet (S 28 C to S 58 C) of the thickness under 160 n shall conform to Table 8.

(c) The steel plate and sheet of the thickness 160 mm and over shall be as agreed upon between the purchaser and the manufacturer.

Table 8. Permissible Maximum Values for Flatness of Hot Rolled Steel Plate and Sheet (S 28 C to S 58 C) Unit: mm

Thickness/Width	Under 1250	1250 to 1600 excl.	1600 to 2000 excl.	2000 to 2500 excl.	2500 to 3000 excl.	3000 and over
under 1.60	27	30	-	-	-	-
1.60 to 4.00 excl.	24	27	30	-	-	-
4.00 to 6.30 excl.	21	24	27	33	39	42
6.30 to 10.0 excl.	18	21	24	30	36	39
10.0 to 25.0 excl.	15	18	21	24	27	30
25.0 to 63.0 excl.	12	15	18	21	24	27

63.0 to 160 excl.	12	12	15	18	21	24

Remarks

1. Not applicable to steel plate and sheet supplied after treated with stretcher leveler.

2. The above Table shall be applicable to any 4000 mm in length of steel plates and sheets, and to full length of plates and sheets under 4000 mm in length.

3. The values for flatness of steel plates and sheets shall be measured from the maximum warping of the upper surface of the plates by reducing the thickness thereof.

4. Not applicable to as rolled steel plates and sheets having rims.

5. The measurement of flatness of steel plates and sheets shall generally be done on a surface plate.

5.3 Hot Rolled Flat Steel

5.3.1 Appearance

The hot rolled flat steel shall be free from injurious defects to use in appearance.

5.3.2 Reference of Flaw Dressing

The reference of flaw dressing on the hot rolled flat steel shall conform to (1) and (2) of 8.2.1 specified in JIS G 3194.

5.3.3 Standard Dimension

The standard dimension of the hot rolled flat steel shall conform to 4. specified in JIS G 3194.

5.3.4 Shape and Dimensional Tolerances

The shape and dimensional tolerances of the hot rolled flat steel shall conform to 5. specified in JIS G 3194.

5.4 The appearance. reference of flaw dressing, shape, dimension and dimensional tolerances on steel other than those specified in 5.1, 5.2 and 5.3 shall be as agreed upon between the purchaser and the manufacturer.

6. Test

6.1 Test

6.1 The general requirements for the chemical analysis and the method of sampling for the ladle analysis shall comply with 3. specified in JIS G 0303.

6.2 The method of sampling for the product analysis shall comply with 3. specified in JIS G 0321.

6.3 The method of analysis shall conform to the requirements specified in either of the following standards:

JIS G 1211	JIS G 1212	JIS G 1213	JIS G 1214
JIS G 1215	JIS G 1216	JIS G 1217	JIS G 1219
JIS G 1252	JIS G 1253	JIS G 1256	JIS G 1257

7. Inspection

7.1 The general requirements for inspection shall be in accordance with JIS G 0303.

7.2 The results of inspection for the chemical composition, the appearance, the shape and dimensions shall satisfy the requirements specified in 4. and 5.

7.3 Besides the inspection and tests specified in 7.2, the purchaser may designate the inspection and tests given below. In this case, the purchaser shall have prior agreement with the manufacturer upon inspection items, method of sampling, test method and the criteria of acceptance or rejection.

Magnetic particle inspection (1), ultrasonic inspection (2), decarburizaiton inspection (3), nonmetallic inclusions inspection (4), grain size inspection (5), mechanical properties inspection (6), harden ability inspection (7), macrostructure detecting inspection (8), macro-streak flaw inspection (9) and microscopic structure inspection.

Notes

(1) This shall conform to JIS G 0565.

(2) This shall conform to JIS Z 2344.

(3) This shall conform to JIS G 0558.

(4) This shall conform to JIS G 0555.

(5) This shall conform to JIS G 0551.

(6) This shall conform to JIS Z 2201, JIS Z 2241, JIS Z 2202, JIS Z 2242 and JIS G 0561.

(7) This shall conform to JIS G 0561.

(8) This shall conform to JIS G 0553. However, this standard shall apply mainly to the steel bar.

(9) This shall conform to JIS G 0556. However, this standard shall apply mainly to the steel bar.

8. Marking

8.1 Flat Steel, Steel Bar and Wire Rod

The marking on each flat steel, steel bar and wire rod shall be done with the following items by a suitable method. The flat steel and the steel bar under 30 mm in diameter or width across flats may be bound up, and the marking may be made on each bundle by a suitable method. A part of following particulars may be omitted when agreed upon by the purchaser.

(1) Symbol of class

(2) Heat No. or other manufacturing No.

(3) Name of manufacturer or its abbreviation

8.2 Steel Plate, Sheet and Strip

The marking on the steel plate, sheet and strip shall b e done with the following items by a suitable method on each steel or bundle. A part of following particulars may be omitted when agreed upon by the purchaser.

(1) Symbol of class

(2) Heat No. or other manufacturing No.

(3) Dimension

(4) Name of manufacturer or its abbreviation

9. Report

The report shall conform to 8. specified in JIS G 0303. Submitting of test results specified in 7.3, however, shall be made after the agreement between the purchaser and the manufacturer.