



HOT ROLLED PRODUCTS

Hot Rolled Coils and Sheets

Rourkela Steel Plant

Rationalised sizes of Hot Rolled Coils

Thickness (mm)	Width (mm)
2.0, 2.1, 2.2, 2.3	910, 920, 930, 1010, 1020, 1025, 1030, 1040, 1060
2.5, 2.6	910, 920, 930, 1010, 1020, 1025, 1030, 1040, 1060, 1130
2.7, 2.8	910, 920, 930, 1010, 1020, 1025, 1030, 1040, 1060, 1130, 1250
2.9	1125, 1150, 1155, 1160, 1220
3.1, 3.5	910, 920, 930, 1010, 1020, 1025, 1030, 1040, 1060, 1130, 1250, 1310
3.7	910, 920, 930, 1010, 1020, 1025, 1030, 1040, 1060, 1130, 1250, 1310, 1410
3.8	910, 920, 930, 1010, 1020, 1025, 1030, 1040, 1060, 1130, 1250, 1310, 1400, 1410
4.0	910, 920, 930, 1010, 1020, 1025, 1030, 1040, 1060, 1130, 1220, 1250, 1310, 1400, 1410, 1410
4.1, 4.3, 4.5, 4.6, 4.8, 5.0, 5.6, 5.8, 6.0, 6.6, 7.0, 7.4, 7.8, 8.0, 9.0, 9.8, 10.0	910, 920, 930, 1010, 1020, 1025, 1030, 1040, 1060, 1130, 1220, 1250, 1310, 1400, 1410, 1420

Coils can also be supplied in other width/thickness combination, as per mutual agreement.

Inner diameter of coils : 760 mm. **Coil weight :** 8 -17 tonnes

Bokaro Steel Plant

Rationalised sizes of Hot Rolled Coils

Thickness (mm)	Width (mm)
2	1030, 1070, 1250, 1270, 1310, 1400
2.1, 2.2	1030, 1070, 1250, 1270, 1310, 1400
2.3, 2.37	1030, 1250, 1270, 1305, 1400
2.5	1030, 1070, 1130, 1250, 1270, 1310, 1400, 1420
2.6	1030, 1100, 1250, 1270, 1310, 1400, 1420
2.7, 2.8	1030, 1070, 1250, 1270, 1310, 1400, 1420
2.9	1030, 1090, 1130, 1150, 1155, 1160, 1250, 1270, 1280, 1310, 1400, 1420, 1680, 1685
2.95, 3.0, 3.10, 3.15 3.2	1030, 1130, 1250, 1270, 1310, 1400, 1420
3.35	1030, 1250, 1270, 1310, 1385, 1400, 1420, 1500, 1550
3.5, 3.55, 3.6	1030, 1250, 1270, 1310, 1360, 1400, 1420, 1500, 1550
3.65	1030, 1250, 1270, 1310, 1385, 1400, 1420, 1500, 1550
3.8, 3.9, 3.95	1030, 1250, 1270, 1310, 1400, 1420, 1500, 1550
4	1030, 1250, 1270, 1310, 1400, 1420, 1500, 1550
4.10	1030, 1250, 1270, 1310, 1385, 1400, 1420, 1500, 1550
4.3	1030, 1250, 1270, 1310, 1350, 1360, 1400, 1420, 1500, 1550, 1730
4.50	1030, 1100, 1250, 1270, 1310, 1360, 1400, 1420, 1500, 1550, 1730
4.8, 4.9	1030, 1250, 1270, 1310, 1360, 1385, 1400, 1420, 1500, 1550, 1730
5	1030, 1250, 1310, 1400, 1420, 1500, 1550, 1730, 1830
5.30, 5.4, 5.6	1030, 1060, 1310, 1360, 1400, 1420, 1500, 1550, 1730
5.8	1030, 1250, 1310, 1360, 1400, 1420, 1500, 1550, 1730
6	1030, 1250, 1310, 1360, 1400, 1420, 1500, 1550, 1730, 1830
6.3, 6.6	1030, 1130, 1250, 1310, 1360, 1400, 1420, 1500, 1550, 1730
7	1030, 1250, 1310, 1360, 1400, 1420, 1500, 1550, 1730, 1830
7.2, 7.3, 7.5, 7.8	1030, 1130, 1150, 1250, 1310, 1360, 1400, 1420, 1500, 1550, 1730
8.0, 8.7	1030, 1250, 1310, 1360, 1400, 1420, 1500, 1550, 1730, 1830
9.2, 9.8, 10, 11.8, 12	1030, 1150, 1250, 1310, 1400, 1420, 1500, 1550, 1730, 1830
16	1250, 1310, 1400, 1420, 1500, 1550, 1730, 1830

– 1100 mm width as already indicated will be through concast route for which sequential order will be required.

– Coils can also be supplied in other sizes, as per mutual agreement.

Inner diameter of coils : 850 mm

Outer diameter of coils : 2300 mm (max)

Coil weight : 29 tonnes max.

Bokaro Steel Plant

Rationalised sizes of Hot Rolled Sheets

Thickness, mm (gauge)	Width (mm)	Length (mm)
2 (14)	930, 1000, 1030, 1100, 1130, 1250, 1310	2500
2.50 (12)	930, 1000, 1030, 1100, 1130, 1250, 1310, 1400	2500
2.9	1000, 1100, 1250, 1400	2500, 4000, 4500
3.15 (10)	1000, 1100, 1250, 1400	2500, 4000, 4500
3.55 (9)	1000, 1100, 1250, 1400	2500, 4000, 4500
4 (8)	1000, 1100, 1250, 1400	2500, 4000, 4500

Thickness and width tolerances are as per IS: 1852/2003. Closer tolerances can also be supplied on demand.

Packaging : Bare bundles with cross-wise steel strip. Packet weight : 7 - 18 tonnes. Marking : Paint marked on the top sheet of the bundle OR Sticker/label on top sheet of bundle with required details.

Common grades for Hot Rolled Coils and Sheets : IS 10748/2009 grades I-V, API 5L Grades A, B, X42, X46, X52, X56, X60, SAIL-WTCR, IS: 11513/2011 grades O, D, DD, EDD, IS: 1079/ 1994 grades O, D, DD, EDD, Medium Carbon Strapping Steel, HCRS, SAE-1040, SAE – 1055, C 30, 40, 50, Medium Silicon Electrical Steel, IS: 6240/2008, SAIL HS LPG, SAILMA, IS: 2062/2011, IS: 5986/2011 Fe 330, 360, 410, 510, SAILRIM, IS: 2062/2011 Grade with copper, SAILCOR/IRSM-41, SAE 1012, SAE 1541 Auto Chassis Grade: E 34 / E38 / 46 & SAPH 45.

Materials are also available in the following foreign specifications : For structural and general purposes- ASTM-A 36/A 569/A 570 Grades 33/40, JISG 3101 SS400, JISG 3131 SPHC, DIN 17100 ST 37.2/ST 44.2, BS 4360 Grades 40/43A, EN 10025; For Tube-making and other grades : JISG 3132 SPHT 1/2, DIN 1614 Pt. 1/2 ST 22/23/24, SAE 1006, SAE 1018 or equivalents, if sufficient orders are available.

HR Sheets for Conventional LPG Cylinders

Thickness (mm)	Width (mm)	Length (mm)
2.9	1240	2480
2.8	1250	2500

Sheets can also be supplied in the following sizes on mutual agreement : 2.9 x 1360 x 2720 mm, 2.9 x 1270 x 2540 mm, 3.0 x 1360 x 2700 mm

Other sizes of hot rolled coils and sheets can be supplied as per mutual agreement.

HR Coils for LPG Cylinders

Grade	Thickness (mm)	Width (mm)
Conventional (IS: 6240/2008)	2.9	1090, 1160, 1250, 1685
SAIL HS LPG (JISG 3116/EN10120/ IS 15914)	2.2 - 4.0	1090, 1160, 1250

Applications (Hot Rolled Coils and Sheets)

Specification	Application
IS 10748/2004, Grades I, II, III, IV, V	Tube making
SAIL-WTCR, IS 11513/2011 Grades CR1, CR2, CR3, CR4, SAIL DRAW (EDD with CBT)	Cold reducing segment
IS 1079/2009 Grades HR1, HR2, HR3, HR4	General structural applications
SAILRIM	Manufacture of cycle rims
SAE 1012	Manufacture of wheel disc and cold formed products
SAIL PROP (SAE 1020) SAIL PREFAB (SAE 1020 Spl.)	Manufacture of propeller shaft Manufacture of Prefabricated structures
IS 2062/2011, with Copper SAILCOR/IRSM-41/HCRS	Manufacture of corrosion resistant engineering products
SAILMA, IS 2062/2011, IS 5986/2011	Fabrication of engineering structurals Manufacture of Hamilton and other poles, flanging applications
Strapping quality (IRS P 41)	Strapping for packaging
SAE 1541	Manufacture of fork and spokes for two wheelers
Medium Carbon Grades (SAIL MC 40/45/50/55/60 SAE 1040, SAE 1045, SAE 1055)	Chains, hair clip, sprocket, clutch plate, hacksaw blade etc.
Medium silicon electrical steel	Manufacture of electrical equipment
IS 6240/2008	Domestic/Auto LPG Cylinders
SAIL HS LPG (JISG 3116, EN 10120)	Export quality LPG Cylinders
SAIL FORM 34, 38, 46 (E 34, E 38, E 46/ BSK 46)	Fabrication of long & cross members for LCV, MCV and HCV
SAIL SUPER FORM 45 (JISG 3113, SAPH 440)	Long and cross member of LCV & MCV, wheel disc, wheel rim and other structural components of passenger car
HSFQ 250/350/450/500/550 (Thickness < 8 mm)	Auto Components & Pre Engineered Building (PEB) Sections (For forming at ambient temperature)
SAIL FORMING 250/350/410/450/550	Auto components (For forming at high temperature – Hot forming)
MnB Steel	Crash Resistant Auto Components (For Simultaneous Forming & Quenching in Die - Hot Stamping)
API 5L, Grades A, B, X42, X46, X52, X56, X60, X65, X70, PSL 1/2	Manufacture of tubes & pipes mostly for oil and gas sector
IS 15962/2012	Seismic resistant application
IS 15914/2011	Lighter (thinner) cylinder

Rolling and Cutting Tolerance as per IS:1852 - 1985 (Reaffirmed 2003)

Tolerance on Width of Strip Supplied with as Rolled Edges

Width (mm)	Tolerance (mm)
Up to 250	+ 4, - 0
> 250 to 600	+ 6, - 0
> 600 to 800	+ 10, - 0
> 800 to 1250	+ 30, - 0
> 1250 to 1550	+ 35, - 0
> 1550 to 1850	+ 40, - 0

Tolerance on Thickness of Strip up to and including 500 mm width

Width (mm)	Tolerance on thickness (mm)
Upto 200	± 0.20
> 200 to 320	± 0.23
> 320 to 400	± 0.25
> 400 to 500	± 0.30

Tolerance on Thickness for Strip above 500 mm width

Width (mm)	Tolerance on thickness (mm)				
	> 1.6 to 2	> 2 to 3	> 3 to 5	> 5 to 8	> 8 to 10
500 to 1250	± 0.18	± 0.20	± 0.25	± 0.30	± 0.35
1250 to 1550	± 0.20	± 0.25	± 0.30	± 0.35	± 0.40
1550 to 1850	± 0.22	± 0.28	± 0.35	± 0.40	± 0.40

Rolling and Cutting Tolerance for HR Sheets

as per IS: 1852 - 1985 (Reaffirmed 2003)

Width (mm)	Tolerance (mm)	Length (mm)	Tolerance
Up to 1250	+ 6, - 0	Up to 2500	+ 25 mm, - 0 mm
> 1250 to 1550	+ 0.5%, - 0	Over 2500	+ 1% of the length (max 70 mm), - 0 mm

Thickness tolerance for sheets as per table of HR Coils

Note : Cutting tolerance for all lengths for all products except plate, strip and sheet shall be + 100 mm, - 0 mm.

Closer tolerances can be supplied on mutual agreement.

Chemical Composition IS: 2062/2011

Grade	Quality	Ladle Analysis, wt % Max					Carbon Equivalent, Max	Mode of Deoxidation
		C	Mn	S	P	Si		
E 250	A	0.23	1.50	0.045	0.045	0.40	0.42	Semi Killed/Killed
	BR, BO	0.22	1.50	0.045	0.045	0.40	0.41	Semi Killed/Killed
	C	0.20	1.50	0.040	0.040	0.40	0.39	Killed
E 275	A	0.23	1.50	0.045	0.045	0.40	0.43	Semi Killed/Killed
	BR, BO	0.22	1.50	0.045	0.045	0.40	0.42	Semi Killed/Killed
	C	0.20	1.50	0.040	0.040	0.40	0.41	Killed
E 300	A, BR, BO	0.20	1.50	0.045	0.045	0.45	0.44	Semi Killed/Killed
	C	0.20	1.50	0.040	0.040	0.45	0.44	Killed
E 350	A, BR, BO	0.20	1.55	0.045	0.045	0.45	0.47	Semi Killed/Killed
	C	0.20	1.55	0.040	0.040	0.45	0.45	Killed
E 410	A, BR, BO	0.20	1.60	0.045	0.045	0.45	0.50	Semi Killed/Killed
	C	0.20	1.60	0.040	0.040	0.45	0.50	Killed
E 450	A, BR	0.22	1.65	0.045	0.045	0.45	0.52	Semi Killed/Killed
E 550	A, BR	0.22	1.65	0.020	0.025	0.50	0.54	Semi Killed/Killed
E 600	A, BR	0.22	1.70	0.020	0.025	0.50	0.54	Semi Killed/Killed

Notes:

1. New grade designation system based on minimum yield stress has been adopted.
2. For semi-killed steel, silicon shall be less than 0.10 percent. For killed steel, when the steel is killed by aluminium alone, the total aluminium content shall not be less than 0.02 percent. When the steel is killed by silicon alone, the silicon content shall not be less than 0.10 percent. When the steel is silicon-aluminium killed, the silicon content shall not be less than 0.03 percent and total aluminium content shall not be less than 0.01 percent.
3. Steels of qualities A, BR, BO and C are generally suitable for welding processes. The weldability increases from quality A to C for grade designation E 250 and E 275.
4. Carbon equivalent (CE) would be calculated based on ladle analysis, only
$$CE = C + \frac{Mn}{6} + \frac{(C + Mo + V)}{5} + \frac{(Ni + Cu)}{15}$$
5. Micro-alloying elements like Nb, V and Ti may be added singly or in combination. Total micro-alloying elements shall not be more than 0.25 percent.

Chemical Composition IS: 2062/2011

6. Alloying elements such as C, Ni, Mo and B may be added under agreement between the purchaser and the manufacturer. In case of E 600 and E 650 the limit of C and Ni either singly or in combination, shall not exceed 0.50 percent and 0.60 percent respectively.
7. Copper may be present between 0.20 to 0.35 percent as mutually agreed to between the purchaser and the manufacturer. The copper bearing quality shall be designated with a suffix Cu, for example E 250 Cu. In case of product analysis the copper content shall be between 0.17 and 0.38 percent.
8. Incidental element - Elements not quoted in Table 1 shall not be intentionally added to steel without the agreement of the purchaser, other than for the purpose of finishing the heat. All reasonable precautions shall be taken to prevent the addition from scrap or other materials used in manufacturer of such elements which affect the hardenability, mechanical properties and applicability.
9. Nitrogen content of steel shall not exceed 0.012 percent which shall be ensured by the manufacturer by occasional check analysis.
10. The steel, if required, may be treated with calcium based compound or rare earth element for better formability.
11. Lower limits for carbon equivalent and closer limits for other elements may be mutually agreed to between the purchaser and the manufacturer.

Mechanical Properties : 2062/2011

Grade Designation	Quality	Tensile Strength R _m Min MPa	Yield Stress Min MPa			Percentage Elongation A, at Gauge Length, L=5.65 √S ₀ Min	Internal Bend Diameter Min		Charpy Impact Test	
			≤ 20	20-40	> 40		<25	> 25	Temp °C	J, Min
E-250	A	410	250	240	230	23	2t	3t	-	-
	BR								RT	27
	BO								0	27
	C								(-) 20	27
E-275	A	430	275	265	256	22	2t	3t	-	-
	BR								RT	27
	BO								0	27
	C								(-) 20	27
E-300	A	440	300	290	280	22	2t	-	-	-
	BR								RT	27
	BO								0	27
	C								(-) 20	27
E-350	A	490	350	330	320	22	2t	-	-	-
	BR								RT	27
	BO								0	27
	C								(-) 20	27
E-410	A	540	410	390	380	20	2t	-	-	-
	BR								RT	25
	BO								0	25
	C								(-) 20	25
E-450	A	570	450	430	420	20	2.5t	-	-	-
	BR								RT	20
E-550	A	650	550	530	520	12	3.0t	-	-	-
	BR								RT	15
E-600	A	730	600	580	570	12	3.5t	-	-	-
	BR								RT	15

- In case of product thickness/diameter more than 100 mm, lower minimum limit of tensile strength may be mutually agreed to between the purchaser and the manufacturer/supplier

Chemical Composition : SAILMA Grades

Grade	C max.	Mn max.	S max.	P max.	Al min.	Si max.	CE max.	MAE (Nb+V+Ti) max.
SAILMA 300	0.20	1.50	0.045	0.045	0.02	0.45	0.44	≤ 0.25
SAILMA 300 HI	0.20	1.50	0.040	0.040	0.02	0.45	0.43	≤ 0.25
SAILMA 350	0.20	1.55	0.045	0.045	0.02	0.45	0.46	≤ 0.25
SAILMA 350 HI	0.20	1.55	0.040	0.040	0.02	0.45	0.45	≤ 0.25
SAILMA 410	0.20	1.60	0.045	0.045	0.02	0.45	0.48	≤ 0.25
SAILMA 410 HI	0.20	1.60	0.040	0.040	0.02	0.45	0.48	≤ 0.25
SAILMA 450	0.20	1.65	0.045	0.045	0.02	0.45	0.50	≤ 0.25
SAILMA 450 HI	0.20	1.65	0.040	0.040	0.02	0.45	0.50	≤ 0.25
SAILMA 550	0.20	1.65	0.020	0.025	0.02	0.50	0.54	≤ 0.25
SAILMA 550 HI	0.20	1.65	0.015	0.025	0.02	0.50	0.54	≤ 0.25
SAILMA 600	0.22	1.70	0.015	0.025	0.02	0.50	0.54	≤ 0.25

For Hot Rolled coils, S is maintained below 0.030%

Mechanical Properties : SAILMA Grades

Grade	YS, MPa min			UTS Mpa, min	% El min Std GL	Internal Bend Diameter, min		Charpy Impact Test	
	≤25mm	>25 mm	>40 mm			Temp ⁰ C	J, min		
	<25 mm	25-40 mm	>40 mm						
SAILMA 300	300	290	280	440	24	2t	-	-	-
SAILMA 300 HI	300	290	280	440	24	2t	-	0	40
SAILMA 350	350	330	320	490	24	2t	-	-	-
SAILMA 350 HI	350	330	320	490	24	2t	-	0 -20	40 30
SAILMA 410	410	390	380	540	22	2t	-	-	-
SAILMA 410 HI	410	390	380	540	22	2t	-	0 -20	35 25
SAILMA 450	450	430	420	570	22	2.5t	-	-	-
SAILMA 450 HI	450	430	420	570	22	2.5t	-	0 -20	30 20
SAILMA 550	550	530	520	650	14	3t	-	-	-
SAILMA 450 HI	550	530	520	650	14	3t	-	0 -20	25 15
SAILMA 600	600	580	570	730	14	3.5t	-	-	-

Impact will be given for any one temperature. For 450 HI & above impact is for < 10 mm. For < 12 mm impact to be given only if specified.

Chemical Composition: IS 1079/2009

Quality		Constituent, Percent, Max				
Designation	Old Designation	Name	Carbon	Manganese	Phosphorus	Sulphur
HR0	(New)	Ordinary	0.25	1.70	0.050	0.045
HR1	O	Commercial	0.15	0.60	0.050	0.035
HR2	D	Drawing	0.10	0.45	0.040	0.035
HR3	DD	Deep Drawing	0.08	0.40	0.035	0.030
HR4	EDD	Extra Deep Drawing	0.08	0.35	0.030	0.030
HR5	(New)	Micro-alloyed	0.16	1.6	0.020	0.020

Notes:

1. Steel of these grades can be supplied with the addition of micro-alloying elements like Boron, Titanium, Niobium and vanadium. The micro-alloying elements shall not exceed 0.008 percent in case of Boron and 0.20 percent in case of other elements.
2. The Nitrogen content of the steel not be more than 0.007 percent. For Aluminium killed or Silicon-Aluminium killed, the Nitrogen content shall not exceed 0.012 percent. This has to be ensured by the manufacturer by occasional check analysis.
3. Grade HR4 and HR5 shall be supplied in fully Aluminium killed condition or Aluminium with stabilising elements.
4. When the steel is Aluminium killed, the total Aluminium content shall not be less than 0.02 percent. When the steel is Silicon killed, the Silicon content shall not be less than 0.10 percent. When the steel is Aluminium-Silicon killed, the Silicon content shall not be less than 0.03 percent and total Aluminium content shall not be less than 0.01 percent.
5. When Copper bearing steel is required the Copper content shall be between 0.20 and 0.35 percent. In case of product analysis, the Copper content shall be between 0.17 and 0.38 percent.
6. Restricted chemistry may be mutually agreed to between the purchaser and the supplier.

Mechanical Properties : IS 1079/2009

Desi- gination	Quality Old Desi- gination	Name	Tensile Strength Rm2 max MPa	Percentage Elongation after Fracture A, min			
				t ≤ 3		t > 3	
				Gauge length Lo=80	Gauge length Lo=50	Gauge length Lo=5.65 √So	Gauge length Lo=50
HR0	(New)	Ordinary	*	*	*	*	*
HR1	O	Commercial	440	23	24	28	20
HR2	D	Drawing	420	25	26	30	31
HR3	DD	Deep Drawing	400	28	29	33	34
HR4	EDD	Extra Deep Drawing	380	31	32	36	37
HR5	SAIL FORM 34	YS 340	400-500	*	*	26	27
	SAIL FORM 38	YS 380	450-570	*	*	24	25
	SAIL FORM 45	YS 450	500-620	*	*	20	21

Notes:

1. 1 MPa = 1 N/mm²
 2. Minimum tensile strength for qualities HR1, HR2, HR3 and HR4 would normally be expected to be 270 MPa. Where minimum tensile is required, the value of 270 MPa may be specified. All tensile strength values are determined to the nearest 10 MPa.
 3. The non proportional test with a fixed original gauge length (50 mm) up to 6 mm thick sheet can be used in conjunction with a conversion table. In case of dispute, however, only the results obtained on a proportional test piece will be valid for material 3 mm and over in thickness.
 4. Where 't' is thickness of steel sheet, in mm.
 5. Tensile testing is not mandatory for HR1, unless agreed to between the purchaser and manufacturer.
- * Proper on mutual agreement between the purchaser and manufacturer.

Chemical Composition : IS 5986/2011

Grade	Constituents, Percent, Max				
	Carbon	Manganese	Phosphorus	Sulphur	Carbon Equivalents
165	0.12	0.60	0.040	0.040	–
205	0.15	0.80	0.040	0.040	–
235	0.17	1.00	0.040	0.040	–
255	0.20	1.30	0.040	0.040	0.42
325	0.20	1.30	0.040	0.040	0.42
355	0.20	1.50	0.035	0.035	0.45
420	0.20	1.50	0.035	0.035	0.45
490	0.20	1.50	0.035	0.030	0.45
560	0.20	1.50	0.035	0.030	0.45

Notes:

1. The nitrogen content of the steel shall not be more than 0.009 percent. For aluminium killed or aluminium silicon killed the nitrogen content shall not exceed 0.012 percent. This shall be ensured by ensured by occasional checking.
2. When the steel is killed by aluminium the total aluminium content should not be less than 0.02 percent. When steel is silicon content shall not be less than 0.03 percent and total aluminium content shall not be less than 0.01 percent.
3. The material may be supplied in the copper bearing quality in which case the copper shall be between 0.20 and 0.35 percent on analysis.
4. The steel can be made with micro-alloying element like Nb, V, Ti and B either individually or in combination on mutual agreement. In which case the total micro-alloying elements should not exceed 0.2 percent in ladle analysis. However, in case of boron, the limit shall be 0.001 percent.
5. As the form of sulphide inclusions may have certain influence on the cold forming properties, steel may be treated with elements like Ce or Ca, if agreed to between the manufacturer and purchaser.

$$\text{Carbon equivalent (CE) based on ladle analysis} = C + \frac{\text{Mn}}{6} + \frac{(\text{Cr} + \text{Mo} + \text{V})}{5} + \frac{(\text{Ni} + \text{Cu})}{15}$$

Mechanical Properties : IS:5986/2011

Specification	Grade	Yield Strength MPa, Min	Ultimate Tensile Strength, MPa, Min	Elongation% min GL5.65 $\sqrt{S_0}$	Internal Diameter of bend	
					≤ 12 mm	> 12 mm
				> 3 mm		
IS:5986:2011	165	165	290-400	30	Close	t
	205	205	330-440	28	t	2t
	235	235	360-470	26	t	2t
	255	255	410-520	24	t	2t
	325	325	420-530	19	2t	3t
	355	355	420-530	18	2t	3t
	420	420	480-590	15	2t	3t
	490	490	540-650	12	2t	3t
	560	560	610-720	10	2t	3t

Grade 165 may be supplied based on chemical composition only, if agreed to

Chemical Composition : SAILCOR

Specification	Grade	C % max	Mn % max	P % max	S % max	Si % max
SAILCOR	IRSM 41	0.10	0.25-0.45	0.75-0.140	0.030	0.28-0.72
Cr 0.35-0.60, Ni 0.20-0.47, Cu 0.30-0.60, Al 0.03 max						

Mechanical Properties : SAILCOR

Specification	Grade	Yield Strength MPa min	Ultimate Tensile Strength MPa min	Elongation% Std GL	Internal Diameter of bend
SAILCOR	HR	340	480	22	t

Chemical Composition : IS 10748/2004

Grade	C % max	Mn % max	P % max	S % max
I	0.10	0.50	0.040	0.040
II	0.12	0.60	0.040	0.040
III	0.16	1.20	0.040	0.040
IV	0.20	1.30	0.040	0.040
V	0.25	1.30	0.040	0.040
CE:0.45 max for grades IV and V				

Notes:

- CE based on ladle analysis = $C + \frac{\text{Mn}}{6} + \frac{(\text{Cr} + \text{Mo} + \text{V})}{5} + \frac{(\text{Ni} + \text{Cu})}{15}$
- For semi-killed quality silicon content shall be 0.08 percent, maximum.
- When the steel is killed by aluminium alone, the total aluminium content shall not be less than 0.02 percent. When the steel is killed by silicon alone, the silicon content shall not be less than 0.10 percent. When the steel is silicon-aluminium killed, the silicon content shall not be less than 0.03 percent and total aluminium content shall not be less than 0.01 percent.
- Micro-alloying may be allowed subject to mutual agreement between the purchaser and the supplier. Micro-alloying elements like Nb, V or Ti, when used individually or in combination, the total content shall not exceed 0.20 percent.
- Nitrogen content of steel shall not exceed 0.012 percent, which shall be ensured by the manufacturer by occasional check analysis.
- Closer limits of composition may be agreed to between the supplier and the purchaser.

Mechanical Properties : IS 10748/2004

Grade	Yield Strength	Ultimate Tensile Strength	Elongation% GL=5.65 √So	Internal Diameter of bend
	MPa min	MPa min		
I	170	290	30	T
II	210	330	28	2T
III	240	410	25	2T
IV	275	430	20	3T
V	310	490	15	3T

* Supplied on basis of chemical composition for IS10748

Chemical Composition : IS 11513/2011

Sl. No.	Designation	Grade	Name	Constituent, Percent, Max				
				Carbon	Manganese	Sulphur	Phosphorus	MA
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(i)	CR0	H	Hard	0.25	1.70	0.045	0.050	–
(ii)	CR1	O	Commercial	0.15	0.60	0.040	0.040	–
(iii)	CR2	D	Drawing	0.12	0.50	0.035	0.035	–
(iv)	CR3	DD	Deep Drawing	0.10	0.45	0.030	0.030	–
(v)	CR4	EDD	Extra deep drawing aluminium killed (non-ageing)	0.08	0.40	0.025	0.025	–

Notes:

1. Steels of these grades can be supplied with the addition of MA (micro-alloying) elements like boron, titanium, niobium and vanadium. The micro-alloying elements shall not exceed 0.008 percent in case of boron and 0.20 percent in case of other elements.
2. The nitrogen content of the steel shall not be more than 0.007 percent. For aluminium killed or silicon-aluminium killed, the nitrogen content shall not exceed 0.012 percent. This shall be ensured by the manufacturer by occasional check analysis.
3. Micro-alloyed grade shall be supplied in fully aluminium killed condition or aluminium with stabilizing elements.
4. When the steel is aluminium killed, the total aluminium content shall not be less than 0.02 percent. When the steel is silicon killed the silicon content shall not be less than 0.10 percent. When the steel is aluminium silicon killed, the silicon content shall not be less than 0.03 percent and total aluminium content shall not be less than 0.01 percent.
5. When copper bearing steel is required the copper content shall be between 0.20 and 0.35 percent. In case of product analysis, the copper content shall be between 0.17 and 0.38 percent.
6. Restricted chemistry may be mutually agreed to between the purchaser and the supplier.

* Supplied on basis of chemical composition

Chemical Composition

Specification	Grade	C % max	Mn % max	P % max	S % max	Si % max	
SAIL RIM		0.07-0.11	0.30-0.45	0.040	0.040		
SAE 1012		0.10-0.15	0.30-0.60	0.030	0.035	0.10 max	
SAIL PROP	SAE 1020	0.17-0.23	0.32-0.6	0.04	0.03		
SAIL PREFAB	SAE 1020 spl	0.23 max	1.35 max	0.04	0.03		Nb: 0.005-0.05

Specification	Grade	C % max	Mn % max	P % max	S % max	Si % max	Al % min
Strapping Quality	IRS P 41	0.25-0.45	1.20-1.45	0.040	0.040	0.15-0.35	
	SAE 1541	0.36-0.44	1.30-1.60	0.030	0.030	0.15-0.35	
Medium Carbon Grades	SAIL MC 30	0.26-0.35	0.60-0.90	0.04	0.04	0.15-0.35	0.02
	SAIL MC 40	0.36-0.45	0.60-0.90	0.04	0.04	0.15-0.35	0.02
	SAIL MC 45	0.41-0.50	0.60-0.90	0.04	0.04	0.15-0.35	0.02
	SAIL MC 50	0.46-0.55	0.60-0.90	0.40	0.04	0.15-0.35	0.02
	SAIL MC 55	0.51-0.60	0.60-0.90	0.04	0.04	0.15-0.35	0.02
	SAIL MC 60	0.56-0.65	0.60-0.90	0.04	0.04	0.15-0.35	0.02
Medium Si Electrical Steel		0.05	0.40	0.025	0.025	0.30 - 1.50	
IS 6240		0.16	0.30 min	0.025	0.025	0.25	0.02
MAE, 0.1% (Nb, Ti, B) N < 90 ppm							
SAIL HS LPG	SG 255	0.20	0.30 min	0.04	0.040	-	
JISG 3116	SG 295	0.20	1.00	0.04	0.040	0.35	
SAIL HS LPG EN 10120	P245NB	0.16	0.30 min	0.025	0.015	0.25	0.020
	P265NB	0.19	0.40 min	0.025	0.015	0.25	0.020
	P310NB	0.20	0.70 min	0.025	0.015	0.50	0.020
	Nb 0.05 max Ti 0.03 max for EN 10120						

Chemical Composition

Speci- fication	Grade	C % max	Mn % max	P % max	S % max	Si % max	Nb% max	V% max	Ti% max	Al min
E-34	SAIL FORM 34	0.10	0.70	0.030	0.030	0.20	0.055	0.095	0.045	0.02-0.06
E-38	SAIL FORM 38	0.10	1.00	0.030	0.030	0.40	0.055	0.095	0.045	0.02-0.06
E-46	SAIL FORM 45	0.12	1.00	0.025	0.025	0.40	0.060	0.095	0.045	0.02
BSK-46		0.12	1.40	0.030	0.025	0.25	0.080	-	-	0.02
JISG 3113 SAPH 440	SAIL SUPER FORM	0.14	1.20	0.040	0.040	0.15	-	-	-	-

Nb + Ti 0.10 max for SAIL FORM Grade

Specification		% ^{a, g}							
	Steel grade	C Max	Mn Max	P Max	S Max	V Max	Nb Max	Ti Max	
API 5 L PSL 1	A	0.22	0.90	0.030	0.030	-	-	-	
	B	0.26	1.20	0.030	0.030	c, d	c, d	d	
	X42	0.26	1.30	0.030	0.030	d	d	d	
	X46	0.26	1.40	0.030	0.030	d	d	d	
	X52	0.26	1.40	0.030	0.030	d	d	d	
	X56	0.26	1.40	0.030	0.030	d	d	d	
	X60	0.26e	1.40e	1.40	0.030	f	f	f	
	X65	0.26e	1.45e	0.030	0.030	f	f	f	
	X70	0.26e	1.65e	0.030	0.030	f	f	f	

- ^a Cu ≤ 0.50%; Ni ≤ 0.50%; Cr ≤ 0.50% and Mo ≤ 0.15%
- ^b For each reduction of 0.01% below the specified maximum concentration for carbon, an increase of 0.05% above the specified maximum concentration for Mn is permissible, up to a maximum of 1.65% for grades ≤ B, but ≤ X52; up to a maximum of 1.75% for grades > X52, but < X70; and up to a maximum of 2.00% for grade X70.
- ^c Unless otherwise agreed, Nb + V ≤ 0.06%
- ^d Nb + V + ≤ Ti 0.15%
- ^e Unless otherwise agreed
- ^f Unless otherwise agreed, Nb + Ti ≤ 0.15%
- ^g No deliberate addition of B is permitted and the residual B ≤ 0.001%

Chemical Composition

Specification	Steel grade	% Maximum									Carbon equivalent a % maximum	
		C ^b	Si	Mn ^b	P	S	V	Nb	Ti	Other	CE _{IW}	CE _{pcm}
API 5 L PSL2		Welded Pipe										
	BM	0.22	0.45	1.20	0.025	0.015	0.05	0.05	0.04	e,l	0.43	0.25
	X42M	0.22	0.45	1.30	0.025	0.015	0.05	0.05	0.04	e,l	0.43	0.25
	X46M	0.22	0.45	1.30	0.025	0.015	0.05	0.05	0.04	e,l	0.43	0.25
	X52M	0.22	0.45	1.40	0.025	0.015	d	d	d	e,l	0.43	0.25
	X56M	0.22	0.45	1.40	0.025	0.015	d	d	d	e,l	0.43	0.25
	X60M	0.12 ^f	0.45 ^f	1.60 ^f	0.025	0.015	g	g	g	h,l	0.43	0.25
	X65M	0.12 ^f	0.45 ^f	1.60 ^f	0.025	0.015	g	g	g	h,l	0.43	0.25
	X70M	0.2 ^f	0.45 ^f	1.70 ^f	0.025	0.015	g	g	g	h,l	0.43	0.25

- ^a Based upon product analysis. The CE_{IW} limits apply if C > 0,12% and the CE_{pcm} limits apply if C ≤ 0,12%
- ^b For each reduction of 0.01% below the specified maximum for C, an increase of 0.05% above the specified maximum for Mn is permissible, up to a maximum of 1.65% for grades ≤ B, but ≤ X52; up to a maximum of 1.75% for grades ≥ X 52, but ≤ X70; up to a maximum of 2.00% for grade X70
- ^c Nb + V + Ti ≤ 0,15%
- ^d Unless otherwise agreed, Cu ≤ 0.50%; Ni ≤ 0.30%; Cr ≤ 0.30% and Mo ≤ 0.15%
- ^e Unless otherwise agreed
- ^f Unless otherwise agreed, Nb + V + Ti ≤ 0.15%
- ^g Unless otherwise agreed, Cu ≤ 0.50%; Ni ≤ 0.50%; Cr ≤ 0.50% and Mo ≤ 0.50%
- ^h Unless otherwise agreed no intentional addition of B is permitted and residual B ≤ 0.001%

Chemical Composition

Grade	C max	Mn max	S max	P max	Al min	Si max	MAE max
HSFQ 250	0.12	1.00	0.020	0.025	0.02	0.25	-
HSFQ 350	0.12	1.20	0.020	0.025	0.02	0.25	0.03
HSFQ 450	0.12	1.40	0.020	0.025	0.02	0.40	0.05
HSFQ 500	0.12	1.50	0.020	0.025	0.02	0.50	0.10
HSFQ 550	0.12	1.60	0.020	0.025	0.02	0.50	0.15
SAIL FORMING 250	0.12	1.40	0.025	0.030	0.02	0.30	0.04
SAIL FORMING 350	0.12	1.50	0.025	0.030	0.02	0.40	0.08
SAIL FORMING 410	0.12	1.55	0.025	0.030	0.02	0.45	0.12
SAIL FORMING 450	0.12	1.60	0.025	0.030	0.02	0.50	0.12
MnB Steel	0.25	1.50	0.025	0.030	0.02	0.40	0.40

Chemical Composition of Seismic Resistant Structural Steel IS 15962:2012

Grade	C max	Mn max	P max	S max	Simax	CE* max	Mode of Deoxidation
E250S	0.20	1.50	0.035	0.045	0.40	0.39	Semi-killed/Killed
E300S	0.20	1.50	0.035	0.045	0.45	0.40	Semi-killed/Killed
E350S	0.20	1.60	0.035	0.045	0.45	0.42	Semi-killed/Killed
E450S	0.22	1.60	0.035	0.045	0.45	0.47	Semi-killed/Killed

- Microalloying elements (MAE) like Nb, V and Ti may be added singly or in combination. Total MAE shall not be more than 0.15%.
- Cr, Ni, Mo may be added but not more than 0.60% singly or in combination.
- Cu may be present between 0.20 and 0.35%.
- Nitrogen content shall not be more than 0.012%.

**Chemical Composition for high tensile flat rolled steel for lighter cylinder
IS 15914:2011**

Grade	Constituent, Percent					
	Carbon Max	Manganese Min	Silicon Max	Sulphur Max	Phosphorus Max	Alluminium Min
HS 235	0.16	0.30	0.25	0.025	0.025	0.015
HS 265	0.18	0.40	0.30	0.025	0.025	0.015
HS 295	0.19	0.50	0.35	0.025	0.025	0.015
HS 345	0.20	0.70	0.45	0.025	0.025	0.015

NOTES:

1. Elements not listed in this table may not be added to the steel. All suitable arrangements are to be made to prevent such elements being added from scrap or other materials used during manufacture, which impair the mechanical properties and usability.
2. Steel may be supplied with the addition of micro alloying elements like niobium, titanium, vanadium and boron. The micro-alloying elements shall not exceed 0.10% when added individually or in combination.
3. The nitrogen content of the steel shall not be more than 0.009%. This has to be ensured by the manufacturer by occasional check analysis.

Mechanical Properties

Specification	Grade	Yield Strength MPa min	Ultimate Tensile Strength MPa	Elongation %	Internal dia meter of bend
SAIL PROP	SAE 1020	310-320	440	15	
SAIL PRE FAB	SAE 1020 spl.	345 min	450 min	21	
IS 6240/2008		240	350-450	25	GL=5.65√S ₀
SAIL HS LPG	SG 255	255	400	28	GL=50 mm
JISG 3116	SG 295	295	440	26	
EN 10120	P245NB	245	360-450	Up to 3 mm GL=80 mm 26 34 24 32 21 28	GL=5.65√S ₀
	P265NB	265	410-500		
	P310NB	310	460-550		
EN 34		330-410	390-490	27 mm	0.5t- close
E 38		370-460	440-560	25 min	0.5t- close
E 46		450-530	490-610	21 min	0.5t- close
BSK 46		451-560	490-640	21 min	1t- close
SAIL SUPER FORM JISG 3113	SAPH 440	305 (t: 1 to 6 mm) 295 (t: 6 to 8 mm)	440	GL: 50 mm 34 (t < 6 mm) GL: 5.65 √S ₀ 32 (t: 6-8 mm)	
APL-5L	A	210	335	% elongation 1.940A ^{0.2} /U 0.9 (GL : 50.8 mm) for all API Grades A : Cross sectional area in mm ² U: Minimum UTS in MPa	
	B	245	415		
	X42	290	415		
	X46	320	435		
	X52	360	460		
	X56	390	490		
	X60	415	520		
	X65	450	535		
	X70	485	570		

NOTES : These are pipe properties. Hot rolled plate/coil properties are to be mutually agreed upon by producer and pipe manufacturers.

Mechanical Properties

Pipe grade	Yield strength ^a R _{10.5} MPa		Tensile strength ^b R _m MPa		Ratio ^{a,b} R _{10.5} /R _m	Elongation (on 50 mm) A%
	minimum	maximum	minimum	maximum	maximum	minimum
B	245	450 ^c	415	655	0.93	d
X42	290	495	415	655	0.93	d
X46	320	525	435	655	0.93	d
X52	360	530	460	760	0.93	d
X56	390	545	490	760	0.93	d
X60	415	565	520	760	0.93	d
X65	450	600	535	760	0.93	d
X70	485	635	570	760	0.93	d

^a For intermediate grades, the difference between the specified maximum yield strength and the specified minimum yield strength shall be as given in the table for the next higher grade, and the difference between the specified minimum tensile strength and the specified minimum yield strength shall be as given in the table for the next higher grade. For intermediate grades up to X46, the tensile strength shall be ≤ 655 MPa. For intermediate grades greater than X46 and lower than X70, the tensile strength shall be ≤ 760 MPa. The calculated value shall be rounded to the nearest 5 MPa

^b This limit applies for pipe with $D > 323.9$ mm (12.750 in).

^c For pipe requiring longitudinal testing, the maximum yield strength shall be ≤ 495 MPa.

^d The specified minimum elongation, A_f shall be as determined using the following equation:

$$A_f = C \frac{A_{xc}^{0.2}}{U^{0.9}}$$
 where C is 1.940 for calculations; A_{xc} is the applicable tensile test piece cross-sectional area, expressed in square millimetres as follows:

– for circular cross-section test pieces, 130 mm² for 12.7 mm and 8.9 mm diameter test pieces; and 65 mm² for 6.4 mm diameter test pieces;

– for full-section test pieces, the lesser of (a) 485 mm² and (b) the cross-sectional area of the test piece, derived using the specified outside diameter and the specified wall thickness of the pipe, derived using the specified outside diameter and the specified wall thickness of the pipe, rounded to the nearest 10 mm²;

– for strip test pieces, the lesser of (a) 485 mm² and (b) the cross-sectional area of the test piece, derived using the specified width of the test piece and the specified wall thickness of the pipe, rounded to the nearest 10 mm²;

U is the specified minimum tensile strength, expressed in megapascals.

Mechanical Properties

Grade	YS, MPa, min	UTS, MPa, min	% El min (Std GL)
HSFQ 250	250	380	30
HSFQ 350	350	400	28
HSFQ 450	450	520	25
HSFQ 500	500	560	22
HSFQ 550	550	620	18
SAIL FORMING 250	250	410	26
SAIL FORMING 350	350	490	24
SAIL FORMING 410	410	540	22
SAIL FORMING 450	450	550	22

Mechanical Properties of Seismic Resistant Structural Steel (IS 15962:2012)

Grade	UTS (MPa, min.)	Yield Strength (MPa, min.)			% El min. GL=5.65√A ₀	Charpy Impact (J at 0°C) min.	YS/UTS max.
		<20 mm	20-40 mm	>40 mm			
E250S	410	250	240	230	23	27	0.80
E300S	440	300	290	280	22	27	0.80
E350S	490	350	330	320	22	27	0.85
E450S	570	450	430	420	20	27	0.88

Mechanical Properties of high tensile flat rolled steel for lighter cylinder (IS 15914:2011)

Grade	Tensile Strength MPa	Yield Stress MPa Min	Percentage Elongation Min at Gauge Length (under revision) min		Reference Heat Treatment Austenitizing Temperature °C
			80 mm	5.65√S ₀	
			<3 mm	3 to 6 mm	
HS 235	360-460	235	25	32	920-960
HS 265	410-510	265	22	30	890-930
HS 295	450-560	295	20	28	890-930
HS 345	490-610	345	18	24	880-920

The above properties are specified for cold formed and normalized cylinder. However tensile properties of hot rolled plate/sheet/strip are to be mutually agreed upon by the producer and by the cylinder manufacturer.