

Chemical Composition

IS: 2062/2011

Grade Designation	Quality	Ladle Analysis, Percent, Max					Carbon Equivalent (CE), Max	Method of Deoxidation
		C	Mn	S	P	Si		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
E 350	A							
	BR	0.20	1.55	0.045	0.045	0.45	0.47	Semi killed/killed
	BO							
	C	0.20	1.55	0.040	0.040	0.45	0.45	Killed
E 410	A							
	BR	0.20	1.60	0.045	0.045	0.45	0.50	Semi killed/killed
	BO							
	C	0.20	1.60	0.040	0.040	0.45	0.50	Killed
E 450	A	0.22	1.65	0.045	0.045	0.45	0.52	Semi killed/killed
	BR							
E 550	A	0.22	1.65	0.020	0.025	0.50	0.54	Semi killed/killed
	BR							
E 600	A	0.22	1.70	0.020	0.025	0.50	0.54	Semi killed/killed
	BR							

SAILMA

Nb + Ti + V%

Grade	C max	Mn max	S max	P max	Al min	Si max	CE max	MAE max
300	0.20	1.50	0.045	0.045	0.02	0.45	0.44	≤ 0.25
300 HI	0.20	1.50	0.040	0.040	0.02	0.45	0.43	≤ 0.25
350	0.20	1.55	0.045	0.045	0.02	0.45	0.46	≤ 0.25
350 HI	0.20	1.55	0.040	0.040	0.02	0.45	0.45	≤ 0.25
410	0.20	1.60	0.045	0.045	0.02	0.45	0.47	≤ 0.25
410 HI	0.20	1.60	0.040	0.040	0.02	0.45	0.46	≤ 0.25
450	0.20	1.65	0.045	0.045	0.02	0.45	0.48	≤ 0.25
450 HI	0.20	1.65	0.040	0.040	0.02	0.45	0.47	≤ 0.25
550	0.20	1.65	0.020	0.025	0.02	0.50	0.54	≤ 0.25
550 HI	0.20	1.65	0.015	0.025	0.02	0.50	0.54	≤ 0.25
600	0.20	1.70	0.015	0.025	0.02	0.50	0.54	≤ 0.25

Specification	Grade	C % max	Mn % max	P % max	S % max	Si %	
SAIL-FRS		0.20	1.5	0.040	0.040	Cr+Mo %=1.00	Nb+V+Ti (max)% 0.12

Note: Micro alloying elements like Nb, V, Ti or B shall be added singly or in combination and total micro alloying shall be as indicated or as per mutual agreement between SAIL & Purchaser.

IS: 2041-2009 - Chemical Composition (wt %)

(Steel Plates for pressure vessels used at moderate and low temperature)

Grade	C max	Si	Mn	P max	S max	Al (total) min	N max	Nb max	V max	Ti max	Nb+V+Ti min	Cr max	Cu max	Mo max	Ni max
R 220	0.21	0.15-0.35	0.60-1.50	0.035	0.035	0.020	0.012	–	–	–	–	–	–	–	–
R 260	0.25	0.15-0.35	0.85-1.50	0.035	0.035	0.020	0.012	–	–	–	–	–	–	–	–
R 275	0.16	0.40 max	0.80-1.50	0.025	0.015	0.020	0.012	0.05	0.05	0.03	0.05	0.30	0.30	0.08	0.50
R 355	0.18	0.50 max	1.10-1.70	0.025	0.015	0.020	0.012	0.05	0.10	0.03	0.12	0.30	0.30	0.08	0.50
H 235	0.16	0.35 max	0.60-1.20	0.025	0.015	0.020	0.012	0.02	0.02	0.03	0.06	0.30	0.30	0.08	0.30
H 265	0.2	0.40 max	0.80-1.40	0.025	0.015	0.020	0.012	0.02	0.02	0.03	0.06	0.30	0.30	0.08	0.30
H 295	0.2	0.40 max	0.90-1.50	0.025	0.015	0.020	0.012	0.02	0.02	0.03	0.06	0.30	0.30	0.08	0.30
H 355	0.22	0.60 max	1.10-1.70	0.025	0.015	0.020	0.012	0.02	0.02	0.03	0.06	0.30	0.30	0.08	0.30

NOTES :

1. For Grades R220, R 260, R275, R355 Carbon content over the maximum specified shall be increased by 0.03 percent for plates over 12 mm thickness.
2. Microalloying elements Nb and V maybe added to Grades R220 & R260, subject to mutual agreement between purchaser and manufacturer/supplier.
3. For product thicknesses <6 mm, a minimum Mn of 0.6 percent is permitted.
4. The minimum Al (total) content may not be applicable, if Nb, Ti or V either singly or in combination are additionally used for Nitrogen binding.
5. If only Al is used for nitrogen binding, a ratio Al/N >= 2 shall apply.
6. Cr+Cu+Mo shall not exceed 0.45 percent.
7. Elements not listed in the table shall not be intentionally added to the steel without agreement of the purchaser.
8. Closer limits of composition maybe agreed to between the supplier and the purchaser.
9. Whenever micro alloying elements are added for achieving the strength, maximum carbon equivalent shall not exceed 0.50 for steels used for welding.
10. Carbon equivalent (CE) based on ladle analysis = $C + Mn/6 + \sqrt{Cr+Mo+V}/5 + (Ni+Cu)/15$.

IS: 2041- 2009 Mechanical Properties

(Steel Plates for pressure vessels used at moderate and low temperature)

Grade	Yield Stress MPa, min				Tensile Strength MPa	Elongation percent on Gauge Length 5.65 $\sqrt{S_0}$, min	Impact Energy (J) min at a temperature in °C				0.2% proof stress at 300° C MPa, min				
	≤ 16	> 16 to 40 mm	> 40 to 60 mm	> 60 to 100 mm			20	0	−20	−40					
R 220	220	220	220	220	415-540	21	50	40	27	20	–	Impact test optional for R 220 and R 260			
R 260	260	260	260	260	490-620	21	50	40	27	20	–				
R 275	275	265	255	235	390-510	23	80	70	50	40	–				
R 355	355	345	335	315	490-640	21	80	70	50	40	–				
H 235	235	225	215	200	360-480	24	40	34	27	–	153				
H 265	265	255	245	215	410-530	22	40	34	27	–	173				
H 295	295	290	285	260	460-580	21	40	34	27	–	192				
H 355	355	345	335	315	510-650	20	40	34	27	–	232				

NOTES :

1. Impact test shall be at any one temperature as mutually agreed.
2. Impact test is optional for Grades R220 and R260.
3. The orientation of Impact test specimen shall be longitudinal to the rolling direction for R220, R260, R275, R355 grades and transverse to the rolling direction for H235, H265, H295 and H355 grades.
4. Stringent impact test temperature and values can be mutually agreed.
5. For thickness > 100 mm, Yield stress to be mutually agreed.

Mechanical Properties: IS: 2062/2011

Grade Designation	Quality	Tensile Strength Rm Min Mpa	Yield Strength min, MPa			Percentage Elongation A, at Gauge Length, L=5.65 √S Min	Internal Bend Diameter Min (See Note 2)		Charpy Impact Test (See Note 3 & 4)	
			<20 mm	20-40 mm	>40 mm		≤25 mm	>25 mm	Temp °C	Min
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
E-250	A	410	250	240	230	23	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	3t	—	—	—
	BR								RT	15
E 600	A	730	600	580	570	12	3.5t	—	—	—
	BR								RT	15

Mechanical Properties:

SAILMA

Specification Grade	Yield MPa, min	UTS, MPa, min	% EI min 5.65√S	Internal Bend Diameter, min		Charpy Impact Test	
				≤25 mm	>25 mm	Temp °C	J, min
SAILMA 300	300	440	24	2t	—	—	—
SAILMA 300 HI	300	440	24	2t	—	0	40
SAILMA 350	350	490	24	2t	—	—	—
SAILMA 350HI	350	490	24	2t	—	0 -20	40 30
SAILMA 410	410	540	22	2t	—	—	—
SAILMA 410 HI	410	540	22	2t	—	0 -20	35 25
SAILMA 450	450	570	22	2.5t	—	—	—
SAILMA 450 HI	450	570	22	2.5t	—	0 -20	30 20
SAILMA 550	550	650	14	3t	—	—	—
SAILMA 550 HI	550	650	14	3t	—	0 -20	25 15
SAILMA 600	600	730	14	3.5t	—	—	—
SAIL FRS	300	450	20	1.50	—	—	—

Chemical Composition:

Specification	Grade	C % max	Mn%	P % max	S % max	Si %	CE
ASTM A-36		0.25	0.80-1.20	0.04	0.05	0.15-0.40	

Specification	Grade	Constituents, Percent, Max				
IS: 5986:2011		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 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 killed the silicon content shall not be less than 0.1 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.
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.

Chemical Composition

Specification	Grade	C %	Mn %	P % max	S % max	Si %	CE
ASTM-A-588		0.19 max	0.80- 1.25	0.040	0.050	0.30- 0.65	
Al 0.02 min, Cr 0.40-0.65, Ni 0.40 max, Cu 0.25-0.40, V 0.02-0.10							
DIN 17100	ST 52.3	0.20-0.22	1.6 0	0.040	0.040	0.55	Al 0.02 min
HCRS (Cu+P)		0.15	0.25-0.8	0.07-0.15	0.03	0.28- 0.50	Cu 0.2 min
SAILCOR (IRS M-41)		0.10	0.25- 0.45	0.075-0.140	0.03	0.30- 0.60	
Al 0.03 max, Cr 0.35-0.60, Ni 0.20-0.47, Cu 0.30-0.60 V 0.05 max							
IS: 2002/2009	1	0.18 max	0.50- 1.20	0.035	0.040	0.15- 0.35	0.44 max Cu 0.10% max residual
	2	0.20 max	0.50- 1.20	0.035	0.040	0.15- 0.35	0.44 max Al 0.020% max
	3	0.22 max	0.50- 1.20	0.035	0.040	0.15- 0.35	0.44 max
ASTM-A-285	C	0.28 max	0.90	0.035	0.035		
ASTM-A-515	60	0.24 – 0.27	0.90	0.035	0.035	0.15- 0.40	Al 0.02% max
	65	0.28 – 0.31	0.90	0.035	0.035	0.15- 0.40	
	70	0.31 – 0.33	1.20	0.035	0.035	0.15- 0.40	
ASTM-A-516	55	0.18 – 0.22	0.60- 0.90	0.035	0.035		
	65	0.24 – 0.28	0.85- 1.20	0.035	0.035		
	70	0.27 – 0.30	0.85- 1.20	0.035	0.035		
– For each reduction of 0.10% of C below the specified max, an increase of 0.60% of Mn above the specified max is permitted up to 1.50%. – Grade 60 plates, Mn 0.85-1.20 for thickness ≤ 12.5 mm – Heats will be micro alloyed for orders requiring impact test							
ASTM-A-537	Cl 1	0.24 max	0.7- 1.60	0.035	0.035	0.15- 0.50	Micro alloyed with Nb/V, if required
Al 0.02 min, Cr 0.25 max, Ni 0.25 max, Cu 0.35 max, Mo 0.08 max							
DIN 17155	H1	0.16	0.40-1.20	0.035	0.030	0.35	
Al 0.02% min, Cr 0.25% max, Ni 0.30% max, Cu 0.30% max, Nb 0.01% max, V 0.03% max, Ti 0.03% max, Mo 0.10% max							

Mechanical Properties

Specification	Grade	Yield Strength, MPa, min	Ultimate Tensile Strength, MPa, min		Elongation % min GL 5.65 √So		Internal diameter of bend		
ASTM-A-36		250	400-550		200 mm GL -18 50 mm GL-21				
							< 12 mm	> 12 mm	
IS: 5986:2011	165	165	290-400		30		Close	1t	
	205	205	330-440		28		1t	2t	
	235	235	360-470		26		1t	2t	
	255	255	410-520		24		1t	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	
ASTM-A-588		345	485 min		200 mm GL 16	50 mm GL 19	</-20 1t	<20 1.5t	>25 <40 2t
DIN 17100	ST 52.3 <16 mm	355	490-630			18			
	16-40	345							
	>40-63	355							
Charpy Impact energy 27J at -20°C									
SAILCOR (IRSM-41) HCRS(Cu+P)		340	480		22		1t		
		< 16 mm	16-40 mm	40-60 mm	UTS				
IS 2002/2009	1	235	225	215	360-480		24		2t
	2	265	255	245	410-530		22		2t
	3	290	285	280	460-580		21		3t
		YS		UTS	200 mm GL	50 mm GL			
ASTM-A-285	C	205	385-515		23	27			
ASTM-A-515	60	220	415-550		21	25			
	65	240	450-585		19	23			
	70	260	485-620		17	21			
ASTM-A516	55	205	380-515		23	27			
	60	220	415-550		21	25			
	65	240	450-585		19	23			
	70	260	485-620		17	21			
Charpy Impact energy 18J for Gr 60 & 65 at -51°C and 20J for Gr 70 at -46°C for upto 25 mm: 18J for Gr 60 & 65 at -46°C and 20J for Gr 70 at -40°C for >25 <50									
ASTM-A-537	Class I	345	485-620			18 22			
DIN 17155	HI	235 for <16mm	225 for 16-40 mm	360-480			24		
Charpy Impact energy 31J at 0°C									

For ASTM-A-588/285/204/ 515/ 516/ 537 & DIN 17100
Bend Test is a supplementary requirement

Chemical Composition

Specification	Grade	C % max	Mn % max	P % max	S % max	Si % max	CE
ASTM-A-204	B	0.20- 0.23	0.90	0.035	0.035	0.15- 0.40	
		Mo 0.45 - 0.60%					
ASTM-A -517	F	0.1-0.2	0.6-1.0	0.035	0.035	0.15-0.35	
		Ni 0.7-1.0, Cr 0.4-0.65, Mo 0.4-0.6, V 0.03-0.08, Cu 0.15- 0.50, Bo 0.0005-0.0006					
API-5L	A	0.22	0.90	0.030	0.030		
	B	0.26	1.20	0.030	0.030		
(PSL-I)	X-42	0.26	1.30	0.030	0.030		
	X-46	0.28	1.40	0.030	0.030		
	X-52	0.28	1.40	0.030	0.030		
	X-56	0.26	1.40	0.030	0.030		
	X-60	0.26	1.40	0.030	0.030		
	X-65	0.26	1.45	0.030	0.030		
	X-70	0.26	1.65	0.03	0.03		
		Nb+V+Ti<0.15%					
IS: 3039/1988	I	0.23	*	0.040	0.040	**	0.42 ***
		* Mn content not less than 2.5 times Carbon content if thickness > 12.5 mm.					
		** Si 0.10-0.35% if killed quality. *** Al min 0.01%					
	II	0.21	0.70-1.4	0.040	0.040	0.10-0.35	
	III	0.18	0.70-1.5	0.040	0.040	0.19-0.50	*
		* Al min 0.015% for grade III					
Lloyds Grade	A	0.21	2.5xC% min	0.035	0.035	0.50	
	B	0.21	0.80min	0.035	0.035	0.35	
		For Gr B Mn 0.60% min if impact tested.					
SAILHARD		0.23	1.6	0.050	0.050	0.50	
		Al 0.10 max, Cr 0.65 max, Nb+V+Ti 0.15 max					
GOST 19282	09G2S	0.12	1.3-1.7	0.035	0.040	0.5-0.8	
	10G2S1	0.12	1.3-1.65	0.035	0.040	0.8-1.1	
		Al 0.050 max, Cr 0.30 max, Ni 0.30 max, Cu 0.30 max, Ti 0.03 max, N 0.008 max					

Chemical Composition

Specification	Grade	C % max	Mn % max	P % max	S % max	Si %	Others
SAIL SPP 400	Hardox 400	0.22	1.60	0.02	0.01	0.10-0.70	Cr : 1.40 max Mo : 0.60 max Ni : 0.50 max B : 40 ppm max
SAIL SPP 700	Weldox 700E	0.20	1.60	0.02	0.01	0.60 max	Cr : 0.70 Mo : 0.70 V : 0.08
SAIL HITEN 690 AR		0.22	1.60	0.025	0.015	0.60	Al - 0.02 max V - 0.20 max Ti - 0.02 max Nb - 0.050 max

Mechanical Properties

Specification	Grade	Yield Strength MPa Min		Ultimate Tensile Strength MPa Min	Elongation % min GL 5.65 S ₀		Internal diameter of bend
ASTM-A-204 M					200 mm	50 mm	<25 mm >25 mm < 40 mm
	B	275		485-620	17	21	1.5T 2T
ASTM-A-517	F	690		795-930	16		
API 5L (PSL-I)	A	210		335	25		
	B	245		415	1.944A 0.2/ U0.9		
	X-42	290		415	A :Cross sectional area in mm ²		
	X-46	320		435	U : Minimum UTS in MPa		
	X-52	360		460			
	X-56	390		490			
	X-60	415		520			
	X-65	450		535			
	X-70	485		570			
IS 3039/1988		≤ 25 mm	> 25 < 50 mm				
	I	230	220	400-900	22		
	II	235	235	400-900	22		
	III	235	235	400-900	22		
Lloyds Grade	A	235		400-520	22		
	B	235		400-520	22		CE : 27 J at 0°C

Impact 27J at 0°C for >25mm

Mechanical Properties

Specification	Grade	Yield Strength (MPa min)	Ultimate Tensile Strength (MPa min)	%Elongation (min)	Bend	Hardness
SAILHARD						200 BHN
DSQ LO-PEARL		245	375	25	37	
SAIL SPP 400	HARDOX 400	900	1100	10		
SAIL SPP 700	WELDOX 700E	620	725-860	16		
SAIL HITEN		550	690	15	3.5T	
GOST 19282	09G2S	345 (t:8-10) 325 (t:10-20) 305 (t:20-32) 285 (t:32-40)	490 (t:8-10) 470 (t:10-20) 460 (t:20-32) 450 (t:32-40)	21	2T	
	10G2S1	345 (t:8-10) 335 (t:10-20) 325 (t:20-32) 325 (t:32-40)	490 (t:8-10) 480 (t:10-20) 470 (t:20-32) 450 (t:32-40)	21	2T	

Note : The mechanical properties specified in API Grades are for pipes only.
HRC/Plate properties are to be mutually agreed upon by the producers & pipe manufacturers.

ABS Steel Plates

Grade	Chemistry	Tensile Strength
A	C 0.21, Mn 2.5 x C% min S, P 0.035, Si : 0.50 max Al 0.02 min, CE 0.40	YS 235 MPa, % EL : 22 (50 GL) UTS 400-520 MPa Impact 34J/RT (> 50 mm)
B	C 0.21, Mn 0.80 min S, P 0.035, Si : 0.35 max Al 0.02 min, CE 0.40	YS 235 MPa UTS 400-520 MPa Impact 27J/0° (> 25 mm)
C	C 0.21, Mn 0.60 min S, P 0.035 Al 0.03 min, CE 0.040	YS 315 MPa UTS 400-520 MPa Impact 27J/-20°C for all thicknesses
AH 32 DH 32 EH 32	C 0.18, Mn 0.90-1.60 Nb 0.02-0.05, Si : 0.50 max S 0.035, P 0.035 V 0.05-0.10, Ti 0.02 max	YS 315 MPa, UTS : 440-590 MPa Imp AH 32 34 J min at 0°C DH 32 34 J min at -20°C EH 32 34 J min at -40°C
AH 36 DH 36 EH 36	C 0.18, Mn 0.90-1.60 Si : 0.50 max S 0.035, P 0.035, Nb 0.02-0.05 V 0.05-0.10, Ti 0.02 max	YS 355 MPa UTS 490-620 MPa Imp AH 36 34 J min at 0°C DH 36 34 J min at -20°C EH 36 34 J min at -40°C

Mechanical Properties

Processing of plate orders for Home Sales through Vacuum Degassing (VD)/Isothermal/normal route as per customer requirements.

Requirement			Process		
Category	Grade	Specifications/ Sub Grades	Vacuum Degassing (VD) (Ref. A20/A20 M:07 CI 5.3.4 & S1)	Isothermal (Ref. A20/A20 M:07 CI 5.3.4)	Normal
UT	Mild	IS 2062 E 250 A, B, C, A/SA 283 A/SA 36, BS4360 Gr 43A, BS/DIN EN 10025 S235, 275 JIS G 3101 SS 400, DIN 17100 RSt 37.2, 44.2 Other Equivalent grades	> = 50 mm All grades with UT	40 to < 50 mm All grades with UT	< 40 mm All grades
	Boiler Quality (Normal strength)	IS 2002/1,2,3, IS2041/1,2 A/SA 515 & 516 Grades A/SA 285	> = 50 mm	40 to < 50 mm	< 40 mm
		DIN 17155 HI, EN 10028 2-P 235 GH, P265GH, EN 10028-2-P275	All thickness	–	–
	Boiler Quality (High Strength)	BS 1501-1 BS EN 10028-2-P295GH & 355GH BS EN 10028-3-P355	All thickness	–	–
		A/SA 537 Class 1, IS2041/3	> = 50 mm	40 to < 50 mm	< 40 mm
	Boiler Qty. (Spl)	A/SA 204, SAIL FRS	All thickness	–	–
	High Tensile	IS 2062 E 300, 350, 410 Sailma 300, 300HI/350, 350HI/410, 410HI ASTM A 572 Gr 42, 50, DIN 17100 St 52.3 BS/DIN EN S355 JO, JR, J2, NL GOST 9G2S, 10G2S1, BS4360 Gr 50	> = 50 mm	40 to < 50 mm	< 40 mm
Special	API, DMR, SAIL HITEN, SAILHARD, SAILMA 450 550, 600 SAILMA 450HI 550HI, 600HI, HT 750 IS 2062 E 450 D, E A 588, A 242, GOST5521 Hot Saw Disc	All thickness			
UT	All grades	All specifications/ Sub grades	> = 50 mm	40 to < 50 mm	< 40 mm
IMPACT	All grades	All specifications/ Sub grades	Impact test tempe- rature lower than (-) 20°C		
SPL TDC	All grades	All specifications/ sub grades	As per Customer's requirement or agreement		
Normalised Plate	As per mandatory requirement of the specification or as per agreed TDC				
Normalised Rolling	As per requirement of the customer				