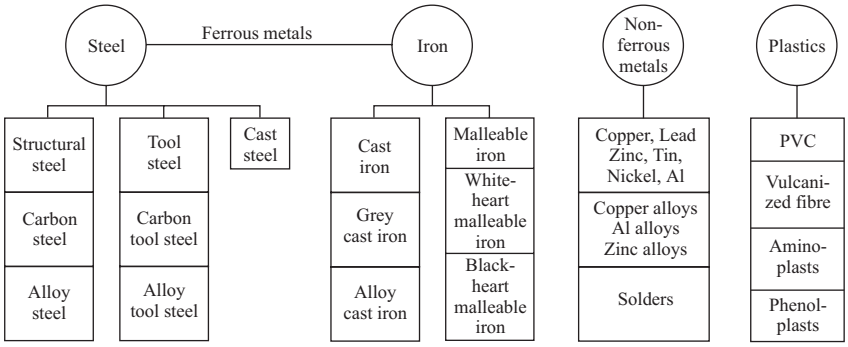
Materials

Classification and categories



General properties of materials

Chemical elements

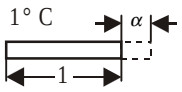
Specific weight—Melting points—Coefficient of linear (thermal) expansion

Symbol	*Element*	*Specific weight gf/cm³*	*Melting or solidification point °C*	*Coefficient of linear (thermal) expansion α*	*Symbol*	*Element*	*Specific weight gf/cm³*	*Melting or solidification point °C*	*Coefficient of linear (thermal) expansion α*
Ag	Silver	10.5	961	0.000 020	Ni	Nickel	8.9	1453	0.000 013
Al	Aluminium	2.7	660	0.000 024	P	Phosphorus	1.82	44	0.000 124
Au	Gold	19.3	1063	0.000 014	Pb	Lead	11.35	327	0.000 029
Ba	Barium	3.74	704		Pt	Platinum	21.45	1769	0.000 009
Be	Beryllium	1.85	1283	0.000 012	Ra	Radium	5.00	700	
Bi	Bismuth	9.75	271	0.000 013	S	Sulphur	2.06	113	0.000 064
C	Carbon				Sb	Antimony	6.69	630	0.000 011
	Graphite	2.25	3550	0.000 008	Se	Selenium	4.5	217	0.000 037
	Diamond	3.52	3600	0.000 001	Si	Silicon	2.4	1410	0.000 008
Ca	Calcium	1.55	850		Sn	Tin	7.3	232	0.000 023
Cd	Cadmium	8.64	321	0.000 029	Ta	Tantalum	16.6	3030	0.000 007
Ce	Cerium	6.9	775		Th	Thorium	11.2	1827	0.000 011
Co	Cobalt	8.8	1492	0.000 013	Ti	Titanium	4.52	1812	0.000 009
Cr	Chromium	7.1	1800	0.000 007	U	Uranium	18.7	1132	
Cu	Copper	8.9	1083	0.000 017	V	Vanadium	5.96	1730	
Fe	Iron	7.86	1535	0.000 012	W	Tangsten	19.27	3380	0.000 004
Ir	Iridium	22.42	2443	0.000 006	Zn	Zinc	7.13	420	0.000 026
K	Potassium	0.86	63	0.000 084	Zr	Zirconium	6.5	1852	0.000 005
La	Lanthanum	6.18	826		Hg	Mercury	13.5	– 39	
Li	Lithium	0.53	180	0.000 058	Cl	Chlorine		– 101	
Mg	Magnesium	1.74	650	0.000 026	H	Hydrogen		– 259	
Mn	Manganese	7.3	1244	0.000 023	He	Helium		– 272	
Mo	Molybdenum	10.21	2610	0.000 005	N	Nitrogen		– 210	
Na	Sodium	0.97	98	0.000 071	Ne	Neon		– 249	
Nb	Niobium	8.55	2415	0.000 007	O	Oxygen		– 219	

Specific Weight—Melting Point—Coefficient of Thermal Expansion—Shrinkage

Specific weight = Weight per unit volume (gf/cm³ or kgf/dm³)

Melting point (Fusion point) = Temperature at which particular material starts melting



Coefficient of linear (thermal) expansion α = Increase in length of unit length of a solid for temperature rise of 1°C.

Materials

Material	*Specific weight gf/cm³*	*Melting point °C*	*Material*	*Coefficient of linear expansion*
Steel	7.85	1350…1450	Iron and Steel	0.000 012
Cast steel	7.85		Chrome steel	0.000 010
Grey cast iron	7.2	1150…1250	Nickel steel	0.000 012
High-speed steel	9.0	≈ 2000	Tungsten carbide	0.000 006
Tungsten carbide	14.75	≈ 2000	Invar	0.000 0015
Constantan	8.89	≈ 1600	Chromium	0.000 007
Invar (36% Ni)	8.7	1450	Constantan	0.000 015
Brass	8.5	≈ 900	Electron	0.000 024
Al bronze	8.4		Aluminium	0.000 023
Al cast bronze	7.6		Magnesium	0.000 026
Tin bronze	8.6	≈ 900	Gold	0.000 014
Lead bronze	9.5		Silver	0.000 019
Al-alloy (Al, Cu, Mg)	2.8	≈ 650	Zinc	0.000 030
Mg-alloy	1.8	≈ 650	Tin	0.000 023
Babbitt metal	7.5...10.1	300…400	Lead	0.000 029
Plexiglass	1.2		Nickel	0.000 013
			Platinum	0.000 009
Alcohol at 18°C	0.79	–110	Brass	0.000 018
Petrol at 15°C	0.72	–150	Brouce	0.000 017
Copper sulphate	1.11		Plexiglass	0.000 010
Water at 4°C	1.0	0	Glass	0.000 008
			Porcelain	0.000 003
Acetylene at 0°C	1.17 kg/m³	–84		
Carbon dioxide at 0°C	1.90 kg/m³	–78		
Air at 0°C	1.29 kg/m³	–194		
Propane at 0°C	2.00 kg/m³	–43		

Shrinkage = difference in volume of the mould compared with the volume of the casting after cooling, in percent

Material	*Shrinkage*	*Material*	*Shrinkage*
Grey cast iron	1%	Brass	1.5%
Cast steel	2%	Copper	1%
Malleable iron	1.6%	Tin, lead	1%
Brouce	1.5%	Zinc alloys	1.5%
Gun metal	1.5%	Al, Mg alloys	1.25%

System of Designation of Iron and Steel

IS:1762–1961
IS:4843–1968

Steel

Plain carbon steels	< 0.5 % < 0.8 % < 0.1 % < 0.25%	Silicon Manganese Al or Ti or Copper	> 0.5 % > 0.8 % > 0.1 % > 0.25%	**Alloy steels**

Steels not required to receive heat treatment	**Steels** required to receive heat treatment	**Carbon tool steels**	**Low alloy steels** < 5% special alloying element	**High alloy steels** > 5% special alloying element

The System of Designation is as follows

1. Letter St 2. Minimum tensile strength in kgf/mm^2	1. Letter C for Carbon 2. Index number for carbon following letter C, denoting average Carbon content in hundredths of a percent	Letter T for Tool steels Index number for Carbon following letter T, denoting average Carbon content in hundredths of a percent	1. Average C content in hundredths of a percent without prefix C and with prefix T for Alloy Tool Steels 2. Chemical symbols of the significant elements arranged in descending order of percentage contents 3. Alloy Index indicating the average percentage of each alloying element	
e.g. St. 42 Steel having a minimum tensile strength of 42 kgf/mm^2	e.g. C 35 Carbon steel having an average of 0.35% Carbon	e.g. T 90 Tool steel having an average of 0.90% Carbon	e.g. 15 Cr 65 Chrome steel with average percentages of C = 0.15 and Cr = 0.65	e.g. 20 Cr 18 Ni 2 Chrome Nickel Steel with average percentages of C = 0.20; Cr = 18 and Ni = 2.00
Applicable for steels which are standardized on the basis of their tensile strength without detailed chemical composition	Steels with special limits for maximum S & P, receive the suffix "K", e.g. C 35 K	To indicate the treatment given to the steel, symbols are used, e.g. T 90a, "a" is used to indicate annealing (ref. Page 4, Add. symbols)	Alloy index number is assigned as follows:	

Nominal or average alloy content	Alloy index number
1. Up to 1 percent.	Average alloy content up to 2 decimal places underlined by a bar
2. 1 percent and over.	Rounded to the nearest whole number. Up to 0.5 rounded down, 0.5 and over rounded up.

Castings

System of Designation of Plain Castings

1. Symbols indicating the type of castings
2. Symbol for mechanical properties

OR

1. Symbols indicating the type of castings
2. Symbol for chemical composition similar to the designation of steels

System of Designation of Alloy Castings

1. Symbols indicating the type of castings
2. Average carbon content in hundredths of a percent following the type symbols of castings
3. Chemical symbols for the significant elements arranged in descending order
4. Alloy index number for the average percentages of alloying elements

CS-Steel Castings	*FG-Grey Iron Castings*	*SG-Spherical or Nodular Graphite Iron Castings*	*Malleable Iron Castings*
CS 125—Unalloyed steel castings with minimum tensile strength 125 kgf/mm^2 CSM 35—Unalloyed special steel castings with minimum tensile strength 35 kgf/mm^2 GS 50 Cr 1V 20—Alloy steel castings with average percentage of C = 0.50; Cr = 1.00; V = 2.20	FG 15—Grey iron castings with minimum tensile strength 15 kgf/mm^2 FG 35 Si 15—Special grey iron castings with minimum total carbon percentage = 3.5 and average Silicon percentage = 1.50	SG 80/2—Spheroidal or Nodular graphite iron castings with minimum Tensile strength 80 kgf/mm^2 and minimum elongation 2% on gauge length equal to five times the diameter of test bar	BM 35—Black heart malleable iron castings with minimum tensile strength 35 kgf/mm^2 PM 70—Pearlitic malleable iron castings with minimum tensile strength 70 kgf/mm^2 WM 42—White heart malleable iron castings with minimum tensile strength 42 kgf/mm^2
CSH—Heat resistant steel castings CSC—Corrosion resistant steel castings	AFG—Austenitic flake graphite iron castings	ASG—Austenitic spheroidal or nodular graphite iron castings	ABR—Abrasion resistant iron castings

Tensile strengths are on 30 mm Dia Test Bars as-cast.

Additional symbols
Denoting special properties

Steel quality		*Treatment given*	
A–Non-ageing quality	R–Rimming quality	a–Annealed or softened	o–Spherodized
E–Stabilized against stress corrosion	G–Grain size controlled	c–Case carburized	p–Patented
L–Control cooled to ensure freedom from flakes	H–Hardenability controlled	d–Hard drawn, cold reduced	q–Hardened and tempered
D–Fully killed	I–Inclusion controlled	h–Hot-rolled	s–Stress relieved
D_2–Semi killed	M–Structural homogeneity guaranteed by Macro-etch test	n–Normalized	t–Tempered

e.g., St 42 An–Non-ageing steel with 42 kgf/mm² minimum tensile strength-normalizedof
15 Cr 3c–Chromium steel with average percentages C = 0.15, Cr = 3.0 and case carburized

E–Electric Furnace Steel; R–Open Hearth Steel; BO–Basic Oxygen

Grey iron castings IS:210–1970

Code for designation	*Grades*	*Tensile strength Min, kgf/mm²*	*Transverse test*			*Typical applications*
			Breaking load Min, kgf	*Corresponding transverse rupture stress kgf/mm²*	*Deflection Min, mm*	
FG 15	15	15	800	34.0	4.0	Parts requiring no special grades for general structural purposes
FG 20	20	20	900	38.2	4.5	
FG 25	25	25	1000	42.4	5.0	Parts subjected to severe strains such as cylinder parts, etc.
FG 30	30	30	1100	46.7	5.5	
FG 35	35	35	1350	57.3	5.5	
FG 40	40	40	1500	63.7	5.5	For extraordinary use

Malleable iron castings IS:2108–1962, IS:2640–1964, IS:2107–1962

Code for designation	*Grades*	*Tensile strength, Min, kgf/mm²*	*0.5% Proof stress, Min, kgf/mm²*	*Elongation % (gauge length = 3 dia of test bars) Min*	*Brinell hardness HB Max*	*Phosphorous contact % Max*	*Typical applications*
BM 35	A	35	21	14	149	0.12	Thin walled castings; mass production parts wheels, keys, Parts for locks and sewing machine parts.
BM 30	C	30	–	6	163	0.20	
PM 70	A	70	55	2	241 to 285	0.12	
PM 45	E	45	28	7	149 to 201	0.12	
WM 42	A	42	26	4	217	0.15	
WM 35	B	35	–	3	217	0.15	

Steel castings IS:1030–1962

Code for designation	*Grades*	*Tensile strength Min, kgf/mm²*	*Elongation % on gauge length 5.65 $\sqrt{S_0}$, Min,*	*S % Max*	*P % Max*	*Typical applications*
CS 55	1	55	12	0.060	0.060	Used for general engineering purposes instead of grey iron castings if greater strength and tenacity are to be met.
CS 47	2	47	17	0.060	0.060	
CS 41	3	41	18	0.060	0.060	
CS 65	1	65	17	0.050	0.050	High strength, good toughness and high abrasion resistance properties; used in transportation equipment and agricultural machinery parts.
CS 85	2	85	12	0.050	0.050	
CS 125	3	125	5	0.050	0.050	

Alloy steel castings for high temperature service IS:3038–1965, IS:2856–1964

Grades	*Tensile strength Min, kgf/mm²*	*Elongation % on 5.56 $\sqrt{S_0}$ gauge length, Min*	*Yield stress or 0.5% proof stress Min, kgf/mm²*	*C %*	*Si %*	*Mn %*	*S % Max*	*P % Max*	*Typical applications*
1	55	17	35	0.20–0.25	0.15–4.40	1.25–1.45	0.050	0.050	Cast parts which preferably are to withstand temperatures between 300°C to 525°C
2	47	17	25	0.25 Max	0.20–0.50	0.50–1.00	0.050	0.050	
3	52	15	31	0.15 Max	0.40 Max	0.40–0.80	0.050	0.050	
4	49	17	28	0.20 Max	0.60 Max	0.50–0.80	0.050	0.050	
5	52	17	31	0.08–0.15	0.35 Max	0.30–0.70	0.050	0.050	
6	63	15	43	0.20 Max	0.75 Max	0.40–0.70	0.050	0.050	
7	63	15	43	0.20 Max	1.00 Max	0.30–0.70	0.050	0.050	
CS_N–C20	42	20	21	0.25 Max	0.60 Max	0.70 Max	0.050	0.050	Parts which to be fusion welded
CS_w–C25	49	18	25	0.30 Max	0.60 Max	1.00 Max	0.050	0.050	

Specification on Structural and Heat treatable Steels

General structural steels

IS:1977–1969; IS:2062–1969
IS: 226–1969; IS: 961–1962

Designation of steel	*Tensile strength kgf/mm²*	*Yield strength for thicknesses* upto 20 mm	20–40 mm	*Elongation % on gauge length 5.65 $\sqrt{S_0}$, Min*	*C % Max*	*S % Max*	*P % Max*	*Typical applications*
St 32–O	32–44	—	—	26	—	0.07	0.07	Intended for general engineering purposes.
St 42–O	42–54	26.0	—	23	—	0.07	0.07	
St 42–S	42–54	26.0	24.0	23	0.25	0.055	0.055	Intended for all types of structures weldable upon certain conditions.
St 42–W	42–54	26.0	24.0	23	0.20	0.055	0.055	Can be subjected to fusion welding.
St 58–HT	58 Min	36.0	35.0	20	0.27	0.055	0.055	Intended for use in structures where fabrication is done by methods other than welding.
St 55–HTW	55 Min	36.0	35.0	20	0.20	0.055	0.055	Intended for use in structures where welding is employed for fabrication and where guaranteed weldability is required.

Standard sizes of hot-rolled products made of general structural steels

IS Number	*Product*	*Page*	*IS Number*	*Product*	*Page*
808	Beam, channel and angle sections	21	1732	Round and square bars	19
1173	Tee bars	22	1863	Bulb plates	—
1252	Bulb angles	—	1864	Unequal angles	21
1730	Plates, sheet and strip	20	3954	Channel sections for general engineering purposes	22
1731	Flats	20			

Case hardening steels

IS: 4432–1967

Designation of steel	*Case hardened* Tensile strength Min kgf/mm²	Elongation % Min	*Temperatures for °C* Carburizing	Softening	Case hardening	Annealing	*Typical applications*
C10, C14, 19 S11	50	17	900–920	650–680	760–780	—	These steels are used for components requiring high wear resistant surfaces, coupled with tough cores to resist shock loads and strength to give longer service life.
14 Mn IS14, 11Mn2	60	17	900–930	650–680	760–780	800–920	
15 Cr 65	60	13	900–930	650–680	770–800	870–900	
17 Mn 1 Cr 95	80	10	900–930	650–680	810–840	850–880	
20 Mn Cr 1	100	8	900–930	650–680	810–840	850–880	
16 Ni 80 Cr 60	70	15	880–920	650–680	780–820	850–880	
16 Ni 1 Cr 80	85	12	900–930	650–660	780–820	850–880	
13 Ni 3 Cr 80	85	12	900–930	620–650	760–780	860–880	
15 Ni 4 Cr 1	135	9	900–930	600–630	760–780	860–880	
20 Ni 2 Mo 25	85	12	880–920	650–660	760–780	—	
20 Ni55 Cr50 Mo 20	90	11	880–920	650–660	780–820	—	
15 Ni Cr 1 Mo 12	100	9	900–930	630–650	780–820	860–880	
15 Ni 2 Cr 1 Mo 15	110	9	900–930	630–650	780–820	860–880	
16 Ni Cr 2 Mo 20	135	9	900–930	630–650	800–820	850–880	

Flame and induction hardening steels

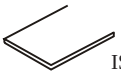
IS: 3930-1966

Designation of steel	*Properties in quenched and tempered conditions* Tensile range kgf/mm²	0.2% proof stress, Min kgf/mm²	Izod impact Min. kgf.m	Surface hardness obtainable HRC	*Hardening temperature* For oil quench	For water quench	*Typical applications*
C 30	60 to 75	36	5.5	45–50	860–890	860–890	These wrought unalloyed and alloyed steels for flame and induction hardening are used when high cold strength and good impact properties are required.
C 45	70 to 85	44	3.5	55–61	830–860	820–850	
T 70	70 to 85	40	2.8	60–63	810–840	780–810	
37 Mn 2	60 to 75	40	4.8	53–59	850–870	840–860	
40 Mn 2S 12	70 to 85	46	4.8	53–59	850–870	840–860	
35 Mn 2 Mo 45	80 to 95	56	5.5	53–59	840–860	830–850	
50 Cr 1	80 to 95	48	2.8	57–62	850–870	840–860	
50 Cr 1 V23	80 to 95	48	2.8	57–62	850–870	840–860	
40 Ni 3	80 to 95	56	5.5	54–60	830–860	840–870	
40 Ni2 Cr 1 Mo 28	90 to 105	66	5.5	54–60	830–840	810–830	
31 Ni3 Cr 65 Mo 55	90 to 105	66	5.5	49–54	850–880	820–840	

Steels for hardening and tempering IS: 5517–1969

Designation of steel	*Properties in hardened and tempered condition*		*Normalizing temperature °C*	*Hardening temperature °C*	*Quenching medium*	*Tempering temperature °C*	*Typical applications*
	Tensile strength kgf/mm²	*Yield stress Min, kgf/mm²*					
C 30	60 to 75	40	860 to 890	860 to 890	Water or oil	550 to 660	These wrought unalloyed and alloyed steels in the form of billets and bars for general engineering purposes are intended to be used in the hardened and tempered condition
C 35 Mn 75	60 to 75	40	850 to 880	840 to 880	Water or oil	530 to 760	
C 40	60 to 75	38	830 to 860	830 to 860	Water or oil	550 to 660	
C 45	60 to 75	38	830 to 860	830 to 860	Water or oil	530 to 670	
C 50	80 to 95	54	810 to 840	810 to 840	Oil	550 to 660	
C 55 Mn 75	80 to 95	54	810 to 840	810 to 840	Oil	550 to 660	
40 S 18	70 to 85	48	830 to 860	830 to 860	Oil	550 to 660	
40 Mn 2 S12	60 to 75	40	840 to 870	840 to 870	Oil	550 to 660	
20 Mn 2	60 to 75	44	860 to 900	860 to 900	Water or oil	550 to 660	
27 Mn 2	70 to 85	46	840 to 880	840 to 880	Water or oil	550 to 660	
35 Mn 2 Mo 45	100 to 115	80	—	840 to 860	Oil	550 to 660	
55 Cr 70	90 to 105	66	800 to 850	800 to 850	Oil	500 to 700	
40 Cr 1	80 to 95	60	850 to 880	850 to 880	Oil	550 to 700	
40 Cr 1 Mo 28	80 to 95	60	850 to 880	850 to 880	Oil	550 to 720	
40 Cr Al I Mo 18	90 to 105	70	—	850 to 900	Oil	550 to 700	
40 Ni 3	90 to 105	70	830 to 860	850 to 860	Oil	550 to 650	
35 Ni 1 Cr 60	90 to 105	70	—	820 to 850	Water or oil	550 to 660	
30Ni4 Cr 1	120 to 135	130	—	810 to 830	Air or oil	> 250	
40Ni 2 Cr 1 Mo 28	120 to 135	130	—	830 to 850	Oil	550 to 660	
31Ni 3 Cr 65 Mo 55	120 to 135	10	—	830 to 850	Oil	upto 660	
40 Ni 3 Cr 65 Mo 55	120 to 135	0 130	830 to 850	830 to 850	Oil	upto 660	

Cold rolled carbon steel sheets

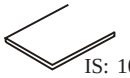


IS: 513–1963

Types	*Tensile strength (for design purpose only) kgf/mm²*	*C % Max*	*Mn % Max*	*S % Max*	*P % Max*	*For all types*		*Typical applications*
						Delivery condition	*Surface finish*	
O: Ordinary	28	0.15	—	0.060	0.060	(1) Scale-free	Coarse or rough	Course or rough for enamelling and lacquering
D: Drawing	28	0.12	0.50	0.050	0.050			
DD: Deep drawing	28	0.10	0.50	0.040	0.040	(2) Improved surface	Medium or dull	Medium or dull for general purposes (not suitable for plating)
EDD: Extra deep drawing	28	0.10	0.50	0.035	0.035	(3) Best surface	Fine or bright	Fine or bright for electroplating

Note: Sheet conforming to this standard are of weldable quality and are suitable both for fusion and spot welding.

Hot rolled carbon steel sheet and strip



IS: 1079–1968

Grade	*Tensile strength kgf/mm²*	*Yield stress kgf/mm²*	*Elongation % Min*	*C% Max*	*Mn% Max*	*S% Max*	*P% Max*	*Delivery condition*	*Typical applications*
O-1079	—	—	—	—	—	0.060	0.060	Hot-rolled	Used for cold formed structural members and for other general engineering purposes
D-1079	—	—	—	0.12	0.50	0.050	0.050	Annealed	
DD-1079	27–40	—	23	0.10	0.50	0.040	0.040	Normalized	
EDD-1079	27–39	—	25	0.10	0.50	0.035	0.035	and	
St 34-1079	34–42	21.0	25	0.15	—	0.050	0.050	Descaled	
St 42-1079	42–50	24.0	22	0.25	—	0.050	0.050		
St 50-1079	50–60	30.0	20	0.30	—	0.050	0.050		
St 52-1079	52–62	36.0	20	0.22	—	0.050	0.050		

Spring steel — Hot-rolled spring steel — IS:3431–1965

Designation of steel	*Grade*	*C %*	*Mn %*	*Si %*	*S % max*	*P % max*	*Cr %*	*V %*	*Typical applications*
50 Cr IV **23** 55 Si 2 Mn **90**	1 2	0.45–0.55 0.50–0.60	0.50–0.80 0.80–1.00	0.10–0.35 1.50–2.00	0.050 0.050	0.050 0.050	0.90–1.20 —	0.1–0.30 —	Steels in the form of Barm and flats for manufacture of volute, helical and laminated springs for automative suspension.

Cold-rolled steel strip for springs — IS: 2507–1965

Designation of steel	*Grade*	*Tensile strength kgf/mm²*		*C %*	*Si%*	*Hardened in oil at °C*	*Annealed at °C*	*Typical applications*
		Hardened and tempered	*Annealed max*					
C 45	1	120–145	60	0.40–0.50	0.10–0.35	830–860	600–650	Cold rolled steel strip for the manufacture of springs for various purposes.
C 65	3	120–145	60	0.60–0.70	0.10–0.35	810–840	600–650	
C 75	5	120–160	65	0.70–0.80	0.10–0.35	780–810	600–650	
C 98	8	160–180	70	0.90–1.05	0.10–0.35	770–800	620–660	
55 Si 2 Mn **90**	9	160–200	80	0.50–0.60	1.50–2.00	830–860	640–680	
50 Cr I	10	170–230	80	0.45–0.55	0.10–0.35	830–860	640–680	
50 Cr IV **23**	11	190–240	80	0.45–0.55	0.10–0.35	830–860	600–680	

Spring steels for use under elevated temperatures — IS:4454–1967

Grades	*Classification*	*Tensile strength (for wire dia up to 7 mm) min*	*C %*	*Si %*	*Cr %*	*Va %*	*Typical applications*
1S	S denotes static	150	0.45–0.55	0.15–0.35	0.90–1.20	0.15–0.30	Used for manufacturing cold formed helical springs, volute springs, etc. working under elevated temperatures.
1D	stressed springs; D	145	0.45–0.55	0.15–0.35	0.90–1.20	0.15–0.00	
2S	denotes dynamic	175	0.50–0.60	1.20–1.60	0.50–0.80	—	
2D	stressed springs	175	0.50–0.60	1.20–1.60	0.50–0.80	—	

Steels for Screws Manufacture

Carbon steel wire for the manufacture of machine screws — IS: 1976–1960

Designation of steel	*Grade*	*Tensile strength*	*C % max*	*Mn %*	*S % max*	*P % max*	*Typical applications*
—	1	44–55 kgf/mm²	0.15	0.30–0.65	0.065	0.060	Used for the manufacture of machine screws by the cold reading process.
—	2	55–71 kgf/mm²	0.15	0.30–0.65	0.065	0.060	

Carbon steel wire for the manufacture of wood screws — IS: 1673–1960

C10	—	460 N/mm²	0.17	0.30–0.65	0.055	0.055	Used for the manufacture of wood screws by the cold heading process.
C 15	—	460 N/mm²	0.22	0.30–0.65	0.055	0.055	
10 S **11**	—	460 N/mm²	0.17	0.60–0.95	0.08–0.15	0.055	

Boilor Steel Plates — IS: 2002–1962

Grades	*Tensile strength kgf/mm² min*	*Elongation % min*	*C % max*	*Si %*	*S % max*	*P % max*	*Typical applications*
1	37–45	26	0.18	0.10–0.35	0.040	0.040	Plates which are required to be either welded, flanged or flame cut plates of non-flanging quality (low tensile) Plates of non-flanging quality (high tensile)
2 A	42–50	25	0.20	0.10–0.35	0.050	0.050	
2 B	52–62	20	0.22	0.10–0.35	0.050	0.050	

Seamless Steel Pipes — For high-temperature service — IS: 2002–1962

Designation of steel	*Tensile strength (normalised and tempered) N/mm² min*	*Elongation % min*	*C %*	*Si %*	*S % max*	*P % max*	*Typical applications*
16 Mo **30**	440–590	22	0.12–0.20	0.12–0.35	0.040	0.040	Used when the wall of pipes reach temperatures up to 580° C and are exposed to high pressure; can be fused and are welded; can be bent or folded in cold state.
15 Cr **90** Mo **55**	440–590	22	0.10–0.20	0.10–0.35	0.040	0.040	
10 Cr 5 Mo **55**	490–640	16	0.15 max	0.55 max	0.030	0.030	
14 Cr **45** Mo **60** V **27**	460–610	15	0.10–0.35	0.10–0.35	0.040	0.040	

Seamless Steel Pipes — For high test line pipes — IS: 1979–1971

Designation of steel	*Tensile strength min kgf/mm²*	*Yield strength min kgf/mm²*	*C % max*	*C % max*	*S % max*	*P % max*	*Typical applications*
Y St 30	42.2	29.5	0.29	1.25	0.04	0.05	Cover pipes intended for use in oil industry.
Y St 32	44.3	32.3	0.31	1.35	0.04	0.05	
Y St 37	46.4	36.6	0.29	1.25	0.04	0.05	

For dimensional requirements IS: 4431; 2507; 2591; 2002; 6630; 1979 may be referred

Cold Rolled Steel Strips for general engineering purposes — IS:4030–1967

Temper of strips	*Rockwell hardness (B Scale)* Min	Max	*C % max*	*Mn % max*	*S % max*	*P % max*	*Surface finish*	*Typical applications*
No. 1—Hard	90	—	0.25	0.60	0.050	0.040	(*a*) Coarse or rough	Coarse or rough for enamelling and lacquering
No. 2—Half Hard	70	90	0.25	0.60	0.050	0.040	(*b*) Medium or dull	Medium or dull for general purpose
No. 3—Quarter Hard	60	75	0.25	0.60	0.050	0.040		
No. 4—Skin Rolled	—	65	0.15	0.60	0.050	0.040	(*c*) Fine or bright	Fine or bright for electroplating
No. 5—Dead Soft	—	55	0.15	0.60	0.050	0.040		

Steels for Rivet Bars — IS: 1148–1973, IS: 1149–1973

Designation of steel	*Tensile strength kgf/mm²*	*Elongation % min*	*C % max*	*S % max*	*P % max*	*Typical applications*
St 42 R	42 to 54	23	0.23	0.055	0.055	For manufacture of hot forged rivets for structural purposes.
St 47 R	47 min	22	0.23	0.055	0.055	High tensile steel rivet bars for structural purposes

Free Cutting Steels — IS:4431–1967

Designation of steel	*Tensile strength kgf/mm²*	*Elongation % min*	*C %*	*Si %*	*Mn %*	*S %*	*P % max*	*Typical applications*
10 S **11**	37–49	24	0.15 max	0.05–0.30	0.60 to 0.90	0.08 to 0.13	0.060	Suitable also for case hardening
14 Mn 1S **14**	44–54	22	0.10–0.18	0.05–0.30	1.20 to 1.50	0.10 to 0.18	0.060	
25 Mn 1S **14**	50–60	20	0.20–0.30	0.25 max	1.00 to 1.50	0.10 to 0.18	0.060	These have good machinability and satisfactory chip-break
40 S **18**	55–65	17	0.35–0.45	0.25 max	0.80 to 1.20	0.14 to 0.22	0.060	
13 S **25**	37–49	22	0.08–0.18	0.10 max	0.80 to 1.20	0.22 to 0.30	0.060	(Rapid machining steel for repetition work)
40 Mn 2 S **12**	60–70	15	0.35–0.45	0.25 max	1.30 to 1.70	0.08 to 0.15	0.060	

Black Bars for production of machined parts — IS:2073–1970

Designation of steel	*Tensile strength kgf/mm²*	*Elongation % min*	*C %*	*Si %*	*Mn %*	*S % max*	*P % max*	*Typical applications*
C 14	37–45	26	0.10–0.18	—	0.40–0.70	0.055	0.055	These types are carbon steel black bars for production of machined parts for general engineering purposes
C 20	44–52	24	0.15–0.25	0.05–0.35	0.60–0.90	0.055	0.055	
C 30	50–60	21	0.25–0.35	0.05–0.35	0.60–0.90	0.055	0.055	
C 40	58–68	18	0.35–0.45	0.05–0.35	0.60–0.90	0.055	0.055	
C 45	63–71	15	0.40–0.50	0.05–0.35	0.60–0.90	0.055	0.055	
C 55 Mn **75**	72 min	13	0.50–0.60	0.05–0.35	0.60–0.90	0.055	0.055	
C 65	75 min	10	0.60–0.70	0.05–0.35	0.50–0.80	0.055	0.055	

Symbolic Designation
of essential properties of materials
(iron and steel)
Examples and Explanations

IS No.	*Title*	*See Page*	*Designation (example)*	*Explanations*
1977	Structural steels	5	St 32–0	St = Steel; 32 kgf/mm² minimum tensile strength
1977	–do–	5	St 42–0	O = Ordinary quality 42 kgf/mm² minimum tensile strength
226	–do–	5	St 42–S	S = Standard quality
226	–do–	5	St 42–Sc	c = Copper bearing quality
226	–do–	5	St 42–Kw	K = Special limits for max P and S w = Weldable
2062	–do–	5	St 42–W	W = Fusion welding quality
961	–do–	5	St 55–HTw	HT = High tensile steel w = Fusion weldable
1148	Rivet steels	8	St 42–R	R = Rivet bars
2002	Boiler plates	7	Grade 1	Plates required to be welded, flanged or flame-out
2002	–do–	7	Grade 2 A	Non-flanging quality (low tensile)
2002	–do–	7	Grade 2 B	–do– (high tensile)
5517	Heat-treatable steels	6	C 30	C = Carbon 30 = Average C contents 0.30%
5517	–do–	6	T 50a	T = Tool steel; a = annealed
5517	–do–	6	C 35 Mn **75**	C35 = Average carbon content 0.35% Mn **75** = Average manganese of 0.75%, represented without decimal point, underlined by a bar. (Applicable for alloying element upto 1%)
4432	Case-hardening steels	5	C 10c	C = Carbon; c = case carburized
4432	–do–	5	11 Mn **2**	Carbon average 0.11%; Manganese average 1.5%. (Average alloy content more than 1% is rounded to the nearest whole number, upto 0.5 rounded down; 0.5 and over rounded up.
3431	Hot Rolled steels for springs	7	55 Si 2 Mn **90**h	h = Hot rolled
2507	Cold rolled steels strips for springs	7	C 45q	q = Hardened and tempered
4454	High temperature steels for springs	7	1S; 1D	S = Static stressed springs; D = Dynamic stressed
1079	Hot rolled carbon steel sheet and strip	6	0; D; DD; EDD	O = Ordinary; D = Drawn; DD = Deep drawn EDD = Extra deep drawn
513	Cold rolled carbon steel sheets	6	J; J2 J3; J4	J = Bright drawn or bright rolled; J2 = Precision ground; J3 = descalled; J4 = shot blast
513	–do–	6	F; F2 F3; F7	F = Black sheet; F3 = Pickled surface; F7 = Cold finished; F2 = Black sheet for enamelling and galvanizing
1030	Steel castings	4	CS 125	C S = Cast steel-unalloyed; 125 = Minimum tensile strength 125 kgf/mm²
210	Grey iron castings	4	FG 15	FG = Grey iron castings; 15 = Minimum tensile strength 15 kgf/mm²
2108	Malleable iron castings	4	BM 35	BM = Black heart malleable iron castings
2640	–do–	4	PM 70	PM = Pearlitic malleable iron castings
2107	–do–	4	WM 42	WM = White heart malleable iron casting. For castings tensile strengths are on 30 mm dia test bars as cast

Tool and dye steels

Tool and dye steels for hot work — IS:3748–1966

Designation of steel	*C %*	*Si %*	*Mn %*	*Cr %*	*Mo %*	*V %*	*W %*	*Brinell hardness (annealed) HB, max*	*Typical application*
T33W9Cr3V**38**	0.25–0.40	0.10–0.35	0.20–0.40	2.80–3.30	—	0.25–0.50	8.00–10.0	241	Used for extrusion dyes, hot swaging dyes, forging dye inserts, brass forging dyes, hot shear blades, trimmer dyes, dye-casting dyes for copper etc.
T35Cr5MolV**30**	0.30–0.40	0.80–1.20	0.25–0.50	4.75–5.25	1.20–1.60	0.20–0.40	—	229	
T35Cr5MoV1	0.30–0.40	0.80–1.20	0.25–0.50	4.75–5.25	1.20–1.60	1.00–12.0	—	229	
T35Cr5MoW1V**30**	0.30–0.40	0.80–1.20	0.25–0.50	4.75–5.25	1.20–1.60	0.20–0.40	1.20–1.60	229	
T55W14Cr3V**45**	0.50–0.60	0.10–0.35	0.20–0.40	2.80–3.30	—	0.30–0.40	13.0–15.0	248	

Tool and dye steels for cold work — IS:3749–1966

T50	0.45–0.55	0.10–0.35	0.60–0.90	—	—	—	—	240	Covers the requirements for plain carbon and alloy tool and dye steels in the form of bars, blanks, rings, and other shapes for cold work, capable of being hardened and tempered. These are used for the making tools and dyes for blanking, trimming, shaping and shearing.
T60	0.50–0.60	0.10–0.35	0.60–0.90	—	—	—	—	240	
T70Mn**65**	0.65–0.75	0.10–0.35	0.50–0.80	—	—	—	—	240	
T80Mn**65**	0.75–0.85	0.10–0.35	0.50–0.80	—	—	—	—	240	
T90	0.85–0.95	0.10–0.30	0.20–0.35	—	—	—	—	200	
T103	0.95–1.10	0.10–0.30	0.20–0.35	—	—	—	—	200	
T133	1.25–1.40	0.10–0.30	0.20–0.35	—	—	—	—	210	
T90V**23**	0.85–0.95	0.10–0.30	0.20–0.35	—	—	0.15–0.30	—	200	
T118Cr**45**	1.10–1.25	0.10–0.30	0.20–0.35	0.30–0.60	—	0.30 max	—	200	
T105Cr1Mn**60**	0.90–1.20	0.10–0.35	0.40–0.80	1.00–1.60	—	—	—	230	
T140W4Cr**50**	1.30–1.50	0.10–0.35	0.25–0.50	0.30–0.70	—	—	3.50–4.20	250	
T55Ni2Cr**65**Mo**30**	0.50–0.60	0.10–0.35	0.50–0.80	0.50–0.80	0.25–0.35	—	—	255	
T105W2Cr**60**V**25**	0.90–1.20	0.10–0.35	0.25–0.50	0.40–0.80	0.25 max	0.20–0.30	1.25–1.75	230	
T110W2Cr1	1.00–1.20	0.10–0.35	0.25–0.50	0.90–1.30	—	—	1.25–1.75	230	
T90Mn2W**50**Cr**45**	0.85–0.95	0.10–0.35	1.25–1.75	0.30–0.60	—	0.25 max	0.40–0.60	230	
T215Cr12	2.00–2.30	0.10–0.35	0.25–0.50	11.0–13.0	0.80 max	0.80 max	—	260	
T45Cr1Si**95**	0.40–0.50	0.80–1.10	0.55–0.75	1.20–1.60	—	—	—	230	
T55Cr**70**V**15**	0.50–0.60	0.10–0.35	0.60–0.80	0.60–0.80	—	0.10–0.20	—	230	
T55Si2Mn**90**Mo**33**	0.50–0.60	1.50–2.00	0.80–1.00	—	0.25–0.40	0.12–0.20	—	230	
T40W2Cr1V**18**	0.35–0.45	0.50–1.00	0.20–0.40	1.00–1.50	—	0.10–0.25	1.75–2.25	230	
T50W2Cr1V**18**	0.45–0.55	0.50–1.00	0.20–0.40	1.00–1.50	—	0.10–0.25	1.75–2.25	230	

Steels for dye blocks for drop forgings

Designation of steel	*C %*	*Si %*	*Mn %*	*Ni %*	*Cr %*	*Mo %*	*Brinell hardness HB*		*Typical applications*
							Annealed max	*Hardened and tempered*	
T60	0.55–0.65	0.15–0.35	0.50–0.80	—	—	—	209	212–269	Steel for dye blocks in square, rectangular and sections for drop forgings.
T60Ni1	0.55–0.65	0.15–0.35	0.50–0.80	1.0–1.4	—	—	209	212–269	
T55NiCr**65**	0.50–0.60	0.15–0.35	0.50–0.80	1.25–1.65	0.50–0.80	—	230	235–302	
T50NiCr**35**	0.48–0.53	0.15–0.35	0.45–0.65	0.80–1.00	0.80–1.00	0.30–0.40	255	269–477	

Classification of carbide tips according to their range of application (IS: 2428–1964)

Designation	*Increasing direction of the characteristic of*		*Range of application*	
Identification colour	Carbide tip	Cutting	Material to be machined	Machining conditions
P01	Resistance to wear ↑ Toughness ↓	Cutting speed ↓ Feed ↓	Steel, steel casting	Precision turning and fine boring Cutting speed: high, Feed: low
P10			Steel, steel casting	Turning, threading and milling Cutting speed: high. Feed: low or medium
P20			Steel, steel casting, malleable cast iron forming long chips	Turning, milling. Cutting speed and feed: medium. Planning: with low feed rate
P30			Steel, steel casting, malleable cast iron forming long chips	Turning, planning, milling. Cutting speed: medium to low. Feed: medium to high even if operating conditions are unfavourable
P40			Steel, steel castings with sand inclusions or shrinkage cavities	Turning, planning, shaping. Cutting speed: low. Feed: high. Rake angle: high, for machining under unfavourable conditions and work on automatic machines
P50			Steel, steel castings of medium or low tensile strength with sand inclusions or shrinkage cavities	Turning, planning, shaping. Cutting speed: low. Feed: high. Rake angle large for machining under unfavourable conditions and work on automatic machines
M10	Resistance to wear ↑ Toughness ↓	Cutting speed ↓ Feed ↓	Steel, steel castings, manganese steel, grey cast iron, alloyed cast iron.	Turning. Cutting speed: medium to high. Feed: low to medium
M20			Steel, steel casting, austenitic steel, manganese steel, grey cast iron, spheroidised cast iron and malle-able cast iron	Turning, milling. Cutting speed: medium. Feed: medium
M30			Steel, steel casting, austenitic steel, grey cast iron, heat resisting alloys	Turning, milling, planning. Cutting speed: medium. Feed: medium or high
M40			Free cutting steel, low tensile strength steel, brass and light alloy	Turning, profile turning, parting off especially in automatic machines
K01	Resistance to wear ↑ Toughness ↑	Cutting speed ↓ Feed ↓	Very hard grey cast iron, chilled castings of hardness up to 60 HRC. Aluminium alloys with high silicon content, hardened steel, plastics of abrasive type, hard board and ceramics	Turning, precision turning and boring, milling, scraping
K10			Grey cast iron of hardness more than 220 HB, malleable cast iron forming short chips, tempered steel, aluminium alloys containing silicon, copper alloys plastics, glass, hard rubber, hard cardboard, porcelain, stone	Turning, milling, boring, reaming, broaching, scraping
K20			Grey cast iron of hardness up to 220 HB, non-ferrous metals, such as copper, brass, aluminium, laminated wood of abrasive type	Turning, milling, planning, reaming, broaching
K30			Soft grey cast iron, low tensile strength steel, laminated wood	Turning, planning, shaping, milling. Rake angle: large even under unfavourable conditions
K40			Soft or hard natural wood, nonferrous, metals	Turning, milling, planning, shaping. Rake angle: large even under unfavourable machining conditions

Nomenclature	*Grade*	*Minimum contents*	*Physical properties*	*Typical applications*
Copper				IS: 191–1967
Electrolytic tough pitch copper	ETP	99.9% Cu	Soft	For electrical parts
Fire refined high conductivity copper	FRHC	99.9% Cu	High conductivity	For conductors
Fire refined tough pitch copper	FRTP–1 FRTP–2	99.8% Cu 99.5% Cu	Easy to cast	For castings
Tough pitch arsenical copper	ATP	99.2% Cu	Good bearing property	For bearings
Oxygen free high conductivity copper	OF	99.95% Cu	High conductivity	For conductors
Lead				IS: 27–1965
Pig lead	Pb 99.99	99.99% Pb	Soft, can be cast,	Plates in storage batt
Pig lead	Pb 98.94	99.94% Pb	soldered and welded	For alloying
Zinc				IS: 4699–1968
Refined secondary zinc	SZn 99.5	99.5% Zn	Can be cast, resistant	For alloying
Refined secondary zinc	SZn 98.5	98.5% Zn	to corrosion	For galvanizing
Tin				IS: 4280–1967
Refined secondary tin	Sn 99	99% Sn	Soft, can be cast, rolled	For plating, casting
Refined secondary tin	Sn 96	96% Sn	to foils	For alloying
Aluminium				IS: 734–1967
Aluminium	F1A	99.8% Al	Tensile strength 5.5 kgf/mm^2	May be cast, weldable
Aluminium	F1B	99.5% Al	More resistant to corrosion	Available in the form of sheets, plates, tubes, wires, forgings. Used for cladding, on stronger alloys, food and chemical plants, electrical conductors and reflectors
Aluminium	F1C	99.0% Al	Very ductile, resistant to corrosion, good conductor.	Available in the form of sheets, plates, tubes, wires, rods and forgings. Used for panelling and moulding, lightly stressed and decorative assemblies, equipment for food, chemical and brewing industries, packing and cooking utensils
Aluminium (commercial quality)	AO	99% Al	Excellent, electrical, conductivity, resistant to corrosion.	For induction motor, rotors, power transmission cable accessories, vessels and fittings for food and chemical industries