Presentation
on

Applications of

Ferrous and non-ferrous metals

Generic Syllabus on the subject of

Applications of Ferrous and non-ferrous metals

Ferrous materials: Applications of important ferrous materials like stainless steels, tool and die steels, high speed steels, and alloyed cast irons: their composition, heat treatment and properties

Non-ferrous materials: Applications of important non-ferrous metals like Cu base, Al base, Ti base and Mg base alloys- their compositions, heat treatment, and properties

Mechanical Working of Metals:

- Forging (open die and closed die forging),
- Rolling, Extrusion (direct and indirect extrusion),
- Sheet Metal Forming (deep drawing),
- Casting

Forging: Classification, calculation of forging loads, forging defects- causes and remedies, residual stresses in forging;

Rolling- Classification of rolling processes, forces and geometrical relationship in rolling, analysis of rolling load, torque and power, rolling defects

Extrusion and drawing: Direct and indirect extrusion, variables affecting extrusion, deformation pattern, simple analysis of extrusion

Sheet metal forming and other processes: Forming methods - shearing, blanking, bending, stretch forming, deep drawing defects in formed part, sheet metal formability,

Casting and solidification - Melting of metals and alloys for casting: Brief mention of various melting units, melting and post melting treatments, melting practices as adopted for a few metals and alloys such as Al, Cu, steel, cast irons.

STANDARDS RELATING TO FERROUS PRODUCTS

BASE STANDARDS:

IS 1762 {Part 1)-1974 - CODE FOR DESIGNATION OF STEELS

PART I BASED ON LETTER SYMBOLS

SCOPE

This standard (Part I) covers the code designation of wrought steel based on letter symbols.

CODE DESIGNATION OF STEELS BASED ON LETTER SYMBOLS:

For the purpose of code designation, steels shall be classified as follows:

- Steels designated on the basis of mechanical properties and other properties:

  - These steels are carbon and low allow steels where the main criterion in the selection and inspection of steel is the tensile strength or yield stress.

  - These steels are carbon and low allow steels where the main criterion in the selection and inspection of steel is the tensile strength or yield stress. In such cases, provided the specified mechanical properties are attained, it is not usual to specify a detailed chemical composition but the quality of the material is designated where necessary by specifying certain quality levels.

- The code designation shall consist of the following in the order given:

  a) Symbol ‘Fe' or ‘Fe’ depending on whether the steel has been specified on the basis of minimum tensile strength or yield stress.

  b) Figure indicating the minimum tensile strength or yield stress in N/mm^2.If no minimum tensile or yield strength is guaranteed, the figure shall be 00.

  c) Chemical symbols for elements the presence of which characterize the steel,

  d) Symbol indicating special characteristics covering method of deoxidation, steel quality, degree of purity, weldability guarantee, resistance to brittle fracture, surface condition, formability, surface finish, heat treatment, elevated temperature and low temperature properties.

  e) Symbol indicating applications, if necessary.

  f) In addition to above, steels are classified based on

  i. *Method of deoxidation*
  ii. *Steel quality*
  iii. *Degree of purity*

iv. *Weldability guarantee*
v. *Resistance to brittle fracture*
vi. *Surface condition*
vii. Formability *(applicable to sheet only*)
viii. *Surface finish (applicable, to sheet only)*

For complete details on the above subject, please see IS 1762 (Part 1)

- Steels designated on the basis of chemical composition:

Unalloyed steels - The code designation shall consist of the following in the order given:

a) Figure indicating 100 times the average percentage of carbon content,
b) Letter 'C' and
c) Figure indicating 10 times the average percentage of manganese content. The figure after multiplying shall be rounded off to the nearest integer.

Unalloyed tool steels- The designation shall consist:

- Figure indicating 100 times the average percentage of carbon; Symbol ' T' for tool steel; and
- Figure indicating 10 times the average percent manganese content.

Unalloyed free cutting steels - The designation shall consist:

- Figure indicating 100 times the average percentage of carbon, Letter 'C'
- Figure indicating 10 times the average percentage of manganese;
- Symbol 'S', 'Se', 'Te' or ' Pb ' depending on the element present which makes the steel free cutting followed by the figure indicating 100 times the percentage content of the element. In the case of the phosphorized steels the symbol "P' shall be included; and
- Symbol indicating special characteristics covering the method of deoxidation, surface condition and heat treatment

Alloy steels:

a) *Low and medium alloy steels (total alloying elements not exceeding* 10 *percent)* - The designation of steels shall consist of:

1) Figure indicating 100 times the average percentage carbon,
2) Chemical symbols for alloying elements each followed by the figure for its average percent content multiplied by a factor
3) Symbol indicating special characteristics covering degree of purity hardenability, weldability guarantee, elevated temperature properties, surface condition, surface finish and heat treatment:

Examples:

- 25Cr4Mo2G Steel with guaranteed hardenability and having average 0'25 percent carbon, 1 percent chromium and 0'25 percent molybdenum
- 40Ni8Cr8V2 Hot rolled steel with average 0'40 percent carbon, 2 percent chromium, 2 percent nickel and 0'2 percent vanadium

b) High alloy steels (total alloying elements more than 10 percent) –

- The designation shall consist of:

I) Letter 'X'.
2) Figure indicating 100 times the percentage carbon content.
3) Chemical symbol for alloying elements each followed by the figure for its average percentage content rounded off to the nearest integer
4) Chemical symbol to indicate specially added element to attain the desired properties.
5) Symbol indicating specific characteristics covering hardenability, weldability guarantee, elevated temperature properties, surface condition, surface finish and heat treatment

Examples:

a) XIOCrl8Ni9S3 - Steel in pickled condition with average carbon 0'10 percent, chromium 18 percent and nickel 9 percent.
b) XI5Cr25Nil2 - Steel with ,0'15 percent carbon, 25 percent chromium and 12 percent nickel

c) *Alloy too! steels* - The steel designation shall be as for low, medium and high alloy steels as given under (a) and (b) above except that the symbol 'T' will be included in the beginning of the designation low alloy and medium alloy tool steels and ‘XT’ instead of 'X' in the case of high alloy tool steels.

Examples:

a) XT75WIHCr4Vi - High alloy tool steel with average carbon 0'75 percent, tungsten 18 percent, chromium 4 percent and vanadium 1 percent
b) XT98WGMo5Cr4Vi - High alloy steels with average carbon 0'98 percent, tungsten 6 percent, molybdenum 5 percent, chromium 4percent and vanadium 1percent.

- See the specification IS 1762 (Part-1) for details.

IS 13752: 1993: Guidelines for reporting sequence of elements in steel and pig iron and mechanical properties in steels

Scope: a) This standard covers the general guidelines for sequential reporting of chemical elements in steel/pig iron.

- Chemical composition of steel/pig iron (cast, wrought and alloy) may be reported in the sequence given below:

C, Si, Mn, P, S, Cr, MO, Ni.

- Any other element may be reported in alphabetical order of their chemical symbols, for example, Al, As, Cu, Nb, V, etc.

b) The standard also provides guidelines for standardizing the sequential reporting of mechanical properties and uniform format for the test certificate issued by the manufacturer.

- Sequence of mechanical properties to be reported in test certificate is given below:

a) Yield Strength/0.2% Proof Strength, MPa
b) Ultimate Tensile Strength, MPa
c) % Elongation
d) %Reduction,'
e) Bend Test
f) Re-bend Test
g) Impact Charpy/Izod, Joules
h) Hardness
i) Weldability
j) Others

- See the specification IS 13752 for details.

FERROUS CASTINGS — DESIGNATION CODES

Ferrous castings shall be designated by a group of symbols indicating the important characteristics in the following order:

a) Type of castings; and

b) Mechanical properties or chemical composition.

- SYMBOLS FOR TYPE OF CASTINGS:

Ferrous Casting	Designation
Grey iron	FG
Malleable iron	
- Black heart	BM
- Pearlitic	PM
- White heart	WM
Speheroidal or nodular graphite iron	SG

Spheroidal flake graphite iron AFG

Austenititic spheroidal or nodular graphite iron - ASG

Abrasion resistant iron ABR

Steel castings CS

Heat resistant steel casting CSH

Corrosion resistant steel casting CSC

- SYMBOLS FOR MECHANICAL PROPERTIES

The tensile strength in kgf/mm^2 to follow the group symbol shall be the minimum for the 30 mm section in case of grey iron castings and the minimum for the heaviest section in case of various other castings. Where the minimum tensile strength requirement does not vary with the sectional thickness within the same grade, the group symbol shall be followed by the minimum tensile strength indicated for the grade. In the case of spheroidal or nodular graphite iron castings, the tensile strength shall be followed by the minimum elongation on gauge length $5.65\sqrt{S_o}$.

- SYMBOLS FOR CHEMICAL COMPOSITION

In the case of grey iron castings where chemical composition is more important than the tensile properties and for alloy iron and alloy steel castings, the group symbol shall be followed by the chemical symbol in accordance with IS 1762.

- EXAMPLES

Examples of code designation of Grey Iron Castings – General Engineering Castings are: FG 15, FG 40, etc.

Examples of Black-heart malleable iron castings – BM 30, BM 35, etc

Examples of Pearlitic malleable iron castings – PM 50, PM 70, etc.

Examples of Spheroidal or nodular graphite iron casting – SG 60/2, SG80/2, etc, where 60, 70, etc are minimum Tensile strength values and number 2 is the minimum percentage elongation.

Note: For complete details on the above subject please see IS 210 & IS 4843

Glossary of terms relating to Iron and steel

- The standard, IS 1956 has been prepared for the guidance of the manufactures and the users to assist them in the uniform interpretation of the common terms used in the iron and steel industry. The terminology of various terms relating to Iron and steel are given in seven parts of the standard and the details are given below:

a) Part 1 General metallurgy, heat treatment and testing
b) Part 2 Steel making
c) Part 3 Hot rolled steel products (excluding sheet and Strip)
d) Part 4 Steel sheet and strip
e) Part 5 Bright steel bar and steel wire (withdrawn)
f) Part 6 Forging (including drop forging)
g) Part 7 Wrought iron
h) Part 8 Steel tubes and pipes

- Some of the terms relating to Iron and Steel defined in the above standards are given below:

Alloy - A substance having metallic properties consisting of two or more elements in which the major constituent is a metal, or of metallic and non-metallic elements which are miscible with each other when molten, and have not separated into distinct layers when solid.

Alloying element - An element (metal or non-metal) added deliberately to a metal to modify its mechanical and/or physical properties.

Alloy Steel - A steel containing one or more alloying elements as a result of which it develops specific characteristics.

Casting — Pouring or teeming molten metal into moulds. This also refers to metal objects so produced.

Cast Iron — An alloy essentially of iron and carbon containing more than 2 percent carbon (usually between 2-5 and 4 percent). It also contains silicon, manganese, sulphur and phosphorus in varying amounts.

Cold-Working - Substantial mechanical working (usually above 5 percent), for example, drawing, rolling, forging, etc, of a metal or alloy below its normal recrystallization temperature.

Fatigue - The tendency to fracture by means of a progressive crack under repeated alternating and/or cyclic stresses considerably below the tensile strength.

Hardenability - The property that determines the ability of a given steel to harden right through and is assessed by measuring hardness distribution from surface to interior after quenching under specified condition

Heat Treatment - Combination of heating and cooling operations in a prescribed manner (with respect to time, temperature and rate of heating and cooling) to induce desired properties in metals and alloys in the solid state. The conventional heating for hot-working does not come within the scope of heat treatment.

High carbon steel - Carbon steel containing generally more than 0.60 percent carbon.

High Speed Steel- A special variety of tool steel which, by virtue of its composition, retains its cutting hardness at a low red heat.

Hot Galvanizing (Hot Dip Galvanizing) – Coating with zinc by immersion in a bath of molten zinc.

Ingot- Castings of suitable shape and size intended for subsequent hot-working.

Medium Carbon Steel - Carbon steel containing generally minimum of 0.30 percent carbon and maximum of 0.60 percent carbon.

Mild Steel - Carbon steel containing generally less than 0.30 percent carbon.

Normalizing - A process of heat treatment for improving mechanical properties brought about by grain refinement and uniformity in structure. The process involves heating to and holding for a specified time at a suitable temperature above the transformation range, followed by cooling freely in air.

Pig Iron - The primary product of smelting iron ore containing usually between 3 to 4.5 percent carbon along with silicon, manganese, phosphorus and sulphur in varying amounts depending upon the quality of raw materials used. Pig iron is used in the foundry or for conversion into steel.

Stainless Steel - An alloy steel containing about 12 percent or over of chromium with or without nickel together with other elements, and is characterized by its high resistance to corrosive media.

Semi-finished Products — Continuously cast products and products generally obtained by forging or rolling ingots and intended for transformation into finished products. The cross-section is generally square, rectangular with angles more or less rounded; the section has uniform dimension all along the length of the piece. The tolerances are generally wider than those for finished products. The surfaces can be partially or totally conditioned by scaring, chipping, grinding, planning or milling and turning.

a) Semi-finished products of square cross- section — Semi-finished products with sides of 50 mm or over, generally described as blooms, if the sides are greater than 200 mm or as billets, if smaller.

b) Semi-finished products of rectangular cross- section — Semi-finished product of cross-sectional area of 2500 mm^2 or over of width up to twice the thickness, generally described as blooms, if the cross-sectional area is greater than 40000 mm^2 or as billets, if smaller.

c) Slab —A semi-finished product of rectangular cross-section with a thickness of at least 50 mm and a width of at least twice the thickness, described as a slab.

d) Sheet bar (Slab bars) — Semi-finished products of rectangular section, of a thickness not less than 6 mm, width not less than 150 mm and of such dimensions that the thickness does not exceed one quarter of the width.

e) Sheet Slab — A slab of suitable size for rolling into sheet.

f) Round semi-finished products — Continuously cast or forged semi-finished products of circular cross- section.

Long Products: Long products have a constant cross- section that is usually defined by a standard that establishes the normal size ranges and the tolerances on shape and dimensions. The surface is generally smooth, but in certain cases, for example reinforcing bars, may have a regularly raised or indented pattern.

a) Rod— Hot rolled long product having a nominal size generally 5 mm or above and wound into irregular coils.

b) Wire rod — Rod in the coiled form generally intended for conversion into wire.

c) Wire — Product of constant full cross-section along its length, obtained by cold drawing rod through a reducing die or passing under pressure between rollers and rewinding the drawn product.

d) Piano wire (Music wire) — Avery high quality high carbon (usually 0.80 to 0.95 percent), patented drawn and polished wire having a tensile strength in excess of 1 865 N/ mm^2 (190 kgf/mm^2) and generally in sizes of 1.6 mm and finer. The term music wire also includes wire intended for mandolins.

e) Hot-finished bars — Product supplied in straight lengths but not in coils, thus differentiating them from rod.

f) Hot rolled bars - Hot rolled products in straight lengths of constant transverse section having a solid (convex) cross-section.

g) Rounds — Bars having a circular cross- section of diameter generally 8 mm or above.

h) Square, hexagon and octagon bar — Bars having a square, hexagonal or octagonal cross-section; the side is generally 8 mm or over for squares, or 13 mm or over for hexagons. Squares of sides up to 50 mm with rounded comers are considered to be square bars.

i) Flat bar — Bars of rectangular cross-section rolled on the four faces of thickness generally 5 mm or above and with a width not over 150 mm.

j) Bars of special shape — Products hot rolled in lengths of particular full cross-sectional shapes including in particular trapezoids, bevels, triangles, bars for grooved springs, semi-rounds and half flat semi- rounds such as BULB BAR / Z bar.

k) Forged bars — Products obtained by forging and that do not undergo subsequent hot conversion. These products are mainly in the form of rounds or squares.

l) Bright Bar — Round bar of various cross- sectional shapes obtained by drawing or turning

m) Drawn product — Products of various cross- sectional shapes obtained by drawing of hot rolled bars or rod, on a draw bench (cold deformation without removing material), after descaling.

Rolling — The shaping of metal by pressing it between two rotating rolls.

Roll Straightening — The straightening of metal stock of various shapes by passing it through a series of staggered rolls, the rolls usually being in horizontal and vertical planes, or by reeling in two-roll straightening machines.

Reheating — Heating of steel to a uniform temperature in readiness for hot working.

Roll Pass (Pass) — Openings of definite shapes formed between a set of rolls through which hot steel passes for taking up the given shape or undergoing a desired amount of reduction in sectional area. This term also applies to a single passage through a pair of rolls for the purpose of altering the shape and/or reducing the cross-sectional area.

Terms and Definitions — Defects

Blister — A small raised area on the surface resulting from the expansion of gas concentrated at a sub-surface inclusion or other imperfections. May occur as isolated spots, but often found in longitudinal streaks.

Camber — The curvature observed in long products caused by differential cooling or faulty setting of the rolls. It is measured by the maximum deviation of the middle region from the straight line joining the ends.

Decarburization — Depletion of carbon from the surface layer of a ferrous product. This depletion may be either partial (partial decarburization) or nominally complete (complete decarburization). The sum of the two types of decarburization (partial and complete) is termed total decarburization.

Inclusions - Particles of oxides, sulphides, silicates, refractories, etc, embedded in the metal. These are products of oxidation.

Laminations — A defect in rolled materials, characterized by a tendency to split into layers along the direction of rolling usually due to the presence of non-metallic inclusions or other discontinuity in the steel.

Pipe (Contraction Cavity, Shrinkage Cavity) — An axial cavity caused by contraction during solidification of an ingot. Also, the defect arising from the axial cavity in the semi-finished or finished products. It may also refer to tubular products.

Segregation — A non-uniform distribution of some constituents and/or impurities in a cast product characterized by the mode of solidification of alloys.

Segregation usually persists through subsequent hot and cold working. Generally, the concentration of low melting point constituents tends to be higher in the centre than the surface. Sometimes the reverse of this phenomenon takes place and is known as inverse segregation.

Terms & Definitions – Flat Products

Annealing - It is the process of heat treatment which involves heating the cold reduced steel to above the recrystallization temperature, maintaining for a suitable time, and then cooling under controlled conditions. Different annealing cycle may cause different changes in structure and thereby properties.

- Continuous Annealing - Annealing of cold- reduced strip in a single thickness within a protective atmosphere. This produces relatively stiffer product which exhibits a finer grain size than batch annealed material.

Cold-Rolling (Cold-Reduction) - Rolling steel (generally sheet or strip) below its recrystallization temperature with the degree of reduction being usually above 5 percent.

Cold-Working - Substantial mechanical working (usually above 5 percent), for example, drawing, rolling, forging, etc, of a metal or alloy below its recrystallization temperature.

Heat Treatment - It is the process wherein a microstructure of the material is altered by predetermined heating and cooling cycle, causing changes in its properties such as strength and hardness.

Hot-Dip Galvanizing - It is a form of galvanizing. In this process, zinc coating is deposited by dipping/passing through its molten bath at 460°C.

Normalizing - A heat treatment process that has the object of relieving internal stresses, refining the grain size and improving the mechanical properties. The steel is heated to austenizing temperature (>800°C) according to its chemical composition, soaked at that temperature for requisite time and then air cooled.

Normalizing Rolling - A hot rolling process in which the final rolling passes are carried out at temperature above AR3 (Austenitic to ferritic transformation temperature), followed by cooling in natural air to a ambient temperature, in order to produce a structure analogous to that obtained by normalizing treatment of hot rolled product.

Skin Passing (Pinch Passing) - Light cold rolling of hot rolled/annealed/normalized/coated steel sheet/strip for improving surface quality, removing kinks stretcher strains or similar conditions on surface only (the cold reduction being very light, usually less than 5 percent). The skin pass suppresses yield point elongation besides improving flatness. Some increase in hardness and some loss in ductility may result from skin passing.

Slitting - Cutting a strip into a number of narrower strips by means of rotary cutters.

Stress Relieving - Heating the metal below its recrystallization temperature and if required holding at that temperature followed by cooling for the sole purpose of removing internal stresses

Thermo-mechanical Rolling/Processing - It is also known as thermo-mechanical treatment (TMT) is a metallurgical process which incorporates controlled deformation under specific thermal/heated condition

Cold Rolled - Products generally obtained by the cold rolling of hot rolled finished products during which it would have undergone a reduction in cross- section of at least 25 percent without prior reheating. In the case of flat products of a width less than 600 mm and for certain qualities of special steel, levels of reduction of cross-section less than 25 percent may be included. It is further classified as follows:

a) CRFH - Cold rolled full hard produced by cold reduction of more than 50 percent.

b) CRCA - Cold rolled closed annealed.

c) Skin passed - Cold rolled and annealed have been given a very light cold rolling pass, normally less than 5 percent.

d) Temper rolled - Cold rolled and annealed have been given cold reduction of 5 percent to 50 percent.

Hot Rolled - Products obtained by hot rolling of semi-finished products and, more rarely, by hot rolling of crude products. This hot rolled could be with/ without pickling and oiling. Hot rolled pickled and oiled is termed as HRPO. Hot rolled flat products also include those which have been given a very light cold rolling pass, normally less than 5 percent, known as a skin-pass or dressing pass. HRSPO stands for Hot rolled pickled, oiled and skin passed.

Terms & Definitions – Steel Tubes & Pipes

Boiler Tubes - Tubes which form part of the heating surface of a boiler, as distinct from superheater tubes. The tubes may contain water and be surrounded by the furnace gases as in a water tube boiler, or they may act as flues and be surrounded by water as in a smoke tube boiler.

Bore — Commonly used to indicate inside diameter.

Cased Tube — A close-joint tube of steel, over which a close-joint or seamless or welded tube of another metal is drawn.

- Casing (Oil Well Casing) — Tubes used for lining bore holes to prevent caving in of the surrounding strata and the undesired entry of water.

Cold Drawing — Reducing the cross-sectional area of a tube, when cold, by drawing through a die. The tubes are occasionally pushed through the die.

- Cold Drawn Welded Tube — Welded tube subsequently cold drawn.

- Gold Sinking — Reducing the cross-sectional area and diameter of a tube by drawing when cold through a die.

Extrusion - The production of a seamless tube from a hot billet by forcing the latter to flow through a die over a mandrel positioned centrally in the die.

- Extrusion Billet — A short length of billet or hot rolled bar, either solid or with a central hole.

Flanging - The turning back of a small portion of a tube end at right angles to the axis of the tube.

Hollow — The hot finished tube from which a cold drawn tube is manufactured

Hot Drawn — Tubes which have been reduced in diameter, or diameter and thickness both, by drawing hot on a mandrel through a die.

- Hot Finished — Tubes made and finished by a hot-working process, generally applied to seamless tubes. Other kinds of tubes are also hot finished, for example, by the continuous weld process and lap weld process.

- Hot Rolled — Tubes produced hot by one of the several processes employing rolls.

Mandrel Drawing (Bar Drawing) — Cold drawing in which a tube is drawn through a die together with a mandrel which supports it internally. The tube and the bar are occasionally pushed through the die together. The release of bar is accomplished by rolling which has the effect of expanding the bore of the tubes sufficiently to release the mandrel.

Nominal Bore - A bore, which may be the actual bore or an approximation to it, which is standardized formally or by general usage. The tubes have standard outside diameters but thicknesses according to the purpose for which they are used

Socket - Commonly refers to the internally screwed sleeve for connecting the screwed pipe ends of a screwed and socketed joint.

Swaging (Cressing) - Reducing the diameter, usually for short distances, at the ends of tubes.

Tube (Pipe) - A long, hollow, open-ended object of circular or other cross section. The terms ‘tube ' and ‘pipe’ are often used synonymously.

STANDARDS RELATING TO FERROUS PRODUCTS:

Standards relating to ferrous products are sub-divided

- Based on process of production,
  - Rolling- Hot rolling / Cold rolling,
    a) Blooms, Slabs, Billets, Ingots
    b) Plates, Sheets, strips
    c) Bars, wire rods, wires
  - Casting:
    a) Cast Iron Products
    b) Pipe Products
    c) Fittings
- Based on Alloy Constituents
  I. Plain carbon steel products
  II. Alloy Steel products
  III. Stainless steel products

Note: The total list of standards relating to above subjects can be seen from the list of standards placed at MTD-04, MTD-06, MTD-16 & MTD-19.

Some of the standards of Ferrous products are given below:

IS 10748 : 2004 - Hot - Rolled steel strip for welded tubes and pipes

IS 11513 : 2017 - Hot rolled carbon steel strip for cold rolling purposes

IS 14246 : 2024 - Continuously Pre-Painted Galvanized Steel Sheets And Strips

IS 16732 : 2019 - Galvanized structural steel

IS 2062 : 2011 - Hot rolled medium and high tensile structural steel

IS 280 : 2006 - Mild steel wire for general engineering purposes

IS 2830 : 2012 - Carbon steel cast billet ingots billets blooms and slabs for re-rolling into steel for general structural purposes

IS 513 (Part 1) : 2016 - Cold reduced carbon steel sheet and strip Part 1 cold forming and drawing purpose

IS 13352 : 1992 - Stock for forgings produced from continuously cast blooms billets and slabs

IS 3748 : 2022 - Tool Steels

IS 5522 : 2014 - Stainless steel sheets and strips for utensils

IS 6528 : 1995 - Stainless steel wire

IS 6911 : 2017 - Stainless steel plate sheet and strip

IS 1161 : 2014 - Steel tubes for structural purposes

IS 1239 (Part 1) : 2004 - Steel tubes tubulars and other wrought steel fittings - Specification Part 1 steel tubes

IS 7138 : 1973 - Specification for steel tubes for furniture purposes

IS 13502 : 2023 - PIG IRON

IS 14329 : 1995 - Malleable iron castings

IS 1536 : 2023 - Centrifugally cast spun iron pressure pipes for water gas and sewage

IS 1879 : 2010 - Malleable cast iron pipe fittings

IS 210 : 2009 - Grey iron castings

IS 8329 : 2000 - Centrifugally cast Spun ductile iron pressure pipes for water gas and sewage

STANDARDS RELATING TO NON-FERROUS PRODUCTS

Bureau of Indian standards has formulated nearly 164 standards relating to Non-ferrous products. These standards are relating basically of Aluminium and copper and some standards are relating to products of other non-ferrous metals such as zinc, lead, Antimony, Tungsten, Molybdenum, etc.

Note: The total list of standards relating to above subjects can be seen from the list of standards placed at MTD-07, MTD-08 & MTD-09.

Out of all the non-ferrous metal products, let us see some of the standards relating to Aluminium and Copper.

STANDARDS RELATING TO ALUMINIUM

BASE STANDARDS:

IS 5052:1993 - ALUMINIUM AND ITS ALLOYS – TEMPER DESIGNATIONS

This standard cover temper designation for cast and wrought products of aluminium and its alloys.

BASIS OF CODIFICATION

The temper designations are based on the sequence of basic treatments used to produce the tempers. The temper designations, which are used for all cast and wrought products except ingots, follow the designation of aluminium and its alloys and is separated from them by a dash.

Basic temper designations consist of letters. If sub-divisions of basic tempers are required, they are indicated by a digit, following the letter of the basic temper. Only those treatments or operations which significantly influence the product characteristics are recognized.

BASIC TEMPER DESIGNATIONS

M as Manufactured - This designation applies to the product which acquired some temper from hot shaping processes for which mechanical property limits apply. This temper designation is applicable for cast products only.

F as Fabricated - This designation applies to the products of shaping processes without special control thermal condition or strain hardening and for which no mechanical property limits apply. This temper designation is applicable for wrought products only.

0 as Annealed - This designation applies to wrought products which are fully annealed to obtain the lowest strength condition and to cast products which are annealed to improve ductility and dimensional stability.

H as Strain Hardened (Wrought Products only) - This designation applies to products which are subjected to the application of cold work after annealing (or hot forming) or to a combination of cold work and partial annealing or stabilizing treatment in order to secure the specified mechanical properties. The letter H is always followed by one or more digits according to basic operation and the final degree of strain hardening.

T as Thermally Treated to Produce Tempers other than M, F, 0 or H - This designation applies to products which have their strength increased by thermal treatment, with or without supplementary strain hardening. The letter T is always followed by one or more digits indicating the specific sequence of treatments.

SUB-DIVISION OF BASIC TEMPER DESIGNATIONS

- The Basic Temper designations are sub-divided as:

  - H Strain Hardened - H1, H2, H3, HX2, HX4, etc

  - T Thermally Treated – T1, T2, T3, --------T10

Note For complete details of this standard, please see IS 5052

GLOSSARY OF TERMS RELATING TO ALUMINIUM

The standard, IS 5047 has been prepared for the guidance of the manufactures and the users to assist them in the uniform interpretation of the common terms used in Aluminium metals industry. The terminology of various terms relating to Aluminium metals are given in three parts of the standard and the details are given below:

IS 5047-Part 1: Glossary of terms relating to aluminium and aluminium alloys: Part 1 unwrought and wrought metals
IS 5047-Part 2: Glossary of terms relating to aluminium aluminium alloys and: Part 2 plant and operations, thermal treatment, control and testing, finishing
IS 5047-Part 3: Glossary of terms relating to aluminium and aluminium alloys: Part 3 geometrical properties and tolerance, structural and surface defects

- Some of the terms relating to Aluminium defined in the above standards are given below:

Primary or Virgin Aluminium - Aluminium obtained by reduction of alumina by electric smelting or reduction furnace and not subjected to any fabrication other than casting into pigs or ingots for re-melting, redraw rod, rolling slabs, extrusion billets, wire bars, forging stock, etc. It may incorporate suitably, identified uncontaminated scrap from producer's own primary production operations.

Secondary Aluminium - Aluminium which has been recovered from scrap by re-melting.

Aluminium Alloy - An alloy based on aluminium to which other elements are added to bring about an improvement in mechanical, physical and/or chemical properties to meet particular end uses.

Pig - Primary metal cast direct from the reduction cell or through melting and/or holding furnace.

Aluminium Shot and Pellets - Metals in the form of small spherical or nearly spherical pellets, usually made by causing molten metal to fall drop-wise from a suitable height in a quenching medium.

Rerolling Stock - A semi-finished product of rectangular section suitable for further rolling. It may be either in straight length or in coil form.

Foil Stock - Semi-finished coiled sheet for further rolling to foil.

Foil - A cold rolled product of rectangular section of a thickness not greater than 0’15 mm.

Alclad rod - Rod having on its surface a metallurgically bonded aluminium of aluminium alloy coating that is anodic to the core alloy to which it is bonded, thus electrolytically protecting the core alloy against corrosion.

Lithographic Sheet - Sheet having a superior finish on one side with respect to freedom from surface imperfections and supplied with a maximum degree of flatness for use as a plate in offset printing.

Chill Casting - A process in which molten metal is poured into a permanent mould and solidified.

Direct Chill (D.C.) Continuous Casting - A process in which liquid metal is solidified rapidly in a short water-cooled metallic mould or die and continuously withdrawn and cut to length whilst the mould is being simultaneously replenished with liquid metal.

STANDARDS RELATING TO ALUMINIUM PRODUCTS:

Standards relating to Aluminium products are also sub-divided

- Based on process of production,
    - Rolling- Hot rolling / Cold rolling,
        a) Billets, Ingots
        b) Plates, Sheets, strips
        c) Bars, wire rods, wires
    - Casting:
- Based on Alloy Constituents

Note: The total list of standards relating to above subjects can be seen from the list of standards placed at MTD-07.

Some of the examples of Aluminium Product Standards are:

IS 21 : 1992 - Wrought aluminium and aluminium alloys for manufacture of utensils

IS 737 : 2008 - Wrought aluminium and aluminium alloy sheet and strip for general engineering purposes

IS 1254 : 2007 - Corrugated aluminium sheet

IS 1285 : 2023 - Wrought aluminium and aluminium alloys extruded round tube and hollow sections for general engineering purposes

IS 15392 : 2003 - Aluminium and aluminium alloy bare foil for food packaging

IS 2590 : 1987 - Specification for primary aluminium ingots for re-melting for general engineering purposes

IS 5082 : 1998 - Wrought aluminium and aluminium alloy bars, rods, tubes, sections, plates and sheets for electrical applications

IS 733 : 1983 - Specification for wrought aluminium and aluminium alloy bars, rods and sections (For General Engineering Purposes)

IS 9612 : 1980 - Specification for aluminium tubes for refrigeration purposes

STANDARDS RELATING TO COPPER

BASE STANDARDS:

IS 2378 : 1974 - CODE FOR DESIGNATION OF COPPER AND COPPER ALLOYS

This standard specifies the symbols which shall be used for the designation of copper and copper alloys on the basis of chemical composition, physical condition, etc.

Copper and copper alloys may be designated by a group of symbols indicating the important characteristics in the following order:

a) Chemical composition
b) Special requirements

If there are more than one symbols under any of the above categories, they shall be arranged in the alphabetical order.

Examples:

- Various types of castings are designated as: G, GC, GD, GW, GX
- Hot rolled is designated as: h
- Cold-worked (rolled, drawn or extruded) is designated as: d
- Hot extruded is designated as: e
- Forged is designated as: f

SYMBOLS FOR CHEMICAL COMPOSITION

- Symbol for Pure copper - The symbol ‘Cu’ shall be followed by the internationally accepted symbols and shall be coded as given below:

Grade	Designation
Cathode copper	CUCATH
Electrolytic tough pitch copper	CUETP
Fire-refined high conductivity copper	CUFRHC

- Symbol for Copper Alloy (Alloy Index)

The chemical symbol of copper shall be followed by the chemical symbol of the next most significant element after which other significant elements shall be stated in the order of decreasing percentage or, when equal, in alphabetical order. The nominal or average percentage of each alloying element shall be indicated by an index number as given below and shall immediately follow the respective chemical symbol; only the minimum number of symbols necessary to identify the alloy shall be used:

Nominal or Average Alloy Content	Index Number
1.Up to 1 percent	Only the alloy symbol shall be used in the descending order of percentage content
2. 1 percent and over	The average or nominal alloying content shall be rounded to the nearest whole number

Where two or more significant alloying elements have the same alloy index in an alloy, the chemical symbols shall be grouped together followed by their alloy index.

- SYMBOLS FOR TEMPER DESIGNATIONS:

Temper designations are based on the sequence of basic treatments used to produce various tempers and are identified as: O, H, T, OS, HA, HB, HC, TA, TB, TC, TD, etc

Example: Copper sheet, Hot rolled and having Chemical elements: Copper, Arsenic, Antimony, Bismuth, Oxygen, Lead is designated as: CU ATph

For detailed designations of Copper, please see IS 2378:1974.& IS 5052:1993.

GLOSSARY OF TERMS RELATING TO COPPER

The standard, IS 3288 has been prepared for the guidance of the manufactures and the users to assist them in the uniform interpretation of the common terms used in Copper metals industry. The terminology of various terms relating to Copper metals are given in Eight parts of the standard and the details are given below:

IS 3288 (Part 1) : 1986 - Glossary of terms relating to copper and copper alloys: Part 1 materials

IS 3288 (Part 2) : 1986 - Glossary of terms relating to copper and copper alloys: Part 2 unwrought and cast form

IS 3288 (Part 3) : 1986 - Glossary of terms relating to copper and copper alloys: Part 3 wrought forms

IS 3288 (Part 4) : 1986 – Glossary of terms relating to copper and copper alloys: Part 4 processing

IS 3288 (Part 5) : 1986 – Glossary of terms relating to copper and copper alloys: Part 5 heat treatment

IS 3288 (Part 6) : 1986 – Glossary of terms relating to copper and copper alloys: Part 6 finishes

IS 3288 (Part 7) : 1986 – Glossary of terms relating to copper and copper alloys: Part 7 dimensional surface and structural characteristics

IS 3288 (Part 8) : 1986 - Glossary of terms relating to copper and copper alloys: Part 8 packing

- Some of the terms relating to Copper defined in the above standards are given below:

Unrefined Copper

Copper Matte – An intermediate product consisting mainly of ferrous and cuprous sulphides, which is oxidized in convertors to produce metallic copper, usually termed blister copper.

Black Copper - An impure form of copper produced by smelting, impure copper scrap and/ or oxidized copper ores, usually in a shaft furnace.

Blister Copper - An impure form of copper produced by blowing air through molten copper matte. During the conversion process, sulphur, iron and other impurities are oxidized. The copper content is normally above 96 percent.

Cement copper - An impure, finely divided mixture of copper and copper oxide obtained by precipitation of copper usually by iron (cementation) from aqueous solution of copper compounds. The copper content, dry basis, varies widely, usually 50 percent and above.

Cathode - A rough, flat, unwrought product made by electrolytic deposition and normally used for re-melting.

Types of copper

Oxygen-Free Copper - Copper containing less than 10 ppm oxygen.

Tough Pitch Copper - Copper containing less than 0.06 percent oxygen, either electrolytically or fire refined, cast in the form of refinery shapes, containing a controlled amount of oxygen for the purpose of obtaining a level set in the casting. By extension, the term is applicable to fabricators products made there from.

Electrolytic Copper (ETP) - Copper, of any origin, refined by electrolytic deposition. Usually when this term is used alone, it refers to electrolytic tough pitch copper. This designation applies to the following.

- Cathodes, that are the direct products of refining operation.
- Electrodeposited copper, cast from melted cathodes into refinery shape, suitable for hot or cold working or both and by extension, fabricators products made therefrom.
- Electrodeposited copper, cast into ingot or ingot bar, suitable for remelting.
- Fire refined Copper -Copper of any rigin or type finished by furnace refining. Usually when the term 'fire refined copper' is used alone, it refers to fire-refined tough pitch copper. This designation applies to the following:

  a) Copper cast in the form of refinery shapes suitable for hot or cold working or both, and by extension, fabricators' products made therefrom **(FRTP-1).**

  b) Ingot or ingot bar suitable for re-melting **(FRTP-2).**

  c) Fire-Refined High Conductivity Copper **(FRHC)** - Copper which, in the annealed condition, has a minimum electrical conductivity of 100 percent of International Annealed Copper Standard (IACS).

  d) Deoxidized Copper - Copper cast in form of refinery shapes, produced free from cuprous oxide through the use of deoxidizers. By extension, the term applies to fabricators' products made therefrom.

  e) Deoxidized Copper High Residual Phosphorus **(DHP)** – Copper deoxidized by phosphorous, usually residual in excess. It is not susceptible to hydrogen embrittlement but is of relatively low electrical conductivity due to the amount of phosphorus present.

  f) Deoxidized Copper Lower Residual Phosphorous **(DLP)** – Copper deoxidized by phosphorous, usually has residual in small quantity. It is not susceptible to hydrogen embrittlement and has electrical conductivity of 90 percent IACS.

  g) Arsenical Tough Pitch Copper **(ATP)** - Copper containing arsenic in amounts as agreed to between the supplier and the purchaser, and are produced tough pitch variety.

  h) Phosphorus Deoxidized Arsenical Copper (DPA) - Copper deoxidized by phosphorus and containing arsenic in amounts as agreed to between the supplier and the purchaser.

Copper Alloys

Brass- Any copper alloy with zinc as the principal alloying element with or without small quantities of some other elements.

Bronze - A term originally used for referring to copper alloys having tin as the only or principal alloying elements. In modern usage the term 'bronze' is seldom used alone; and the term 'Phosphor Bronze' or 'Tin Bronze' is used for indicating copper-tin alloys. In fact, the term 'Bronze' , together with a suitable qualifying adjective has, in recent years, been intended to apply to any of a great variety of copper alloys.

Nickel Silver - Copper alloy containing nickel and zinc, sometimes called German Silver.

Cupro Nickel - A copper alloy composed of copper and nickel with small addition of elements such as iron and manganese.

Aluminium Bronze - Alloys of copper and aluminium, with or without other element when other elements are present, aluminium predominates by mass over each of other elements.

High Copper - Copper containing very low percentage of alloying elements say up to about 2 percent.

STANDARDS RELATING TO COPPER PRODUCTS:

Standards relating to Copper products are also sub-divided

- Based on process of production,
  - Rolling- Hot rolling / Cold rolling,
    - a) Billets, Ingots
    - b) Plates, Sheets, strips
    - c) Bars, wire rods, wires
  - Casting:
- Based on Alloy Constituents

Note: The total list of standards relating to above subjects can be seen from the list of standards placed at MTD-08.

Some of the examples of Copper Product Standards are:

IS 10773 : 1995 - Wrought copper tubes for refrigeration and air - Conditioning purposes

IS 12443 : 1988 - Specification for rolled brass plates for general engineering purposes

IS 11109 : 1984 - Specification for silicon brass ingots and castings

IS 14810 : 2000 - Copper tubes for plumbing

IS 191 : 2007 - Copper – Specification

IS 2501 : 1995 - Solid drawn copper tubes for general engineering purposes

IS 28 : 1985 - Phosphor bronze ingots and castings

IS 407 : 1981 - Specification for brass tubes for general purposes

IS 4171 : 1983 - Specification for copper rods and bars for general engineering purposes