Chapter 72

Iron and steel

Notes.

1.- In this Chapter and, in the case of Notes (d), (e) and (f) throughout the Nomenclature, the following expressions have the meanings hereby assigned to them :

(a) **Pig iron**

Iron-carbon alloys not usefully malleable, containing more than 2 % by weight of carbon and which may contain by weight one or more other elements within the following limits :

- not more than 10 % of chromium
- not more than 6 % of manganese
- not more than 3 % of phosphorus
- not more than 8 % of silicon
- a total of not more than 10 % of other elements.

(b) **Spiegeleisen**

Iron-carbon alloys containing by weight more than 6 % but not more than 30 % of manganese and otherwise conforming to the specification at (a) above.

(c) **Ferro-alloys**

Alloys in pigs, blocks, lumps or similar primary forms, in forms obtained by continuous casting and also in granular or powder forms, whether or not agglomerated, commonly used as an additive in the manufacture of other alloys or as de-oxidants, de-sulphurising agents or for similar uses in ferrous metallurgy and generally not usefully malleable, containing by weight 4 % or more of the element iron and one or more of the following :

- more than 10 % of chromium
- more than 30 % of manganese
- more than 3 % of phosphorus
- more than 8 % of silicon
- a total of more than 10 % of other elements, excluding carbon, subject to a maximum content of 10 % in the case of copper.

(d) **Steel**

Ferrous materials other than those of heading 72.03 which (with the exception of certain types produced in the form of castings) are usefully malleable and which contain by weight 2 % or less of carbon. However, chromium steels may contain higher proportions of carbon.

(e) **Stainless steel**

Alloy steels containing, by weight, 1.2 % or less of carbon and 10.5 % or more of chromium, with or without other elements.

(f) **Other alloy steel**

Steels not complying with the definition of stainless steel and containing by weight one or more of the following elements in the proportion shown :

- 0.3 % or more of aluminium
- 0.0008 % or more of boron
- 0.3 % or more of chromium
- 0.3 % or more of cobalt
- 0.4 % or more of copper
- 0.4 % or more of lead
- 1.65 % or more of manganese
- 0.08 % or more of molybdenum
- 0.3 % or more of nickel
- 0.06 % or more of niobium
- 0.6 % or more of silicon
- 0.05 % or more of titanium
- 0.3 % or more of tungsten (wolfram)
- 0.1 % or more of vanadium
- 0.05 % or more of zirconium
- 0.1 % or more of other elements (except sulphur, phosphorus, carbon and nitrogen), taken separately.

(g) **Remelting scrap ingots of iron or steel**

Products roughly cast in the form of ingots without feeder-heads or hot tops, or of pigs, having obvious surface faults and not complying with the chemical composition of pig iron, spiegeleisen or ferro-alloys.

(h) **Granules**

Products of which less than 90 % by weight passes through a sieve with a mesh aperture of 1 mm and of which 90 % or more by weight passes through a sieve with a mesh aperture of 5 mm.

(ij) **Semi-finished products**

Continuous cast products of solid section, whether or not subjected to primary hot-rolling; and Other products of solid section, which have not been further worked than subjected to primary hot-rolling or roughly shaped by forging, including blanks for angles, shapes or sections.

These products are not presented in coils.

(k) **Flat-rolled products**

Rolled products of solid rectangular (other than square) cross-section, which do not conform to the definition at (ij) above in the form of :

- coils of successively superimposed layers, or

- straight lengths, which if of a thickness less than 4.75 mm are of a width measuring at least ten times the thickness or if of a thickness of 4.75 mm or more are of a width which exceeds 150 mm and measures at least twice the thickness.

Flat-rolled products include those with patterns in relief derived directly from rolling (for example, grooves, ribs, chequers, tears, buttons, lozenges) and those which have been perforated, corrugated or polished, provided that they do not thereby assume the character of articles or products of other headings.

Flat-rolled products of a shape other than rectangular or square, of any size, are to be classified as products of a width of 600 mm or more, provided that they do not assume the character of articles or products of other headings.

(l) **Bars and rods, hot-rolled, in irregularly wound coils**

Hot-rolled products in irregularly wound coils, which have a solid cross-section in the shape of circles, segments of circles, ovals, rectangles (including squares), triangles or other convex polygons (including "flattened circles" and "modified rectangles", of which two opposite sides are convex arcs, the other two sides being straight, of equal length and parallel). These products may have indentations, ribs, grooves or other deformations produced during the rolling process (reinforcing bars and rods).

(m) **Other bars and rods**

Products which do not conform to any of the definitions at (ij), (k) or (l) above or to the definition of wire, which have a uniform solid cross-section along their whole length in the shape of circles, segments of circles, ovals, rectangles (including squares), triangles or other convex polygons (including "flattened circles" and "modified rectangles", of which two opposite sides are convex arcs, the other two sides being straight, of equal length and parallel). These products may :

- have indentations, ribs, grooves or other deformations produced during the rolling process (reinforcing bars and rods);

- be twisted after rolling.

(n) **Angles, shapes and sections**

Products having a uniform solid cross-section along their whole length which do not conform to any of the definitions at (ij), (k), (l) or (m) above or to the definition of wire.

Chapter 72 does not include products of heading 73.01 or 73.02.

(o) **Wire**

Cold-formed products in coils, of any uniform solid cross-section along their whole length, which do not conform to the definition of flat-rolled products.

(p) **Hollow drill bars and rods**

Hollow bars and rods of any cross-section, suitable for drills, of which the greatest external dimension of the cross-section exceeds 15 mm but does not exceed 52 mm, and of which the greatest internal dimension does not exceed one half of the greatest external dimension. Hollow bars and rods of iron or steel not conforming to this definition are to be classified in heading 73.04.

2.- Ferrous metals clad with another ferrous metal are to be classified as products of the ferrous metal predominating by weight.

3.- Iron or steel products obtained by electrolytic deposition, by pressure casting or by sintering are to be classified, according to their form, their composition and their appearance, in the headings of this Chapter appropriate to similar hot-rolled products.

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Subheading Notes.

1.- In this Chapter the following expressions have the meanings hereby assigned to them :

(a) **Alloy pig iron**

Pig iron containing, by weight, one or more of the following elements in the specified proportions :

- more than 0.2 % of chromium
- more than 0.3 % of copper
- more than 0.3 % of nickel
- more than 0.1 % of any of the following elements : aluminium, molybdenum, titanium, tungsten (wolfram), vanadium.

(b) **Non-alloy free-cutting steel**

Non-alloy steel containing, by weight, one or more of the following elements in the specified proportions :

- 0.08 % or more of sulphur
- 0.1 % or more of lead
- more than 0.05 % of selenium
- more than 0.01 % of tellurium
- more than 0.05 % of bismuth.

(c) **Silicon-electrical steel**

Alloy steels containing by weight at least 0.6 % but not more than 6 % of silicon and not more than 0.08 % of carbon. They may also contain by weight not more than 1 % of aluminium but no other element in a proportion that would give the steel the characteristics of another alloy steel.

(d) **High speed steel**

Alloy steels containing, with or without other elements, at least two of the three elements molybdenum, tungsten and vanadium with a combined content by weight of 7 % or more, 0.6 % or more of carbon and 3 to 6 % of chromium.

(e) **Silico-manganese steel**

Alloy steels containing by weight :

- not more than 0.7 % of carbon,

- 0.5 % or more but not more than 1.9 % of manganese, and
- 0.6 % or more but not more than 2.3 % of silicon, but no other element in a proportion that would give the steel the characteristics of another alloy steel.

2.- For the classification of ferro-alloys in the subheadings of heading 72.02 the following rule should be observed :

A ferro-alloy is considered as binary and classified under the relevant subheading (if it exists) if only one of the alloy elements exceeds the minimum percentage laid down in Chapter Note 1 (c); by analogy, it is considered respectively as ternary or quaternary if two or three alloy elements exceed the minimum percentage.

For the application of this rule the unspecified "other elements" referred to in Chapter Note 1 (c) must each exceed 10 % by weight.

GENERAL

This Chapter covers the ferrous metals, i.e., pig iron, spiegeleisen, ferro-alloys and other primary materials (sub-Chapter I), as well as certain products of the iron and steel industry (ingots and other primary forms, semi-finished products and the principal products derived directly therefrom) of iron or non-alloy steel (sub-Chapter II), of stainless steel (sub-Chapter III) and of other alloy steel (sub-Chapter IV).

Further worked articles, such as castings, forgings, etc., and sheet piling, welded angles, shapes and sections, railway or tramway track construction material and tubes are classified in **Chapter 73** or, in certain cases, in other Chapters.

As raw material, the iron and steel industry uses various natural iron ores (oxides, hydrated oxides, carbonates) listed in the Explanatory Note to heading 26.01, pyrites cinder (the sintered iron oxides remaining after burning off the sulphur from pyrite, marcasite, pyrrhotite, etc.) and waste and scrap of iron or steel.

(I) Conversion (reduction) of iron ore

Iron ore is converted by reduction either into pig iron, in blast furnaces or electric furnaces, or into a spongy form (sponge iron) or into lumps by various direct reduction processes; only when iron of exceptional purity is required for special use (e.g., in the chemical industry) is it obtained by electrolysis or other chemical processes.

(A) Conversion of iron ore by blast furnace process

Most iron obtained from iron ore is still extracted by the blast furnace process. This process uses mainly ore as raw material, but waste and scrap metal, pre-reduced iron ores and other ferrous waste can also be used.

Blast furnace reductants consist essentially of hard coke, sometimes combined with small quantities of coal or liquid or gaseous hydrocarbons.

The iron so obtained is in the form of molten pig iron. The by-products are slag, blast furnace gas and blast furnace dust.

Most of the molten pig iron thus produced is converted directly into steel in steelworks.

Some may be used in foundries (ironworks), for the manufacture of ingot moulds, cast iron tubes and pipes, etc.

The remainder may be cast into the form of pigs or blocks, in casting machines or in sand-beds; or it may be produced in the form of irregularly shaped lumps, sometimes known as "plate iron", or be granulated by being poured into water.

Solid pig iron is either remelted in steelworks with ferrous scrap, to produce steel, or melted in iron foundries, in cupolas or electric furnaces, again with ferrous scrap, and converted into castings.

(B) **Conversion of iron ore in direct reduction plants**

In contrast to the process described above, here the reductants are usually gaseous or liquid hydrocarbons or coal, so that the need for hard coke is eliminated.

In these processes, the reduction temperature is lower so that the resulting products (generally known as sponge iron) are obtained, without passing through the molten state, in the form of sponge, pre-reduced pellets or lumps. For this reason, their carbon content is usually lower than that of blast furnace pig iron (where molten metal is in close contact with the carbon). Most of these crude products are melted in steelworks and converted into steel.

(II) **Steel production**

Pig or cast iron in molten or solid form and the ferrous products obtained by direct reduction (sponge iron) constitute, with waste and scrap, the primary steelmaking materials. To these materials are added certain slag-forming additives such as quick-lime, fluorspar, de-oxidants (e.g., ferro-manganese, ferro-silicon, aluminium) and various alloying elements.

Steelmaking processes fall into two main categories viz : "pneumatic" processes in which molten pig iron is refined in a converter or by blowing air, and hearth processes, such as open hearth or electric furnace.

The pneumatic processes require no external source of heat. They are used when the charge consists mainly of molten pig iron. The oxidation of certain elements present in the pig iron (e.g., carbon, phosphorus, silicon and manganese) generates enough heat to keep the steel liquid and even to remelt any added scrap. These processes include those in which pure oxygen is blown into the molten metal (Linz-Donawitz processes : LD or LDAC, OBM, OLP, Kaldo and others) and those, now becoming obsolete, in which air, sometimes oxygen-enriched, is used (Thomas and Bessemer processes).

Open-hearth refining processes, however, require an external source of heat. They are used when a solid charge (e.g., waste or scrap iron, sponge iron and solid pig iron) forms the raw material.

The two main processes in this category are the Martin furnace process in which the heat is provided by heavy oil or gas, and the arc or induction furnace process, where the heat is supplied by electricity.

For the production of certain steels two different processes may be applied successively (duplex process). For example, refining may begin in a Martin furnace and end in an electric furnace; or steel melted in an electric furnace may be transferred to a special converter where decarburisation is completed by blowing oxygen and argon on to the charge (a process used, for example, in the production of stainless steel).

Many new processes have been evolved for producing steels of special composition or with special properties. These processes include electric arc melting in a vacuum, melting by electronic bombardment and the electroslag process. In all these processes the steel is produced from a self-consuming electrode which, on melting, drips into a water-cooled ingot mould. The mould may be made in one piece, or the bottom may be removable so that the solidified casting can be withdrawn from below.

Liquid steel obtained by the above-mentioned processes, with or without further refining, is generally run into a receiving ladle. At this stage alloying elements or de-oxidising agents, in solid or liquid form, may be added. This may be done in a vacuum to ensure freedom from gaseous impurities.

Steels obtained by all these processes are divided, according to their content of alloying elements, into "non-alloy steels" and "alloy steels" (stainless or other). They are further divided in accordance with their special properties into free-cutting steel, silicon-electrical steel, high speed steel or silico-manganese steel, for example.

(III) **Production of ingots or other primary forms and of semi-finished products**

Although molten steel may be cast (in foundries) into its final shape in moulds (steel castings), most molten steel is cast into ingots in ingot moulds.

At the casting or pouring stage and at the solidification stage, steel is divided into three main groups : rimming (or "effervescent") steel, killed (or "non-effervescent") steel and semi-killed (or "balanced") steel. Steel cast or poured in the rimming state is so named because during and after the pouring process there is a reaction between the iron oxide and carbon dissolved in the steel rendering it "effervescent". During the cooling stage, the impurities concentrate in the central core and upper half of the ingots. The outer layer, which is not affected by these impurities, will subsequently give a better surface appearance to the rolled products obtained from these ingots. This more economical kind of steel is also used for cold dishing.

In many cases, steel cannot be satisfactorily cast in the "effervescent" state. This applies, in particular, to alloy steels and high carbon steels. In these cases, the steel must be killed, i.e., de-oxidised. De-oxidation may be partially carried out by treatment in a vacuum, but is more usually achieved by the addition of elements such as silicon, aluminium, calcium or manganese. In this way, the residual impurities are more evenly distributed throughout the ingot, giving a better assurance, for certain uses, that the properties of the steel will be the same throughout its mass.

Some steels may be partly de-oxidised and are then known as semi-killed (or balanced) steels.

After they have solidified and their temperature has been equalised, the ingots are rolled into semi-finished products (blooms, billets, rounds, slabs, sheet bars) on primary cogging or roughing mills (blooming, slabbing, etc.) or converted by drop hammer or on a forging press into semi-finished forgings.

An increasing amount of steel is being cast directly into the form of semi-finished products in **continuous casting** machines. Their cross-sectional shape may, in certain cases, approach that of finished products. Semi-finished products obtained by the continuous casting process are characterised by their external surface appearance which usually shows transverse rings of different colours at more or less regular distances, as well as by the appearance of their cut cross-section which usually shows radial crystallisation resulting from rapid cooling. Continuously cast steel is always killed.

(IV) **Production of finished products**

Semi-finished products and, in certain cases, ingots are subsequently converted into finished products.

These are generally subdivided into **flat products** ("wide flats", including "universal plates", "wide coil", sheets, plates and strip) and **long products** (bars and rods, hot-rolled, in irregularly wound coils, other bars and rods, angles, shapes, sections and wire).

These products are obtained by plastic deformation, either hot, directly from ingots or semi-finished products (by hot-rolling, forging or hot-drawing) or cold, indirectly from hot finished products (by cold-rolling, extrusion, wire-drawing, bright-drawing), followed in some cases by finishing operations (e.g., cold-finished bars obtained by centre-less grinding or by precision turning).

According to Note 3 to this Chapter, iron and steel products obtained by electrolytic deposition, by casting under pressure or by sintering are to be classified, according to their form, their composition and their appearance, in the headings of this Chapter appropriate to similar hot-rolled products.

For the purpose of this Note, the following expressions have the meanings hereby assigned to them :

(1) **Casting under pressure** (die casting)

This process consists of injecting an alloy in molten or pasty form into a mould under a more or less high pressure.

Such a process facilitates production in large quantities and ensures dimensional precision.

(2) **Sintering**

This is an operation of powder metallurgy by means of which a compacted powder product, obtained by moulding, usually coupled with pressing, is subsequently heated in a special furnace.

This operation, which gives the final properties to the sintered materials, is carried out under specified conditions of temperature, timing and atmosphere. It produces an agglomeration in solid form. Sintering may also be carried out in a vacuum.

(A) **Hot plastic deformation**

(1) **Hot-rolling** means rolling at a temperature between the point of rapid recrystallisation and that of the beginning of fusion. The temperature range depends on various factors such as the composition of the steel. As a rule, the final temperature of the work-piece in hot-rolling is about 900 °C.

(2) **Forging** means the hot deformation of the metal in the mass by means of drop hammers or on forging presses, to obtain pieces of any shape.

(3) In **hot-drawing**, the steel is heated and passed through a die to produce bars, tubes or sections of various shapes.

(4) **Hot drop forging and drop stamping** means producing metal shapes or sections (usually on the conveyor line) by the hot shaping of cut blanks in dies (closed or with burr joints) by means of special tools. The work, carried out by impact or pressure, is generally effected in successive phases, following preliminary operations of rolling, hammering, hand forging or bending.

(B) **Cold plastic deformation**

(1) **Cold-rolling** is carried out at ambient temperatures, i.e., below the recrystallisation temperature.

(2) **Cold drop forging and drop stamping** means producing shapes or sections by cold processes similar to those described in Item A (4) above.

(3) **Extrusion** is a process, generally cold, for deforming steel in the mass under high pressure between a die and a press tool, in a space enclosed on all sides except that through which the charge passes, to assume the desired shape.

(4) **Wire-drawing** is a cold process in which bars or rods in irregularly wound coils are drawn through one or more dies at high speed to obtain coiled wire of smaller diameter.

(5) **Bright-drawing** is a cold process in which bars or rods, whether or not in irregularly wound coils, are drawn (at relatively low speed) through one or more dies to obtain products of smaller or different shaped section.

Cold-worked products can be distinguished from hot-rolled or hot-drawn products by the following criteria :

- the surface of cold-worked products has a better appearance than that of products obtained by a hot process and never has a layer of scale;
- the dimensional tolerances are smaller for cold-worked products;
- thin-flat products (thin "wide coil", sheets, plates and strip) are usually produced by cold-reduction;
- microscopic examination of cold-worked products reveals a marked deformation of the grains and grain orientation parallel to the direction of working. By contrast, products obtained by hot processes show almost regular grains owing to recrystallisation;

In addition, cold-worked products have the following properties which may be shared by certain hot-rolled or hot-drawn products :

(a) because of the strain or work hardening they have undergone, cold-worked products are very hard and possess great tensile strength, though these properties may diminish appreciably with heat treatment;

(b) elongation at fracture is very low in cold-worked products; it is higher in products that have undergone suitable heat treatment.

The very light cold-rolling process (known as a skin pass or pinch pass) which is applied to certain hot-rolled flat products without significant reduction of their thickness does not change their character of finished hot-rolled products. This cold pass under low pressure acts essentially on the surface of the products only, whereas cold-rolling in the true sense (also known as cold-reduction) changes the crystalline structure of the work piece by considerably reducing its cross-section.

(C) **Subsequent manufacture and finishing**

The finished products may be subjected to further finishing treatments or converted into other articles by a series of operations such as :

(1) **Mechanical working**, i.e., turning, milling, grinding, perforation or punching, folding, sizing, peeling, etc.; however, it should be noted that rough turning merely to eliminate the oxidation scale and crust and rough trimming are not regarded as finishing operations leading to a change in classification.

(2) **Surface treatments** or other operations, including cladding, to improve the properties or appearance of the metal, protect it against rusting and corrosion, etc. Except as otherwise provided in the text of certain headings, such treatments do not affect the heading in which the goods are classified. They include :

(a) Annealing, hardening, tempering, case-hardening, nitriding and similar heat treatments to improve the properties of the metal.

(b) Descaling, pickling, scraping and other processes to remove the oxide scale and crust formed during the heating of the metal.

(c) Rough coating intended solely to protect products from rust or other oxidation, to prevent slipping during transport and to facilitate handling e.g., paints containing an active anti-rust pigment (red lead, zinc powder, zinc oxide, zinc chromate, iron oxide, iron minium, jewellers' rouge), and non-pigmented coatings with a basis of oil, grease, wax, paraffin wax, graphite, tar or bitumen.

(d) Surface finishing treatment, including;

(i) polishing and burnishing or similar treatment;

(ii) artificial oxidation (by various chemical processes, such as immersion in an oxidising solution), patina finishing, blueing (blue annealing) browning or bronzing (by various techniques), which also from a film of oxide on the surface of the product, to improve its appearance. The operations increase resistance to rusting;

(iii) chemical surface treatments, such as :

- phosphatising, which consists of immersing the product in a solution of metallic acid phosphates, particularly those of manganese, iron and zinc; this process is known as parkerising or bonderising, depending on the period of the operation and the temperature of the bath;
- oxalating, borating, etc., using methods similar to those for phosphatising, with the appropriate salts or acids;
- chromating, which consists of immersing the product in a solution whose main contents are chronic acid or chromates; this process is for the surface treatment of e.g., steel plate plated or coated with zinc.

These chemical surface treatments have the advantage of protecting the surface of metal, facilitating any later cold deformation of the products treated and the application of paints or other non-metallic protective coatings.

(iv) coating with metal (metallisation) the main processes being :

- immersion in a bath of molten metal or metal alloy e.g., hot-dip galvanising, tinning, hot-coating with lead, and aluminium coating;
- electroplating (cathodic deposition of a coating metal on the product to be coated, by electrolysis of a suitable solution of metallic salts), e.g., with zinc, cadmium, tin, lead, chromium, chromium/chromate, copper, nickel, gold or silver;
- impregnation or diffusion (by heating the product to be coated with the required coating metal in powder form e.g., sherardising (cementation with zinc) and calorising (cementation with aluminium) and chromising (with diffusion of chromium);
- spraying (atomising the molten coating metal and directing the spray on to the product to be coated), e.g., the Schoop process and the gas pistol, arc, plasma and electrostatic spray processes;
- metallisation by evaporating the coating metal in a vacuum. etc.;
- metallisation by bombarding the coating metal with ions in a glow discharge (ion plating);
- coating by cathode vaporisation (sputtering).

(v) coating with non-metallic substances, e.g., enamelling, varnishing, lacquering, painting, surface printing, coating with ceramics or plastics, including special processes such as glow discharge, electrophoresis, electrostatic projection and immersion in an electrostatic fluidised bath followed by radiation firing, etc.

(e) Cladding, i.e., the association of layers of metals of different colours or natures by molecular interpenetration of the surfaces in contact. This limited diffusion is characteristic of clad products and differentiates them from products metallised in the manner specified in the preceding paragraphs (e.g., by normal electroplating).

The various cladding processes include pouring molten cladding metal on to the basic metal, followed by rolling; simple hot-rolling of the cladding metal to ensure efficient welding to the basic metal; any other method of deposition or superimposing of the cladding metal followed by any mechanical or thermal process to ensure welding (e.g., electro-cladding), in which the cladding metal (nickel, chromium, etc.) is applied to the basic metal by electroplating, molecular interpenetration of the surfaces in contact then being obtained by heat treatment at the appropriate temperature with subsequent cold-rolling.

Ferrous products clad with non-ferrous metals remain in their respective headings in Chapter 72 **provided** that iron or steel is the predominating metal by weight (see Note 7 to Section XV). Iron or steel products, clad with another ferrous metal, which, according to the composition of the original products, or of the cladding metal, could be classified in two sub-Chapters (II, III or IV) have similarly to be classified according to the metal predominating by weight (see Note 2 to this Chapter); e.g., a bar of non-alloy ordinary steel clad with stainless steel is therefore classified in sub-Chapter II if the former metal predominates by weight, or in sub-Chapter III if not.

(f) Removal of small portions of the metal for testing purposes.

(g) Lamination, for example, the superimposing of metal layers over an intermediate layer of viscoelastic material, the latter layer serving as a sound, etc., insulator.

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The classification of alloys of ferrous metals and of composite articles is dealt with in the General Explanatory Note to Section XV.
